Note

Before using this information and the product it supports, be sure to read the general information under “Notices” on page 801.

First edition (30 April 2020)

This edition applies to Version 6 Release 1 of IBM® Enterprise COBOL for z/OS® (program number 5655-EC6) and to all subsequent releases and modifications until otherwise indicated in new editions. Make sure that you are using the correct edition for the level of the product.

You can view or download softcopy publications free of charge in the Enterprise COBOL for z/OS library. Because Enterprise COBOL for z/OS supports the continuous delivery (CD) model and publications are updated to document the features delivered under the CD model, it is a good idea to check for updates once every two months.

It is our intention to update the product documentation for this release periodically, without updating the order number. If you need to uniquely refer to the version of your product documentation, refer to the order number with the date of update.

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<td>759</td>
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</tr>
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<td>129. SYSADATA nested program record</td>
<td>773</td>
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<td>130. SYSADATA library record</td>
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<td>132. SYSADATA EVENTS TIMESTAMP record layout</td>
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<td>775</td>
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<td>776</td>
</tr>
<tr>
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<td>776</td>
</tr>
<tr>
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<td>776</td>
</tr>
<tr>
<td>137. SYSADATA EVENTS ERROR record layout</td>
<td>777</td>
</tr>
</tbody>
</table>
Preface

About this information

This information is for COBOL programmers and system programmers. It helps you understand how to use Enterprise COBOL for z/OS to compile COBOL programs. It also describes the operating system features that you might need to optimize program performance or handle errors.

For information about COBOL language, and for references needed to write a program for an IBM COBOL compiler, see the Enterprise COBOL for z/OS Language Reference.

Important: Enterprise COBOL for z/OS is referred to as Enterprise COBOL throughout this information.

How this information will help you

This information will help you write and compile Enterprise COBOL programs. It will also help you define object-oriented classes and methods, invoke methods, and refer to objects in your programs.

This information assumes experience in developing application programs and some knowledge of COBOL. It focuses on using Enterprise COBOL to meet your programming objectives and not on the definition of the COBOL language. For complete information about COBOL syntax, see the IBM Enterprise COBOL for z/OS Language Reference.

For information about migrating programs to Enterprise COBOL, see the IBM Enterprise COBOL for z/OS Migration Guide.

IBM z/OS Language Environment® provides the runtime environment and runtime services that are required to run Enterprise COBOL programs. You can find information about link-editing and running programs in the IBM z/OS Language Environment Programming Guide and IBM z/OS Language Environment Programming Reference.

For a comparison of commonly used Enterprise COBOL and Language Environment terms, see “Comparison of commonly used terms” on page xxvi.

Abbreviated terms

Certain terms are used in a shortened form in this information. Abbreviations for the product names used most frequently are listed alphabetically in the following table.

<table>
<thead>
<tr>
<th>Term used</th>
<th>Long form</th>
</tr>
</thead>
<tbody>
<tr>
<td>CICS®</td>
<td>CICS Transaction Server</td>
</tr>
<tr>
<td>Enterprise COBOL</td>
<td>IBM Enterprise COBOL for z/OS</td>
</tr>
<tr>
<td>Language Environment</td>
<td>IBM z/OS Language Environment</td>
</tr>
<tr>
<td>MVS™</td>
<td>MVS/ESA</td>
</tr>
<tr>
<td>z/OS UNIX</td>
<td>z/OS UNIX System Services</td>
</tr>
</tbody>
</table>

In addition to these abbreviated terms, the term "85 COBOL Standard" is used to refer to the combination of the following standards:

- ISO 1989:1985, Programming languages - COBOL
- ISO/IEC 1989/AMD2:1994, Programming languages - Correction and clarification amendment for COBOL
- ANSI INCITS 23-1985, Programming Languages - COBOL
Comparison of commonly used terms

To better understand the terms used throughout the IBM z/OS Language Environment and IBM Enterprise COBOL for z/OS information, and to understand which terms are meant to be equivalent, see the following table.

<table>
<thead>
<tr>
<th>Language Environment term</th>
<th>Enterprise COBOL equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>Group item</td>
</tr>
<tr>
<td>Array</td>
<td>A table created using the OCCURS clause</td>
</tr>
<tr>
<td>Array element</td>
<td>Table element</td>
</tr>
<tr>
<td>Enclave</td>
<td>Run unit</td>
</tr>
<tr>
<td>External data</td>
<td>WORKING-STORAGE data defined using the EXTERNAL clause</td>
</tr>
<tr>
<td>Local data</td>
<td>Any non-EXTERNAL data item</td>
</tr>
<tr>
<td>Pass parameters directly, by value</td>
<td>BY VALUE</td>
</tr>
<tr>
<td>Pass parameters indirectly, by reference</td>
<td>BY REFERENCE</td>
</tr>
<tr>
<td>Pass parameters indirectly, by value</td>
<td>BY CONTENT</td>
</tr>
<tr>
<td>Routine</td>
<td>Program</td>
</tr>
<tr>
<td>Scalar</td>
<td>Elementary item</td>
</tr>
</tbody>
</table>

How to read syntax diagrams

Use the following description to read the syntax diagrams in this information.

• Read the syntax diagrams from left to right, from top to bottom, following the path of the line.
  
  The >>> symbol indicates the beginning of a syntax diagram.
  
  The ---- symbol indicates that the syntax diagram is continued on the next line.
  
  The >-- symbol indicates that the syntax diagram is continued from the previous line.
  
  The --->< symbol indicates the end of a syntax diagram.
  
  Diagrams of syntactical units other than complete statements start with the >-- symbol and end with the ---> symbol.

• Required items appear on the horizontal line (the main path):

```plaintext
  ▶️ required_item ◀️
```

• Optional items appear below the main path:

```plaintext
  ▶️ required_item ◀️
  optional_item
```
• If you can choose from two or more items, they appear vertically, in a stack. If you must choose one of the items, one item of the stack appears on the main path:

```
  required_item  required_choice1  
   \                       \       \ 
    required_choice2       
```

If choosing one of the items is optional, the entire stack appears below the main path:

```
  required_item  
   \          \       \ 
    optional_choice1  
     \       \       \ 
      optional_choice2  
```

If one of the items is the default, it appears above the main path and the remaining choices are shown below:

```
  required_item  
   \          \       
       default_choice  
     \       \       \ 
      optional_choice  
       \       \       \ 
        optional_choice  
```

• An arrow returning to the left, above the main line, indicates an item that can be repeated:

```
  required_item  \   \       
                  \       \       \ 
                   \       repeatable_item  
```

If the repeat arrow contains a comma, you must separate repeated items with a comma:

```
  required_item  \          \   \       
                  \       \       \       \ 
                   \       repeatable_item  
                      \       \       \ 
                       \       repeatable_item  
```

• Keywords appear in uppercase (for example, FROM). They must be spelled exactly as shown. Variables appear in lowercase italics (for example, column-name). They represent user-supplied names or values.

• If punctuation marks, parentheses, arithmetic operators, or other such symbols are shown, you must enter them as part of the syntax.

**How examples are shown**

This information shows numerous examples of sample COBOL statements, program fragments, and small programs to illustrate the coding techniques being described. The examples of program code are written in lowercase, uppercase, or mixed case to demonstrate that you can write your programs in any of these ways.

To more clearly separate some examples from the explanatory text, they are presented in a monospace font.
COBOL keywords and compiler options that appear in text are generally shown in SMALL UPPERCASE. Other terms such as program variable names are sometimes shown in an italic font for clarity.

Additional documentation and support

IBM Enterprise COBOL for z/OS provides Portable Document Format (PDF) versions of the entire library for this version and for previous versions on the product site at www.ibm.com/software/awdtools/cobol/zos/library/.

Support information is also available on the product site at http://www.ibm.com/support/entry/portal/Overview/Software/Rational®/Enterprise_COBOL_for_z-OS.

Summary of changes

This section lists the major changes that have been made to this document for Enterprise COBOL Version 6 Release 1 and Version 6 Release 1 with PTFs installed. The latest technical changes are marked within >| and <| in the HTML version, or marked by vertical bars (|) in the left margin in the PDF version.

Version 6 Release 1 with PTFs installed

New, changed, and removed compiler options

• The following compiler options are new:
  - PI68226: INITCHECK ("INITCHECK" on page 311)
  - PI71625: NUMCHECK ("NUMCHECK" on page 320)
  - PI77981: INLINE ("INLINE" on page 312)
  - PI78089: PARMCHECK ("PARMCHECK" on page 327)
  - PI96231: COPYLOC ("COPYLOC" on page 297)

• The following compiler options are modified:
  - PI68023 and PI81838: NOSTGOPT: The default behaviour of the NOSTGOPT compiler option has been changed. ("STGOPT" on page 340)
  - PI74933: SSRANGE: New suboptions MSG and ABD are added to the SSRANGE compiler option to control how the compiler checks reference modification lengths. ("SSRANGE" on page 339)
  - PI98996: NUMCHECK(PAC): For packed decimal (COMP-3) data items that have an even number of digits, the unused bits are checked for zeros. ("NUMCHECK" on page 320)
  - PH01251: NUMCHECK(ZON): New suboptions ALPHNUM | NOALPHNUM are added to the NUMCHECK(ZON) option to control whether the compiler will generate code for an implicit numeric class test for zoned decimal data items that are being compared with an alphanumeric data item, alphanumeric literal or alphanumeric figurative constant. ("NUMCHECK" on page 320)
  - PH13943: NUMCHECK(BIN): NUMCHECK(BIN) will check for binary data items (COMP, COMP-4, and USAGE BINARY) even when TRUNC(BIN) is in effect. ("NUMCHECK" on page 320)
  - PH24414: INITCHECK: New suboptions LAX | STRICT are added to the INITCHECK option to control whether the compiler will issue warning messages for data items unless they are initialized on at least one, or on all, logical paths to a statement. ("INITCHECK" on page 311)

• The following compiler option is removed:
  - PI71625: ZONECHECK is deprecated but is tolerated for compatibility, and it is replaced by NUMCHECK(ZON). ("ZONECHECK" on page 351)
Statement changes

- PI92944: A new LOC(24|31) phrase is added to the ALLOCATE statement to control the location of dynamic storage that is acquired, which overrides the influence of the DATA compiler option. (“Storage and its addressability” on page 37)

Version 6 Release 1

New, changed, and removed compiler options

- The following compiler options are new:
  - SUPPRESS (“SUPPRESS” on page 341)
  - VSAMOPENFS (“VSAMOPENFS” on page 348)
  - ZONECHECK (“ZONECHECK” on page 351)

- The following compiler options are modified:
  - LANGUAGE: To specify the language of compiler messages, you can use the LANGUAGE compiler option and also set the Language Environment runtime option NATLANG at compile time. (“LANGUAGE” on page 313)
  - SSRANGE: New suboptions ZLEN and NOZLEN are added to the SSRANGE compiler option to control how the compiler checks reference modification lengths. (“SSRANGE” on page 339)

New statements

- The new JSON GENERATE statement converts data to JSON format. (Chapter 29, “Producing JSON output,” on page 499)

Listing changes

- Changes are made to the STATIC MAP section of the compilation listing. (“Example: Static map ” on page 394)
- The LVLINFO0 installation option is removed. The build level information is always included in the listing header.

How to send your comments

Your feedback is important in helping us to provide accurate, high-quality information. If you have comments about this information or any other Enterprise COBOL documentation, send your comments to: compinfo@cn.ibm.com.

Be sure to include the name of the document, the publication number, the version of Enterprise COBOL, and, if applicable, the specific location (for example, the page number or section heading) of the text that you are commenting on.

When you send information to IBM, you grant IBM a nonexclusive right to use or distribute the information in any way that IBM believes appropriate without incurring any obligation to you.
Part 1. Coding your program
Chapter 1. Structuring your program

COBOL programs consist of four divisions: IDENTIFICATION DIVISION, ENVIRONMENT DIVISION, DATA DIVISION, and PROCEDURE DIVISION. Each division has a specific logical function.

To define a program, only the IDENTIFICATION DIVISION is required.

To define a COBOL class or method, you need to define some divisions differently than you do for a program.

related tasks
“Identifying a program” on page 3
“Describing the computing environment” on page 5
“Describing the data” on page 10
“Processing the data” on page 16
“Defining a class” on page 560
“Defining a class instance method” on page 564
“Structuring OO applications” on page 594

Identifying a program

Use the IDENTIFICATION DIVISION to name a program and optionally provide other identifying information.

You can use the optional AUTHOR, INSTALLATION, DATE-WRITTEN, and DATE-COMPILED paragraphs for descriptive information about a program. The data you enter in the DATE-COMPILED paragraph is replaced with the latest compilation date.

IDENTIFICATION DIVISION.
Program-ID.    Helloprog.
Author.        A. Programmer.
Installation.  Computing Laboratories.
Date-Written.  03/10/2016.
Date-Compiled. 03/18/2016.

Use the PROGRAM-ID paragraph to name your program. The program-name that you assign is used in these ways:

• Other programs use that name to call your program.
• The name appears in the header on each page, except the first, of the program listing that is generated when you compile the program.
• If you use the NAME compiler option, the name is placed on the NAME binder (linkage-editor) control statement to identify the object module that the compilation creates.

Tip: Do not use program-names that start with prefixes used by IBM products. If you use program-names that start with any of the following prefixes, your CALL statements might resolve to IBM library or compiler routines rather than to your intended program:

– AFB
– AFH
– CBC
– CEE
– CEH
– CEL
– CEQ
Tip: If a program-name is case sensitive, avoid mismatches with the name that the compiler is looking for. Verify that the appropriate setting of the PGMNAME compiler option is in effect.

related tasks
“Changing the header of a source listing” on page 5
“Identifying a program as recursive” on page 4
“Marking a program as callable by containing programs” on page 4
“Setting a program to an initial state” on page 4

related references
Compiler limits (Enterprise COBOL for z/OS Language Reference)
Conventions for program-names (Enterprise COBOL for z/OS Language Reference)

Identifying a program as recursive

Code the RECURSIVE attribute on the PROGRAM-ID clause to specify that a program can be recursively reentered while a previous invocation is still active.

You can code RECURSIVE only on the outermost program of a compilation unit. Neither nested subprograms nor programs that contain nested subprograms can be recursive. You must code RECURSIVE for programs that you compile with the THREAD option.

related tasks
“Sharing data in recursive or multithreaded programs” on page 15
“Making recursive calls” on page 457

Marking a program as callable by containing programs

Use the COMMON attribute in the PROGRAM-ID paragraph to specify that a program can be called by the containing program or by any program in the containing program. The COMMON program cannot be called by any program contained in itself.

Only contained programs can have the COMMON attribute.

related concepts
“Nested programs” on page 455

Setting a program to an initial state

Use the INITIAL clause in the PROGRAM-ID paragraph to specify that whenever a program is called, that program and any nested programs that it contains are to be placed in their initial state.

When a program is set to its initial state:
• Data items that have VALUE clauses are set to the specified values.
• Changed GO TO statements and PERFORM statements are in their initial states.
• Non-EXTERNAL files are closed.
Changing the header of a source listing

The header on the first page of a source listing contains the identification of the compiler and the current release level, the date and time of compilation, and the page number.

The following example shows these five elements:

```
PP 5655-EC6 IBM Enterprise COBOL for z/OS  6.1.0 P160211    Date 03/18/2016  Time 15:05:19
Page     1
```

The header indicates the compilation platform. You can customize the header on succeeding pages of the listing by using the compiler-directing TITLE statement.

related references
TITLE statement (Enterprise COBOL for z/OS Language Reference)

Describing the computing environment

In the ENVIRONMENT DIVISION of a program, you describe the aspects of the program that depend on the computing environment.

Use the CONFIGURATION SECTION to specify the following items:

- Computer for compiling the program (in the SOURCE-COMPUTER paragraph)
- Computer for running the program (in the OBJECT-COMPUTER paragraph)
- Special items such as the currency sign and symbolic characters (in the SPECIAL-NAMES paragraph)
- User-defined classes (in the REPOSITORY paragraph)

Use the FILE-CONTROL and I-O-CONTROL paragraphs of the INPUT-OUTPUT SECTION to:

- Identify and describe the characteristics of the files in the program.
- Associate your files with the external QSAM, VSAM, or z/OS UNIX file system data sets where they physically reside.

The terms file in COBOL terminology and data set in operating-system terminology have essentially the same meaning and are used interchangeably in this information.

For Customer Information Control System (CICS) and online Information Management System (IMS) message processing programs (MPP), code only the ENVIRONMENT DIVISION header and, optionally, the CONFIGURATION SECTION. Do not code file definitions in your COBOL programs that will run under CICS. IMS allows COBOL definition of files only for batch programs.

- Provide information to control efficient transmission of the data records between your program and the external medium.

“Example: FILE-CONTROL entries” on page 6

related tasks
“Specifying the collating sequence” on page 6
“Defining symbolic characters” on page 8
“Defining a user-defined class” on page 8
“Defining files to the operating system” on page 8

related references
Sections and paragraphs (Enterprise COBOL for z/OS Language Reference)
Example: FILE-CONTROL entries
The following table shows example FILE-CONTROL entries for a QSAM sequential file, a VSAM indexed file, and a line-sequential file.

<table>
<thead>
<tr>
<th>Table 1. FILE-CONTROL entries</th>
<th>QSAM file</th>
<th>VSAM file</th>
<th>Line-sequential file</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SELECT</strong> PRINTFILE&lt;sup&gt;1&lt;/sup&gt;</td>
<td><strong>SELECT</strong> COMMUTER-FI&lt;sup&gt;1&lt;/sup&gt;</td>
<td><strong>SELECT</strong> PRINTFILE&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>ASSIGN TO UPDPRINT&lt;sup&gt;2&lt;/sup&gt;</td>
<td>ASSIGN TO COMMUTER&lt;sup&gt;2&lt;/sup&gt;</td>
<td>ASSIGN TO UPDPRINT&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>ORGANIZATION IS SEQUENTIAL&lt;sup&gt;3&lt;/sup&gt;</td>
<td>ORGANIZATION IS INDEXED&lt;sup&gt;3&lt;/sup&gt;</td>
<td>ORGANIZATION IS LINE SEQUENTIAL&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>ACCESS IS SEQUENTIAL&lt;sup&gt;4&lt;/sup&gt;</td>
<td>ACCESS IS RANDOM&lt;sup&gt;4&lt;/sup&gt;</td>
<td>ACCESS IS SEQUENTIAL&lt;sup&gt;4&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

1. The **SELECT** clause chooses a file in the COBOL program to be associated with an external data set.
2. The **ASSIGN** clause associates the program’s name for the file with the external name for the actual data file. You can define the external name with a DD statement or an environment variable.
3. The **ORGANIZATION** clause describes the file’s organization. For QSAM files, the **ORGANIZATION** clause is optional.
4. The **ACCESS MODE** clause defines the manner in which the records are made available for processing: sequential, random, or dynamic. For QSAM and line-sequential files, the **ACCESS MODE** clause is optional. These files always have sequential organization.
5. For VSAM files, you might have additional statements in the FILE-CONTROL paragraph depending on the type of VSAM file you use.

related tasks
Chapter 9, “Processing QSAM files,” on page 151
Chapter 10, “Processing VSAM files,” on page 173
Chapter 11, “Processing line-sequential files,” on page 199
“Describing the computing environment” on page 5

Specifying the collating sequence
You can use the **PROGRAM COLLATING SEQUENCE** clause and the **ALPHABET** clause of the **SPECIAL-NAMES** paragraph to establish the collating sequence that is used in several operations on alphanumeric items.

These clauses specify the collating sequence for the following operations on alphanumeric items:
- Comparisons explicitly specified in relation conditions and condition-name conditions
- **HIGH-VALUE** and **LOW-VALUE** settings
- **SEARCH ALL**
- **SORT** and **MERGE** unless overridden by a **COLLATING SEQUENCE** phrase in the **SORT** or **MERGE** statement

“Example: specifying the collating sequence” on page 7
The sequence that you use can be based on one of these alphabets:
• EBCDIC: references the collating sequence associated with the EBCDIC character set
• NATIVE: references the same collating sequence as EBCDIC
• STANDARD-1: references the collating sequence associated with the ASCII character set defined by ANSI INCITS X3.4, Coded Character Sets - 7-bit American National Standard Code for Information Interchange (7-bit ASCII)
• STANDARD-2: references the collating sequence associated with the character set defined by ISO/IEC 646 -- Information technology -- ISO 7-bit coded character set for information interchange, International Reference Version
• An alteration of the EBCDIC sequence that you define in the SPECIAL-NAMES paragraph

The PROGRAM COLLATING SEQUENCE clause does not affect comparisons that involve national or DBCS operands.

related tasks
“Choosing alternate collating sequences” on page 215
“Comparing national (UTF-16) data” on page 140

Example: specifying the collating sequence
The following example shows the ENVIRONMENT DIVISION coding that you can use to specify a collating sequence in which uppercase and lowercase letters are similarly handled in comparisons and in sorting and merging.

When you change the EBCDIC sequence in the SPECIAL-NAMES paragraph, the overall collating sequence is affected, not just the collating sequence of the characters that are included in the SPECIAL-NAMES paragraph.

```
IDENTIFICATION DIVISION.
  . . .
ENVIRONMENT DIVISION.
  . . .
  CONFIGURATION SECTION.
    Source-Computer. IBM-390. Object-Computer. IBM-390
    Program Collating Sequence Special-Sequence.
    Special-Names.
      Alphabet Special-Sequence Is
        "A" Also "a"
        "B" Also "b"
        "C" Also "c"
        "D" Also "d"
        "E" Also "e"
        "F" Also "f"
        "G" Also "g"
        "H" Also "h"
        "I" Also "i"
        "J" Also "j"
        "K" Also "k"
        "L" Also "l"
        "M" Also "m"
        "N" Also "n"
        "O" Also "o"
        "P" Also "p"
        "Q" Also "q"
        "R" Also "r"
        "S" Also "s"
        "T" Also "t"
        "U" Also "u"
        "V" Also "v"
        "W" Also "w"
        "X" Also "x"
        "Y" Also "y"
        "Z" Also "z".
```

related tasks
“Specifying the collating sequence” on page 6
Defining symbolic characters
Use the SYMBOLIC CHARACTERS clause to give symbolic names to any character of the specified alphabet. Use ordinal position to identify the character, where position 1 corresponds to character X'00'.

For example, to give a name to the backspace character (X'16' in the EBCDIC alphabet), code:

```plaintext
SYMBOLIC CHARACTERS BACKSPACE IS 23
```

Defining a user-defined class
Use the CLASS clause to give a name to a set of characters that you list in the clause.

For example, name the set of digits by coding the following clause:

```plaintext
CLASS DIGIT IS "0" THROUGH "9"
```

You can reference the class-name only in a class condition. (This user-defined class is not the same as an object-oriented class.)

Defining files to the operating system
For all files that you process in your COBOL program, you need to define the files to the operating system with an appropriate system data definition.

Depending on the operating system, this system data definition can take any of the following forms:

- DD statement for MVS JCL.
- ALLOCATE command under TSO.
- Environment variable for z/OS or z/OS UNIX. The contents can define either an MVS data set or a file in the z/OS UNIX file system.

The following examples show the relationship of a FILE-CONTROL entry to the system data definition and to the FD entry in the FILE SECTION:

- JCL DD statement:

```plaintext
(1) //OUTFILE DD DSNAME=MY.OUT171,UNIT=SYSDA,SPACE=(TRK,(50,5)) /*
```

- Environment variable (export command):

```plaintext
(1) export OUTFILE=DSN(MY.OUT171),UNIT(SYSDA),SPACE(TRK,(50,5))
```

- COBOL code:

```plaintext
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
   SELECT CARPOOL
   ASSIGN TO OUTFILE (1)
   ORGANIZATION IS SEQUENTIAL.
...
DATA DIVISION.
FILE SECTION.
FD CARPOOL (2)
   LABEL RECORD STANDARD
   BLOCK CONTAINS 0 CHARACTERS
   RECORD CONTAINS 80 CHARACTERS
```
The assignment-name in the ASSIGN clause points to the ddname OUTFILE in the DD statement or the environment variable OUTFILE in the export command:

- //OUTFILE DD DSNAME=OUT171 . . ., or
- export OUTFILE=. . .

When you specify a file file-name in a FILE-CONTROL entry, you must describe the file in an FD entry:

```
SELECT CARPOOL
FD `CARPOOL
```

related tasks
"Optimizing buffer and device space" on page 10

related references
"FILE SECTION entries" on page 11
FILE SECTION (Enterprise COBOL for z/OS Language Reference)

Varying the input or output file at run time
The file-name that you code in a SELECT clause is used as a constant throughout your COBOL program, but you can associate the name of that file with a different system file at run time.

Changing a file-name within a COBOL program would require changing the input statements and output statements and recompiling the program. Alternatively, you can change the DSNAME value in the DD statement or the DSN or PATH value in the export command to use a different file at run time.

Environment variable values that are in effect at the time of the OPEN statement are used for associating COBOL file-names to the system file-names (including any path specifications).

The name that you use in the assignment-name of the ASSIGN clause must be the same as the ddname in the DD statement or the environment variable in the export command.

The file-name that you use in the SELECT clause (such as SELECT MASTER) must be the same as in the FD file-name entry.

Two files should not use the same ddname or environment variable name in their SELECT clauses; otherwise, results could be unpredictable. For example, if DISPLAY output is directed to SYSOUT, do not use SYSOUT as the ddname or environment variable name in the SELECT clause for a file.

Example: using different input files
This example shows that you use the same COBOL program to access different files by coding a DD statement or an export command before the programs runs.

Consider a COBOL program that contains the following SELECT clause:

```
SELECT MASTER ASSIGN TO DA-3330-S-MASTERA
```

Assume the three possible input files are MASTER1, MASTER2, and MASTER3. Before running the program, code one of the following DD statements in the job step that calls for program execution, or issue one of the following export commands from the same shell from which you run the program:

```
//MASTERA DD DSNAME=MY.MASTER1, . . .
export MASTERA=DSN(MY.MASTER1), . . .

//MASTERA DD DSNAME=MY.MASTER2, . . .
export MASTERA=DSN(MY.MASTER2), . . .

//MASTERA DD DSNAME=MY.MASTER3, . . .
export MASTERA=DSN(MY.MASTER3), . . .
```
Any reference in the program to MASTER will therefore be a reference to the file that is currently assigned to the ddname or environment-variable name MASTERA.

Notice that in this example, you cannot use the PATH(path) form of the export command to reference a line-sequential file in the z/OS UNIX file system, because you cannot specify an organization field (S- or AS-) with a line-sequential file.

**Optimizing buffer and device space**

Use the APPLY WRITE-ONLY clause to make optimum use of buffer and device space when you create a sequential file with blocked variable-length records.

With APPLY WRITE-ONLY specified, a buffer is truncated only when the next record does not fit in the unused portion of the buffer. Without APPLY WRITE-ONLY specified, a buffer is truncated when it does not have enough space for a maximum-size record.

The APPLY WRITE-ONLY clause has meaning only for sequential files that have variable-length records and are blocked.

The AWO compiler option applies an implicit APPLY WRITE-ONLY clause to all eligible files. The NOAWO compiler option has no effect on files that have the APPLY WRITE-ONLY clause specified. The APPLY WRITE-ONLY clause takes precedence over the NOAWO compiler option.

The APPLY WRITE ONLY clause can cause input files to use a record area rather than process the data in the buffer. This use might affect the processing of both input files and output files.

**related references**

“AWO” on page 292

---

**Describing the data**

Define the characteristics of your data, and group your data definitions into one or more of the sections in the DATA DIVISION.

You can use these sections for defining the following types of data:

- Data used in input-output operations: FILE SECTION
- Data developed for internal processing:
  - To have storage be statically allocated and exist for the life of the run unit: WORKING-STORAGE SECTION
  - To have storage be allocated each time a program is entered, and deallocated on return from the program: LOCAL-STORAGE SECTION
- Data from another program: LINKAGE SECTION

The Enterprise COBOL compiler limits the maximum size of DATA DIVISION elements. For details, see the related reference about compiler limits below.

**related concepts**

“Comparison of WORKING-STORAGE and LOCAL-STORAGE” on page 13

**related tasks**

“Using data in input and output operations” on page 10

“Using data from another program” on page 15

**related references**

Compiler limits (Enterprise COBOL for z/OS Language Reference)

**Using data in input and output operations**

Define the data that you use in input and output operations in the FILE SECTION.

Provide the following information about the data:
• Name the input and output files that the program will use. Use the FD entry to give names to the files that the input-output statements in the PROCEDURE DIVISION can refer to.

Data items defined in the FILE SECTION are not available to PROCEDURE DIVISION statements until the file has been successfully opened.

• In the record description that follows the FD entry, describe the fields of the records in the file:
  - You can code a level-01 description of the entire record, and then in the WORKING-STORAGE SECTION code a working copy that describes the fields of the record in more detail. Use the READ INTO statement to bring the records into WORKING-STORAGE. Processing occurs on the copy of data in WORKING-STORAGE. A WRITE FROM statement writes processed data into the record area defined in the FILE SECTION.
  - The record-name established is the object of WRITE and REWRITE statements.
  - For QSAM files only, you can set the record format in the RECORDING MODE clause. If you omit the RECORDING MODE clause, the compiler determines the record format based on the RECORD clause and on the level-01 record descriptions.
  - For QSAM files, you can set a blocking factor for the file in the BLOCK CONTAINS clause. If you omit the BLOCK CONTAINS clause, the file defaults to unblocked. However, you can override this with z/OS data management facilities (including a DD file job-control statement).
  - For line-sequential files, you can set a blocking factor for the file in the BLOCK CONTAINS clause. When you code BLOCK CONTAINS 1 RECORDS, or BLOCK CONTAINS n CHARACTERS, where n is the length of one logical record in bytes, WRITE statements result in the record being transferred immediately to the file rather than being buffered. This technique is useful when you want each record written immediately, such as to an error log.

Programs in the same run unit can share, or have access to, common files. The method for doing this depends on whether the programs are part of a nested (contained) structure or are separately compiled (including programs compiled as part of a batch sequence).

You can use the EXTERNAL clause for separately compiled programs. A file that is defined as EXTERNAL can be referenced by any program in the run unit that describes the file.

You can use the GLOBAL clause for programs in a nested, or contained, structure. If a program contains another program (directly or indirectly), both programs can access a common file by referencing a GLOBAL file-name.

related concepts
“Nested programs” on page 455

related tasks
“Sharing files between programs (external files)” on page 471

related references
“FILE SECTION entries” on page 11

**FILE SECTION entries**
The entries that you can use in the FILE SECTION are summarized in the table below.

<table>
<thead>
<tr>
<th>Clause</th>
<th>To define</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD</td>
<td>The file-name to be referred to in PROCEDURE DIVISION input-output statements (OPEN, CLOSE, READ, also START and DELETE for VSAM)</td>
<td>Must match file-name in the SELECT clause. file-name is associated with a ddname through the assignment-name.</td>
</tr>
</tbody>
</table>

Table 2. FILE SECTION entries
<table>
<thead>
<tr>
<th>Clause</th>
<th>To define</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLOCK CONTAINS</td>
<td>Size of physical records</td>
<td>If the CHARACTERS phrase is specified, size indicates the number of bytes in a record regardless of the USAGE of the data items in the record.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>QSAM: If provided, must match information on JCL or data-set label. If specified as BLOCK CONTAINS 0, or not provided, the system determines the optimal block size for you.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Line sequential: Can be specified to control buffering for WRITE statements.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VSAM: Syntax-checked, but has no effect on execution.</td>
</tr>
<tr>
<td>RECORD CONTAINS n</td>
<td>Size of logical records (fixed length)</td>
<td>Integer size indicates the number of bytes in a record regardless of the USAGE of the data items in the record. If the clause is provided, it must match information on JCL or data-set label. If n is equal to 0, LRECL must be coded on JCL or data-set label.</td>
</tr>
<tr>
<td>RECORD IS VARYING</td>
<td>Size of logical records (variable length)</td>
<td>Integer size or sizes, if specified, indicate the number of bytes in a record regardless of the USAGE of the data items in the record. If the clause is provided, it must match information on JCL or data-set label; compiler checks that record descriptions match.</td>
</tr>
<tr>
<td>RECORD CONTAINS n TO m</td>
<td>Size of logical records (variable length)</td>
<td>The integer sizes indicate the number of bytes in a record regardless of the USAGE of the data items in the record. If the clause is provided, it must match information on JCL or data-set label; compiler checks that record descriptions match.</td>
</tr>
<tr>
<td>LABEL RECORDS</td>
<td>Labels for QSAM files</td>
<td>VSAM: Handled as comments</td>
</tr>
<tr>
<td>STANDARD</td>
<td>Labels exist</td>
<td>QSAM: Handled as comments</td>
</tr>
<tr>
<td>OMITTED</td>
<td>Labels do not exist</td>
<td>QSAM: Handled as comments</td>
</tr>
<tr>
<td>data-name</td>
<td>Labels defined by the user</td>
<td>QSAM: Allowed for (optional) tape or disk</td>
</tr>
<tr>
<td>VALUE OF</td>
<td>An item in the label records associated with file</td>
<td>Comments only</td>
</tr>
<tr>
<td>DATA RECORDS</td>
<td>Names of records associated with file</td>
<td>Comments only</td>
</tr>
<tr>
<td>LINAGE</td>
<td>Depth of logical page</td>
<td>QSAM only</td>
</tr>
<tr>
<td>CODE-SET</td>
<td>ASCII or EBCDIC files</td>
<td>QSAM only. When an ASCII file is identified with the CODE-SET clause, the corresponding DD statement might need to have DCB=(OPTCD=Q... ) or DCB=(RECFM=D... ) coded if the file was not created using VS COBOL II, COBOL for OS/390® &amp; VM, or IBM Enterprise COBOL for z/OS.</td>
</tr>
</tbody>
</table>
Comparison of WORKING-STORAGE and LOCAL-STORAGE

How data items are allocated and initialized varies depending on whether the items are in the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION.

WORKING-STORAGE for programs is allocated when the run unit is started. Any data items that have VALUE clauses are initialized to the appropriate value at that time. For the duration of the run unit, WORKING-STORAGE items persist in their last-used state. Exceptions are:

- A program with INITIAL specified in the PROGRAM-ID paragraph
  In this case, WORKING-STORAGE data items are reinitialized each time that the program is entered.
- A subprogram that is dynamically called and then canceled
  In this case, WORKING-STORAGE data items are reinitialized on the first reentry into the program following the CANCEL.

WORKING-STORAGE is deallocated at the termination of the run unit.

See the related tasks for information about WORKING-STORAGE in COBOL class definitions.

A separate copy of LOCAL-STORAGE data is allocated for each call of a program or invocation of a method, and is freed on return from the program or method. If you specify a VALUE clause for a LOCAL-STORAGE item, the item is initialized to that value on each call or invocation. If a VALUE clause is not specified, the initial value of the item is undefined.

Threading: Each invocation of a program that runs simultaneously on multiple threads shares access to a single copy of WORKING-STORAGE data. Each invocation has a separate copy of LOCAL-STORAGE data.

“Example: storage sections” on page 13

related tasks
“Ending and reentering main programs or subprograms” on page 446
Chapter 27, “Preparing COBOL programs for multithreading,” on page 487
“WORKING-STORAGE SECTION for defining class instance data” on page 563

related references
WORKING-STORAGE SECTION (Enterprise COBOL for z/OS Language Reference)
LOCAL-STORAGE SECTION (Enterprise COBOL for z/OS Language Reference)

Example: storage sections
The following example is a recursive program that uses both WORKING-STORAGE and LOCAL-STORAGE.

CBL pgmn(lu)
*********************************
* Recursive Program - Factorials
*********************************
IDENTIFICATION DIVISION.
Program-Id. factorial recursive.
ENVIRONMENT DIVISION.
DATA DIVISION.
WORKING-STORAGE SECTION.
  01 numb pic 9(4) value 5.
  01 fact pic 9(8) value 0.
LOCAL-STORAGE SECTION.
  01 num pic 9(4).
PROCEDURE DIVISION.
   move numb to num.
   if numb = 0
      move 1 to fact
   else
      subtract 1 from numb
      call 'factorial'
      multiply numb by fact
   end-if.
   display num '!' = ' fact.
goback.
End Program factorial.

The program produces the following output:

0000! = 00000001
0001! = 00000001
0002! = 00000002
0003! = 00000006
0004! = 00000024
0005! = 00000120

The following tables show the changing values of the data items in LOCAL-STORAGE and WORKING-STORAGE in the successive recursive calls of the program, and in the ensuing gobacks. During the gobacks, fact progressively accumulates the value of 5! (five factorial).

<table>
<thead>
<tr>
<th>Recursive calls</th>
<th>Value for num in LOCAL-STORAGE</th>
<th>Value for numb in WORKING-STORAGE</th>
<th>Value for fact in WORKING-STORAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gobacks</th>
<th>Value for num in LOCAL-STORAGE</th>
<th>Value for numb in WORKING-STORAGE</th>
<th>Value for fact in WORKING-STORAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Main</td>
<td>5</td>
<td>0</td>
<td>120</td>
</tr>
</tbody>
</table>

related concepts
“Comparison of WORKING-STORAGE and LOCAL-STORAGE” on page 13
Using data from another program

How you share data depends on the type of program. You share data differently in programs that are separately compiled than you do for programs that are nested or for programs that are recursive or multithreaded.

related tasks
“Sharing data in separately compiled programs” on page 15
“Sharing data in nested programs” on page 15
“Sharing data in recursive or multithreaded programs” on page 15
“Passing data” on page 461

Sharing data in separately compiled programs
Many applications consist of separately compiled programs that call and pass data to one another. Use the LINKAGE SECTION in the called program to describe the data passed from another program.

In the calling program, code a CALL . . . USING or INVOKE . . . USING statement to pass the data.

related tasks
“Passing data” on page 461
“Coding the LINKAGE SECTION” on page 465

Sharing data in nested programs
Some applications consist of nested programs, that is, programs that are contained in other programs. Level-01 data items can include the GLOBAL attribute. This attribute allows any nested program that includes the declarations to access these data items.

A nested program can also access data items in a sibling program (one at the same nesting level in the same containing program) that is declared with the COMMON attribute.

related concepts
“Nested programs” on page 455

Sharing data in recursive or multithreaded programs
If your program has the RECURSIVE attribute or is compiled with the THREAD compiler option, data that is defined in the LINKAGE SECTION is not accessible on subsequent invocations of the program.

To address a record in the LINKAGE SECTION, use either of these techniques:

• Pass an argument to the program and specify the record in an appropriate position in the USING phrase in the program.
• Use the format-5 SET statement.

If your program has the RECURSIVE attribute or is compiled with the THREAD compiler option, the address of the record is valid for a particular instance of the program invocation. The address of the record in another execution instance of the same program must be reestablished for that execution instance. Unpredictable results will occur if you refer to a data item for which the address has not been established.

related concepts
“Multithreading” on page 487

related tasks
“Making recursive calls” on page 457
“Processing files with multithreading” on page 490

related references
“THREAD” on page 344
SET statement (Enterprise COBOL for z/OS Language Reference)
**Processing the data**

In the PROCEDURE DIVISION of a program, you code the executable statements that process the data that you defined in the other divisions. The PROCEDURE DIVISION contains one or two headers and the logic of your program.

The PROCEDURE DIVISION begins with the division header and a procedure-name header. The division header for a program can simply be:

```
PROCEDURE DIVISION.
```

You can code the division header to receive parameters by using the USING phrase, or to return a value by using the RETURNING phrase.

To receive an argument that was passed by reference (the default) or by content, code the division header for a program in either of these ways:

```
PROCEDURE DIVISION USING dataname
PROCEDURE DIVISION USING BY REFERENCE dataname
```

Be sure to define `dataname` in the LINKAGE SECTION of the DATA DIVISION.

To receive a parameter that was passed by value, code the division header for a program as follows:

```
PROCEDURE DIVISION USING BY VALUE dataname
```

To return a value as a result, code the division header as follows:

```
PROCEDURE DIVISION RETURNING dataname2
```

You can also combine USING and RETURNING in a PROCEDURE DIVISION header:

```
PROCEDURE DIVISION USING dataname RETURNING dataname2
```

Be sure to define `dataname` and `dataname2` in the LINKAGE SECTION.

**related concepts**

- “How logic is divided in the PROCEDURE DIVISION” on page 16

**related tasks**

- “Coding the LINKAGE SECTION” on page 465
- “Coding the PROCEDURE DIVISION for passing arguments” on page 466
- “Using PROCEDURE DIVISION RETURNING . . .” on page 470
- “Eliminating repetitive coding” on page 641

**related references**

- The procedure division header (Enterprise COBOL for z/OS Language Reference)
- The USING phrase (Enterprise COBOL for z/OS Language Reference)
- CALL statement (Enterprise COBOL for z/OS Language Reference)

**How logic is divided in the PROCEDURE DIVISION**

The PROCEDURE DIVISION of a program is divided into sections and paragraphs, which contain sentences, statements, and phrases.

**Section**

Logical subdivision of your processing logic.
A section has a section header and is optionally followed by one or more paragraphs. A section can be the subject of a PERFORM statement. One type of section is for declaratives.

**Paragraph**
Subdivision of a section, procedure, or program.
A paragraph has a name followed by a period and zero or more sentences.
A paragraph can be the subject of a statement.

**Sentence**
Series of one or more COBOL statements that ends with a period.

**Statement**
Performs a defined step of COBOL processing, such as adding two numbers.
A statement is a valid combination of words, and begins with a COBOL statement. Statements are imperative (indicating unconditional action), conditional, or compiler-directing. Using explicit scope terminators instead of periods to show the logical end of a statement is preferred.

**Phrase**
A subdivision of a statement.

**related concepts**
“Compiler-directing statements” on page 18
“Scope terminators” on page 18
“Imperative statements” on page 17
“Conditional statements” on page 17
“Declaratives” on page 20

**related references**
PROCEDURE DIVISION structure
*Enterprise COBOL for z/OS Language Reference*

**Imperative statements**
An imperative statement (such as ADD, MOVE, INVOKE, or CLOSE) indicates an unconditional action to be taken.
You can end an imperative statement with an implicit or explicit scope terminator.
A conditional statement that ends with an explicit scope terminator becomes an imperative statement called a delimited scope statement. Only imperative statements (or delimited scope statements) can be nested.

**related concepts**
“Conditional statements” on page 17
“Scope terminators” on page 18

**Conditional statements**
A conditional statement is either a simple conditional statement (IF, EVALUATE, SEARCH) or a conditional statement made up of an imperative statement that includes a conditional phrase or option.
You can end a conditional statement with an implicit or explicit scope terminator. If you end a conditional statement explicitly, it becomes a delimited scope statement (which is an imperative statement).
You can use a delimited scope statement in these ways:
- To delimit the range of operation for a COBOL conditional statement and to explicitly show the levels of nesting
  For example, use an END-IF phrase instead of a period to end the scope of an IF statement within a nested IF.
- To code a conditional statement where the COBOL syntax calls for an imperative statement
For example, code a conditional statement as the object of an inline PERFORM:

```cobol
PERFORM UNTIL TRANSACTION-EOF
  PERFORM 200-EDIT-UPDATE-TRANSACTION
  IF NO-ERRORS
    PERFORM 300-UPDATE-COMMUTER-RECORD
  ELSE
    PERFORM 400-PRINT-TRANSACTION-ERRORS
  END-IF
  READ UPDATE-TRANSACTION-FILE INTO WS-TRANSACTION-RECORD
  AT END
  SET TRANSACTION-EOF TO TRUE
END-READ
END-PERFORM
```

An explicit scope terminator is required for the inline PERFORM statement, but it is not valid for the out-of-line PERFORM statement.

For additional program control, you can use the NOT phrase with conditional statements. For example, you can provide instructions to be performed when a particular exception does not occur, such as NOT ON SIZE ERROR. The NOT phrase cannot be used with the ON OVERFLOW phrase of the CALL statement, but it can be used with the ON EXCEPTION phrase.

Do not nest conditional statements. Nested statements must be imperative statements (or delimited scope statements) and must follow the rules for imperative statements.

The following statements are examples of conditional statements if they are coded without scope terminators:

- Arithmetic statement with ON SIZE ERROR
- Data-manipulation statements with ON OVERFLOW
- CALL statements with ON OVERFLOW
- I/O statements with INVALID KEY, AT END, or AT END-OF-PAGE
- RETURN with AT END

**related concepts**

“Imperative statements” on page 17
“Scope terminators” on page 18

**related tasks**

“Selecting program actions” on page 89

**related references**

Conditional statements (Enterprise COBOL for z/OS Language Reference)

**Compiler-directing statements**

A compiler-directing statement causes the compiler to take specific action about the program structure, COPY processing, listing control, or control flow.

A compiler-directing statement is not part of the program logic.

**related references**

Chapter 18, “Compiler-directing statements,” on page 357
Compiler-directing statements (Enterprise COBOL for z/OS Language Reference)

**Scope terminators**

A scope terminator ends a statement. Scope terminators can be explicit or implicit.

Explicit scope terminators end a statement without ending a sentence. They consist of END followed by a hyphen and the name of the statement being terminated, such as END-IF. An implicit scope terminator is a period (.) that ends the scope of all previous statements not yet ended.
Each of the two periods in the following program fragment ends an IF statement, making the code equivalent to the code after it that instead uses explicit scope terminators:

```plaintext
IF ITEM = "A"
    DISPLAY "THE VALUE OF ITEM IS " ITEM
    ADD 1 TO TOTAL
    MOVE "C" TO ITEM
    DISPLAY "THE VALUE OF ITEM IS NOW " ITEM.
IF ITEM = "B"
    ADD 2 TO TOTAL.
```

If you use implicit terminators, the end of statements can be unclear. As a result, you might end statements unintentionally, changing your program's logic. Explicit scope terminators make a program easier to understand and prevent unintentional ending of statements. For example, in the program fragment below, changing the location of the first period in the first implicit scope example changes the meaning of the code:

```plaintext
IF ITEM = "A"
    DISPLAY "VALUE OF ITEM IS " ITEM
    ADD 1 TO TOTAL.
    MOVE "C" TO ITEM
    DISPLAY " VALUE OF ITEM IS NOW " ITEM
IF ITEM = "B"
    ADD 2 TO TOTAL.
```

The MOVE statement and the DISPLAY statement after it are performed regardless of the value of ITEM, despite what the indentation indicates, because the first period terminates the IF statement.

For improved program clarity and to avoid unintentional ending of statements, use explicit scope terminators, especially within paragraphs. Use implicit scope terminators only at the end of a paragraph or the end of a program.

Be careful when coding an explicit scope terminator for an imperative statement that is nested within a conditional statement. Ensure that the scope terminator is paired with the statement for which it was intended. In the following example, the scope terminator will be paired with the second READ statement, though the programmer intended it to be paired with the first.

```plaintext
READ FILE1
    AT END
    MOVE A TO B
    READ FILE2
END-READ
```

To ensure that the explicit scope terminator is paired with the intended statement, the preceding example can be recoded in this way:

```plaintext
READ FILE1
    AT END
    MOVE A TO B
    READ FILE2
END-READ
END-READ
```
Declaratives

Declaratives provide one or more special-purpose sections that are executed when an exception condition occurs.

Start each declarative section with a USE statement that identifies the function of the section. In the procedures, specify the actions to be taken when the condition occurs.

related tasks

“Finding and handling input-output errors” on page 362

related references

Declaratives (Enterprise COBOL for z/OS Language Reference)
Chapter 2. Using data

This information is intended to help non-COBOL programmers relate terms for data used in other programming languages to COBOL terms. It introduces COBOL fundamentals for variables, structures, literals, and constants; assigning and displaying values; intrinsic (built-in) functions, and tables (arrays) and pointers.

related concepts
“Storage and its addressability” on page 37

related tasks
“Using variables, structures, literals, and constants” on page 21
“Assigning values to data items” on page 25
“Displaying values on a screen or in a file (DISPLAY)” on page 33
“Using intrinsic functions (built-in functions)” on page 36
“Using tables (arrays) and pointers” on page 37
Chapter 7, “Processing data in an international environment,” on page 119

Using variables, structures, literals, and constants

Most high-level programming languages share the concept of data being represented as variables, structures (group items), literals, or constants.

The data in a COBOL program can be alphabetic, alphanumeric, double-byte character set (DBCS), national, or numeric. You can also define index-names and data items described as USAGE POINTER, USAGE FUNCTION-POINTER, USAGE PROCEDURE-POINTER, or USAGE OBJECT REFERENCE. You place all data definitions in the DATA DIVISION of your program.

related tasks
“Using variables” on page 21
“Using data items and group items” on page 22
“Using literals” on page 23
“Using constants” on page 24
“Using figurative constants” on page 24

related references
Classes and categories of data (Enterprise COBOL for z/OS Language Reference)

Using variables

A variable is a data item whose value can change during a program. The value is restricted, however, to the data type that you define when you specify a name and a length for the data item.

For example, if a customer name is an alphanumeric data item in your program, you could define and use the customer name as shown below:

```
Data Division.
  01 Customer-Name Pic X(20).
  01 Original-Customer-Name Pic X(20).
  .
Procedure Division.
  Move Customer-Name to Original-Customer-Name
  .
```
You could instead define the customer names above as national data items by specifying their PICTURE clauses as Pic N(20) and specifying the USAGE NATIONAL clause for the items. National data items are represented in Unicode UTF-16, in which most characters are represented in 2 bytes of storage.

**related concepts**

“Unicode and the encoding of language characters” on page 123

**related tasks**

“Using national data (Unicode) in COBOL” on page 124

**related references**

“NSYMBOL” on page 319

“Storage of character data” on page 131

PICTURE clause (Enterprise COBOL for z/OS Language Reference)

### Using data items and group items

Related data items can be parts of a hierarchical data structure. A data item that does not have subordinate data items is called an **elementary item**. A data item that is composed of one or more subordinate data items is called a **group item**.

A record can be either an elementary item or a group item. A group item can be either an **alphanumeric group item** or a **national group item**.

For example, **Customer-Record** below is an alphanumeric group item that is composed of two subordinate alphanumeric group items (Customer-Name and Part-Order), each of which contains elementary data items. These groups items implicitly have USAGE DISPLAY. You can refer to an entire group item or to parts of a group item in MOVE statements in the PROCEDURE DIVISION as shown below:

```
Data Division.
File Section.
FD  Customer-File
  Record Contains 45 Characters.
  01  Customer-Record.
     05  Customer-Name.
        10  Last-Name  Pic x(17).
        10  Filler     Pic x.
        10  Initials   Pic xx.
     05  Part-Order.
        10  Part-Name  Pic x(15).
        10  Part-Color Pic x(10).
Working-Storage Section.
  01  Orig-Customer-Name.
     05  Surname      Pic x(17).
     05  Initials     Pic x(3).
  01  Inventory-Part-Name Pic x(15).

Procedure Division.
  Move Customer-Name to Orig-Customer-Name
  Move Part-Name to Inventory-Part-Name
  . .
```

You could instead define **Customer-Record** as a national group item that is composed of two subordinate national group items by changing the declarations in the DATA DIVISION as shown below. National group items behave in the same way as elementary category national data items in most operations. The GROUP-USAGE NATIONAL clause indicates that a group item and any group items subordinate to it are national groups. Subordinate elementary items in a national group must be explicitly or implicitly described as USAGE NATIONAL.

```
Data Division.
File Section.
FD  Customer-File
  Record Contains 90 Characters.
  01  Customer-Record  Group-Usage National.
     05  Customer-Name.
```

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In the example above, the group items could instead specify the USAGE NATIONAL clause at the group level. A USAGE clause at the group level applies to each elementary data item in a group (and thus serves as a convenient shorthand notation). However, a group that specifies the USAGE NATIONAL clause is not a national group despite the representation of the elementary items within the group. Groups that specify the USAGE clause are alphanumeric groups and behave in many operations, such as moves and compares, like elementary data items of USAGE DISPLAY (except that no editing or conversion of data occurs).

**related concepts**

“Unicode and the encoding of language characters” on page 123
“National groups” on page 127

**related tasks**

“Using national data (Unicode) in COBOL” on page 124
“Using national groups” on page 128

**related references**

“FILE SECTION entries” on page 11
“Storage of character data” on page 131
Classes and categories of group items
(Enterprise COBOL for z/OS Language Reference)
PICTURE clause (Enterprise COBOL for z/OS Language Reference)
MOVE statement (Enterprise COBOL for z/OS Language Reference)
USAGE clause (Enterprise COBOL for z/OS Language Reference)

**Using literals**

A literal is a character string whose value is given by the characters themselves. If you know the value you want a data item to have, you can use a literal representation of the data value in the PROCEDURE DIVISION.

You do not need to define a data item for the value nor refer to it by using a data-name. For example, you can prepare an error message for an output file by moving an alphanumeric literal:

```
Move "Name is not valid" To Customer-Name
```

You can compare a data item to a specific integer value by using a numeric literal. In the example below, "Name is not valid" is an alphanumeric literal, and 03519 is a numeric literal:

```
01 Part-number Pic 9(5).
  If Part-number = 03519 then display "Part number was found"
```
You can use the opening delimiter N" or N' to designate a national literal if the NSYMBOL (NATIONAL) compiler option is in effect, or to designate a DBCS literal if the NSYMBOL (DBCS) compiler option is in effect.

You can use the opening delimiter NX" or NX' to designate national literals in hexadecimal notation (regardless of the setting of the NSYMBOL compiler option). Each group of four hexadecimal digits designates a single national character.

related concepts
“Unicode and the encoding of language characters” on page 123

related tasks
“Using national literals” on page 125
“Using DBCS literals” on page 143

related references
“NSYMBOL” on page 319
Literals (Enterprise COBOL for z/OS Language Reference)

Using constants
A constant is a data item that has only one value. COBOL does not define a construct for constants. However, you can define a data item with an initial value by coding a VALUE clause in the data description (instead of coding an INITIALIZE statement).

```
Data Division.
  01 Report-Header   pic x(50)  value "Company Sales Report".
  01 Interest        pic 9v9999 value 1.0265.
```

The example above initializes an alphanumeric and a numeric data item. You can likewise use a VALUE clause in defining a national or DBCS constant.

related tasks
“Using national data (Unicode) in COBOL” on page 124
“Coding for use of DBCS support” on page 142

Using figurative constants
Certain commonly used constants and literals are available as reserved words called figurative constants: ZERO, SPACE, HIGH-VALUE, LOW-VALUE, QUOTE, NULL, and ALL literal. Because they represent fixed values, figurative constants do not require a data definition.

For example:
```
Move Spaces To Report-Header
```

related tasks
“Using national-character figurative constants” on page 126
“Coding for use of DBCS support” on page 142

related references
Figurative constants (Enterprise COBOL for z/OS Language Reference)
Assigning values to data items

After you have defined a data item, you can assign a value to it at any time. Assignment takes many forms in COBOL, depending on what you want to do.

Table 3. Assignment to data items in a program

<table>
<thead>
<tr>
<th>What you want to do</th>
<th>How to do it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assign values to a data item or large data area.</td>
<td>Use one of these ways:</td>
</tr>
<tr>
<td></td>
<td>• INITIALIZE statement</td>
</tr>
<tr>
<td></td>
<td>• MOVE statement</td>
</tr>
<tr>
<td></td>
<td>• STRING or UNSTRING statement</td>
</tr>
<tr>
<td></td>
<td>• VALUE clause (to set data items to the values you want them to have when the program is in initial state)</td>
</tr>
<tr>
<td>Assign the results of arithmetic.</td>
<td>Use COMPUTE, ADD, SUBTRACT, MULTIPLY, or DIVIDE statements.</td>
</tr>
<tr>
<td>Examine or replace characters or groups of characters in a data item.</td>
<td>Use the INSPECT statement.</td>
</tr>
<tr>
<td>Receive values from a file.</td>
<td>Use the READ (or READ INTO) statement.</td>
</tr>
<tr>
<td>Receive values from a system input device or a file.</td>
<td>Use the ACCEPT statement.</td>
</tr>
<tr>
<td>Establish a constant.</td>
<td>Use the VALUE clause in the definition of the data item, and do not use the data item as a receiver. Such an item is in effect a constant even though the compiler does not enforce read-only constants.</td>
</tr>
<tr>
<td>One of these actions:</td>
<td>Use the SET statement.</td>
</tr>
<tr>
<td>• Place a value associated with a table element in an index.</td>
<td></td>
</tr>
<tr>
<td>• Set the status of an external switch to ON or OFF.</td>
<td></td>
</tr>
<tr>
<td>• Move data to a condition-name to make the condition true.</td>
<td></td>
</tr>
<tr>
<td>• Set a POINTER, PROCEDURE-POINTER, or FUNCTION-POINTER data item to an address.</td>
<td></td>
</tr>
<tr>
<td>• Associate an OBJECT REFERENCE data item with an object instance.</td>
<td></td>
</tr>
</tbody>
</table>

“Examples: initializing data items” on page 26

related tasks

“Initializing a structure (INITIALIZE)” on page 29
“Assigning values to elementary data items (MOVE)” on page 30
“Assigning values to group data items (MOVE)” on page 31
“Assigning input from a screen or file (ACCEPT)” on page 33
“Joining data items (STRING)” on page 101
“Splitting data items (UNSTRING)” on page 103
Examples: initializing data items

The following examples show how you can initialize many kinds of data items, including alphanumeric, national-edited, and numeric-edited data items, by using INITIALIZE statements.

An INITIALIZE statement is functionally equivalent to one or more MOVE statements. The related tasks about initializing show how you can use an INITIALIZE statement on a group item to conveniently initialize all the subordinate data items that are in a given data category.

Initializing a data item to blanks or zeros:

```
INITIALIZE identifier-1
```

<table>
<thead>
<tr>
<th>identifier-1 PICTURE</th>
<th>identifier-1 before</th>
<th>identifier-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>9(5)</td>
<td>12345</td>
<td>00000</td>
</tr>
<tr>
<td>X(5)</td>
<td>AB123</td>
<td>bbbbbb&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>N(3)</td>
<td>004100420031&lt;sup&gt;2&lt;/sup&gt;</td>
<td>002000200020&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>99XX9</td>
<td>12AB3</td>
<td>bbbbbb&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>XXBX/XX</td>
<td>ABbc/DE</td>
<td>bbbb/bb&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>**99.9CR</td>
<td>1234.5CR</td>
<td>**00.0bb&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A(5)</td>
<td>ABCDE</td>
<td>bbbbbb&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>+99.99E+99</td>
<td>+12.34E+02</td>
<td>+00.00E+00</td>
</tr>
</tbody>
</table>

1. The symbol <sup>b</sup> represents a blank space.
2. Hexadecimal representation of the national (UTF-16) characters 'AB1'. The example assumes that <sup>identifier-1</sup> has Usage National.
3. Hexadecimal representation of the national (UTF-16) characters ' ' (three blank spaces). Note that if <sup>identifier-1</sup> were not defined as Usage National, and if NSYMBOL(DBCS) were in effect, INITIALIZE would instead store DBCS spaces ('4040') into <sup>identifier-1</sup>.

Initializing an alphanumeric data item:

```
01 ALPHANUMERIC-1 PIC X VALUE "y".
01 ALPHANUMERIC-3 PIC X(1) VALUE "A".
   " INITIALIZE ALPHANUMERIC-1 REPLACING ALPHANUMERIC DATA BY ALPHANUMERIC-3
```

<table>
<thead>
<tr>
<th>ALPHANUMERIC-3</th>
<th>ALPHANUMERIC-1 before</th>
<th>ALPHANUMERIC-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>y</td>
<td>A</td>
</tr>
</tbody>
</table>

Initializing an alphanumeric right-justified data item:

```
01 ANJUST PIC X(8) VALUE SPACES JUSTIFIED RIGHT.
```
01 ALPHABETIC-1 PIC A(4) VALUE "ABCD".

  INITIALIZE ANJUST
  REPLACING ALPHANUMERIC DATA BY ALPHABETIC-1

<table>
<thead>
<tr>
<th>ALPHABETIC-1</th>
<th>ANJUST before</th>
<th>ANJUST after</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABCD</td>
<td>bbbbbbbb1</td>
<td>bbbbABCD1</td>
</tr>
</tbody>
</table>

1. The symbol b represents a blank space.

Initializing an alphanumerically-edited data item:

01 ALPHANUM-EDIT-1 PIC XXBX/XXX VALUE "AbbC/DEF".
01 ALPHANUM-EDIT-3 PIC X/BB VALUE "M/bb".

  INITIALIZE ALPHANUM-EDIT-1
  REPLACING ALPHANUMERIC-EDITED DATA BY ALPHANUM-EDIT-3

<table>
<thead>
<tr>
<th>ALPHANUM-EDIT-3</th>
<th>ALPHANUM-EDIT-1 before</th>
<th>ALPHANUM-EDIT-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/bb1</td>
<td>ABbc/DEF1</td>
<td>M/bb/bbb1</td>
</tr>
</tbody>
</table>

1. The symbol b represents a blank space.

Initializing a national data item:

01 NATIONAL-1 PIC NN USAGE NATIONAL VALUE N"AB".
01 NATIONAL-3 PIC NN USAGE NATIONAL VALUE N"CD".

  INITIALIZE NATIONAL-1
  REPLACING NATIONAL DATA BY NATIONAL-3
  INITIALIZE NATIONAL-1 NATIONAL TO VALUE

<table>
<thead>
<tr>
<th>NATIONAL-3</th>
<th>NATIONAL-1 before first INITIALIZE</th>
<th>NATIONAL-1 after first INITIALIZE</th>
<th>NATIONAL-1 after second INITIALIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>004300441</td>
<td>004100422</td>
<td>004300441</td>
<td>004100422</td>
</tr>
</tbody>
</table>

1. Hexadecimal representation of the national characters 'CD'
2. Hexadecimal representation of the national characters 'AB'

Initializing a national-edited data item:

01 NATL-EDIT-1 PIC 0NN USAGE NATIONAL VALUE N"123".
01 NATL-3    PIC NNN USAGE NATIONAL VALUE N"456".

  INITIALIZE NATL-EDIT-1
  REPLACING NATIONAL-EDITED DATA BY NATL-3

<table>
<thead>
<tr>
<th>NATL-3</th>
<th>NATL-EDIT-1 before</th>
<th>NATL-EDIT-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>0034003500361</td>
<td>00310032000332</td>
<td>00300034000353</td>
</tr>
</tbody>
</table>

1. Hexadecimal representation of the national characters '456'
2. Hexadecimal representation of the national characters '123'
3. Hexadecimal representation of the national characters '045'
Initializing a numeric (zoned decimal) data item:

```
01 NUMERIC-1    PIC 9(8)    VALUE 98765432.
01 NUM-INT-CMPT-3 PIC 9(7) COMP VALUE 1234567.
  . . .
  INITIALIZE NUMERIC-1
      REPLACING NUMERIC DATA BY NUM-INT-CMPT-3
```

<table>
<thead>
<tr>
<th>NUM-INT-CMPT-3</th>
<th>NUMERIC-1 before</th>
<th>NUMERIC-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234567</td>
<td>98765432</td>
<td>01234567</td>
</tr>
</tbody>
</table>

Initializing a numeric (national decimal) data item:

```
01 NAT-DEC-1    PIC 9(3) USAGE NATIONAL VALUE 987.
01 NUM-INT-BIN-3 PIC 9(2) BINARY VALUE 12.
  . . .
  INITIALIZE NAT-DEC-1
      REPLACING NUMERIC DATA BY NUM-INT-BIN-3
```

<table>
<thead>
<tr>
<th>NUM-INT-BIN-3</th>
<th>NAT-DEC-1 before</th>
<th>NAT-DEC-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>003900380037(^1)</td>
<td>003000310032(^2)</td>
</tr>
</tbody>
</table>

1. Hexadecimal representation of the national characters '987'
2. Hexadecimal representation of the national characters '012'

Initializing a numeric-edited (USAGE DISPLAY) data item:

```
01 NUM-EDIT-DISP-1 PIC $ZZ9V VALUE "$127".
01 NUM-DISP-3    PIC 999V VALUE 12.
  . . .
  INITIALIZE NUM-EDIT-DISP-1
      REPLACING NUMERIC-EDITED DATA BY NUM-DISP-3
```

<table>
<thead>
<tr>
<th>NUM-DISP-3</th>
<th>NUM-EDIT-DISP-1 before</th>
<th>NUM-EDIT-DISP-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>012</td>
<td>$127</td>
<td>$ 12</td>
</tr>
</tbody>
</table>

Initializing a numeric-edited (USAGE NATIONAL) data item:

```
01 NUM-EDIT-NATL-1 PIC $ZZ9V NATIONAL VALUE N"$127".
01 NUM-NATL-3    PIC 999V NATIONAL VALUE 12.
  . . .
  INITIALIZE NUM-EDIT-NATL-1
      REPLACING NUMERIC-EDITED DATA BY NUM-NATL-3
```

<table>
<thead>
<tr>
<th>NUM-NATL-3</th>
<th>NUM-EDIT-NATL-1 before</th>
<th>NUM-EDIT-NATL-1 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>003000310032(^1)</td>
<td>0024003100320037(^2)</td>
<td>0024002000310032(^3)</td>
</tr>
</tbody>
</table>

1. Hexadecimal representation of the national characters '012'
2. Hexadecimal representation of the national characters '$127'
3. Hexadecimal representation of the national characters '$ 12'

related tasks
“Initializing a structure”
Initializing a structure (INITIALIZE)

You can reset the values of all subordinate data items in a group item by applying the INITIALIZE statement to that group item. However, it is inefficient to initialize an entire group unless you really need all the items in the group to be initialized.

The following example shows how you can reset fields to spaces and zeros in transaction records that a program produces. The values of the fields are not identical in each record that is produced. (The transaction record is defined as an alphanumeric group item, TRANSACTION-OUT.)

```
01 TRANSACTION-OUT.
  05 TRANSACTION-CODE        PIC X.
  05 PART-NUMBER             PIC 9(6).
  05 TRANSACTION-QUANTITY    PIC 9(5).
  05 PRICE-FIELDS.
    10 UNIT-PRICE          PIC 9(5)V9(2).
    10 DISCOUNT            PIC V9(2).
    10 SALES-PRICE         PIC 9(5)V9(2).

... INITIALIZE TRANSACTION-OUT
```

<table>
<thead>
<tr>
<th>Record</th>
<th>TRANSACTION-OUT before</th>
<th>TRANSACTION-OUT after</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R0013830002400000000000</td>
<td>b00000000000000000000000</td>
</tr>
<tr>
<td>2</td>
<td>R0013900004800000000000</td>
<td>b00000000000000000000000</td>
</tr>
<tr>
<td>3</td>
<td>S0014100001200000000000</td>
<td>b00000000000000000000000</td>
</tr>
<tr>
<td>4</td>
<td>C0013830000000004250000000</td>
<td>b00000000000000000000000</td>
</tr>
<tr>
<td>5</td>
<td>C00201000000000010000000</td>
<td>b00000000000000000000000</td>
</tr>
</tbody>
</table>

1. The symbol b represents a blank space.

You can likewise reset the values of all the subordinate data items in a national group item by applying the INITIALIZE statement to that group item. The following structure is similar to the preceding structure, but instead uses Unicode UTF-16 data:

```
01 TRANSACTION-OUT GROUP-USAGE NATIONAL.
  05 TRANSACTION-CODE        PIC N.
  05 PART-NUMBER             PIC 9(6).
  05 TRANSACTION-QUANTITY    PIC 9(5).
  05 PRICE-FIELDS.
    10 UNIT-PRICE          PIC 9(5)V9(2).
    10 DISCOUNT            PIC V9(2).
    10 SALES-PRICE         PIC 9(5)V9(2).

... INITIALIZE TRANSACTION-OUT
```

Regardless of the previous contents of the transaction record, after the INITIALIZE statement above is executed:

- TRANSACTION-CODE contains NX"0020" (a national space).
- Each of the remaining 27 national character positions of TRANSACTION-OUT contains NX"0030" (a national-decimal zero). 

Chapter 2. Using data 29
When you use an INITIALIZE statement to initialize an alphanumeric or national group data item, the data item is processed as a group item, that is, with group semantics. The elementary data items within the group are recognized and processed, as shown in the examples above. If you do not code the REPLACING phrase of the INITIALIZE statement:

- SPACE is the implied sending item for alphabetic, alphanumeric, alphanumeric-edited, DBCS, category national, and national-edited receiving items.
- ZERO is the implied sending item for numeric and numeric-edited receiving items.

**related concepts**
“National groups” on page 127

**related tasks**
“Initializing a table (INITIALIZE)” on page 71
“Using national groups” on page 128

**related references**
INITIALIZE statement (Enterprise COBOL for z/OS Language Reference)

**Assigning values to elementary data items (MOVE)**

Use a MOVE statement to assign a value to an elementary data item.

The following statement assigns the contents of an elementary data item, Customer-Name, to the elementary data item Orig-Customer-Name:

```
Move Customer-Name to Orig-Customer-Name
```

If Customer-Name is longer than Orig-Customer-Name, truncation occurs on the right. If Customer-Name is shorter, the extra character positions on the right in Orig-Customer-Name are filled with spaces.

For data items that contain numbers, moves can be more complicated than with character data items because there are several ways in which numbers can be represented. In general, the algebraic values of numbers are moved if possible, as opposed to the digit-by-digit moves that are performed with character data. For example, after the MOVE statement below, Item-x contains the value 3.0, represented as 0030:

```
01  Item-x      Pic 999v9.
    . . .
Move 3.06 to Item-x
```

You can move an alphabetic, alphanumeric, alphanumeric-edited, DBCS, integer, or numeric-edited data item to a category national or national-edited data item; the sending item is converted. You can move a national data item to a category national or national-edited data item. If the content of a category national data item has a numeric value, you can move that item to a numeric, numeric-edited, external floating-point, or internal floating-point data item. You can move a national-edited data item only to a category national data item or another national-edited data item. Padding or truncation might occur.

For complete details about elementary moves, see the related reference below about the MOVE statement.

The following example shows an alphanumeric data item in the Greek language that is moved to a national data item:

```
CBL CODEPAGE(00875)
...
01 Data-in-Unicode   Pic N(100) usage national.
01 Data-in-Greek     Pic X(100).
    . . .
Read Greek-file into Data-in-Greek
    Move Data-in-Greek to Data-in-Unicode
```
Assigning values to group data items (MOVE)

Use the MOVE statement to assign values to group data items.

You can move a national group item (a data item that is described with the GROUP-USAGE NATIONAL clause) to another national group item. The compiler processes the move as though each national group item were an elementary item of category national, that is, as if each item were described as PIC N(m), where m is the length of that item in national character positions.

You can move an alphanumeric group item to an alphanumeric group item or to a national group item. You can also move a national group item to an alphanumeric group item. The compiler performs such moves as group moves, that is, without consideration of the individual elementary items in the sending or receiving group, and without conversion of the sending data item. Be sure that the subordinate data descriptions in the sending and receiving group items are compatible. The moves occur even if a destructive overlap could occur at run time.

You can code the CORRESPONDING phrase in a MOVE statement to move subordinate elementary items from one group item to the identically named corresponding subordinate elementary items in another group item:

```
01  Group-X.
   02  T-Code   Pic X   Value "A".
   02  Month    Pic 99  Value 04.
   02  State    Pic XX  Value "CA".
   02  Filler   Pic X.

01  Group-N  Group-Usage National.
   02  State    Pic NN.
   02  Month    Pic 99.
   02  Filler   Pic N.
   02  Total    Pic 999.
```

```
MOVE CORR Group-X TO Group-N
```

In the example above, State and Month within Group-N receive the values in national representation of State and Month, respectively, from Group-X. The other data items in Group-N are unchanged. (Filler items in a receiving group item are unchanged by a MOVE CORRESPONDING statement.)

In a MOVE CORRESPONDING statement, sending and receiving group items are treated as group items, not as elementary data items; group semantics apply. That is, the elementary data items within each group are recognized, and the results are the same as if each pair of corresponding data items were referenced in a separate MOVE statement. Data conversions are performed according to the rules for the MOVE statement as specified in the related reference below. For details about which types of elementary data items correspond, see the related reference about the CORRESPONDING phrase.
related tasks
“Assigning values to elementary data items (MOVE)” on page 30
“Using national groups” on page 128
“Converting to or from national (Unicode) representation” on page 131

related references
Classes and categories of group items
(Enterprise COBOL for z/OS Language Reference)
MOVE statement (Enterprise COBOL for z/OS Language Reference)
CORRESPONDING phrase (Enterprise COBOL for z/OS Language Reference)

Assigning arithmetic results (MOVE or COMPUTE)
When assigning a number to a data item, consider using the COMPUTE statement instead of the MOVE statement.

```
Move w to z
Compute z = w
```

In the example above, the two statements in most cases have the same effect. The MOVE statement however carries out the assignment with truncation. You can use the DIAGTRUNC compiler option to request that the compiler issue a warning for MOVE statements that might truncate numeric receivers.

When significant left-order digits would be lost in execution, the COMPUTE statement can detect the condition and allow you to handle it. If you use the ON SIZE ERROR phrase of the COMPUTE statement, the compiler generates code to detect a size-overflow condition. If the condition occurs, the code in the ON SIZE ERROR phrase is performed, and the content of z remains unchanged. If you do not specify the ON SIZE ERROR phrase, the assignment is carried out with truncation. There is no ON SIZE ERROR support for the MOVE statement.

You can also use the COMPUTE statement to assign the result of an arithmetic expression or intrinsic function to a data item. For example:

```
Compute z = y + (x ** 3)
Compute x = Function Max(x y z)
```

You can assign the results of date, time, mathematical, and other calculations to data items by using Language Environment callable services. Language Environment services are available through a standard COBOL CALL statement, and the values they return are passed in the parameters of the CALL statement. For example, you can call the Language Environment service CEESIABS to find the absolute value of a data item by coding the following statement:

```
Call 'CEESIABS' Using Arg, Feedback-code, Result.
```

As a result of this call, data item Result is assigned the absolute value of the value in data item Arg; data item Feedback-code contains the return code that indicates whether the service completed successfully. You have to define all the data items in the DATA DIVISION using the correct descriptions according to the requirements of the particular callable service. For the example above, the data items could be defined as follows:

```
77 Arg Pic s9(9) Binary.
77 Feedback-code Pic x(12) Display.
77 Result Pic s9(9) Binary.
```

related references
“DIAGTRUNC” on page 301
Assigning input from a screen or file (ACCEPT)

One way to assign a value to a data item is to read the value from a screen or a file.

To enter data from the screen, first associate the monitor with a mnemonic-name in the SPECIAL-NAMES paragraph. Then use ACCEPT to assign the line of input entered at the screen to a data item. For example:

```
Environment Division.
Configuration Section.
Special-Names.
   Console is Names-Input.
      Accept Customer-Name From Names-Input
```

To read from a file instead of the screen, make the following change:

- Change Console to device, where device is any valid system device (for example, SYSIN). For example:

```
SYSIN is Names-Input
```

device can be a ddname that references a z/OS UNIX file system path. If this ddname is not defined and your program is running in the z/OS UNIX environment, stdin is the input source. If this ddname is not defined and your program is not running in the z/OS UNIX environment, the ACCEPT statement fails.

When you use the ACCEPT statement, you can assign a value to an alphanumeric or national group item, or to an elementary data item that has USAGE DISPLAY, USAGE DISPLAY-1, or USAGE NATIONAL.

When you assign a value to a USAGE NATIONAL data item, input data from the console is converted from the EBCDIC code page specified in the CODEPAGE compiler option to national (Unicode UTF-16) representation. This is the only case where conversion of national data is done when you use the ACCEPT statement. Conversion is done in this case because the input is known to be coming from a screen.

To have conversion done when the input data is from any other device, use the NATIONAL-OF intrinsic function.

related concepts
“Unicode and the encoding of language characters” on page 123

related tasks
“Converting alphanumeric or DBCS to national (NATIONAL-OF)” on page 132

related references
“CODEPAGE” on page 295
ACCEPT statement (Enterprise COBOL for z/OS Language Reference)
SPECIAL-NAMES paragraph (Enterprise COBOL for z/OS Language Reference)

Displaying values on a screen or in a file (DISPLAY)

You can display the value of a data item on a screen or write it to a file by using the DISPLAY statement.

```
Display "No entry for surname " Customer-Name "" found in the file.".
```
In the example above, if the content of data item Customer-Name is JOHNSON, then the statement displays the following message on the system logical output device:

No entry for surname 'JOHNSON' found in the file.

To write data to a destination other than the system logical output device, use the UPON phrase with a destination other than SYSOUT. For example, the following statement writes to the file that is specified in the SYSPUNCH DD statement:

Display "Hello" upon syspunch.

You can specify a file in the z/OS UNIX file system by using the SYSPUNCH DD statement. For example, the following definition causes DISPLAY output to be written to the file /u/userid/cobol/demo.lst:

```
//SYSPUNCH DD PATH='/u/userid/cobol/demo.lst',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),PATHMODE=SIRWXU,
// FILEDATA=TEXT
```

The following statement writes to the job log or console and to the TSO screen if you are running under TSO:

Display "Hello" upon console.

When you display the value of a USAGE NATIONAL data item to the console, the data item is converted from Unicode (UTF-16) representation to EBCDIC based on the value of the CODEPAGE option. This is the only case in which conversion of national data is done when you use the DISPLAY statement. Conversion is done in this case because the output is known to be directed to a screen.

To have a national data item be converted when you direct output to a different device, use the DISPLAY-OF intrinsic function, as in the following example:

```
01 Data-in-Unicode pic N(10) usage national.
   . . Display function Display-of(Data-in-Unicode, 00037)
```

related concepts
“Unicode and the encoding of language characters” on page 123

related tasks
“Displaying data on the system logical output device” on page 34
“Using WITH NO ADVANCING” on page 35
“Converting national to alphanumeric (DISPLAY-OF)” on page 133
“Coding COBOL programs to run under CICS” on page 407

related references
“CODEPAGE” on page 295
DISPLAY statement (Enterprise COBOL for z/OS Language Reference)
The output is directed to the ddname that you specify in the OUTDD compiler option. You can specify a file in the z/OS UNIX file system with this ddname.

If the OUTDD ddname is not allocated and you are not running in the z/OS UNIX environment, a default DD of SYSOUT=* is allocated. If the OUTDD ddname is not allocated and you are running in the z/OS UNIX environment, the _IGZ_SYSOUT environment variable is used as follows:

**Undefined or set to stdout**
   - Output is routed to stdout (file descriptor 1).

**Set to stderr**
   - Output is routed to stderr (file descriptor 2).

**Otherwise (set to something other than stdout or stderr)**
   - The DISPLAY statement fails; a severity-3 Language Environment condition is raised.

When DISPLAY output is routed to stdout or stderr, the output is not subdivided into records. The output is written as a single stream of characters without line breaks.

If OUTDD and the Language Environment runtime option MSGFILE specify the same ddname, both DISPLAY output and Language Environment runtime diagnostics are routed to the Language Environment message file.

**related tasks**
   - “Setting and accessing environment variables” on page 436

**related references**
   - “OUTDD” on page 326
   - DISPLAY statement ([Enterprise COBOL for z/OS Language Reference](https://www.redbooks.ibm.com/abstracts/sg247511.html))

### Using WITH NO ADVANCING

If you specify the WITH NO ADVANCING phrase, and output is going to a ddname, the printer control character + (plus) is placed into the first output position from the next DISPLAY statement. + is the ANSI-defined printer control character that suppresses line spacing before a record is printed.

If you specify the WITH NO ADVANCING phrase and the output is going to stdout or stderr, a newline character is not appended to the end of the stream. A subsequent DISPLAY statement might add additional characters to the end of the stream.

If you do not specify WITH NO ADVANCING, and the output is going to a ddname, the printer control character ' ' (space) is placed into the first output position from the next DISPLAY statement, indicating single-spaced output.

```cobol
DISPLAY "ABC"
DISPLAY "CDEF" WITH NO ADVANCING
DISPLAY "GHIJK" WITH NO ADVANCING
DISPLAY "LMNOPQ"
DISPLAY "RSTUVWX"
```

If you code the statements above, the result sent to the output device is:

```
ABC
CDEF
+GHIJK
+LMNOPQ
RSTUVWX
```

The output that is printed depends on how the output device interprets printer control characters.

If you do not specify the WITH NO ADVANCING phrase and the output is going to stdout or stderr, a newline character is appended to the end of the stream.

**related references**
   - DISPLAY statement ([Enterprise COBOL for z/OS Language Reference](https://www.redbooks.ibm.com/abstracts/sg247511.html))
Using intrinsic functions (built-in functions)

Some high-level programming languages have built-in functions that you can reference in your program as if they were variables that have defined attributes and a predetermined value. In COBOL, these functions are called *intrinsic functions*. They provide capabilities for manipulating strings and numbers.

Because the value of an intrinsic function is derived automatically at the time of reference, you do not need to define functions in the DATA DIVISION. Define only the nonliteral data items that you use as arguments. Figurative constants are not allowed as arguments.

A *function-identifier* is the combination of the COBOL reserved word FUNCTION followed by a function name (such as Max), followed by any arguments to be used in the evaluation of the function (such as x, y, z). For example, the groups of highlighted words below are function-identifiers:

```
Unstring Function Upper-case(Name) Delimited By Space
   Into FName Lname
Compute A = 1 + Function Log10(x)
Compute M = Function Max(x y z)
```

A function-identifier represents both the invocation of the function and the data value returned by the function. Because it actually represents a data item, you can use a function-identifier in most places in the PROCEDURE DIVISION where a data item that has the attributes of the returned value can be used.

The COBOL word function is a reserved word, but the function-names are not reserved. You can use them in other contexts, such as for the name of a data item. For example, you could use Sqrt to invoke an intrinsic function and to name a data item in your program:

```
Working-Storage Section.
  01 x     Pic 99 value 2.
  01 y     Pic 99 value 4.
  01 z     Pic 99 value 16.
  01 Sqrt  Pic 99 value 0.

  Compute Sqrt = 16 ** .5
  Compute z = x + Function Sqrt(y)
```

A function-identifier represents a value that is of one of these types: alphanumeric, national, numeric, or integer. You can include a substring specification (reference modifier) in a function-identifier for alphanumeric or national functions. Numeric intrinsic functions are further classified according to the type of numbers they return.

The functions MAX and MIN can return either type of value depending on the type of arguments you supply.

Functions can reference other functions as arguments provided that the results of the nested functions meet the requirements for the arguments of the outer function. For example, Function Sqrt(5) returns a numeric value. Thus, the three arguments to the MAX function below are all numeric, which is an allowable argument type for this function:

```
Compute x = Function Max((Function Sqrt(5)) 2.5 3.5)
```

related tasks

“Processing table items using intrinsic functions” on page 85
“Converting data items (intrinsic functions)” on page 112
“Evaluating data items (intrinsic functions)” on page 114
Using tables (arrays) and pointers

In COBOL, arrays are called tables. A table is a set of logically consecutive data items that you define in the DATA DIVISION by using the OCCURS clause.

Pointers are data items that contain virtual storage addresses. You define them either explicitly with the USAGE IS POINTER clause in the DATA DIVISION or implicitly as ADDRESS OF special registers.

You can perform the following operations with pointer data items:

• Pass them between programs by using the CALL . . . BY REFERENCE statement.
• Move them to other pointers by using the SET statement.
• Compare them to other pointers for equality by using a relation condition.
• Initialize them to contain an invalid address by using VALUE IS NULL.

Use pointer data items to:

• Accomplish limited base addressing, particularly if you want to pass and receive addresses of a record area that is defined with OCCURS DEPENDING ON and is therefore variably located.
• Handle a chained list.

related tasks
“Defining a table (OCCURS)” on page 65
“Using procedure and function pointers” on page 457

Storage and its addressability

When you run COBOL programs, the programs and the data that they use reside in virtual storage. Storage that you use with COBOL can be either below the 16 MB line or above the 16 MB line but below the 2 GB bar. Two modes of addressing are available to address this storage: 24-bit and 31-bit.

You can address storage below (but not above) the 16 MB line with 24-bit addressing. You can address storage either above or below the 16 MB line with 31-bit addressing. Unrestricted storage is addressable by 31-bit addressing and therefore encompasses all the storage available to your program, both above and below the 16 MB line.

Enterprise COBOL does not directly exploit the 64-bit virtual addressing capability of z/OS; however, COBOL applications running in 31-bit or 24-bit addressing mode are fully supported on 64-bit z/OS systems.

Addressing mode (AMODE) is the attribute that tells which hardware addressing mode is supported by your program: 24-bit addressing, 31-bit addressing, or either 24-bit or 31-bit addressing. These attributes are AMODE 24, AMODE 31, and AMODE ANY, respectively. The program object and the executing program each have an AMODE attribute. Enterprise COBOL V5.1.1 object programs are either AMODE MIN for cases where AMODE 24 is possible, or AMODE 31 in all other cases. See “Restrictions for AMODE” on page 38.

Residency mode (RMODE) is the attribute of a program object that identifies where in virtual storage the program will reside: below the 16 MB line, or either below or above. This attribute is RMODE 24 or RMODE ANY.

Enterprise COBOL uses Language Environment services to control the storage used at run time. Thus COBOL compiler options and Language Environment runtime options influence the AMODE and RMODE attributes of your program and data, alone and in combination:

DATA

Compiler option that influences the location of storage for WORKING-STORAGE data, I-O buffers, and parameter lists for programs compiled with RENT.

RMODE

Compiler option that influences the residency mode.
RENT
Compiler option to generate a reentrant program.

HEAP
Runtime option that controls storage for the runtime heap. For example, COBOL WORKING-STORAGE is allocated from heap storage when the COBOL program is compiled with the RENT option and is in one of the following cases:

- Compiled with Enterprise COBOL V4.2 or earlier releases
- Compiled with the DATA (24) compiler option
- Running in CICS
- A COBOL V5.1.1 or later program in a program object that contains only COBOL programs (except COBOL 5.1.0) and assembler. There are no Language Environment interlanguage calls within the program object and no COBOL V5.1.0 programs.
- A COBOL V5 program in a program object where the main entry point is COBOL V5. In this case, the program object can contain Language Environment interlanguage calls, with COBOL statically linking with C, C++ or PL/I. All COBOL V5 programs within such program objects (even if they are not the main entry point) have their WORKING-STORAGE allocated from heap storage.
- A COBOL V6.1 or later program

STACK
Runtime option that controls storage for the runtime stack. For example, COBOL LOCAL-STORAGE is allocated from stack storage.

ALL31
Runtime option that specifies whether an application can run entirely in AMODE 31.

Restrictions for AMODE
AMODE 24 execution is not supported in the following cases, and the applications must run in AMODE 31. This is the same set of AMODE 24 restrictions as COBOL V3 and V4.

- Programs containing XML PARSE statements
- Programs containing XML GENERATE statements
- Program objects containing COBOL bound together with C, C++, or PL/I programs, and communicating via static CALL
- Programs containing object-oriented language syntax, such as INVOKE statements, or object-oriented class definitions
- Programs compiled with any of the following compiler options:
  - DLL
  - PGMNAME (LONGUPPER)
  - PGMNAME (LONGMIXED)
- Multithreaded applications

Note: A program compiled with the THREAD option can run in AMODE 24, but only in an application that does not have multiple threads or PL/I tasks.

- Programs run from the z/OS UNIX file system

Note: An AMODE 31 driver program resident in the z/OS UNIX file system can contain a dynamic call to an AMODE 24 program module resident in an MVS PDSE.

- Programs used as COBOL compiler exit modules that are specified on the EXIT compiler option
- Language Environment enclaves that use XPLINK, including either the enclaves that contain non-COBOL programs compiled with the XPLINK compiler option, or run with the XPLINK runtime option

Note: To run COBOL programs with addressing mode 24, you must compile all COBOL programs with Enterprise COBOL V5.1.1, or later versions; or Enterprise COBOL V4.2 or earlier versions. If any component of a program object is compiled with Enterprise COBOL V5.1.0, the program object must run
in addressing mode 31. COBOL programs that run with addressing mode 24 must be linked with the binder option RMODE(24).

Settings for RMODE

The RMODE and RENT options determine the RMODE attribute of your program.

<table>
<thead>
<tr>
<th>RMODE compiler option</th>
<th>RENT compiler option</th>
<th>RMODE attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMODE (AUTO)</td>
<td>RENT</td>
<td>RMODE ANY</td>
</tr>
<tr>
<td>RMODE (AUTO)</td>
<td>NORENT</td>
<td>RMODE 24</td>
</tr>
<tr>
<td>RMODE (24)</td>
<td>RENT or NORENT</td>
<td>RMODE 24</td>
</tr>
<tr>
<td>RMODE (ANY)</td>
<td>RENT</td>
<td>RMODE ANY</td>
</tr>
<tr>
<td>RMODE (ANY)</td>
<td>NORENT</td>
<td>Compiler option conflict.</td>
</tr>
</tbody>
</table>

If the NORENT option is specified, the RMODE (24) or RMODE (AUTO) compiler option must be specified.

Link-edit considerations: When the object code that COBOL generates has an attribute of RMODE 24, you must link-edit it with RMODE 24. When the object code that COBOL generates has an attribute of RMODE ANY, you can link-edit it with RMODE ANY or RMODE 24.

Storage restrictions for passing data

Do not pass parameters that are allocated in storage above the 16 MB line to AMODE 24 subprograms. Force the WORKING-STORAGE data and parameter lists below the line for programs that run in 31-bit addressing mode and pass data to programs that run in AMODE 24:

- Compile with the RENT and DATA (24) compiler options, or if the WORKING-STORAGE is on the HEAP (see previous description of the HEAP option), run them with the HEAP (,,BELOW) runtime option.
- Compile with the NORENT compiler option.

Location of data areas

For reentrant programs, the DATA compiler option, and the HEAP runtime option control whether storage for data areas such as WORKING-SECTION and FD record areas is obtained from below the 16 MB line or from unrestricted storage. Compile programs with RENT and RMODE (ANY) or RMODE (AUTO) if they will be run with 31-bit addressing in virtual storage addresses above the 16 MB line. The DATA option does not affect programs that are compiled with NORENT.

Storage for LOCAL-STORAGE data

The location of LOCAL-STORAGE data items is controlled by the STACK runtime option and the AMODE of the program. LOCAL-STORAGE data items are acquired in unrestricted storage when the STACK(,,ANYWHERE) runtime option is in effect and the program is running in AMODE 31. Otherwise LOCAL-STORAGE is acquired below the 16 MB line. The DATA compiler option does not influence the location of LOCAL-STORAGE data.

Storage for external data

In addition to affecting how storage is obtained for dynamic data areas (WORKING-STORAGE, FD record areas, and parameter lists), the DATA compiler option can also influence where storage for EXTERNAL data is obtained. Storage required for EXTERNAL data is obtained from unrestricted storage if the following conditions are met:

- The program is compiled with the DATA(31) and RENT compiler options.
• The HEAP(), ANYWHERE runtime option is in effect.
• The ALL31(ON) runtime option is in effect.

In all other cases, the storage for EXTERNAL data is obtained from below the 16 MB line. If you specify the ALL31(ON) runtime option, all the programs in the run unit must be capable of running in 31-bit addressing mode.

Storage for QSAM input-output buffers

The DATA compiler option can also influence where input-output buffers for QSAM files are obtained. See the related references below for information about allocation of buffers for QSAM files and the DATA compiler option.

Storage for ALLOCATE statement

The DATA compiler option setting influences how ALLOCATE acquires storage:

• If DATA(24) is in effect and the LOC 31 phrase of the ALLOCATE statement is not specified, ALLOCATE acquires storage from below the 16 MB line.
• If DATA(31) is in effect and the LOC 24 phrase of the ALLOCATE statement is not specified, ALLOCATE will attempt to acquire storage from above the 16 MB line.

related concepts
“AMODE switching” on page 450
Language Environment Programming Guide (AMODE considerations for heap storage)

related tasks
Chapter 24, “Using subprograms,” on page 445
Chapter 25, “Sharing data,” on page 461

related references
“Allocation of buffers for QSAM files” on page 170
“Allocation of record areas for VSAM files” on page 195
“DATA” on page 300
“RENT” on page 331
“RMODE” on page 332
“Performance-related compiler options” on page 636
ALLOCATE statement
(Enterprise COBOL for z/OS Language Reference)
Language Environment Programming Reference (HEAP, STACK, ALL31)
MVS Program Management: User’s Guide and Reference
Chapter 3. Working with numbers and arithmetic

In general, you can view COBOL numeric data as a series of decimal digit positions. However, numeric items can also have special properties such as an arithmetic sign or a currency sign.

To define, display, and store numeric data so that you can perform arithmetic operations efficiently:

• Use the PICTURE clause and the characters 9, +, -, P, S, and V to define numeric data.
• Use the PICTURE clause and editing characters (such as Z, comma, and period) along with MOVE and DISPLAY statements to display numeric data.
• Use the USAGE clause with various formats to control how numeric data is stored.
• Use the numeric class test to validate that data values are appropriate.
• Use ADD, SUBTRACT, MULTIPLY, DIVIDE, and COMPUTE statements to perform arithmetic.
• Use the CURRENCY SIGN clause and appropriate PICTURE characters to designate the currency you want.

related tasks
“Defining numeric data” on page 41
“Displaying numeric data” on page 43
“Controlling how numeric data is stored” on page 44
“Checking for incompatible data (numeric class test)” on page 52
“Performing arithmetic” on page 53
“Using currency signs” on page 62

Defining numeric data

Define numeric items by using the PICTURE clause with the character 9 in the data description to represent the decimal digits of the number. Do not use an X, which is for alphanumeric data items.

For example, Count-y below is a numeric data item, an external decimal item that has USAGE DISPLAY (a zoned decimal item):

```
05  Count-y        Pic 9(4)  Value 25.
05  Customer-name  Pic X(20) Value "Johnson".
```

You can similarly define numeric data items to hold national characters (UTF-16). For example, Count-n below is an external decimal data item that has USAGE NATIONAL (a national decimal item):

```
05  Count-n        Pic 9(4)  Value 25  Usage National.
```

You can code up to 18 digits in the PICTURE clause when you compile using the default compiler option ARITH(COMPAT) (referred to as compatibility mode). When you compile using ARITH(EXTEND) (referred to as extended mode), you can code up to 31 digits in the PICTURE clause.

Other characters of special significance that you can code are:

- **P**
  Indicates leading or trailing zeros
- **S**
  Indicates a sign, positive or negative
- **V**
  Implies a decimal point
The s in the following example means that the value is signed:

05 Price Pic s99v99.

The field can therefore hold a positive or a negative value. The v indicates the position of an implied decimal point, but does not contribute to the size of the item because it does not require a storage position. An s usually does not contribute to the size of a numeric item, because by default s does not require a storage position.

However, if you plan to port your program or data to a different machine, you might want to code the sign for a zoned decimal data item as a separate position in storage. In the following case, the sign takes 1 byte:

05 Price Pic s99V99 Sign Is Leading, Separate.

This coding ensures that the convention your machine uses for storing a nonseparate sign will not cause unexpected results on a machine that uses a different convention.

Separate signs are also preferable for zoned decimal data items that will be printed or displayed.

Separate signs are required for national decimal data items that are signed. The sign takes 2 bytes of storage, as in the following example:

05 Price Pic s99V99 Usage National Sign Is Leading, Separate.

You cannot use the PICTURE clause with internal floating-point data (COMP-1 or COMP-2). However, you can use the VALUE clause to provide an initial value for an internal floating-point literal:

05 Compute-result Usage Comp-2 Value 06.23E-24.

For information about external floating-point data, see the examples referenced below and the related concept about formats for numeric data.

“Examples: numeric data and internal representation” on page 48

related concepts
“Formats for numeric data” on page 45
Appendix A, “Intermediate results and arithmetic precision,” on page 649

related tasks
“Displaying numeric data” on page 43
“Controlling how numeric data is stored” on page 44
“Performing arithmetic” on page 53
“Defining national numeric data items” on page 127

related references
“Sign representation of zoned and packed-decimal data” on page 51
“Storage of character data” on page 131
“ARITH” on page 291
“NUMPROC” on page 322
SIGN clause (Enterprise COBOL for z/OS Language Reference)
Displaying numeric data

You can define numeric items with certain editing symbols (such as decimal points, commas, dollar signs, and debit or credit signs) to make the items easier to read and understand when you display or print them.

For example, in the code below, Edited-price is a numeric-edited item that has USAGE DISPLAY. (You can specify the clause USAGE IS DISPLAY for numeric-edited items; however, it is implied. It means that the items are stored in character format.)

```
05 Price Pic 9(5)v99.
05 Edited-price Pic $zz,zz9.99.
...
Move Price To Edited-price
Display Edited-price
```

If the contents of Price are 0150099 (representing the value 1,500.99), $ 1,500.99 is displayed when you run the code. The z in the PICTURE clause of Edited-price indicates the suppression of leading zeros.

You can define numeric-edited data items to hold national (UTF-16) characters instead of alphanumeric characters. To do so, define the numeric-edited items as USAGE NATIONAL. The effect of the editing symbols is the same for numeric-edited items that have USAGE NATIONAL as it is for numeric-edited items that have USAGE DISPLAY, except that the editing is done with national characters. For example, if Edited-price is declared as USAGE NATIONAL in the code above, the item is edited and displayed using national characters.

To display numeric or numeric-edited data items that have USAGE NATIONAL in EBCDIC, direct them to CONSOLE. For example, if Edited-price in the code above has USAGE NATIONAL, $ 1,500.99 is displayed when you run the program if the last statement above is:

```
Display Edited-price Upon Console
```

You can cause an elementary numeric or numeric-edited item to be filled with spaces when a value of zero is stored into it by coding the BLANK WHEN ZERO clause for the item. For example, each of the DISPLAY statements below causes blanks to be displayed instead of zeros:

```
05 Price Pic 9(5)v99.
05 Edited-price-D Pic $99,999.99 Blank When Zero.
...
Move 0 to Price
Move Price to Edited-price-D
Move Price to Edited-price-N
Display Edited-price-D
Display Edited-price-N upon console
```

You cannot use numeric-edited items as sending operands in arithmetic expressions or in ADD, SUBTRACT, MULTIPLY, DIVIDE, or COMPUTE statements. (Numeric editing takes place when a numeric-edited item is the receiving field for one of these statements, or when a MOVE statement has a numeric-edited receiving field and a numeric-edited or numeric sending field.) You use numeric-edited items primarily for displaying or printing numeric data.
You can move numeric-edited items to numeric or numeric-edited items. In the following example, the value of the numeric-edited item (whether it has USAGE DISPLAY or USAGE NATIONAL) is moved to the numeric item:

<table>
<thead>
<tr>
<th>Move Edited-price to Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display Price</td>
</tr>
</tbody>
</table>

If these two statements immediately followed the statements in the first example above, then Price would be displayed as 0150099, representing the value 1,500.99. Price would also be displayed as 0150099 if Edited-price had USAGE NATIONAL.

You can also move numeric-edited items to alphanumeric, alphanumeric-edited, floating-point, and national data items. For a complete list of the valid receiving items for numeric-edited data, see the related reference about the MOVE statement.

“Examples: numeric data and internal representation” on page 48

related tasks
“Displaying values on a screen or in a file (DISPLAY)” on page 33
“Controlling how numeric data is stored” on page 44
“Defining numeric data” on page 41
“Performing arithmetic” on page 53
“Defining national numeric data items” on page 127
“Converting to or from national (Unicode) representation” on page 131

related references
MOVE statement (Enterprise COBOL for z/OS Language Reference)
BLANK WHEN ZERO clause (Enterprise COBOL for z/OS Language Reference)

Controlling how numeric data is stored

You can control how the computer stores numeric data items by coding the USAGE clause in your data description entries.

You might want to control the format for any of several reasons such as these:

- Arithmetic performed with computational data types is more efficient than with USAGE DISPLAY or USAGE NATIONAL data types.
- Packed-decimal format requires less storage per digit than USAGE DISPLAY or USAGE NATIONAL data types.
- Packed-decimal format converts to and from DISPLAY or NATIONAL format more efficiently than binary format does.
- Floating-point format is well suited for arithmetic operands and results with widely varying scale, while maintaining the maximal number of significant digits.
- You might need to preserve data formats when you move data from one machine to another.

The numeric data you use in your program will have one of the following formats available with COBOL:

- External decimal (USAGE DISPLAY or USAGE NATIONAL)
- External floating point (USAGE DISPLAY or USAGE NATIONAL)
- Internal decimal (USAGE PACKED-DECIMAL)
- Binary (USAGE BINARY)
- Native binary (USAGE COMP-5)
- Internal floating point (USAGE COMP-1 or USAGE COMP-2)

COMP and COMP-4 are synonymous with BINARY, and COMP-3 is synonymous with PACKED-DECIMAL.
The compiler converts displayable numbers to the internal representation of their numeric values before using them in arithmetic operations. Therefore it is often more efficient if you define data items as BINARY or PACKED-DECIMAL than as DISPLAY or NATIONAL. For example:

```
05 Initial-count Pic S9(4) Usage Binary Value 1000.
```

Regardless of which USAGE clause you use to control the internal representation of a value, you use the same PICTURE clause conventions and decimal value in the VALUE clause (except for internal floating-point data, for which you cannot use a PICTURE clause).

“Examples: numeric data and internal representation” on page 48

related concepts
“Formats for numeric data” on page 45
“Data format conversions” on page 50
Appendix A, “Intermediate results and arithmetic precision,” on page 649

related tasks
“Defining numeric data” on page 41
“Displaying numeric data” on page 43
“Performing arithmetic” on page 53

related references
“Conversions and precision” on page 50
“Sign representation of zoned and packed-decimal data” on page 51

**Formats for numeric data**

Several formats are available for numeric data.

**External decimal (DISPLAY and NATIONAL) items**

When USAGE DISPLAY is in effect for a category numeric data item (either because you have coded it, or by default), each position (byte) of storage contains one decimal digit. The items are stored in displayable form. External decimal items that have USAGE DISPLAY are referred to as *zoned decimal* data items.

When USAGE NATIONAL is in effect for a category numeric data item, 2 bytes of storage are required for each decimal digit. The items are stored in UTF-16 format. External decimal items that have USAGE NATIONAL must only contain valid UTF-16 digits. If they do not, the data is illegal and the behaviour of the generated code is undefined. External decimal items that have USAGE NATIONAL are referred to as *national decimal* data items.

National decimal data items, if signed, must have the SIGN SEPARATE clause in effect. All other rules for zoned decimal items apply to national decimal items. You can use national decimal items anywhere that other category numeric data items can be used.

External decimal (both zoned decimal and national decimal) data items are primarily intended for receiving and sending numbers between your program and files, terminals, or printers. You can also use external decimal items as operands and receivers in arithmetic processing. However, if your program performs a lot of intensive arithmetic, and efficiency is a high priority, COBOL’s computational numeric types might be a better choice for the data items used in the arithmetic.

**External floating-point (DISPLAY and NATIONAL) items**

When USAGE DISPLAY is in effect for a floating-point data item (either because you have coded it, or by default), each PICTURE character position (except for v, an implied decimal point, if used) takes 1 byte of storage. The items are stored in displayable form. External floating-point items that have USAGE DISPLAY are referred to as *display floating-point* data items in this information when necessary to distinguish them from external floating-point items that have USAGE NATIONAL.
In the following example, Compute-Result is implicitly defined as a display floating-point item:

```
05 Compute-Result Pic -9v9(9)E-99.
```

The minus signs (-) do not mean that the mantissa and exponent must necessarily be negative numbers. Instead, they mean that when the number is displayed, the sign appears as a blank for positive numbers or a minus sign for negative numbers. If you instead code a plus sign (+), the sign appears as a plus sign for positive numbers or a minus sign for negative numbers.

When USAGE NATIONAL is in effect for a floating-point data item, each PICTURE character position (except for v, if used) takes 2 bytes of storage. The items are stored as national characters (UTF-16). External floating-point items that have USAGE NATIONAL are referred to as national floating-point data items.

The existing rules for display floating-point items apply to national floating-point items.

In the following example, Compute-Result-N is a national floating-point item:

```
05 Compute-Result-N Pic -9v9(9)E-99 Usage National.
```

If Compute-Result-N is displayed, the signs appear as described above for Compute-Result, but in national characters. To instead display Compute-Result-N in EBCDIC characters, direct it to the console:

```
Display Compute-Result-N Upon Console
```

You cannot use the VALUE clause for external floating-point items.

As with external decimal numbers, external floating-point numbers have to be converted (by the compiler) to an internal representation of their numeric value before they can be used in arithmetic operations. If you compile with the default option ARITH (COMPAT), external floating-point numbers are converted to long (64-bit) floating-point format. If you compile with ARITH (EXTEND), they are instead converted to extended-precision (128-bit) floating-point format.

**Binary (COMP) items**

BINARY, COMP, and COMP-4 are synonyms. Binary-format numbers occupy 2, 4, or 8 bytes of storage. If the PICTURE clause specifies that an item is signed, the leftmost bit is used as the operational sign.

A binary number with a PICTURE description of four or fewer decimal digits occupies 2 bytes; five to nine decimal digits, 4 bytes; and 10 to 18 decimal digits, 8 bytes. Binary items with nine or more digits require more handling by the compiler. Testing them for the SIZE ERROR condition and rounding is more cumbersome than with other types.

You can use binary items, for example, for indexes, subscripts, switches, and arithmetic operands or results.

Use the TRUNC(STD|OPT|BIN) compiler option to indicate how binary data (BINARY, COMP, or COMP-4) is to be truncated.

**Native binary (COMP-5) items**

Data items that you define as USAGE COMP-5 are represented in storage as binary data. However, unlike USAGE COMP items, they can contain values of magnitude up to the capacity of the native binary representation (2, 4, or 8 bytes) rather than being limited to the value implied by the number of 9s in the PICTURE clause.

When you move or store numeric data into a COMP-5 item, truncation occurs at the binary field size rather than at the COBOL PICTURE size limit. When you reference a COMP-5 item, the full binary field size is used in the operation.
COMP-5 is thus particularly useful for binary data items that originate in non-COBOL programs where the data might not conform to a COBOL PICTURE clause.

The table below shows the ranges of possible values for COMP-5 data items.

<table>
<thead>
<tr>
<th>PICTURE</th>
<th>Storage representation</th>
<th>Numeric values</th>
</tr>
</thead>
<tbody>
<tr>
<td>S9(1) through S9(4)</td>
<td>Binary halfword (2 bytes)</td>
<td>-32768 through +32767</td>
</tr>
<tr>
<td>S9(5) through S9(9)</td>
<td>Binary fullword (4 bytes)</td>
<td>-2,147,483,648 through +2,147,483,647</td>
</tr>
<tr>
<td>S9(10) through S9(18)</td>
<td>Binary doubleword (8 bytes)</td>
<td>-9,223,372,036,854,775,808 through +9,223,372,036,854,775,807</td>
</tr>
<tr>
<td>9(1) through 9(4)</td>
<td>Binary halfword (2 bytes)</td>
<td>0 through 65535</td>
</tr>
<tr>
<td>9(5) through 9(9)</td>
<td>Binary fullword (4 bytes)</td>
<td>0 through 4,294,967,295</td>
</tr>
<tr>
<td>9(10) through 9(18)</td>
<td>Binary doubleword (8 bytes)</td>
<td>0 through 18,446,744,073,709,551,615</td>
</tr>
</tbody>
</table>

You can specify scaling (that is, decimal positions or implied integer positions) in the PICTURE clause of COMP-5 items. If you do so, you must appropriately scale the maximal capacities listed above. For example, a data item you describe as PICTURE S99V99 COMP-5 is represented in storage as a binary halfword, and supports a range of values from -327.68 through +327.67.

**Large literals in VALUE clauses:** Literals specified in VALUE clauses for COMP-5 items can, with a few exceptions, contain values of magnitude up to the capacity of the native binary representation. See *Enterprise COBOL for z/OS Language Reference* for the exceptions.

Regardless of the setting of the TRUNC compiler option, COMP-5 data items behave like binary data does in programs compiled with TRUNC (BIN).

**Packed-decimal (COMP-3) items**

PACKED-DECIMAL and COMP-3 are synonyms. Packed-decimal items occupy 1 byte of storage for every two decimal digits you code in the PICTURE description, except that the rightmost byte contains only one digit and the sign. This format is most efficient when you code an odd number of digits in the PICTURE description, so that the leftmost byte is fully used. Packed-decimal items are handled as fixed-point numbers for arithmetic purposes.

**Internal floating-point (COMP-1 and COMP-2) items**

COMP-1 refers to short floating-point format and COMP-2 refers to long floating-point format, which occupy 4 and 8 bytes of storage, respectively. The leftmost bit contains the sign and the next 7 bits contain the exponent; the remaining 3 or 7 bytes contain the mantissa.

COMP-1 and COMP-2 data items are stored in System z® hexadecimal format.

related concepts
“Unicode and the encoding of language characters” on page 123
Appendix A, “Intermediate results and arithmetic precision,” on page 649

related tasks
“Defining numeric data” on page 41
“Defining national numeric data items” on page 127

related references
“Storage of character data” on page 131
“TRUNC” on page 345
Classes and categories of data (*Enterprise COBOL for z/OS Language Reference*)
Examples: numeric data and internal representation

The following table shows the internal representation of numeric items.

<table>
<thead>
<tr>
<th>Numeric type</th>
<th>PICTURE and USAGE and optional SIGN clause</th>
<th>Value</th>
<th>Internal representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>External decimal</td>
<td>PIC S9999 DISPLAY</td>
<td>+ 1234</td>
<td>F1 F2 F3 C4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1234</td>
<td>F1 F2 F3 D4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1234</td>
<td>F1 F2 F3 C4</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 DISPLAY</td>
<td>1234</td>
<td>F1 F2 F3 F4</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 NATIONAL</td>
<td>1234</td>
<td>00 31 00 32 00 33 00 34</td>
</tr>
<tr>
<td></td>
<td>PIC S9999 DISPLAY SIGN LEADING</td>
<td>+ 1234</td>
<td>C1 F2 F3 F4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1234</td>
<td>D1 F2 F3 F4</td>
</tr>
<tr>
<td></td>
<td>PIC S9999 DISPLAY SIGN LEADING</td>
<td>+ 1234</td>
<td>4E F1 F2 F3 F4</td>
</tr>
<tr>
<td></td>
<td>SIGN LEADING</td>
<td>- 1234</td>
<td>60 F1 F2 F3 F4</td>
</tr>
<tr>
<td></td>
<td>SEPARATE</td>
<td>+ 1234</td>
<td>F1 F2 F3 F4 4E</td>
</tr>
<tr>
<td></td>
<td>SIGN TRAILING</td>
<td>- 1234</td>
<td>F1 F2 F3 F4 60</td>
</tr>
<tr>
<td></td>
<td>SEPARATE</td>
<td>+ 1234</td>
<td>00 2B 00 31 00 32 00 33 00 34</td>
</tr>
<tr>
<td></td>
<td>SIGN LEADING</td>
<td>- 1234</td>
<td>00 2D 00 31 00 32 00 33 00 34</td>
</tr>
<tr>
<td></td>
<td>SEPARATE</td>
<td>+ 1234</td>
<td>00 31 00 32 00 33 00 34 00 2B</td>
</tr>
<tr>
<td></td>
<td>SIGN TRAILING</td>
<td>- 1234</td>
<td>00 31 00 32 00 33 00 34 00 2D</td>
</tr>
<tr>
<td>Numeric type</td>
<td>PICTURE and USAGE and optional SIGN clause</td>
<td>Value</td>
<td>Internal representation</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------</td>
<td>-------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Binary</td>
<td>PIC 9999 BINARY</td>
<td>+ 1234</td>
<td>04 D2</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 COMP-4</td>
<td>- 1234</td>
<td>FB 2E</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 COMP-5</td>
<td>+ 1234(^1)</td>
<td>30 39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1234(^1)</td>
<td>CF C7</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 BINARY</td>
<td>1234</td>
<td>04 D2</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 COMP-4</td>
<td>60000(^1)</td>
<td>EA 60</td>
</tr>
<tr>
<td>Internal decimal</td>
<td>PIC 9999 PACKED-DECIMAL</td>
<td>+ 1234</td>
<td>01 23 4C</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 COMP-3</td>
<td>- 1234</td>
<td>01 23 4D</td>
</tr>
<tr>
<td></td>
<td>PIC 9999 PACKED-DECIMAL</td>
<td>1234</td>
<td>01 23 4F</td>
</tr>
<tr>
<td>Internal floating point</td>
<td>COMP-1</td>
<td>+ 1234</td>
<td>43 4D 20 00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1234</td>
<td>C3 4D 20 00</td>
</tr>
<tr>
<td></td>
<td>COMP-2</td>
<td>+ 1234</td>
<td>43 4D 20 00 00 00 00 00 00 00 00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1234</td>
<td>C3 4D 20 00 00 00 00 00 00 00 00 00 00</td>
</tr>
<tr>
<td>External floating point</td>
<td>PIC (+9(2)).(9(2))E+99 DISPLAY</td>
<td>+ 12.34E+02</td>
<td>4E F1 F2 4B F3 F4 C5 4E F0 F2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 12.34E+02</td>
<td>60 F1 F2 4B F3 F4 C5 4E F0 F2</td>
</tr>
<tr>
<td></td>
<td>PIC (+9(2)).(9(2))E+99 NATIONAL</td>
<td>+ 12.34E+02</td>
<td>00 2B 00 31 00 32 00 2E 00 33 00 34 00 45 00 2B 00 30 00 32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 12.34E+02</td>
<td>00 2D 00 31 00 32 00 2E 00 33 00 34 00 45 00 2B 00 30 00 32</td>
</tr>
</tbody>
</table>
### Table 6. Internal representation of numeric items (continued)

<table>
<thead>
<tr>
<th>Numeric type</th>
<th>PICTURE and USAGE and optional SIGN clause</th>
<th>Value</th>
<th>Internal representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. The example demonstrates that COMP-5 data items can contain values of magnitude up to the capacity of the native binary representation (2, 4, or 8 bytes), rather than being limited to the value implied by the number of 9s in the PICTURE clause.

### Data format conversions

When the code in your program involves the interaction of items that have different data formats, the compiler converts those items either temporarily, for comparisons and arithmetic operations, or permanently, for assignment to the receiver in a MOVE or COMPUTE statement.

A conversion is actually a move of a value from one data item to another. The compiler performs any conversions that are required during the execution of arithmetic or comparisons by using the same rules that are used for MOVE and COMPUTE statements.

When possible, the compiler performs a move to preserve numeric value instead of a direct digit-for-digit move.

Conversion generally requires additional storage and processing time because data is moved to an internal work area and converted before the operation is performed. The results might also have to be moved back into a work area and converted again.

Conversions between fixed-point data formats (external decimal, packed decimal, or binary) are without loss of precision provided that the target field can contain all the digits of the source operand.

A loss of precision is possible in conversions between fixed-point data formats and floating-point data formats (short floating point, long floating point, or external floating point). These conversions happen during arithmetic evaluations that have a mixture of both fixed-point and floating-point operands.

**related references**

"Conversions and precision" on page 50
"Sign representation of zoned and packed-decimal data" on page 51

### Conversions and precision

In some numeric conversions, a loss of precision is possible; other conversions preserve precision or result in rounding.

Because both fixed-point and external floating-point items have decimal characteristics, references to fixed-point items in the following examples include external floating-point items unless stated otherwise.

When the compiler converts from fixed-point to internal floating-point format, fixed-point numbers in base 10 are converted to the numbering system used internally.

When the compiler converts short form to long form for comparisons, zeros are used for padding the shorter number.

**Conversions that lose precision**

When a USAGE COMP-1 data item is moved to a fixed-point data item that has more than nine digits, the fixed-point data item will receive only nine significant digits, and the remaining digits will be zero.

When a USAGE COMP-2 data item is moved to a fixed-point data item that has more than 18 digits, the fixed-point data item will receive only 18 significant digits, and the remaining digits will be zero.
**Conversions that preserve precision**

If a fixed-point data item that has six or fewer digits is moved to a USAGE COMP-1 data item and then returned to the fixed-point data item, the original value is recovered.

If a USAGE COMP-1 data item is moved to a fixed-point data item of nine or more digits and then returned to the USAGE COMP-1 data item, the original value is recovered.

If a fixed-point data item that has 15 or fewer digits is moved to a USAGE COMP-2 data item and then returned to the fixed-point data item, the original value is recovered.

If a USAGE COMP-2 data item is moved to a fixed-point (not external floating-point) data item of 18 or more digits and then returned to the USAGE COMP-2 data item, the original value is recovered.

**Conversions that result in rounding**

If a USAGE COMP-1 data item, a USAGE COMP-2 data item, an external floating-point data item, or a floating-point literal is moved to a fixed-point data item, rounding occurs in the low-order position of the target data item.

If a USAGE COMP-2 data item is moved to a USAGE COMP-1 data item, rounding occurs in the low-order position of the target data item.

If a fixed-point data item is moved to an external floating-point data item and the PICTURE of the fixed-point data item contains more digit positions than the PICTURE of the external floating-point data item, rounding occurs in the low-order position of the target data item.

**related concepts**

Appendix A, “Intermediate results and arithmetic precision,” on page 649

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**Sign representation of zoned and packed-decimal data**

Sign representation affects the processing and interaction of zoned decimal and internal decimal data.

Given \(X' \text{sd}'\), where \(s\) is the sign representation and \(d\) represents the digit, the valid sign representations for zoned decimal (USAGE DISPLAY) data without the SIGN IS SEPARATE clause are:

**Positive:**
- C, A, E, and F

**Negative:**
- D and B

The COBOL NUMPROC compiler option affects sign processing for zoned decimal and internal decimal data. NUMPROC has no effect on binary data, national decimal data, or floating-point data.

**NUMPROC(PFD)**

Given \(X' \text{sd}'\), where \(s\) is the sign representation and \(d\) represents the digit, when you use NUMPROC(PFD), the compiler assumes that the sign in your data is one of three preferred signs:

**Signed positive or 0:**
- \(X' \text{C}'\)

**Signed negative:**
- \(X' \text{D}'\)

**Unsigned or alphanumeric:**
- \(X' \text{F}'\)

Based on this assumption, the compiler uses whatever sign it is given to process data. The preferred sign is generated only where necessary (for example, when unsigned data is moved to signed data). Using the NUMPROC(PFD) option can save processing time, but you must use preferred signs with your data for correct processing.
NUMPROC(NOPFD)

When the NUMPROC(NOPFD) compiler option is in effect, the compiler accepts any valid sign configuration. The preferred sign is always generated in the receiver. NUMPROC(NOPFD) is less efficient than NUMPROC(PFD), but you should use it whenever data that does not use preferred signs might exist.

If an unsigned, zoned-decimal sender is moved to an alphanumeric receiver, the sign is unchanged (even with NUMPROC(NOPFD) in effect).

related references
“NUMPROC” on page 322
“ZWB” on page 355

Checking for incompatible data (numeric class test)

The compiler assumes that values you supply for a data item are valid for the PICTURE and USAGE clauses, and does not check their validity. Ensure that the contents of a data item conform to the PICTURE and USAGE clauses before using the item in additional processing.

It can happen that values are passed into your program and assigned to items that have incompatible data descriptions for those values. For example, nonnumeric data might be moved or passed into a field that is defined as numeric, or a signed number might be passed into a field that is defined as unsigned. In either case, the receiving fields contain invalid data. When you give an item a value that is incompatible with its data description, references to that item in the PROCEDURE DIVISION are undefined and your results are unpredictable.

You can use the numeric class test to perform data validation. For example:

```
Linkage Section.
01  Count-x   Pic 999.
    . . .
Procedure Division Using Count-x.
    If Count-x is numeric then display "Data is good"
```

The numeric class test checks the contents of a data item against a set of values that are valid for the PICTURE and USAGE of the data item. For example, a packed-decimal item is checked for hexadecimal values X’0’ through X’9’ in the digit positions and for a valid sign value in the sign position (whether separate or nonseparate). An external decimal data item that has USAGE DISPLAY is checked for hexadecimal values X’0’ through X’9’ in the digit positions (the lower 4 bits of each byte), for a valid zone code in the upper 4 bits of each byte and for a valid sign value in the sign position (whether separate or nonseparate). The sign code is in the upper 4 bits of the sign byte or in a separate byte if SIGN IS SEPARATE was specified. If the SIGN IS SEPARATE clause is used, the upper four bits of all bytes must be x’F’.

Note: Although the ZONEDATA(MIG|NOPFD) compiler option allows toleration of invalid zone codes in USAGE DISPLAY numeric (zoned decimal) data items in numeric comparisons, invalid zone codes in zoned decimal data items will be treated as nonnumeric by the numeric class test.

For zoned decimal and packed-decimal items, the numeric class test is affected by the NUMPROC compiler option and the NUMCLS option (which is set at installation time). To determine the NUMCLS setting used at your installation, consult your system programmer.

If NUMCLS(PRIM) is in effect at your installation, use the following table to find the values that the compiler considers valid for the sign.

<table>
<thead>
<tr>
<th>signed</th>
<th>NUMPROC(NOPFD)</th>
<th>NUMPROC(PFD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signed</td>
<td>C, D, F</td>
<td>C, D, +0 (positive zero)</td>
</tr>
<tr>
<td>Unsigned</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>
### Table 7. NUMCLS(PRIM) and valid signs (continued)

<table>
<thead>
<tr>
<th>NUMPROC(NOPFD)</th>
<th>NUMPROC(PFD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separate sign</td>
<td>+, -</td>
</tr>
<tr>
<td></td>
<td>+, -, +0 (positive zero)</td>
</tr>
</tbody>
</table>

If NUMCLS(ALT) is in effect at your installation, use the following table to find the values that the compiler considers valid for the sign.

### Table 8. NUMCLS(ALT) and valid signs

<table>
<thead>
<tr>
<th>NUMPROC(NOPFD)</th>
<th>NUMPROC(PFD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signed</td>
<td>A to F</td>
</tr>
<tr>
<td></td>
<td>C, D, +0 (positive zero)</td>
</tr>
<tr>
<td>Unsigned</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td>Separate sign</td>
<td>+, -</td>
</tr>
<tr>
<td></td>
<td>+, -, +0 (positive zero)</td>
</tr>
</tbody>
</table>

You can also use the NUMCHECK(ZON,PAC) option to have the compiler generate implicit numeric class tests for zoned decimal (numeric USAGE DISPLAY) and packed decimal (COMP-3) data items that are used as sending data items. This numeric class test validates data and also validates sign fields against the NUMPROC compiler option to help you decide whether you can use NUMPROC(PFD) or not. For details, see “NUMCHECK” on page 320.

#### Related references
- “NUMCHECK” on page 320
- “NUMPROC” on page 322
- “ZONECHECK” on page 351
- “ZONEDATA” on page 353

### Performing arithmetic

You can use any of several COBOL language features (including COMPUTE, arithmetic expressions, numeric intrinsic functions, and math and date callable services) to perform arithmetic. Your choice depends on whether a feature meets your particular needs.

For most common arithmetic evaluations, the COMPUTE statement is appropriate. If you need to use numeric literals, numeric data, or arithmetic operators, you might want to use arithmetic expressions. In places where numeric expressions are allowed, you can save time by using numeric intrinsic functions. Language Environment callable services for mathematical functions and for date and time operations also provide a means of assigning arithmetic results to data items.

#### Related tasks
- “Using COMPUTE and other arithmetic statements” on page 53
- “Using arithmetic expressions” on page 54
- “Using numeric intrinsic functions” on page 55
- “Using math-oriented callable services” on page 56
- “Using date callable services” on page 57

### Using COMPUTE and other arithmetic statements

Use the COMPUTE statement for most arithmetic evaluations rather than ADD, SUBTRACT, MULTIPLY, and DIVIDE statements. Often you can code only one COMPUTE statement instead of several individual arithmetic statements.

The COMPUTE statement assigns the result of an arithmetic expression to one or more data items:

```plaintext
Compute z = a + b / c ** d - e
Compute x y z = a + b / c ** d - e
```
Some arithmetic calculations might be more intuitive using arithmetic statements other than COMPUTE. For example:

<table>
<thead>
<tr>
<th>COMPUTE</th>
<th>Equivalent arithmetic statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compute Increment = Increment + 1</td>
<td>Add 1 to Increment</td>
</tr>
<tr>
<td>Compute Balance = Balance - Overdraft</td>
<td>Subtract Overdraft from Balance</td>
</tr>
<tr>
<td>Compute IncrementOne = IncrementOne + 1</td>
<td>Add 1 to IncrementOne, IncrementTwo, IncrementThree</td>
</tr>
<tr>
<td>Compute IncrementTwo = IncrementTwo + 1</td>
<td></td>
</tr>
<tr>
<td>Compute IncrementThree = IncrementThree + 1</td>
<td></td>
</tr>
</tbody>
</table>

You might also prefer to use the DIVIDE statement (with its REMAINDER phrase) for division in which you want to process a remainder. The REM intrinsic function also provides the ability to process a remainder.

When you perform arithmetic calculations, you can use national decimal data items as operands just as you use zoned decimal data items. You can also use national floating-point data items as operands just as you use display floating-point operands.

**related concepts**
“Fixed-point contrasted with floating-point arithmetic” on page 60
Appendix A, “Intermediate results and arithmetic precision,” on page 649

**related tasks**
“Defining numeric data” on page 41

**Using arithmetic expressions**

You can use arithmetic expressions in many (but not all) places in statements where numeric data items are allowed.

For example, you can use arithmetic expressions as comparands in relation conditions:

If (a + b) > (c - d + 5) Then...

Arithmetic expressions can consist of a single numeric literal, a single numeric data item, or a single intrinsic function reference. They can also consist of several of these items connected by arithmetic operators.

Arithmetic operators are evaluated in the following order of precedence:

<table>
<thead>
<tr>
<th>Table 9. Order of evaluation of arithmetic operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Unary + or -</td>
</tr>
<tr>
<td>**</td>
</tr>
<tr>
<td>/ or *</td>
</tr>
<tr>
<td>Binary + or -</td>
</tr>
</tbody>
</table>
Operators at the same level of precedence are evaluated from left to right; however, you can use parentheses to change the order of evaluation. Expressions in parentheses are evaluated before the individual operators are evaluated. Parentheses, whether necessary or not, make your program easier to read.

related concepts
“Fixed-point contrasted with floating-point arithmetic” on page 60
Appendix A, “Intermediate results and arithmetic precision,” on page 649

Using numeric intrinsic functions
You can use numeric intrinsic functions only in places where numeric expressions are allowed. These functions can save you time because you don't have to code the many common types of calculations that they provide.

Numeric intrinsic functions return a signed numeric value, and are treated as temporary numeric data items.

Numeric functions are classified into the following categories:

**Integer**
Those that return an integer

**Floating point**
Those that return a long (64-bit) or extended-precision (128-bit) floating-point value (depending on whether you compile using the default option ARITH(COMPAT) or using ARITH(EXTEND))

**Mixed**
Those that return an integer, a floating-point value, or a fixed-point number with decimal places, depending on the arguments

You can use intrinsic functions to perform several different arithmetic operations, as outlined in the following table.

<table>
<thead>
<tr>
<th>Table 10. Numeric intrinsic functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number handling</strong></td>
</tr>
<tr>
<td>LENGTH</td>
</tr>
<tr>
<td>MAX</td>
</tr>
<tr>
<td>MIN</td>
</tr>
<tr>
<td>NUMVAL</td>
</tr>
<tr>
<td>NUMVAL-C</td>
</tr>
<tr>
<td>ORD-MAX</td>
</tr>
<tr>
<td>ORD-MIN</td>
</tr>
<tr>
<td>WHEN-COMPILED</td>
</tr>
<tr>
<td>YEAR-TO-YYYY</td>
</tr>
</tbody>
</table>

“Examples: numeric intrinsic functions” on page 58
You can reference one function as the argument of another. A nested function is evaluated independently of the outer function (except when the compiler determines whether a mixed function should be evaluated using fixed-point or floating-point instructions).

You can also nest an arithmetic expression as an argument to a numeric function. For example, in the statement below, there are three function arguments (a, b, and the arithmetic expression (c / d)):

\[
\text{Compute } x = \text{Function Sum}(a \ b \ (c \ / \ d))
\]

You can reference all the elements of a table (or array) as function arguments by using the ALL subscript.

You can also use the integer special registers as arguments wherever integer arguments are allowed.

Many of the capabilities of numeric intrinsic functions are also provided by Language Environment callable services.

**related concepts**

“Fixed-point contrasted with floating-point arithmetic” on page 60

Appendix A, “Intermediate results and arithmetic precision,” on page 649

**related references**

“ARITH” on page 291

### Using math-oriented callable services

Most COBOL intrinsic functions have corresponding math-oriented callable services that you can use to produce the same results.

When you compile with the default option ARITH(COMPAT), COBOL floating-point intrinsic functions return long (64-bit) results. When you compile with option ARITH(EXTEND), COBOL floating-point intrinsic functions (with the exception of RANDOM) return extended-precision (128-bit) results.

For example (considering the first row of the table below), if you compile using ARITH(COMPAT), CEESDACS returns the same result as ACOS. If you compile using ARITH(EXTEND), CEESQACS returns the same result as ACOS.

<table>
<thead>
<tr>
<th>COBOL intrinsic function</th>
<th>Corresponding long-precision Language Environment callable service</th>
<th>Corresponding extended-precision Language Environment callable service</th>
<th>Results same for intrinsic function and callable service?</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACOS</td>
<td>CEESDACS</td>
<td>CEESQACS</td>
<td>Yes</td>
</tr>
<tr>
<td>ASIN</td>
<td>CEESDASN</td>
<td>CEESQASN</td>
<td>Yes</td>
</tr>
<tr>
<td>ATAN</td>
<td>CEESDATN</td>
<td>CEESQATN</td>
<td>Yes</td>
</tr>
<tr>
<td>COS</td>
<td>CEESDCOS</td>
<td>CEESQCOS</td>
<td>Yes</td>
</tr>
<tr>
<td>LOG</td>
<td>CEESDLOG</td>
<td>CEESQLOG</td>
<td>Yes</td>
</tr>
<tr>
<td>LOG10</td>
<td>CEESDLG1</td>
<td>CEESQLG1</td>
<td>Yes</td>
</tr>
<tr>
<td>RANDOM¹</td>
<td>CEERAN0</td>
<td>none</td>
<td>No</td>
</tr>
<tr>
<td>REM</td>
<td>CEESDMOD</td>
<td>CEESQMOD</td>
<td>Yes</td>
</tr>
<tr>
<td>SIN</td>
<td>CEESDSIN</td>
<td>CEESQ SIN</td>
<td>Yes</td>
</tr>
<tr>
<td>SQRT</td>
<td>CEESDSQRT</td>
<td>CEESQ SQRT</td>
<td>Yes</td>
</tr>
<tr>
<td>TAN</td>
<td>CEESDTAN</td>
<td>CEESQTAN</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Both the RANDOM intrinsic function and CEERAN0 service generate random numbers between zero and one. However, because each uses its own algorithm, RANDOM and CEERAN0 produce different random numbers from the same seed.

Even for functions that produce the same results, how you use intrinsic functions and Language Environment callable services differs. The rules for the data types required for intrinsic function arguments are less restrictive. For numeric intrinsic functions, you can use arguments that are of any numeric data type. When you invoke a Language Environment callable service with a CALL statement, however, you must ensure that the parameters match the numeric data types (generally COMP-1 or COMP-2) required by that service.

The error handling of intrinsic functions and Language Environment callable services sometimes differs. If you pass an explicit feedback token when calling the Language Environment math services, you must check the feedback code after each call and take explicit action to deal with errors. However, if you call with the feedback token explicitly OMITTED, you do not need to check the token; Language Environment automatically signals any errors.

related concepts
“Fixed-point contrasted with floating-point arithmetic” on page 60
Appendix A, “Intermediate results and arithmetic precision,” on page 649

related tasks
“Using Language Environment callable services” on page 643

related references
“ARITH” on page 291

Using date callable services
Both the COBOL date intrinsic functions and the Language Environment date callable services are based on the Gregorian calendar. However, the starting dates can differ depending on the setting of the INDATE compiler option.

When INDATE (LILIAN) is in effect, COBOL uses October 15, 1582 as day 1. Language Environment always uses October 15, 1582 as day 1. If you use INDATE (LILIAN), you get equivalent results from COBOL intrinsic functions and Language Environment date callable services. The following table compares the results when INDATE (LILIAN) is in effect.

<table>
<thead>
<tr>
<th>COBOL intrinsic function</th>
<th>Language Environment callable service</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE-OF-INTEGER</td>
<td>CEEDATE with picture string YYYYMMDD</td>
<td>Compatible</td>
</tr>
<tr>
<td>DAY-OF-INTEGER</td>
<td>CEEDATE with picture string YYYYDDD</td>
<td>Compatible</td>
</tr>
<tr>
<td>INTEGER-OF-DATE</td>
<td>CEEDAYS</td>
<td>Compatible</td>
</tr>
<tr>
<td>INTEGER-OF-DATE</td>
<td>CEECBLDY</td>
<td>Incompatible</td>
</tr>
</tbody>
</table>
When the default setting of INTDATE(ANSI) is in effect, COBOL uses January 1, 1601 as day 1. The following table compares the results when INTDATE(ANSI) is in effect.

<table>
<thead>
<tr>
<th>COBOL intrinsic function</th>
<th>Language Environment callable service</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTEGER-OF-DATE</td>
<td>CEECBLDY</td>
<td>Compatible</td>
</tr>
<tr>
<td>DATE-OF-INTEGER</td>
<td>CEEDATE with picture string YYYYMMDD</td>
<td>Incompatible</td>
</tr>
<tr>
<td>DAY-OF-INTEGER</td>
<td>CEEDATE with picture string YYYYDDD</td>
<td>Incompatible</td>
</tr>
<tr>
<td>INTEGER-OF-DATE</td>
<td>CEEDAYS</td>
<td>Incompatible</td>
</tr>
</tbody>
</table>

related tasks
“Using Language Environment callable services” on page 643

related references
“INTDATE” on page 313

Examples: numeric intrinsic functions
The following examples and accompanying explanations show intrinsic functions in each of several categories.

Where the examples below show zoned decimal data items, national decimal items could instead be used. (Signed national decimal items, however, require that the SIGN SEPARATE clause be in effect.)

**General number handling**
Suppose you want to find the maximum value of two prices (represented below as alphanumeric items with dollar signs), put this value into a numeric field in an output record, and determine the length of the output record. You can use NUMVAL-C (a function that returns the numeric value of an alphanumeric or national literal, or an alphanumeric or national data item) and the MAX and LENGTH functions to do so:

01 X Pic 9(2).
01 Price1 Pic x(8) Value "$8000".
01 Price2 Pic x(8) Value "$2000".
01 Output-Record.
  05 Product-Name Pic x(20).
  05 Product-Number Pic 9(9).
  05 Product-Price Pic 9(6).

Procedure Division.
  Compute Product-Price = Function Max (Function Numval-C(Price1) Function Numval-C(Price2))
  Compute X = Function Length(Output-Record)

Additionally, to ensure that the contents in Product-Name are in uppercase letters, you can use the following statement:

Move Function Upper-case (Product-Name) to Product-Name

**Date and time**
The following example shows how to calculate a due date that is 90 days from today. The first eight characters returned by the CURRENT-DATE function represent the date in a four-digit year, two-digit month, and two-digit day format (YYYYMMDD). The date is converted to its integer value; then 90 is added to this value and the integer is converted back to the YYYYMMDD format.

01 YYYYMMDD Pic 9(8).
01 Integer-Form Pic S9(9).
Move Function Current-Date(1:8) to YYYYMMDD
Compute Integer-Form = Function Integer-of-Date(YYYYMMDD)
Add 90 to Integer-Form
Compute YYYYMMDD = Function Date-of-Integer(Integer-Form)
Display 'Due Date: ' YYYYMMDD

Finance

Business investment decisions frequently require computing the present value of expected future cash inflows to evaluate the profitability of a planned investment. The present value of an amount that you expect to receive at a given time in the future is that amount, which, if invested today at a given interest rate, would accumulate to that future amount.

For example, assume that a proposed investment of $1,000 produces a payment stream of $100, $200, and $300 over the next three years, one payment per year respectively. The following COBOL statements calculate the present value of those cash inflows at a 10% interest rate:

```
01 Series-Amt1 Pic 9(9)V99 Value 100.
01 Series-Amt2 Pic 9(9)V99 Value 200.
01 Series-Amt3 Pic 9(9)V99 Value 300.
01 Discount-Rate Pic S9(2)V9(6) Value .10.
01 Todays-Value Pic 9(9)V99.
```

```
Compute Todays-Value = Function Present-Value(Discount-Rate Series-Amt1 Series-Amt2 Series-Amt3).
```

You can use the ANNUITY function in business problems that require you to determine the amount of an installment payment (annuity) necessary to repay the principal and interest of a loan. The series of payments is characterized by an equal amount each period, periods of equal length, and an equal interest rate each period. The following example shows how you can calculate the monthly payment required to repay a $15,000 loan in three years at a 12% annual interest rate (36 monthly payments, interest per month = .12/12):

```
01 Loan Pic 9(9)V99.
01 Payment Pic 9(9)V99.
01 Interest Pic 9(9)V99.
01 Number-Periods Pic 99.
```

```
Compute Loan = 15000
Compute Interest = .12
Compute Number-Periods = 36
Compute Payment = Loan * Function Annuity((Interest / 12) Number-Periods).
```

Mathematics

The following COBOL statement demonstrates that you can nest intrinsic functions, use arithmetic expressions as arguments, and perform previously complex calculations simply:

```
Compute Z = Function Log(Function Sqrt (2 * X + 1)) + Function Rem(X 2).
```

Here in the addend the intrinsic function REM (instead of a DIVIDE statement with a REMAINDER clause) returns the remainder of dividing X by 2.

Statistics

Intrinsic functions make calculating statistical information easier. Assume you are analyzing various city taxes and want to calculate the mean, median, and range (the difference between the maximum and minimum taxes):

```
01 Tax-$ Pic 99v999 value .045.
01 Tax-T Pic 99v999 value .02.
01 Tax-W Pic 99v999 value .035.
```
Fixed-point contrasted with floating-point arithmetic

How you code arithmetic in a program (whether an arithmetic statement, an intrinsic function, an expression, or some combination of these nested within each other) determines whether the evaluation is done with floating-point or fixed-point arithmetic.

Many statements in a program could involve arithmetic. For example, each of the following types of COBOL statements requires some arithmetic evaluation:

• General arithmetic

  ```cobol
  compute report-matrix-col = (emp-count ** .5) + 1
  add report-matrix-min to report-matrix-max giving report-matrix-tot
  ```

• Expressions and functions

  ```cobol
  compute report-matrix-col = function sqrt(emp-count) + 1
  compute whole-hours = function integer-part((average-hours) + 1)
  ```

• Arithmetic comparisons

  ```cobol
  if report-matrix-col < function sqrt(emp-count) + 1
  if whole-hours not = function integer-part((average-hours) + 1)
  ```

Floating-point evaluations

In general, if your arithmetic coding has either of the characteristics listed below, it is evaluated in floating-point arithmetic:

• An operand or result field is floating point.

  An operand is floating point if you code it as a floating-point literal or if you code it as a data item that is defined as USAGE COMP-1, USAGE COMP-2, or external floating point (USAGE DISPLAY or USAGE NATIONAL with a floating-point PICTURE).

  An operand that is a nested arithmetic expression or a reference to a numeric intrinsic function results in floating-point arithmetic when any of the following conditions is true:
  – An argument in an arithmetic expression results in floating point.
  – The function is a floating-point function.
  – The function is a mixed function with one or more floating-point arguments.

• An exponent contains decimal places.

  An exponent contains decimal places if you use a literal that contains decimal places, give the item a PICTURE that contains decimal places, or use an arithmetic expression or function whose result has decimal places.

  An arithmetic expression or numeric function yields a result that has decimal places if any operand or argument (excluding divisors and exponents) has decimal places.
Fixed-point evaluations

In general, if an arithmetic operation contains neither of the characteristics listed above for floating point, the compiler causes it to be evaluated in fixed-point arithmetic. In other words, arithmetic evaluations are handled as fixed point only if all the operands are fixed point, the result field is defined to be fixed point, and none of the exponents represent values with decimal places. Nested arithmetic expressions and function references must also represent fixed-point values.

Arithmetic comparisons (relation conditions)

When you compare numeric expressions using a relational operator, the numeric expressions (whether they are data items, arithmetic expressions, function references, or some combination of these) are comparands in the context of the entire evaluation. That is, the attributes of each can influence the evaluation of the other: both expressions are evaluated in fixed point, or both are evaluated in floating point. This is also true of abbreviated comparisons even though one comparand does not explicitly appear in the comparison. For example:

\[
\text{if } (a + d) = (b + e) \text{ and } c
\]

This statement has two comparisons: \((a + d) = (b + e)\), and \((a + d) = c\). Although \((a + d)\) does not explicitly appear in the second comparison, it is a comparand in that comparison. Therefore, the attributes of \(c\) can influence the evaluation of \((a + d)\).

The compiler handles comparisons (and the evaluation of any arithmetic expressions nested in comparisons) in floating-point arithmetic if either comparand is a floating-point value or resolves to a floating-point value.

The compiler handles comparisons (and the evaluation of any arithmetic expressions nested in comparisons) in fixed-point arithmetic if both comparands are fixed-point values or resolve to fixed-point values.

Implicit comparisons (no relational operator used) are not handled as a unit, however; the two comparands are treated separately as to their evaluation in floating-point or fixed-point arithmetic. In the following example, five arithmetic expressions are evaluated independently of one another's attributes, and then are compared to each other.

\[
\text{evaluate (} a + d \text{) when (} b + e \text{) thru } c \\
\text{when (} f / g \text{) thru } (h * i)
\]

Examples: fixed-point and floating-point evaluations

The following example shows statements that are evaluated using fixed-point arithmetic and using floating-point arithmetic.

Assume that you define the data items for an employee table in the following manner:

```
01 employee-table.
  05 emp-count         pic 9(4).
  05 employee-record occurs 1 to 1000 times 
    depending on emp-count.
    10 hours          pic +9(5)ve+99.
  . . .
01 report-matrix-col     pic 9(3).
01 report-matrix-min     pic 9(3).
01 report-matrix-max     pic 9(3).
01 report-matrix-tot     pic 9(3).
```
These statements are evaluated using floating-point arithmetic:

```cobol
compute report-matrix-col = (emp-count ** .5) + 1
compute report-matrix-col = function sqrt(emp-count) + 1
if report-matrix-tot < function sqrt(emp-count) + 1
```

These statements are evaluated using fixed-point arithmetic:

```cobol
add report-matrix-min to report-matrix-max giving report-matrix-tot
compute report-matrix-max = function max(report-matrix-max report-matrix-tot)
if whole-hours not = function integer-part((average-hours) + 1)
```

### Using currency signs

Many programs need to process financial information and present that information using the appropriate currency signs. With COBOL currency support (and the appropriate code page for your printer or display unit), you can use several currency signs in a program.

You can use one or more of the following signs:

- Symbols such as the dollar sign ($)
- Currency signs of more than one character (such as USD or EUR)
- Euro sign, established by the Economic and Monetary Union (EMU)

To specify the symbols for displaying financial information, use the `CURRENCY SIGN` clause (in the `SPECIAL-NAMES` paragraph in the `CONFIGURATION SECTION`) with the `PICTURE` characters that relate to those symbols. In the following example, the `PICTURE` character $ indicates that the currency sign $US is to be used:

```cobol
77 Invoice-Amount Pic $$,$$9.99.
`. . .' Display "Invoice amount is " Invoice-Amount.
```

In this example, if `Invoice-Amount` contained 1500.00, the display output would be:

```
Invoice amount is  $US1,500.00
```

By using more than one `CURRENCY SIGN` clause in your program, you can allow for multiple currency signs to be displayed.

You can use a hexadecimal literal to indicate the currency sign value. Using a hexadecimal literal could be useful if the data-entry method for the source program does not allow the entry of the intended characters easily. The following example shows the hexadecimal value X'9F' used as the currency sign:

```cobol
Currency Sign X'9F' with Picture Symbol 'U'.
01 Deposit-Amount pic UUUUU9.99.
```

If there is no corresponding character for the euro sign on your keyboard, you need to specify it as a hexadecimal value in the `CURRENCY SIGN` clause. The hexadecimal value for the euro sign is either X'9F' or X'5A' depending on the code page in use, as shown in the following table.
Table 14. Hexadecimal values of the euro sign

<table>
<thead>
<tr>
<th>Code page</th>
<th>Applicable countries</th>
<th>Modified from</th>
<th>Euro sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>1140</td>
<td>USA, Canada, Netherlands, Portugal, Australia, New Zealand</td>
<td>037</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1141</td>
<td>Austria, Germany</td>
<td>273</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1142</td>
<td>Denmark, Norway</td>
<td>277</td>
<td>X'5A'</td>
</tr>
<tr>
<td>1143</td>
<td>Finland, Sweden</td>
<td>278</td>
<td>X'5A'</td>
</tr>
<tr>
<td>1144</td>
<td>Italy</td>
<td>280</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1145</td>
<td>Spain, Latin America - Spanish</td>
<td>284</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1146</td>
<td>UK</td>
<td>285</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1147</td>
<td>France</td>
<td>297</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1148</td>
<td>Belgium, Canada, Switzerland</td>
<td>500</td>
<td>X'9F'</td>
</tr>
<tr>
<td>1149</td>
<td>Iceland</td>
<td>871</td>
<td>X'9F'</td>
</tr>
</tbody>
</table>

related references
“CURRENCY” on page 299
CURRENCY SIGN clause (Enterprise COBOL for z/OS Language Reference)

Example: multiple currency signs
The following example shows how you can display values in both euro currency (as EUR) and Swiss francs (as CHF).

IDENTIFICATION DIVISION.
PROGRAM-ID. EuroSamp.
Environment Division.
Configuration Section.
Special-Names.
Currency Sign is "CHF " with Picture Symbol "F"
Currency Sign is "EUR " with Picture Symbol "U".
Data Division.
WORKING-STORAGE SECTION.
01 Deposit-in-Euro Pic S9999V99 Value 8000.00.
01 Deposit-in-CHF Pic S99999V99.
01 Deposit-Report.
  01 EUR-to-CHF-Conv-Rate Pic 9V99999 Value 1.53893.

PROCEDURE DIVISION.
Report-Deposit-in-CHF-and-EUR.
  Move Deposit-in-Euro to Report-in-Euro
  Compute Deposit-in-CHF Rounded
  = Deposit-in-Euro * EUR-to-CHF-Conv-Rate
  On Size Error
  Perform Conversion-Error
  Not On Size Error
  Move Deposit-in-CHF to Report-in-Franc
  Display "Deposit in euro = " Report-in-Euro
  Display "Deposit in franc = " Report-in-Franc
  End-Compute
End-Compute
Conversion-Error.
  Display "Conversion error from EUR to CHF"
End-Conversion-Error.
The above example produces the following display output:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposit in euro</td>
<td>EUR 8000.00</td>
</tr>
<tr>
<td>Deposit in franc</td>
<td>CHF 12311.44</td>
</tr>
</tbody>
</table>

The exchange rate used in this example is for illustrative purposes only.
Chapter 4. Handling tables

A table is a collection of data items that have the same description, such as account totals or monthly averages. A table consists of a table name and subordinate items called table elements. A table is the COBOL equivalent of an array.

In the example above, SAMPLE-TABLE-ONE is the group item that contains the table. TABLE-COLUMN names the table element of a one-dimensional table that occurs three times.

Rather than defining repetitious items as separate, consecutive entries in the DATA DIVISION, you use the OCCURS clause in the DATA DIVISION entry to define a table. This practice has these advantages:

- The code clearly shows the unity of the items (the table elements).
- You can use subscripts and indexes to refer to the table elements.
- You can easily repeat data items.

Tables are important for increasing the speed of a program, especially a program that looks up records.

related concepts
“Complex OCCURS DEPENDING ON” on page 79

related tasks
“Defining a table (OCCURS)” on page 65
“Nesting tables” on page 67
“Referring to an item in a table” on page 68
“Putting values into a table” on page 71
“Creating variable-length tables (DEPENDING ON)” on page 76
“Searching a table” on page 82
“Sorting a table” on page 85
“Processing table items using intrinsic functions” on page 85
“Working with unbounded tables and groups” on page 86

“Handling tables efficiently” on page 632

Defining a table (OCCURS)

To code a table, give the table a group name and define a subordinate item (the table element) to be repeated n times.

```cobol
01 table-name.
   05 element-name OCCURS n TIMES.
   . . . (subordinate items of the table element)
```
In the example above, table-name is the name of an alphanumeric group item. The table element definition (which includes the OCCURS clause) is subordinate to the group item that contains the table. The OCCURS clause cannot be used in a level-01 description.

If a table is to contain only Unicode (UTF-16) data, and you want the group item that contains the table to behave like an elementary category national item in most operations, code the GROUP-USAGE NATIONAL clause for the group item:

```
01  table-nameN Group-Usage National.
   05  element-nameN OCCURS m TIMES.
      10  elementN1  Pic nn.
      10  elementN2  Pic S99 Sign Is Leading, Separate.
      . . .
```

Any elementary item that is subordinate to a national group must be explicitly or implicitly described as USAGE NATIONAL, and any subordinate numeric data item that is signed must be implicitly or explicitly described with the SIGN IS SEPARATE clause.

To create tables of two to seven dimensions, use nested OCCURS clauses.

To create a variable-length table, code the DEPENDING ON phrase of the OCCURS clause.

To specify that table elements will be arranged in ascending or descending order based on the values in one or more key fields of the table, code the ASCENDING or DESCENDING KEY phrases of the OCCURS clause, or both. Specify the names of the keys in decreasing order of significance. Keys can be of class alphabetic, alphanumeric, DBCS, national, or numeric. (If it has USAGE NATIONAL, a key can be of category national, or can be a national-edited, numeric-edited, national decimal, or national floating-point item.)

You must code the ASCENDING or DESCENDING KEY phrase of the OCCURS clause to do a binary search (SEARCH ALL) of a table. You can use a format 2 SORT statement to order the table according to its defined keys, thereby making the table searchable by the SEARCH ALL statement. Note that SEARCH ALL will return unpredictable results if the table has not been ordered according to the keys.

“Example: binary search” on page 84

related concepts
“National groups” on page 127

related tasks
“Nesting tables” on page 67
“Referring to an item in a table” on page 68
“Putting values into a table” on page 71
“Creating variable-length tables (DEPENDING ON)” on page 76
“Using national groups” on page 128
“Doing a binary search (SEARCH ALL)” on page 84
“Defining numeric data” on page 41

related references
OCCURS clause (Enterprise COBOL for z/OS Language Reference)
SIGN clause (Enterprise COBOL for z/OS Language Reference)
ASCENDING KEY and DESCENDING KEY phrases (Enterprise COBOL for z/OS Language Reference)
SORT statement (Enterprise COBOL for z/OS Language Reference)
Nesting tables

To create a two-dimensional table, define a one-dimensional table in each occurrence of another one-dimensional table.

**COBOL Code**

```cobol
01 SAMPLE-TABLE-TWO.  
  05 TABLE-ROW OCCURS 2 TIMES.  
    10 TABLE-COLUMN OCCURS 3 TIMES.  
      15 TABLE-ITEM-1 PIC X(2).  
      15 TABLE-ITEM-2 PIC X(1).  
```

For example, in `SAMPLE-TABLE-TWO` above, `TABLE-ROW` is an element of a one-dimensional table that occurs two times. `TABLE-COLUMN` is an element of a two-dimensional table that occurs three times in each occurrence of `TABLE-ROW`.

To create a three-dimensional table, define a one-dimensional table in each occurrence of another one-dimensional table, which is itself contained in each occurrence of another one-dimensional table. For example:

**COBOL Code**

```cobol
01 SAMPLE-TABLE-THREE.  
  05 TABLE-DEPTH OCCURS 2 TIMES.  
    10 TABLE-ROW OCCURS 2 TIMES.  
      15 TABLE-COLUMN OCCURS 3 TIMES.  
        20 TABLE-ITEM-1 PIC X(2).  
        20 TABLE-ITEM-2 PIC X(1).  
```

In `SAMPLE-TABLE-THREE`, `TABLE-DEPTH` is an element of a one-dimensional table that occurs two times. `TABLE-ROW` is an element of a two-dimensional table that occurs two times within each occurrence of `TABLE-DEPTH`. `TABLE-COLUMN` is an element of a three-dimensional table that occurs three times within each occurrence of `TABLE-ROW`.

In a two-dimensional table, the two subscripts correspond to the row and column numbers. In a three-dimensional table, the three subscripts correspond to the depth, row, and column numbers.

“Example: subscripting” on page 68
“Example: indexing” on page 68

**related tasks**

“Defining a table (OCCURS)” on page 65
“Referring to an item in a table” on page 68
“Putting values into a table” on page 71
“Creating variable-length tables (DEPENDING ON)” on page 76
“Searching a table” on page 82
“Processing table items using intrinsic functions” on page 85
“Handling tables efficiently” on page 632

**related references**

OCCURS clause (Enterprise COBOL for z/OS Language Reference)
Example: subscripting
The following example shows valid references to SAMPLE-TABLE-THREE that use literal subscripts. The spaces are required in the second example.

| TABLE-COLUMN (2, 2, 1)   |
| TABLE-COLUMN (2 2 1)    |

In either table reference, the first value (2) refers to the second occurrence within TABLE-DEPTH, the second value (2) refers to the second occurrence within TABLE-ROW, and the third value (1) refers to the first occurrence within TABLE-COLUMN.

The following reference to SAMPLE-TABLE-TWO uses variable subscripts. The reference is valid if SUB1 and SUB2 are data-names that contain positive integer values within the range of the table.

| TABLE-COLUMN (SUB1 SUB2) |

related tasks
“Subscripting” on page 69

Example: indexing
The following example shows how displacements to elements that are referenced with indexes are calculated.

Consider the following three-dimensional table, SAMPLE-TABLE-FOUR:

```cobol
01 SAMPLE-TABLE-FOUR
   05 TABLE-DEPTH OCCURS 3 TIMES Indexed by INX-A.
      10 TABLE-ROW OCCURS 4 TIMES Indexed by INX-B.
         15 TABLE-COLUMN OCCURS 8 TIMES Indexed by INX-C PIC X(8).
```

Suppose you code the following relative indexing reference to SAMPLE-TABLE-FOUR:

| TABLE-COLUMN (INX-A + 1, INX-B + 2, INX-C - 1) |

This reference causes the following computation of the displacement to the TABLE-COLUMN element:

```
(contents of INX-A) + (256 * 1)  
+ (contents of INX-B) + (64 * 2)  
+ (contents of INX-C) - (8 * 1)  
```

This calculation is based on the following element lengths:
- Each occurrence of TABLE-DEPTH is 256 bytes in length (4 * 8 * 8).
- Each occurrence of TABLE-ROW is 64 bytes in length (8 * 8).
- Each occurrence of TABLE-COLUMN is 8 bytes in length.

related tasks
“Indexing” on page 70

Referring to an item in a table
A table element has a collective name, but the individual items within it do not have unique data-names.

To refer to an item, you have a choice of three techniques:
• Use the data-name of the table element, along with its occurrence number (called a subscript) in parentheses. This technique is called subscripting.
• Use the data-name of the table element, along with a value (called an index) that is added to the address of the table to locate an item (as a displacement from the beginning of the table). This technique is called indexing, or subscripting using index-names.
• Use both subscripts and indexes together.

**related tasks**
“Subscripting” on page 69
“Indexing” on page 70

**Subscripting**

The lowest possible subscript value is 1, which references the first occurrence of a table element. In a one-dimensional table, the subscript corresponds to the row number.

You can use a literal or a data-name as a subscript. If a data item that has a literal subscript is of fixed length, the compiler resolves the location of the data item.

When you use a data-name as a variable subscript, you must describe the data-name as an elementary numeric integer. The most efficient format is COMPUTATIONAL (COMP) with a PICTURE size that is smaller than five digits. You cannot use a subscript with a data-name that is used as a subscript. The code generated for the application resolves the location of a variable subscript at run time.

You can increment or decrement a literal or variable subscript by a specified integer amount. For example:

TABLE-COLUMN (SUB1 - 1, SUB2 + 3)

You can change part of a table element rather than the whole element. To do so, refer to the character position and length of the substring to be changed. For example:

```
01  ANY-TABLE.
   05 TABLE-ELEMENT   PIC X(10) OCCURS 3 TIMES VALUE "ABCDEFGHIJ".
   .
   MOVE "??" TO TABLE-ELEMENT (1) (3 : 2).
```

The MOVE statement in the example above moves the string '??' into table element number 1, beginning at character position 3, for a length of 2 characters.

“Example: subscripting” on page 68

**related tasks**
“Indexing” on page 70
“Putting values into a table” on page 71
“Searching a table” on page 82
“Handling tables efficiently” on page 632
Indexing

You create an index by using the INDEXED BY phrase of the OCCURS clause to identify an index-name. For example, INX-A in the following code is an index-name:

```
05 TABLE-ITEM PIC X(8) OCCURS 10 INDEXED BY INX-A.
```

The compiler calculates the value contained in the index as the occurrence number (subscript) minus 1, multiplied by the length of the table element. Therefore, for the fifth occurrence of TABLE-ITEM, the binary value contained in INX-A is (5 - 1) * 8, or 32.

You can use an index-name to reference another table only if both table descriptions have the same number of table elements, and the table elements are of the same length.

You can use the USAGE IS INDEX clause to create an index data item, and can use an index data item with any table. For example, INX-B in the following code is an index data item:

```
77 INX-B USAGE IS INDEX.
```

```
SET INX-A TO 10
SET INX-B TO INX-A.
PERFORM VARYING INX-A FROM 1 BY 1 UNTIL INX-A > INX-B
   DISPLAY TABLE-ITEM (INX-A)
END-PERFORM.
```

The index-name INX-A is used to traverse table TABLE-ITEM above. The index data item INX-B is used to hold the index of the last element of the table. The advantage of this type of coding is that calculation of offsets of table elements is minimized, and no conversion is necessary for the UNTIL condition.

You can use the SET statement to assign to an index data item the value that you stored in an index-name, as in the statement SET INX-B TO INX-A above. For example, when you load records into a variable-length table, you can store the index value of the last record into a data item defined as USAGE IS INDEX. Then you can test for the end of the table by comparing the current index value with the index value of the last record. This technique is useful when you look through or process a table.

You can increment or decrement an index-name by an elementary integer data item or a nonzero integer literal, for example:

```
SET INX-A DOWN BY 3
```

The integer represents a number of occurrences. It is converted to an index value before being added to or subtracted from the index.

Initialize the index-name by using a SET, PERFORM VARYING, or SEARCH ALL statement. You can then use the index-name in SEARCH or relational condition statements. To change the value, use a PERFORM, SEARCH, or SET statement.

Because you are comparing a physical displacement, you can directly use index data items only in SEARCH and SET statements or in comparisons with indexes or other index data items. You cannot use index data items as subscripts or indexes.

“Example: indexing” on page 68

related tasks

“Subscripting” on page 69
“Putting values into a table” on page 71
“Searching a table” on page 82
“Processing table items using intrinsic functions” on page 85
“Handling tables efficiently” on page 632
Putting values into a table

You can put values into a table by loading the table dynamically, initializing the table with the INITIALIZE statement, or assigning values with the VALUE clause when you define the table.

related tasks
“Loading a table dynamically” on page 71
“Loading a variable-length table” on page 78
“Initializing a table (INITIALIZE)” on page 71
“Assigning values when you define a table (VALUE)” on page 72
“Assigning values to a variable-length table” on page 78

Loading a table dynamically

If the initial values of a table are different with each execution of your program, you can define the table without initial values. You can instead read the changed values into the table dynamically before the program refers to the table.

To load a table, use the PERFORM statement and either subscripting or indexing.

When reading data to load your table, test to make sure that the data does not exceed the space allocated for the table. Use a named value (rather than a literal) for the maximum item count. Then, if you make the table bigger, you need to change only one value instead of all references to a literal.

“Example: PERFORM and subscripting” on page 74
“Example: PERFORM and indexing” on page 75

related references
PERFORM statement (Enterprise COBOL for z/OS Language Reference)

Initializing a table (INITIALIZE)

You can load a table by coding one or more INITIALIZE statements.

For example, to move the value 3 into each of the elementary numeric data items in a table called TABLE-ONE, shown below, you can code the following statement:

```
INITIALIZE TABLE-ONE REPLACING NUMERIC DATA BY 3.
```

To move the character 'X' into each of the elementary alphanumeric data items in TABLE-ONE, you can code the following statement:

```
INITIALIZE TABLE-ONE REPLACING ALPHANUMERIC DATA BY "X".
```

When you use the INITIALIZE statement to initialize a table, the table is processed as a group item (that is, with group semantics); elementary data items within the group are recognized and processed. For example, suppose that TABLE-ONE is an alphanumeric group that is defined like this:

```
01 TABLE-ONE.
  02 Trans-out Occurs 20.
      05 Trans-code Pic X Value "R".
      05 Part-number Pic XX Value "13".
      05 Trans-quan Pic 99 Value 10.
  05 Price-fields.
```
The table below shows the content that each of the twenty 12-byte elements Trans-out(n) has before execution and after execution of the INITIALIZE statement shown above:

<table>
<thead>
<tr>
<th>Trans-out(n) before</th>
<th>Trans-out(n) after</th>
</tr>
</thead>
<tbody>
<tr>
<td>R13105025375</td>
<td>XXb0303030031</td>
</tr>
</tbody>
</table>

1. The symbol b represents a blank space.

You can similarly use an INITIALIZE statement to load a table that is defined as a national group. For example, if TABLE-ONE shown above specified the GROUP-USAGE NATIONAL clause, and Trans-code and Part-number had N instead of X in their PICTURE clauses, the following statement would have the same effect as the INITIALIZE statement above, except that the data in TABLE-ONE would instead be encoded in UTF-16:

```
Initialize TABLE-ONE Replacing Numeric Data By 3
   National Data By "X"
```

The REPLACING NUMERIC phrase initializes floating-point data items also.

You can use the REPLACING phrase of the INITIALIZE statement similarly to initialize all of the elementary ALPHABETIC, DBCS, ALPHANUMERIC-EDITED, NATIONAL-EDITED, and NUMERIC-EDITED data items in a table.

The INITIALIZE statement cannot assign values to a variable-length table (that is, a table that was defined using the OCCURS DEPENDING ON clause).

related tasks
“Initializing a structure (INITIALIZE)” on page 29
“Assigning values when you define a table (VALUE)” on page 72
“Assigning values to a variable-length table” on page 78
“Looping through a table” on page 98
“Using data items and group items” on page 22
“Using national groups” on page 128

related references
INITIALIZE statement (Enterprise COBOL for z/OS Language Reference)

Assigning values when you define a table (VALUE)
If a table is to contain stable values (such as days and months), you can set the specific values when you define the table.

Set static values in tables in one of these ways:
• Initialize each table item individually.
• Initialize an entire table at the group level.
• Initialize all occurrences of a given table element to the same value.

related tasks
“Initializing each table”
Initializing each table item individually
If a table is small, you can set the value of each item individually by using a VALUE clause.

Use the following technique, which is shown in the example code below:

1. Define a record (such as Error-Flag-Table below) that contains the items that are to be in the table.
2. Set the initial value of each item in a VALUE clause.
3. Code a REDEFINES entry to make the record into a table.

```
  01 Error-Flag-Table   Value Spaces.
   88 No-Errors          Value Spaces.
      05 Type-Error      Pic X.
      05 Shift-Error     Pic X.
      05 Home-Code-Error Pic X.
      05 Work-Code-Error Pic X.
      05 Name-Error       Pic X.
      05 Initials-Error   Pic X.
      05 Duplicate-Error Pic X.
      05 Not-Found-Error  Pic X.
  01 Filler Redefines Error-Flag-Table.
      05 Error-Flag Occurs 8 Times
          Indexed By Flag-Index Pic X.
```

In the example above, the VALUE clause at the 01 level initializes each of the table items to the same value. Each table item could instead be described with its own VALUE clause to initialize that item to a distinct value.

To initialize larger tables, use MOVE, PERFORM, or INITIALIZE statements.

related tasks
“Initializing a structure (INITIALIZE)” on page 29
“Assigning values to a variable-length table” on page 78

related references
REDEFINES clause (Enterprise COBOL for z/OS Language Reference)
OCCURS clause (Enterprise COBOL for z/OS Language Reference)

Initializing a table at the group level
Code an alphanumeric or national group data item and assign to it, through the VALUE clause, the contents of the whole table. Then, in a subordinate data item, use an OCCURS clause to define the individual table items.

In the following example, the alphanumeric group data item TABLE-ONE uses a VALUE clause that initializes each of the four elements of TABLE-TWO:

```
  01 TABLE-ONE     VALUE "1234".
    05 TABLE-TWO OCCURS 4 TIMES PIC X.
```

In the following example, the national group data item Table-OneN uses a VALUE clause that initializes each of the three elements of the subordinate data item Table-TwoN (each of which is implicitly USAGE
NATIONAL). Note that you can initialize a national group data item with a VALUE clause that uses an alphanumerical literal, as shown below, or a national literal.

```cobol
01 Table-OneN Group-Usage National Value "AB12CD34EF56".
  05 Table-TwoN Occurs 3 Times Indexed By MyI.
    10 ElementOneN Pic nn.
    10 ElementTwoN Pic 99.
```

After Table-OneN is initialized, ElementOneN(1) contains NX"00410042" (the UTF-16 representation of 'AB'), the national decimal item ElementTwoN(1) contains NX"00310032" (the UTF-16 representation of '12'), and so forth.

**related references**

OCCURS clause (Enterprise COBOL for z/OS Language Reference)
GROUP-USAGE clause (Enterprise COBOL for z/OS Language Reference)

**Initializing all occurrences of a given table element**

You can use the VALUE clause in the data description of a table element to initialize all instances of that element to the specified value.

```cobol
01 T2.
  05 T-OBJ          PIC 9   VALUE 3.
  05 T OCCURS 5 TIMES DEPENDING ON T-OBJ.
    10 X          PIC XX VALUE "AA".
    10 Y          PIC 99 VALUE 19.
    10 Z          PIC XX VALUE "BB".
```

For example, the code above causes all the X elements (1 through 5) to be initialized to AA, all the Y elements (1 through 5) to be initialized to 19, and all the Z elements (1 through 5) to be initialized to BB. T-OBJ is then set to 3.

**related tasks**

“Assigning values to a variable-length table” on page 78

**related references**

OCCURS clause (Enterprise COBOL for z/OS Language Reference)

**Example: PERFORM and subscripting**

This example traverses an error-flag table using subscripting until an error code that has been set is found. If an error code is found, the corresponding error message is moved to a print report field.

```cobol
***********************************************************
***           E R R O R   F L A G   T A B L E           ***
***********************************************************
01  Error-Flag-Table                    Value Spaces.
  88 No-Errors                          Value Spaces.
  05 Type-Error                       Pic X.
  05 Shift-Error                      Pic X.
  05 Home-Code-Error                  Pic X.
  05 Work-Code-Error                  Pic X.
  05 Name-Error                       Pic X.
  05 Initials-Error                   Pic X.
  05 Duplicate-Error                  Pic X.
  05 Not-Found-Error                  Pic X.
01  Filler Redefines Error-Flag-Table.
  05 Error-Flag Occurs 8 Times
      Indexed By Flag-Index      Pic X.
  77 Error-on                    Pic X  Value "E".
***********************************************************
***           E R R O R   M E S S A G E   T A B L E       ***
***********************************************************
01  Error-Message-Table.
05  Filler                           Pic X(25) Value
```

Transaction Type Invalid".

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Example: PERFORM and indexing

This example traverses an error-flag table using indexing until an error code that has been set is found. If an error code is found, the corresponding error message is moved to a print report field.

### ERROR FLAG TABLE

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error-Flag-Table</td>
<td>Value Spaces.</td>
</tr>
<tr>
<td>No-Errors</td>
<td>Value Spaces.</td>
</tr>
<tr>
<td>Type-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Shift-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Home-Code-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Work-Code-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Name-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Initials-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Duplicate-Error</td>
<td>Pic X.</td>
</tr>
<tr>
<td>Not-Found-Error</td>
<td>Pic X.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Error-Flag</th>
<th>E</th>
</tr>
</thead>
</table>

### ERROR MESSAGE TABLE

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error-Message-Table</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Transaction Type Invalid</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Shift Code Invalid</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Home Location Code Inval.</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Work Location Code Inval.</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Last Name - Blanks.</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Initials - Blanks.</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Duplicate Record Found.</td>
<td>Pic X(25) Value</td>
</tr>
<tr>
<td>Commuter Record Not Found</td>
<td>Pic X(25) Value</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Error-Message</th>
<th>Pic X(25) Value</th>
</tr>
</thead>
</table>

PROCEDURE DIVISION.
Creating variable-length tables (DEPENDING ON)

If you do not know before run time how many times a table element occurs, define a variable-length table. To do so, use the OCCURS DEPENDING ON (ODO) clause.

X OCCURS 1 TO 10 TIMES DEPENDING ON Y

In the example above, X is called the ODO subject, and Y is called the ODO object.

You can also specify unbounded tables and groups, see Variable-length tables in the Enterprise COBOL for z/OS Language Reference for details.

Two factors affect the successful manipulation of variable-length records:

- Correct calculation of record lengths
  The length of the variable portions of a group item is the product of the object of the DEPENDING ON phrase and the length of the subject of the OCCURS clause.
- Conformance of the data in the object of the OCCURS DEPENDING ON clause to its PICTURE clause
  If the content of the ODO object does not match its PICTURE clause, the program could terminate abnormally. You must ensure that the ODO object correctly specifies the current number of occurrences of table elements.

The following example shows a group item (REC-1) that contains both the subject and object of the OCCURS DEPENDING ON clause. The way the length of the group item is determined depends on whether it is sending or receiving data.

```
WORKING-STORAGE SECTION.
  01 MAIN-AREA.
    03 REC-1.
      05 FIELD-1 PIC 9.
      05 FIELD-2 OCCURS 1 TO 5 TIMES DEPENDING ON FIELD-1 PIC X(05).
    01 REC-2.
      03 REC-2-DATA PIC X(50).
```

If you want to move REC-1 (the sending item in this case) to REC-2, the length of REC-1 is determined immediately before the move, using the current value in FIELD-1. If the content of FIELD-1 conforms to its PICTURE clause (that is, if FIELD-1 contains a zoned decimal item), the move can proceed based on the actual length of REC-1. Otherwise, the result is unpredictable. You must ensure that the ODO object has the correct value before you initiate the move.

When you do a move to REC-1 (the receiving item in this case), the length of REC-1 is determined using the maximum number of occurrences. In this example, five occurrences of FIELD-2, plus FIELD-1, yields a length of 26 bytes. In this case, you do not need to set the ODO object (FIELD-1) before referencing REC-1 as a receiving item. However, the sending field's ODO object (not shown) must be set.
to a valid numeric value between 1 and 5 for the ODO object of the receiving field to be validly set by the move.

However, if you do a move to REC-1 (again the receiving item) where REC-1 is followed by a variably located group (a type of complex ODO), the actual length of REC-1 is calculated immediately before the move, using the current value of the ODO object (FIELD-1). In the following example, REC-1 and REC-2 are in the same record, but REC-2 is not subordinate to REC-1 and is therefore variably located:

```cobol
01 MAIN-AREA
   03 REC-1.
      05 FIELD-1          PIC 9.
      05 FIELD-3          PIC 9.
      05 FIELD-2 OCCURS 1 TO 5 TIMES
                           DEPENDING ON FIELD-1
                           PIC X(05).
   03 REC-2.
      05 FIELD-4 OCCURS 1 TO 5 TIMES
                           DEPENDING ON FIELD-3
                           PIC X(05).
```

The compiler issues a message that lets you know that the actual length was used. This case requires that you set the value of the ODO object before using the group item as a receiving field.

The following example shows how to define a variable-length table when the ODO object (LOCATION-TABLE-LENGTH below) is outside the group:

```cobol
DATA DIVISION.
FILE SECTION.
FD LOCATION-FILE
   RECORDING MODE F
   BLOCK 0 RECORDS
   RECORD 80 CHARACTERS
   LABEL RECORD STANDARD.
   01 LOCATION-RECORD.
      05 LOC-CODE            PIC XX.
      05 LOC-DESCRIPTION      PIC X(20).
      05 FILLER              PIC X(58).
   WORKING-STORAGE SECTION.
   01 FLAGS.
      05 LOCATION-EOF-FLAG   PIC X(5) VALUE SPACE.
      88 LOCATION-EOF         VALUE "FALSE".
   01 MISC-VALUES.
      05 LOCATION-TABLE-LENGTH PIC 9(3) VALUE ZERO.
      05 LOCATION-TABLE-MAX   PIC 9(3) VALUE 100.
   *****************************************************************
   ***                L O C A T I O N   T A B L E                ***
   ***                FILE CONTAINS LOCATION CODES.              ***
   *****************************************************************
   01 LOCATION-TABLE.
      05 LOCATION-CODE OCCURS 1 TO 100 TIMES
                           DEPENDING ON LOCATION-TABLE-LENGTH
                           PIC X(80).
```

**related concepts**

“Complex OCCURS DEPENDING ON” on page 79

**related tasks**

“Assigning values to a variable-length table” on page 78

“Loading a variable-length table” on page 78

“Preventing overlay when adding elements to a variable table” on page 81

“Finding the length of data items” on page 117

**related references**

OCCURS DEPENDING ON clause
(Enterprise COBOL for z/OS Language Reference)
Variable-length tables (Enterprise COBOL for z/OS Language Reference)
Loading a variable-length table

You can use a \textit{do-until} structure (a TEST \texttt{AFTER} loop) to control the loading of a variable-length table. For example, after the following code runs, \texttt{LOCATION-TABLE-LENGTH} contains the subscript of the last item in the table.

```cobol
DATA DIVISION.
FILE SECTION.
FD LOCATION-FILE
  RECORDING MODE F
  BLOCK 0 RECORDS
  RECORD 80 CHARACTERS
  LABEL RECORD STANDARD.
01 LOCATION-RECORD.
  05 LOC-CODE               PIC XX.
  05 LOC-DESCRIPTION        PIC X(20).
  05 FILLER                 PIC X(58).
  . . .
WORKING-STORAGE SECTION.
01 FLAGS.
  05 LOCATION-EOF-FLAG       PIC X(5) VALUE SPACE.
  88 LOCATION-EOF                  VALUE "YES".
01 MISC-VALUES.
  05 LOCATION-TABLE-LENGTH   PIC 9(3) VALUE ZERO.
  05 LOCATION-TABLE-MAX      PIC 9(3) VALUE 100.
  *****************************************************************
  ***                L O C A T I O N   T A B L E                ***
  ***                FILE CONTAINS LOCATION CODES.              ***
  *****************************************************************
01 LOCATION-TABLE.
  05 LOCATION-CODE OCCURS 1 TO 100 TIMES
    DEPENDING ON LOCATION-TABLE-LENGTH   PIC X(80).
  . . .
PROCEDURE DIVISION.
  . . .
  Perform Test After
    Varying Location-Table-Length From 1 By 1
    Until Location-EOF
  05 Location-Table-Length = Location-Table-Max
  05 Move Location-Record To
    Location-Code (Location-Table-Length)
  05 Read Location-File
    At End Set Location-EOF To True
  05 End-Read
  05 End-Perform
```

Assigning values to a variable-length table

You can code a \texttt{VALUE} clause for an alphanumeric or national group item that has a subordinate data item that contains the \texttt{OCCURS} clause with the \texttt{DEPENDING ON} phrase. Each subordinate structure that contains the \texttt{DEPENDING ON} phrase is initialized using the maximum number of occurrences.

If you define the entire table by using the \texttt{DEPENDING ON} phrase, all the elements are initialized using the maximum defined value of the ODO (\texttt{OCCURS DEPENDING ON}) object.

If the ODO object is initialized by a \texttt{VALUE} clause, it is logically initialized after the ODO subject has been initialized.

```cobol
01 TABLE-THREE           VALUE "3ABCDE".
  05 X                  PIC 9.
  05 Y OCCURS 5 TIMES
    DEPENDING ON X     PIC X.
```

For example, in the code above, the ODO subject \texttt{Y(1)} is initialized to ‘A’, \texttt{Y(2)} to ‘B’, . . ., \texttt{Y(5)} to ‘E’, and finally the ODO object \texttt{X} is initialized to 3. Any subsequent reference to \texttt{TABLE-THREE} (such as in a \texttt{DISPLAY} statement) refers to \texttt{X} and the first three elements, \texttt{Y(1)} through \texttt{Y(3)}, of the table.

related tasks

“Assigning values when you define a table (VALUE)” on page 72
Complex OCCURS DEPENDING ON

Several types of complex OCCURS DEPENDING ON (complex ODO) are possible. Complex ODO is supported as an extension to the 85 COBOL Standard.

The basic forms of complex ODO permitted by the compiler are as follows:

- Variably located item or group: A data item described by an OCCURS clause with the DEPENDING ON phrase is followed by a nonsubordinate elementary or group data item.
- Variably located table: A data item described by an OCCURS clause with the DEPENDING ON phrase is followed by a nonsubordinate data item described by an OCCURS clause.
- Table that has variable-length elements: A data item described by an OCCURS clause contains a subordinate data item described by an OCCURS clause with the DEPENDING ON phrase.
- Index name for a table that has variable-length elements.
- Element of a table that has variable-length elements.

Example: complex ODO

The following example illustrates the possible types of occurrence of complex ODO.

```
01 FIELD-A.
  02 COUNTER-1 PIC S99.
  02 COUNTER-2 PIC S99.
  02 TABLE-1.
    03 RECORD-1 OCCURS 1 TO 5 TIMES DEPENDING ON COUNTER-1 PIC X(3).
    02 EMPLOYEE-NUMBER PIC X(5). (1)
    02 TABLE-2 OCCURS 5 TIMES INDEXED BY INDX. (2)(3)
    03 TABLE-ITEM PIC 99. (4)
    03 RECORD-2 OCCURS 1 TO 3 TIMES DEPENDING ON COUNTER-2.
  04 DATA-NUM PIC S99.
```

Definition: In the example, COUNTER-1 is an ODO object, that is, it is the object of the DEPENDING ON clause of RECORD-1. RECORD-1 is said to be an ODO subject. Similarly, COUNTER-2 is the ODO object of the corresponding ODO subject, RECORD-2.

The types of complex ODO occurrences shown in the example above are as follows:

1. A variably located item: EMPLOYEE-NUMBER is a data item that follows, but is not subordinate to, a variable-length table in the same level-01 record.
A variably located table: TABLE-2 is a table that follows, but is not subordinate to, a variable-length table in the same level-01 record.

A table with variable-length elements: TABLE-2 is a table that contains a subordinate data item, RECORD-2, whose number of occurrences varies depending on the content of its ODO object.

An index-name, INDX, for a table that has variable-length elements.

An element, TABLE-ITEM, of a table that has variable-length elements.

**How length is calculated**

The length of the variable portion of each record is the product of its ODO object and the length of its ODO subject. For example, whenever a reference is made to one of the complex ODO items shown above, the actual length, if used, is computed as follows:

- The length of TABLE-1 is calculated by multiplying the contents of COUNTER-1 (the number of occurrences of RECORD-1) by 3 (the length of RECORD-1).
- The length of TABLE-2 is calculated by multiplying the contents of COUNTER-2 (the number of occurrences of RECORD-2) by 2 (the length of RECORD-2), and adding the length of TABLE-ITEM.
- The length of FIELD-A is calculated by adding the lengths of COUNTER-1, COUNTER-2, TABLE-1, EMPLOYEE-NUMBER, and TABLE-2 times 5.

**Setting values of ODO objects**

You must set every ODO object in a group item before you reference any complex ODO item in the group. For example, before you refer to EMPLOYEE-NUMBER in the code above, you must set COUNTER-1 and COUNTER-2 even though EMPLOYEE-NUMBER does not directly depend on either ODO object for its value.

**Restriction:** An ODO object cannot be variably located.

**Effects of change in ODO object value**

If a data item that is described by an OCCURS clause with the DEPENDING ON phrase is followed in the same group by one or more nonsubordinate data items (a form of complex ODO), any change in value of the ODO object affects subsequent references to complex ODO items in the record.

For example:

- The size of any group that contains the relevant ODO clause reflects the new value of the ODO object.
- A MOVE to a group that contains the ODO subject is made based on the new value of the ODO object.
- The location of any nonsubordinate items that follow the item described with the ODO clause is affected by the new value of the ODO object. (To preserve the contents of the nonsubordinate items, move them to a work area before the value of the ODO object changes, then move them back.)

The value of an ODO object can change when you move data to the ODO object or to the group in which it is contained. The value can also change if the ODO object is contained in a record that is the target of a READ statement.

**related tasks**

“Preventing index errors when changing ODO object value” on page 80
“Preventing overlay when adding elements to a variable table” on page 81

**Preventing index errors when changing ODO object value**

Be careful if you reference a complex-ODO index-name, that is, an index-name for a table that has variable-length elements, after having changed the value of the ODO object for a subordinate data item in the table.
When you change the value of an ODO object, the byte offset in an associated complex-ODO index is no longer valid because the table length has changed. Unless you take precautions, you will have unexpected results if you then code a reference to the index-name such as:

- A reference to an element of the table
- A SET statement of the form SET integer-data-item TO index-name (format 1)
- A SET statement of the form SET index-name UP|DOWN BY integer (format 2)

To avoid this type of error, do these steps:

1. Save the index in an integer data item. (Doing so causes an implicit conversion: the integer item receives the table element occurrence number that corresponds to the offset in the index.)
2. Change the value of the ODO object.
3. Immediately restore the index from the integer data item. (Doing so causes an implicit conversion: the index-name receives the offset that corresponds to the table element occurrence number in the integer item. The offset is computed according to the table length then in effect.)

The following code shows how to save and restore the index-name (shown in “Example: complex ODO” on page 79) when the ODO object COUNTER-2 changes.

```cobol
77 INTEGER-DATA-ITEM-1 PIC 99.
      SET INDX TO 5.
      * INDX is valid at this point.
      SET INTEGER-DATA-ITEM-1 TO INDX.
      * INTEGER-DATA-ITEM-1 now has the occurrence number that corresponds to INDX.
      MOVE NEW-VALUE TO COUNTER-2.
      * INDX is not valid at this point.
      SET INDX TO INTEGER-DATA-ITEM-1.
      * INDX is now valid, containing the offset that corresponds to INTEGER-DATA-ITEM-1, and can be used with the expected results.
```

related references
SET statement (Enterprise COBOL for z/OS Language Reference)

Preventing overlay when adding elements to a variable table
Be careful if you increase the number of elements in a variable-occurrence table that is followed by one or more nonsubordinate data items in the same group. When you increment the value of the ODO object and add an element to a table, you can inadvertently overlay the variably located data items that follow the table.

To avoid this type of error, do these steps:

1. Save the variably located data items that follow the table in another data area.
2. Increment the value of the ODO object.
3. Move data into the new table element (if needed).
4. Restore the variably located data items from the data area where you saved them.

In the following example, suppose you want to add an element to the table VARY-FIELD-1, whose number of elements depends on the ODO object CONTROL-1. VARY-FIELD-1 is followed by the nonsubordinate variably located data item GROUP-ITEM-1, whose elements could potentially be overlaid.

```cobol
WORKING-STORAGE SECTION.
01 VARIABLE-REC.
   05 FIELD-1 PIC X(10).
   05 CONTROL-1 PIC S99.
   05 CONTROL-2 PIC S99.
   05 VARY-FIELD-1 OCCURS 1 TO 10 TIMES DEPENDING ON CONTROL-1 PIC X(5).
   05 GROUP-ITEM-1.
      10 VARY-FIELD-2
```
Each element of VARY-FIELD-1 has 5 bytes, and each element of VARY-FIELD-2 has 9 bytes. If CONTROL-1 and CONTROL-2 both contain the value 3, you can picture storage for VARY-FIELD-1 and VARY-FIELD-2 as follows:

<table>
<thead>
<tr>
<th>VARY-FIELD-1(1)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VARY-FIELD-1(2)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-1(3)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-2(1)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-2(2)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-2(3)</td>
<td></td>
</tr>
</tbody>
</table>

To add a fourth element to VARY-FIELD-1, code as follows to prevent overlaying the first 5 bytes of VARY-FIELD-2. (GROUP-ITEM-2 serves as temporary storage for the variably located GROUP-ITEM-1.)

```
MOVE GROUP-ITEM-1 TO GROUP-ITEM-2.
ADD 1 TO CONTROL-1.
MOVE five-byte-field TO VARY-FIELD-1 (CONTROL-1).
MOVE GROUP-ITEM-2 TO GROUP-ITEM-1.
```

You can picture the updated storage for VARY-FIELD-1 and VARY-FIELD-2 as follows:

<table>
<thead>
<tr>
<th>VARY-FIELD-1(1)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VARY-FIELD-1(2)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-1(3)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-1(4)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-2(1)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-2(2)</td>
<td></td>
</tr>
<tr>
<td>VARY-FIELD-2(3)</td>
<td></td>
</tr>
</tbody>
</table>

Note that the fourth element of VARY-FIELD-1 did not overlay the first element of VARY-FIELD-2.

### Searching a table

COBOL provides two search techniques for tables: serial and binary.

To do serial searches, use SEARCH and indexing. For variable-length tables, you can use PERFORM with subscripting or indexing.

To do binary searches, use SEARCH ALL and indexing.

A binary search can be considerably more efficient than a serial search. For a serial search, the number of comparisons is of the order of \( n \), the number of entries in the table. For a binary search, the number of comparisons is of the order of only the logarithm (base 2) of \( n \). A binary search, however, requires that the table items already be sorted.

**related tasks**

“Doing a serial search (SEARCH)” on page 83
“Doing a binary search (SEARCH ALL)” on page 84
Doing a serial search (SEARCH)

Use the SEARCH statement to do a serial (sequential) search beginning at the current index setting. To modify the index setting, use the SET statement.

The conditions in the WHEN phrase are evaluated in the order in which they appear:

- If none of the conditions is satisfied, the index is increased to correspond to the next table element, and the WHEN conditions are evaluated again.
- If one of the WHEN conditions is satisfied, the search ends. The index remains pointing to the table element that satisfied the condition.
- If the entire table has been searched and no conditions were met, the AT END imperative statement is executed if there is one. If you did not code AT END, control passes to the next statement in the program.

You can reference only one level of a table (a table element) with each SEARCH statement. To search multiple levels of a table, use nested SEARCH statements. Delimit each nested SEARCH statement with END-SEARCH.

**Performance:** If the found condition comes after some intermediate point in the table, you can speed up the search by using the SET statement to set the index to begin the search after that point. Arranging the table so that the data used most often is at the beginning of the table also enables more efficient serial searching. If the table is large and is presorted, a binary search is more efficient.

“Example: serial search” on page 83

**related references**
SEARCH statement (*Enterprise COBOL for z/OS Language Reference*)

**Example: serial search**
The following example shows how you might find a particular string in the innermost table of a three-dimensional table.

Each dimension of the table has its own index (set to 1, 4, and 1, respectively). The innermost table (TABLE-ENTRY3) has an ascending key.

```cobol
01  TABLE-ONE.
   05 TABLE-ENTRY1 OCCURS 10 TIMES
      INDEXED BY TE1-INDEX.
   10 TABLE-ENTRY2 OCCURS 10 TIMES
      INDEXED BY TE2-INDEX.
   15 TABLE-ENTRY3 OCCURS 5 TIMES
      ASCENDING KEY IS KEY1
      INDEXED BY TE3-INDEX.
   20 KEY1       PIC X(5).
   20 KEY2       PIC X(10).
   . . .
PROCEDURE DIVISION.
   SET TE1-INDEX TO 1
   SET TE2-INDEX TO 4
   SET TE3-INDEX TO 1
   MOVE "A1234" TO KEY1 (TE1-INDEX, TE2-INDEX, TE3-INDEX + 2)
   MOVE "AAAAAAAAAAAA00" TO KEY2 (TE1-INDEX, TE2-INDEX, TE3-INDEX + 2)
   SEARCH TABLE-ENTRY3
      AT END
      MOVE 4 TO RETURN-CODE
      WHEN TABLE-ENTRY3(TE1-INDEX, TE2-INDEX, TE3-INDEX)
         = "A1234AAAAAAAA00"
      MOVE 0 TO RETURN-CODE
   END-SEARCH
```

**Values after execution:**

- TE1-INDEX = 1
- TE2-INDEX = 4
Doing a binary search (SEARCH ALL)

If you use SEARCH ALL to do a binary search, you do not need to set the index before you begin. The index is always the one that is associated with the first index-name in the OCCURS clause. The index varies during execution to maximize the search efficiency.

To use the SEARCH ALL statement to search a table, the table must specify the ASCENDING or DESCENDING KEY phrases of the OCCURS clause, or both, and must already be ordered on the key or keys that are specified in the ASCENDING and DESCENDING KEY phrases. You can use a format 2 SORT statement to order the table according to its defined keys, thereby making the table searchable by the SEARCH ALL statement. Note that SEARCH ALL will return unpredictable results if the table has not been ordered according to the keys.

In the WHEN phrase of the SEARCH ALL statement, you can test any key that is named in the ASCENDING or DESCENDING KEY phrases for the table, but you must test all preceding keys, if any. The test must be an equal-to condition, and the WHEN phrase must specify either a key (subscripted by the first index-name associated with the table) or a condition-name that is associated with the key. The WHEN condition can be a compound condition that is formed from simple conditions that use AND as the only logical connective.

Each key and its object of comparison must be compatible according to the rules for comparison of data items. Note though that if a key is compared to a national literal or identifier, the key must be a national data item.

“Example: binary search” on page 84

related tasks
“Defining a table (OCCURS)” on page 65

related references
SEARCH statement (Enterprise COBOL for z/OS Language Reference)
General relation conditions (Enterprise COBOL for z/OS Language Reference)

Example: binary search
The following example shows how you can code a binary search of a table.

Suppose you define a table that contains 90 elements of 40 bytes each, and three keys. The primary and secondary keys (KEY-1 and KEY-2) are in ascending order, but the least significant key (KEY-3) is in descending order:

```
01 TABLE-A.
   65 TABLE-ENTRY OCCURS 90 TIMES
       ASCENDING KEY-1, KEY-2
       DESCENDING KEY-3
       INDEXED BY INDX-1.
   10 PART-1   PIC 99.
   10 KEY-1    PIC 9(5).
   10 PART-2   PIC 9(6).
   10 KEY-2    PIC 9(4).
   10 PART-3   PIC 9(18).
   10 KEY-3    PIC 9(5).
```

You can search this table by using the following statements:

```
SEARCH ALL TABLE-ENTRY
AT END
PERFORM NOENTRY
WHEN KEY-1 (INDX-1) = VALUE-1 AND
   KEY-2 (INDX-1) = VALUE-2 AND
   KEY-3 (INDX-1) = VALUE-3
MOVE PART-1 (INDX-1) TO OUTPUT-AREA
END-SEARCH
```
If an entry is found in which each of the three keys is equal to the value to which it is compared (VALUE-1, VALUE-2, and VALUE-3, respectively), PART-1 of that entry is moved to OUTPUT-AREA. If no matching key is found in the entries in TABLE-A, the NOENTRY routine is performed.

**Sorting a table**

You can sort a table by using the format 2 SORT statement. It is part of the 2002 COBOL Standard.

The format 2 SORT statement sorts table elements according to the specified table keys, and it is especially useful for tables used with SEARCH ALL. You can specify the keys for sorting as part of the table definition, which can also be used in the SEARCH ALL statement. Alternatively, you can also specify the keys for sorting as part of the SORT statement, either if you want to sort the table using different keys than those specified in the table definition, or if the table has no keys specified.

With the format 2 SORT statement, you don't need to use the input and output procedures as you do with the format 1 SORT statement.

See the following example in which the table is sorted based on specified keys:

```cobol
WORKING-STORAGE SECTION.
01 GROUP-ITEM.
   05 TABL OCCURS 10 TIMES
   10 ELEM-ITEM1 PIC X.
   10 ELEM-ITEM2 PIC X.
   10 ELEM-ITEM3 PIC X.

PROCEDURE DIVISION.
...
   SORT TABL DESCENDING ELEM-ITEM2 ELEM-ITEM3.
   IF TABL (1)...
```

**Processing table items using intrinsic functions**

You can use intrinsic functions to process alphabetic, alphanumeric, national, or numeric table items. (You can process DBCS data items only with the NATIONAL-OF intrinsic function.) The data descriptions of the table items must be compatible with the requirements for the function arguments.

Use a subscript or index to reference an individual data item as a function argument. For example, assuming that Table-One is a 3 x 3 array of numeric items, you can find the square root of the middle element by using this statement:

```cobol
Compute X = Function Sqrt(Table-One(2,2))
```

You might often need to iteratively process the data in tables. For intrinsic functions that accept multiple arguments, you can use the subscript ALL to reference all the items in the table or in a single dimension of the table. The iteration is handled automatically, which can make your code shorter and simpler.

You can mix scalars and array arguments for functions that accept multiple arguments:

```cobol
Compute Table-Median = Function Median(Arg1 Table-One(ALL))
```

**related references**

SORT statement (Enterprise COBOL for z/OS Language Reference)
“Using the format 2 SORT statement to sort a table” on page 646

**related tasks**

“Using intrinsic functions (built-in functions)” on page 36
Example: processing tables using intrinsic functions

These examples show how you can apply an intrinsic function to some or all of the elements in a table by using the ALL subscript.

Assuming that Table-Two is a 2 x 3 x 2 array, the following statement adds the values in elements Table-Two(1,3,1), Table-Two(1,3,2), Table-Two(2,3,1), and Table-Two(2,3,2):

```
Compute Table-Sum = FUNCTION SUM (Table-Two(ALL, 3, ALL))
```

The following example computes various salary values for all the employees whose salaries are encoded in Employee-Table:

```
01 Employee-Table.
  05 Emp-Count   Pic s9(4) usage binary.
  05 Emp-Record  Occurs 1 to 500 times
depending on Emp-Count.
     10 Emp-Name   Pic x(20).
     10 Emp-Idme   Pic 9(9).
     10 Emp-Salary Pic 9(7)v99.

. . .

Procedure Division.
  Compute Max-Salary    = Function Max(Emp-Salary(ALL))
  Compute I             = Function Ord-Max(Emp-Salary(ALL))
  Compute Avg-Salary    = Function Mean(Emp-Salary(ALL))
  Compute Salary-Range  = Function Range(Emp-Salary(ALL))
  Compute Total-Payroll = Function Sum(Emp-Salary(ALL))
```

Working with unbounded tables and groups

You can process an unbounded group as the input parameter to a called program. The memory for the unbounded group is provided by the calling program. Alternatively, you can define, initialize, and process unbounded groups in a single program.

To work with unbounded tables and groups in a single program, do these steps:

1. In the LINKAGE SECTION, define an unbounded table (with the syntax of OCCURS n TO UNBOUNDED), which will be part of an unbounded group.

2. In the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION, define the OCCURS DEPENDING ON objects.

3. In the PROCEDURE DIVISION, do these steps to process unbounded groups:
   a. Set the OCCURS DEPENDING ON objects.
   b. Use the LENGTH special register or the LENGTH intrinsic function to compute the total size of the group.
   c. Use the CALL statement to call a storage allocation service, such as the Language Environment service CEEGTST. Allocate enough memory for the total length of the group. You will need a pointer to this memory (the CEEGTST service returns a pointer).
   d. Use the SET statement to establish addressability. For example, SET ADDRESS OF group TO pointer.

4. Use the unbounded table and its containing unbounded group according to the following rules:
   - You can reference unbounded tables in COBOL syntax anywhere a table can be referenced.
• You can reference unbounded groups in COBOL syntax anywhere an alphanumeric or national group can be referenced, with the following exceptions:

– You cannot specify unbounded groups as a BY CONTENT argument in a CALL statement.
– You cannot specify unbounded groups as data-name-2 on the PROCEDURE DIVISION RETURNING phrase.
– You cannot specify unbounded groups as arguments to intrinsic functions, except as an argument to the LENGTH intrinsic function.

Example: Using unbounded tables for parsing XML documents

Consider using unbounded tables when parsing an XML document with an unknown number of repetitive elements.

You can use any of the following methods:

• Predetermine the number of elements to expect. One method to determine the number of elements is to parse the XML document twice. During the first parse, count the number of occurrences of each unbounded element in the corresponding OCCURS UNBOUNDED DEPENDING ON object. Then, allocate storage for the data items using these computed values, and parse the XML document a second time to process its payload.

• Pick initial sizes and allow for expansion of the tables. It might be more efficient to set arbitrary limits in the OCCURS UNBOUNDED DEPENDING ON objects based on previous experience, and parse the document directly to process its content. For each unbounded element, check if the current limit is about to be exceeded. If so, allocate more storage for the corresponding array, copy the data from the old array to the expanded array, then free the storage for the old array.

The following examples illustrate the first method. See the XML schema example, and note that elements B and C have a maxOccurs value of unbounded, and thus can occur an unlimited number of times in the sequence within element G. In the XML document example, element B in fact occurs three times, and element C occurs five times.

In the XML processing program example, the processing procedure for the first XML PARSE statement simply computes the number of occurrences of elements B and C. After allocating the required storage, the program executes a second XML PARSE statement to process the XML payload.

XML schema

```xml
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema targetNamespace="http://example.org"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:element name="G">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element name="A" type="xsd:string" maxOccurs="1" />
        <xsd:element name="B" type="xsd:int" maxOccurs="unbounded" />
        <xsd:element name="C" type="xsd:int" maxOccurs="unbounded" />
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>
</xsd:schema>
```

XML document

```xml
<?xml version="1.0" encoding="UTF-8"?>
<p:G xmlns:p="http://example.org" >
```
XML processing program

Identification division.
Program-id. XMLProc.
Data division.
Working-storage section.
01 NB pic S9(9) binary value zero.
01 NC pic S9(9) binary value zero.
01 Gptr pointer.
01 Gsize pic 9(9) binary.
01 Heap0 pic 9(9) binary value zero.
Linkage section.
01 XML-Doc pic X(500000).
01 G.
   02 A pic x(5).
   02 B pic s9(9) occurs 1 to unbounded depending on NB.
   02 C pic s9(9) occurs 1 to unbounded depending on NC.
Procedure division using XML-Doc.
   XML parse XML-Doc processing procedure CountElements
   Move length of G to Gsize
   Call "CEEGTST" using Heap0 Gsize Gptr omitted
   Set address of G to Gptr
   XML parse XML-doc processing procedure acquireContent
   ...
   Goback.
   CountElements.
   If xml-event = 'START-OF-ELEMENT'
      Evaluate xml-text
      When 'B'
         Add 1 to NB
      When 'C'
         Add 1 to NC
      When other
         Continue
      End-evaluate
   End-if.
End program XMLProc.

related tasks
“Working with unbounded tables and groups” on page 86
Chapter 5. Selecting and repeating program actions

Use COBOL control language to choose program actions based on the outcome of logical tests, to iterate over selected parts of your program and data, and to identify statements to be performed as a group.

These controls include the IF, EVALUATE, and PERFORM statements, and the use of switches and flags.

related tasks
“Selecting program actions” on page 89
“Repeating program actions” on page 96

Selecting program actions

You can provide for different program actions depending on the tested value of one or more data items.

The IF and EVALUATE statements in COBOL test one or more data items by means of a conditional expression.

related tasks
“Coding a choice of actions” on page 89
“Coding conditional expressions” on page 93

related references
IF statement (Enterprise COBOL for z/OS Language Reference)
EVALUATE statement (Enterprise COBOL for z/OS Language Reference)

Coding a choice of actions

Use IF . . . ELSE to code a choice between two processing actions. (The word THEN is optional.) Use the EVALUATE statement to code a choice among three or more possible actions.

```cobol
IF condition-p
  statement-1
ELSE
  statement-2
END-IF
```

When one of two processing choices is no action, code the IF statement with or without ELSE. Because the ELSE clause is optional, you can code the IF statement as follows:

```cobol
IF condition-q
  statement-1
END-IF
```

Such coding is suitable for simple cases. For complex logic, you probably need to use the ELSE clause. For example, suppose you have nested IF statements in which there is an action for only one of the processing choices. You could use the ELSE clause and code the null branch of the IF statement with the CONTINUE statement:

```cobol
IF condition-q
  statement-1
ELSE
  CONTINUE
END-IF
```

The EVALUATE statement is an expanded form of the IF statement that allows you to avoid nesting IF statements, a common source of logic errors and debugging problems.
Using nested IF statements

If an IF statement contains an IF statement as one of its possible branches, the IF statements are said to be nested. Theoretically, there is no limit to the depth of nested IF statements.

However, use nested IF statements sparingly. The logic can be difficult to follow, although explicit scope terminators and indentation can help. If a program has to test a variable for more than two values, EVALUATE is probably a better choice.

The following pseudocode depicts a nested IF statement:

```plaintext
IF condition-p
  IF condition-q
    statement-1
  ELSE
    statement-2
  END-IF
ELSE
  statement-3
END-IF
ELSE
  statement-4
END-IF
```

In the pseudocode above, an IF statement and a sequential structure are nested in one branch of the outer IF. In this structure, the END-IF that closes the nested IF is very important. Use END-IF instead of a period, because a period would end the outer IF structure also.

The following figure shows the logic structure of the pseudocode above.

related tasks
“Coding a choice of actions” on page 89

related references
Explicit scope terminators (Enterprise COBOL for z/OS Language Reference)
**Using the EVALUATE statement**

You can use the EVALUATE statement instead of a series of nested IF statements to test several conditions and specify a different action for each. Thus you can use the EVALUATE statement to implement a case structure or decision table.

You can also use the EVALUATE statement to cause multiple conditions to lead to the same processing, as shown in these examples:

- **“Example: EVALUATE using THRU phrase” on page 91**
- **“Example: EVALUATE using multiple WHEN phrases” on page 92**

In an EVALUATE statement, the operands before the WHEN phrase are referred to as selection subjects, and the operands in the WHEN phrase are called the selection objects. Selection subjects can be identifiers, literals, conditional expressions, or the word TRUE or FALSE. Selection objects can be identifiers, literals, conditional or arithmetic expressions, or the word TRUE, FALSE, or ANY.

You can separate multiple selection subjects with the ALSO phrase. You can separate multiple selection objects with the ALSO phrase. The number of selection objects within each set of selection objects must be equal to the number of selection subjects, as shown in this example:

- **“Example: EVALUATE testing several conditions” on page 92**

Identifiers, literals, or arithmetic expressions that appear within a selection object must be valid operands for comparison to the corresponding operand in the set of selection subjects. Conditions or the word TRUE or FALSE that appear in a selection object must correspond to a conditional expression or the word TRUE or FALSE in the set of selection subjects. (You can use the word ANY as a selection object to correspond to any type of selection subject.)

The execution of the EVALUATE statement ends when one of the following conditions occurs:

- The statements associated with the selected WHEN phrase are performed.
- The statements associated with the WHEN OTHER phrase are performed.
- No WHEN conditions are satisfied.

WHEN phrases are tested in the order that they appear in the source program. Therefore, you should order these phrases for the best performance. First code the WHEN phrase that contains selection objects that are most likely to be satisfied, then the next most likely, and so on. An exception is the WHEN OTHER phrase, which must come last.

**related tasks**

- “Coding a choice of actions” on page 89

**related references**


**Example: EVALUATE using THRU phrase**

This example shows how you can code several conditions in a range of values to lead to the same processing action by coding the THRU phrase. Operands in a THRU phrase must be of the same class.

In this example, CARPOOL-SIZE is the selection subject; 1, 2, and 3 THRU 6 are the selection objects:

```
EVALUATE CARPOOL-SIZE
  WHEN 1
    MOVE "SINGLE" TO PRINT-CARPOOL-STATUS
  WHEN 2
    MOVE "COUPLE" TO PRINT-CARPOOL-STATUS
  WHEN 3 THRU 6
    MOVE "SMALL GROUP" TO PRINT-CARPOOL STATUS
  WHEN OTHER
    MOVE "BIG GROUP" TO PRINT-CARPOOL STATUS
END-EVALUATE
```
The following nested IF statements represent the same logic:

```
IF CARPOOL-SIZE = 1 THEN
  MOVE "SINGLE" TO PRINT-CARPOOL-STATUS
ELSE
  IF CARPOOL-SIZE = 2 THEN
    MOVE "COUPLE" TO PRINT-CARPOOL-STATUS
  ELSE
    IF CARPOOL-SIZE >= 3 AND CARPOOL-SIZE <= 6 THEN
      MOVE "SMALL GROUP" TO PRINT-CARPOOL-STATUS
    ELSE
      MOVE "BIG GROUP" TO PRINT-CARPOOL-STATUS
    END-IF
  END-IF
END-IF
END-IF
```

**Example: EVALUATE using multiple WHEN phrases**

The following example shows that you can code multiple WHEN phrases if several conditions should lead to the same action. Doing so gives you more flexibility than using only the THRU phrase, because the conditions do not have to evaluate to values in a range nor have the same class.

```
EVALUATE MARITAL-CODE
  WHEN "M" ADD 2 TO PEOPLE-COUNT
  WHEN "S"
  WHEN "D"
  WHEN "W" ADD 1 TO PEOPLE-COUNT
END-EVALUATE
```

The following nested IF statements represent the same logic:

```
IF MARITAL-CODE = "M" THEN
  ADD 2 TO PEOPLE-COUNT
ELSE
  IF MARITAL-CODE = "S" OR MARITAL-CODE = "D" OR MARITAL-CODE = "W" THEN
    ADD 1 TO PEOPLE-COUNT
  END-IF
END-IF
```

**Example: EVALUATE testing several conditions**

This example shows the use of the ALSO phrase to separate two selection subjects (True ALSO True) and to separate the two corresponding selection objects within each set of selection objects (for example, When A + B < 10 Also C = 10).

Both selection objects in a WHEN phrase must satisfy the TRUE, TRUE condition before the associated action is performed. If both objects do not evaluate to TRUE, the next WHEN phrase is processed.
Coding conditional expressions

Using the IF and EVALUATE statements, you can code program actions that will be performed depending on the truth value of a conditional expression.

You can specify the following conditions:

- **Relation conditions**, such as:
  - Numeric comparisons
  - Alphanumeric comparisons
  - DBCS comparisons
  - National comparisons
- **Class conditions**; for example, to test whether a data item:
  - IS NUMERIC
  - IS ALPHABETIC
  - IS DBCS
  - IS KANJI
  - IS NOT KANJI
- **Condition-name conditions**, to test the value of a conditional variable that you define
- **Sign conditions**, to test whether a numeric operand IS POSITIVE, NEGATIVE, or ZERO
- **Switch-status conditions**, to test the status of UPSI switches that you name in the SPECIAL-NAMES paragraph
- **Complex conditions**, such as:
  - Negated conditions; for example, NOT (A IS EQUAL TO B)
  - Combined conditions (conditions combined with logical operators AND or OR)

**related concepts**
“Switches and flags” on page 94

**related tasks**
“Defining switches and flags” on page 94
“Resetting switches and flags” on page 95
“Checking for incompatible data (numeric class test)” on page 52
“Comparing national (UTF-16) data” on page 140
Switches and flags

Some program decisions are based on whether the value of a data item is true or false, on or off, yes or no. Control these two-way decisions by using level-88 items with meaningful names (condition-names) to act as switches.

Other program decisions depend on the particular value or range of values of a data item. When you use condition-names to give more than just on or off values to a field, the field is generally referred to as a flag.

Flags and switches make your code easier to change. If you need to change the values for a condition, you have to change only the value of that level-88 condition-name.

For example, suppose a program uses a condition-name to test a field for a given salary range. If the program must be changed to check for a different salary range, you need to change only the value of the condition-name in the DATA DIVISION. You do not need to make changes in the PROCEDURE DIVISION.

Defining switches and flags

In the DATA DIVISION, define level-88 items that will act as switches or flags, and give them meaningful names.

To test for more than two values with flags, assign more than one condition-name to a field by using multiple level-88 items.

The reader can easily follow your code if you choose meaningful condition-names and if the values assigned to them have some association with logical values.

Example: switches

The following examples show how you can use level-88 items to test for various binary-valued (on-off) conditions in your program.

For example, to test for the end-of-file condition for an input file named Transaction-File, you can use the following data definitions:

```
WORKING-STORAGE SECTION.
  01 Switches.
    05 Transaction-EOF-Switch Pic X value space.
    88 Transaction-EOF value "y".
```

The level-88 description says that a condition named Transaction-EOF is in effect when Transaction-EOF-Switch has value 'y'. Referencing Transaction-EOF in the PROCEDURE DIVISION expresses the same condition as testing Transaction-EOF-Switch = "y". For example,
the following statement causes a report to be printed only if Transaction-EOF-Switch has been set to 'y':

```plaintext
If Transaction-EOF Then
   Perform Print-Report-Summary-Lines
End-if
```

**Example: flags**
The following examples show how you can use several level-88 items together with an EVALUATE statement to determine which of several conditions in a program is true.

Consider for example a program that updates a master file. The updates are read from a transaction file. The records in the file contain a field that indicates which of the three functions is to be performed: add, change, or delete. In the record description of the input file, code a field for the function code using level-88 items:

```plaintext
01  Transaction-Input Record
   05  Transaction-Type         Pic X.
       88  Add-Transaction      Value "A".
       88  Change-Transaction   Value "C".
       88  Delete-Transaction   Value "D".
```

The code in the PROCEDURE DIVISION for testing these condition-names to determine which function is to be performed might look like this:

```plaintext
Evaluate True
   When Add-Transaction
      Perform Add-Master-Record-Paragraph
   When Change-Transaction
      Perform Update-Existing-Record-Paragraph
   When Delete-Transaction
      Perform Delete-Master-Record-Paragraph
End-Evaluate
```

**Resetting switches and flags**
Throughout your program, you might need to reset switches or flags to the original values they had in their data descriptions. To do so, either use a SET statement or define a data item to move to the switch or flag.

When you use the SET condition-name TO TRUE statement, the switch or flag is set to the original value that it was assigned in its data description. For a level-88 item that has multiple values, SET condition-name TO TRUE assigns the first value (A in the example below):

```plaintext
88 Record-is-Active Value "A" "O" "S"
```

Using the SET statement and meaningful condition-names makes it easier for readers to follow your code.

“Example: set switch on” on page 95
“Example: set switch off” on page 96

**Example: set switch on**
The following examples show how you can set a switch on by coding a SET statement that moves the condition name value to the conditional variable.

For example, the SET statement in the following example has the same effect as coding the statement Move "y" to Transaction-EOF-Switch:

```plaintext
01  Switches
   05  Transaction-EOF-Switch   Pic X  Value space.
      88  Transaction-EOF      Value "y".
```

Chapter 5. Selecting and repeating program actions 95
The following example shows how to assign a value to a field in an output record based on the transaction code of an input record:

```
01 Input-Record.
   05 Transaction-Type Pic X(9).
01 Data-Record-Out.
   05 Data-Record-Type Pic X.
      88 Record-Is-Active Value "A".
      88 Record-Is-Suspended Value "S".
      88 Record-Is-Deleted Value "D".
   05 Key-Field Pic X(5).

Procedure Division.
   Evaluate Transaction-Type of Input-Record
      When "ACTIVE"
         Set Record-Is-Active to TRUE
      When "SUSPENDED"
         Set Record-Is-Suspended to TRUE
      When "DELETED"
         Set Record-Is-Deleted to TRUE
   End-Evaluate
```

Example: set switch off
The following example shows how you can set a switch off by coding a MOVE statement that moves the condition name value to the conditional variable.

For example, you can use a data item called SWITCH-OFF to set an on-off switch to off, as in the following code, which resets a switch to indicate that end-of-file has not been reached:

```
01 Switches.
   05 Transaction-EOF-Switch Pic X Value space.
      88 Transaction-EOF Value "y".
   01 SWITCH-OFF Pic X Value "n".

Procedure Division.
   Move SWITCH-OFF to Transaction-EOF-Switch
```

Repeating program actions
Use a PERFORM statement to repeat the same code (that is, loop) either a specified number of times or based on the outcome of a decision.

You can also use a PERFORM statement to execute a paragraph and then implicitly return control to the next executable statement. In effect, this PERFORM statement is a way of coding a closed subroutine that you can enter from many different parts of the program.

PERFORM statements can be inline or out-of-line.

related tasks
“Choosing inline or out-of-line PERFORM” on page 97
“Coding a loop” on page 97
“Looping through a table” on page 98
“Executing multiple paragraphs or sections” on page 99

related references
PERFORM statement (Enterprise COBOL for z/OS Language Reference)
Choosing inline or out-of-line PERFORM

An inline PERFORM is an imperative statement that is executed in the normal flow of a program; an out-of-line PERFORM entails a branch to a named paragraph and an implicit return from that paragraph.

To determine whether to code an inline or out-of-line PERFORM statement, answer the following questions:

• Is the PERFORM statement used in several places?
  Use an out-of-line PERFORM when you want to use the same portion of code in several places in your program.

• Which placement of the statement will be easier to read?
  If the code to be performed is short, an inline PERFORM can be easier to read. But if the code extends over several screens, the logical flow of the program might be clearer if you use an out-of-line PERFORM. (Each paragraph in structured programming should perform one logical function, however.)

• What are the efficiency tradeoffs?
  An inline PERFORM avoids the overhead of branching that occurs with an out-of-line PERFORM. But even out-of-line PERFORM coding can improve code optimization, so efficiency gains should not be overemphasized.

In the 1974 COBOL standard, the PERFORM statement is out-of-line and thus requires a branch to a separate paragraph and an implicit return. If the performed paragraph is in the subsequent sequential flow of your program, it is also executed in that logic flow. To avoid this additional execution, place the paragraph outside the normal sequential flow (for example, after the GOBACK) or code a branch around it.

The subject of an inline PERFORM is an imperative statement. Therefore, you must code statements (other than imperative statements) within an inline PERFORM with explicit scope terminators.

“Example: inline PERFORM statement” on page 97

Example: inline PERFORM statement

This example shows the structure of an inline PERFORM statement that has the required scope terminators and the required END-PERFORM phrase.

```
Perform 100-Initialize-Paragraph
* The following statement is an inline PERFORM:
  Perform Until Transaction-EOF
  Read Update-Transaction-File Into WS-Transaction-Record
  At End
  Set Transaction-EOF To True
  Not At End
  Perform 200-Edit-Update-Transaction
  If No-Errors
    Perform 300-Update-Commuter-Record
  Else
    Perform 400-Print-Transaction-Errors
  * End-If is a required scope terminator
End-If
Perform 410-Re-Initialize-Fields
* End-Read is a required scope terminator
End-Read
End-Perform
```

Coding a loop

Use the PERFORM . . . TIMES statement to execute a paragraph a specified number of times.

```
PERFORM 010-PROCESS-ONE-MONTH 12 TIMES
INSPECT . . .
```

In the example above, when control reaches the PERFORM statement, the code for the paragraph 010-PROCESS-ONE-MONTH is executed 12 times before control is transferred to the INSPECT statement.
Use the `PERFORM . . . UNTIL` statement to execute a paragraph until a condition you choose is satisfied. You can use either of the following forms:

```
PERFORM . . . WITH TEST AFTER . . . UNTIL . . .
PERFORM . . . [WITH TEST BEFORE] . . . UNTIL . . .
```

Use the `PERFORM . . . WITH TEST AFTER . . . UNTIL` statement if you want to execute the paragraph at least once, and test before any subsequent execution. This statement is equivalent to a do-unti

structure:

```
Do one iteration of PERFORM
```

In the following example, the implicit `WITH TEST BEFORE` phrase provides a do-while structure:

```
PERFORM 010-PROCESS-ONE-MONTH
UNTIL MONTH GREATER THAN 12
INSPECT . . .
```

When control reaches the `PERFORM` statement, the condition `MONTH GREATER THAN 12` is tested. If the condition is satisfied, control is transferred to the `INSPECT` statement. If the condition is not satisfied, `010-PROCESS-ONE-MONTH` is executed, and the condition is tested again. This cycle continues until the condition tests as true. (To make your program easier to read, you might want to code the `WITH TEST BEFORE` clause.)

```
Do one iteration of PERFORM
```

**Looping through a table**

You can use the `PERFORM . . . VARYING` statement to initialize a table. In this form of the `PERFORM` statement, a variable is increased or decreased and tested until a condition is satisfied.

Thus you use the `PERFORM` statement to control looping through a table. You can use either of these forms:

```
PERFORM . . . WITH TEST AFTER . . . VARYING . . . UNTIL . . .
PERFORM . . . [WITH TEST BEFORE] . . . VARYING . . . UNTIL . . .
```

The following section of code shows an example of looping through a table to check for invalid data:

```
PERFORM TEST AFTER VARYING WS-DATA-IX
   FROM 1 BY 1 UNTIL WS-DATA-IX = 12
   IF WS-DATA (WS-DATA-IX) EQUALS SPACES
      SET SERIOUS-ERROR TO TRUE
      DISPLAY ELEMENT-NUM-MSG5
   END-IF
END-PERFORM
INSPECT . . .
```

When control reaches the `PERFORM` statement above, `WS-DATA-IX` is set equal to 1 and the `PERFORM` statement is executed. Then the condition `WS-DATA-IX = 12` is tested. If the condition is true, control drops through to the `INSPECT` statement. If the condition is false, `WS-DATA-IX` is increased by 1, the
PERFORM statement is executed, and the condition is tested again. This cycle of execution and testing continues until WS-DATA-IX is equal to 12.

The loop above controls input-checking for the 12 fields of item WS-DATA. Empty fields are not allowed in the application, so the section of code loops and issues error messages as appropriate.

**Executing multiple paragraphs or sections**

In structured programming, you usually execute a single paragraph. However, you can execute a group of paragraphs, or a single section or group of sections, by coding the `PERFORM . . . THRU` statement.

When you use the `PERFORM . . . THRU` statement, code a paragraph-EXIT statement to clearly indicate the end point of a series of paragraphs.

**related tasks**

“Processing table items using intrinsic functions” on page 85
Chapter 6. Handling strings

COBOL provides language constructs for performing many different operations on string data items. For example, you can:

- Join or split data items.
- Manipulate null-terminated strings, such as count or move characters.
- Refer to substrings by their ordinal position and, if needed, length.
- Tally and replace data items, such as count the number of times a specific character occurs in a data item.
- Convert data items, such as change to uppercase or lowercase.
- Evaluate data items, such as determine the length of a data item.

related tasks
“Joining data items (STRING)” on page 101
“Splitting data items (UNSTRING)” on page 103
“Manipulating null-terminated strings” on page 106
“Referring to substrings of data items” on page 107
“Tallying and replacing data items (INSPECT)” on page 110
“Converting data items (intrinsic functions)” on page 112
“Evaluating data items (intrinsic functions)” on page 114
Chapter 7, “Processing data in an international environment,” on page 119

Joining data items (STRING)

Use the STRING statement to join all or parts of several data items or literals into one data item. One STRING statement can take the place of several MOVE statements.

The STRING statement transfers data into a receiving data item in the order that you indicate. In the STRING statement you also specify:

- A delimiter for each set of sending fields that, if encountered, causes those sending fields to stop being transferred (DELIMITED BY phrase)
- (Optional) Action to be taken if the receiving field is filled before all of the sending data has been processed (ON OVERFLOW phrase)
- (Optional) An integer data item that indicates the leftmost character position within the receiving field into which data should be transferred (WITH POINTER phrase)

The receiving data item must not be an edited item, or a display or national floating-point item. If the receiving data item has:

- USAGE DISPLAY, each identifier in the statement except the POINTER identifier must have USAGE DISPLAY, and each literal in the statement must be alphanumeric
- USAGE NATIONAL, each identifier in the statement except the POINTER identifier must have USAGE NATIONAL, and each literal in the statement must be national
- USAGE DISPLAY-1, each identifier in the statement except the POINTER identifier must have USAGE DISPLAY-1, and each literal in the statement must be DBCS

Only that portion of the receiving field into which data is written by the STRING statement is changed.
Example: STRING statement

The following example shows the STRING statement selecting and formatting information from a record into an output line.

The FILE SECTION defines the following record:

```
01 RCD-01.
   05 CUST-INFO.
      10 CUST-NAME PIC X(15).
      10 CUST-ADDR PIC X(35).
   05 BILL-INFO.
      10 INV-NO PIC X(6).
      10 INV-AMT PIC $$,$$$.99.
      10 AMT-PAID PIC $$,$$$.99.
      10 DATE-PAID PIC X(8).
      10 BAL-DUE PIC $$,$$$.99.
      10 DATE-DUE PIC X(8).
```

The WORKING-STORAGE SECTION defines the following fields:

```
77 RPT-LINE PIC X(120).
77 LINE-POS PIC 9(5) VALUE 1.
77 DEC-POINT PIC X VALUE ".".
```

The record RCD-01 contains the following information (the symbol b indicates a blank space):

```
J.B. bSMITH bbbbb
444 bSPRING bbbbb, bCHICAGO, bBILL bbbbb
A14275
$4,736.85
$2,480.00
09/22/76
$2,336.85
10/22/76
```

In the PROCEDURE DIVISION, these settings occur before the STRING statement:

- RPT-LINE is set to SPACES.
- LINE-POS, the data item to be used as the POINTER field, is set to 4.

Here is the STRING statement:

```
STRING LINE-NO SPACE CUST-INFO INV-NO SPACE DATE-DUE SPACE
      DELIMITED BY SIZE
      BAL-DUE
      DELIMITED BY DEC-POINT
      INTO RPT-LINE
      WITH POINTER LINE-POS.
```

Because the POINTER field LINE-POS has value 4 before the STRING statement is performed, data is moved into the receiving field RPT-LINE beginning at character position 4. Characters in positions 1 through 3 are unchanged.
The sending items that specify **DELIMITED BY SIZE** are moved in their entirety to the receiving field. Because **BAL-DUE** is delimited by **DEC-POINT**, the moving of **BAL-DUE** to the receiving field stops when a decimal point (the value of **DEC-POINT**) is encountered.

**STRING results**

When the STRING statement is performed, items are moved into **RPT-LINE** as shown in the table below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINE-NO</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Space</td>
<td>9</td>
</tr>
<tr>
<td>CUST-INFO</td>
<td>10 - 59</td>
</tr>
<tr>
<td>INV-NO</td>
<td>60 - 65</td>
</tr>
<tr>
<td>Space</td>
<td>66</td>
</tr>
<tr>
<td>DATE-DUE</td>
<td>67 - 74</td>
</tr>
<tr>
<td>Space</td>
<td>75</td>
</tr>
<tr>
<td>Portion of <strong>BAL-DUE</strong> that precedes the decimal point</td>
<td>76 - 81</td>
</tr>
</tbody>
</table>

After the STRING statement is performed, the value of **LINE-POS** is 82, and **RPT-LINE** has the values shown below.

<table>
<thead>
<tr>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>444 SPRING ST., CHICAGO, ILL.</td>
</tr>
<tr>
<td>A14275  10/22/76  $2,336</td>
</tr>
</tbody>
</table>

**Splitting data items (UNSTRING)**

Use the UNSTRING statement to split a sending field into several receiving fields. One UNSTRING statement can take the place of several MOVE statements.

In the UNSTRING statement you can specify:

- Delimiters that, when one of them is encountered in the sending field, cause the current receiving field to stop receiving and the next, if any, to begin receiving (**DELIMITED BY** phrase)
- A field for the delimiter that, when encountered in the sending field, causes the current receiving field to stop receiving (**DELIMITER IN** phrase)
- An integer data item that stores the number of characters placed in the current receiving field (**COUNT IN** phrase)
- An integer data item that indicates the leftmost character position within the sending field at which UNSTRING processing should begin (**WITH POINTER** phrase)
- An integer data item that stores a tally of the number of receiving fields that are acted on (**TALLYING IN** phrase)
- Action to be taken if all of the receiving fields are filled before the end of the sending data item is reached (**ON OVERFLOW** phrase)

The sending data item and the delimiters in the **DELIMITED BY** phrase must be of category alphabetic, alphanumeric, alphanumeric-edited, DBCS, national, or national-edited.

Receiving data items can be of category alphabetic, alphanumeric, numeric, DBCS, or national. If numeric, a receiving data item must be zoned decimal or national decimal. If a receiving data item has:
• USAGE DISPLAY, the sending item and each delimiter item in the statement must have USAGE DISPLAY, and each literal in the statement must be alphanumeric.

• USAGE NATIONAL, the sending item and each delimiter item in the statement must have USAGE NATIONAL, and each literal in the statement must be national.

• USAGE DISPLAY-1, the sending item and each delimiter item in the statement must have USAGE DISPLAY-1, and each literal in the statement must be DBCS.

“Example: UNSTRING statement” on page 104

related concepts
“Unicode and the encoding of language characters” on page 123

related tasks
“Handling errors in joining and splitting strings” on page 224

related references
UNSTRING statement (Enterprise COBOL for z/OS Language Reference)
Classes and categories of data (Enterprise COBOL for z/OS Language Reference)

Example: UNSTRING statement

The following example shows the UNSTRING statement transferring selected information from an input record. Some information is organized for printing and some for further processing.

The FILE SECTION defines the following records:

```
* Record to be acted on by the UNSTRING statement:
01 INV-RCD.
   05 CONTROL-CHARS   PIC XX.
   05 ITEM-INDENT     PIC X(20).
   05 FILLER          PIC X.
   05 INV-CODE        PIC X(10).
   05 FILLER          PIC X.
   05 NO-UNITS        PIC 9(6).
   05 FILLER          PIC X.
   05 PRICE-PER-M     PIC 99999.
   05 FILLER          PIC X.
   05 RTL-AMT         PIC 9(6).99.

* UNSTRING receiving field for printed output:
01 DISPLAY-REC.
   05 INV-NO          PIC X(6).
   05 FILLER          PIC X VALUE SPACE.
   05 ITEM-NAME       PIC X(20).
   05 FILLER          PIC X VALUE SPACE.
   05 DISPLAY-DOLS    PIC 9(6).

* UNSTRING receiving field for further processing:
01 WORK-REC.
   05 M-UNITS         PIC 9(6).
   05 FIELD-A         PIC 9(6).
   05 WK-PRICE REDEFINES FIELD-A PIC 99999V99.
   05 INV-CLASS       PIC X(3).

* UNSTRING statement control fields:
  77 DBY-1           PIC X.
  77 CTR-1           PIC S9(3).
  77 CTR-2           PIC S9(3).
  77 CTR-3           PIC S9(3).
  77 CTR-4           PIC S9(3).
  77 DLTR-1          PIC X.
  77 DLTR-2          PIC X.
  77 CHAR-CT         PIC S9(3).
  77 FLDS-FILLED     PIC S9(3).
```

In the PROCEDURE DIVISION, these settings occur before the UNSTRING statement:

• A period (.) is placed in DBY-1 for use as a delimiter.
• CHAR-CT (the POINTER field) is set to 3.
• The value zero (0) is placed in FLDS-FILLED (the TALLYING field).
• Data is read into record INV-RCD, whose format is as shown below.

Here is the UNSTRING statement:

```
* Move subfields of INV-RCD to the subfields of DISPLAY-REC
* and WORK-REC:
UNSTRING INV-RCD
   DELIMITED BY ALL SPACES OR "/" OR DBY-1
   INTO ITEM-NAME    COUNT IN CTR-1
   INV-NO       DELIMITER IN DLTR-1  COUNT IN CTR-2
   INV-CLASS
   M-UNITS      COUNT IN CTR-3
   FIELD-A
   DISPLAY-DOLS DELIMITER IN DLTR-2  COUNT IN CTR-4
   WITH POINTER CHAR-CT
   TALLYING IN  FLDS-FILLED
   ON OVERFLOW  GO TO UNSTRING-COMPLETE.
```

Because the POINTER field CHAR-CT has value 3 before the UNSTRING statement is performed, the two character positions of the CONTROL-CHARS field in INV-RCD are ignored.

**UNSTRING results**

When the UNSTRING statement is performed, the following steps take place:

1. Positions 3 through 18 (FOUR-PENNY-NAILS) of INV-RCD are placed in ITEM-NAME, left justified in the area, and the four unused character positions are padded with spaces. The value 16 is placed in CTR-1.

2. Because ALL SPACES is coded as a delimiter, the five contiguous space characters in positions 19 through 23 are considered to be one occurrence of the delimiter.

3. Positions 24 through 29 (707890) are placed in INV-NO. The delimiter character slash (/) is placed in DLTR-1, and the value 6 is placed in CTR-2.

4. Positions 31 through 33 (BBA) are placed in INV-CLASS. The delimiter is SPACE, but because no field has been defined as a receiving area for delimiters, the space in position 34 is bypassed.

5. Positions 35 through 40 (475120) are placed in M-UNITS. The value 6 is placed in CTR-3. The delimiter is SPACE, but because no field has been defined as a receiving area for delimiters, the space in position 41 is bypassed.

6. Positions 42 through 46 (00122) are placed in FIELD-A and right justified in the area. The high-order digit position is filled with a zero (0). The delimiter is SPACE, but because no field was defined as a receiving area for delimiters, the space in position 47 is bypassed.

7. Positions 48 through 53 (000379) are placed in DISPLAY-DOLS. The period (.) delimiter in DBY-1 is placed in DLTR-2, and the value 6 is placed in CTR-4.

8. Because all receiving fields have been acted on and two characters in INV-RCD have not been examined, the ON OVERFLOW statement is executed. Execution of the UNSTRING statement is completed.

After the UNSTRING statement is performed, the fields contain the values shown below.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISPLAY-REC</td>
<td>707890 FOUR-PENNY-NAILS 000379</td>
</tr>
<tr>
<td>WORK-REC</td>
<td>475120000122BBA</td>
</tr>
</tbody>
</table>
Manipulating null-terminated strings

You can construct and manipulate null-terminated strings (for example, strings that are passed to or from a C program) by various mechanisms.

For example, you can:

- Use null-terminated literal constants (Z". . . ").
- Use an INSPECT statement to count the number of characters in a null-terminated string:

```cobol
MOVE 0 TO char-count
INSPECT source-field TALLYING char-count
FOR CHARACTERS BEFORE X'00'
```

- Use an UNSTRING statement to move characters in a null-terminated string to a target field, and get the character count:

```cobol
WORKING-STORAGE SECTION.
01 source-field PIC X(1001).
01 char-count  COMP-5 PIC 9(4).
01 target-area.
   02 individual-char OCCURS 1 TO 1000 TIMES DEPENDING ON char-count PIC X.

PROCEDURE DIVISION.
UNSTRING source-field DELIMITED BY X"00"
INTO target-area
COUNT IN char-count
ON OVERFLOW
   DISPLAY "source not null terminated or target too short"
END-UNSTRING
```

- Use a SEARCH statement to locate trailing null or space characters. Define the string being examined as a table of single characters.
- Check each character in a field in a loop (PERFORM). You can examine each character in a field by using a reference modifier such as source-field (I:1).

“Example: null-terminated strings” on page 106

related tasks
“Handling null-terminated strings” on page 467

related references
Alphanumeric literals (Enterprise COBOL for z/OS Language Reference)

Example: null-terminated strings

The following example shows several ways in which you can process null-terminated strings.

```cobol
01 L pic X(20) value z'ab'.
01 M pic X(20) value z'cd'.
01 N pic X(20).
01 N-Length pic 9(4) value zero.
01 Y pic X(13) value 'Hello, World!'.

* Display null-terminated string:
   Inspect N tallying N-length
```
for characters before initial x'00'
Display 'N: ' N(1:N-Length) ' Length: ' N-Length

* Move null-terminated string to alphanumeric, strip null:
  Unstring N delimited by X'00' into X

* Create null-terminated string:
  String Y delimited by size
    X'00' delimited by size
    into N.

* Concatenate two null-terminated strings to produce another:
  String L delimited by x'00'
    M delimited by x'00'
    X'00' delimited by size
    into N.

---

**Referring to substrings of data items**

Refer to a substring of a data item that has USAGE DISPLAY, DISPLAY-1, or NATIONAL by using a reference modifier. You can also refer to a substring of an alphanumeric or national character string that is returned by an intrinsic function by using a reference modifier.

**Note:** To get a substring of a character string argument that is encoded in UTF-8, use the USUBSTR function as described in “Using intrinsic functions to process UTF-8 encoded data” on page 135.

The following example shows how to use a reference modifier to refer to a twenty-character substring of a data item called Customer-Record:

```plaintext
Move Customer-Record(1:20) to Orig-Customer-Name
```

You code a reference modifier in parentheses immediately after the data item. As the example shows, a reference modifier can contain two values that are separated by a colon, in this order:

1. Ordinal position (from the left) of the character that you want the substring to start with
2. (Optional) Length of the required substring in **character positions**

The reference-modifier position and length for an item that has USAGE DISPLAY are expressed in terms of single-byte characters. The reference-modifier position and length for items that have USAGE DISPLAY-1 or NATIONAL are expressed in terms of DBCS character positions and national character positions, respectively.

If you omit the length in a reference modifier (coding only the ordinal position of the first character, followed by a colon), the substring extends to the end of the item. Omit the length where possible as a simpler and less error-prone coding technique.

You can refer to substrings of USAGE DISPLAY data items, including alphanumeric groups, alphanumeric-edited data items, numeric-edited data items, display floating-point data items, and zoned decimal data items, by using reference modifiers. When you reference-modify any of these data items, the result is of category alphanumeric. When you reference-modify an alphabetic data item, the result is of category alphabetic.

You can refer to substrings of USAGE NATIONAL data items, including national groups, national-edited data items, numeric-edited data items, national floating-point data items, and national decimal data items, by using reference modifiers. When you reference-modify any of these data items, the result is of category national. For example, suppose that you define a national decimal data item as follows:

```plaintext
01 NATL-DEC-ITEM Usage National Pic 999 Value 123.
```

You can use NATL-DEC-ITEM in an arithmetic expression because NATL-DEC-ITEM is of category numeric. But you cannot use NATL-DEC-ITEM(2:1) (the national character 2, which in hexadecimal notation is NX"0032") in an arithmetic expression, because it is of category national.
You can refer to substrings of table entries, including variable-length entries, by using reference modifiers. To refer to a substring of a table entry, code the subscript expression before the reference modifier. For example, assume that PRODUCT-TABLE is a properly coded table of character strings. To move D to the fourth character in the second string in the table, you can code this statement:

```
MOVE 'D' to PRODUCT-TABLE (2), (4:1)
```

You can code either or both of the two values in a reference modifier as a variable or as an arithmetic expression.

“Example: arithmetic expressions as reference modifiers” on page 109

Because numeric function identifiers can be used anywhere that arithmetic expressions can be used, you can code a numeric function identifier in a reference modifier as the leftmost character position or as the length, or both.

“Example: intrinsic functions as reference modifiers” on page 110

Each number in the reference modifier must have a value of at least 1. The sum of the two numbers must not exceed the total length of the data item by more than 1 character position so that you do not reference beyond the end of the substring.

If the leftmost character position or the length value is a fixed-point noninteger, truncation occurs to create an integer. If either is a floating-point noninteger, rounding occurs to create an integer.

The SSRANGE compiler option detects out-of-range reference modifiers, and flags violations with a runtime message.

related concepts
“Reference modifiers” on page 108
“Unicode and the encoding of language characters” on page 123

related tasks
“Referring to an item in a table” on page 68

related references
“SSRANGE” on page 339
Reference modification (Enterprise COBOL for z/OS Language Reference)
Function definitions (Enterprise COBOL for z/OS Language Reference)

Reference modifiers

Reference modifiers let you easily refer to a substring of a data item.

For example, assume that you want to retrieve the current time from the system and display its value in an expanded format. You can retrieve the current time with the ACCEPT statement, which returns the hours, minutes, seconds, and hundredths of seconds in this format:

```
HHMMSSss
```

However, you might prefer to view the current time in this format:

```
HH:MM:SS
```

Without reference modifiers, you would have to define data items for both formats. You would also have to write code to convert from one format to the other.
With reference modifiers, you do not need to provide names for the subfields that describe the TIME elements. The only data definition you need is for the time as returned by the system. For example:

```
01 REFMOD-TIME-ITEM PIC X(8).
```

The following code retrieves and expands the time value:

```
ACCEPT REFMOD-TIME-ITEM FROM TIME.
   DISPLAY "CURRENT TIME IS: "
   * Retrieve the portion of the time value that corresponds to
   *   the number of hours:
     REFMOD-TIME-ITEM (1:2)
   * Retrieve the portion of the time value that corresponds to
   *   the number of minutes:
     REFMOD-TIME-ITEM (3:2)
   * Retrieve the portion of the time value that corresponds to
   *   the number of seconds:
     REFMOD-TIME-ITEM (5:2)
```

"Example: arithmetic expressions as reference modifiers” on page 109
"Example: intrinsic functions as reference modifiers” on page 110

related tasks
“Assigning input from a screen or file (ACCEPT)” on page 33
“Referring to substrings of data items” on page 107
"Using national data (Unicode) in COBOL” on page 124

related references
Reference modification (Enterprise COBOL for z/OS Language Reference)

Example: arithmetic expressions as reference modifiers
Suppose that a field contains some right-justified characters, and you want to move those characters to another field where they will be left justified. You can do so by using reference modifiers and an INSPECT statement.

Suppose a program has the following data:

```
01 LEFTY PIC X(30).
01 RIGHTY PIC X(30) JUSTIFIED RIGHT.
01 I PIC 9(9) USAGE BINARY.
```

The program counts the number of leading spaces and, using arithmetic expressions in a reference modifier, moves the right-justified characters into another field, justified to the left:

```
MOVE SPACES TO LEFTY
MOVE ZERO TO I
INSPECT RIGHTY
   TALLYING I FOR LEADING SPACE.
   IF I IS LESS THAN LENGTH OF RIGHTY THEN
      MOVE RIGHTY (I + 1 : LENGTH OF RIGHTY - I) TO LEFTY
   END-IF
```

The MOVE statement transfers characters from RIGHTY, beginning at the position computed as I + 1 for a length that is computed as LENGTH OF RIGHTY - I, into the field LEFTY.
Example: intrinsic functions as reference modifiers

You can use intrinsic functions in reference modifiers if you do not know the leftmost position or length of a substring at compile time.

For example, the following code fragment causes a substring of Customer-Record to be moved into the data item WS-name. The substring is determined at run time.

```
05 WS-name Pic x(20).
05 Left-posn Pic 99.
05 I Pic 99.
.. .
Move Customer-Record(Function Min(Left-posn I):Function Length(WS-name)) to WS-name
```

If you want to use a noninteger function in a position that requires an integer function, you can use the INTEGER or INTEGER-PART function to convert the result to an integer. For example:

```
Move Customer-Record(Function Integer(Function Sqrt(I)): ) to WS-name
```

related references

INTEGER (Enterprise COBOL for z/OS Language Reference)
INTEGER-PART (Enterprise COBOL for z/OS Language Reference)

Tallying and replacing data items (INSPECT)

Use the INSPECT statement to inspect characters or groups of characters in a data item and to optionally replace them.

Use the INSPECT statement to do the following tasks:

- Count the number of times a specific character occurs in a data item (TALLYING phrase).
- Fill a data item or selected portions of a data item with specified characters such as spaces, asterisks, or zeros (REPLACING phrase).
- Convert all occurrences of a specific character or string of characters in a data item to replacement characters that you specify (CONVERTING phrase).

You can specify one of the following data items as the item to be inspected:

- An elementary item described explicitly or implicitly as USAGE DISPLAY, USAGE DISPLAY-1, or USAGE NATIONAL
- An alphanumeric group item or national group item

If the inspected item has:

- USAGE DISPLAY, each identifier in the statement (except the TALLYING count field) must have USAGE DISPLAY, and each literal in the statement must be alphanumeric
- USAGE NATIONAL, each identifier in the statement (except the TALLYING count field) must have USAGE NATIONAL, and each literal in the statement must be national
- USAGE DISPLAY-1, each identifier in the statement (except the TALLYING count field) must have USAGE DISPLAY-1, and each literal in the statement must be a DBCS literal

“Examples: INSPECT statement” on page 111

related concepts

“Unicode and the encoding of language characters” on page 123

related references

INSPECT statement (Enterprise COBOL for z/OS Language Reference)
Examples: INSPECT statement

The following examples show some uses of the INSPECT statement to examine and replace characters.

In the following example, the INSPECT statement examines and replaces characters in data item DATA-2. The number of times a leading zero (0) occurs in the data item is accumulated in COUNTR. The first instance of the character A that follows the first instance of the character C is replaced by the character 2.

```plaintext
77 COUNTR PIC 9 VALUE ZERO.
01 DATA-2 PIC X(11).
  .  .  .  INSPECT DATA-2
     TALLYING COUNTR FOR LEADING "0"
     REPLACING FIRST "A" BY "2" AFTER INITIAL "C"
```

<table>
<thead>
<tr>
<th>DATA-2 before</th>
<th>COUNTR after</th>
<th>DATA-2 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>00ACADEMY00</td>
<td>2</td>
<td>00AC2DEMY00</td>
</tr>
<tr>
<td>0000ALABAMA</td>
<td>4</td>
<td>0000ALABAMA</td>
</tr>
<tr>
<td>CHATHAM0000</td>
<td>0</td>
<td>CH2THAM0000</td>
</tr>
</tbody>
</table>

In the following example, the INSPECT statement examines and replaces characters in data item DATA-3. Each character that precedes the first instance of a quotation mark (" ) is replaced by the character 0.

```plaintext
77 COUNTR PIC 9 VALUE ZERO.
01 DATA-3 PIC X(8).
  .  .  .  INSPECT DATA-3
     REPLACING CHARACTERS BY ZEROS BEFORE INITIAL QUOTE
```

<table>
<thead>
<tr>
<th>DATA-3 before</th>
<th>COUNTR after</th>
<th>DATA-3 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>456&quot;ABEL</td>
<td>0</td>
<td>000&quot;ABEL</td>
</tr>
<tr>
<td>ANDES&quot;12</td>
<td>0</td>
<td>00000&quot;12</td>
</tr>
<tr>
<td>&quot;TWAS BR</td>
<td>0</td>
<td>&quot;TWAS BR</td>
</tr>
</tbody>
</table>

The following example shows the use of INSPECT CONVERTING with AFTER and BEFORE phrases to examine and replace characters in data item DATA-4. All characters that follow the first instance of the character / but that precede the first instance of the character ? (if any) are translated from lowercase to uppercase.

```plaintext
01 DATA-4 PIC X(11).
  .  .  .  INSPECT DATA-4
     CONVERTING
       "abcdefghijklmnopqrstuvwxyz" TO
       "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
     AFTER INITIAL "/"
     BEFORE INITIAL "?"
```

<table>
<thead>
<tr>
<th>DATA-4 before</th>
<th>DATA-4 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>a/five/?six</td>
<td>a/FIVE/?six</td>
</tr>
<tr>
<td>r/Rexx/RRRr</td>
<td>r/REXX/RRRR</td>
</tr>
<tr>
<td>zfour?inspe</td>
<td>zfour?inspe</td>
</tr>
</tbody>
</table>
Converting data items (intrinsic functions)

You can use intrinsic functions to convert character-string data items to several other formats, for example, to uppercase or lowercase, to reverse order, to numbers, or to one code page from another.

You can use the NATIONAL-OF and DISPLAY-OF intrinsic functions to convert to and from national (Unicode) strings.

You can also use the INSPECT statement to convert characters.

“Examples: INSPECT statement” on page 111

related tasks
“Changing case (UPPER-CASE, LOWER-CASE)” on page 112
“Transforming to reverse order (REVERSE)” on page 112
“Converting to numbers (NUMVAL, NUMVAL-C)” on page 113
“Converting from one code page to another” on page 114

Changing case (UPPER-CASE, LOWER-CASE)

You can use the UPPER-CASE and LOWER-CASE intrinsic functions to easily change the case of alphanumeric, alphabetic, or national strings.

```
01 Item-1  Pic x(30)  Value "Hello World!".
01 Item-2  Pic x(30).
.
  Display Item-1
  Display Function Upper-case(Item-1)
  Display Function Lower-case(Item-1)
  Move Function Upper-case(Item-1) to Item-2
  Display Item-2
```

The code above displays the following messages on the system logical output device:

```
Hello World!
HELLO WORLD!
hello world!
HELLO WORLD!
```

The DISPLAY statements do not change the actual contents of Item-1, but affect only how the letters are displayed. However, the MOVE statement causes uppercase letters to replace the contents of Item-2.

Note: The UPPER-CASE and LOWER-CASE intrinsic functions do not support alphanumeric arguments that contain UTF-8 encoded data.

related tasks
“Assigning input from a screen or file (ACCEPT)” on page 33
“Displaying values on a screen or in a file (DISPLAY)” on page 33

Transforming to reverse order (REVERSE)

You can reverse the order of the characters in a string by using the REVERSE intrinsic function.

```
Move Function Reverse(Orig-cust-name) To Orig-cust-name
```

For example, the statement above reverses the order of the characters in Orig-cust-name. If the starting value is JOHNSONbbb, the value after the statement is performed is bbbNOSNH0J, where b represents a blank space.
Converting to numbers (NUMVAL, NUMVAL-C)

The NUMVAL and NUMVAL-C functions convert character strings (alphanumeric or national literals, or class alphanumeric or class national data items) to numbers. Use these functions to convert free-format character-representation numbers to numeric form so that you can process them numerically.

```
01  R       Pic x(20)  Value "- 1234.5678".
01  S       Pic x(20)  Value "$12,345.67CR".
01  Total   Usage is Comp-1.

. . .
Compute Total = Function Numval(R) + Function Numval-C(S)
```

Use NUMVAL-C when the argument includes a currency symbol or comma or both, as shown in the example above. You can also place an algebraic sign before or after the character string, and the sign will be processed. The arguments must not exceed 18 digits when you compile with the default option ARITH(COMPAT) (compatibility mode) nor 31 digits when you compile with ARITH(EXTEND) (extended mode), not including the editing symbols.

NUMVAL and NUMVAL-C return long (64-bit) floating-point values in compatibility mode, and return extended-precision (128-bit) floating-point values in extended mode. A reference to either of these functions represents a reference to a numeric data item.

At most 15 decimal digits can be converted accurately to long-precision floating point (as described in the related reference below about conversions and precision). If the argument to NUMVAL or NUMVAL-C has more than 15 digits, it is recommended that you specify the ARITH(EXTEND) compiler option so that an extended-precision function result that can accurately represent the value of the argument is returned.

When you use NUMVAL or NUMVAL-C, you do not need to statically define numeric data in a fixed format nor input data in a precise manner. For example, suppose you define numbers to be entered as follows:

```
01  X   Pic S999V99  leading sign is separate.
  .  Accept X from Console
```

The user of the application must enter the numbers exactly as defined by the PICTURE clause. For example:

```
+001.23
-300.00
```

However, using the NUMVAL function, you could code:

```
01  A   Pic x(10).
01  B   Pic S999V99.
  .  Accept A from Console
  Compute B = Function Numval(A)
```

The input could then be:

```
1.23
-300
```
Converting from one code page to another

You can nest the DISPLAY-OF and NATIONAL-OF intrinsic functions to easily convert from any code page to any other code page.

For example, the following code converts an EBCDIC string to an ASCII string:

```
77 EBCDIC-CCSID PIC 9(4) BINARY VALUE 1140.
77 ASCII-CCSID PIC 9(4) BINARY VALUE 819.
77 Input-EBCDIC PIC X(80).
77 ASCII-Output PIC X(80).

* Convert EBCDIC to ASCII
  Move Function Display-of
  (Function National-of (Input-EBCDIC EBCDIC-CCSID),
   ASCII-CCSID)
  to ASCII-Output
```

Evaluating data items (intrinsic functions)

You can use intrinsic functions to determine the ordinal position of a character in the collating sequence, to find the largest or smallest item in a series, to find the length of data item, or to determine when a program was compiled.

Use these intrinsic functions:

- **CHAR** and **ORD** to evaluate integers and single alphabetic or alphanumeric characters with respect to the collating sequence used in a program
- **MAX**, **MIN**, **ORD-MAX**, and **ORD-MIN** to find the largest and smallest items in a series of data items, including USAGE NATIONAL data items
- **LENGTH** to find the length of data items, including USAGE NATIONAL data items
- **WHEN-COMPILED** to find the date and time when a program was compiled
Evaluating single characters for collating sequence

To find out the ordinal position of a given alphabetic or alphanumeric character in the collating sequence, use the ORD function with the character as the argument. ORD returns an integer that represents that ordinal position.

You can use a one-character substring of a data item as the argument to ORD:

```
IF Function Ord(Customer-record(1:1)) IS > 194 THEN . . .
```

If you know the ordinal position in the collating sequence of a character, and want to find the character that it corresponds to, use the CHAR function with the integer ordinal position as the argument. CHAR returns the required character. For example:

```
INITIALIZE Customer-Name REPLACING ALPHABETIC BY Function Char(65)
```

Finding the largest or smallest data item

To determine which of two or more alphanumeric, alphabetic, or national data items has the largest value, use the MAX or ORD-MAX intrinsic function. To determine which item has the smallest value, use MIN or ORD-MIN. These functions evaluate according to the collating sequence.

To compare numeric items, including those that have USAGE NATIONAL, you can use MAX, ORD-MAX, MIN, or ORD-MIN. With these intrinsic functions, the algebraic values of the arguments are compared.

The MAX and MIN functions return the content of one of the arguments that you supply. For example, suppose that your program has the following data definitions:

```
05  Arg1   Pic x(10)  Value "THOMASSON ".
05  Arg2   Pic x(10)  Value "THOMAS    ".
05  Arg3   Pic x(10)  Value "VALLEJO   ".
```

The following statement assigns VALLEJObbb to the first 10 character positions of Customer-record, where b represents a blank space:

```
Move Function Max(Arg1 Arg2 Arg3) To Customer-record(1:10)
```

If you used MIN instead, then THOMASbbb would be assigned.

The functions ORD-MAX and ORD-MIN return an integer that represents the ordinal position (counting from the left) of the argument that has the largest or smallest value in the list of arguments that you supply. If you used the ORD-MAX function in the previous example, the compiler would issue an error message because the reference to a numeric function is not in a valid place. Using the same arguments as in the previous example, ORD-MAX can be used as follows:

```
Compute x = Function Ord-max(Arg1 Arg2 Arg3)
```

The statement above assigns the integer 3 to x if the same arguments are used as in the previous example. If you used ORD-MIN instead, the integer 2 would be returned. The examples above might be more realistic if Arg1, Arg2, and Arg3 were successive elements of an array (table).

If you specify a national item for any argument, you must specify all arguments as class national.
Returning variable results with alphanumeric or national functions

The results of alphanumeric or national functions could be of varying lengths and values depending on the function arguments.

In the following example, the amount of data moved to R3 and the results of the COMPUTE statement depend on the values and sizes of R1 and R2:

```
01  R1    Pic x(10) value "e".
01  R2    Pic x(05) value "f".
01  R3    Pic x(20) value spaces.
01  L     Pic 99.
   .
   .
   Move Function Max(R1 R2) to R3
   Compute L = Function Length(Function Max(R1 R2))
```

This code has the following results:

- R2 is evaluated to be larger than R1.
- The string 'fbbbb' is moved to R3, where b represents a blank space. (The unfilled character positions in R3 are padded with spaces.)
- L evaluates to the value 5.

If R1 contained 'g' instead of 'e', the code would have the following results:

- R1 would evaluate as larger than R2.
- The string 'gbbbbbbbb' would be moved to R3. (The unfilled character positions in R3 would be padded with spaces.)
- The value 10 would be assigned to L.

If a program uses national data for function arguments, the lengths and values of the function results could likewise vary. For example, the following code is identical to the fragment above, but uses national data instead of alphanumeric data.

```
01  R1    Pic n(10) national value "e".
01  R2    Pic n(05) national value "f".
01  R3    Pic n(20) national value spaces.
01  L     Pic 99    national.
   .
   .
   Move Function Max(R1 R2) to R3
   Compute L = Function Length(Function Max(R1 R2))
```

This code has the following results, which are similar to the first set of results except that these are for national characters:

- R2 is evaluated to be larger than R1.
- The string NX"0066 0020 0020 0020 0020" (the equivalent in national characters of 'fbbbb', where b represents a blank space), shown here in hexadecimal notation with added spaces for readability, is moved to R3. The unfilled character positions in R3 are padded with national spaces.
- L evaluates to the value 5, the length in national character positions of R2.
You might be dealing with variable-length output from alphanumeric or national functions. Plan your program accordingly. For example, you might need to think about using variable-length files when the records that you are writing could be of different lengths:

File Section.
FD Output-File Recording Mode V.
  01 Short-Customer-Record Pic X(50).
  01 Long-Customer-Record Pic X(70).
Working-Storage Section.
  01 R1 Pic X(50).
  01 R2 Pic X(70).
  .
  .
  If R1 > R2
  Write Short-Customer-Record from R1
  Else
  Write Long-Customer-Record from R2
  End-if

related tasks
“Finding the largest or smallest data item” on page 115
“Performing arithmetic” on page 53

related references
MAX (Enterprise COBOL for z/OS Language Reference)

Finding the length of data items
You can use the LENGTH function in many contexts (including tables and numeric data) to determine the length of an item. For example, you can use the LENGTH function to determine the length of an alphanumeric or national literal, or a data item of any type except DBCS.

The LENGTH function returns the length of a national item (a literal, or any item that has USAGE NATIONAL, including national group items) as an integer equal to the length of the argument in national character positions. It returns the length of any other data item as an integer equal to the length of the argument in alphanumeric character positions.

The following COBOL statement demonstrates moving a data item into the field in a record that holds customer names:

   Move Customer-name To Customer-record(1:Function Length(Customer-name))

You can also use the LENGTH OF special register, which returns the length in bytes even for national data. Coding either Function Length(Customer-name) or LENGTH OF Customer-name returns the same result for alphanumeric items: the length of Customer-name in bytes.

You can use the LENGTH function only where arithmetic expressions are allowed. However, you can use the LENGTH OF special register in a greater variety of contexts. For example, you can use the LENGTH OF special register as an argument to an intrinsic function that accepts integer arguments. (You cannot use an intrinsic function as an operand to the LENGTH OF special register.) You can also use the LENGTH OF special register as a parameter in a CALL statement.

related tasks
“Performing arithmetic” on page 53
“Creating variable-length tables (DEPENDING ON)” on page 76
“Processing table items using intrinsic functions” on page 85

related references
LENGTH (Enterprise COBOL for z/OS Language Reference)
LENGTH OF (Enterprise COBOL for z/OS Language Reference)
Finding the date of compilation

You can use the WHEN-COMPILED intrinsic function to determine when a program was compiled. The 21-character result indicates the four-digit year, month, day, and time (in hours, minutes, seconds, and hundredths of seconds) of compilation, and the difference in hours and minutes from Greenwich mean time.

The first 16 positions are in the following format:

```
YYYYMMDDhhmmsshh
```

You can instead use the WHEN-COMPILED special register to determine the date and time of compilation in the following format:

```
MM/DD/YYhh.mm.ss
```

The WHEN-COMPILED special register supports only a two-digit year, and does not carry fractions of a second. You can use this special register only as the sending field in a MOVE statement.

related references

WHEN-COMPILED (Enterprise COBOL for z/OS Language Reference)
Chapter 7. Processing data in an international environment

Enterprise COBOL supports Unicode UTF-16 as national character data at run time. UTF-16 provides a consistent and efficient way to encode plain text. Using UTF-16, you can develop software that will work with various national languages.

Use these COBOL facilities to code and compile programs that process national data:

- **Data types and literals:**
  - Character data types, defined with the USAGE NATIONAL clause and a PICTURE clause that defines data of category national, national-edited, or numeric-edited
  - Numeric data types, defined with the USAGE NATIONAL clause and a PICTURE clause that defines a numeric data item (a national decimal item) or an external floating-point data item (a national floating-point item)
  - National literals, specified with literal prefix N or NX
  - Figurative constant ALL national-literal
  - Figurative constants QUOTE, SPACE, HIGH-VALUE, LOW-VALUE, or ZERO, which have national character (UTF-16) values when used in national-character contexts

- **The COBOL statements shown in the related reference below about COBOL statements and national data

- **Intrinsic functions:**
  - NATIONAL-OF to convert an alphanumeric or double-byte character set (DBCS) character string to USAGE NATIONAL (UTF-16)
  - DISPLAY-OF to convert a national character string to USAGE DISPLAY in a selected code page (EBCDIC, ASCII, EUC, or UTF-8)
  - The other intrinsic functions shown in the related reference below about intrinsic functions and national data

- **The GROUP-USAGE NATIONAL clause to define groups that contain only USAGE NATIONAL data items and that behave like elementary category national items in most operations

- **Compiler options:**
  - CODEPAGE to specify the code page to use for alphanumeric and DBCS data in your program
  - NSYMBOL to control whether national or DBCS processing is used for the N symbol in literals and PICTURE clauses

You can also take advantage of implicit conversions of alphanumeric or DBCS data items to national representation. The compiler performs such conversions (in most cases) when you move these items to national data items, or compare these items with national data items.

**related concepts**

“Unicode and the encoding of language characters” on page 123

“National groups” on page 127

**related tasks**

“Using national data (Unicode) in COBOL” on page 124

“Converting to or from national (Unicode) representation” on page 131

“Processing UTF-8 data” on page 134

“Processing Chinese GB 18030 data” on page 139
COBOL statements and national data

You can use national data with the PROCEDURE DIVISION and compiler-directing statements shown in the table below.

<table>
<thead>
<tr>
<th>COBOL statement</th>
<th>Can be national</th>
<th>Comment</th>
<th>For more information</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCEPT</td>
<td>identifier-1, identifier-2</td>
<td>identifier-1 is converted from the native code page specified in the CODEPAGE compiler option only if input is from CONSOLE.</td>
<td>“Assigning input from a screen or file (ACCEPT)” on page 33</td>
</tr>
<tr>
<td>ADD</td>
<td>All identifiers can be numeric items that have USAGE NATIONAL. identifier-3 ( GIVING) can be numeric-edited with USAGE NATIONAL.</td>
<td></td>
<td>“Using COMPUTE and other arithmetic statements” on page 53</td>
</tr>
<tr>
<td>CALL</td>
<td>identifier-2, identifier-3, identifier-4, identifier-5; literal-2, literal-3</td>
<td></td>
<td>“Passing data” on page 461</td>
</tr>
<tr>
<td>COMPUTE</td>
<td>identifier-1 can be numeric or numeric-edited with USAGE NATIONAL. arithmetic-expression can contain numeric items that have USAGE NATIONAL.</td>
<td></td>
<td>“Using COMPUTE and other arithmetic statements” on page 53</td>
</tr>
<tr>
<td>COPY . . . REPLACING</td>
<td>operand-1, operand-2 of the REPLACING phrase</td>
<td></td>
<td>Chapter 18, “Compiler-directing statements,” on page 357</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>identifier-1</td>
<td>identifier-1 is converted to EBCDIC only if the CONSOLE mnemonic-name is specified directly or indirectly.</td>
<td>“Displaying values on a screen or in a file (DISPLAY)” on page 33</td>
</tr>
<tr>
<td>COBOL statement</td>
<td>Can be national</td>
<td>Comment</td>
<td>For more information</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
<td>---------</td>
<td>----------------------</td>
</tr>
<tr>
<td>DIVIDE</td>
<td>All identifiers can be numeric items that have USAGE NATIONAL. <em>identifier-3</em> (GIVING) and <em>identifier-4</em> (REMAINDER) can be numeric-edited with USAGE NATIONAL.</td>
<td>If you specify REPLACING NATIONAL or REPLACING NATIONAL-EDITED, <em>identifier-2</em> or <em>literal-1</em> must be valid as a sending operand in a move to <em>identifier-1</em>.</td>
<td>“Using COMPUTE and other arithmetic statements” on page 53</td>
</tr>
<tr>
<td>INITIALIZE</td>
<td><em>identifier-1</em>; <em>identifier-2</em> or <em>literal-1</em> of the REPLACING phrase</td>
<td>If any of these (other than <em>identifier-2</em>, the TALLYING integer data item, have USAGE NATIONAL, all must be national.</td>
<td>“Examples: initializing data items” on page 26</td>
</tr>
<tr>
<td>INSPECT</td>
<td>All identifiers and literals. (<em>identifier-2</em>, the TALLYING integer data item, can have USAGE NATIONAL.)</td>
<td></td>
<td>“Tallying and replacing data items (INSPECT)” on page 110</td>
</tr>
<tr>
<td>INVOKE</td>
<td>Method-name as <em>identifier-2</em> or <em>literal-1</em>; <em>identifier-3</em> or <em>literal-2</em> in the BY VALUE phrase</td>
<td></td>
<td>“Invoking methods (INVOKE)” on page 576</td>
</tr>
<tr>
<td>MERGE</td>
<td>Merge keys</td>
<td>The COLLATING SEQUENCE phrase does not apply.</td>
<td>“Setting sort or merge criteria” on page 213</td>
</tr>
<tr>
<td>MOVE</td>
<td>Both the sender and receiver, or only the receiver</td>
<td>Implicit conversions are performed for valid MOVE operands.</td>
<td>“Assigning values to elementary data items (MOVE)” on page 30 “Assigning values to group data items (MOVE)” on page 31</td>
</tr>
<tr>
<td>MULTIPLY</td>
<td>All identifiers can be numeric items that have USAGE NATIONAL. <em>identifier-3</em> (GIVING) can be numeric-edited with USAGE NATIONAL.</td>
<td></td>
<td>“Using COMPUTE and other arithmetic statements” on page 53</td>
</tr>
<tr>
<td>SEARCH ALL</td>
<td>Both the key data item and its object of comparison</td>
<td>The key data item and its object of comparison must be compatible according to the rules of comparison. If the object of comparison is of class national, the key must be also.</td>
<td>“Doing a binary search (SEARCH ALL)” on page 84</td>
</tr>
<tr>
<td>SORT</td>
<td>Sort keys</td>
<td>The COLLATING SEQUENCE phrase does not apply.</td>
<td>“Setting sort or merge criteria” on page 213</td>
</tr>
<tr>
<td>COBOL statement</td>
<td>Can be national</td>
<td>Comment</td>
<td>For more information</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
<td>---------</td>
<td>---------------------</td>
</tr>
<tr>
<td>STRING</td>
<td>All identifiers and literals. <em>(identifier-4, the POINTER integer data item, can have USAGE NATIONAL.)</em></td>
<td>If identifier-3, the receiving data item, is national, all identifiers and literals (other than identifier-4, the POINTER identifier) must be national.</td>
<td>“Joining data items (STRING)” on page 101</td>
</tr>
<tr>
<td>SUBTRACT</td>
<td>All identifiers can be numeric items that have USAGE NATIONAL. identifier-3 (GIVING) can be numeric-edited with USAGE NATIONAL.</td>
<td></td>
<td>“Using COMPUTE and other arithmetic statements” on page 53</td>
</tr>
<tr>
<td>UNSTRING</td>
<td>All identifiers and literals. <em>(identifier-6 and identifier-7, the COUNT and TALLYING integer data items, respectively, can have USAGE NATIONAL.)</em></td>
<td>If identifier-4, a receiving data item, has USAGE NATIONAL, the sending data item and each delimiter must have USAGE NATIONAL, and each literal must be national.</td>
<td>“Splitting data items (UNSTRING)” on page 103</td>
</tr>
<tr>
<td>XML GENERATE</td>
<td>identifier-1 (the generated XML document); identifier-2 (the source field or fields); identifier-4 or literal-4 (the namespace identifier); identifier-5 or literal-5 (the namespace prefix)</td>
<td></td>
<td>Chapter 31, “Producing XML output,” on page 541</td>
</tr>
<tr>
<td>XML PARSE</td>
<td>identifier-1 (the XML document)</td>
<td>The XML-NTEXT special register contains national character document fragments during parsing. XML-NNAMESPACE and XML-NNAMESPACE-PREFIX special registers contain the associated namespace identifier and namespace prefix, if any, in national characters.</td>
<td>Chapter 30, “Processing XML input,” on page 501</td>
</tr>
</tbody>
</table>

**related tasks**

“Defining numeric data” on page 41
“Displaying numeric data” on page 43
“Using national data (Unicode) in COBOL” on page 124
“Comparing national (UTF-16) data” on page 140
Intrinsic functions and national data

You can use arguments of class national with the intrinsic functions shown in the table below.

<table>
<thead>
<tr>
<th>Intrinsic function</th>
<th>Function type</th>
<th>For more information</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISPLAY-OF</td>
<td>Alphanumeric</td>
<td>“Converting national to alphanumeric (DISPLAY-OF)” on page 133</td>
</tr>
<tr>
<td>LENGTH</td>
<td>Integer</td>
<td>“Finding the length of data items” on page 117</td>
</tr>
<tr>
<td>LOWER-CASE, UPPER-CASE</td>
<td>National</td>
<td>“Changing case (UPPER-CASE, LOWER-CASE)” on page 112</td>
</tr>
<tr>
<td>NUMVAL, NUMVAL-C</td>
<td>Numeric</td>
<td>“Converting to numbers (NUMVAL, NUMVAL-C)” on page 113</td>
</tr>
<tr>
<td>MAX, MIN</td>
<td>National</td>
<td>“Finding the largest or smallest data item” on page 115</td>
</tr>
<tr>
<td>ORD-MAX, ORD-MIN</td>
<td>Integer</td>
<td>“Finding the largest or smallest data item” on page 115</td>
</tr>
<tr>
<td>REVERSE</td>
<td>National</td>
<td>“Transforming to reverse order (REVERSE)” on page 112</td>
</tr>
</tbody>
</table>

You can use national decimal arguments wherever zoned decimal arguments are allowed. You can use national floating-point arguments wherever display floating-point arguments are allowed. (See the related reference below about arguments for a complete list of intrinsic functions that can take integer or numeric arguments.)

related tasks

“Defining numeric data” on page 41
“Using national data (Unicode) in COBOL” on page 124

related references

Arguments (Enterprise COBOL for z/OS Language Reference)
Classes and categories of data (Enterprise COBOL for z/OS Language Reference)

Unicode and the encoding of language characters

Enterprise COBOL provides basic runtime support for Unicode, which can handle tens of thousands of characters that cover all commonly used characters and symbols in the world.

A character set is a defined set of characters, but is not associated with a coded representation. A coded character set (also referred to in this documentation as a code page) is a set of unambiguous rules that relate the characters of the set to their coded representation. Each code page has a name and is like a table that sets up the symbols for representing a character set; each symbol is associated with a unique bit pattern, or code point. Each code page also has a coded character set identifier (CCSID), which is a value from 1 to 65,536.

Unicode has several encoding schemes, called Unicode Transformation Format (UTF), such as UTF-8, UTF-16, and UTF-32. Enterprise COBOL uses UTF-16 (CCSID 1200) in big-endian format as the representation for national literals and data items that have USAGE NATIONAL.
UTF-8 represents ASCII invariant characters a-z, A-Z, 0-9, and certain special characters such as '@', ., +, =, /, * the same way that they are represented in ASCII. UTF-16 represents these characters as '00nn', where 'nn' is the representation of the character in ASCII.

For example, the string 'ABC' is represented in UTF-16 as '004100420043'. In UTF-8, 'ABC' is represented as '414243'.

One or more encoding units are used to represent a character from a coded character set. For UTF-16, an encoding unit takes 2 bytes of storage. Any character defined in any EBCDIC, ASCII, or EUC code page is represented in one UTF-16 encoding unit when the character is converted to the national data representation.

Cross-platform considerations: Enterprise COBOL and COBOL for AIX support UTF-16 in big-endian format in national data. COBOL for Windows supports UTF-16 in little-endian format (UTF-16LE) in national data. If you are porting Unicode data that is encoded in UTF-16LE representation to Enterprise COBOL from another platform, you must convert that data to UTF-16 in big-endian format to process the data as national data.

related tasks
“Converting to or from national (Unicode) representation” on page 131

related references
“Storage of character data” on page 131
Character sets and code pages (Enterprise COBOL for z/OS Language Reference)

Using national data (Unicode) in COBOL

In Enterprise COBOL, you can specify national (UTF-16) data in any of several ways. These types of national data are available:

- National data items (categories national, national-edited, and numeric-edited)
- National literals
- Figurative constants as national characters
- Numeric data items (national decimal and national floating-point)

In addition, you can define national groups that contain only data items that explicitly or implicitly have USAGE NATIONAL, and that behave in the same way as elementary category national data items in most operations.

These declarations affect the amount of storage that is needed.

related concepts
“Unicode and the encoding of language characters” on page 123
“National groups” on page 127

related tasks
“Defining national data items” on page 125
“Using national literals” on page 125
“Using national-character figurative constants” on page 126
“Defining national numeric data items” on page 127
“Using national groups” on page 128
“Converting to or from national (Unicode) representation” on page 131
“Comparing national (UTF-16) data” on page 140
Defining national data items
Define national data items with the USAGE NATIONAL clause to hold national (UTF-16) character strings.

You can define national data items of the following categories:
- National
- National-edited
- Numeric-edited

To define a category national data item, code a PICTURE clause that contains only one or more PICTURE symbols N.

To define a national-edited data item, code a PICTURE clause that contains at least one of each of the following symbols:
- Symbol N
- Simple insertion editing symbol B, 0, or /

To define a numeric-edited data item of class national, code a PICTURE clause that defines a numeric-edited item (for example, -$999.99) and code a USAGE NATIONAL clause. You can use a numeric-edited data item that has USAGE NATIONAL in the same way that you use a numeric-edited item that has USAGE DISPLAY.

You can also define a data item as numeric-edited by coding the BLANK WHEN ZERO clause for an elementary item that is defined as numeric by its PICTURE clause.

If you code a PICTURE clause but do not code a USAGE clause for data items that contain only one or more PICTURE symbols N, you can use the compiler option NSYMBOL(NATIONAL) to ensure that such items are treated as national data items instead of as DBCS items.

Using national literals
To specify national literals, use the prefix character N and compile with the option NSYMBOL(NATIONAL).

You can use either of these notations:
- N"character-data"
- N'character-data'

If you compile with the option NSYMBOL(DBCS), the literal prefix character N specifies a DBCS literal, not a national literal.

To specify a national literal as a hexadecimal value, use the prefix NX. You can use either of these notations:
- NX"hexadecimal-digits"
- NX'hexadecimal-digits'
Each of the following MOVE statements sets the national data item Y to the UTF-16 value of the characters 'AB':

```cobol
01 Y pic NN usage national.
   . . .
  Move NX'00410042' to Y
  Move N"AB"        to Y
  Move "AB"         to Y
```

Do not use alphanumeric hexadecimal literals in contexts that call for national literals, because such usage is easily misunderstood. For example, the following statement also results in moving the UTF-16 characters 'AB' (not the hexadecimal bit pattern C1C2) to Y, where Y is defined as USAGE NATIONAL:

```cobol
    Move X"C1C2" to Y
```

You cannot use national literals in the SPECIAL-NAMES paragraph or as program-names. You can use a national literal to name an object-oriented method in the METHOD-ID paragraph or to specify a method-name in an INVOKE statement.

related tasks
“Using literals” on page 23

related references
“NSYMBOL” on page 319
National literals (Enterprise COBOL for z/OS Language Reference)

Using national-character figurative constants
You can use the figurative constant ALL national-literal in a context that requires national characters. ALL national-literal represents all or part of the string that is generated by successive concatenations of the encoding units that make up the national literal.

You can use the figurative constants QUOTE, SPACE, HIGH-VALUE, LOW-VALUE, or ZERO in a context that requires national characters, such as a MOVE statement, an implicit move, or a relation condition that has national operands. In these contexts, the figurative constant represents a national-character (UTF-16) value.

When you use the figurative constant HIGH-VALUE in a context that requires national characters, its value is NX'FFFF'. When you use LOW-VALUE in a context that requires national characters, its value is NX'0000'.

Restrictions: You must not use HIGH-VALUE or the value assigned from HIGH-VALUE in a way that results in conversion of the value from one data representation to another (for example, between USAGE DISPLAY and USAGE NATIONAL). X'FF' (the value of HIGH-VALUE in an alphanumeric context when the EBCDIC collating sequence is being used) does not represent a valid EBCDIC character, and NX'FFFF' does not represent a valid national character. Conversion of such a value to another representation results in a substitution character being used (not X'FF' or NX'FFFF'). Consider the following example:

```cobol
01 natl-data  PIC NN  Usage National.
01 alph-data  PIC XX.
   . .
  MOVE HIGH-VALUE TO natl-data, alph-data
  IF natl-data = alph-data . . .
```

The IF statement above evaluates as false even though each of its operands was set to HIGH-VALUE. Before an elementary alphanumeric operand is compared to a national operand, the alphanumeric operand is treated as though it were moved to a temporary national data item, and the alphanumeric characters are converted to the corresponding national characters. When X'FF' is converted to UTF-16, however, the UTF-16 item gets a substitution character value and so does not compare equally to NX'FFFF'.
Defining national numeric data items

Define data items with the USAGE NATIONAL clause to hold numeric data that is represented in national characters (UTF-16). You can define national decimal items and national floating-point items.

To define a national decimal item, code a PICTURE clause that contains only the symbols 9, P, S, and V. If the PICTURE clause contains S, the SIGN IS SEPARATE clause must be in effect for that item.

To define a national floating-point item, code a PICTURE clause that defines a floating-point item (for example, +99999.9E-99).

You can use national decimal items in the same way that you use zoned decimal items. You can use national floating-point items in the same way that you use display floating-point items.

related tasks
“Defining numeric data” on page 41
“Displaying numeric data” on page 43

related references
SIGN clause (Enterprise COBOL for z/OS Language Reference)

National groups

National groups, which are specified either explicitly or implicitly with the GROUP-USAGE NATIONAL clause, contain only data items that have USAGE NATIONAL. In most cases, a national group item is processed as though it were redefined as an elementary category national item described as PIC N(m), where m is the number of national (UTF-16) characters in the group.

For some operations on national groups, however (just as for some operations on alphanumeric groups), group semantics apply. Such operations (for example, MOVE CORRESPONDING and INITIALIZE) recognize or process the elementary items within the national group.

Where possible, use national groups instead of alphanumeric groups that contain USAGE NATIONAL items. National groups provide several advantages for the processing of national data compared to the processing of national data within alphanumeric groups:

- When you move a national group to a longer data item that has USAGE NATIONAL, the receiving item is padded with national characters. By contrast, if you move an alphanumeric group that contains national characters to a longer alphanumeric group that contains national characters, alphanumeric spaces are used for padding. As a result, mishandling of data items could occur.
- When you move a national group to a shorter data item that has USAGE NATIONAL, the national group is truncated at national-character boundaries. By contrast, if you move an alphanumeric group that contains national characters to a shorter alphanumeric group that contains national characters, truncation might occur between the 2 bytes of a national character.
- When you move a national group to a national-edited or numeric-edited item, the content of the group is edited. By contrast, if you move an alphanumeric group to an edited item, no editing takes place.
- When you use a national group as an operand in a STRING, UNSTRING, or INSPECT statement:
  - The group content is processed as national characters rather than as single-byte characters.
TALLYING and POINTER operands operate at the logical level of national characters.

- The national group operand is supported with a mixture of other national operand types.

By contrast, if you use an alphanumeric group that contains national characters in these contexts, the characters are processed byte by byte. As a result, invalid handling or corruption of data could occur.

**USAGE NATIONAL groups:** A group item can specify the **USAGE NATIONAL** clause at the group level as a convenient shorthand for the usage of each of the elementary data items within the group. Such a group is not a national group, however, but an alphanumeric group, and behaves in many operations, such as moves and compares, like an elementary data item of **USAGE DISPLAY** (except that no editing or conversion of data occurs).

**related tasks**
- “Assigning values to group data items (MOVE)” on page 31
- “Joining data items (STRING)” on page 101
- “Splitting data items (UNSTRING)” on page 103
- “Tallying and replacing data items (INSPECT)” on page 110
- “Using national groups” on page 128

**related references**
GROUP-USAGE clause (Enterprise COBOL for z/OS Language Reference)

**Using national groups**

To define a group data item as a national group, code a **GROUP-USAGE NATIONAL** clause at the group level for the item. The group can contain only data items that explicitly or implicitly have **USAGE NATIONAL**.

The following data description entry specifies that a level-01 group and its subordinate groups are national group items:

```
01 Nat-Group-1 GROUP-USAGE NATIONAL.
   02 Group-1.
      04 Month PIC 99.
      04 DayOf PIC 99.
      04 Year PIC 9999.
   02 Group-2 GROUP-USAGE NATIONAL.
      04 Amount PIC 9(4).99 USAGE NATIONAL.
```

In the example above, Nat-Group-1 is a national group, and its subordinate groups Group-1 and Group-2 are also national groups. A **GROUP-USAGE NATIONAL** clause is implied for Group-1, and **USAGE NATIONAL** is implied for the subordinate items in Group-1. Month, DayOf, and Year are national decimal items, and Amount is a numeric-edited item that has **USAGE NATIONAL**.

You can subordinate national groups within alphanumeric groups as in the following example:

```
01 Alpha-Group-1.
   02 Group-1.
      04 Month PIC 99.
      04 DayOf PIC 99.
      04 Year PIC 9999.
   02 Group-2 GROUP-USAGE NATIONAL.
```

In the example above, Alpha-Group-1 and Group-1 are alphanumeric groups; **USAGE DISPLAY** is implied for the subordinate items in Group-1. (If Alpha-Group-1 specified **USAGE NATIONAL** at the group level, **USAGE NATIONAL** would be implied for each of the subordinate items in Group-1. However, Alpha-Group-1 and Group-1 would be alphanumeric groups, not national groups, and would behave like alphanumeric groups during operations such as moves and compares.) Group-2 is a national group, and **USAGE NATIONAL** is implied for the numeric-edited item Amount.
You cannot subordinate alphanumeric groups within national groups. All elementary items within a national group must be explicitly or implicitly described as USAGE NATIONAL, and all group items within a national group must be explicitly or implicitly described as GROUP-USAGE NATIONAL.

related concepts
“National groups” on page 127

related tasks
“Using national groups as elementary items” on page 129
“Using national groups as group items” on page 129

related references
GROUP-USAGE clause (Enterprise COBOL for z/OS Language Reference)

Using national groups as elementary items
In most cases, you can use a national group as though it were an elementary data item.

In the following example, a national group item, Group-1, is moved to a national-edited item, Edited-date. Because Group-1 is treated as an elementary data item during the move, editing takes place in the receiving data item. The value in Edited-date after the move is 06/23/2010 in national characters.

```
01 Edited-date PIC NN/NN/NNNN USAGE NATIONAL.
01 Group-1 GROUP-USAGE NATIONAL.
  02 Month PIC 99 VALUE 06.
  02 DayOf PIC 99 VALUE 23.
  02 Year PIC 9999 VALUE 2010.
  MOVE Group-1 to Edited-date.
```

If Group-1 were instead an alphanumeric group in which each of its subordinate items had USAGE NATIONAL (specified either explicitly with a USAGE NATIONAL clause on each elementary item, or implicitly with a USAGE NATIONAL clause at the group level), a group move, rather than an elementary move, would occur. Neither editing nor conversion would take place during the move. The value in the first eight character positions of Edited-date after the move would be 06232010 in national characters, and the value in the remaining two character positions would be 4 bytes of alphanumeric spaces.

related tasks
“Assigning values to group data items (MOVE)” on page 31
“Comparing national data and alphanumeric-group operands” on page 142
“Using national groups as group items” on page 129

related references
MOVE statement (Enterprise COBOL for z/OS Language Reference)

Using national groups as group items
In some cases when you use a national group, it is handled with group semantics; that is, the elementary items in the group are recognized or processed.

In the following example, an INITIALIZE statement that acts upon national group item Group-OneN causes the value 15 in national characters to be moved to only the numeric items in the group:

```
01 Group-OneN Group-Usage National.
  05 Trans-codeN Pic N Value "A".
  05 Part-numbeN Pic NN Value "XX".
  05 Trans-quanN Pic 99 Value 10.
```
Because only Trans-quantN in Group-OneN above is numeric, only Trans-quantN receives the value 15. The other subordinate items are unchanged.

The table below summarizes the cases where national groups are processed with group semantics.

**Table 17. National group items that are processed with group semantics**

<table>
<thead>
<tr>
<th>Language feature</th>
<th>Uses of national group items</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORRESPONDING phrase of the ADD, SUBTRACT, or MOVE statement</td>
<td>Specify a national group item for processing as a group in accordance with the rules of the CORRESPONDING phrase.</td>
<td>Elementary items within the national group are processed like elementary items that have USAGE NATIONAL within an alphanumeric group.</td>
</tr>
<tr>
<td>Host variable in EXEC SQL statement</td>
<td>Specify a national group item as a host variable.</td>
<td>The national group item is in effect shorthand for the set of host variables that are subordinate to the group item.</td>
</tr>
<tr>
<td>INITIALIZE statement</td>
<td>Specify a national group for processing as a group in accordance with the rules of the INITIALIZE statement.</td>
<td>Elementary items within the national group are initialized like elementary items that have USAGE NATIONAL within an alphanumeric group.</td>
</tr>
<tr>
<td>Name qualification</td>
<td>Use the name of a national group item to qualify the names of elementary data items and of subordinate group items in the national group.</td>
<td>Follow the same rules for qualification as for an alphanumeric group.</td>
</tr>
<tr>
<td>THROUGH phrase of the RENAMES clause</td>
<td>To specify a national group item in the THROUGH phrase, use the same rules as for an alphanumeric group item.</td>
<td>The result is an alphanumeric group item.</td>
</tr>
<tr>
<td>FROM phrase of the XML GENERATE statement</td>
<td>Specify a national group item in the FROM phrase for processing as a group in accordance with the rules of the XML GENERATE statement.</td>
<td>Elementary items within the national group are processed like elementary items that have USAGE NATIONAL within an alphanumeric group.</td>
</tr>
</tbody>
</table>

**related tasks**

- "Initializing a structure (INITIALIZE)” on page 29
- "Initializing a table (INITIALIZE)” on page 71
- "Assigning values to elementary data items (MOVE)” on page 30
- "Assigning values to group data items (MOVE)” on page 31
- "Finding the length of data items” on page 117
- "Generating XML output” on page 541
- "Using national group items in SQL statements” on page 420

**related references**

- Qualification (Enterprise COBOL for z/OS Language Reference)
- RENAMES clause (Enterprise COBOL for z/OS Language Reference)
Storage of character data

Use the table below to compare alphanumeric (DISPLAY), DBCS (DISPLAY-1), and Unicode (NATIONAL) encoding and to plan storage usage.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>DISPLAY</th>
<th>DISPLAY-1</th>
<th>NATIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Character encoding unit</td>
<td>1 byte</td>
<td>2 bytes</td>
<td>2 bytes</td>
</tr>
<tr>
<td>Code page</td>
<td>EBCDIC</td>
<td>EBCDIC DBCS</td>
<td>UTF-16BE</td>
</tr>
<tr>
<td>Encoding units per graphic character</td>
<td>1</td>
<td>1</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Bytes per graphic character</td>
<td>1 byte</td>
<td>2 bytes</td>
<td>2 or 4 bytes</td>
</tr>
</tbody>
</table>

1. Use the CODEPAGE compiler option to specify the EBCDIC code page that is applicable to alphanumeric or DBCS data.
2. Most characters are represented in UTF-16 using one encoding unit. In particular, the following characters are represented using a single UTF-16 encoding unit per character:
   - COBOL characters A-Z, a-z, 0-9, space, + - * / = $ , ; . " ( ) > < :
   - All characters that are converted from an EBCDIC or ASCII code page

related concepts
“Unicode and the encoding of language characters” on page 123

Converting to or from national (Unicode) representation

You can implicitly or explicitly convert data items to national (UTF-16) representation.

You can implicitly convert alphabetic, alphanumeric, DBCS, or integer data to national data by using the MOVE statement. Implicit conversions also take place in other COBOL statements, such as IF statements that compare an alphanumeric data item with a data item that has USAGE NATIONAL.

You can explicitly convert to and from national data items by using the intrinsic functions NATIONAL-OF and DISPLAY-OF, respectively. By using these intrinsic functions, you can specify a code page for the conversion that is different from the code page that is in effect with the CODEPAGE compiler option.

related tasks
“Converting alphanumeric, DBCS, and integer to national (MOVE)” on page 131
“Converting alphanumeric or DBCS to national (NATIONAL-OF)” on page 132
“Converting national to alphanumeric (DISPLAY-OF)” on page 133
“Overriding the default code page” on page 133
“Comparing national (UTF-16) data” on page 140

related references
“CODEPAGE” on page 295
“Conversion exceptions” on page 133

Converting alphanumeric, DBCS, and integer to national (MOVE)

You can use a MOVE statement to implicitly convert data to national representation.
You can move the following kinds of data to category national or national-edited data items, and thus convert the data to national representation:

- Alphabetic
- Alphanumeric
- Alphanumeric-edited
- DBCS
- Integer of USAGE DISPLAY
- Numeric-edited of USAGE DISPLAY

You can likewise move the following kinds of data to numeric-edited data items that have USAGE NATIONAL:

- Alphanumeric
- Display floating-point (floating-point of USAGE DISPLAY)
- Numeric-edited of USAGE DISPLAY
- Integer of USAGE DISPLAY

For complete rules about moves to national data, see the related reference about the MOVE statement.

For example, the MOVE statement below moves the alphanumeric literal "AB" to the national data item UTF16-Data:

```cobol
01  UTF16-Data  Pic N(2) Usage National.
    . . .
    Move "AB" to UTF16-Data
```

After the MOVE statement above, UTF16-Data contains NX'00410042', the national representation of the alphanumeric characters 'AB'.

If padding is required in a receiving data item that has USAGE NATIONAL, the default UTF-16 space character (NX'0020') is used. If truncation is required, it occurs at the boundary of a national-character position.

**related tasks**

- “Assigning values to elementary data items (MOVE)” on page 30
- “Assigning values to group data items (MOVE)” on page 31
- “Displaying numeric data” on page 43
- “Coding for use of DBCS support” on page 142

**related references**

MOVE statement (Enterprise COBOL for z/OS Language Reference)

**Converting alphanumeric or DBCS to national (NATIONAL-OF)**

Use the NATIONAL-OF intrinsic function to convert alphabetic, alphanumeric, or DBCS data to a national data item. Specify the source code page as the second argument if the source is encoded in a different code page than is in effect with the CODEPAGE compiler option.

“Example: converting to and from national data” on page 133

**related tasks**

- “Processing UTF-8 data” on page 134
- “Processing Chinese GB 18030 data” on page 139
- “Processing alphanumeric data items that contain DBCS data” on page 144
related references
“CODEPAGE” on page 295
NATIONAL-OF (Enterprise COBOL for z/OS Language Reference)

Converting national to alphanumeric (DISPLAY-OF)
Use the DISPLAY-OF intrinsic function to convert national data to an alphanumeric (USAGE DISPLAY) character string that is represented in a code page that you specify as the second argument.

If you omit the second argument, the output code page is the one that was in effect with the CODEPAGE compiler option when the source was compiled.

If you specify an EBCDIC or ASCII code page that combines single-byte character set (SBCS) and DBCS characters, the returned string might contain a mixture of SBCS and DBCS characters. The DBCS substrings are delimited by shift-in and shift-out characters if the code page in effect for the function is an EBCDIC code page.

“Example: converting to and from national data” on page 133

related tasks
“Processing UTF-8 data” on page 134
“Processing Chinese GB 18030 data” on page 139

related references
DISPLAY-OF (Enterprise COBOL for z/OS Language Reference)

Overriding the default code page
In some cases, you might need to convert data to or from a code page that differs from the CCSID that is specified as the CODEPAGE option value. To do so, convert the item by using a conversion function in which you explicitly specify the code page.

If you specify a code page as an argument to the DISPLAY-OF intrinsic function, and the code page differs from the code page that is in effect with the CODEPAGE compiler option, do not use the function result in any operations that involve implicit conversion (such as an assignment to, or comparison with, a national data item). Such operations assume the EBCDIC code page that is specified with the CODEPAGE compiler option.

related references
“CODEPAGE” on page 295

Conversion exceptions
Implicit or explicit conversion between national data and alphanumeric data can fail and generate a severity-3 Language Environment condition.

Failure can occur if the code page that you specified implicitly or explicitly is not a valid code page.

A character that does not have a counterpart in the target CCSID does not result in a conversion exception. Such a character is converted to a substitution character in the target code page.

related references
“CODEPAGE” on page 295

Example: converting to and from national data
The following example shows the NATIONAL-OF and DISPLAY-OF intrinsic functions and the MOVE statement for converting to and from national (UTF-16) data items. It also demonstrates the need for explicit conversions when you operate on strings that are encoded in multiple code pages.

CBL CODEPAGE(00037)
*
01 Data-in-Unicode pic N(100) usage national.
01 Data-in-Greek pic X(100).

related references
“CODEPAGE” on page 295
The example above works correctly because the input code page is specified. Data-in-Greek is converted as data represented in CCSID 00875 (Greek). However, the following statement results in an incorrect conversion unless all the characters in the item happen to be among those that have a common representation in both the Greek and the English code pages:

```
Move Data-in-Greek to Data-in-Unicode
```

The MOVE statement above converts Data-in-Greek to Unicode representation based on the CCSID 00037 (U.S. English) to UTF-16 conversion. This conversion does not produce the expected results because Data-in-Greek is encoded in CCSID 00875.

If you can correctly set the CODEPAGE compiler option to CCSID 00875 (that is, the rest of your program also handles EBCDIC data in Greek), you can code the same example correctly as follows:

```
CBL CODEPAGE(00875)
* . . .
01 Data-in-Unicode pic N(100) usage national.
01 Data-in-Greek pic X(100).
* . . .
Read Greek-file into Data-in-Greek
* . . . process Data-in-Greek here . . .
* . . . or do the following (if need to process data in Unicode):
  Move Data-in-Greek to Data-in-Unicode
  process Data-in-Unicode
  Move function Display-of(Data-in-Unicode) to Data-in-Greek
Write Greek-record from Data-in-Greek
```

**Processing UTF-8 data**

To process UTF-8 data, first convert the UTF-8 data to UTF-16 in a national data item. After processing the national data, convert it back to UTF-8 for output. For the conversions, use the intrinsic functions NATIONAL-OF and DISPLAY-OF, respectively. Use code page 1208 for UTF-8 data.

National data is encoded in UTF-16, which uses one encoding unit for almost all commonly encountered characters. With this property, you can use string operations such as reference modification on the national data. If it is more convenient to retain the UTF-8 encoding, use the Unicode intrinsic functions to assist with processing the data. For details, see “Using intrinsic functions to process UTF-8 encoded data” on page 135.

Take the following steps to convert ASCII or EBCDIC data to UTF-8:

1. Use the function NATIONAL-OF to convert the ASCII or EBCDIC string to a national (UTF-16) string.
2. Use the function DISPLAY-OF to convert the national string to UTF-8.

The following example converts Greek EBCDIC data to UTF-8:

```
01 Greek-EBCDIC pic X(10) value "αβγδεζηθ".
01 UnicodeString pic N(10).
01 UTF-8-String pic X(20).
  Move function National-of(Greek-EBCDIC, 00875) to UnicodeString
  Move function Display-of(UnicodeString, 01208) to UTF-8-String
```
Usage note: Use care if you use reference modification to refer to data encoded in UTF-8. UTF-8 characters are encoded with a varying number of bytes per character. Avoid operations that might split a multibyte character.

related tasks
“Referring to substrings of data items” on page 107
“Converting to or from national (Unicode) representation” on page 131
“Parsing XML documents encoded in UTF-8” on page 522
“Using intrinsic functions to process UTF-8 encoded data” on page 135

Using intrinsic functions to process UTF-8 encoded data
If it is more convenient to keep your data encoded in UTF-8, use the Unicode intrinsic functions to facilitate testing and processing the UTF-8 data.

You can use the following intrinsic functions:

UVALID
To verify that the UTF-8 character data is well-formed

USUPPLEMENTARY
If the data is to be converted to national, and it is important that every character can be represented by a single 16-bit encoding unit, use the USUPPLEMENTARY function to determine whether a valid UTF-8 character string contains a Unicode supplementary code point; that is, a code point with a Unicode scalar value above U+FFFF, requiring a 4-byte representation in UTF-8.

USUBSTR
It provides a convenient alternative to reference modification for referring to substrings of the UTF-8 character string. USUBSTR expects character position and length arguments versus the computed byte locations and counts required by reference modification.

Auxiliary functions can provide additional information about a valid UTF-8 character string:

ULENGTH
To determine the total number of Unicode code points in the string

UPOS
To determine the byte position in the string of the nth Unicode code point

UWIDTH
To determine the width in bytes of the nth Unicode code point in the string

The following code fragment illustrates UTF-8 validity checking, and the use of the auxiliary functions:

```plaintext
checkUTF-8-validity.
Compute u = function UVALID(UTF-8-testStr)
If u not = 0
  Display 'checkUTF-8-validity failure:
  Display ' The UTF-8 representation is not valid,' 'starting at byte ' u '.
  Compute v = function ULENGTH(UTF-8-testStr(1:u - 1))
  Compute u = function UPOS(UTF-8-testStr v)
  Compute w = function UWIDTH(UTF-8-testStr v)
  Display ' The ' v 'th and last valid code point starts' 'at byte ' u ' for ' w ' bytes.'
End-if.
```

In the following string, the sequence that starts with \x'F5' is not valid UTF-8 because no byte can have a value in the range \x'F5' to \x'FF':

```
x'6162D0B0E4B8CF5646364'
```
The output from `checkUTF-8-validity` for this string is as follows:

```
checkUTF-8-validity failure:
The UTF-8 representation is not valid, starting at byte 08.
The 04th and last valid code point starts at byte 05 for 03 bytes.
```

The following code fragment illustrates checking for the presence of a Unicode supplementary code point, requiring a 4-byte representation in UTF-8:

```
checkUTF-8-supp.
  Compute u = function USUPPLEMENTARY(UTF-8-testStr)
  If u not = 0
    Display ' checkUTF-8-supp hit:'
    Compute v = function ULENGTH(UTF-8-testStr(1:u - 1))
    Compute w = function UWIDTH(UTF-8-testStr v + 1)
    Display ' The ' v 'th code point of the string'
    ' , starting at byte ' u ','
    Display ' is a Unicode supplementary code point, '
    ' width ' w ' bytes.'
  End-if.
```

In the following string, the sequence `xF0908C82` is a supplementary character (as is any valid UTF-8 sequence beginning with a byte in the range `xF0` to `xF4`):

```
x'6162D0B0E4BA8CF0908C826364'
```

The output from `checkUTF-8-supp` for this string is as follows:

```
checkUTF-8-supp hit:
The 04th code point of the string, starting at byte 08,
is a Unicode supplementary code point, width 04 bytes.
```

**related references**

“CODEPAGE” on page 295

**Example: deriving initials from UTF-8 names**

The following program uses the Unicode functions to derive composers’ initials from a table of names in Czech. It is intended to illustrate these functions, and is not necessarily the most efficient way of doing the task. Although the program processes the composer names in UTF-8, the data begins and ends in EBCDIC in order to permit a meaningful display of the program source and output. The compiler option `CODEPAGE(1153)` ensures that the names are interpreted correctly when translated to and from Unicode.
Program initials

Process codepage(1153)
*---------------------------------------------------------------*
* For a table of Czech composer names represented in UTF-8,  *
* determine and print out the initials of each name.          *
*---------------------------------------------------------------*

Identification division.
  Program-id. initials.
Data division.
  Working-storage section.
    1 utilityVariables.
      2 UTF-8-space pic x value x'20'.
      2 UTF-8-hyphen pic x value x'2D'.
      2 UTF-8-ch pic xxx.
      2 i comp pic 9.
      2 j comp pic 99.
      2 hex pic x(160).
    1 EBCDICnameData.
      2 pic x(40) value 'Antonín Leopold Dvořák'.
      2 pic x(40) value 'Leoš Janáček'.
      2 pic x(40) value 'Rafael Jeroným Kubelík'.
      2 pic x(40) value 'Favel Křížkovský'.
      2 pic x(40) value 'Jan Václav Hugo Voříšek'.
    1 redefines EBCDICnameData.
      2 EBCDICname pic x(40) occurs 5 times.
    1 UTF-8-nameData.
      2 composer pic x(40) occurs 5 times.
    1 composerInitials.
      2 occurs 5.
        3 clenSize comp pic 99.
        3 clen pic x(5).
      1 state pic 9.
  88 seekingInitial value 0.  /* Skip space and hyphen
  88 seekingSeparator value 1. /* Skip all but space and hyphen

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Program initials, continued

```
Procedure division.
   main.
      Display 'Compute composer initials...'
      Initialize composerInitials
      Perform test before varying i from 1 by 1 until i > 5
      * Start by translating each composer name from EBCDIC to UTF-8.
      Move function display-of
           (function national-of(EBCDICName(i)) 1208)
           to composer(i)
      * Test each character of the name; skip leading spaces, etc.
      Set seekingInitial to true
      Move 1 to cInitSize(i)
      Perform varying j from 1 by 1
      until j > function ULENGTH(composer(i))
      Move function USUBSTR(composer(i) j 1) to UTF-8-ch
      * Initial found. Save in buffer, then skip to next space/hyphen.
      If seekingInitial and
         UTF-8-ch not = UTF-8-Space and UTF-8-Hyphen
         String function USUBSTR(composer(i) j 1)
         delimited by size
         into cInit(i) with pointer cInitSize(i)
      Set seekingSeparator to true
      End-if
      * Space/hyphen found; skip spaces or hyphens to next initial.
      If seekingSeparator and
         (UTF-8-ch = UTF-8-Space or UTF-8-Hyphen)
         Set seekingInitial to true
      End-if
      End-perform
      * Adjust string pointer to number of initials found.
      Subtract 1 from cInitSize(i)
      End-perform
      * Print out the UTF-8 initials, translated to EBCDIC, and
      * also in hexadecimal, using program ToHex (listed later).
      Perform test before varying i from 1 by 1 until i > 5
      Call 'toHex' using hex cInit(i) value cInitSize(i)
      Display ' #1 :' function display-of(
                  function national-of(cInit(1)(1:cInitSize(1)) 1208))
               (x'' hex(1:2 * cInitSize(1)) ''')
      End-perform.
      Goback.
   End program initials.
```

Output from program initials

Compute composer initials...
#1: ALD (x'414C44')
#2: LJ (x'4C4A')
#3: RJK (x'524A4B')
#4: PK (x'504B')
#5: JVHV (x'4A564856')

Program toHex

```
Identification division.
   Program-id. toHex.
Data division.
   Working-storage section.
      1 hexv.
      2 pic x(32) value '000102030405060708090A0B0C0D0E0F'.
      2 pic x(32) value '101112131415161718191A1B1C1D1E1F'.
      2 pic x(32) value '202122232425262728292A2B2C2D2E2F'.
      2 pic x(32) value '303132333435363738393A3B3C3D3E3F'.
      2 pic x(32) value '404142434445464748494A4B4C4D4E4F'.
      2 pic x(32) value '505152535455565758595A5B5C5D5E5F'.
      2 pic x(32) value '606162636465666768696A6B6C6D6E6F'.
      2 pic x(32) value '707172737475767778797A7B7C7D7E7F'.
```
Processing Chinese GB 18030 data

GB 18030 is a national-character standard specified by the government of the People's Republic of China. GB 18030 characters can be encoded in either UTF-16 or in code page CCSID 1392. Code page 1392 is an ASCII multibyte code page that uses 1, 2, or 4 bytes per character. A subset of the GB 18030 characters can be encoded in the Chinese ASCII code page, CCSID 1386, or in the Chinese EBCDIC code page, CCSID 1388.

Enterprise COBOL does not have explicit support for GB 18030, but does support the processing of GB 18030 characters in several ways. You can:

- Use DBCS data items to process GB 18030 characters that are represented in CCSID 1388.
- Use national data items to define and process GB 18030 characters that are represented in UTF-16, CCSID 01200.
- Process data in any code page (including CCSID 1388 or 1392) by converting the data to UTF-16, processing the UTF-16 data, and then converting the data back to the original code-page representation.

When you need to process Chinese GB 18030 data that requires conversion, first convert the input data to UTF-16 in a national data item. After you process the national data item, convert it back to Chinese GB 18030 for output. For the conversions, use the intrinsic functions NATIONAL-OF and DISPLAY-OF, respectively, and specify code page 1388 or 1392 as the second argument of each function.

The following example illustrates these conversions:
Comparing national (UTF-16) data

You can compare national (UTF-16) data, that is, national literals and data items that have USAGE NATIONAL (whether of class national or class numeric), explicitly or implicitly with other kinds of data in relation conditions.

You can code conditional expressions that use national data in the following statements:

- EVALUATE
- IF
- INSPECT
- PERFORM
- SEARCH
- STRING
- UNSTRING

For full details about comparing national data items to other data items, see the related references.

related tasks
“Comparing two class national operands” on page 140
“Comparing class national and class numeric operands” on page 141
“Comparing national numeric and other numeric operands” on page 141
“Comparing national and other character-string operands” on page 142
“Comparing national data and alphanumeric-group operands” on page 142

related references
Relation conditions (Enterprise COBOL for z/OS Language Reference)
General relation conditions (Enterprise COBOL for z/OS Language Reference)
National comparisons (Enterprise COBOL for z/OS Language Reference)
Group comparisons (Enterprise COBOL for z/OS Language Reference)

Comparing two class national operands

You can compare the character values of two operands of class national.

Either operand (or both) can be any of the following types of items:

- A national group
• An elementary category national or national-edited data item
• A numeric-edited data item that has USAGE NATIONAL

One of the operands can instead be a national literal or a national intrinsic function.

When you compare two class national operands that have the same length, they are determined to be equal if all pairs of the corresponding characters are equal. Otherwise, comparison of the binary values of the first pair of unequal characters determines the operand with the larger binary value.

When you compare operands that have unequal lengths, the shorter operand is treated as if it were padded on the right with default UTF-16 space characters (NX'0020') to the length of the longer operand.

The PROGRAM COLLATING SEQUENCE clause does not affect the comparison of two class national operands.

related concepts
“National groups” on page 127

related tasks
“Using national groups” on page 128

related references
National comparisons (Enterprise COBOL for z/OS Language Reference)

Comparing class national and class numeric operands
You can compare national literals or class national data items to integer literals or numeric data items that are defined as integer (that is, national decimal items or zoned decimal items). At most one of the operands can be a literal.

You can also compare national literals or class national data items to floating-point data items (that is, display floating-point or national floating-point items).

Numeric operands are converted to national (UTF-16) representation if they are not already in national representation. A comparison is made of the national character values of the operands.

related references
General relation conditions (Enterprise COBOL for z/OS Language Reference)

Comparing national numeric and other numeric operands
National numeric operands (national decimal and national floating-point operands) are data items of class numeric that have USAGE NATIONAL.

You can compare the algebraic values of numeric operands regardless of their USAGE. Thus you can compare a national decimal item or a national floating-point item with a binary item, an internal-decimal item, a zoned decimal item, a display floating-point item, or any other numeric item.

related tasks
“Defining national numeric data items” on page 127

related references
General relation conditions (Enterprise COBOL for z/OS Language Reference)
Comparing national and other character-string operands

You can compare the character value of a national literal or class national data item with the character value of any of the following other character-string operands: alphabetic, alphanumeric, alphanumeric-edited, DBCS, or numeric-edited of USAGE DISPLAY.

These operands are treated as if they were moved to an elementary national data item. The characters are converted to national (UTF-16) representation, and the comparison proceeds with two national character operands.

related tasks
“Using national-character figurative constants” on page 126

related references
National comparisons (Enterprise COBOL for z/OS Language Reference)

Comparing national data and alphanumeric-group operands

You can compare a national literal, a national group item, or any elementary data item that has USAGE NATIONAL to an alphanumeric group.

Neither operand is converted. The national operand is treated as if it were moved to an alphanumeric group item of the same size in bytes as the national operand, and the two groups are compared. An alphanumeric comparison is done regardless of the representation of the subordinate items in the alphanumeric group operand.

For example, Group-XN is an alphanumeric group that consists of two subordinate items that have USAGE NATIONAL:

```
01 Group-XN.
   02 TransCode PIC NN Value "AB" Usage National.
   02 Quantity PIC 999 Value 123 Usage National.
   If N"AB123" = Group-XN Then Display "EQUAL"
   Else Display "NOT EQUAL".
```

When the IF statement above is executed, the 10 bytes of the national literal N"AB123" are compared byte by byte to the content of Group-XN. The items compare equally, and "EQUAL" is displayed.

related references
Group comparisons (Enterprise COBOL for z/OS Language Reference)

Coding for use of DBCS support

IBM Enterprise COBOL for z/OS supports using applications in any of many national languages, including languages that use double-byte character sets (DBCS).

The following list summarizes the support for DBCS:

- DBCS characters in user-defined words (DBCS names)
- DBCS characters in comments
- DBCS data items (defined with PICTURE N, G, or G and B)
- DBCS literals
- DBCS compiler option
Defining DBCS data

Use the PICTURE and USAGE clauses to define DBCS data items. DBCS data items can use PICTURE symbols G, G, and B, or N. Each DBCS character position is 2 bytes in length.

You can specify a DBCS data item by using the USAGE DISPLAY-1 clause. When you use PICTURE symbol G, you must specify USAGE DISPLAY-1. When you use PICTURE symbol N but omit the USAGE clause, USAGE DISPLAY-1 or USAGE NATIONAL is implied depending on the setting of the NSYMBOL compiler option.

If you use a VALUE clause with the USAGE clause in the definition of a DBCS item, you must specify a DBCS literal or the figurative constant SPACE or SPACES.

For the purpose of handling reference modifications, each character in a DBCS data item is considered to occupy the number of bytes that corresponds to the code-page width (that is, 2).

Using DBCS literals

You can use the prefix N or G to represent a DBCS literal.

That is, you can specify a DBCS literal in either of these ways:

• N 'dbcs characters'
• G 'dbcs characters'

You can use quotation marks (" or apostrophes (’) as the delimiters of a DBCS literal irrespective of the setting of the APOST or QUOTE compiler option. You must code the same opening and closing delimiter for a DBCS literal.

The shift-out (SO) control character X'0E' must immediately follow the opening delimiter, and the shift-in (SI) control character X'0F' must immediately precede the closing delimiter.

In addition to DBCS literals, you can use alphanumeric literals to specify any character in one of the supported code pages. However, any string of DBCS characters that is within an alphanumeric literal must be delimited by the SO and SI characters, and the DBCS compiler option must be in effect for the SO and SI characters to be recognized as shift codes.

You cannot continue an alphanumeric literal that contains DBCS characters. The length of a DBCS literal is likewise limited by the available space in Area B on a single source line. The maximum length of a DBCS literal is thus 28 double-byte characters.

An alphanumeric literal that contains DBCS characters is processed byte by byte, that is, with semantics appropriate for single-byte characters, except when it is converted explicitly or implicitly to national data representation, as for example in an assignment to or comparison with a national data item.
Testing for valid DBCS characters

The Kanji class test tests for valid Japanese graphic characters. This testing includes Katakana, Hiragana, Roman, and Kanji character sets.

The Kanji class test is done by checking characters for the range X'41' through X'7E' in the first byte and X'41' through X'FE' in the second byte, plus the space character X'4040'.

The DBCS class test tests for valid graphic characters for the code page.

The DBCS class test is done by checking characters for the range X'41' through X'FE' in both the first and second byte of each character, plus the space character X'4040'.

Processing alphanumeric data items that contain DBCS data

If you use byte-oriented operations (for example, STRING, UNSTRING, or reference modification) on an alphanumeric data item that contains DBCS characters, results are unpredictable. You should instead convert the item to a national data item before you process it.

That is, do these steps:

1. Convert the item to UTF-16 in a national data item by using a MOVE statement or the NATIONAL-OF intrinsic function.
2. Process the national data item as needed.
3. Convert the result back to an alphanumeric data item by using the DISPLAY-OF intrinsic function.

related tasks

“Joining data items (STRING)” on page 101
“Splitting data items (UNSTRING)” on page 103
“Referring to substrings of data items” on page 107
“Converting to or from national (Unicode) representation” on page 131
Chapter 8. Processing files

Reading and writing data is an essential part of every program. Your program retrieves information, processes it as you request, and then produces the results.

The source of the information and the target for the results can be one or more of the following items:

- Another program
- Direct-access storage device
- Magnetic tape
- Printer
- Terminal
- Card reader or punch

The information as it exists on an external device is in a physical record or block, a collection of information that is handled as a unit by the system during input or output operations.

Your COBOL program does not directly handle physical records. It processes logical records. A logical record can correspond to a complete physical record, part of a physical record, or to parts or all of one or more physical records. Your COBOL program handles logical records exactly as you have defined them.

In COBOL, a collection of logical records is a file, a sequence of pieces of information that your program can process.

**related concepts**

“File organization and input-output devices” on page 145

**related tasks**

“Choosing file organization and access mode” on page 146
“Allocating files” on page 148
“Checking for input or output errors” on page 149

File organization and input-output devices

Depending on the input-output devices, your file organization can be sequential, line sequential, indexed, or relative. Decide on the file types and devices to be used when you design your program.

You have the following choices of file organization:

**Sequential file organization**

The chronological order in which records are entered when a file is created establishes the arrangement of the records. Each record except the first has a unique predecessor record, and each record except the last has a unique successor record. Once established, these relationships do not change.

The access (record transmission) mode allowed for sequential files is sequential only.

**Line-sequential file organization**

Line-sequential files are sequential files that reside in the z/OS UNIX file system and that contain only characters as data. Each record ends with a newline character.

The only access (record transmission) mode allowed for line-sequential files is sequential.

**Indexed file organization**

Each record in the file contains a special field whose contents form the record key. The position of the key is the same in each record. The index component of the file establishes the logical arrangement of the file, an ordering by record key. The actual physical arrangement of the records in the file is not significant to your COBOL program.
An indexed file can also use alternate indexes in addition to the record key. These keys let you access the file using a different logical ordering of the records.

The access (record transmission) modes allowed for indexed files are sequential, random, or dynamic. When you read or write indexed files sequentially, the sequence is that of the key values.

**Relative file organization**

Records in the file are identified by their location relative to the beginning of the file. The first record in the file has a relative record number of 1, the tenth record has a relative record number of 10, and so on.

The access (record transmission) modes allowed for relative files are sequential, random, or dynamic. When relative files are read or written sequentially, the sequence is that of the relative record number.

With IBM Enterprise COBOL for z/OS, requests to the operating system for the storage and retrieval of records from input-output devices are handled by the two access methods QSAM and VSAM, and the z/OS UNIX file system.

The device type upon which you elect to store your data could affect the choices of file organization available to you. Direct-access storage devices provide greater flexibility in the file organization options. Sequential-only devices limit organization options but have other characteristics, such as the portability of tapes, that might be useful.

**Sequential-only devices**

Terminals, printers, card readers, and punches are called *unit-record devices* because they process one line at a time. Therefore, you must also process records one at a time sequentially in your program when it reads from or writes to unit-record devices.

On tape, records are ordered sequentially, so your program must process them sequentially. Use QSAM physical sequential files when processing tape files. The records on tape can be fixed length or variable length.

**Direct-access storage devices**

Direct-access storage devices hold many records. The record arrangement of files stored on these devices determines the ways that your program can process the data. When using direct-access devices, you have greater flexibility within your program, because you can use several types of file organization:

- Sequential (VSAM or QSAM)
- Line sequential (z/OS UNIX)
- Indexed (VSAM)
- Relative (VSAM)

**related tasks**

- “Allocating files” on page 148
- Chapter 9, “Processing QSAM files,” on page 151
- Chapter 10, “Processing VSAM files,” on page 173
- Chapter 11, “Processing line-sequential files,” on page 199
- “Choosing file organization and access mode” on page 146

**Choosing file organization and access mode**

There are several guidelines you can use to determine which file organization and access mode to use in an application.

Consider the following guidelines when choosing file organization:

- If an application accesses records (whether fixed-length or variable-length) only sequentially and does not insert records between existing records, a QSAM or VSAM sequential file is the simplest type.
If you are developing an application for z/OS UNIX file system that sequentially accesses records that contain only printable characters and certain control characters, line-sequential files work best.

If an application requires both sequential and random access (whether records are fixed length or variable length), a VSAM indexed file is the most flexible type.

If an application inserts and deletes records randomly, a relative file works well.

Consider the following guidelines when choosing access mode:

- If a large percentage of a file is referenced or updated in an application, sequential access is faster than random or dynamic access.
- If a small percentage of records is processed during each run of an application, use random or dynamic access.

Table 19. Summary of file organizations, access modes, and record formats of COBOL files

<table>
<thead>
<tr>
<th>File organization</th>
<th>Sequential access</th>
<th>Random access</th>
<th>Dynamic access</th>
<th>Fixed length</th>
<th>Variable length</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSAM (physical sequential)</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Line sequential</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X^1</td>
<td>X</td>
</tr>
<tr>
<td>VSAM sequential (ESDS)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VSAM indexed (KSDS)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VSAM relative (RRDS)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

1. The data itself is in variable format but can be read into and written from COBOL fixed-length records.

related references
“Format for coding input and output” on page 147
“Control characters in line-sequential files” on page 200

Format for coding input and output
The following example shows the general format of input-output coding. Explanations of the user-supplied information are shown after the code.

IDENTIFICATION DIVISION.

ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT filename ASSIGN TO assignment-name (1) (2)
    ORGANIZATION IS org ACCESS MODE IS access (3) (4)
    FILE STATUS IS file-status (5)

DATA DIVISION.
FILE SECTION.
FD filename
    01 recordname (6) (7) (8)

WORKING-STORAGE SECTION
    01 file-status PICTURE 99.

PROCEDURE DIVISION.
    OPEN iomode filename (9)
    READ filename
    WRITE recordname
    CLOSE filename
The user-supplied information in the code above is described below:

(1) filename
Any legal COBOL name. You must use the same file-name in the SELECT clause and in the FD entry, and in the READ, OPEN, and CLOSE statements. In addition, the file-name is required if you use the START or DELETE statements. This name is not necessarily the actual name of the data set as known to the system. Each file requires its own SELECT clause, FD entry, and input-output statements.

(2) assignment-name
Any name you choose, provided that it follows COBOL and system naming rules. The name can be 1 - 30 characters long if it is a user-defined word, or 1 - 160 characters long if it is a literal. You code the name part of the assignment-name in a DD statement, in an ALLOCATE command (TSO), or as an environment variable (for example, in an export command) (z/OS UNIX).

(3) org
The organization can be SEQUENTIAL, LINE SEQUENTIAL, INDEXED, or RELATIVE. This clause is optional for QSAM files.

(4) access
The access mode can be SEQUENTIAL, RANDOM, or DYNAMIC. For sequential file processing, including line-sequential, you can omit this clause.

(5) file-status
The COBOL file status key. You can specify the file status key as a two-character category alphanumeric or category national item, or as a two-digit zoned decimal (USAGE DISPLAY) or national decimal (USAGE NATIONAL) item.

(6) recordname
The name of the record used in the WRITE or REWRITE statements.

(7) fieldlength
The logical length of the field.

(8) type
The record format of the file. If you break the record entry beyond the level-01 description, map each element accurately against the fields in the record.

(9) iomode
The INPUT or OUTPUT mode. If you are only reading from a file, code INPUT. If you are only writing to a file, code OUTPUT or EXTEND. If you are both reading and writing, code I-O, except for organization LINE SEQUENTIAL.

related tasks
Chapter 9, “Processing QSAM files,” on page 151
Chapter 10, “Processing VSAM files,” on page 173
Chapter 11, “Processing line-sequential files,” on page 199

Allocating files
For any type of file (sequential, line sequential, indexed, or relative) in your z/OS or z/OS UNIX applications, you can define the external name with either a ddname or an environment-variable name. The external name is the name in the assignment-name of the ASSIGN clause.

If the file is in the z/OS UNIX file system, you can use either a DD definition or an environment variable to define the file by specifying its path name with the PATH keyword.

The environment-variable name must be uppercase. The allowable attributes for its value depend on the organization of the file being defined.

Because you can define the external name in either of two ways, the COBOL run time goes through the following steps to find the definition of the file:
1. If the ddname is explicitly allocated, it is used. The definition can be from a DD statement in JCL, an
ALLOCATE command from TSO/E, or a user-initiated dynamic allocation.

2. If the ddname is not explicitly allocated and an environment variable of the same name is set, the
value of the environment variable is used.

The file is dynamically allocated using the attributes specified by the environment variable. At a
minimum, you must specify either the PATH() or DSN() option. All options and attributes must be in
uppercase, except for the path-name suboption of the PATH option, which is case sensitive. You
cannot specify a temporary data-set name in the DSN() option.

File status code 98 results from any of the following cases:

- The contents (including a value of null or all blanks) of the environment variable are not valid.
- The dynamic allocation of the file fails.
- The dynamic deallocation of the file fails.

The COBOL run time checks the contents of the environment variable at each OPEN statement. If a file
with the same external name was dynamically allocated by a previous OPEN statement, and the
contents of the environment variable have changed since that OPEN, the run time dynamically
deallocates the previous allocation and reallocates the file using the options currently set in the
environment variable. If the contents of the environment variable have not changed, the run time uses
the current allocation.

3. If neither a ddname nor an environment variable is defined, the following steps occur:

   a) If the allocation is for a QSAM file and the CBLQDA runtime option is in effect, CBLQDA dynamic
      allocation processing takes place for those eligible files. This type of "implicit" dynamic allocation
      persists for the life of the run unit and cannot be reallocated.

   b) Otherwise, the allocation fails.

The COBOL run time deallocates all dynamic allocations at run unit termination, except for implicit
CBLQDA allocations.

related tasks
“Setting and accessing environment variables” on page 436
“Defining and allocating QSAM files” on page 164
“Dynamically creating QSAM files” on page 161
“Allocating VSAM files” on page 192

Checking for input or output errors

After each input or output statement is performed, the file status key is updated with a value that
indicates the success or failure of the operation.

Using a FILE STATUS clause, test the file status key after each input or output statement, and call an
error-handling procedure if a nonzero file status code is returned. With VSAM files, you can use a second
data item in the FILE STATUS clause to get additional VSAM status code information.

Another way of handling errors in input and output operations is to code ERROR (synonymous with
EXCEPTION) declaratives.

related tasks
“Handling errors in input
and output operations” on page 225
“Coding ERROR declaratives” on page 228
“Using file status keys” on page 229
Chapter 9. Processing QSAM files

Queued sequential access method (QSAM) files are unkeyed files in which the records are placed one after another, according to entry order.

Your program can process these files only sequentially, retrieving (with the READ statement) records in the same order as they are in the file. Each record is placed after the preceding record. To process QSAM files in your program, use COBOL language statements that:

• Identify and describe the QSAM files in the ENVIRONMENT DIVISION and the DATA DIVISION.
• Process the records in these files in the PROCEDURE DIVISION.

After you have created a record, you cannot change its length or its position in the file, and you cannot delete it. You can, however, update QSAM files on direct-access storage devices (using REWRITE), though not in the z/OS UNIX file system.

QSAM files can be on tape, direct-access storage devices (DASDs), unit-record devices, and terminals. QSAM processing is best for tables and intermediate storage.

You can also access byte-stream files in the z/OS UNIX file system using QSAM. These files are binary byte-oriented sequential files with no record structure. The record definitions that you code in your COBOL program and the length of the variables that you read into and write from determine the amount of data transferred.

related concepts
z/OS DFSMS: Using Data Sets (Access methods)

related tasks
“Defining QSAM files and records in COBOL” on page 151
“Coding input and output statements for QSAM files” on page 160
“Handling errors in QSAM files” on page 163
“Working with QSAM files” on page 163
“Accessing z/OS UNIX files using QSAM” on page 170
“Processing QSAM ASCII files on tape” on page 171

Defining QSAM files and records in COBOL

Use the FILE-CONTROL entry to define the files in a COBOL program as QSAM files, and to associate the files with their external file-names.

An external file-name (a ddname or environment variable name) is the name by which a file is known to the operating system. In the following example, COMMUTER-FILE-MST is your program’s name for the file; COMMUTR is the external name:

```cobol
FILE-CONTROL.
  SELECT COMMUTER-FILE-MST
  ASSIGN TO S-COMMUTR
  ORGANIZATION IS SEQUENTIAL
  ACCESS MODE IS SEQUENTIAL.
```

The ASSIGN clause name can include an S- before the external name to document that the file is a QSAM file. Both the ORGANIZATION and ACCESS MODE clauses are optional.

related tasks
“Establishing record formats” on page 152
“Setting block sizes” on page 158
Establishing record formats

In the FD entry in the DATA DIVISION, code the record format and indication of whether the records are blocked. In the associated record description entry or entries, specify the record-name and record length.

You can code a record format of F, V, S, or U in the RECORDING MODE clause. COBOL determines the record format from the RECORD clause or from the record descriptions associated with the FD entry for the file. If you want the records to be blocked, code the BLOCK CONTAINS clause in the FD entry.

The following example shows how the FD entry might look for a file that has fixed-length records:

```cobol
FILE SECTION.
FD COMMUTER-FILE-MST
  RECORDING MODE IS F
  BLOCK CONTAINS 0 RECORDS
  RECORD CONTAINS 80 CHARACTERS.
  01 COMMUTER-RECORD-MST.
    05 COMMUTER-NUMBER PIC X(16).
    05 COMMUTER-DESCRIPTION PIC X(64).
```

A recording mode of S is not supported for files in the z/OS UNIX file system. The above example is appropriate for such a file.

related concepts
“Logical records” on page 152

related tasks
“Requesting fixed-length format” on page 152
“Requesting variable-length format” on page 153
“Requesting spanned format” on page 155
“Requesting undefined format” on page 157
“Defining QSAM files and records in COBOL” on page 151

related references
“FILE SECTION entries” on page 11

Logical records

COBOL uses the term logical record in a slightly different way than z/OS QSAM.

For format-V and format-S files, a QSAM logical record includes a 4-byte prefix in front of the user data portion of the record that is not included in the definition of a COBOL logical record.

For format-F and format-U files, and for byte-stream files in the z/OS UNIX file system, the definitions of QSAM logical record and COBOL logical record are identical.

In this information, QSAM logical record refers to the QSAM definition, and logical record refers to the COBOL definition.

related references
“Layout of format-F records” on page 153
“Layout of format-V records” on page 154
“Layout of format-S records” on page 156
“Layout of format-U records” on page 157

Requesting fixed-length format

Fixed-length records are in format F. Use RECORDING MODE F to explicitly request this format.

You can omit the RECORDING MODE clause. The compiler determines the recording mode to be F if the length of the largest level-01 record associated with the file is not greater than the block size coded in the BLOCK CONTAINS clause, and you take one of the following actions:

• Use the RECORD CONTAINS integer clause (format-1 RECORD clause) to indicate the length of the record in bytes.
When you use this clause, the file is always fixed format with record length *integer* even if there are multiple level-01 record description entries with different lengths associated with the file.

- Omit the RECORD CONTAINS *integer* clause, but code the same fixed size and no OCCURS DEPENDING ON clause for all level-01 record description entries associated with the file. This fixed size is the record length.

In an unblocked format-F file, the logical record is the same as the block.

In a blocked format-F file, the number of logical records in a block (the *blocking factor*) is constant for every block in the file except the last block, which might be shorter.

Files in the z/OS UNIX file system are never blocked.

**related concepts**

“Logical records” on page 152

**related tasks**

“Requesting variable-length format” on page 153
“Requesting spanned format” on page 155
“Requesting undefined format” on page 157
“Establishing record formats” on page 152

**related references**

“Layout of format-F records” on page 153

---

**Layout of format-F records**

The layout of format-F QSAM records is shown below.

```
<table>
<thead>
<tr>
<th>Unblocked Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Record</td>
</tr>
<tr>
<td>Fixed Length</td>
</tr>
</tbody>
</table>
```

```
<table>
<thead>
<tr>
<th>Blocked Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Record</td>
</tr>
<tr>
<td>Logical Record</td>
</tr>
<tr>
<td>Logical Record</td>
</tr>
<tr>
<td>Fixed Length</td>
</tr>
</tbody>
</table>
```

**related concepts**

“Logical records” on page 152

**related tasks**

“Requesting fixed-length format” on page 152

**z/OS DFSMS: Using Data Sets (Fixed-length record formats)**

**related references**

“Layout of format-V records” on page 154
“Layout of format-S records” on page 156
“Layout of format-U records” on page 157

---

**Requesting variable-length format**

Variable-length records can be in format V or format D. Format-D records are variable-length records on ASCII tape files. Format-D records are processed in the same way as format-V records.

Use RECORDING MODE V for both. You can omit the RECORDING MODE clause. The compiler determines the recording mode to be V if the largest level-01 record associated with the file is not greater than the block size set in the BLOCK CONTAINS clause, and you take one of the following actions:

- Use the RECORD IS VARYING clause (format-3 RECORD clause).

If you provide values for *integer-1* and *integer-2* (RECORD IS VARYING FROM *integer-1* TO *integer-2*), the maximum record length is the value coded for *integer-2* regardless of the lengths coded in the
level-01 record description entries associated with the file. The integer sizes indicate the minimum and maximum record lengths in numbers of bytes regardless of the USAGE of the data items in the record.

If you omit integer-1 and integer-2, the maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.

- Use the RECORD CONTAINS integer-1 TO integer-2 clause (format-2 RECORD clause). Make integer-1 and integer-2 match the minimum length and the maximum length in bytes of the level-01 record description entries associated with the file. The maximum record length is the integer-2 value.
- Omit the RECORD clause, but code multiple level-01 records (associated with the file) that are of different sizes or contain an OCCURS DEPENDING ON clause.

The maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.

When you specify a READ INTO statement for a format-V file, the record size read for that file is used in the MOVE statement generated by the compiler. Consequently, you might not get the result you expect if the record just read does not correspond to the level-01 record description. All other rules of the MOVE statement apply. For example, when you specify a MOVE statement for a format-V record read in by the READ statement, the size of the record moved corresponds to its level-01 record description.

When you specify a READ statement for a format-V file followed by a MOVE of the level-01 record, the actual record length is not used. The program will attempt to move the number of bytes described by the level-01 record description. If this number exceeds the actual record length and extends outside the area addressable by the program, results are unpredictable. If the number of bytes described by the level-01 record description is shorter than the physical record read, truncation of bytes beyond the level-01 description occurs. To find the actual length of a variable-length record, specify data-name-1 in format 3 of the RECORD clause of the File Definition (FD).

related tasks
“Requesting fixed-length format” on page 152
“Requesting spanned format” on page 155
“Requesting undefined format” on page 157
“Establishing record formats” on page 152

related references
“FILE SECTION entries” on page 11
“Layout of format-V records” on page 154
Enterprise COBOL Migration Guide (Moving from the VS COBOL II run time)

**Layout of format-V records**
Format-V QSAM records have control fields that precede the data. The QSAM logical record length is determined by adding 4 bytes (for the control fields) to the record length defined in your program. However, you must not include these 4 bytes in the description of the record and record length.

![Diagram of layout of format-V records]

**CC**
The first 4 bytes of each block contain control information.

**LL** Represents 2 bytes designating the length of the block (including the CC field).

**BB** Represents 2 bytes reserved for system use.
The first 4 bytes of each logical record contain control information.

**cc** Represents 2 bytes designating the logical record length (including the cc field).

**bb** Represents 2 bytes reserved for system use.

The block length is determined as follows:
- **Unblocked format-V records:** CC + cc + the data portion
- **Blocked format-V records:** CC + the cc of each record + the data portion of each record

The operating system provides the control bytes when the file is written; the control byte fields do not appear in the description of the logical record in the DATA DIVISION of your program. COBOL allocates input and output buffers that are large enough to accommodate the control bytes. These control fields in the buffer are not available for you to use in your program. When variable-length records are written on unit record devices, control bytes are neither printed nor punched. They appear however on other external storage devices, as well as in buffer areas of storage. If you move V-mode records from an input buffer to a WORKING-STORAGE area, the records will be moved without the control bytes.

Files in the z/OS UNIX file system are never blocked.

**related concepts**
“Logical records” on page 152

**related tasks**
“Requesting variable-length format” on page 153

**related references**
“Layout of format-F records” on page 153
“Layout of format-S records” on page 156
“Layout of format-U records” on page 157

**Requesting spanned format**
Spanned records are in format S. A *spanned record* is a QSAM logical record that can be contained in one or more physical blocks.

You can code RECORDING MODE S for spanned records in QSAM files that are assigned to magnetic tape or to direct access devices. Do not request spanned records for files in the z/OS UNIX file system. You can omit the RECORDING MODE clause. The compiler determines the recording mode to be S if the maximum record length (in bytes) plus 4 is greater than the block size set in the BLOCK CONTAINS clause.

For files with format S in your program, the compiler determines the maximum record length with the same rules as are used for format V. The length is based on your usage of the RECORD clause.

When creating files that contain format-S records and a record is larger than the remaining space in a block, COBOL writes a segment of the record to fill the block. The rest of the record is stored in the next block or blocks depending on its length. COBOL supports QSAM spanned records up to 32,760 bytes in length.

When retrieving files that have format-S records, a program can retrieve only complete records.

**Benefits of format-S files:** You can efficiently use external storage and still organize your files with logical record lengths by defining files with format-S records:
- You can set block lengths to efficiently use track capacities on direct access devices.
- You are not required to adjust the logical record lengths to device-dependent physical block lengths. One logical record can span two or more physical blocks.
- You have greater flexibility when you want to transfer logical records between direct access storage types.

You will, however, have additional overhead in processing format-S files.

**Format-S files and READ INTO:** When you specify a READ INTO statement for a format-S file, the compiler generates a MOVE statement that uses the size of the record that it just read for that file. If the
record just read does not correspond to the level-01 record description, you might not get the result that you expect. All other rules of the MOVE statement apply.

related concepts
“Logical records” on page 152
“Spanned blocked and unblocked files” on page 156

related tasks
“Requesting fixed-length format” on page 152
“Requesting variable-length format” on page 153
“Requesting undefined format” on page 157
“Establishing record formats” on page 152

related references
“FILE SECTION entries” on page 11
“Layout of format-S records” on page 156

Spanned blocked and unblocked files
A spanned blocked QSAM file is made up of blocks, each containing one or more logical records or segments of logical records. A spanned unblocked file is made up of physical blocks, each containing one logical record or one segment of a logical record.

In a spanned blocked file, a logical record can be either fixed or variable in length, and its size can be smaller than, equal to, or larger than the physical block size. There are no required relationships between logical records and physical block sizes.

In a spanned unblocked file, the logical records can be either fixed or variable in length. When the physical block contains one logical record, the block length is determined by the logical record size. When a logical record has to be segmented, the system always writes the largest physical block possible. The system segments the logical record when the entire logical record cannot fit on a track.

related concepts
“Logical records” on page 152

related tasks
“Requesting spanned format” on page 155

Layout of format-S records
Spanned records are preceded by control fields, as explained below.

Each block is preceded by a 4-byte block descriptor field (‘BDF’ in the image above). There is only one block descriptor field at the beginning of each physical block.

Each segment of a record in a block is preceded by a 4-byte segment descriptor field (‘SDF’ in the image) even if the segment is the entire record. There is one segment descriptor field for each record segment in the block. The segment descriptor field also indicates whether the segment is the first, the last, or an intermediate segment.

You do not describe these fields in the DATA DIVISION, and the fields are not available for you to use in your COBOL program.

related tasks
“Requesting spanned format” on page 155

related references
“Layout of format-F records” on page 153
“Layout of format-V records” on page 154
“Layout of format-U records” on page 157
Requesting undefined format
Format-U records have undefined or unspecified characteristics. With format U, you can process blocks that do not meet format-F or format-V specifications.

When you use format-U files, each block of storage is one logical record. A read of a format-U file returns the entire block as a record. A write to a format-U file writes a record out as a block. The compiler determines the recording mode to be U only if you code RECORDING MODE U.

It is recommended that you not use format U to update or extend a file that was written with a different record format. If you use format U to update a file that was written with a different format, the RECFM value in the data-set label could be changed or the data set could contain records written in different formats.

The record length is determined in your program based on how you use the RECORD clause:

- If you use the RECORD CONTAINS integer clause (format-1 RECORD clause), the record length is the integer value regardless of the lengths of the level-01 record description entries associated with the file. The integer size indicates the number of bytes in a record regardless of the USAGE of its data items.
- If you use the RECORD IS VARYING clause (format-3 RECORD clause), the record length is determined based on whether you code integer-1 and integer-2.
   - If you code integer-1 and integer-2 (RECORD IS VARYING FROM integer-1 TO integer-2), the maximum record length is the integer-2 value regardless of the lengths of the level-01 record description entries associated with the file. The integer sizes indicate the minimum and maximum record lengths in numbers of bytes regardless of the USAGE of the data items in the record.
   - If you omit integer-1 and integer-2, the maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.
- If you use the RECORD CONTAINS integer-1 TO integer-2 clause (format-2 RECORD clause), with integer-1 and integer-2 matching the minimum length and the maximum length in bytes of the level-01 record description entries associated with the file, the maximum record length is the integer-2 value.
- If you omit the RECORD clause, the maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.

Format-U files and READ INTO: When you specify a READ INTO statement for a format-U file, the compiler generates a MOVE statement that uses the size of the record that it just read for that file. If the record just read does not correspond to the level-01 record description, you might not get the result that you expect. All other rules of the MOVE statement apply.

related tasks
“Requesting fixed-length format” on page 152
“Requesting variable-length format” on page 153
“Requesting spanned format” on page 155
“Establishing record formats” on page 152

related references
“FILE SECTION entries” on page 11
“Layout of format-U records” on page 157

Layout of format-U records
With format-U, each block of external storage is handled as a logical record. There are no record-length or block-length fields.

related concepts
“Logical records” on page 152
Setting block sizes

In COBOL, you establish the size of a physical record by using the BLOCK CONTAINS clause. If you omit this clause, the compiler assumes that the records are not blocked.

Blocking QSAM files on tape and disk can enhance processing speed and minimize storage requirements. You can block files in the z/OS UNIX file system, PDSE members, and spooled data sets, but doing so has no effect on how the system stores the data.

If you set the block size explicitly in the BLOCK CONTAINS clause, the size must not be greater than the maximum block size for the device. If you specify the CHARACTERS phrase of the BLOCK CONTAINS clause, size must indicate the number of bytes in a record regardless of the USAGE of the data items in the record. The block size that is set for a format-F file must be an integral multiple of the record length.

If your program uses QSAM files on tape, use a physical block size of at least 12 to 18 bytes. Otherwise, the block will be skipped over when a parity check occurs during one of the following actions:

- Reading a block of records of fewer than 12 bytes
- Writing a block of records of fewer than 18 bytes

Larger blocks generally give you better performance. Blocks of only a few kilobytes are particularly inefficient; you should choose a block size of at least tens of kilobytes. If you specify record blocking and omit the block size, the system will pick a block size that is optimal for device utilization and for data transfer speed.

Letting z/OS determine block size: To maximize performance, do not explicitly set the block size for a blocked file in your COBOL source program. For new blocked data sets, it is simpler to allow z/OS to supply a system-determined block size. To use this feature, follow these guidelines:

- Code BLOCK CONTAINS 0 in your source program or compile with the BLOCK0 option. For details about BLOCK0, see “BLOCK0” on page 292.
- Do not code RECORD CONTAINS 0 in your source program.
- Do not code a BLKSIZE value in the JCL DD statement.

Setting block size explicitly: If you prefer to set a block size explicitly, your program will be most flexible if you follow these guidelines:

- Code BLOCK CONTAINS 0 in your source program.
- Code a BLKSIZE value in the ddname definition (the JCL DD statement).

For extended-format data sets on z/OS, z/OS DFSMS adds a 32-byte block suffix to the physical record. If you specify a block size explicitly (using JCL or ISPF), do not include the size of this block suffix in the block size. This block suffix is not available for you to use in your program. z/OS DFSMS allocates the space used to read in the block suffix. However, when you calculate how many blocks of an extended-format data set will fit on a track of a direct-access device, you need to include the size of the block suffix in the block size.

If you specify a block size that is larger than 32760 directly in the BLOCK CONTAINS clause or indirectly with the use of BLOCK CONTAINS n RECORDS, the OPEN of the data set fails with file status code 90 unless you define the data set to be on tape.

For existing blocked data sets, it is simplest to:

- Code BLOCK CONTAINS 0 in your source program.
- Not code a BLKSIZE value in the ddname definition.
When you omit the BLKSIZE from the ddname definition, the block size is automatically obtained by the system from the data-set label.

**Taking advantage of LBI:** You can improve the performance of tape data sets by using the large block interface (LBI) for large block sizes. When the LBI is available, the COBOL run time automatically uses this facility for those tape files for which you use system-determined block size. LBI is also used for those files for which you explicitly define a block size in JCL or a BLOCK CONTAINS clause. Use of the LBI allows block sizes to exceed 32760 if the tape device supports it.

The LBI is not used in all cases. An attempt to use a block size greater than 32760 in the following cases is diagnosed at compile time or results in a failure at OPEN:

- Spanned records
- OPEN I-O

Using a block size that exceeds 32760 might result in your not being able to read the tape on another system. A tape that you create with a block size greater than 32760 can be read only on a system that has a tape device that supports block sizes greater than 32760. If you specify a block size that is too large for the file, the device, or the operating system level, a runtime message is issued.

To limit a system-determined block size to 32760, do not specify BLKSIZE anywhere, and set one of the following items to 32760:

- The BLKSZLIM keyword on the DD statement for the data set
- BLKSZLIM for the data class by using the BLKSZLIM keyword (must be set by your systems programmer)
- A block-size limit for the system in the DEV$SUPxx member of SYS1.PARMLIB by using the keyword TAPEBLKSZLIM (must be set by your systems programmer)

The block-size limit is the first nonzero value that the compiler finds by checking these items.

If no BLKSIZE or BLKSZLIM value is available from any source, the system limits BLKSIZE to 32760. You can then enable block sizes larger than 32760 in one of two ways:

- Specify a BLKSZLIM value greater than 32760 in the DD statement for the file and use BLOCK CONTAINS 0 in your COBOL source.
- Specify a value greater than 32760 for the BLKSIZE in the DD statement or in the BLOCK CONTAINS clause in your COBOL source.

BLKSZLIM is device-independent.

**Block size and the DCB RECFM subparameter:** Under z/OS, you can code the S or T option in the DCB RECFM subparameter:

- Use the S (standard) option in the DCB RECFM subparameter for a format-F record with only standard blocks (ones that have no truncated blocks or unfilled tracks in the file, except for the last block of the file). S is also supported for records on tape. It is ignored if the records are not on DASD or tape.

  Using this standard block option might improve input-output performance, especially for direct-access devices.

- The T (track overflow) option for QSAM files is no longer useful.

**related tasks**
“Defining QSAM files and records in COBOL” on page 151
z/OS DFSMS: Using Data Sets

**related references**
“FILE SECTION entries” on page 11
“BLOCKO” on page 292
BLOCK CONTAINS clause (Enterprise COBOL for z/OS Language Reference)
You can code the following input and output statements to process a QSAM file or a byte-stream file in the z/OS UNIX file system using QSAM: OPEN, READ, WRITE, REWRITE, and CLOSE.

**OPEN**
Initiates the processing of files. You can open all QSAM files as INPUT, OUTPUT, or EXTEND (depending on device capabilities).

You can also open QSAM files on direct access storage devices as I-O. You cannot open z/OS UNIX files as I-O; a file status of 37 results if you attempt to do so.

**READ**
Reads a record from the file. With sequential processing, your program reads one record after another in the same order in which they were entered when the file was created.

**WRITE**
Creates a record in the file. Your program writes new records to the end of the file.

**REWRITE**
Updates a record. You cannot update a file in the z/OS UNIX file system using REWRITE.

**CLOSE**
Releases the connection between the file and your program.

**related tasks**
- “Opening QSAM files” on page 160
- “Dynamically creating QSAM files” on page 161
- “Adding records to QSAM files” on page 161
- “Updating QSAM files” on page 161
- “Writing QSAM files to a printer or spooled data set” on page 162
- “Closing QSAM files” on page 162

**related references**
- OPEN statement ([Enterprise COBOL for z/OS Language Reference](#))
- READ statement ([Enterprise COBOL for z/OS Language Reference](#))
- WRITE statement ([Enterprise COBOL for z/OS Language Reference](#))
- REWRITE statement ([Enterprise COBOL for z/OS Language Reference](#))
- CLOSE statement ([Enterprise COBOL for z/OS Language Reference](#))
- File status key ([Enterprise COBOL for z/OS Language Reference](#))

**Opening QSAM files**
Before a program can use any READ, WRITE, or REWRITE statements to process records in a file, it must first open the file by using an OPEN statement.

An OPEN statement works if both of the following conditions are true:

- The file is available or has been dynamically allocated.
- The **fixed file attributes** coded in the ddname definition or the data-set label for the file match the attributes coded for that file in the SELECT clause and FD entry.

Mismatches in the file-organization attributes, code set, maximum record size, or record format (fixed or variable) result in file status code 39, and the failure of the OPEN statement. Mismatches in maximum record size and record format are not errors when opening files in the z/OS UNIX file system.

For fixed-length QSAM files, if you code RECORD CONTAINS 0 in the FD entry, the record size attributes are not in conflict. The record size is taken from the DD statement or the data-set label, and the OPEN statement is successful.

Code CLOSE WITH LOCK so that the file cannot be opened again while the program is running.
Use the REVERSED option of the OPEN statement to process tape files in reverse order. The file is positioned at the end, and READ statements read the data records in reverse order, starting with the last record. The REVERSED option is supported only for files that have fixed-length records.

related tasks
“Dynamically creating QSAM files” on page 161
“Ensuring that file attributes match your program” on page 167

related references
OPEN statement (Enterprise COBOL for z/OS Language Reference)

Dynamically creating QSAM files

Sometimes a QSAM file is unavailable on the operating system, but a COBOL program specifies that the file be created. Under certain circumstances, the file is created for you dynamically.

A QSAM file is considered to be available on z/OS when it has been identified to the operating system using a valid DD statement, an export command for an environment variable, or a TSO ALLOCATE command. Otherwise the file is unavailable.

Note that a DD statement with a misspelled ddname is equivalent to a missing DD statement, and an environment variable with a value that is not valid is equivalent to an unset variable.

The QSAM file is implicitly created if you use the runtime option CBLQDA and one of the following circumstances exists:

• An optional file is being opened as EXTEND or I-O.

  Optional files are files that are not necessarily available each time the program is run. You define a file that is being opened in INPUT, I-O, or EXTEND mode as optional by coding the SELECT OPTIONAL clause in the FILE-CONTROL paragraph.

• The file is being opened for OUTPUT, regardless of the OPTIONAL phrase.

The file is allocated with the system default attributes established at your installation and the attributes coded in the SELECT clause and FD entry in your program.

Do not confuse this implicit allocation mechanism with the explicit dynamic allocation of files by means of environment variables. Explicit dynamic allocation requires that a valid environment variable be set. CBLQDA support is used only when the QSAM file is unavailable as defined above, which includes no valid environment variable being set.

Under z/OS, files created using the CBLQDA option are temporary data sets and do not exist after the program has run.

related tasks
“Opening QSAM files” on page 160

Adding records to QSAM files

To add to a QSAM file, open the file as EXTEND and use the WRITE statement to add records immediately after the last record in the file.

To add records to a file opened as I-O, you must first close the file and open it as EXTEND.

related references
READ statement (Enterprise COBOL for z/OS Language Reference)
WRITE statement (Enterprise COBOL for z/OS Language Reference)

Updating QSAM files

You can update QSAM files only if they reside on direct access storage devices. You cannot update files in the z/OS UNIX file system.

Replace an existing record with another record of the same length by doing these steps:

1. Open the file as I-O.
2. Use REWRITE to update an existing record. (The last file processing statement before REWRITE must have been a successful READ statement.)

You cannot open as I-O an extended format data set that you allocate in compressed format.

related references
REWRITE statement (Enterprise COBOL for z/OS Language Reference)

Writing QSAM files to a printer or spooled data set
COBOL provides language statements to control the size of a printed page and control the vertical positioning of records.

Controlling the page size: Use the LINAGE clause of the FD entry to control the size of your printed page: the number of lines in the top and bottom margins and in the footing area of the page. When you use the LINAGE clause, COBOL handles the file as if you had also requested the ADV compiler option.

If you use the LINAGE clause in combination with WRITE BEFORE | AFTER ADVANCING nn LINES, be careful about the values you set. With the ADVANCING nn LINES phrase, COBOL first calculates the sum of LINAGE-COUNTER plus nn. Subsequent actions depend on the size of nn. The END-OF-PAGE imperative phrase is performed after the LINAGE-COUNTER is increased. Consequently, the LINAGE-COUNTER could be pointing to the next logical page instead of to the current footing area when the END-OF-PAGE phrase is performed.

AT END-OF-PAGE or NOT AT END-OF-PAGE imperative phrases are performed only if the write operation completes successfully. If the write operation is unsuccessful, control is passed to the end of the WRITE statement, and all conditional phrases are omitted.

Controlling the vertical positioning of records: Use the WRITE ADVANCING statement to control the vertical positioning of each record you write on a printed page.

BEFORE ADVANCING prints the record before the page is advanced. AFTER ADVANCING prints the record after the page is advanced.

Specify the number of lines the page is advanced with an integer (or an identifier with a mnemonic-name) following ADVANCING. If you omit the ADVANCING phrase from a WRITE statement, the effect is as if you had coded:

```
AFTER ADVANCING 1 LINE
```

related references
WRITE statement (Enterprise COBOL for z/OS Language Reference)

Closing QSAM files
Use the CLOSE statement to disconnect your program from a QSAM file. If you try to close a file that is already closed, you will get a logic error.

If you do not close a QSAM file, the file is automatically closed for you under the following conditions:

- When the run unit ends normally, the run time closes all open files that are defined in any COBOL programs in the run unit.
- If the run unit ends abnormally and the TRAP(ON) runtime option is in effect, the run time closes all open files that are defined in any COBOL programs in the run unit.
- When Language Environment condition handling has completed and the application resumes in a routine other than where the condition occurred, the run time closes all open files that are defined in any COBOL programs in the run unit that might be called again and reentered.

You can change the location where the program resumes running (after a condition is handled) by moving the resume cursor with the Language Environment CEEMRCR callable service or by using language constructs such as a C longjmp.
• When you use CANCEL for a COBOL subprogram, the run time closes any open nonexternal files that are defined in that program.

• When a COBOL subprogram with the INITIAL attribute returns control, the run time closes any open nonexternal files that are defined in that program.

• When a thread of a multithreaded application ends, both external and nonexternal files that you opened from within that same thread are closed.

File status key data items in the DATA DIVISION are set when these implicit CLOSE operations are performed, but your EXCEPTION/ERROR declarative is not invoked.

Errors: If you open a QSAM file in a multithreaded application, you must close it from the same thread of execution from which the file was opened. Attempting to close the file from a different thread results in a close failure with file-status condition 90.

related references
CLOSE statement (Enterprise COBOL for z/OS Language Reference)

Handling errors in QSAM files

When an input statement or output statement fails, COBOL does not take corrective action for you. You choose whether your program should continue running after a less-than-severe input or output error occurs.

COBOL provides these ways for you to intercept and handle certain QSAM input and output errors:
• End-of-file phrase (AT END)
• EXCEPTION/ERROR declarative
• FILE STATUS clause
• INVALID KEY phrase

If you do not code a FILE STATUS key or a declarative, serious QSAM processing errors will cause a message to be issued and a Language Environment condition to be signaled, which will cause an abend if you specify the runtime option ABTERMENC(ABEND).

If you use the FILE STATUS clause or the EXCEPTION/ERROR declarative, code EROPT=ACC in the DCB of the DD statement for that file. Otherwise, your COBOL program will not be able to continue processing after some error conditions.

If you use the FILE STATUS clause, be sure to check the key and take appropriate action based on its value. If you do not check the key, your program might continue, but the results will probably not be what you expected.

related tasks
“Handling errors in input and output operations” on page 225

Working with QSAM files

To work with QSAM files in a COBOL program, you define and allocate the files, retrieve them, and ensure that their file attributes match those in the program. You can also use striped extended-format QSAM data sets to help improve performance.

related tasks
“Defining and allocating QSAM files” on page 164
“Retrieving QSAM files” on page 166
“Ensuring that file attributes match your program” on page 167
“Using striped extended-format QSAM data sets” on page 169
Defining and allocating QSAM files

You can define a QSAM file or a byte-stream file in the z/OS UNIX file system by using either a DD statement or an environment variable. Allocation of these files follows the general rules for the allocation of COBOL files.

When you use an environment variable, the name must be in uppercase. Specify the MVS data set in one of these ways:

- `DSN(data-set-name)`
- `DSN(data-set-name(member-name))`

`data-set-name` must be fully qualified and cannot be a temporary data set (that is, it must not start with `&`).

**Restriction:** You cannot create a PDS or PDSE by using an environment variable.

You can optionally specify the following attributes in any order after `DSN`:

- A disposition value, one of: NEW, OLD, SHR, or MOD
- TRACKS or CYL
- SPACE(`nnn,mmm`)
- VOL(`volume-serial`)
- UNIT(`type`)
- KEEP, DELETE, CATALOG, or UNCATALOG
- STORCLAS(`storage-class`)
- MGMTCLAS(`management-class`)
- DATACLAS(`data-class`)

You can use either an environment variable or a DD definition to define a file in the z/OS UNIX file system. To do so, define one of the following items with a name that matches the external name in the ASSIGN clause:

- A DD allocation that uses `PATH='absolute-path-name'` and FILEDATA=BINARY
- An environment variable with a value `PATH(pathname)`, where `pathname` is an absolute path name (starting with `/`)

For compatibility with releases of COBOL before COBOL for OS/390 & VM Version 2 Release 2, you can also specify FILEDATA=TEXT when using a DD allocation for z/OS UNIX files, but this use is not recommended. To process text files in the z/OS UNIX file system, use LINE SEQUENTIAL organization. If you do use QSAM to process text files in the z/OS UNIX file system, you cannot use environment variables to define the files.

When you define a QSAM file, use the parameters as shown below.

<table>
<thead>
<tr>
<th>What you want to do</th>
<th>DD parameter to use</th>
<th>EV keyword to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name the file.</td>
<td>DSNAME(data-set-name)</td>
<td>DSN</td>
</tr>
<tr>
<td>Select the type and quantity of input-output devices to be allocated for the file.</td>
<td>UNIT</td>
<td>UNIT for type only</td>
</tr>
<tr>
<td>Give instructions for the volume in which the file will reside and for volume mounting.</td>
<td>VOLUME (or let the system choose an output volume)</td>
<td>VOL</td>
</tr>
</tbody>
</table>
Table 20. *QSAM file allocation* (continued)

<table>
<thead>
<tr>
<th>What you want to do</th>
<th>DD parameter to use</th>
<th>EV keyword to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocate the type and amount of space the file needs. (Only for direct-access storage devices.)</td>
<td>SPACE</td>
<td>SPACE for the amount of space (primary and secondary only); TRACKS or CYL for the type of space</td>
</tr>
<tr>
<td>Specify the type and some of the contents of the label associated with the file.</td>
<td>LABEL</td>
<td>n/a</td>
</tr>
<tr>
<td>Indicate whether you want to catalog, pass, or keep the file after the job step is completed.</td>
<td>DISP</td>
<td>NEW, OLD, SHR, MOD plus KEEP, DELETE, CATALOG, or UNCATALOG</td>
</tr>
<tr>
<td>Complete any data control block information that you want to add.</td>
<td>DCB subparameters</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Some of the information about the QSAM file must always be coded in the FILE-CONTROL paragraph, the FD entry, and other COBOL clauses. Other information must be coded in the DD statement or environment variable for output files. For input files, the system can obtain information from the file label (for standard label files). If DCB information is provided in the DD statement for input files, it overrides information on the data-set label. For example, the amount of space allocated for a new direct-access device file can be set in the DD statement by the SPACE parameter.

You cannot express certain characteristics of QSAM files in the COBOL language, but you can code them in the DD statement for the file by using the DCB parameter. Use the subparameters of the DCB parameter to provide information that the system needs for completing the data set definition, including the following items:

- Block size (BLKSIZE=), if BLOCK CONTAINS 0 RECORDS was coded at compile time (recommended)
- Options to be executed if an error occurs in reading or writing a record
- TRACK OVERFL0W or standard blocks
- Mode of operation for a card reader or punch

DCB attributes coded for a DD DUMMY do not override those coded in the FD entry of your COBOL program.

“Example: setting and accessing environment variables” on page 438

**related tasks**

“Setting block sizes” on page 158

“Defining QSAM files and records in COBOL” on page 151

“Allocating files” on page 148

**related references**

“Parameters for creating QSAM files” on page 166

*MVS Program Management: User’s Guide and Reference*
Parameters for creating QSAM files
The following DD statement parameters are frequently used to create QSAM files.

```
DSNAME= [dataset-name
         dataset-name(member-name)
         &name
         &name(member-name)]

DSN= (name[],unitcount)

UNIT= (name[],unitcount)

        ... ,SSR={volume-serial[,]volume-serial}...)
        REF={dsname
             *.ddname
             *stepname.ddname
             *stepname.procstep.ddname}

     ... ,SSR={volume-serial[,]volume-serial}...)
     REF={dsname
          *.ddname
          *stepname.ddname
          *stepname.procstep.ddname}

SPACE= ([TRK
           CYL
           average-record-length]
           (primary-quantity[,secondary-quantity][,directory-quantity]))

LABEL= ([Data-set-sequence-number,]
          [NL
           SL
           SUL]
          ,EJPTD={yyyyyy
                  yyyydd})

DISP= (NEW
       MOD
       KEEP
       PASS
       CATLG)

DCB= (subparameter-list)
```

related tasks
“Defining and allocating QSAM files” on page 164

Retrieving QSAM files
You retrieve QSAM files, cataloged or not, by using job control statements or environment variables.

Cataloged files
All data set information, such as volume and space, is stored in the catalog and file label. All you have
to code are the data set name and a disposition. When you use a DD statement, this is the DSNAME
parameter and the DISP parameter. When you use an environment variable, this is the DSN parameter
and one of the parameters OLD, SHR, or MOD.

Noncataloged files
Some information is stored in the file label, but you must code the unit and volume information, and
the dsname and disposition.

If you are using JCL, and you created the file in the current job step or in a previous job step in the current
job, you can refer to the previous DD statement for most of the data set information. You do, however,
needs to code DSNAME and DISP.

related references
“Parameters for retrieving QSAM files” on page 167
Parameters for retrieving QSAM files
The following DD statement parameters are used to retrieve previously created files.

```
DSNAME= dataset-name
      dataset-name(member-name)
      *.ddname
      *.
      stepname.
      name
      n

UNIT= name(unitcount)

VOLUME= subparameter-list

LABEL= subparameter-list

DISP= ( OLD
       SHR
       MOD
       DELETE
       KEEP
       PASS
       CATLG
       UNCATLG
       DELETE
       KEEP
       CATLG
       UNCATLG )

DCB= subparameter-list
```

related tasks
“Retrieving QSAM files” on page 166

Ensuring that file attributes match your program
When the fixed file attributes in the DD statement or the data-set label and the attributes that are coded for that file in the SELECT clause and FD entry are not consistent, an OPEN statement in your program might not work.

Mismatches in the attributes for file organization, record format (fixed or variable), record length, or the code set result in file status code 39 and the failure of the OPEN statement. An exception exists for files in the z/OS UNIX file system: mismatches in record format and record length do not cause an error.

To prevent common file status 39 problems, follow the guidelines for processing existing or new files.

If you have not made a file available with a DD statement or a TSO ALLOCATE command, and your COBOL program specifies that the file be created, Enterprise COBOL dynamically allocates the file. When the file is opened, the file attributes that are coded in your program are used. You do not have to worry about file attribute conflicts.

Remember that information in the JCL or environment variable overrides information in the data-set label.

related tasks
“Processing existing files” on page 168
“Processing new files” on page 169
“Opening QSAM files” on page 160

related references
“FILE SECTION entries” on page 11
**Processing existing files**
When your program processes an existing file, code the description of the file in your COBOL program to be consistent with the file attributes of the data set. Use the guidelines below to define the maximum record length.

<table>
<thead>
<tr>
<th>For this format:</th>
<th>Specify this:</th>
</tr>
</thead>
<tbody>
<tr>
<td>V or S</td>
<td>Exactly 4 bytes less than the length attribute of the data set</td>
</tr>
<tr>
<td>F</td>
<td>Same value as the length attribute of the data set</td>
</tr>
<tr>
<td>U</td>
<td>Same value as the length attribute of the data set</td>
</tr>
</tbody>
</table>

The easiest way to define variable-length (format-V) records in a program is to use the `RECORD IS VARYING FROM integer-1 TO integer-2` clause in the FD entry and set an appropriate value for `integer-2`. Express the integer sizes in bytes regardless of the underlying USAGE of the data items in the record. For example, assume that you determine that the length attribute of the data set is 104 bytes (LRECL=104). Remembering that the maximum record length is determined from the `RECORD IS VARYING` clause and not from the level-01 record descriptions, you could define a format-V file in your program with this code:

```cobol
FILE SECTION.
FD COMMUTER-FILE-MST
  RECORDING MODE IS V
  RECORD IS VARYING FROM 4 TO 100 CHARACTERS.
  01 COMMUTER-RECORD-A PIC X(4).
  01 COMMUTER-RECORD-B PIC X(75).
```

Assume that the existing file in the previous example was format-U instead of format-V. If the 104 bytes are all user data, you could define the file in your program with this code:

```cobol
FILE SECTION.
FD COMMUTER-FILE-MST
  RECORDING MODE IS U
  RECORD IS VARYING FROM 4 TO 104 CHARACTERS.
  01 COMMUTER-RECORD-A PIC X(4).
  01 COMMUTER-RECORD-B PIC X(75).
```

To define fixed-length records in your program, either code the `RECORD CONTAINS integer` clause, or omit this clause and code all level-01 record descriptions to be the same fixed size. In either case, use a value that equals the value of the length attribute of the data set. If you intend to use the same program to process different files at run time, and those files have differing fixed lengths, avoid record-length conflicts by coding `RECORD CONTAINS 0`.

If the existing file is an ASCII data set (DCB=(OPTCD=Q)), you must use the `CODE-SET` clause in the FD entry for the file.

**related tasks**
- “Processing new files” on page 169
- “Requesting fixed-length format” on page 152
- “Requesting variable-length format” on page 153
- “Requesting undefined format” on page 157
- “Opening QSAM files” on page 160

**related references**
- “FILE SECTION entries” on page 11
Processing new files

If your COBOL program writes records to a new file that will be made available before the program runs, ensure that the file attributes in the DD statement, the environment variable, or the allocation do not conflict with the attributes in the program.

Usually you need to code only a minimum of parameters when predefining files. But if you need to explicitly set a length attribute for the data set (for example, you are using an ISPF allocation panel, or your DD statement is for a batch job in which the program uses RECORD CONTAINS 0), follow these guidelines:

- For format-V and format-S files, set a length attribute that is 4 bytes larger than that defined in the program.
- For format-F and format-U files, set a length attribute that is the same as that defined in the program.
- If you open the file as OUTPUT and write it to a printer, the compiler might add 1 byte to the record length to account for the carriage-control character, depending on the ADV compiler option and the language used in your program. In such a case, take the added byte into account when coding the LRECL value.

For example, if your program contains the following code for a file that has variable-length records, the LRECL value in the DD statement or allocation should be 54.

```
FILE SECTION.
FD  COMMUTER-FILE-MST
  RECORDING MODE IS V
  RECORD CONTAINS 10 TO 50 CHARACTERS.
01  COMMUTER-RECORD-A   PIC X(10).
01  COMMUTER-RECORD-B   PIC X(50).
```

related tasks

“Processing existing files” on page 168
“Requesting fixed-length format” on page 152
“Requesting variable-length format” on page 153
“Requesting undefined format” on page 157
“Opening QSAM files” on page 160
“Dynamically creating QSAM files” on page 161

related references

“FILE SECTION entries” on page 11

Using striped extended-format QSAM data sets

Striped extended-format QSAM data sets can benefit applications that process files that have large amounts of data or in which the time needed for I/O operations significantly affects overall performance.

A striped extended-format QSAM data set is an extended-format QSAM data set that is spread over multiple volumes, thus allowing parallel data access.

For you to gain the maximum benefit from using QSAM striped data sets, z/OS DFSMS needs to be able to allocate the required number of buffers above the 16 MB line. When you develop applications that contain files allocated to QSAM striped data sets, follow these guidelines:

- Avoid using a QSAM striped data set for a file that cannot have buffers allocated above the 16 MB line.
- Omit the RESERVE clause in the FILE-CONTROL entry for the file. Doing so lets z/OS DFSMS determine the optimum number of buffers for the data set.
- Compile your program with the DATA(31) and RENT compiler options, and make the program object AMODE 31.
- Specify the ALL31(ON) runtime option if the file is an EXTERNAL file with format-F, format-V, or format-U records.

Note that all striped data sets are extended-format data sets, but not all extended-format data sets are striped.
**Allocation of buffers for QSAM files**

/z/OS DFSMS automatically allocates buffers for storing input and output for a QSAM file above or below the 16 MB line as appropriate for the file.

Most QSAM files have buffers allocated above the 16 MB line. Exceptions are:

- Programs running in AMODE 24.
- Programs compiled with the DATA(24) and RENT options.
- Programs compiled with the NORENT option.
- EXTERNAL files when the ALL31(0FF) runtime option is specified. To specify the ALL31(ON) runtime option, all programs in the run unit must be capable of running in 31-bit addressing mode.
- Files allocated to the TSO terminal.
- A file with format-S (spanned) records, if the file is any of the following ones:
  - An EXTERNAL file (even if ALL31(ON) is specified)
  - A file specified in a SAME RECORD AREA clause of the I-O-CONTROL paragraph
  - A blocked file that is opened I-O and updated using the REWRITE statement

**Accessing z/OS UNIX files using QSAM**

You can process byte-stream files in the z/OS UNIX file system as ORGANIZATION SEQUENTIAL files using QSAM. To do this, specify as the assignment-name in the ASSIGN clause either a ddname or an environment-variable name.

**ddname**

A DD allocation that identifies the file with the keywords PATH= and FILEDATA=BINARY

**Environment-variable name**

An environment variable that holds the runtime value of the z/OS UNIX file system path for the file

Observe the following restrictions:

- Spanned record format is not supported.
- OPEN I-O and REWRITE are not supported. If you attempt one of these operations, one of the following file-status conditions results:
  - 37 from OPEN I-O
  - 47 from REWRITE (because you could not have successfully opened the file as I-O)

**Usage notes**

- File status 39 (fixed file attribute conflict) is not enforced for either of the following types of conflicts:
  - Record-length conflict
  - Record-type conflict (fixed as opposed to variable)
- A READ returns the number of bytes of the maximum logical record size for the file except for the last record, which might be shorter.

For example, suppose that a file definition has level-01 record descriptions of 3, 5, and 10 bytes long, and you write the following three records: 'abc', 'defgh', and 'ijklmnopqr', in that order. The first READ of
this file returns 'abcdefghij', the second READ returns 'klmnopqr', and the third READ results in the AT END condition.

For compatibility with releases of IBM COBOL before COBOL for OS/390 & VM Version 2 Release 2, you can also specify FILEDATA=TEXT when using a DD allocation for z/OS UNIX files, but this use is not recommended. To process text files in the z/OS UNIX file system, use LINE SEQUENTIAL organization. If you use QSAM to process text files in the z/OS UNIX file system, you cannot use environment variables to define the files.

related tasks
“Allocating files” on page 148
“Defining and allocating QSAM files” on page 164
z/OS DFSMS: Using Data Sets (Using HFS data sets)

Processing QSAM ASCII files on tape

If your program processes a QSAM ASCII file, you must request the ASCII alphabet, define the record formats, and define the ddname (with JCL).

In addition, if your program processes signed numeric data items from ASCII files, define the numeric data as zoned decimal items with separate signs, that is, as USAGE DISPLAY and with the SEPARATE phrase of the SIGN clause.

The CODEPAGE compiler option has no effect on the code page used for conversions between ASCII and EBCDIC for ASCII tape support. For information about how CCSIDs used for the ASCII tape support are selected and what the default CCSIDs are, see the z/OS DFSMS documentation.

**Requesting the ASCII alphabet:** In the SPECIAL-NAMES paragraph, code STANDARD-1 for ASCII:

```
ALPHABET-NAME IS STANDARD-1
```

In the FD entry for the file, code:

```
CODE-SET IS ALPHABET-NAME
```

**Defining the record formats:** Process QSAM ASCII tape files with any of these record formats:

- Fixed length (format F)
- Undefined (format U)
- Variable length (format V)

If you use variable-length records, you cannot explicitly code format D; instead, code RECORDING MODE V. The format information is internally converted to D mode. D-mode records have a 4-byte record descriptor for each record.

**Defining the ddname:** Under z/OS, processing ASCII files requires special JCL coding. Code these subparameters of the DCB parameter in the DD statement:

BUFOFF=[L|n]

- L
  - A 4-byte block prefix that contains the block length (including the block prefix)
- n
  - The length of the block prefix:
    - For input, from 0 through 99
    - For output, either 0 or 4
  - Use this value if you coded BLOCK CONTAINS 0.
**BLKSIZE=**\(n\)

\(n\)

The size of the block, including the length of the block prefix

**LABEL=[AL|AUL|NL]**

**AL**

American National Standard (ANS) labels

**AUL**

ANS and user labels

**NL**

No labels

**OPTCD=Q**

**Q**

This value is required for ASCII files and is the default if the file is created using Enterprise COBOL.

**related references**

*z/OS DFSMS: Using Data Sets* (Character data conversion)
Chapter 10. Processing VSAM files

Virtual storage access method (VSAM) is an access method for files on direct-access storage devices. With VSAM you can load files, retrieve records from files, update files, and add, replace, and delete records in files.

VSAM processing has these advantages over QSAM:

- Protection of data against unauthorized access
- Compatibility across systems
- Independence of devices (no need to be concerned with block size and other control information)
- Simpler JCL (information needed by the system is provided in integrated catalogs)
- Ability to use indexed file organization or relative file organization

The following table shows how VSAM terms differ from COBOL terms and other terms that you might be familiar with.

<table>
<thead>
<tr>
<th>VSAM term</th>
<th>COBOL term</th>
<th>Similar non-VSAM term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data set</td>
<td>File</td>
<td>Data set</td>
</tr>
<tr>
<td>Entry-sequenced data set (ESDS)</td>
<td>Sequential file</td>
<td>QSAM data set</td>
</tr>
<tr>
<td>Key-sequenced data set (KSDS)</td>
<td>Indexed file</td>
<td>ISAM data set</td>
</tr>
<tr>
<td>Relative-record data set (RRDS)</td>
<td>Relative file</td>
<td>BDAM data set</td>
</tr>
<tr>
<td>Control interval</td>
<td>Block</td>
<td></td>
</tr>
<tr>
<td>Control interval size (CISZ)</td>
<td>Block size</td>
<td></td>
</tr>
<tr>
<td>Buffers (BUFNI/BUFND)</td>
<td>BUFNO</td>
<td></td>
</tr>
<tr>
<td>Access method control block (ACB)</td>
<td>Data control block (DCB)</td>
<td></td>
</tr>
<tr>
<td>Cluster (CL)</td>
<td>Data set</td>
<td></td>
</tr>
<tr>
<td>Cluster definition</td>
<td>Data-set allocation</td>
<td></td>
</tr>
<tr>
<td>AMP parameter of JCL DD statement</td>
<td>DCB parameter of JCL DD statement</td>
<td></td>
</tr>
<tr>
<td>Record size</td>
<td>Record length</td>
<td></td>
</tr>
</tbody>
</table>

The term file in this VSAM documentation refers to either a COBOL file or a VSAM data set.

If you have complex requirements or frequently use VSAM, see the VSAM publications for your operating system.

related concepts
“VSAM files” on page 174

related tasks
“Defining VSAM file organization and records” on page 175
“Coding input and output statements for VSAM files” on page 180
“Handling errors in VSAM files” on page 188
“Protecting VSAM files with a password” on page 188
“Working with VSAM data sets under z/OS and z/OS UNIX” on page 189
“Improving VSAM performance” on page 195
VSAM files

The physical organization of VSAM data sets differs considerably from the organizations used by other access methods.

VSAM data sets are held in control intervals (CI) and control areas (CA). The size of the CI and CA is normally determined by the access method; and the way in which they are used is not visible to you.

You can use three types of file organization with VSAM:

**VSAM sequential file organization**
(Also referred to as VSAM ESDS (entry-sequenced data set) organization.) In VSAM sequential file organization, the records are stored in the order in which they were entered.

VSAM entry-sequenced data sets are equivalent to QSAM sequential files. The order of the records is fixed.

**VSAM indexed file organization**
(Also referred to as VSAM KSDS (key-sequenced data set) organization.) In a VSAM indexed file (KSDS), the records are ordered according to the collating sequence of an embedded prime key field, which you define. The prime key consists of one or more consecutive characters in the records. The prime key uniquely identifies the record and determines the sequence in which it is accessed with respect to other records. A prime key for a record might be, for example, an employee number or an invoice number.

**VSAM relative file organization**
(Also referred to as VSAM fixed-length or variable-length RRDS (relative-record data set) organization.) A VSAM relative-record data set (RRDS) contains records ordered by their relative key. The relative key is the relative record number, which represents the location of the record relative to where the file begins. The relative record number identifies the fixed- or variable-length record.

In a VSAM fixed-length RRDS, records are placed in a series of fixed-length slots in storage. Each slot is associated with a relative record number. For example, in a fixed-length RRDS that contains 10 slots, the first slot has a relative record number of 1, and the tenth slot has a relative record number of 10.

In a VSAM variable-length RRDS, the records are ordered according to their relative record number. Records are stored and retrieved according to the relative record number that you set.

Throughout this information, the term VSAM relative-record data set (or RRDS) is used to mean both relative-record data sets with fixed-length records and with variable-length records, unless they need to be differentiated.

The following table compares the characteristics of the different types of VSAM data sets.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Entry-sequenced data set (ESDS)</th>
<th>Key-sequenced data set (KSDS)</th>
<th>Relative-record data set (RRDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of records</td>
<td>Order in which they are written</td>
<td>Collating sequence by key field</td>
<td>Order of relative record number</td>
</tr>
<tr>
<td>Access</td>
<td>Sequential</td>
<td>By key through an index</td>
<td>By relative record number, which is handled like a key</td>
</tr>
</tbody>
</table>
Table 23. **Comparison of VSAM data-set types** (continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Entry-sequenced data set (ESDS)</th>
<th>Key-sequence data set (KSDS)</th>
<th>Relative-record data set (RRDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate indexes</td>
<td>Can have one or more alternate indexes, although not supported in COBOL</td>
<td>Can have one or more alternate indexes</td>
<td>Cannot have alternate indexes</td>
</tr>
<tr>
<td>Relative byte address (RBA) and relative record number (RRN) of a record</td>
<td>RBA cannot change.</td>
<td>RBA can change.</td>
<td>RRN cannot change.</td>
</tr>
<tr>
<td>Space for adding records</td>
<td>Uses space at the end of the data set</td>
<td>Uses distributed free space for inserting records and changing their lengths in place</td>
<td>For fixed-length RRDS, uses empty slots in the data set</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>For variable-length RRDS, uses distributed free space and changes the lengths of added records in place</td>
</tr>
<tr>
<td>Space from deleting records</td>
<td>You cannot delete a record, but you can reuse its space for a record of the same length.</td>
<td>Space from a deleted or shortened record is automatically reclaimed in a control interval.</td>
<td>Space from a deleted record can be reused.</td>
</tr>
<tr>
<td>Spanned records</td>
<td>Can have spanned records</td>
<td>Can have spanned records</td>
<td>Cannot have spanned records</td>
</tr>
<tr>
<td>Reuse as work file</td>
<td>Can be reused unless it has an alternate index, is associated with key ranges, or exceeds 123 extents per volume</td>
<td>Can be reused unless it has an alternate index, is associated with key ranges, or exceeds 123 extents per volume</td>
<td>Can be reused</td>
</tr>
</tbody>
</table>

**related tasks**

*“Specifying sequential organization for VSAM files” on page 176*

*“Specifying indexed organization for VSAM files” on page 176*

*“Specifying relative organization for VSAM files” on page 177*

*“Defining VSAM files” on page 190*

---

**Defining VSAM file organization and records**

Use an entry in the FILE-CONTROL paragraph in the ENVIRONMENT DIVISION to define the file organization and access modes for the VSAM files in your COBOL program.

In the FILE SECTION of the DATA DIVISION, code a file description (FD) entry for the file. In the associated record description entry or entries, define the **record-name** and record length. Code the logical size of the records by using the RECORD clause.

**Important:** You can process VSAM data sets in Enterprise COBOL programs only after you define them by using access method services.
Table 24. VSAM file organization, access mode, and record format

<table>
<thead>
<tr>
<th>File organization</th>
<th>Sequential access</th>
<th>Random access</th>
<th>Dynamic access</th>
<th>Fixed length</th>
<th>Variable length</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSAM sequential (ESDS)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VSAM indexed (KSDS)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VSAM relative (RRDS)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

related tasks

“Specifying sequential organization for VSAM files” on page 176
“Specifying indexed organization for VSAM files” on page 176
“Specifying relative organization for VSAM files” on page 177
“Specifying access modes for VSAM files” on page 178
“Defining record lengths for VSAM files” on page 179
“Using file status keys” on page 229
“Using VSAM status codes (VSAM files only)” on page 230
“Defining VSAM files” on page 190

Specifying sequential organization for VSAM files

Identify VSAM ESDS files in a COBOL program with the ORGANIZATION IS SEQUENTIAL clause. You can access (read or write) records in sequential files only sequentially.

After you place a record in the file, you cannot shorten, lengthen, or delete it. However, you can update (REWRITE) a record if the length does not change. New records are added at the end of the file.

The following example shows typical FILE-CONTROL entries for a VSAM sequential file (ESDS):

```cobol
SELECT S-FILE
  ASSIGN TO SEQUENTIAL-AS-FILE
  ORGANIZATION IS SEQUENTIAL
  ACCESS IS SEQUENTIAL
  FILE STATUS IS FSTAT-CODE VSAM-CODE.
```

related concepts

“VSAM files” on page 174

Specifying indexed organization for VSAM files

Identify a VSAM KSDS file in a COBOL program by using the ORGANIZATION IS INDEXED clause. Code a prime key for the record by using the RECORD KEY clause. You can also use alternate keys and an alternate index.

```cobol
RECORD KEY IS data-name
```

In the example above, data-name is the name of the prime key field as you define it in the record description entry in the DATA DIVISION. The prime key data item can be class alphabetic, alphanumeric, DBCS, numeric, or national. If it has USAGE NATIONAL, the prime key can be category national, or can be a national-edited, numeric-edited, national decimal, or national floating-point data item. The collation of record keys is based on the binary value of the keys regardless of the class or category of the keys.

The following example shows the statements for a VSAM indexed file (KSDS) that is accessed dynamically. In addition to the primary key, COMMUTER-NO, an alternate key, LOCATION-NO, is specified:

```cobol
SELECT I-FILE
  ASSIGN TO INDEXED-FILE
  ORGANIZATION IS INDEXED
```
ACCESS IS DYNAMIC
RECORD KEY IS IFILE-RECORD-KEY
ALTERNATE RECORD KEY IS IFILE-ALTREC-KEY
FILE STATUS IS FSTAT-CODE VSAM-CODE.

related concepts
“VSAM files” on page 174

related tasks
“Using alternate keys” on page 177
“Using an alternate index” on page 177

related references
RECORD KEY clause (Enterprise COBOL for z/OS Language Reference)
Classes and categories of data (Enterprise COBOL for z/OS Language Reference)

Using alternate keys
In addition to the primary key, you can code one or more alternate keys for a VSAM KSDS file. By using alternate keys, you can access an indexed file to read records in some sequence other than the prime-key sequence.

Alternate keys do not need to be unique. More than one record could be accessed if alternate keys are coded to allow duplicates. For example, you could access the file through employee department rather than through employee number.

You define the alternate key in your COBOL program with the ALTERNATE RECORD KEY clause:

```
ALTERNATE RECORD KEY IS data-name
```

In the example above, `data-name` is the name of the alternate key field as you define it in the record description entry in the DATA DIVISION. Alternate key data items, like prime key data items, can be class alphabetic, alphanumeric, DBCS, numeric, or national. The collation of alternate keys is based on the binary value of the keys regardless of the class or category of the keys.

Using an alternate index
To use an alternate index for a VSAM KSDS file, you need to define a data set called the alternate index (AIX) by using access method services.

The AIX contains one record for each value of a given alternate key. The records are in sequential order by alternate-key value. Each record contains the corresponding primary keys of all records in the associated indexed files that contain the alternate-key value.

related tasks
“Creating alternate indexes” on page 190

Specifying relative organization for VSAM files
Identify VSAM RRDS files in a COBOL program by using the ORGANIZATION IS RELATIVE clause. Use the RELATIVE KEY IS clause to associate each logical record with its relative record number.

The following example shows a relative-record data set (RRDS) that is accessed randomly by the value in the relative key:

```
SELECT R-FILE
ASSIGN TO RELATIVE-FILE
ORGANIZATION IS RELATIVE
ACCESS IS RANDOM
RELATIVE KEY IS RFILE-RELATIVE-KEY
FILE STATUS IS FSTAT-CODE VSAM-CODE.
```

You can use a randomizing routine to associate a key value in each record with the relative record number for that record. Although there are many techniques to convert a record key to a relative record number, the most commonly used is the division/remainder technique. With this technique, you divide the key by a
value equal to the number of slots in the data set to produce a quotient and remainder. When you add one to the remainder, the result is a valid relative record number.

Alternate indexes are not supported for VSAM RRDS.

**related concepts**

“VSAM files” on page 174

“Fixed-length and variable-length RRDS” on page 178

**related tasks**

“Using variable-length RRDS” on page 178

“Defining VSAM files” on page 190

**Fixed-length and variable-length RRDS**

In an RRDS that has fixed-length records, each record occupies one slot. You store and retrieve records according to the relative record number of the slot. A variable-length RRDS does not have slots; instead, the free space that you define allows for more efficient record insertions.

When you load an RRDS that has fixed-length records, you have the option of skipping over slots and leaving them empty. When you load an RRDS that has variable-length records, you can skip over relative record numbers.

**Using variable-length RRDS**

To use relative-record data sets (RRDS) that have variable-length records, you must use VSAM variable-length RRDS support.

Do these steps:

1. Define the file with the ORGANIZATION IS RELATIVE clause.
2. Use FD entries to describe the records with variable-length sizes.
3. Use the NOSIMVRD runtime option.
4. Define the VSAM file through access-method services as an RRDS.

**related tasks**

“Defining VSAM files” on page 190

**related references**

z/OS DFSMS: Access Method Services for Catalogs

**Specifying access modes for VSAM files**

You can access records in VSAM sequential files only sequentially. You can access records in VSAM indexed and relative files in three ways: sequentially, randomly, or dynamically.

For sequential access, code ACCESS IS SEQUENTIAL in the FILE-CONTROL entry. Records in indexed files are then accessed in the order of the key field selected (either primary or alternate). Records in relative files are accessed in the order of the relative record numbers.

For random access, code ACCESS IS RANDOM in the FILE-CONTROL entry. Records in indexed files are then accessed according to the value you place in a key field. Records in relative files are accessed according to the value you place in the relative key.

For dynamic access, code ACCESS IS DYNAMIC in the FILE-CONTROL entry. Dynamic access is a mixed sequential-random access in the same program. Using dynamic access, you can write one program to perform both sequential and random processing, accessing some records in sequential order and others by their keys.

“Example: using dynamic access with VSAM files” on page 179

**related tasks**

“Reading records from a VSAM file” on page 185
Example: using dynamic access with VSAM files
Suppose that you have an indexed file of employee records, and the employee’s hourly wage forms the record key.

If your program processes those employees who earn between $15.00 and $20.00 per hour and those who earn $25.00 per hour and above, using dynamic access of VSAM files, the program would:

1. Retrieve the first record randomly (with a random-retrieval READ) based on the key of 1500.
2. Read sequentially (using READ NEXT) until the salary field exceeds 2000.
3. Retrieve the next record randomly, based on a key of 2500.
4. Read sequentially until the end of the file.

related tasks
“Reading records from a VSAM file” on page 185

Defining record lengths for VSAM files
You can define VSAM records to be fixed or variable in length. COBOL determines the record format from the RECORD clause and the record descriptions that are associated with the FD entry for a file.

Because the concept of blocking has no meaning for VSAM files, you can omit the BLOCK CONTAINS clause. The clause is syntax-checked, but it has no effect on how the program runs.

related tasks
“Defining fixed-length records” on page 179
“Defining variable-length records” on page 179

Enterprise COBOL Migration Guide
related references
“FILE SECTION entries” on page 11

Defining fixed-length records
To define VSAM records as fixed length, use one of these coding options.

<table>
<thead>
<tr>
<th>Table 25. Definition of VSAM fixed-length records</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECORD clause</td>
</tr>
<tr>
<td>Code RECORD CONTAINS integer.</td>
</tr>
<tr>
<td>Omit the RECORD clause, but code all level-01 records that are associated with the file as the same size; and code none with an OCCURS DEPENDING ON clause.</td>
</tr>
</tbody>
</table>

related references
RECORD clause (Enterprise COBOL for z/OS Language Reference)

Defining variable-length records
To define VSAM records as variable length, use one of these coding options.
Table 26. Definition of VSAM variable-length records

<table>
<thead>
<tr>
<th>RECORD clause</th>
<th>Clause format</th>
<th>Maximum record length</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code RECORD IS VARYING FROM integer-6 TO integer-7.</td>
<td>3</td>
<td>integer-7 bytes</td>
<td>The lengths of the level-01 record description entries associated with the file do not matter.</td>
</tr>
<tr>
<td>Code RECORD IS VARYING.</td>
<td>3</td>
<td>Size of the largest level-01 record description entry associated with the file</td>
<td>The compiler determines the maximum record length.</td>
</tr>
<tr>
<td>Code RECORD CONTAINS integer-4 TO integer-5.</td>
<td>2</td>
<td>integer-5 bytes</td>
<td>The minimum record length is integer-4 bytes.</td>
</tr>
<tr>
<td>Omit the RECORD clause, but code multiple level-01 records that are associated with the file and are of different sizes or contain an OCCURS DEPENDING ON clause.</td>
<td></td>
<td>Size of the largest level-01 record description entry associated with the file</td>
<td>The compiler determines the maximum record length.</td>
</tr>
</tbody>
</table>

When you specify a READ INTO statement for a format-V file, the record size that is read for that file is used in the MOVE statement generated by the compiler. Consequently, you might not get the result you expect if the record read in does not correspond to the level-01 record description. All other rules of the MOVE statement apply. For example, when you specify a MOVE statement for a format-V record read in by the READ statement, the size of the record corresponds to its level-01 record description.

related references
RECORD clause (Enterprise COBOL for z/OS Language Reference)

Coding input and output statements for VSAM files

Use the COBOL statements shown below to process VSAM files.

**OPEN**
To connect the VSAM data set to your COBOL program for processing.

**WRITE**
To add records to a file or load a file.

**START**
To establish the current location in the cluster for a READ NEXT statement.
START does not retrieve a record; it only sets the current record pointer.

**READ and READ NEXT**
To retrieve records from a file.

**REWRITE**
To update records.

**DELETE**
To logically remove records from indexed and relative files only.

**CLOSE**
To disconnect the VSAM data set from your program.

All of the following factors determine which input and output statements you can use for a given VSAM data set:
• Access mode (sequential, random, or dynamic)
• File organization (ESDS, KSDS, or RRDS)
• Mode of OPEN statement (INPUT, OUTPUT, I-O, or EXTEND)

The following table shows the possible combinations of statements and open modes for sequential files (ESDS). The X indicates that you can use a statement with the open mode shown at the top of the column.

### Table 27. I/O statements for VSAM sequential files

<table>
<thead>
<tr>
<th>Access mode</th>
<th>COBOL statement</th>
<th>OPEN INPUT</th>
<th>OPEN OUTPUT</th>
<th>OPEN I-O</th>
<th>OPEN EXTEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential</td>
<td>OPEN</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>WRITE</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>START</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>READ</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>REWRITE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DELETE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CLOSE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

The following table shows the possible combinations of statements and open modes that you can use with indexed (KSDS) files and relative (RRDS) files. The X indicates that you can use the statement with the open mode shown at the top of the column.

### Table 28. I/O statements for VSAM relative and indexed files

<table>
<thead>
<tr>
<th>Access mode</th>
<th>COBOL statement</th>
<th>OPEN INPUT</th>
<th>OPEN OUTPUT</th>
<th>OPEN I-O</th>
<th>OPEN EXTEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential</td>
<td>OPEN</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>WRITE</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>START</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>READ</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>REWRITE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DELETE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CLOSE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Random

<table>
<thead>
<tr>
<th>Access mode</th>
<th>COBOL statement</th>
<th>OPEN INPUT</th>
<th>OPEN OUTPUT</th>
<th>OPEN I-O</th>
<th>OPEN EXTEND</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OPEN</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WRITE</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>START</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>READ</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>REWRITE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DELETE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>CLOSE</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 28. I/O statements for VSAM relative and indexed files (continued)

<table>
<thead>
<tr>
<th>Access mode</th>
<th>COBOL statement</th>
<th>OPEN INPUT</th>
<th>OPEN OUTPUT</th>
<th>OPEN I-O</th>
<th>OPEN EXTEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>OPEN</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WRITE</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>START</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>READ</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>REWRITE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DELETE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>CLOSE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

The fields that you code in the FILE STATUS clause are updated by VSAM after each input-output statement to indicate the success or failure of the operation.

**related concepts**
“File position indicator” on page 182

**related tasks**
“Opening a file (ESDS, KSDS, or RRDS)” on page 182
“Reading records from a VSAM file” on page 185
“Updating records in a VSAM file” on page 185
“Adding records to a VSAM file” on page 186
“Replacing records in a VSAM file” on page 187
“Deleting records from a VSAM file” on page 187
“Closing VSAM files” on page 187

**related references**
File status key (Enterprise COBOL for z/OS Language Reference)

**File position indicator**
The file position indicator marks the next record to be accessed for sequential COBOL requests. You do not set the file position indicator in your program. It is set by successful OPEN, START, READ, and READ NEXT statements.

Subsequent READ or READ NEXT requests use the established file position indicator location and update it.

The file position indicator is not used or affected by the output statements WRITE, REWRITE, or DELETE. The file position indicator has no meaning for random processing.

**related tasks**
“Reading records from a VSAM file” on page 185

**Opening a file (ESDS, KSDS, or RRDS)**
Before you can use WRITE, START, READ, REWRITE, or DELETE statements to process records in a file, you must first open the file with an OPEN statement.

Whether a file is available or optional affects OPEN processing, file creation, and the resulting file status key. For example, if you open in EXTEND, I-O, or INPUT mode a nonexistent non-OPTIONAL file, the result is an OPEN error, and file status 35 is returned. If the file is OPTIONAL, however, the same OPEN statement returns file status 05, and, for open modes EXTEND and I-O, creates the file.

An OPEN operation works successfully only if you set fixed file attributes in the DD statement or data-set label for a file, and specify consistent attributes for the file in the SELECT clause and FD entries of your COBOL program. Mismatches in the following items result in a file status key 39 and the failure of the OPEN statement:
• Attributes for file organization (sequential, relative, or indexed)
• Prime record key
• Alternate record keys
• Maximum record size
• Record type (fixed or variable)

How you code the OPEN statement for a VSAM file depends on whether the file is empty (a file that has never contained records) or loaded. For either type of file, your program should check the file status key after each OPEN statement.

related tasks
“Opening an empty file” on page 183
“Opening a loaded file (a file with records)” on page 184

related references
“Statements to load records into a VSAM file” on page 184

Opening an empty file
To open a file that has never contained records (an empty file), use a form of the OPEN statement.

Depending on the type of file that you are opening, use one of the following statements:

• OPEN OUTPUT for ESDS files.
• OPEN OUTPUT or OPEN EXTEND for KSDS and RRDS files. (Either coding has the same effect.) If you coded the file for random or dynamic access and the file is optional, you can use OPEN I-O.

Optional files are files that are not necessarily available each time a program is run. You can define files opened in INPUT, I-O, or OUTPUT mode as optional by defining them with the SELECT OPTIONAL clause in the FILE-CONTROL paragraph.

Initially loading a file sequentially: Initially loading a file means writing records into the file for the first time. Doing so is not the same as writing records into a file from which all previous records have been deleted. To initially load a VSAM file:

1. Open the file.
2. Use sequential processing (ACCESS IS SEQUENTIAL). (Sequential processing is faster than random or dynamic processing.)
3. Use WRITE to add a record to the file.

Using OPEN OUTPUT to load a VSAM file significantly improves the performance of your program. Using OPEN I-O or OPEN EXTEND has a negative effect on the performance of your program.

When you load VSAM indexed files sequentially, you optimize both loading performance and subsequent processing performance, because sequential processing maintains user-defined free space. Future insertions will be more efficient.

With ACCESS IS SEQUENTIAL, you must write the records in ascending RECORD KEY order.

When you load VSAM relative files sequentially, the records are placed in the file in the ascending order of relative record numbers.

Initially loading a file randomly or dynamically: You can use random or dynamic processing to load a file, but they are not as efficient as sequential processing. Because VSAM does not support random or dynamic processing, COBOL has to perform some extra processing to enable you to use ACCESS IS RANDOM or ACCESS IS DYNAMIC with OPEN OUTPUT or OPEN I-O. These steps prepare the file for use and give it the status of a loaded file because it has been used at least once.

In addition to extra overhead for preparing files for use, random processing does not consider any user-defined free space. As a result, any future insertions might be inefficient. Sequential processing maintains user-defined free space.
When you are loading an extended-format VSAM data set, file status 30 will occur for the OPEN if z/OS DFSMS system-managed buffering sets the buffering to local shared resources (LSR). To successfully load the VSAM data set in this case, specify ACCBIAS=USER in the DD AMP parameter for the VSAM data set to bypass system-managed buffering.

**Loading a VSAM data set with access method services:** You can load or update a VSAM data set by using the access method services REPRO command. Use REPRO whenever possible.

**related tasks**
“Opening a loaded file (a file with records)” on page 184

**related references**
“Statements to load records into a VSAM file” on page 184
z/OS DFSMS: Access Method Services for Catalogs (REPRO)

**Statements to load records into a VSAM file**
Use the statements shown below to load records into a VSAM file.

| Table 29. Statements to load records into a VSAM file |
|---------------------------------|----------------|-------------------|
| **Division** | **ESDS** | **KSDS** | **RRDS** |
| ENVIRONMENT DIVISION | SELECT ASSIGN FILE STATUS PASSWORD ACCESS MODE | SELECT ASSIGN ORGANIZATION IS INDEXED RECORD KEY ALTERNATE RECORD KEY FILE STATUS PASSWORD ACCESS MODE | SELECT ASSIGN ORGANIZATION IS RELATIVE RECORD KEY FILE STATUS PASSWORD ACCESS MODE |
| DATA DIVISION | FD entry | FD entry | FD entry |
| PROCEDURE DIVISION | OPEN OUTPUT OPEN EXTEND WRITE CLOSE | OPEN OUTPUT OPEN EXTEND WRITE CLOSE | OPEN OUTPUT OPEN EXTEND WRITE CLOSE |

**related tasks**
“Opening an empty file” on page 183
“Updating records in a VSAM file” on page 185

**Opening a loaded file (a file with records)**
To open a file that already contains records, use OPEN INPUT, OPEN I-O, or OPEN EXTEND.

If you open a VSAM entry-sequenced or relative-record file as EXTEND, the added records are placed after the last existing records in the file.

If you open a VSAM key-sequenced file as EXTEND, each record you add must have a record key higher than the highest record in the file.

**related tasks**
“Opening an empty file” on page 183
“Working with VSAM data sets under z/OS and z/OS UNIX” on page 189
Reading records from a VSAM file

Use the READ statement to retrieve (READ) records from a file. To read a record, you must have opened the file INPUT or I-O. Your program should check the file status key after each READ.

You can retrieve records in VSAM sequential files only in the sequence in which they were written.

You can retrieve records in VSAM indexed and relative record files in any of the following ways:

Sequentially
According to the ascending order of the key you are using, the RECORD KEY or the ALTERNATE RECORD KEY, beginning at the current position of the file position indicator for indexed files, or according to ascending relative record locations for relative files

Randomly
In any order, depending on how you set the RECORD KEY or ALTERNATE RECORD KEY or the RELATIVE KEY before your READ request

Dynamically
Mixed sequential and random

With dynamic access, you can switch between reading a specific record directly and reading records sequentially, by using READ NEXT for sequential retrieval and READ for random retrieval (by key).

When you want to read sequentially, beginning at a specific record, use START before the READ NEXT statement to set the file position indicator to point to a particular record. When you code START followed by READ NEXT, the next record is read and the file position indicator is reset to the next record. You can move the file position indicator randomly by using START, but all reading is done sequentially from that point.

```
START file-name KEY IS EQUAL TO ALTERNATE-RECORD-KEY
```

When a direct READ is performed for a VSAM indexed file, based on an alternate index for which duplicates exist, only the first record in the data set (base cluster) with that alternate key value is retrieved. You need a series of READ NEXT statements to retrieve each of the data set records with the same alternate key. A file status code of 02 is returned if there are more records with the same alternate key value to be read; a code of 00 is returned when the last record with that key value has been read.

related concepts
“File position indicator” on page 182

related tasks
“Specifying access modes for VSAM files” on page 178

Updating records in a VSAM file

To update a VSAM file, use these PROCEDURE DIVISION statements.
Table 30. **Statements to update records in a VSAM file**

<table>
<thead>
<tr>
<th>Access method</th>
<th>ESDS</th>
<th>KSDS</th>
<th>RRDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACCESS IS SEQUENTIAL</strong></td>
<td>OPEN EXTEND WRITE</td>
<td>OPEN EXTEND WRITE</td>
<td>OPEN EXTEND WRITE</td>
</tr>
<tr>
<td></td>
<td>CLOSE</td>
<td>CLOSE</td>
<td>CLOSE</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>OPEN I-O</td>
<td>OPEN I-O</td>
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<tr>
<td></td>
<td></td>
<td>CLOSE</td>
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</tr>
</tbody>
</table>

**related references**

“Statements to load records into a VSAM file” on page 184

**Adding records to a VSAM file**

Use the COBOL WRITE statement to add a record to a file without replacing any existing records. The record to be added must not be larger than the maximum record size that you set when you defined the file. Your program should check the file status key after each WRITE statement.

**Adding records sequentially:** Use ACCESS IS SEQUENTIAL and code the WRITE statement to add records sequentially to the end of a VSAM file that has been opened with either OUTPUT or EXTEND. Sequential files are always written sequentially.
For indexed files, you must write new records in ascending key sequence. If you open the file EXTEND, the record keys of the records to be added must be higher than the highest primary record key on the file when you opened the file.

For relative files, the records must be in sequence. If you include a RELATIVE KEY data item in the SELECT clause, the relative record number of the record to be written is placed in that data item.

Adding records randomly or dynamically: When you write records to an indexed data set and ACCESS IS RANDOM or ACCESS IS DYNAMIC, you can write the records in any order.

Replacing records in a VSAM file
To replace a record in a VSAM file, use REWRITE on a file that you opened as I-O. If the file was not opened as I-O, the record is not rewritten and the status key is set to 49. Check the file status key after each REWRITE statement.

For sequential files, the length of the replacement record must be the same as the length of the original record. For indexed files or variable-length relative files, you can change the length of the record you replace.

To replace a record randomly or dynamically, you do not have to first READ the record. Instead, locate the record you want to replace as follows:
• For indexed files, move the record key to the RECORD KEY data item, and then issue the REWRITE.
• For relative files, move the relative record number to the RELATIVE KEY data item, and then issue the REWRITE.

Deleting records from a VSAM file
To remove an existing record from an indexed or relative file, open the file I-O and use the DELETE statement. You cannot use DELETE on a sequential file.

When you use ACCESS IS SEQUENTIAL or the file contains spanned records, your program must first read the record to be deleted. The DELETE then removes the record that was read. If the DELETE is not preceded by a successful READ, the deletion is not done and the status key value is set to 92.

When you use ACCESS IS RANDOM or ACCESS IS DYNAMIC, your program does not have to first read the record to be deleted. To delete a record, move the key of the record to be deleted to the RECORD KEY data item, and then issue the DELETE. Your program should check the file status key after each DELETE statement.

Closing VSAM files
Use the CLOSE statement to disconnect your program from a VSAM file. If you try to close a file that is already closed, you will get a logic error. Check the file status key after each CLOSE statement.

If you do not close a VSAM file, the file is automatically closed for you under the following conditions:
• When the run unit ends normally, all open files defined in any COBOL programs in the run unit are closed.
• When the run unit ends abnormally, if the TRAP(ON) runtime option has been set, all open files defined in any COBOL programs in the run unit are closed.
• When Language Environment condition handling has completed and the application resumes in a routine other than where the condition occurred, open files defined in any COBOL programs in the run unit that might be called again and reentered are closed.

You can change the location where a program resumes after a condition is handled. To make this change, you can, for example, move the resume cursor with the CEEMRCR callable service or use language constructs such as a C longjmp statement.
• When you issue CANCEL for a COBOL subprogram, any open nonexternal files defined in that program are closed.
• When a COBOL subprogram with the INITIAL attribute returns control, any open nonexternal files defined in that program are closed.
• When a thread of a multithreaded application ends, both external and nonexternal files that were opened from within that same thread are closed.

File status key data items in the DATA DIVISION are set when these implicit CLOSE operations are performed, but your EXCEPTION/ERROR declarative is not invoked.

Errors: If you open a VSAM file in a multithreaded application, you must close it from the same thread of execution. Attempting to close the file from a different thread results in a close failure with file-status condition 90.

Handling errors in VSAM files

When an input or output statement operation fails, COBOL does not perform corrective action for you. All OPEN and CLOSE errors with a VSAM file, whether logical errors in your program or input/output errors on the external storage media, return control to your COBOL program even if you coded no DECLARATIVE and no FILE STATUS clause.

If any other input or output statement operation fails, you choose whether your program will continue running after a less-than-severe error.

COBOL provides these ways for you to intercept and handle certain VSAM input and output errors:
• End-of-file phrase (AT END)
• EXCEPTION/ERROR declarative
• FILE STATUS clause (file status key and VSAM status code)
• INVALID KEY phrase

You should define a status key for each VSAM file that you define in your program. Check the status key value after each input or output request, especially OPEN and CLOSE.

If you do not code a file status key or a declarative, serious VSAM processing errors will cause a message to be issued and a Language Environment condition to be signaled, which will cause an abend if you specify the runtime option ABTERMENC (ABEND).

related tasks
“Handling errors in input and output operations” on page 225
“Using VSAM status codes (VSAM files only)” on page 230

related references
z/OS DFSMS Macro Instructions for Data Sets (VSAM macro return and reason codes)

Protecting VSAM files with a password

Although the preferred security mechanism on a z/OS system is RACF, Enterprise COBOL also supports using explicit passwords on VSAM files to prevent unauthorized access and update.

To use explicit passwords, code the PASSWORD clause in the FILE-CONTROL paragraph. Use this clause only if the catalog entry for the files includes a read or an update password:

• If the catalog entry includes a read password, you cannot open and access the file in a COBOL program unless you use the PASSWORD clause in the FILE-CONTROL paragraph and describe it in the DATA DIVISION. The data-name referred to must contain a valid password when the file is opened.
• If the catalog entry includes an update password, you can open and access it, but not update it, unless you code the PASSWORD clause in the FILE-CONTROL paragraph and describe it in the DATA DIVISION.

• If the catalog entry includes both a read password and an update password, specify the update password to both read and update the file in your program.

If your program only retrieves records and does not update them, you need only the read password. If your program loads files or updates them, you need to specify the update password that was cataloged.

For indexed files, the PASSWORD data item for the RECORD KEY must contain the valid password before the file can be successfully opened.

If you password-protect a VSAM indexed file, you must also password-protect each alternate index in order to be fully password protected. Where you place the PASSWORD clause is important because each alternate index has its own password. The PASSWORD clause must directly follow the key clause to which it applies.

Example: password protection for a VSAM indexed file

The following example shows the COBOL code used for a VSAM indexed file that has password protection.

```
. . .
INPUT-OUTPUT SECTION.
FILE-CONTROL.
  SELECT LIBFILE
  ASSIGN TO PAYMAST
  ORGANIZATION IS INDEXED
  RECORD KEY IS EMPL-NUM
  PASSWORD IS BASE-PASS
  ALTERNATE RECORD KEY IS EMPL-PHONE
  PASSWORD IS PATH1-PASS
. . .
WORKING-STORAGE SECTION.
  01  BASE-PASS          PIC X(8) VALUE "25BSREAD".
  01  PATH1-PASS         PIC X(8) VALUE "25ATREAD".
```

Working with VSAM data sets under z/OS and z/OS UNIX

Be aware of special coding considerations for VSAM files under z/OS and z/OS UNIX for access method services (IDCAMS) commands, environment variables, and JCL.

A VSAM file is *available* if all of the following conditions are true:

• You define it using access method services.

• You define it for your program by providing a DD statement, an environment variable, or an ALLOCATE command.

• It has previously contained a record.

A VSAM file is *unavailable* if it has never contained a record, even if you have defined the file.

You always get a return code of zero on completion of the OPEN statement for a VSAM sequential file.

Use the access method services REPRO command to empty a file. Deleting records in this manner resets the high-use relative byte address (RBA) of the file to zero. The file is effectively empty and appears to COBOL as if it never contained a record.

related tasks
“Defining files to the operating system” on page 8
“Defining VSAM files” on page 190
“Creating alternate indexes” on page 190
“Allocating VSAM files” on page 192
“Sharing VSAM files through RLS” on page 193
Defining VSAM files

You can process VSAM entry-sequenced, key-sequenced, and relative-record data sets in Enterprise COBOL only after you define them through access method services (IDCAMS).

A VSAM cluster is a logical definition for a VSAM data set and has one or two components:

- The data component of a VSAM cluster contains the data records.
- The index component of a VSAM key-sequenced cluster consists of the index records.

Use the DEFINE CLUSTER access-method services command to define VSAM data sets (clusters). This process includes creating an entry in an integrated catalog without any data transfer. Define the following information about the cluster:

- Name of the entry
- Name of the catalog to contain this definition and its password (can use default name)
- Organization (sequential, indexed, or relative)
- Device and volumes that the data set will occupy
- Space required for the data set
- Record size and control interval sizes (CISIZE)
- Passwords (if any) required for future access

Depending on what kind of data set is in the cluster, also define the following information for each cluster:

- For VSAM indexed data sets (KSDS), specify length and position of the prime key in the records.
- For VSAM fixed-length relative-record data sets (RRDS), specify the record size as greater than or equal to the maximum size COBOL record:

```
DEFINE CLUSTER NUMBERED RECORDSIZE(n, n)
```

If you define a data set in this way, all records are padded to the fixed slot size $n$. If you use the RECORD IS VARYING ON data-name form of the RECORD clause, a WRITE or REWRITE uses the length specified in DEPENDING ON data-name as the length of the record to be transferred by VSAM. This data is then padded to the fixed slot size. READ statements always return the fixed slot size in the DEPENDING ON data-name.

- For VSAM variable-length relative-record data sets (RRDS), specify the average size COBOL record expected and the maximum size COBOL record expected:

```
DEFINE CLUSTER NUMBERED RECORDSIZE(avg, m)
```

The average size COBOL record expected must be less than the maximum size COBOL record expected.

related tasks

“Creating alternate indexes” on page 190
“Allocating VSAM files” on page 192
“Specifying relative organization for VSAM files” on page 177

related references

z/OS DFSMS: Access Method Services for Catalogs

Creating alternate indexes

An alternate index provides access to the records in a data set that uses more than one key. It accesses records in the same way as the prime index key of an indexed data set (KSDS).

When planning to use an alternate index, you must know:

- The type of data set (base cluster) with which the index will be associated
• Whether the keys will be unique or not unique
• Whether the index is to be password protected
• Some of the performance aspects of using alternate indexes

Because an alternate index is, in practice, a VSAM data set that contains pointers to the keys of a VSAM
data set, you must define the alternate index and the alternate index path (the entity that establishes the
relationship between the alternate index and the prime index). After you define an alternate index, make
a catalog entry to establish the relationship (or path) between the alternate index and its base cluster.
This path allows you to access the records of the base cluster through the alternate keys.

To use an alternate index, do these steps:

1. Define the alternate index by using the DEFINE ALTERNATEINDEX command. In it, specify these
   items:
   • Name of the alternate index
   • Name of its related VSAM indexed data set
   • Location in the record of any alternate indexes and whether they are unique
   • Whether alternate indexes are to be updated when the data set is changed
   • Name of the catalog to contain this definition and its password (can use default name)

   In your COBOL program, the alternate index is identified solely by the ALTERNATE RECORD KEY
   clause in the FILE-CONTROL paragraph. The ALTERNATE RECORD KEY definitions must match the
   definitions in the catalog entry. Any password entries that you cataloged should be coded directly after
   the ALTERNATE RECORD KEY phrase.

2. Relate the alternate index to the base cluster (the data set to which the alternate index gives you
   access) by using the DEFINE PATH command. In it, specify these items:
   • Name of the path
   • Alternate index to which the path is related
   • Name of the catalog that contains the alternate index

   The base cluster and alternate index are described by entries in the same catalog.

3. Load the VSAM indexed data set.

4. Build the alternate index by using (typically) the BLDINDEX command. Identify the input file as the
   indexed data set (base cluster) and the output file as the alternate index or its path. BLDINDEX reads
   all the records in the VSAM indexed data set (or base cluster) and extracts the data needed to build the
   alternate index.

   Alternatively, you can use the runtime option AIXBLD to build the alternate index at run time.
   However, this option might adversely affect performance.

“Example: entries for alternate indexes” on page 191

related tasks
“Using an alternate index” on page 177

related references
Language Environment Programming Reference (AIXBLD (COBOL only))

Example: entries for alternate indexes
The following example maps the relationships between the COBOL FILE-CONTROL entry and the DD
statements or environment variables for a VSAM indexed file that has two alternate indexes.

Using JCL:

```
//MASTERA DD DSNAME=clusternam,DISP=OLD (1)
//MASTERA1 DD DSNAME=path1,DISP=OLD (2)
//MASTERA2 DD DSNAME=path2,DISP=OLD (3)
```
Using environment variables:

```plaintext
export MASTERA=DSN(clustername),OLD  (1)
export MASTERA=DSN(path1),OLD       (2)
export MASTERA=DSN(path2),OLD       (3)

FILE-CONTROL.
  SELECT MASTER-FILE ASSIGN TO MASTERA (4)
    RECORD KEY IS EM-NAME
    PASSWORD IS PW-BASE
    ALTERNATE RECORD KEY IS EM-PHONE  (5)
      PASSWORD IS PW-PATH1
    ALTERNATE RECORD KEY IS EM-CITY    (6)
      PASSWORD IS PW-PATH2.            (7)
```

1. The base cluster name is `clusertname`.
2. The name of the first alternate index path is `path1`.
3. The name of the second alternate index path is `path2`.
4. The ddname or environment variable name for the base cluster is specified with the ASSIGN clause.
5. Passwords immediately follow their indexes.
6. The key `EM-PHONE` relates to the first alternate index.
7. The key `EM-CITY` relates to the second alternate index.

**related tasks**
“Creating alternate indexes” on page 190

### Allocating VSAM files

You must predefine and catalog all VSAM data sets through the access method services DEFINE command. Most of the information about a VSAM data set is in the catalog, so you need to specify only minimal DD or environment variable information.

Allocation of VSAM files (indexed, relative, and sequential) follows the general rules for the allocation of COBOL files.

When you use an environment variable to allocate a VSAM file, the variable name must be in uppercase. Usually the input and data buffers are the only variables that you are concerned about. You must specify these options in the order shown, but no others:

1. `DSN(dsname)`, where `dsname` is the name of the base cluster
2. OLD or SHR

The basic DD statement that you need for VSAM files and the corresponding export command are these:

```plaintext
//ddname DD   DSN=dsname,DISP=SHR,AMP=AMORG
export   evname="DSN(dsname),SHR"
```

In either case, `dsname` must be the same as the name used in the access method services DEFINE CLUSTER or DEFINE PATH command. DISP must be OLD or SHR because the data set is already cataloged. If you specify MOD when using JCL, the data set is treated as OLD.

AMP is a VSAM JCL parameter that supplements the information that the program supplies about the data set. AMP takes effect when your program opens the VSAM file. Any information that you set through the
AMP parameter takes precedence over the information that is in the catalog or that the program supplies. The AMP parameter is required only under the following circumstances:

- You use a dummy VSAM data set. For example,

```
//ddname DD DUMMY,AMP=AMORG
```

- You request additional index or data buffers. For example,

```
//ddname DD DSN=VSAM,dsname,DISP=SHR,
//               AMP=('BUFNI=4,BUFND=8')
```

You cannot specify AMP if you allocate a VSAM data set with an environment variable.

For a VSAM base cluster, specify the same system-name (ddname or environment variable name) that you specify in the ASSIGN clause after the SELECT clause.

When you use alternate indexes in your COBOL program, you must specify not only a system-name (using a DD statement or environment variable) for the base cluster, but also a system-name for each alternate index path. No language mechanism exists to explicitly declare system-names for alternate index paths within the program. Therefore, you must adhere to the following guidelines for forming the system-name (ddname or environment variable name) for each alternate index path:

- Concatenate the base cluster name with an integer.
- Begin with 1 for the path associated with the first alternate record defined for the file in your program (ALTERNATE RECORD KEY clause of the FILE-CONTROL paragraph).
- Increment by 1 for the path associated with each successive alternate record definition for that file.

For example, if the system-name of a base cluster is ABCD, the system-name for the first alternate index path defined for the file in your program is ABCD1, the system-name for the second alternate index path is ABCD2, and so on.

If the length of the base cluster system-name together with the sequence number exceeds eight characters, the base cluster portion of the system-name is truncated on the right to reduce the concatenated result to eight characters. For example, if the system-name of a base cluster is ABCDEFGH, the system-name of the first alternate index path is ABCDEFG1, the tenth is ABCDEF10, and so on.

**related tasks**

“Allocating files” on page 148

**related references**

*Sharing VSAM files through RLS*

By using the VSAM JCL parameter RLS, you can specify record-level sharing with VSAM. Specifying RLS is the only way to request the RLS mode when running COBOL programs.

Use RLS=CR when consistent read protocols are required, and RLS=NRI when no read integrity protocols are required. You cannot specify RLS if you allocate your VSAM data set with an environment variable.

**related tasks**

“Preventing update problems with VSAM files in RLS mode” on page 194

“Handling errors in VSAM files in RLS mode” on page 194

**related references**

“Restrictions when using RLS” on page 194
Preventing update problems with VSAM files in RLS mode
When you open a VSAM data set in RLS mode for I-O (updates), the first READ causes an exclusive lock of the record regardless of the value of RLS (RLS=CR or RLS=NRI) that you specify.

If the COBOL file is defined as ACCESS RANDOM, VSAM releases the exclusive lock on the record after a WRITE or REWRITE statement is executed or a READ statement is executed for another record. When a WRITE or REWRITE is done, VSAM writes the record immediately.

However, if the COBOL file is defined as ACCESS DYNAMIC, VSAM does not release the exclusive lock on the record after a WRITE or REWRITE statement, nor after a READ statement, unless the I-O statement causes VSAM to move to another control interval (CI). As a result, if a WRITE or REWRITE was done, VSAM does not write the record until processing is moved to another CI and the lock is released. When you use ACCESS DYNAMIC, one way to cause the record to be written immediately, to release the exclusive lock immediately, or both, is to define the VSAM data set to allow only one record per CI.

Specifying RLS=CR locks a record and prevents an update to it until another READ is requested for another record. While a lock on the record being read is in effect, other users can request a READ for the same record, but they cannot update the record until the read lock is released. When you specify RLS=NRI, no lock will be in effect when a READ for input is executed. Another user might update the record.

The locking rules for RLS=CR can cause the application to wait for availability of a record lock. This wait might slow down the READ for input. You might need to modify your application logic to use RLS=CR. Do not use the RLS parameter for batch jobs that update nonrecoverable spheres until you are sure that the application functions correctly in a multiple-updater environment.

When you open a VSAM data set in RLS mode for INPUT or I-O processing, it is good to issue an OPEN or START immediately before a READ. If there is a delay between the OPEN or START and the READ, another user might add records before the record on which the application is positioned after the OPEN or START. The COBOL run time points explicitly to the beginning of the VSAM data set at the time when OPEN was requested, but another user might add records that would alter the true beginning of the VSAM data set if the READ is delayed.

Restrictions when using RLS
When you use RLS mode, several restrictions apply to VSAM cluster attributes and to runtime options.

Be aware of these restrictions:

• The VSAM cluster attributes KEYRANGE and IMBED are not supported when you open a VSAM file.
• The VSAM cluster attribute REPLICATE is not recommended because the benefits are negated by the system-wide buffer pool and potentially large CF cache structure in the storage hierarchy.
• The AIXBLD runtime option is not supported when you open a VSAM file because VSAM does not allow an empty path to be opened. If you need the AIXBLD runtime option to build the alternate index data set, open the VSAM data set in non-RLS mode.
• The SIMVRD runtime option is not supported for VSAM files.
• Temporary data sets are not allowed.

Handling errors in VSAM files in RLS mode
If your application accesses a VSAM data set in RLS mode, be sure to check the file status and VSAM feedback codes after each request.

If your application encounters "SMSVSAM server not available" while processing input or output, explicitly close the VSAM file before you try to open it again. VSAM generates return code 16 for such failures, and there is no feedback code. You can have COBOL programs check the first 2 bytes of the second file status area for VSAM return code 16. The COBOL run time generates message IGZ0205W and automatically closes the file if the error occurs during OPEN processing.

All other RLS mode errors return a VSAM return code of 4, 8, or 12.
Allocation of record areas for VSAM files

For reentrant COBOL programs, the record areas for VSAM files are allocated above the 16 MB line by default.

If you specify the DATA(24) compiler option, the VSAM record areas and other dynamic storage areas are allocated in storage below 16 MB.

Programs that pass data in VSAM file records as CALL...USING parameters to AMODE 24 subprograms are impacted. You can recompile such programs with the DATA(24) compiler option, or use the Language Environment HEAP runtime option, to ensure that the records are addressable by the AMODE 24 programs.

Improving VSAM performance

Your system programmer is most likely responsible for tuning the performance of COBOL and VSAM. As an application programmer, you can control the aspects of VSAM that are listed in the following table.

<table>
<thead>
<tr>
<th>Table 31. Methods for improving VSAM performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aspect of VSAM</strong></td>
</tr>
<tr>
<td>Invoking access methods service</td>
</tr>
<tr>
<td>Buffering</td>
</tr>
</tbody>
</table>
| Loading records, using access methods services| Use the access methods service REPRO command when:  
  • The target indexed data set already contains records.  
  • The input sequential data set contains records to be updated or inserted into the indexed data set. 
  If you use a COBOL program to load the file, use OPEN OUTPUT and ACCESS SEQUENTIAL. | The REPRO command can update an indexed data set as fast or faster than any COBOL program under these conditions. |
Table 31. Methods for improving VSAM performance (continued)

<table>
<thead>
<tr>
<th>Aspect of VSAM</th>
<th>What you can do</th>
<th>Rationale and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>File access modes</td>
<td>For best performance, access records sequentially.</td>
<td>Dynamic access is less efficient than sequential access, but more efficient than random access. Random access results in increased EXCPs because VSAM must access the index for each request.</td>
</tr>
<tr>
<td>Key design</td>
<td>Design the key in the records so that the high-order portion is relatively constant and the low-order portion changes often.</td>
<td>This method compresses the key best.</td>
</tr>
<tr>
<td>Multiple alternate indexes</td>
<td>Avoid using multiple alternate indexes.</td>
<td>Updates must be applied through the primary paths and are reflected through multiple alternate paths, perhaps slowing performance.</td>
</tr>
<tr>
<td>Relative file organization</td>
<td>Use VSAM fixed-length relative data sets rather than VSAM variable-length relative data sets.</td>
<td>Although not as space efficient, VSAM fixed-length relative data sets are more run time efficient than VSAM variable-length relative data sets.</td>
</tr>
<tr>
<td>Control interval sizes (CISZ)</td>
<td>Provide your system programmer with information about the data access and future growth of your VSAM data sets. From this information, your system programmer can determine the best control interval size (CISZ) and FREESPACE size (FSPC). Choose proper values for CISZ and FSPC to minimize control area (CA) splits. You can diagnose the current number of CA splits by issuing the LISTCAT ALL command on the cluster, and then compress (using EXPORT, IMPORT, or REPRO) the cluster to omit all CA splits periodically.</td>
<td>VSAM calculates CISZ to best fit the direct-access storage device (DASD) usage algorithm, which might not, however, be efficient for your application. An average CISZ of 4K is suitable for most applications. A smaller CISZ means faster retrieval for random processing at the expense of inserts (that is, more CISZ splits and therefore more space in the data set). A larger CISZ results in the transfer of more data across the channel for each READ. This is more efficient for sequential processing, similar to a large OS BLKSIZE. Many control area (CA) splits are unfavorable for VSAM performance. The FREESPACE value can affect CA splits, depending on how the file is used.</td>
</tr>
</tbody>
</table>

related tasks
“Specifying access modes for VSAM files” on page 178
z/OS DFSMS: Using Data Sets (Building a resource pool, Selecting the optimal percentage of free space)

related references
z/OS DFSMS: Access Method Services for Catalogs
Extended addressability support

You can access VSAM data sets that are defined with the extended addressability attribute, use those VSAM data sets in COBOL programs without COBOL source changes, and maintain compatibility with previous versions of COBOL.

With extended addressability support, you can define larger VSAM data sets outside of COBOL. The 4 GB VSAM architectural limit for data set size imposed by using the 4-byte field for the relative byte address (RBA) is eliminated.

To use the extended addressability, the VSAM data set must be Storage Management Subsystem (SMS)-managed and be defined as extended format. The size limit for a VSAM data set is determined in either of the following ways:

- Control Interval (CI) size multiplied by 4 GB
- Volume size multiplied by 59

For example, a 4 KB CI size yields a maximum data set size of 16 TB, and a 32 KB CI size yields a maximum data set size of 128 TB. A 4 KB CI size is preferred by many applications for performance reasons. For extended-format data sets that grow beyond 4 GB, the processing time does not increase.

Extended addressability is also supported for programs compiled with earlier versions: VS COBOL II programs compiled with RES and any later compilers.

Extended addressability and extended format are not the same concept. Extended format is a prerequisite for extended addressability. Extended format is a technique that affects the way of storing count key data (CKD) in a 3390/3380 logical track. Extended format implements data striping and increases the performance and the reliability of an I/O operation. If a data set is allocated as an extended-format data set, 32 bytes are added to each physical block.

Restriction: Extended addressability was introduced for KSDS data sets in DFSMS/MVS V1.3. Since DFSMS/MVS V1.4, extended addressability is supported in record level sharing (RLS). With DFSMS/MVS V1.5, support for extended addressability is extended to all other VSAM record organizations.

related tasks

z/OS DFSMS: Using Data Sets
Chapter 11. Processing line-sequential files

Line-sequential files reside in the z/OS UNIX file system and can contain both printable characters and control characters as data. Each record ends with an EBCDIC newline character (X'15'), which is not included in the record length.

Because line-sequential files are sequential, records are placed one after another according to entry order. Your program can process these files only sequentially, retrieving (with the READ statement) records in the same order as they are in the file. A new record is placed after the preceding record.

To process line-sequential files in a program, code COBOL language statements that:

- Identify and describe the files in the ENVIRONMENT DIVISION and the DATA DIVISION
- Process the records in the files in the PROCEDURE DIVISION

After you have created a record, you cannot change its length or its position in the file, and you cannot delete it.

related tasks
“Defining line-sequential files and records in COBOL” on page 199
“Allocating line-sequential files” on page 200
“Coding input-output statements for line-sequential files” on page 201
“Handling errors in line-sequential files” on page 204

UNIX System Services User’s Guide

Defining line-sequential files and records in COBOL

Use the FILE-CONTROL paragraph in the ENVIRONMENT DIVISION to define the files in a COBOL program as line-sequential files, and to associate the files with the corresponding external file-names (ddnames or environment variable names).

An external file-name is the name by which a file is known to the operating system. In the following example, COMMUTER-FILE is the name that your program uses for the file; COMMUTR is the external name:

```
FILE-CONTROL.
  SELECT COMMUTER-FILE
  ASSIGN TO COMMUTR
  ORGANIZATION IS LINE SEQUENTIAL
  ACCESS MODE IS SEQUENTIAL
  FILE STATUS IS ECODE.
```

The ASSIGN assignment-name clause must not include an organization field (S- or AS-) before the external name. The ACCESS phrase and the FILE STATUS clause are optional.

related tasks
“Describing the structure of a line-sequential file” on page 200
“Allocating line-sequential files” on page 200
“Coding input-output statements for line-sequential files” on page 201

related references
“Control characters in line-sequential files” on page 200
Describing the structure of a line-sequential file

In the FILE SECTION, code a file description (FD) entry for the file. In the associated record description entry or entries, define the record-name and record length.

Code the logical size in bytes of the records by using the RECORD clause. Line-sequential files are stream files. Because of their character-oriented nature, the physical records are of variable length.

The following examples show how the FD entry might look for a line-sequential file:

**With fixed-length records:**

```
FILE SECTION.
FD COMMUTER-FILE
    RECORD CONTAINS 80 CHARACTERS.
  01 COMMUTER-RECORD.
    05 COMMUTER-NUMBER        PIC X(16).
    05 COMMUTER-DESCRIPTION   PIC X(64).
```

**With variable-length records:**

```
FILE SECTION.
FD COMMUTER-FILE
    RECORD VARYING FROM 16 TO 80 CHARACTERS.
  01 COMMUTER-RECORD.
    05 COMMUTER-NUMBER        PIC X(16).
    05 COMMUTER-DESCRIPTION   PIC X(64).
```

If you code the same fixed size and no OCCURS DEPENDING ON clause for any level-01 record description entries associated with the file, that fixed size is the logical record length. However, because blanks at the end of a record are not written to the file, the physical records might be of varying lengths.

**related tasks**

“Allocating line-sequential files” on page 200

“Coding input-output statements for line-sequential files” on page 201

**related references**

Data division--file description entries

(Enterprise COBOL for z/OS Language Reference)

---

Control characters in line-sequential files

A line-sequential file can contain control characters. Be aware though that if a line-sequential file contains a newline character (X'15'), the newline character will function as a record delimiter.

Control characters other than newline are treated as data and are part of the record.

---

Allocating line-sequential files

You can allocate a line-sequential file in the z/OS UNIX file system by using either a DD statement or an environment variable. Allocation of line-sequential files follows the general rules for allocating COBOL files.

To allocate a line-sequential file, code a DD allocation or an environment variable that has a name that matches the external name in the ASSIGN clause:

- A DD allocation:
  - A DD statement that specifies PATH= 'absolute-path-name'
  - A TSO allocation that specifies PATH( 'absolute-path-name' )

You can optionally also specify these options:

- PATHOPTS
– PATHMODE
– PATHDISP

• An environment variable that has a value of PATH(absolute-path-name). No other values can be specified.

For example, to have your program use z/OS UNIX file /u/myfiles/commuterfile for a COBOL file that has an assignment-name of COMMUTR, you can use the following command:

```
export COMMUTR="PATH(/u/myfiles/commuterfile)"
```

**related tasks**

“Allocating files” on page 148
“Defining line-sequential files and records in COBOL” on page 199

**related references**

*MVS Program Management: User's Guide and Reference*

---

**Coding input-output statements for line-sequential files**

Code the input and output statements shown below to process a line-sequential file.

**OPEN**
To initiate the processing of a file.

You can open a line-sequential file as INPUT, OUTPUT, or EXTEND. You cannot open a line-sequential file as I-O.

**READ**
To read a record from a file.

With sequential processing, a program reads one record after another in the same order in which the records were entered when the file was created.

**WRITE**
To create a record in a file.

A program writes new records to the end of the file.

**CLOSE**
To release the connection between a file and the program.

**related tasks**

“Defining line-sequential files and records in COBOL” on page 199
“Describing the structure of a line-sequential file” on page 200
“Opening line-sequential files” on page 202
“Reading records from line-sequential files” on page 202
“Adding records to line-sequential files” on page 203
“Closing line-sequential files” on page 203
“Handling errors in line-sequential files” on page 204

**related references**

OPEN statement *(Enterprise COBOL for z/OS Language Reference)*
READ statement *(Enterprise COBOL for z/OS Language Reference)*
WRITE statement *(Enterprise COBOL for z/OS Language Reference)*
CLOSE statement *(Enterprise COBOL for z/OS Language Reference)*
Opening line-sequential files

Before your program can use any READ or WRITE statements to process records in a file, it must first open the file with an OPEN statement. An OPEN statement works if the file is available or has been dynamically allocated.

Code CLOSE WITH LOCK so that the file cannot be opened again while the program is running.

related tasks
“Reading records from line-sequential files” on page 202
“Adding records to line-sequential files” on page 203
“Closing line-sequential files” on page 203
“Allocating line-sequential files” on page 200

related references
OPEN statement (Enterprise COBOL for z/OS Language Reference)
CLOSE statement (Enterprise COBOL for z/OS Language Reference)

Reading records from line-sequential files

To read from a line-sequential file, open the file and use the READ statement. Your program reads one record after another in the same order in which the records were entered when the file was created.

Characters in the file record are read one at a time into the record area until one of the following conditions occurs:

• The record delimiter (the EBCDIC newline character) is encountered.
  The delimiter is discarded and the remainder of the record area is filled with spaces. (Record area is longer than the file record.)

• The entire record area is filled with characters.
  If the next unread character is the record delimiter, it is discarded. The next READ reads from the first character of the next record. (Record area is the same length as the file record.) Otherwise the next unread character is the first character to be read by the next READ. (Record area is shorter than the file record.)

• End-of-file is encountered.
  The remainder of the record area is filled with spaces. (Record area is longer than the file record.)

related tasks
“Opening line-sequential files” on page 202
“Adding records to line-sequential files” on page 203
“Closing line-sequential files” on page 203
“Allocating line-sequential files” on page 200

related references
OPEN statement (Enterprise COBOL for z/OS Language Reference)
WRITE statement (Enterprise COBOL for z/OS Language Reference)
Adding records to line-sequential files

To add to a line-sequential file, open the file as EXTEND and use the WRITE statement to add records immediately after the last record in the file.

Blanks at the end of the record area are removed, and the record delimiter is added. The characters in the record area from the first character up to and including the added record delimiter are written to the file as one record.

Records written to line-sequential files must contain only USAGE DISPLAY and DISPLAY-1 items. Zoned decimal data items must be unsigned or declared with the SEPARATE phrase of the SIGN clause if signed.

related tasks
“Opening line-sequential files” on page 202
“Reading records from line-sequential files” on page 202
“Closing line-sequential files” on page 203
“Allocating line-sequential files” on page 200

related references
OPEN statement (Enterprise COBOL for z/OS Language Reference)
WRITE statement (Enterprise COBOL for z/OS Language Reference)

Closing line-sequential files

Use the CLOSE statement to disconnect your program from a line-sequential file. If you try to close a file that is already closed, you will get a logic error.

If you do not close a line-sequential file, the file is automatically closed for you under the following conditions:

• When the run unit ends normally.
• When the run unit ends abnormally, if the TRAP (ON) runtime option is set.
• When Language Environment condition handling is completed and the application resumes in a routine other than where the condition occurred, open files defined in any COBOL programs in the run unit that might be called again and reentered are closed.

You can change the location where the program resumes (after a condition is handled) by moving the resume cursor with the Language Environment CEEMRCR callable service or using HLL language constructs such as a C longjmp call.

File status codes are set when these implicit CLOSE operations are performed, but EXCEPTION/ERROR declaratives are not invoked.

related tasks
“Opening line-sequential files” on page 202
“Reading records from line-sequential files” on page 202
“Adding records to line-sequential files” on page 203
“Allocating line-sequential files” on page 200

related references
CLOSE statement (Enterprise COBOL for z/OS Language Reference)
Handling errors in line-sequential files

When an input or output statement fails, COBOL does not take corrective action for you. You choose whether your program should continue running after an input or output statement fails.

COBOL provides these language elements for intercepting and handling certain line-sequential input and output errors:

- End-of-file phrase (AT END)
- EXCEPTION/ERROR declarative
- FILE STATUS clause

If you do not use one of these techniques, an error in processing input or output raises a Language Environment condition.

If you use the FILE STATUS clause, be sure to check the key and take appropriate action based on its value. If you do not check the key, your program might continue, but the results will probably not be what you expected.

**related tasks**
- “Coding input-output statements for line-sequential files” on page 201
- “Handling errors in input and output operations” on page 225
Chapter 12. Sorting and merging files

You can arrange records in a particular sequence by using a SORT or MERGE statement. You can mix SORT and MERGE statements in the same COBOL program.

**Note:** The SORT statement, sort processes, and sort restrictions that are described in this topic relate to the format 1 SORT statement only. For more information about sorting a table by using the format 2 SORT statement, see “Sorting a table” on page 85.

**SORT statement**
Accepts input (from a file or an internal procedure) that is not in sequence, and produces output (to a file or an internal procedure) in a requested sequence. You can add, delete, or change records before or after they are sorted.

**MERGE statement**
Compares records from two or more sequenced files and combines them in order. You can add, delete, or change records after they are merged.

A program can contain any number of sort and merge operations. They can be the same operation performed many times or different operations. However, one operation must finish before another begins.

With Enterprise COBOL, your IBM licensed program for sorting and merging must be DFSORT or an equivalent. Where DFSORT is mentioned, you can use any equivalent sort or merge product.

COBOL programs that contain SORT or MERGE statements can reside above or below the 16 MB line.

The steps you take to sort or merge are generally as follows:

1. Describe the sort or merge file to be used for sorting or merging.
2. Describe the input to be sorted or merged. If you want to process the records before you sort them, code an input procedure.
3. Describe the output from sorting or merging. If you want to process the records after you sort or merge them, code an output procedure.
4. Request the sort or merge.
5. Determine whether the sort or merge operation was successful.

**Restrictions:**

- You cannot run a COBOL program that contains SORT or MERGE statements under z/OS UNIX. This restriction includes BPXBATCH.
- You cannot use SORT or MERGE statements in programs compiled with the THREAD option. This includes programs that use object-oriented syntax and multithreaded applications, both of which require the THREAD option. In addition, the COBOL program that uses SORT or MERGE statements cannot call directly or indirectly other applications that require z/OS Unix System Services or applications that use multithreading. For example, the JVM uses both of them.
- You cannot use the DFSORT conventional technique. The conventional technique is used in the following cases:
  - The NOBLKSET option is specified. BLKSET is the default when invoking DFSORT.
  - Tape device is used for intermediate work storage.
  - L5 is used in the RECORD statement of DFSORT OPTION control. L5 specifies the average record length. Instead of using L5, the same can be specified by using the AVGRLEN=n statement.

To assist migration of legacy COBOL programs, toleration runtime APARs PH20569(V2R2) and PH21261(V2R3/V2R4) are provided for programs running in AMODE 31. There is no toleration for AMODE 64. For details, see Using DFSORT option NOBLKSET (Enterprise COBOL Migration Guide).
Sort and merge process

During the sorting of a file, all of the records in the file are ordered according to the contents of one or more fields (keys) in each record. You can sort the records in either ascending or descending order of each key.

If there are multiple keys, the records are first sorted according to the content of the first (or primary) key, then according to the content of the second key, and so on.

To sort a file, use the format 1 SORT statement.

During the merging of two or more files (which must already be sorted), the records are combined and ordered according to the contents of one or more keys in each record. You can order the records in either ascending or descending order of each key. As with sorting, the records are first ordered according to the content of the primary key, then according to the content of the second key, and so on.

Use MERGE . . . USING to name the files that you want to combine into one sequenced file. The merge operation compares keys in the records of the input files, and passes the sequenced records one by one to the RETURN statement of an output procedure or to the file that you name in the GIVING phrase.

Describing the sort or merge file

Describe the sort file to be used for sorting or merging. You need SELECT clauses and SD entries even if you are sorting or merging data items only from WORKING-STORAGE or LOCAL-STORAGE.

Code as follows:
1. Write one or more SELECT clauses in the FILE-CONTROL paragraph of the ENVIRONMENT DIVISION to name a sort file. For example:

```plaintext
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT Sort-Work-1 ASSIGN TO SortFile.
```

*Sort-Work-1* is the name of the file in your program. Use this name to refer to the file.

2. Describe the sort file in an SD entry in the FILE SECTION of the DATA DIVISION. Every SD entry must contain a record description. For example:

```plaintext
DATA DIVISION.
FILE SECTION.
    SD Sort-Work-1
        RECORD CONTAINS 100 CHARACTERS.
        01  SORT-WORK-1-AREA.
            05  SORT-KEY-1 PIC X(10).
            05  SORT-KEY-2 PIC X(10).
            05  FILLER PIC X(80).
```

The file described in an SD entry is the working file used for a sort or merge operation. You cannot perform any input or output operations on this file and you do not need to provide a ddname definition for it.

**related references**

“FILE SECTION entries” on page 11

---

**Describing the input to sorting or merging**

Describe the input file or files for sorting or merging by following the procedure below.

1. Write one or more SELECT clauses in the FILE-CONTROL paragraph of the ENVIRONMENT DIVISION to name the input files. For example:

```plaintext
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT Input-File ASSIGN TO InFile.
```

*Input-File* is the name of the file in your program. Use this name to refer to the file.

2. Describe the input file (or files when merging) in an FD entry in the FILE SECTION of the DATA DIVISION. For example:

```plaintext
DATA DIVISION.
FILE SECTION.
    FD Input-File
        LABEL RECORDS ARE STANDARD
        BLOCK CONTAINS 0 CHARACTERS
        RECORDING MODE IS F
        RECORD CONTAINS 100 CHARACTERS.
        01  Input-Record PIC X(100).
```

**related tasks**

“Coding the input procedure” on page 208

“Requesting the sort or merge” on page 212

**related references**

“FILE SECTION entries” on page 11
Example: describing sort and input files for SORT

The following example shows the ENVIRONMENT DIVISION and DATA DIVISION entries needed to describe sort work files and an input file.

```
ID Division.
Program-ID. SmplSort.
Environment Division.
Input-Output Section.
File-Control.
*  Assign name for a working file is treated as documentation.
*  Select Sort-Work-1 Assign To SortFile.
   Select Sort-Work-2 Assign To SortFile.
   Select Input-File Assign To InFile.
...
Data Division.
File Section.
SD  Sort-Work-1
   Record Contains 100 Characters.
  01  Sort-Work-1-Area.
      05  Sort-Key-1    Pic  X(10).
      05  Sort-Key-2    Pic  X(10).
      05  Filler        Pic  X(80).
SD  Sort-Work-2
   Record Contains 30 Characters.
  01  Sort-Work-2-Area.
      05  Sort-Key      Pic  X(5).
      05  Filler        Pic  X(25).
FD  Input-File
   Label Records Are Standard
   Block Contains 0 Characters
   Recording Mode is F
   Record Contains 100 Characters.
  01  Input-Record      Pic  X(100).
... 
Working-Storage Section.
  01  EOS-Sw            Pic  X.
  01  Filler.
      05  Table-Entry Occurs 100 Times
           Indexed By X1    Pic X(30).
... 
related tasks
"Requesting the sort or merge" on page 212
```

Coding the input procedure

To process the records in an input file before they are released to the sort program, use the INPUT PROCEDURE phrase of the format 1 SORT statement.

You can use an input procedure to:

- Release data items to the sort file from WORKING-STORAGE or LOCAL-STORAGE.
- Release records that have already been read elsewhere in the program.
- Read records from an input file, select or process them, and release them to the sort file.

Each input procedure must be contained in either paragraphs or sections. For example, to release records from a table in WORKING-STORAGE or LOCAL-STORAGE to the sort file SORT-WORK-2, you could code as follows:

```
SORT SORT-WORK-2
   ON ASCENDING KEY SORT-KEY
INPUT PROCEDURE 600-SORT3-INPUT-PROC
...
600-SORT3-INPUT-PROC SECTION.
PERFORM WITH TEST AFTER
```
To transfer records to the sort program, all input procedures must contain at least one RELEASE or RELEASE FROM statement. To release A from X, for example, you can code:

```
MOVE X TO A.
RELEASE A.
```

Alternatively, you can code:

```
RELEASE A FROM X.
```

The following table compares the RELEASE and RELEASE FROM statements.

<table>
<thead>
<tr>
<th>RELEASE</th>
<th>RELEASE FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOVE EXT-RECORD</td>
<td>PERFORM RELEASE-SORT-RECORD</td>
</tr>
<tr>
<td>TO SORT-EXT-RECORD</td>
<td>RELEASE-SORT-RECORD</td>
</tr>
<tr>
<td>PERFORM RELEASE-SORT-RECORD</td>
<td></td>
</tr>
<tr>
<td>. . .</td>
<td>RELEASE-SORT-RECORD FROM SORT-EXT-RECORD</td>
</tr>
<tr>
<td>RELEASE SORT-RECORD</td>
<td></td>
</tr>
</tbody>
</table>

related references
“Restrictions on input and output procedures” on page 211
RELEASE statement (Enterprise COBOL for z/OS Language Reference)

## Describing the output from sorting or merging

If the output from sorting or merging is a file, describe the file by following the procedure below.

1. Write a SELECT clause in the FILE-CONTROL paragraph of the ENVIRONMENT DIVISION to name the output file. For example:

```
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
   SELECT Output-File ASSIGN TO OutFile.
```

`Output-File` is the name of the file in your program. Use this name to refer to the file.

2. Describe the output file (or files when merging) in an FD entry in the FILE SECTION of the DATA DIVISION. For example:

```
DATA DIVISION.
FILE SECTION.
FD Output-File
   LABEL RECORDS ARE STANDARD
   BLOCK CONTAINS 0 CHARACTERS
   RECORDING MODE IS F
   RECORD CONTAINS 100 CHARACTERS.
   01 Output-Record PIC X(100).
```

related tasks
“Coding the output procedure” on page 210
“Requesting the sort or merge” on page 212
Coding the output procedure

To select, edit, or otherwise change sorted records before writing them from the sort work file into another file, use the OUTPUT PROCEDURE phrase of the format 1 SORT statement.

Each output procedure must be contained in either a section or a paragraph. An output procedure must include both of the following elements:

• At least one RETURN statement or one RETURN statement with the INTO phrase
• Any statements necessary to process the records that are made available, one at a time, by the RETURN statement

The RETURN statement makes each sorted record available to the output procedure. (The RETURN statement for a sort file is similar to a READ statement for an input file.)

You can use the AT END and END-RETURN phrases with the RETURN statement. The imperative statements in the AT END phrase are performed after all the records have been returned from the sort file. The END-RETURN explicit scope terminator delimits the scope of the RETURN statement.

If you use RETURN INTO instead of RETURN, the records will be returned to WORKING-STORAGE, LOCAL-STORAGE, or to an output area.

**DFSORT coding:** If you use DFSORT and a RETURN statement does not encounter an AT END condition before a COBOL program finishes running, the format 1 SORT statement could end abnormally with DFSORT message IEC025A. To avoid this situation, be sure to code the RETURN statement with the AT END phrase. In addition, ensure that the RETURN statement is executed until the AT END condition is encountered. The AT END condition occurs after the last record is returned to the program from the sort work file and a subsequent RETURN statement is executed.

**Example: coding the output procedure when using DFSORT**

The following example shows a coding technique that ensures that the RETURN statement encounters the AT END condition before the program finishes running. The RETURN statement, coded with the AT END phrase, is executed until the AT END condition occurs.

```
IDENTIFICATION DIVISION.
DATA DIVISION.
FILE SECTION.
SD OUR-FILE.
  01  OUR-SORT-REC.
    03  SORT-KEY       PIC X(10).
    03  FILLER         PIC X(70).
  . . .
WORKING-STORAGE SECTION.
  01  WS-SORT-REC     PIC X(80).
  01  END-OF-SORT-FILE-INDICATOR PIC X VALUE 'N'.
    88  NO-MORE-SORT-RECORDS VALUE 'Y'.
  . . .
PROCEDURE DIVISION.
  A-CONTROL SECTION.
    SORT OUR-FILE ON ASCENDING KEY SORT-KEY
    INPUT PROCEDURE IS B-INPUT
    OUTPUT PROCEDURE IS C-OUTPUT.
  B-INPUT SECTION.
    MOVE . . . . . . TO WS-SORT-REC.
    RELEASE OUR-SORT-REC FROM WS-SORT-REC.
```

**related references**

“Restrictions on input and output procedures” on page 211
RETURN statement (*Enterprise COBOL for z/OS Language Reference*)
Restrictions on input and output procedures

Several restrictions apply to each input or output procedure called by SORT and to each output procedure called by MERGE.

Observe these restrictions:

• The procedure must not contain any SORT or MERGE statements.
• You can use ALTER, GO TO, and PERFORM statements in the procedure to refer to procedure-names outside the input or output procedure. However, control must return to the input or output procedure after a GO TO or PERFORM statement.
• The remainder of the PROCEDURE DIVISION must not contain any transfers of control to points inside the input or output procedure (with the exception of the return of control from a declarative section).
• In an input or output procedure, you can call a program that follows standard linkage conventions. However, the called program cannot issue a SORT or MERGE statement.
• During a SORT or MERGE operation, the SD data item is used. You must not use it in the output procedure before the first RETURN executes. If you move data into this record area before the first RETURN statement, the first record to be returned will be overwritten.
• Language Environment condition handling does not let user-written condition handlers be established in an input or output procedure.

related tasks
“Coding the input procedure” on page 208
“Coding the output procedure” on page 210
Language Environment Programming Guide (Preparing to link-edit and run)

Defining sort and merge data sets

To use DFSORT under z/OS, code DD statements in the runtime JCL to describe the necessary data sets that are listed below.

Sort or merge work
Define a minimum of three data sets: SORTWK01, SORTWK02, SORTWK03, ..., SORTWKnn (where nn is 99 or less). These data sets cannot be in the z/OS UNIX file system.

SYSOUT
Define for sort diagnostic messages, unless you change the data-set name. (Change the name using either the MSGDDN keyword of the OPTION control statement in the SORT-CONTROL data set, or using the SORT-MESSAGE special register.)

SORTCKPT
Define if the sort or merge is to take checkpoints.

Input and output
Define input and output data sets, if any.
SORTLIB (DFSORT library)

Define the library that contains the sort modules, for example, SYS1.SORTLIB.

related tasks

“Controlling sort behavior” on page 219
“Using checkpoint/restart with DFSORT” on page 221

Sorting variable-length records

Your sort work file will be variable length only if you define it to be variable length, even if the input file to the sort contains variable-length records.

The compiler determines that the sort work file is variable length if you code one of the following elements in the SD entry:

- A RECORD IS VARYING clause
- Two or more record descriptions that define records that have different sizes, or records that contain an OCCURS DEPENDING ON clause

You cannot use RECORDING MODE V for the sort work file because the SD entry does not allow the RECORDING MODE clause.

Performance consideration: To improve sort performance of variable-length files, specify the most frequently occurring record length of the input file (the modal length) on the SMS= control card or in the SORT-MODE-SIZE special register.

related tasks

“Changing DFSORT defaults with control statements” on page 220
“Controlling sort behavior” on page 219

Requesting the sort or merge

To read records from an input file (files for MERGE) without preliminary processing, use SORT . . . USING or MERGE . . . USING and the name of the input file (files) that you declared in a SELECT clause.

To transfer sorted or merged records from the sort or merge program to another file without any further processing, use SORT . . . GIVING or MERGE . . . GIVING and the name of the output file that you declared in a SELECT clause. For example:

```
SORT Sort-Work-1
  ON ASCENDING KEY Sort-Key-1
  USING Input-File
  GIVING Output-File.
```

For SORT . . . USING or MERGE . . . USING, the compiler generates an input procedure to open the file (files), read the records, release the records to the sort or merge program, and close the file (files). The file (files) must not be open when the SORT or MERGE statement begins execution. For SORT . . . GIVING or MERGE . . . GIVING, the compiler generates an output procedure to open the file, return the records, write the records, and close the file. The file must not be open when the SORT or MERGE statement begins execution.

The USING or GIVING files in a SORT or MERGE statement can be sequential files residing in the z/OS UNIX file system.

“Example: describing sort and input files for SORT” on page 208
If you want an input procedure to be performed on the sort records before they are sorted, use `SORT . . . INPUT PROCEDURE`. If you want an output procedure to be performed on the sorted records, use `SORT . . . OUTPUT PROCEDURE`. For example:

```
SORT Sort-Work-1
    ON ASCENDING KEY Sort-Key-1
    INPUT PROCEDURE EditInputRecords
    OUTPUT PROCEDURE FormatData.
```

“Example: sorting with input and output procedures” on page 214

**Restriction:** You cannot use an input procedure with the `MERGE` statement. The source of input to the merge operation must be a collection of already sorted files. However, if you want an output procedure to be performed on the merged records, use `MERGE . . . OUTPUT PROCEDURE`. For example:

```
MERGE Merge-Work
    ON ASCENDING KEY Merge-Key
    USING Input-File-1 Input-File-2 Input-File-3
    OUTPUT PROCEDURE ProcessOutput.
```

In the `FILE SECTION`, you must define `Merge-Work` in an SD entry, and the input files in FD entries.

**related tasks**
“Defining sort and merge data sets” on page 211

**related references**
SORT statement (Enterprise COBOL for z/OS Language Reference)
MERGE statement (Enterprise COBOL for z/OS Language Reference)

**Setting sort or merge criteria**

To set sort or merge criteria, define the keys on which the operation is to be performed.

**Note:** The process of setting sort criteria that is described in this topic relates to the format 1 `SORT` statement only. For more information about sorting a table by using the format 2 `SORT` statement, see “Sorting a table” on page 85.

Do these steps:

1. In the record description of the files to be sorted or merged, define the key or keys.

   There is no maximum number of keys, but the keys must be located in the first 4092 bytes of the record description. The total length of the keys cannot exceed 4092 bytes unless the `EQUALS` keyword is coded in the DFSORT OPTION control statement, in which case the total length of the keys must not exceed 4088 bytes.

   **Restriction:** A key cannot be variably located.

2. In the `SORT` or `MERGE` statement, specify the key fields to be used for sequencing by coding the `ASCENDING` or `DESCENDING KEY` phrase, or both. When you code more than one key, some can be ascending, and some descending.

   Specify the names of the keys in decreasing order of significance. The leftmost key is the primary key. The next key is the secondary key, and so on.

**SORT** and **MERGE** keys can be of class alphabetic, alphanumeric, national, or numeric (but not numeric of `USAGE NATIONAL`). If it has `USAGE NATIONAL`, a key can be of category national or can be a national-edited or numeric-edited data item. A key cannot be a national decimal data item or a national floating-point data item.

The collation order for national keys is determined by the binary order of the keys. If you specify a national data item as a key, any `COLLATING SEQUENCE` phrase in the `SORT` or `MERGE` statement does not apply to that key.
You can mix SORT and MERGE statements in the same COBOL program. A program can perform any number of sort or merge operations. However, one operation must end before another can begin.

related tasks

“Sorting a table” on page 85

related references

DFSORT Application Programming Guide (SORT control statement)
SORT statement (Enterprise COBOL for z/OS Language Reference)
MERGE statement (Enterprise COBOL for z/OS Language Reference)

Example: sorting with input and output procedures

The following example shows the use of an input and an output procedure in a format 1 SORT statement. The example also shows how you can define a primary key (SORT-GRID-LOCATION) and a secondary key (SORT-SHIFT) before using them in the format 1 SORT statement.

```
DATA DIVISION.
  SD SORT-FILE
    RECORD CONTAINS 115 CHARACTERS
    DATA RECORD SORT-RECORD.
  01 SORT-RECORD.
    05 SORT-KEY.
      10 SORT-SHIFT              PIC X(1).
      10 SORT-GRID-LOCATION      PIC X(2).
      10 SORT-REPORT             PIC X(3).
    05 SORT-EXT-RECORD.
      10 SORT-EXT-EMPLOYEE-NUM   PIC X(6).
      10 SORT-EXT-NAME           PIC X(30).
      10 FILLER                  PIC X(73).
  WORKING-STORAGE SECTION.
  01 TAB1.
    05 TAB-ENTRY OCCURS 10 TIMES
      INDEXED BY TAB-INDX.
      10 WS-SHIFT                PIC X(1).
      10 WS-GRID-LOCATION        PIC X(2).
      10 WS-REPORT               PIC X(3).
      10 WS-EXT-EMPLOYEE-NUM     PIC X(6).
      10 WS-EXT-NAME             PIC X(30).
      10 FILLER                  PIC X(73).
  PROCEDURE DIVISION.
    SORT SORT-FILE
      ON ASCENDING KEY SORT-GRID-LOCATION SORT-SHIFT
      INPUT PROCEDURE 600-SORT3-INPUT
      OUTPUT PROCEDURE 700-SORT3-OUTPUT.
  600-SORT3-INPUT.
    PERFORM VARYING TAB-INDX FROM 1 BY 1 UNTIL TAB-INDX > 10
    RELEASE SORT-RECORD FROM TAB-ENTRY(TAB-INDX)
    END-PERFORM.
  700-SORT3-OUTPUT.
    PERFORM VARYING TAB-INDX FROM 1 BY 1 UNTIL TAB-INDX > 10
    RETURN SORT-FILE INTO TAB-ENTRY(TAB-INDX)
    AT END DISPLAY 'Out Of Records In SORT File'
    END-RETURN
    END-PERFORM.
```

related tasks

“Requesting the sort or merge” on page 212
Choosing alternate collating sequences

You can sort or merge records on the EBCDIC or ASCII collating sequence, or on another collating sequence. The default collating sequence is EBCDIC unless you code the PROGRAM COLLATING SEQUENCE clause in the OBJECT-COMPUTER paragraph.

To override the default sequence, use the COLLATING SEQUENCE phrase of the SORT or MERGE statement. You can use different collating sequences for each SORT or MERGE statement in your program.

The PROGRAM COLLATING SEQUENCE clause and the COLLATING SEQUENCE phrase apply only to keys of class alphabetic or alphanumeric.

When you sort or merge an ASCII file, you have to request the ASCII collating sequence. To do so, code the COLLATING SEQUENCE phrase of the SORT or MERGE statement, and define the alphabet-name as STANDARD-1 in the SPECIAL-NAMES paragraph.

related tasks
“Specifying the collating sequence” on page 6
“Setting sort or merge criteria” on page 213

related references
OBJECT-COMPUTER paragraph (Enterprise COBOL for z/OS Language Reference)
SORT statement (Enterprise COBOL for z/OS Language Reference)
Classes and categories of data (Enterprise COBOL for z/OS Language Reference)

Preserving the original sequence of records with equal keys

You can preserve the order of identical collating records from input to output.

Use one of these techniques:

- Install DFSORT with the EQUALS option as the default.
- Provide, at run time, an OPTION card that has the EQUALS keyword in the IGZSRTCD data set.
- Use the WITH DUPLICATES IN ORDER phrase in the SORT statement. Doing so adds the EQUALS keyword to the OPTION card in the IGZSRTCD data set.

Do not use both the NOEQUALS keyword on the OPTION card and the DUPLICATES phrase, or the run unit will end.

related references
DFSORT Application Programming Guide (OPTION control statement)

Determining whether the sort or merge was successful

The DFSORT program returns a completion code of either 0 (successful completion) or 16 (unsuccessful completion) after each sort or merge has finished. The completion code is stored in the SORT-RETURN special register.

You should test for successful completion after each SORT or MERGE statement. For example:

```cobol
SORT SORT-WORK-2
  ON ASCENDING KEY SORT-KEY
  INPUT PROCEDURE IS 600-SORT3-INPUT-PROC
  OUTPUT PROCEDURE IS 700-SORT3-OUTPUT-PROC.
  IF SORT-RETURN NOT=0
    DISPLAY "SORT ENDED ABNORMALLY. SORT-RETURN = " SORT-RETURN.
  . . .
600-SORT3-INPUT-PROC SECTION.
. . .
700-SORT3-OUTPUT-PROC SECTION.
. . .
```
If you do not reference SORT-RETURN anywhere in your program, the COBOL run time tests the completion code. If it is 16, COBOL issues a runtime diagnostic message.

By default, DFSORT diagnostic messages are sent to the SYSOUT data set. If you want to change this default, use the MSGDDN parameter of the DFSORT OPTION control card or use the SORT-MESSAGE special register.

If you test SORT-RETURN for one or more (but not necessarily all) SORT or MERGE statements, the COBOL run time does not check the completion code.

**Related tasks**
- “Checking for sort errors with NOFASTSRT” on page 218
- “Controlling sort behavior” on page 219

**Related references**
DFSORT Application Programming Guide (DFSORT messages and return codes)

### Stopping a sort or merge operation prematurely

To stop a sort or merge operation, move the integer 16 into the SORT-RETURN special register.

Move 16 into the register in either of the following ways:

- Use MOVE in an input or output procedure.
  - Sort or merge processing will be stopped immediately after the next RELEASE or RETURN statement is performed.
- Reset the register in a declarative section entered during processing of a USING or GIVING file.
  - Sort or merge processing will be stopped immediately after the next implicit RELEASE or RETURN is performed, which will occur after a record has been read from or written to the USING or GIVING file.

Control then returns to the statement following the SORT or MERGE statement.

### Improving sort performance with FASTSRT

Using the FASTSRT compiler option improves the performance of most sort operations. With FASTSRT, the DFSORT product (instead of Enterprise COBOL) performs the I/O on the input and output files you name in the SORT . . . USING and SORT . . . GIVING statements.

The compiler issues informational messages to point out statements in which FASTSRT can improve performance.

**Usage notes**
- You cannot use the DFSORT options SORTIN or SORTOUT if you use FASTSRT. The FASTSRT compiler option does not apply to line-sequential files you use as USING or GIVING files.
- If you specify file status and use FASTSRT, file status is ignored during the sort.

**Related references**
- “FASTSRT” on page 308
- “FASTSRT requirements for JCL” on page 216
- “FASTSRT requirements for sort input and output files” on page 217

### FASTSRT requirements for JCL

In the runtime JCL, you must assign the sort work files (SORTWKnn) to a direct-access device, not to tape data sets.

For the input and output files, the DCB parameter of the DD statement must match the FD description.
**FASTSRT requirements for sort input and output files**

If you specify FASTSRT but your code does not meet FASTSRT requirements, the compiler issues a message and the COBOL run time performs the I/O instead. Your program will not experience the performance improvements that are otherwise possible.

**Note:** The "sort input and output files" that is described in this topic relates to the format 1 SORT statement only.

To use FASTSRT, you must describe and process the input files to the sort and the output files from the sort in these ways:

- You can name only one input file in the USING phrase. You can name only one output file in the GIVING phrase.
- You cannot use an input procedure on an input file nor an output procedure on an output file.

Instead of using input or output procedures, you might be able to use these DFSORT control statements:

- `INREC`
- `OUTFILE`
- `OUTREC`
- `INCLUDE`
- `OMIT`
- `STOPAFT`
- `SKIPREC`
- `SUM`

Many DFSORT functions perform the same operations that are common in input or output procedures. Code the appropriate DFSORT control statements instead, and place them either in the IGZSRTCD or SORTCNTL data set.

- Do not code the LINAGE clause for the output FD entry.
- Do not code any INPUT declarative (for input files), OUTPUT declarative (for output files), or file-specific declaratives (for either input or output files) to apply to any FDs used in the sort.
- Do not use a variable relative file as the input or output file.
- Do not use a line-sequential file as the input or output file.
- For either an input or an output file, the record descriptions of the SD and FD entry must define the same format (fixed or variable), and the largest records of the SD and FD entry must define the same record length.

If you code a RELATIVE KEY clause for an output file, it will not be set by the sort.

**Performance tip:** If you block your input and output records, the sort performance could be significantly improved.

**QSAM requirements**

- QSAM files must have a record format of fixed, variable, or spanned.
- A QSAM input file can be empty.
- To use the same QSAM file for both input and output, you must describe the file using two different DD statements. For example, in the FILE-CONTROL SECTION you might code this:

```
SELECT FILE-IN ASSIGN INPUTF.
SELECT FILE-OUT ASSIGN OUTPUTF.
```

In the DATA DIVISION, you would have an FD entry for both FILE-IN and FILE-OUT, where FILE-IN and FILE-OUT are identical except for their names.
In the **PROCEDURE DIVISION**, your **SORT** statement could look like this:

```cobol
SORT file-name
   ASCENDING KEY data-name-1
   USING FILE-IN GIVING FILE-OUT
```

Then in your **JCL**, assuming that data set **INOUT** has been cataloged, you would code:

```jcl
//INPUTF DD DSN=INOUT,DISP=SHR
//OUTPUTF DD DSN=INOUT,DISP=SHR
```

On the other hand, if you code the same **file-name** in the **USING** and **GIVING** phrases, or assign the input and output files the same ddname, then the file can be accepted for **FASTSRT** either for input or output, but not both. If no other conditions disqualify the file from being eligible for **FASTSRT** on input, then the file will be accepted for **FASTSRT** on input, but not on output. If the file was found to be ineligible for **FASTSRT** on input, it might be eligible for **FASTSRT** on output.

A **QSAM** file that qualifies for **FASTSRT** can be accessed by the COBOL program while the format 1 **SORT** statement is being performed. For example, if the file is used for **FASTSRT** on input, you can access it in an output procedure; if it is used for **FASTSRT** on output, you can access it in an input procedure.

**VSAM requirements**

- A VSAM input file must not be empty.
- VSAM files cannot be password-protected.
- You cannot name the same VSAM file in both the **USING** and **GIVING** phrases.
- A VSAM file that qualifies for **FASTSRT** cannot be accessed by the COBOL program until the format 1 **SORT** statement processing is completed. For example, if the file qualifies for **FASTSRT** on input, you cannot access it in an output procedure and vice versa. (If you do so, **OPEN** fails.)

**related tasks**

*DFSORT Application Programming Guide*

**Checking for sort errors with **NOFASTSRT****

When you compile with the **NOFASTSRT** option, the sort process does not check for errors in open, close, or input or output operations for files that you reference in the **USING** or **GIVING** phrase of the format 1 **SORT** statement. Therefore, you might need to check whether **SORT** completed successfully.

**Note:** This topic relates to the format 1 **SORT** statement only.

The code required depends on whether you code a **FILE STATUS** clause or an **ERROR** declarative for the files referenced in the **USING** and **GIVING** phrases, as shown in the table below.

<table>
<thead>
<tr>
<th>FILE STATUS clause?</th>
<th>ERROR declarative?</th>
<th>Then do:</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>No special coding. Any failure during the sort process causes the program to end abnormally.</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>Test the <strong>SORT-RETURN</strong> special register after the format 1 <strong>SORT</strong> statement, and test the file status key. (Not recommended if you want complete file-status checking, because the file status code is set but COBOL cannot check it.)</td>
</tr>
</tbody>
</table>
Table 32. Methods for checking for sort errors with NOFASTSRT (continued)

<table>
<thead>
<tr>
<th>FILE STATUS clause?</th>
<th>ERROR declarative?</th>
<th>Then do:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe</td>
<td>Yes</td>
<td>In the ERROR declarative, set the SORT-RETURN special register to 16 to stop the sort process and indicate that it was not successful. Test the SORT-RETURN special register after the format 1 SORT statement.</td>
</tr>
</tbody>
</table>

related tasks

“Determining whether the sort or merge was successful” on page 215
“Using file status keys” on page 229
“Coding ERROR declaratives” on page 228
“Stopping a sort or merge operation prematurely” on page 216

Controlling sort behavior

You can control several aspects of sort behavior by inserting values in special registers before the sort or by using compiler options. You might also have a choice of control statements and keywords.

You can verify sort behavior by examining the contents of special registers after the sort.

The table below lists those aspects of sort behavior that you can affect by using special registers or compiler options, and the equivalent sort control statement keywords if any are available.

Table 33. Methods for controlling sort behavior

<table>
<thead>
<tr>
<th>To set or test</th>
<th>Use this special register or compiler option</th>
<th>Or this control statement (and keyword if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of main storage to be reserved</td>
<td>SORT-CORE-SIZE special register</td>
<td>OPTION (keyword RESINV)</td>
</tr>
<tr>
<td>Amount of main storage to be used</td>
<td>SORT-CORE-SIZE special register</td>
<td>OPTION (keywords MAINSIZE or MAINSIZE=MAX)</td>
</tr>
<tr>
<td>Modal length of records in a file with variable-length records</td>
<td>SORT-MODE-SIZE special register</td>
<td>SMS=nnnnnn</td>
</tr>
<tr>
<td>Name of sort control statement data set (default IGZSRTCD)</td>
<td>SORT-CONTROL special register</td>
<td>None</td>
</tr>
<tr>
<td>Name of sort message file (default SYSOUT)</td>
<td>SORT-MESSAGE special register</td>
<td>OPTION (keyword MSGDDN)</td>
</tr>
<tr>
<td>Number of sort records</td>
<td>SORT-FILE-SIZE special register</td>
<td>OPTION (keyword FILSZ)</td>
</tr>
<tr>
<td>Sort completion code</td>
<td>SORT-RETURN special register</td>
<td>None</td>
</tr>
</tbody>
</table>

Sort special registers: SORT-CONTROL is an eight-character COBOL special register that contains the ddname of the sort control statement file. If you do not want to use the default ddname IGZSRTCD, assign to SORT-CONTROL the ddname of the data set that contains your sort control statements.

The SORT-CORE-SIZE, SORT-FILE-SIZE, SORT-MESSAGE, and SORT-MODE-SIZE special registers are used in the SORT interface if you assign them nondefault values. At run time, however, any parameters in control statements in the sort control statement data set override corresponding settings in the special registers, and a message to that effect is issued.
You can use the SORT-RETURN special register to determine whether the sort or merge was successful and to stop a sort or merge operation prematurely.

A compiler warning message (W-level) is issued for each sort special register that you set in a program.

related tasks
“Determining whether the sort or merge was successful” on page 215
“Stopping a sort or merge operation prematurely” on page 216
“Changing DFSORT defaults with control statements” on page 220
“Allocating space for sort files” on page 221
DFSORT Application Programming Guide (Using DFSORT program control statements)

related references
“Default characteristics of the IGZSRTCD data set” on page 220

Changing DFSORT defaults with control statements
If you want to change DFSORT system defaults to improve sort performance, pass information to DFSORT through control statements in the runtime data set IGZSRTCD.

The control statements that you can include in IGZSRTCD (in the order listed) are:

1. SMS=nnnnn, where nnnnn is the length in bytes of the most frequently occurring record size. (Use only if the SD file is variable length.)
2. OPTION (except keywords SORTIN or SORTOUT).
3. Other DFSORT control statements (except SORT, MERGE, RECORD, or END).

Code control statements between columns 2 and 71. You can continue a control statement record by ending the line with a comma and starting the next line with a new keyword. You cannot use labels or comments on a record, and a record itself cannot be a DFSORT comment statement.

related tasks
“Controlling sort behavior” on page 219
DFSORT Application Programming Guide (Using DFSORT program control statements)

related references
“Default characteristics of the IGZSRTCD data set” on page 220

Default characteristics of the IGZSRTCD data set
The IGZSRTCD data set is optional. Its defaults are LRECL=80, BLKSIZE=400, and ddname IGZSRTCD.

You can use a different ddname by coding it in the SORT-CONTROL special register. If you defined a ddname for the SORT-CONTROL data set and you receive the message IGZ0027W, an OPEN failure occurred that you should investigate.

related tasks
“Controlling sort behavior” on page 219

Allocating storage for sort or merge operations
Certain parameters set during the installation of DFSORT determine the amount of storage that DFSORT uses. In general, the more storage DFSORT has available, the faster the sort or merge operations in your program will be.

DFSORT installation should not allocate all the free space in the region for its COBOL operation, however. When your program is running, storage must be available for:

• COBOL programs that are dynamically called from an input or output procedure
• Language Environment runtime library modules
• Data management modules that can be loaded into the region for use by an input or output procedure
Any storage obtained by these modules
For a specific sort or merge operation, you can override the DFSORT storage values set at installation. To do so, code the MAINSIZE and RESINV keywords on the OPTION control statement in the sort control statement data set, or use the SORT-CORE-SIZE special register.

Be careful not to override the storage allocation to the extent that all the free space in the region is used for sort operations for your COBOL program.

related tasks
“Controlling sort behavior” on page 219
DFSORT Installation and Customization

related references
DFSORT Application Programming Guide (OPTION control statement)

Allocating space for sort files
If you use NOFASTSRT or an input procedure, DFSORT does not know the size of the file that you are sorting. This can lead to an out-of-space condition when you sort large files or to overallocation of resources when you sort small files.

If this occurs, you can use the SORT-FILE-SIZE special register to help DFSORT determine the amount of resource (for example, workspace or hiperspace) needed for the sort. Set SORT-FILE-SIZE to a reasonable estimate of the number of input records. This value is passed to DFSORT as its FILSZ=E value.

related tasks
“Controlling sort behavior” on page 219
“Coding the input procedure” on page 208
DFSORT Application Programming Guide

Using checkpoint/restart with DFSORT
You cannot use checkpoints taken while DFSORT is running under z/OS to restart, unless the checkpoints are taken by DFSORT.

Checkpoints taken by a COBOL program while SORT or MERGE statements execute are invalid; such restarts are detected and canceled.

To take a checkpoint during a sort or merge operation, do these steps:
1. Add a DD statement for SORTCKPT in the JCL.
2. Code the RERUN clause in the I-O-CONTROL paragraph:

   RERUN ON assignment-name

3. Code the CKPT (or CHKPT) keyword on an OPTION control statement in the sort control statement data set (default ddname IGZSRTCD).

related concepts
Chapter 34, “Interrupts and checkpoint/restart,” on page 615

related tasks
“Changing DFSORT defaults with control statements” on page 220
“Setting checkpoints” on page 615
Sorting under CICS

There is no IBM sort product that is supported under CICS. However, you can use the format 1 SORT statement with a sort program you write that runs under CICS to sort small amounts of data. You can also use the format 2 SORT statement under CICS to sort tables.

You must have both an input and an output procedure for the format 1 SORT statement. In the input procedure, use the RELEASE statement to transfer records from the COBOL program to the sort program before the sort is performed. In the output procedure, use the RETURN statement to transfer records from the sort program to the COBOL program after the sort is performed.

The format 2 SORT statement is supported under CICS and you don't need to write a special SORT program.

related tasks
“Coding the input procedure” on page 208
“Coding the output procedure” on page 210
“Coding COBOL programs to run under CICS” on page 407

related references
“CICS SORT application restrictions” on page 222
“CICS reserved-word table” on page 414

CICS SORT application restrictions
Several restrictions apply to COBOL applications that run under CICS and use the SORT statement.

The restrictions are:
• SORT statements that include the USING or GIVING phrase are not supported.
• Sort control data sets are not supported. Data in the SORT-CONTROL special register is ignored.
• These CICS commands in the input or output procedures can cause unpredictable results:
  – CICS LINK
  – CICS XCTL
  – CICS RETURN
  – CICS HANDLE
  – CICS IGNORE
  – CICS PUSH
  – CICS POP

You can use CICS commands other than these if you use the NOHANDLE or RESP option. Unpredictable results can occur if you do not use NOHANDLE or RESP.

related references
“CICS reserved-word table” on page 414
Chapter 13. Handling errors

Put code in your programs that anticipates possible system or runtime problems. If you do not include such code, output data or files could be corrupted, and the user might not even be aware that there is a problem.

The error-handling code can take actions such as handling the situation, issuing a message, or halting the program. You might for example create error-detection routines for data-entry errors or for errors as your installation defines them. In any event, coding a warning message is a good idea.

Enterprise COBOL contains special elements to help you anticipate and correct error conditions:

- User-requested dumps
- ON OVERFLOW in STRING and UNSTRING operations
- ON SIZE ERROR in arithmetic operations
- Elements for handling input or output errors
- ON EXCEPTION or ON OVERFLOW in CALL statements
- User-written routines for handling errors

related tasks

- “Handling errors in joining and splitting strings” on page 224
- “Handling errors in arithmetic operations” on page 224
- “Handling errors in input and output operations” on page 225
- “Handling errors when calling programs” on page 233
- “Writing routines for handling errors” on page 234

Requesting dumps

You can cause a formatted dump of the Language Environment runtime environment and the member language libraries at any prespecified point in your program by coding a call to the Language Environment callable service CEE3DMP.

```
77 Title-1 Pic x(80) Display.
77 Options Pic x(255) Display.
01 Feedback-code Pic x(12) Display.
```

```
Call "CEE3DMP" Using Title-1, Options, Feedback-code
```

To have symbolic variables included in the formatted dump, compile with the TEST compiler option and use the VARIABLES subparameter of CEE3DMP. You can also request, through runtime options, that a dump be produced for error conditions of your choosing.

You can cause a system dump at any prespecified point in your program. Request an abend without cleanup by calling the Language Environment service CEE3ABD with a cleanup value of zero. This callable service stops the run unit immediately, and a system dump is requested when the abend is issued.

related references

- “TEST” on page 341
- Language Environment Debugging Guide
- Language Environment Programming Reference (CEE3DMP--generate dump)
Handling errors in joining and splitting strings

During the joining or splitting of strings, the pointer used by STRING or UNSTRING might fall outside the range of the receiving field. A potential overflow condition exists, but COBOL does not let the overflow happen.

Instead, the STRING or UNSTRING operation is not completed, the receiving field remains unchanged, and control passes to the next sequential statement. If you do not code the ON OVERFLOW phrase of the STRING or UNSTRING statement, you are not notified of the incomplete operation.

Consider the following statement:

```cobol
String Item-1 space Item-2 delimited by Item-3
  into Item-4
  with pointer String-ptr
  on overflow
    Display "A string overflow occurred"
End-String
```

These are the data values before and after the statement is performed:

<table>
<thead>
<tr>
<th>Data item</th>
<th>PICTURE</th>
<th>Value before</th>
<th>Value after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item-1</td>
<td>X(5)</td>
<td>AAAAA</td>
<td>AAAAA</td>
</tr>
<tr>
<td>Item-2</td>
<td>X(5)</td>
<td>EEEAA</td>
<td>EEEAA</td>
</tr>
<tr>
<td>Item-3</td>
<td>X(2)</td>
<td>EA</td>
<td>EA</td>
</tr>
<tr>
<td>Item-4</td>
<td>X(8)</td>
<td>$b$bbbbb$bb$1</td>
<td>$b$bbbbb$bb$1</td>
</tr>
<tr>
<td>String-ptr</td>
<td>9(2)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1. The symbol $b$ represents a blank space.

Because String-ptr has a value (0) that falls short of the receiving field, an overflow condition occurs and the STRING operation is not completed. (Overflow would also occur if String-ptr were greater than 9.) If ON OVERFLOW had not been specified, you would not be notified that the contents of Item-4 remained unchanged.

Handling errors in arithmetic operations

The results of arithmetic operations might be larger than the fixed-point field that is to hold them, or you might have tried dividing by zero. In either case, the ON SIZE ERROR clause after the ADD, SUBTRACT, MULTIPLY, DIVIDE, or COMPUTE statement can handle the situation.

For ON SIZE ERROR to work correctly for fixed-point overflow and decimal overflow, you must specify the TRAP(ON) runtime option.

The imperative statement of the ON SIZE ERROR clause will be performed and the result field will not change in these cases:

- Fixed-point overflow
- Division by zero
- Zero raised to the zero power
- Zero raised to a negative number
- Negative number raised to a fractional power

Floating-point exponent overflow occurs when the value of a floating-point computation cannot be represented in the System z floating-point operand format. This type of overflow does not cause SIZE
ERROR; an abend occurs instead. You could code a user-written condition handler to intercept the abend and provide your own error recovery logic.

Example: checking for division by zero

The following example shows how you can code an ON SIZE ERROR imperative statement so that the program issues an informative message if division by zero occurs.

```
DIVIDE-TOTAL-COST.
  DIVIDE TOTAL-COST BY NUMBER-PURCHASED
  GIVING ANSWER
  ON SIZE ERROR
    DISPLAY "ERROR IN DIVIDE-TOTAL-COST PARAGRAPH"
    DISPLAY "SPENT " TOTAL-COST, " FOR " NUMBER-PURCHASED
    PERFORM FINISH
  END-DIVIDE
END-DIVIDE
.
FINISH.
STOP RUN.
```

If division by zero occurs, the program writes a message and halts program execution.

Handling errors in input and output operations

When an input or output operation fails, COBOL does not automatically take corrective action. You choose whether your program will continue running after a less-than-severe input or output error.

You can use any of the following techniques for intercepting and handling certain input or output conditions or errors:

- End-of-file condition (AT END)
- ERROR declaratives
- FILE STATUS clause and file status key
- File system status code
- Imperative-statement phrases in READ or WRITE statements
  
  For VSAM files, if you specify a FILE STATUS clause, you can also test the VSAM status code to direct your program to error-handling logic.
- INVALID KEY phrase

To have your program continue, you must code the appropriate error-recovery procedure. You might code, for example, a procedure to check the value of the file status key. If you do not handle an input or output error in any of these ways, a severity-3 Language Environment condition is signaled, which causes the run unit to end if the condition is not handled.

The following figure shows the flow of logic after a VSAM input or output error:
The following figure shows the flow of logic after an input or output error with QSAM or line-sequential files. The error can be from a READ statement, a WRITE statement, or a CLOSE statement with a REEL/UNIT clause (QSAM only).
Possible phrases for QSAM are AT END, AT END-OF-PAGE, and INVALID KEY; for line sequential, AT END.

**You need to write the code to test the file status key.

***Execution of your COBOL program continues after the input or output statement that caused the error.

**related tasks**
- "Using the end-of-file condition (AT END)" on page 228
- "Coding ERROR declaratives" on page 228
- "Using file status keys" on page 229
- "Handling errors in QSAM files" on page 163
- "Using VSAM status codes (VSAM files only)" on page 230
- "Handling errors in line-sequential files" on page 204
- "Coding INVALID KEY phrases" on page 232

**related references**
File status key (Enterprise COBOL for z/OS Language Reference)
Using the end-of-file condition (AT END)

You code the AT END phrase of the READ statement to handle errors or normal conditions, according to your program design. At end-of-file, the AT END phrase is performed. If you do not code an AT END phrase, the associated ERROR declarative is performed.

In many designs, reading sequentially to the end of a file is done intentionally, and the AT END condition is expected. For example, suppose you are processing a file that contains transactions in order to update a master file:

```
PERFORM UNTIL TRANSACTION-EOF = "TRUE"
  READ UPDATE-TRANSACTION-FILE INTO WS-TRANSACTION-RECORD
  AT END
    DISPLAY "END OF TRANSACTION UPDATE FILE REACHED"
    MOVE "TRUE" TO TRANSACTION-EOF
  END READ
END-PERFORM
```

Any NOT AT END phrase is performed only if the READ statement completes successfully. If the READ operation fails because of a condition other than end-of-file, neither the AT END nor the NOT AT END phrase is performed. Instead, control passes to the end of the READ statement after any associated declarative procedure is performed.

You might choose not to code either an AT END phrase or an EXCEPTION declarative procedure, but to code a status key clause for the file instead. In that case, control passes to the next sequential instruction after the input or output statement that detected the end-of-file condition. At that place, have some code that takes appropriate action.

related references
AT END phrases (Enterprise COBOL for z/OS Language Reference)

Coding ERROR declaratives

You can code one or more ERROR declarative procedures that will be given control if an input or output error occurs during the execution of your program. If you do not code such procedures, your job could be canceled or abnormally terminated after an input or output error occurs.

Place each such procedure in the declaratives section of the PROCEDURE DIVISION. You can code:

- A single, common procedure for the entire program
- Procedures for each file open mode (whether INPUT, OUTPUT, I-O, or EXTEND)
- Individual procedures for each file

In an ERROR declarative procedure, you can code corrective action, retry the operation, continue, or end execution. (If you continue processing a blocked file, though, you might lose the remaining records in a block after the record that caused the error.) You can use the ERROR declaratives procedure in combination with the file status key if you want a further analysis of the error.

Multithreading: Avoid deadlocks when coding I/O declaratives in multithreaded applications. When an I/O operation results in a transfer of control to an I/O declarative, the automatic serialization lock associated with the file is held during the execution of the statements within the declarative. If you code I/O operations within your declaratives, your logic might result in a deadlock as illustrated by the following sample:

```
Declaratives.
D1 section.
Use after standard error procedure on F1
Read F2.
  . . .
D2 section.
Use after standard error procedure on F2
Read F1.
  . . .
End declaratives.
```
When this program is running on two threads, the following sequence of events could occur:

1. Thread 1: Rewrite R1 acquires lock on F1 and encounters I/O error.
2. Thread 1: Enter declarative D1, holding lock on F1.
3. Thread 2: Rewrite R2 acquires lock on F2 and encounters I/O error.
4. Thread 2: Enter declarative D2.
5. Thread 1: Read F2 from declarative D1; wait on F2 lock held by thread 2.
6. Thread 2: Read F1 from declarative D2; wait on F1 lock held by thread 1.
7. Deadlock.

**Related references**

EXCEPTION/ERROR declarative (*Enterprise COBOL for z/OS Language Reference*)

**Using file status keys**

After each input or output statement is performed on a file, the system updates values in the two digit positions of the file status key. In general, a zero in the first position indicates a successful operation, and a zero in both positions means that nothing abnormal occurred.

Establish a file status key by coding:

- The FILE STATUS clause in the FILE-CONTROL paragraph:

```
FILE STATUS IS data-name-1
```

- Data definitions in the DATA DIVISION (WORKING-STORAGE, LOCAL-STORAGE, or LINKAGE SECTION), for example:

```
WORKING-STORAGE SECTION.
   01 data-name-1 PIC 9(2) USAGE NATIONAL.
```

Specify the file status key `data-name-1` as a two-character category alphanumeric or category national item, or as a two-digit zoned decimal or national decimal item. This `data-name-1` cannot be variably located.

Your program can check the file status key to discover whether an error occurred, and, if so, what type of error occurred. For example, suppose that a FILE STATUS clause is coded like this:

```
FILE STATUS IS FS-CODE
```

**FS-CODE** is used by COBOL to hold status information like this:

```
FS-CODE
  2 1 Sequence error
Invalid key
```

Follow these rules for each file:

- Define a different file status key for each file.
  Doing so means that you can determine the cause of a file input or output exception, such as an application logic error or a disk error.
- Check the file status key after each input or output request.
If the file status key contains a value other than 0, your program can issue an error message or can take action based on that value.

You do not have to reset the file status key code, because it is set after each input or output attempt.

For VSAM files, you can additionally code a second identifier in the FILE STATUS clause to get more detailed information about VSAM input or output requests.

You can use the file status key alone or in conjunction with the INVALID KEY phrase, or to supplement the EXCEPTION or ERROR declarative. Using the file status key in this way gives you precise information about the results of each input or output operation.

"Example: file status key" on page 230

related tasks
“Using VSAM status codes (VSAM files only)” on page 230
“Coding INVALID KEY phrases” on page 232
“Finding and handling input-output errors” on page 362

related references
FILE STATUS clause (Enterprise COBOL for z/OS Language Reference)
File status key (Enterprise COBOL for z/OS Language Reference)

Example: file status key
The following example shows how you can perform a simple check of the file status key after opening a file.

```cobol
IDENTIFICATION DIVISION.
PROGRAM-ID. SIMCHK.
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
  SELECT MASTERFILE ASSIGN TO AS-MASTERA
  FILE STATUS IS MASTER-CHECK-KEY
DATA DIVISION.
WORKING-STORAGE SECTION.
  01 MASTER-CHECK-KEY PIC X(2).
PROCEDURE DIVISION.
  OPEN INPUT MASTERFILE
  IF MASTER-CHECK-KEY NOT = "00"
    DISPLAY "Nonzero file status returned from OPEN " MASTER-CHECK-KEY
```

Using VSAM status codes (VSAM files only)
Often the COBOL file status code is too general to pinpoint the disposition of a request. You can get more detailed information about VSAM input or output requests by coding a second data item in the FILE STATUS clause.

```cobol
FILE STATUS IS data-name-1 data-name-8
```

The data item `data-name-1` shown above specifies the COBOL file status key, which you define as a two-character alphanumeric or national data item, or as a two-digit zoned decimal or national decimal item.

The data item `data-name-8` specifies the VSAM status code, which you define as a 6-byte alphanumeric group data item that has three subordinate 2-byte binary fields. The VSAM status code contains meaningful values when the COBOL file status key is not 0.
You can define data-name-8 in the WORKING-STORAGE SECTION, as in VSAM-CODE below.

```
01 RETURN-STATUS.
  05 FS-CODE      PIC X(2).
  05 VSAM-CODE.
  10 VSAM-FUNCTION PIC S9(4) Usage Comp-5.
  10 VSAM-FEEDBACK PIC S9(4) Usage Comp-5.
```

Enterprise COBOL uses data-name-8 to pass information supplied by VSAM. In the following example, FS-CODE corresponds to data-name-1 and VSAM-CODE corresponds to data-name-8:

```
Register 15 return code: request not accepted.
Function code: an attempt to access the base cluster.
Feedback-field code: Key ranges were specified for the data set when it was defined, but no range was specified that includes the record to be inserted.
```

“Example: checking VSAM status codes” on page 231

**related references**
- FILE STATUS clause ([Enterprise COBOL for z/OS Language Reference](#))
- File status key ([Enterprise COBOL for z/OS Language Reference](#))
- z/OS DFSMS Macro Instructions for Data Sets ([VSAM macro return and reason codes](#))

**Example: checking VSAM status codes**

The following example reads an indexed file (starting at the fifth record), checks the file status key after each input or output request, and displays the VSAM status codes when the file status key is not zero.

This example also illustrates how output from this program might look if the file being processed contained six records.
OPEN INPUT VSAMFILE.
DISPLAY "OPEN INPUT VSAMFILE FS-CODE: " FS-CODE.

IF FS-CODE NOT = "00"
  PERFORM VSAM-CODE-DISPLAY
  STOP RUN
END-IF.

MOVE "000005" TO VSAMFILE-KEY.
START VSAMFILE KEY IS EQUAL TO VSAMFILE-KEY.
DISPLAY "START VSAMFILE KEY= " VSAMFILE-KEY
  " FS-CODE: " FS-CODE.
IF FS-CODE NOT = "00"
  PERFORM VSAM-CODE-DISPLAY
END-IF.

IF FS-CODE = "00"
  PERFORM READ-NEXT UNTIL FS-CODE NOT = "00"
END-IF.

CLOSE VSAMFILE.
STOP RUN.

READ-NEXT.
READ VSAMFILE NEXT.
DISPLAY "READ NEXT VSAMFILE FS-CODE: " FS-CODE.
IF FS-CODE NOT = "00"
  PERFORM VSAM-CODE-DISPLAY
ELSE
  DISPLAY VSAMFILE-REC
END-IF.

VSAM-CODE-DISPLAY.
DISPLAY "VSAM-CODE ==>"
  " RETURN: " VSAM-RETURN-CODE,
  " COMPONENT: " VSAM-COMPONENT-CODE,
  " REASON: " VSAM-REASON-CODE.

Below is a sample of the output from the example program that checks VSAM status-code information:

OPEN INPUT VSAMFILE FS-CODE: 00
START VSAMFILE KEY=000005 FS-CODE: 00
000005 THIS IS RECORD NUMBER 5
READ NEXT VSAMFILE FS-CODE: 00
000006 THIS IS RECORD NUMBER 6
READ NEXT VSAMFILE FS-CODE: 10
VSAM-CODE ==> RETURN: 08 COMPONENT: 2 REASON: 004

Coding INVALID KEY phrases

You can include an INVALID KEY phrase in READ, START, WRITE, REWRITE, and DELETE statements for VSAM indexed and relative files. The INVALID KEY phrase is given control if an input or output error occurs due to a faulty index key.

You can also include the INVALID KEY phrase in WRITE requests for QSAM files, but the phrase has limited meaning for QSAM files. It is used only if you try to write to a disk that is full.

Use the FILE STATUS clause with the INVALID KEY phrase to evaluate the status key and determine the specific INVALID KEY condition.

INVALID KEY phrases differ from ERROR declaratives in several ways. INVALID KEY phrases:

• Operate for only limited types of errors. ERROR declaratives encompass all forms.
• Are coded directly with the input or output statement. ERROR declaratives are coded separately.
• Are specific for a single input or output operation. ERROR declaratives are more general.

If you code INVALID KEY in a statement that causes an INVALID KEY condition, control is transferred to the INVALID KEY imperative statement. Any ERROR declaratives that you coded are not performed.

If you code a NOT INVALID KEY phrase, it is performed only if the statement completes successfully. If the operation fails because of a condition other than INVALID KEY, neither the INVALID KEY nor the
NOT INVALID KEY phrase is performed. Instead, after the program performs any associated ERROR declaratives, control passes to the end of the statement.

“Example: FILE STATUS and INVALID KEY” on page 233

Example: FILE STATUS and INVALID KEY
The following example shows how you can use the file status code and the INVALID KEY phrase to determine more specifically why an input or output statement failed.

Assume that you have a file that contains master customer records and you need to update some of these records with information from a transaction update file. The program reads each transaction record, finds the corresponding record in the master file, and makes the necessary updates. The records in both files contain a field for a customer number, and each record in the master file has a unique customer number.

The FILE-CONTROL entry for the master file of customer records includes statements that define indexed organization, random access, MASTER-CUSTOMER-NUMBER as the prime record key, and CUSTOMER-FILE-STATUS as the file status key.

```
1. (read the update transaction record)
   MOVE "TRUE" TO TRANSACTION-MATCH
   MOVE UPDATE-CUSTOMER-NUMBER TO MASTER-CUSTOMER-NUMBER
   READ MASTER-CUSTOMER-FILE INTO WS-CUSTOMER-RECORD
   INVALID KEY
      DISPLAY "MASTER CUSTOMER RECORD NOT FOUND"
      DISPLAY "FILE STATUS CODE IS: " CUSTOMER-FILE-STATUS
   MOVE "FALSE" TO TRANSACTION-MATCH
END-READ
```

Handling errors when calling programs
When a program dynamically calls a separately compiled program, the called program might be unavailable. For example, the system might be out of storage or unable to locate the program object. If the CALL statement does not have an ON EXCEPTION or ON OVERFLOW phrase, your application might abend.

Use the ON EXCEPTION phrase to perform a series of statements and to perform your own error handling. For example, in the code fragment below, if program REPORTA is unavailable, control passes to the ON EXCEPTION phrase.

```
MOVE "REPORTA" TO REPORT-PROG
CALL REPORT-PROG
ON EXCEPTION
   DISPLAY "Program REPORTA not available, using REPORTB."
   MOVE "REPORTB" TO REPORT-PROG
   CALL REPORT-PROG
END-CALL
```

The ON EXCEPTION phrase applies only to the availability of the called program on its initial load. If the called program is loaded but fails for any other reason (such as initialization), the ON EXCEPTION phrase is not performed.

related tasks
Enterprise COBOL Migration Guide
Writing routines for handling errors

You can handle most error conditions that might occur while your program is running by using the `ON EXCEPTION` phrase, `ON SIZE ERROR` phrase, or other language constructs. But if an extraordinary condition such as a machine check occurs, usually your application is abnormally terminated.

Enterprise COBOL and Language Environment provide a way for a user-written program to gain control when such conditions occur. Using Language Environment condition handling, you can write your own error-handling routines in COBOL. They can report, analyze, or even fix up a program and enable it to resume running.

When you write your own error-handling routines for an application, the COBOL programs must be compiled with appropriate compiler options. For more information, see “OPTIMIZE” on page 325.

To have Language Environment pass control to a user-written error program, you must first identify and register its entry point to Language Environment. PROCEDURE-POINTER data items enable you to pass the entry address of procedure entry points to Language Environment services.

related tasks
“Using procedure and function pointers” on page 457

related references
“OPTIMIZE” on page 325
Part 2. Compiling and debugging your program
Chapter 14. Compiling under z/OS

You can compile Enterprise COBOL programs under z/OS using job control language (JCL), TSO commands, CLISTs, or ISPF panels.

For compiling with JCL, IBM provides a set of cataloged procedures, which can reduce the amount of JCL coding that you need to write. If the cataloged procedures do not meet your needs, you can write your own JCL. Using JCL, you can compile a single program or compile several programs as part of a batch job.

When compiling under TSO, you can use TSO commands, CLISTs, or ISPF panels.

You can also compile in a z/OS UNIX shell by using the cob2 command.

You might instead want to start the Enterprise COBOL compiler from an assembler program, for example, if your shop has developed a tool or interface that calls the Enterprise COBOL compiler.

As part of the compilation step, you need to define the data sets needed for the compilation and specify any compiler options necessary for your program and the required output.

The compiler translates your COBOL program into language that the computer can process (object code). The compiler also lists errors in your source statements and provides supplementary information to help you debug and tune your program. Use compiler-directing statements and compiler options to control your compilation.

After compiling your program, you need to review the results of the compilation and correct any compiler-detected errors.

related tasks
“Compiling with JCL” on page 237
“Compiling under TSO” on page 244
Chapter 15, “Compiling under z/OS UNIX,” on page 265
“Starting the compiler from an assembler program” on page 246
“Defining compiler input and output” on page 248
“Specifying compiler options under z/OS” on page 254
“Compiling multiple programs (batch compilation)” on page 257
“Correcting errors in your source program” on page 261

related references
Chapter 18, “Compiler-directing statements,” on page 357
“Data sets used by the compiler under z/OS” on page 249
“Compiler options and compiler output under z/OS” on page 256

Compiling with JCL

Include the following information in the JCL for compilation: job description, statement to invoke the compiler, and definitions of the needed data sets (including the directory paths of z/OS UNIX files, if any).

The simplest way to compile your program under z/OS is to code JCL that uses a cataloged procedure. A cataloged procedure is a set of job control statements in a partitioned data set called the procedure library (SYS1.PROCLIB).

The following JCL shows the general format for a cataloged procedure.

```cobol
//jobname JOB parameters
//stepname EXEC [PROC=]procname [{PARM=|PARM. stepname=}]'options'
//SYSIN DD data-set parameters
.....
/*
*/
```
Additional considerations apply when you use cataloged procedures to compile object-oriented programs.

“Example: sample JCL for a procedural DLL application” on page 479

related tasks
“Using a cataloged procedure” on page 238
“Writing JCL to compile programs” on page 242
“Specifying compiler options under z/OS” on page 254
“Specifying compiler options in a batch compilation” on page 259
“Compiling programs to create DLLs” on page 478

related references
“Data sets used by the compiler under z/OS” on page 249

Using a cataloged procedure

Specify a cataloged procedure in an EXEC statement in your JCL.

For example, the following JCL calls the IBM-supplied cataloged procedure IGYWC for compiling an Enterprise COBOL program and defining the required data sets:

```cobol
//JOB1       JOB1
//STEPA      EXEC PROC=IGYWC
//COBOL.SYSIN DD *
000100 IDENTIFICATION DIVISION
   Identification Division
   */ *(the source code)
   */
```

You can omit */ after the source code. If your source code is stored in a data set, replace SYSIN DD * with appropriate parameters that describe the data set.

You can use these procedures with any of the job schedulers that are part of z/OS. When a scheduler encounters parameters that it does not require, the scheduler either ignores them or substitutes alternative parameters.

If the compiler options are not explicitly supplied with the procedure, default options established at the installation apply. You can override these default options by using an EXEC statement that includes the required options.

You can specify data sets to be in the z/OS UNIX file system by overriding the corresponding DD statement. However, the compiler utility files (SYSUTx) and copy libraries (SYSLIB) you specify must be MVS data sets.

Additional details about invoking cataloged procedures, overriding and adding to EXEC statements, and overriding and adding to DD statements are in the Language Environment information.

related tasks
Language Environment Programming Guide

related references
“Compile procedure (IGYWC)” on page 239
“Compile and link-edit procedure (IGYWCL)” on page 240
“Compile, link-edit, and run procedure (IGYWCLG)” on page 241
MVS Program Management: User’s Guide and Reference
Compile procedure (IGYWC)

IGYWC is a single-step cataloged procedure for compiling a program. It produces an object module. The compile steps in all other cataloged procedures that invoke the compiler are similar.

You must supply the following DD statement, indicating the location of the source program, in the input stream:

```plaintext
//COBOL.SYSIN DD * (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```plaintext
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOB5.COBLIB
```

Example: JCL for compiling in the z/OS UNIX file system

The following job uses procedure IGYWC to compile a COBOL program, demo.cbl, that is located in the z/OS UNIX file system. The job writes the generated compiler listing demo.lst, object file demo.o, and SYSADATA file demo.adt in the z/OS UNIX file system.

```plaintext
//UNIXDEMO JOB ,
// TIME=(1),MSGLEVEL=(1,1),MSGCLASS=H,CLASS=A,REGION=50M,
// NOTIFY=&SYSUID,USER=&SYSUID
//COMPILE EXEC IGYWC,
// PARM.COBOL='LIST,MAP,RENT,FLAG(I,I),XREF,ADATA'
//SYSPRINT DD PATH='/u/userid/cobol/demo.lst',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
```

Example: JCL for compiling in the z/OS UNIX file system on page 239
PATH specifies the path name of a file in the z/OS UNIX file system.

PATHOPTS indicates the access for the file (such as read or read-write) and sets the status for the file (such as append, create, or truncate).

PATHMODE indicates the permissions, or file access attributes, to be set when a file is created.

FILEDATA specifies whether the data is to be treated as text or as binary.

You can use a mixture of files in the z/OS UNIX file system (PATH='unix-directory-path') and traditional MVS data sets (DSN=mvs-data-set-name) in the compilation DD statements (shown in this example as overrides). However, the compiler utility files (DD statements SYSUTx) and COPY libraries (DD statements SYSLIB) must be MVS data sets.

related references
“Data sets used by the compiler under z/OS” on page 249
UNIX System Services Command Reference
MVS JCL Reference

Compile and link-edit procedure (IGYWCL)
IGYWCL is a two-step cataloged procedure to compile and link-edit a program.

The COBOL job step produces an object module that is input to the binder (linkage-editor). You can add other object modules. You must supply the following DD statement, indicating the location of the source program, in the input stream:

```
//COBOL.SYSIN DD  *       (or appropriate parameters)
```

If the program uses copybooks, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB  DD  DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```
Compile, link-edit, and run procedure (IGYWCLG)

IGYWCLG is a three-step cataloged procedure to compile, link-edit, and run a program. The COBOL job step produces an object module that is input to the binder (linkage-editor). You can add other object modules. If the COBOL program refers to any data sets, you must also supply DD statements that define these data sets. You must supply the following DD statement, indicating the location of the source program, in the input stream:

```
//COBOL.SYSIN DD *       (or appropriate parameters)
```

If the program uses copybooks, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR, DSN=DEPT88.BOBS.COBLIB
```

(1) STEPLIB can be installation-dependent.

(2) SYSLIB can be installation-dependent.

Chapter 14. Compiling under z/OS 241
STEPLIB can be installation-dependent.

SYSLIB can be installation-dependent.

In the procedure to run a program (GO statement), a valid DDName is up to 8 characters in length. In the ENVIRONMENT DIVISION of the COBOL program, there is a FILE CONTROL paragraph whose assignment-name should match the DDName. For example:

```cobol
//GO DDName DD DSN=data-set-name
```

### Writing JCL to compile programs

If the cataloged procedures do not provide you with the flexibility that you need for more complex programs, write your own job control statements. The following example shows the general format of JCL used to compile a program.

```cobol
//jobname JOB acctno, name, MSGCLASS=1 (1)
//stepname EXEC PGM=IGYCRCTL, PARM=(options) (2)
//STEPLIB DD DSN=IGY.V6R1M0.SIGYCOMP, DISP=SHR (3)
// DD DSN=SYS1.SCEERUN, DISP=SHR
// DD DSN=SYS1.SCEERUN2, DISP=SHR (3)
//DDSUT1 DD UNIT=SYSALLDA, SPACE=(subparms) (4)
//DDSUT2 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT3 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT4 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT5 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT6 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT7 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT8 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT9 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT10 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT11 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT12 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT13 DD UNIT=SYSALLDA, SPACE=(subparms)
//DDSUT14 DD UNIT=SYSALLDA, SPACE=(subparms)
```
The JOB statement indicates the beginning of a job.

The EXEC statement specifies that the Enterprise COBOL compiler (IGYCRCTL) is to be invoked.

This DD statement defines the data set where the Enterprise COBOL compiler resides. The Language Environment SCEERUN and SCEERUN2 data sets must be included in the concatenation (together with the compiler SIGYCOMP data set), unless the Language Environment data sets are available in the LNKLST.

The SYSUT DD statements define the utility data sets that the compiler will use to process the source program. All SYSUT files must be on direct-access storage devices.

The SYSPRINT DD statement defines the data set that receives output from compiler options such as LIST and MAP. SYSOUT=A is the standard designation for data sets whose destination is the system output device.

The SYSLIN DD statement defines the data set (the object module) that receives output from the OBJECT compiler option.

The SYSIN DD statement defines the data set (source code) to be used as input to the job step.

You can use a mixture of files in the z/OS UNIX file system (PATH='unix-directory-path') and traditional MVS data sets (DSN=mvs-data-set-name) in the compilation DD statements for the following data sets:

- Sources files
- Object files
- Listings
- ADATA files
- Debug files
- Executable modules

However, the compiler utility files (DD statements SYSUTx) and COPY libraries (DD statement SYSLIB) must be MVS data sets.

For more examples about the cataloged procedures in JCL, refer to “Using a cataloged procedure” on page 238 and its following topics.

“Example: user-written JCL for compiling” on page 243
“Example: sample JCL for a procedural DLL application” on page 479

related references
MVS JCL Reference
MVS Program Management: User’s Guide and Reference

Example: user-written JCL for compiling
The following example shows a few possibilities for adapting the basic JCL.

//JOB1     JOB
COMPILING UNDER TSO

Under TSO, you can use TSO commands, command lists (CLISTs), REXX execs, or ISPF to compile programs using traditional MVS data sets. You can use TSO commands or REXX execs to compile programs using z/OS UNIX files.

With each method, you need to allocate the data sets and request the compilation:

1. Use the ALLOCATE command to allocate data sets.

   For any compilation, allocate the work data sets (SYSUTn) and the SYSIN and SYSPRINT data sets.

   If you specify certain compiler options, you must allocate other data sets. For example, if you specify the TERMINAL compiler option, you must allocate the SYSTERM data set to receive compiler messages at your terminal.

   You can allocate data sets in any order. However, you must allocate all needed data sets before you start to compile.

2. Use the CALL command at the READY prompt to request compilation:

   CALL 'IGY.V6R1M0.SIGYCOMP (IGYCRCTL)'

You can specify the ALLOCATE and CALL commands on the TSO command line, or, if you are not using z/OS UNIX files, you can include them in a CLIST.
You can allocate z/OS UNIX files for all the compiler data sets except the SYSUTx utility data sets and the SYSLIB libraries. ALLOCATE statements have the following form:

```
ALLOCATE File(SYSIN) Path('/u/myu/myap/std/prog2.cbl')
Pathopts(ORDONLY) Filedata(TEXT)
```

"Example: ALLOCATE and CALL for compiling under TSO" on page 245
"Example: CLIST for compiling under TSO" on page 246

related references
"Data sets used by the compiler under z/OS" on page 249

Example: ALLOCATE and CALL for compiling under TSO
The following example shows how to specify ALLOCATE and CALL commands when you are compiling under TSO.

```
[READY]
ALLOCATE FILE(SYSUT1) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT2) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT3) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT4) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT5) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT6) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT7) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT8) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT9) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT10) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT11) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT12) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT13) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT14) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSUT15) CYLINDERS SPACE(1 1)
[READY]
ALLOCATE FILE(SYSLIN) DATASET(PROG2.OBJ) NEW TRACKS SPACE(3,3)
[READY]
ALLOCATE FILE(SYSIN) DATASET(PROG2.COBOL) SHR
[READY]
CALL 'IGY.V6R1M0.SIGYCOMP(IGYCRCTL)' 'LIST,NOCOMPILE(S),OBJECT,FLAG(E,E),TERMINAL'
 `(COBOL listings and messages)
[READY]
FREE
FILE(SYSUT1, SYSUT2, SYSUT3, SYSUT4, SYSUT5, SYSUT6, SYSUT7, SYSUT8, SYSUT9, SYSUT10, SYSUT11, SYSUT12, SYSUT13, SYSUT14, SYSUT15, SYSLIN, SYMDECK, SYSPRINT, SYSTEM, + SYSIN, SYSLIN)
[READY]
```

Chapter 14. Compiling under z/OS 245
Example: CLIST for compiling under TSO

The following example shows a CLIST for compiling under TSO. The FREE commands are not required. However, good programming practice dictates that you free files before you allocate them.

```clist
PROC 1 MEM
CONTROL LIST
FREE F(SYSUT1)
FREE F(SYSUT2)
FREE F(SYSUT3)
FREE F(SYSUT4)
FREE F(SYSUT5)
FREE F(SYSUT6)
FREE F(SYSUT7)
FREE F(SYSUT8)
FREE F(SYSUT9)
FREE F(SYSUT10)
FREE F(SYSUT11)
FREE F(SYSUT12)
FREE F(SYSUT13)
FREE F(SYSUT14)
FREE F(SYSUT15)
FREE F(SYSMDECK)
FREE F(SYSPRINT)
FREE F(SYSIN)
ALLOC F(SYSPRINT) SYSOUT
ALLOC F(SYSIN) DA(COBOL.SOURCE(&MEM)) SHR REUSE
ALLOC F(SYSPRINT) DA(COBOL.OBJECT(&MEM)) OLD REUSE
ALLOC F(SYSUT1) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT2) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT3) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT4) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT5) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT6) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT7) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT8) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT9) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT10) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT11) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT12) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT13) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT14) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSUT15) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
ALLOC F(SYSMDECK) NEW SPACE(1,1) CYL UNIT(SYSALLDA)
CALL 'IGY.V6R1M0.SIGYCOMP(IGYCRCTL)'
```

related references

TSO/E Command Reference

Starting the compiler from an assembler program

You can start the Enterprise COBOL compiler from within an assembler program by using the ATTACH or the LINK macro by dynamic invocation. You must identify the compiler options and the ddnames of the data sets to be used during processing.

For example:

```clist
symbol {LINK|ATTACH} EP=IGYCRCTL,PARAM=(optionlist[,ddnamelist]),VL=1
```

**EP**

Specifies the symbolic name of the compiler. The control program (from the library directory entry) determines the entry point at which the program should begin running.

**PARAM**

Specifies, as a sublist, address parameters to be passed from the assembler program to the compiler.

The first fullword in the address parameter list contains the address of the COBOL optionlist. The second fullword contains the address of the ddnamelist.
optionlist
Specifies the address of a variable-length list that contains the COBOL options specified for compilation. This address must be written even if no list is provided.

The optionlist must begin on a halfword boundary. The 2 high-order bytes contain a count of the number of bytes in the remainder of the list. If no options are specified, the count must be zero. The optionlist is freeform, with each field separated from the next by a comma. No blanks or zeros should appear. The compiler recognizes only the first 100 characters.

ddnamelist
Specifies the address of a variable-length list that contains alternative ddnames for the data sets used during compiler processing. If standard ddnames are used, the ddnamelist can be omitted.

The ddnamelist must begin on a halfword boundary. The 2 high-order bytes contain a count of the number of bytes in the remainder of the list. Each name of less than 8 bytes must be left justified and padded with blanks. If an alternate ddname is omitted from the list, the standard name is assumed. If the name is omitted, the 8-byte entry must contain binary zeros. You can omit names from the end by shortening the list.

All SYSUTn data sets specified must be on direct-access storage devices and have physical sequential organization. They must not reside in the z/OS UNIX file system.

The following table shows the sequence of the 8-byte entries in the ddnamelist.

<table>
<thead>
<tr>
<th>Alternative ddname 8-byte entry</th>
<th>Name for which alternative ddname is substituted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SYSLIN</td>
</tr>
<tr>
<td>2</td>
<td>Not applicable</td>
</tr>
<tr>
<td>3</td>
<td>Not applicable</td>
</tr>
<tr>
<td>4</td>
<td>SYSLIB</td>
</tr>
<tr>
<td>5</td>
<td>SYSIN</td>
</tr>
<tr>
<td>6</td>
<td>SYSPRINT</td>
</tr>
<tr>
<td>7</td>
<td>SYSPUNCH</td>
</tr>
<tr>
<td>8</td>
<td>SYSUT1</td>
</tr>
<tr>
<td>9</td>
<td>SYSUT2</td>
</tr>
<tr>
<td>10</td>
<td>SYSUT3</td>
</tr>
<tr>
<td>11</td>
<td>SYSUT4</td>
</tr>
<tr>
<td>12</td>
<td>SYSTERM</td>
</tr>
<tr>
<td>13</td>
<td>SYSUT5</td>
</tr>
<tr>
<td>14</td>
<td>SYSUT6</td>
</tr>
<tr>
<td>15</td>
<td>SYSUT7</td>
</tr>
<tr>
<td>16</td>
<td>SYSADATA</td>
</tr>
<tr>
<td>17</td>
<td>SYSJAVA</td>
</tr>
<tr>
<td>18</td>
<td>Not applicable</td>
</tr>
<tr>
<td>19</td>
<td>SYSMDECK</td>
</tr>
<tr>
<td>20</td>
<td>DBRMLIB</td>
</tr>
<tr>
<td>21</td>
<td>SYSOPTF</td>
</tr>
<tr>
<td>22</td>
<td>SYSUT8</td>
</tr>
</tbody>
</table>
### Alternative ddname 8-byte entry

<table>
<thead>
<tr>
<th>Alternative ddname 8-byte entry</th>
<th>Name for which alternative ddname is substituted</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>SYSUT9</td>
</tr>
<tr>
<td>24</td>
<td>SYSUT10</td>
</tr>
<tr>
<td>25</td>
<td>SYSUT11</td>
</tr>
<tr>
<td>26</td>
<td>SYSUT12</td>
</tr>
<tr>
<td>27</td>
<td>SYSUT13</td>
</tr>
<tr>
<td>28</td>
<td>SYSUT14</td>
</tr>
<tr>
<td>29</td>
<td>SYSUT15</td>
</tr>
</tbody>
</table>

**VL**

Specifies that the sign bit is to be set to 1 in the last fullword of the address parameter list.

When the compiler completes processing, it puts a return code in register 15.

**related tasks**

“Defining compiler input and output” on page 248

**related references**

“Data sets used by the compiler under z/OS” on page 249

“Compiler options and compiler output under z/OS” on page 256

---

### Defining compiler input and output

You need to define several kinds of data sets that the compiler uses to do its work. The compiler takes input data sets and libraries and produces various types of output, including object code, listings, and messages. The compiler also uses utility data sets during compilation.

**related tasks**

“Defining the source code data set (SYSIN)” on page 251

“Defining a compiler-option data set (SYSOPTF)” on page 251

“Specifying source libraries (SYSLIB)” on page 252

“Defining the output data set (SYSPRINT)” on page 252

“Directing compiler messages to your terminal (SYSTERM)” on page 253

“Creating object code (SYSLIN or SYSPUNCH)” on page 253

“Defining an associated-data file (SYSADATA)” on page 253

“Defining the Java-source output file (SYSJAVA)” on page 254

“Defining the library-processing output file (SYSMDECK)” on page 254

**related references**

“Data sets used by the compiler under z/OS” on page 249

“Compiler options and compiler output under z/OS” on page 256
## Data sets used by the compiler under z/OS

The following table lists the function, device requirements, and allowable device classes for each data set that the compiler uses.

<table>
<thead>
<tr>
<th>Type</th>
<th>ddname</th>
<th>Function</th>
<th>Required?</th>
<th>Device requirements</th>
<th>Allowable device classes</th>
<th>Can be in z/OS UNIX file system?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input</td>
<td>SYSIN&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Reading source program</td>
<td>Yes</td>
<td>Card reader; intermediate storage</td>
<td>Any</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSOPTF</td>
<td>Reading compiler options</td>
<td>If OPTFILE is in effect</td>
<td>Card reader; intermediate storage; direct access</td>
<td>Any</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSLIB or other copy libraries&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Reading user source libraries (PDSs or PDSEs)</td>
<td>If program has COPY or BASIS statements</td>
<td>Direct access</td>
<td>SYSDA</td>
<td>No</td>
</tr>
<tr>
<td><strong>Utility</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility&lt;sup&gt;2&lt;/sup&gt;</td>
<td>SYSUT1, SYSUT2, SYSUT3, SYSUT4, SYSUT6</td>
<td>Work data set used by compiler during compilation</td>
<td>Yes</td>
<td>Direct access</td>
<td>SYSALLDA</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>SYSUT5</td>
<td>Work data set used by compiler during compilation</td>
<td>If program has COPY, REPLACE, or BASIS statements</td>
<td>Direct access</td>
<td>SYSALLDA</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>SYSUT7</td>
<td>Work data set used by compiler to create listing</td>
<td>Yes</td>
<td>Direct access</td>
<td>SYSALLDA</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>SYSUT8, SYSUT9, SYSUT10, SYSUT11, SYSUT12, SYSUT13, SYSUT14, SYSUT15</td>
<td>Work data set used by compiler during compilation</td>
<td>Yes</td>
<td>Direct access</td>
<td>SYSALLDA</td>
<td>No</td>
</tr>
</tbody>
</table>
Table 34. Compiler data sets (continued)

<table>
<thead>
<tr>
<th>Type</th>
<th>ddname</th>
<th>Function</th>
<th>Required?</th>
<th>Device requirements</th>
<th>Allowable device classes</th>
<th>Can be in z/OS UNIX file system?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>SYSPRINT(^1)</td>
<td>Writing storage map, listings, and messages</td>
<td>Yes</td>
<td>Printer; intermediate storage</td>
<td>SYSSQ, SYSDA, standard output class A</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSTERM</td>
<td>Writing progress and diagnostic messages</td>
<td>If TERM is in effect</td>
<td>Output device; TSO terminal</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSPUNCH</td>
<td>Creating object code</td>
<td>If DECK is in effect</td>
<td>Card punch; direct access</td>
<td>SYSSQ, SYSDA</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSLIN</td>
<td>Creating object module data set as output from compiler and input to binder (linkage-editor)</td>
<td>If OBJECT is in effect</td>
<td>Direct access</td>
<td>SYSSQ, SYSDA</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSADATA(^1)</td>
<td>Writing associated data file records</td>
<td>If ADATA is in effect</td>
<td>Output device</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSJAVA</td>
<td>Creating generated Java source file for a class definition</td>
<td>If compiling a class definition</td>
<td>(Must be a z/OS UNIX file)</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSUDUMP, SYSABEND, or SYSMDUMP</td>
<td>Writing dump (should be rarely used)</td>
<td>If DUMP is in effect</td>
<td>Direct access</td>
<td>SYSDA</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>SYSMDECK</td>
<td>Processing for the MDECK option, or a work data set if NOMDECK is specified</td>
<td>Yes</td>
<td>Direct access</td>
<td>SYSSALLDA</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1. You can use the EXIT option to provide user exits from these data sets.
2. Utility data sets must be single volume, and cannot have DSNTYPE=LARGE (SYSUT1 - SYSUT15).

related references
“Logical record length and block size” on page 250
“EXIT” on page 305

Logical record length and block size
For compiler data sets other than the work data sets (SYSUT\(^n\)) and z/OS UNIX files, you can set the block size by using the BLKSIZE subparameter of the DCB parameter. The value must be permissible for the device on which the data set resides. The values you set depend on whether the data sets are fixed length or variable length.

For fixed-length records (RECFM=F or RECFM=FB), LRECL is the logical record length; and BLKSIZE equals LRECL multiplied by \(n\) where \(n\) is equal to the blocking factor.
The following table shows the defined values for the fixed-length data sets. In general, you should not change these values, but you can change the value for the SYSPRINT data set. You can specify BLKSIZE=0, which results in a system-determined block size.

<table>
<thead>
<tr>
<th>Data set</th>
<th>RECFM</th>
<th>LRECL (bytes)</th>
<th>BLKSIZE¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSIN</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
<tr>
<td>SYSLIB or other copy libraries</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
<tr>
<td>SYSLIN</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
<tr>
<td>SYSMDECK</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
<tr>
<td>SYSOPTF</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
<tr>
<td>SYSPRINT²</td>
<td>F or FB</td>
<td>133</td>
<td>133 x n</td>
</tr>
<tr>
<td>SYSPUNCH</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
<tr>
<td>SYSTERM</td>
<td>F or FB</td>
<td>80</td>
<td>80 x n</td>
</tr>
</tbody>
</table>

1. \( n \) = blocking factor
2. If you specify BLKSIZE=0, the system determines the block size.

For variable-length records (RECFM=V), LRECL is the logical record length, and BLKSIZE equals LRECL plus 4.

<table>
<thead>
<tr>
<th>Data set</th>
<th>RECFM</th>
<th>LRECL (bytes)</th>
<th>BLKSIZE (bytes) minimum acceptable value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSADATA</td>
<td>VB</td>
<td>1020</td>
<td>1024</td>
</tr>
</tbody>
</table>

Defining the source code data set (SYSIN)
Define the data set that contains your source code by using the SYSIN DD statement as shown below.

```cobol
//SYSIN DD DSNAME=dsname,UNIT=SYSSQ,VOLUME=(subparms),DISP=SHR
```

You can place your source code or BASIS statement directly in the input stream. To do so, use this SYSIN DD statement:

```cobol
//SYSIN DD *
```

The source code or BASIS statement must follow the DD * statement. If another job step follows the compilation, the EXEC statement for that step must follow the /* statement or the last source statement.

Defining a compiler-option data set (SYSOPTF)
Define a data set that contains the compiler options for your COBOL program by coding the SYSOPTF DD statement as shown below.

```cobol
//SYSOPTF DD DSNAME=dsname,UNIT=SYSDA,VOLUME=(subparms),DISP=SHR
```

To use a compiler-option data set, specify OPTFILE either as a compiler invocation option or in a PROCESS or CBL statement in your source program.

Within the SYSOPTF data set:
• Specify compiler options in free form between columns 2 and 72, using the same syntax as you use for invocation options or for compiler options in a PROCESS or CBL statement.
• Code an asterisk (*) in column 1 to cause a line to be treated as a comment.
• Optionally code sequence numbers in columns 73 through 80; those columns are ignored.

You can optionally place the compiler options directly in the input stream after the SYSOPTF DD statement if you compile using the OPTFILE option:

```cobol
//COB
//SYSOPTF EXEC PGM=IGYCRCTL,PARM='OPTFILE'
SSRANGE DD DATA,DLM=@@
OPTIMIZE ARITH(COMPAT)
OPTIMIZE . . .
//SYSIN DD . . .
```

You can concatenate multiple SYSOPTF DD statements if you have multiple compiler-option data sets:

```cobol
//SYSOPTF DD DSNNAME=dsname1, . . .
//SYSOPTF DD DSNNAME=dsname2, . . .
```

Compiler options that are in later data sets in the concatenation take precedence over options in earlier data sets in the concatenation.

related references
“Logical record length and block size” on page 250
“OPTFILE” on page 324

Specifying source libraries (SYSLIB)

Use SYSLIB DD statements if your program contains COPY or BASIS statements. These DD statements define the libraries (partitioned data sets) that contain the data requested by COPY statements in the source code or by BASIS statements in the input stream.

```cobol
//SYSLIB DD DSNNAME=copylibname,DISP=SHR
```

Concatenate multiple DD statements if you have multiple copy or basis libraries:

```cobol
//SYSLIB DD DSNNAME=PROJECT.USERLIB,DISP=SHR
//SYSLIB DD DSNNAME=SYSTEM.COPYX,DISP=SHR
```

Libraries are on direct-access storage devices. They cannot be in the z/OS UNIX file system when you compile with JCL or under TSO.

Defining the output data set (SYSPRINT)

You can use ddname SYSPRINT to produce a listing. The listing includes the results of the default or requested options of the PARM parameter (that is, diagnostic messages and the object-code listing).

You can direct the output to a SYSOUT data set, a printer, a direct-access storage device, or a magnetic-tape device. For example:

```cobol
//SYSPRINT DD SYSOUT=A
```

The SYSPRINT data set can be a sequential data set, a PDS or PDSE member, or a z/OS UNIX file. For details about how to specify the record format, record length, and block size of the SYSPRINT data set, see the related reference below.

related references
“Logical record length and block size” on page 250
Directing compiler messages to your terminal (SYSTERM)

If you are compiling under TSO, you can define the SYSTERM data set to send compiler messages to your terminal.

```plaintext
ALLOC F(SYSTERM) DA(*)
```

You can define SYSTERM in various other ways, for example to a SYSOUT data set, a data set on disk, a file in the z/OS UNIX file system, or to another print class.

Creating object code (SYSLIN or SYSPUNCH)

When using the OBJECT compiler option, you can store the object code on disk as a traditional MVS data set or a z/OS UNIX file, or on tape. The compiler uses the file that you define in the SYSLIN or SYSPUNCH DD statement.

```plaintext
//SYSLIN DD DSNAME=dsname,UNIT=SYSDA,
//             SPACE=(subparms),DISP=(MOD,PASS)
```

Use the DISP parameter of the SYSLIN DD statement to indicate whether the object code data set is to be:

- Passed to the binder (linkage-editor)
- Cataloged
- Kept
- Added to an existing cataloged library

In the example above, the data is created and passed to another job step, the binder (linkage-editor) job step.

Your installation might use the DECK option and the SYSPUNCH DD statement. B is the standard output class for punch data sets:

```plaintext
//SYSPUNCH DD SYSOUT=B
```

You do not need the SYSLIN DD statement if the NOOBJECT option is in effect. You do not need the SYSPUNCH DD statement if the NODECK option is in effect.

related references
“OBJECT” on page 323
“DECK” on page 301

Defining an associated-data file (SYSADATA)

Define a SYSADATA file if you use the ADATA compiler option.

```plaintext
//SYSADATA DD DSNAME=dsname,UNIT=SYSDA
```

The SYSADATA file will be a sequential file that contains specific record types that have information about the program that is collected during compilation. The file can be a traditional MVS data set or a z/OS UNIX file.

related references
“ADATA” on page 288
Defining the Java-source output file (SYSJAVA)

Add the SYSJAVA DD statement if you are compiling an OO program. The generated Java source file is written to the SYSJAVA ddname.

```//SYSJAVA DD PATH='/u/userid/java/ClassName.java', // PATHOPTS=(OWRONLY,OCREAT,OTRUNC), // PATHMODE=SIRWXU, // FILEDATA=TEXT```

The SYSJAVA file must be in the z/OS UNIX file system.

related tasks

“Compiling OO applications in JCL or TSO/E” on page 277

Defining the library-processing output file (SYSMDECK)

The SYSMDECK data set is required for all compilations. If you specify the MDECK compiler option, the SYSMDECK DD allocation must specify a permanent data set. However, if you use the NOMDECK option, SYSMDECK can be specified as a utility (temporary) data set.

```//SYSMDECK DD DSNAME=dsname,UNIT=SYSDA```

The SYSMDECK file will contain a copy of the updated input source after library processing, that is, the result of COPY, BASIS, REPLACE, EXEC SQL INCLUDE, and EXEC SQLIMS INCLUDE statements. The file can be a traditional MVS data set or a z/OS UNIX file.

related references

“MDECK” on page 318

Specifying compiler options under z/OS

The compiler is installed with default compiler options. While installing the compiler, the system programmer can fix compiler option settings to, for example, ensure better performance or maintain certain standards. You cannot override any compiler options that are fixed.

For options that are not fixed, you can override the default settings by specifying compiler options in any of these ways:

- Code them on the PROCESS or CBL statement in COBOL source.
- Include them when you start the compiler, either on the PARM parameter on the EXEC statement in the JCL or on the command line under TSO.
- Include them in a SYSOPTF data set, and specify the OPTFILE compiler option in either of the above ways.

The compiler recognizes the options in the following order of precedence from highest to lowest:

1. Installation defaults that are fixed by your site
2. Values of the BUFSIZE, OUTDD, SQL, and SQLIMS compiler options in effect for the first program in a batch
3. Options specified on PROCESS (or CBL) statements, preceding the IDENTIFICATION DIVISION
4. Options specified on the compiler invocation (JCL PARM parameter or the TSO CALL command)
5. Installation defaults that are not fixed

This order of precedence also determines which options are in effect when conflicting or mutually exclusive options are specified.

The precedence of options in a SYSOPTF data set depends on where you specify the OPTFILE compiler option. For example, if you specify OPTFILE in a PROCESS statement, the SYSOPTF options supersede
the options that you specify in the compiler invocation. For further details, see the related reference below about the OPTFILE option.

Most of the options come in pairs; you select one or the other. For example, the option pair for a cross-reference listing is XREF|NOXREF. If you want a cross-reference listing, specify XREF; if you do not, specify NOXREF.

Some options have subparameters. For example, if you want 44 lines per page on your listings, specify LINECOUNT(44).

“Example: specifying compiler options using JCL” on page 256
“Example: specifying compiler options under TSO” on page 256

related tasks
“Defining a compiler-option data set (SYSOPTF)” on page 251
“Specifying compiler options in the PROCESS (CBL) statement” on page 255
“Specifying compiler options in a batch compilation” on page 259

related references
“Compiler options and compiler output under z/OS” on page 256
Chapter 17, “Compiler options,” on page 283
“Conflicting compiler options” on page 287
“OPTFILE” on page 324

Specifying compiler options in the PROCESS (CBL) statement

Within a COBOL program, you can code most compiler options in PROCESS (CBL) statements. Code the statements before the IDENTIFICATION DIVISION header and before any comment lines or compiler-directing statements.

**PROCESS(CBL) statement syntax**

![PROCESS(CBL) statement syntax diagram]

If you do not use a sequence field, you can start a PROCESS statement in column 1 or after. If you use a sequence field, the sequence number must start in column 1 and must contain six characters; the first character must be numeric. If used with a sequence field, PROCESS can start in column 8 or after.

You can use CBL as a synonym for PROCESS. CBL can likewise start in column 1 or after if you do not use a sequence field. If used with a sequence field, CBL can start in column 8 or after.

You must end PROCESS and CBL statements at or before column 72.

Use one or more blanks to separate a PROCESS or CBL statement from the first option in options-list. Separate options with a comma or a blank. Do not insert spaces between individual options and their suboptions.

You can code more than one PROCESS or CBL statement. If you do so, the statements must follow one another with no intervening statements. You cannot continue options across multiple PROCESS or CBL statements.

Your programming organization can inhibit the use of PROCESS (CBL) statements by using the default options module of the COBOL compiler. If PROCESS or CBL statements that are not allowed by the organization are found in a COBOL program, the COBOL compiler generates error diagnostics.

**related references**
Reference format (Enterprise COBOL for z/OS Language Reference)
CBL (PROCESS) statement (Enterprise COBOL for z/OS Language Reference)
Example: specifying compiler options using JCL
The following example shows how to specify compiler options under z/OS using JCL.

//STEP1     EXEC PGM=IGYCRCTL,
            PARM='LIST,NOCOMPILE(S),OBJECT,FLAG(E,E)'

Example: specifying compiler options under TSO
The following example shows how to specify compiler options under TSO.

[READY]
CALL 'SYS1.LINKLIB(IGYCRCTL)' 'LIST,NOCOMPILE(S),OBJECT,FLAG(E,E)'

Compiler options and compiler output under z/OS
When the compiler finishes processing your source program, it will have produced one or more outputs, depending on the compiler options that were in effect.

Table 37. *Types of compiler output under z/OS*

<table>
<thead>
<tr>
<th>Compiler option</th>
<th>Compiler output</th>
<th>Type of output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADATA</td>
<td>Information about the program being compiled</td>
<td>Associated-data file</td>
</tr>
<tr>
<td>DLL</td>
<td>Object module that is enabled for DLL support</td>
<td>Object</td>
</tr>
<tr>
<td>DUMP</td>
<td>System dump, if compilation ended with abnormal termination (requires SYSUDUMP, SYSABEND, or SYSMDUMP DD statement); should be used rarely</td>
<td>Listing</td>
</tr>
<tr>
<td>EXPORTALL</td>
<td>Exported symbols for a DLL</td>
<td>Object</td>
</tr>
<tr>
<td>FLAG</td>
<td>List of errors that the compiler found in your program</td>
<td>Listing</td>
</tr>
<tr>
<td>LIST</td>
<td>Listing of object code in machine and assembler language</td>
<td>Listing</td>
</tr>
<tr>
<td>MAP(HEX) or MAP(DEC)</td>
<td>Map of the data items in your program</td>
<td>Listing</td>
</tr>
<tr>
<td>MDECK</td>
<td>Expansion of library-processing statements in your program</td>
<td>Library-processing side file</td>
</tr>
<tr>
<td>NUMBER</td>
<td>User-supplied line numbers shown in listing</td>
<td>Listing</td>
</tr>
<tr>
<td>OBJECT or DECK with</td>
<td>Your object code</td>
<td>Object</td>
</tr>
<tr>
<td>COMPILE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFFSET</td>
<td>Map of the relative addresses in your object code</td>
<td>Listing</td>
</tr>
<tr>
<td>OPTIMIZE(1) or OPTIMIZE(2)</td>
<td>Optimized object code</td>
<td>Object</td>
</tr>
<tr>
<td>RENT</td>
<td>Reentrant object code</td>
<td>Object</td>
</tr>
<tr>
<td>SOURCE</td>
<td>Listing of your source program</td>
<td>Listing</td>
</tr>
<tr>
<td>SQL</td>
<td>SQL statements and host variable information for DB2 bind process</td>
<td>Database request module (DBRM)</td>
</tr>
<tr>
<td>TERMINAL</td>
<td>Progress and diagnostic messages sent to terminal</td>
<td>Terminal</td>
</tr>
<tr>
<td>TEST</td>
<td>DWARF format debugging information in the object module, to enable interactive debugging</td>
<td>Object</td>
</tr>
<tr>
<td>Compiler option</td>
<td>Compiler output</td>
<td>Type of output</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>NOTEST (DWARF)</td>
<td>Basic DWARF format diagnostic information, to enable application failure analysis tools</td>
<td>Object</td>
</tr>
<tr>
<td>VBREF</td>
<td>Cross-reference listing of statements in your source program</td>
<td>Listing</td>
</tr>
<tr>
<td>XREF</td>
<td>Sorted cross-reference listing of names of procedures, programs, and data</td>
<td>Listing</td>
</tr>
</tbody>
</table>

Listing output from compilation will be in the data set defined by SYSPRINT; object output will be in SYSLIN or SYSPUNCH. Progress and diagnostic messages can be directed to the SYSTERM data set and included in the SYSPRINT data set. The database request module (DBRM) is the data set defined in DBRMLIB.

Save the listings you produced during compilation. You can use them during the testing of your work if you need to debug or tune. You might also use the listings for diagnosis and debugging after the application is in production.

After compilation, fix any errors that the compiler found in your program. If no errors were detected, you can go to the next step in the process: binding (link-editing) your program. (If you used compiler options to suppress object code generation, you must recompile to obtain object code.)

**related tasks**

*Language Environment Programming Guide* (Preparing to link-edit and run)

**related references**

*“Messages and listings for compiler-detected errors” on page 262*

*Chapter 17, “Compiler options,” on page 283*

---

**Compiling multiple programs (batch compilation)**

You can compile a sequence of separate COBOL programs by using a single invocation of the compiler. You can link the object program produced from this compilation into one program object or separate program objects, controlled by the NAME compiler option.

When you compile several programs as part of a batch job, you need to:

- Determine whether you want to create one or more program objects.
- Terminate each program in the sequence.
- Specify compiler options, with an awareness of the effect of compiler options specified in programs within the batch job.

To create separate program objects, precede each set of objects with the NAME compiler option. When the compiler encounters the NAME option, the first program in the sequence and all subsequent programs until the next NAME compiler option is encountered are link-edited into a single program object. Then each successive program that is compiled with the NAME option is included in a separate program object.

Use the END PROGRAM marker to terminate each program in the sequence except the last program in the batch (for which the END PROGRAM marker is optional). Alternatively, you can precede each program in the sequence with a CBL or PROCESS statement.

If you omit the END PROGRAM marker from a program (other than the last program in a sequence of separate programs), the next program in the sequence will be nested in the preceding program. An error can occur in either of the following situations:

- A PROCESS statement is in a program that is now nested.
- A CBL statement is not coded entirely in the sequence number area (columns 1 through 6).
If a CBL statement is coded entirely in the sequence number area (columns 1 through 6), no error message is issued for the CBL statement because it is considered a label for the source statement line.

“Example: batch compilation” on page 258

related tasks
“Specifying compiler options in a batch compilation” on page 259

related references
“NAME” on page 319

Example: batch compilation

The following example shows a batch compilation for three programs (PROG1, PROG2, and PROG3) and the creation of two program objects using one invocation of the IGYWCL cataloged procedure.

The following steps occur:

• PROG1 and PROG2 are link-edited together to form one program object that has the name PROG2. The entry point of this program object defaults to the first program in the program object, PROG1.

• PROG3 is link-edited by itself into a program object that has the name PROG3. Because it is the only program in the program object, the entry point is also PROG3.

```
//jobname  JOB  acctno,name,MSGLEVEL=1
//stepname EXEC IGYWCL
//COBOL.SYSIN  DD *
010100 IDENTIFICATION DIVISION.
 010200 PROGRAM-ID PROG1.
    . . .
 019000 END PROGRAM PROG1.
020100 IDENTIFICATION DIVISION.
 020200 PROGRAM-ID PROG2.
    . . .
 029000 END PROGRAM PROG2.
CBL NAME
030100 IDENTIFICATION DIVISION.
 030200 PROGRAM-ID PROG3.
    . . .
 039000 END PROGRAM PROG3.
/*
//LKED.SYSLMOD DD DSN=&&GOSET  (1)
/*
//P2 EXEC PGM=PROG2
//STEPLIB DD DSN=&&GOSET,DISP=(SHR,PASS)  (2)  (3)
/*
//P3 EXEC PGM=PROG3
//STEPLIB DD DSN=&&GOSET,DISP=(SHR,PASS)  (2)  (4)
/*
//
```

(1) The data-set name for the LKED step SYSLMOD is changed to the temporary name &&GOSET, without any member name.

(2) The temporary data set &&GOSET is used as the STEPLIB for steps P2 and P3 to run the compiled programs. If the Language Environment library does not reside in shared storage, you must also add the library data set as a DD statement for STEPLIB.

(3) Other DD statements and input that are required to run PROG1 and PROG2 must be added.

(4) Other DD statements and input that are required to run PROG3 must be added.

related references
Language Environment Programming Guide (IBM-supplied cataloged procedures)
**Specifying compiler options in a batch compilation**

You can specify compiler options for each program in the batch sequence either with a CBL or PROCESS statement that precedes the program, or upon invocation of the compiler.

If a CBL or PROCESS statement is specified in the current program, the compiler resolves the CBL or PROCESS statements together with the options in effect before the first program. If the current program does not contain CBL or PROCESS statements, the compiler uses the settings of options in effect for the previous program.

You should be aware of the effect of certain compiler options on the precedence of compiler option settings for each program in the batch sequence. Compiler options are recognized in the following order of precedence, from highest to lowest:

1. Installation defaults that are fixed at your site
2. Values of the BUFSIZE, OUTDD, SIZE, SQL, and SQLIMS compiler options in effect for the first program in the batch
3. Options on CBL or PROCESS statements, if any, for the current program
4. Options specified in the compiler invocation (JCL PARM or TSO CALL)
5. Installation defaults that are not fixed

If any program in the batch sequence requires the BUF, OUTDD, SIZE, SQL or SQLIMS option, that option must be in effect for the first program in the batch sequence. (When processing BASIS, COPY, or REPLACE statements, the compiler handles all programs in the batch as a single input file.)

If you specify the option for the batch, you cannot change the NUMBER and SEQUENCE options during the batch compilation. The compiler treats all programs in the batch as a single input file during NUMBER and SEQUENCE processing under the option; therefore, the sequence numbers of the entire input file must be in ascending order.

If the compiler diagnoses the LANGUAGE option on the CBL or PROCESS statement as an error, the language selection reverts to what was in effect before the compiler encountered the first CBL or PROCESS statement. The language in effect during a batch compilation conforms to the rules of processing CBL or PROCESS statements in that environment.

“Example: precedence of options in a batch compilation” on page 259
“Example: LANGUAGE option in a batch compilation” on page 260

**Example: precedence of options in a batch compilation**

The following example listing shows the precedence of compiler options for batch compilation.

```
PP 5655-EC6 IBM Enterprise COBOL for z/OS  6.1.0 P160211  Date 03/18/2016.  . .
Invocation parameters:
NOTERM
PROCESS(CBL) statements:
CBL CURRENCY,FLAG(I,I)
Options in effect:  All options are installation defaults unless otherwise noted:
   NOADATA
   ADV
   QUOTE
   ARITH(COMPAT)
   NOAWO
   NOBLOCK0
   BUFSIZE(4096)
   .  .  .
   CURRENCY    Process option PROGRAM 1
   .  .  .
   FLAG(I,I)    Process option PROGRAM 1
   .  .  .
   NOTERM      INVOCATION option
   .  .  .
End of compilation for program 1
```
Example: LANGUAGE option in a batch compilation

The following example shows the behavior of the LANGUAGE compiler option in a batch environment. The default installation option is ENGLISH (abbreviated EN), and the invocation option is XX, a nonexistent language.

```
CBL LANG(JP),FLAG(I),APOST (1)
IDENTIFICATION DIVISION. (2)
PROGRAM-ID. COMPilee1.
  END PROGRAM COMPilee1.
CBL LANGUAGE(YY) (3)
CBL LANGUAGE(JP),LANG(!!!) (4) (2)
IDENTIFICATION DIVISION.
PROGRAM-ID. COMPilee2.
  END PROGRAM COMPilee2.
IDENTIFICATION DIVISION.
PROGRAM-ID. COMPilee3.
  END PROGRAM COMPilee3.
CBL LANGUAGE(JP),LANGUAGE(YY) (5)
  ...
```

(1) The installation default is EN. The invocation option was XX, a nonexistent language. EN is the language in effect.

(2) After the CBL statement is scanned, JP is the language in effect.

(3) CBL resets the language to EN. YY is ignored because it is superseded by JP.

(4) ! ! is not alphanumeric and is discarded.

(5) CBL resets the language to EN. YY supersedes JP but is nonexistent.

For the program COMPILE1, the default language English (EN) is in effect when the compiler scans the invocation options. A diagnostic message is issued in mixed-case English because XX is a nonexistent language identifier. The default EN remains in effect when the compiler scans the CBL statement. The unrecognized option APOST in the CBL statement is diagnosed in mixed-case English because the CBL statement has not completed processing and EN was the last valid language option. After the compiler processes the CBL options, the language in effect becomes Japanese (JP).
In the program COMPILE2, the compiler diagnoses CBL statement errors in mixed-case English because English is the language in effect before the first program is used. If more than one LANGUAGE option is specified, only the last valid language specified is used. In this example, the last valid language is Japanese (JP). Therefore Japanese becomes the language in effect when the compiler finishes processing the CBL options. If you want diagnostics in Japanese for the options in the CBL and PROCESSES statements, the language in effect before COMPILE1 must be Japanese.

The program COMPILE3 has no CBL statement. It inherits the language in effect, Japanese (JP), from the previous compilation.

After compiling COMPILE3, the compiler resets the language in effect to English (EN) because of the CBL statement. The language option in the CBL statement resolves the last-specified two-character alphanumeric language identifier, YY. Because YY is nonexistent, the language in effect remains English.

Correcting errors in your source program

Messages about source-code errors indicate where the error occurred (LINEID). The text of a message tells you what the problem is. With this information, you can correct the source program.

Although you should try to correct errors, it is not always necessary to correct source code for every diagnostic message. You can leave a warning-level or informational-level message in a program without much risk, and you might decide that the recoding and compilation that are needed to remove the message are not worth the effort. Severe-level and error-level errors, however, indicate probable program failure and should be corrected.

In contrast with the four lower levels of severities, an unrecoverable (U-level) error might not result from a mistake in your source program. It could come from a flaw in the compiler itself or in the operating system. In such cases, the problem must be resolved, because the compiler is forced to end early and does not produce complete object code or a complete listing. If the message occurs for a program that has many S-level syntax errors, correct those errors and compile the program again. You can also resolve job set-up problems (such as missing data-set definitions or insufficient storage for compiler processing) by making changes to the compile job. If your compile job setup is correct and you have corrected the S-level syntax errors, you need to contact IBM to investigate other U-level errors.

After correcting the errors in your source program, recompile the program. If this second compilation is successful, proceed to the link-editing step. If the compiler still finds problems, repeat the above procedure until only informational messages are returned.

related tasks
“Generating a list of compiler messages” on page 261

related references
“Messages and listings for compiler-detected errors” on page 262

Generating a list of compiler messages

You can generate a complete listing of compiler diagnostic messages with their message numbers, severities, and text by compiling a program that has program-name ERRMSG.

You can code just the PROGRAM-ID paragraph, as shown below, and omit the rest of the program.

```plaintext
Identification Division.
Program-ID. ErrMsg.
```

related tasks
“Customizing compiler-message severities” on page 687

related references
“Messages and listings for compiler-detected errors” on page 262
“Format of compiler diagnostic messages” on page 262
Messages and listings for compiler-detected errors

As the compiler processes your source program, it checks for COBOL language errors, and issues diagnostic messages. These messages are collated in the compiler listing (subject to the FLAG option).

Each message in the listing provides information about the nature of the problem, its severity, and the compiler phase that detected it. Wherever possible, the message provides specific instructions for correcting an error.

The messages for errors found during processing of compiler options, CBL and PROCESS statements, and BASIS, COPY, or REPLACE statements are displayed near the top of the listing.

The messages for compilation errors (ordered by line number) are displayed near the end of the listing for each program.

A summary of all problems found during compilation is displayed near the bottom of the listing.

related tasks
“Correcting errors in your source program” on page 261
“Generating a list of compiler messages” on page 261

related references
“Format of compiler diagnostic messages” on page 262
“Severity codes for compiler diagnostic messages” on page 263
“FLAG” on page 308

Format of compiler diagnostic messages

Each message issued by the compiler has a source line number, a message identifier, and message text.

Each message has the following form:

```
nnnnnn  IGYppxxxx-l  message-text
```

- **nnnnnn**: The number of the source statement of the last line that the compiler was processing. Source statement numbers are listed on the source printout of your program. If you specified the NUMBER option at compile time, the numbers are the original source program numbers. If you specified NONUMBER, the numbers are those generated by the compiler.

- **IGY**: A prefix that identifies that the message was issued by the COBOL compiler.

- **pp**: Two characters that identify which phase or subphase of the compiler detected the condition that resulted in a message. As an application programmer, you can ignore this information. If you are diagnosing a suspected compiler error, contact IBM for support.

- **xxxx**: A four-digit number that identifies the message.

- **l**: A character that indicates the severity level of the message: I, W, E, S, or U.

- **message-text**: The message text; for an error message, a short explanation of the condition that caused the error.

Tip: If you used the FLAG option to suppress messages, there might be additional errors in your program.

related references
“Severity codes for compiler diagnostic messages” on page 263
“FLAG” on page 308
Severity codes for compiler diagnostic messages
Conditions that the compiler can detect fall into five levels or categories of severity.

<table>
<thead>
<tr>
<th>Level or category of message</th>
<th>Return code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informational (I)</td>
<td>0</td>
<td>To inform you. No action is required, and the program runs correctly.</td>
</tr>
<tr>
<td>Warning (W)</td>
<td>4</td>
<td>To indicate a possible error. The program probably runs correctly as written.</td>
</tr>
<tr>
<td>Error (E)</td>
<td>8</td>
<td>To indicate a condition that is definitely an error. The compiler attempted to correct the error, but the results of program execution might not be what you expect. You should correct the error.</td>
</tr>
<tr>
<td>Severe (S)</td>
<td>12</td>
<td>To indicate a condition that is a serious error. The compiler was unable to correct the error. The program does not run correctly, and execution should not be attempted. Object code might not be created.</td>
</tr>
<tr>
<td>Unrecoverable (U)</td>
<td>16</td>
<td>To indicate an error condition of such magnitude that the compilation was terminated.</td>
</tr>
</tbody>
</table>

The final return code at the end of compilation is generally the highest return code that occurred for any message during the compilation.

You can suppress compiler diagnostic messages or change their severities, however, which can have an effect upon the final compilation return code. For details, see the related information.

related tasks
“Customizing compiler-message severities” on page 687

related references
“Processing of MSGEXIT” on page 685
Chapter 15. Compiling under z/OS UNIX

Compile Enterprise COBOL programs under z/OS UNIX by using the cob2 command. Under z/OS UNIX, you can compile any COBOL program that you can compile under z/OS. The object code generated by the COBOL compiler can run under z/OS.

As part of the compilation step, you define the files needed for the compilation, and specify any compiler options or compiler-directing statements that are necessary for your program and for the output that you want.

The main job of the compiler is to translate COBOL programs into language that the computer can process (object code). The compiler also lists errors in source statements and provides supplementary information to help you debug and tune programs.

related tasks
“Setting environment variables under z/OS UNIX” on page 265
“Specifying compiler options under z/OS UNIX” on page 266
“Compiling and linking with the cob2 command” on page 267
“Compiling using scripts” on page 271
“Compiling, linking, and running OO applications under z/OS UNIX” on page 273

related references
“Data sets used by the compiler under z/OS” on page 249
“Compiler options and compiler output under z/OS” on page 256

Setting environment variables under z/OS UNIX

An environment variable is a name that is associated with a string of characters and that defines some variable aspect of the program environment. You use environment variables to set values that programs, including the compiler, need.

Set the environment variables for the compiler by using the export command. For example, to set the SYSLIB variable, issue the export command from the shell or from a script file:

```bash
export SYSLIB=/u/mystuff/copybooks
```

The value that you assign to an environment variable can include other environment variables or the variable itself. The values of these variables apply only when you compile from the shell where you issue the export command. If you do not set an environment variable, either a default value is applied or the variable is not defined.

The environment-variable names must be uppercase.

The environment variables that you can set for use by the compiler are as follows:

**COBOPT**
Specify compiler options separated by blanks or commas. Separate suboptions with commas. Blanks at the beginning or the end of the variable value are ignored. Delimit the list of options with quotation marks if it contains blanks or characters that are significant to the z/OS UNIX shell. For example:

```bash
export COBOPT="TRUNC(OPT) XREF"
```

**SYSLIB**
Specify paths to directories to be used in searching for COBOL copybooks if you do not specify an explicit library-name in the COPY statement. Separate multiple paths with a colon. Paths are evaluated in order from the first path to the last in the export command. If you set the variable with multiple files of the same name, the first located copy of the file is used.
For COPY statements in which you have not coded an explicit library-name, the compiler searches for copybooks in this order:

1. In the current directory
2. In the paths you specify with the -I cob2 option
3. In the paths you specify in the SYSLIB environment variable
4. In the locations specified in instances of the COPYLOC option that use the default library name or specify an explicit library name of SYSLIB

If the copybook is not found in any of the z/OS UNIX directories to be searched, and there are instances of the COPYLOC option specified without an explicit library name or specified with the library name SYSLIB, those locations are searched in the order that they were specified.

**library-name**

Specify the directory path from which to copy when you specify an explicit library-name in the COPY statement. The environment-variable name is identical to the library-name in your program. You must set an environment variable for each library; an error will occur otherwise. The environment-variable name library-name must be uppercase.

**text-name**

Specify the name of the file from which to copy text. The environment-variable name is identical to the text-name in your program. The environment-variable name text-name must be uppercase.

**related tasks**

“Specifying compiler options under z/OS UNIX” on page 266
“Compiling and linking with the cob2 command” on page 267
“Setting and accessing environment variables” on page 436

**related references**

Chapter 18, “Compiler-directing statements,” on page 357
Chapter 17, “Compiler options,” on page 283
COPY statement (Enterprise COBOL for z/OS Language Reference)

### Specifying compiler options under z/OS UNIX

The compiler is installed and set up with default compiler options. While installing the compiler, a system programmer can fix compiler option settings to ensure better performance or maintain certain standards. You cannot override any compiler options that your site has fixed.

For options that are not fixed, you can override the default settings by specifying compiler options in any of three ways:

- Code them on the PROCESS or CBL statement in your COBOL source.
- Specify the -q option of the cob2 command.
- Set the COBOPT environment variable.

The compiler recognizes the options in the above order of precedence, from highest to lowest. The order of precedence also determines which options are in effect when conflicting or mutually exclusive options are specified. When you compile using the cob2 command, compiler options are recognized in the following order of precedence, from highest to lowest:

1. Installation defaults fixed as nonoverridable
2. The values of BUFSIZE, SQL, SQLIMS, and OUTDD options in effect for the first program in a batch compilation
3. The values that you specify on PROCESS or CBL statements in COBOL source programs
4. The values that you specify in the cob2 command's -q option string
5. The values that you specify in the COBOPT environment variable
6. Installation defaults that are not fixed
Restrictions:

- Do not use the SQL compiler option under z/OS UNIX.
  Neither the separate SQL precompiler nor the integrated SQL coprocessor runs under z/OS UNIX.
- Do not use the SQLIMS compiler option under z/OS UNIX.
- The OPTFILE option is ignored when you compile using the cob2 command under z/OS UNIX.
  You can use the COBOPT environment variable, which provides a capability that is comparable to OPTFILE, instead.

related tasks

- “Specifying compiler options in the PROCESS (CBL) statement” on page 255
- “Setting environment variables under z/OS UNIX” on page 265
- “Compiling and linking with the cob2 command” on page 267

related references

- “Conflicting compiler options” on page 287
- Chapter 17, “Compiler options,” on page 283

Compiling and linking with the cob2 command

Use the cob2 command to compile and link COBOL programs from the z/OS UNIX shell. You can specify the options and input file-names in any order, using spaces to separate options and names. Any options that you specify apply to all files on the command line.

To compile multiple files (batch compilation), specify multiple source-file names.

When you compile COBOL programs for z/OS UNIX, the RENT option is required. The cob2 command automatically includes the COBOL compiler options RENT and TERM.

The cob2 command invokes the COBOL compiler that is found through the standard MVS search order. If the COBOL compiler is not installed in the LNKLST, or if more than one level of IBM COBOL compiler is installed on your system, you can specify in the STEPLIB environment variable the compiler PDSE that you want to use. For example, the following statement specifies IGY.V6R1M0 as the compiler PDSE:

```bash
export STEPLIB=IGY.V6R1M0.SIGYCOMP
```

The cob2 command implicitly uses the z/OS UNIX shell command c89 for the link step. c89 is the shell interface to the linker (the z/OS program management binder).

The default location for compiler input and output is the current directory.

Only files with the suffix .cbl are passed to the compiler; cob2 passes all other files to the linker.

The listing output that you request from the compilation of a COBOL source program file.cbl is written to file.lst. The listing output that you request from the linker is written to stdout.

The linker causes execution to begin at the first main program.

related tasks

- “Creating a DLL under z/OS UNIX” on page 268
- “Preparing OO applications under z/OS UNIX” on page 274

related references

- “cob2 syntax and options” on page 269
- “cob2 input and output files” on page 270
Creating a DLL under z/OS UNIX

To create a DLL from the z/OS UNIX shell, you must specify the cob2 option -bdll.

```
cob2 -o mydll -bdll mysub.cbl
```

When you specify cob2 -bdll:

- The COBOL compiler uses the compiler options DLL, EXPORTALL, and RENT, which are required for DLLs.
- The link step produces a DLL definition side file that contains IMPORT control statements for each of the names exported by the DLL.

The name of the DLL definition side file is based on the output file-name. If the output name has a suffix, that suffix is replaced with x to form the side-file name. For example, if the output file-name is foo.dll, the side-file name is foo.x.

To use the DLL definition side file later when you create a module that calls that DLL, specify the side file with any other object files (.o) that you need to link. For example, the following command compiles myappl.cbl, uses the DLL option to enable myappl.o to reference DLLs, and links to produce the module myappl:

```
cob2 -o myappl -qdll myappl.cbl mydll.x
```

“Example: using cob2 to compile and link under z/OS UNIX” on page 268

related tasks

Chapter 26, “Creating a DLL or a DLL application,” on page 477
“Compiling programs to create DLLs” on page 478

related references

“cob2 syntax and options” on page 269
“cob2 input and output files” on page 270

Example: using cob2 to compile and link under z/OS UNIX

The following examples illustrate the use of cob2.

- To compile one file called alpha.cbl, enter:

```
cob2 -c alpha.cbl
```

The compiled file is named alpha.o.

- To compile two files called alpha.cbl and beta.cbl, enter:

```
cob2 -c alpha.cbl beta.cbl
```

The compiled files are named alpha.o and beta.o.

- To link two files, compile them without the -c option. For example, to compile and link alpha.cbl and beta.cbl and generate gamma, enter:

```
cob2 alpha.cbl beta.cbl -o gamma
```

This command creates alpha.o and beta.o, then links alpha.o, beta.o, and the COBOL libraries. If the link step is successful, it produces an executable program named gamma.

- To compile alpha.cbl with the LIST and NODATA options, enter:

```
cob2 -qlist,nodata alpha.cbl
```
cob2 syntax and options

You can use the options listed below with the cob2 command. (Do not capitalize cob2.)

<table>
<thead>
<tr>
<th>cob2 command syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>cob2 options filenames</td>
</tr>
</tbody>
</table>

- **-bxxx**
  Passes the string xxx to the linker as parameters. xxx is a list of linker options in name=value format, separated by commas. You must spell out both the name and the value in full (except for the special cases noted below). The name and value are case insensitive. Do not use any spaces between -b and xxx.

  If you do not specify a value for an option, a default value of YES is used except for the following options, which have the indicated default values:

  - LIST=NOIMPORT
  - ALIASES=ALL
  - COMPAT=CURRENT
  - DYNAM=DLL

  One special value for xxx is dll, which specifies that the executable module is to be a DLL. This string is not passed to the linker.

- **-c**
  Compiles programs but does not link them.

- **-comprc_ok=n**
  Controls cob2 behavior on the return code from the compiler. If the return code is less than or equal to n, cob2 continues to the link step or, in the compile-only case, exits with a zero return code. If the return code returned by the compiler is greater than n, cob2 exits with the same return code. When the c89 command is implicitly invoked by cob2 for the link step, the exit value from the c89 command is used as the return code from the cob2 command.

  The default is -comprc_ok=4.

- **-e xxx**
  Specifies the name of the program to be used as the entry point of the module. The program must be one of the programs that will be included in the module. If you do not specify -e, the default entry point is the first program (file.cbl) or object file (file.o) that you specify as a file name on the cob2 command invocation.

- **-g**
  Prepares the program for debugging. Equivalent to specifying the TEST option with no suboptions.

- **-Ixxx**
  Adds a path xxx to the directories to be searched for copybooks for which you do not specify a library-name.

  To specify multiple paths, either use multiple -I options, or use a colon to separate multiple path names within a single -I option value.

  For COPY statements in which you have not coded an explicit library-name, the compiler searches for copybooks in the following order:

  1. In the current directory
  2. In the paths you specify with the -I cob2 option
  3. In the paths you specify in the SYSLIB environment variable
  4. In the locations specified in instances of the COPYLOC option that use the default library name or specify an explicit library name of SYSLIB
-L xxx
Specifies the directory paths to be used to search for archive libraries specified by the -l operand.

-l xxx
Specifies the name of an archive library for the linker. The cob2 command searches for the name libxxx.a in the directories specified in the -L option, then in the usual search order. (This option is lowercase l, not uppercase L.)

-o xxx
Names the object module xxx. If the -o option is not used, the name of the object module is a.out.

-qxxx
Passes xxx to the compiler, where xxx is a list of compiler options separated by blanks or commas. Enclose xxx in quotation marks if a parenthesis is part of the option or suboption, or if you use blanks to separate options. Do not insert spaces between -q and xxx.

-v
Displays the generated commands that are issued by cob2 for the compile and link steps, including the options being passed, and executes them. Here is sample output:

```
cob2 -v -o mini -qssrange mini.cbl
compiler: ATTCRCTL PARM=RENT,TERM,SSRANGE /u/userid/cobol/mini.cbl
PP 5655-EC6 IBM Enterprise COBOL for z/OS  6.1.0 in progress ...
End of compilation 1, program mini, no statements flagged.
linker: /bin/c89 -o mini -e // mini.o
```

-#
Displays compile and link steps, but does not execute them.

related tasks
“Compiling and linking with the cob2 command” on page 267
“Creating a DLL under z/OS UNIX” on page 268
“Setting environment variables under z/OS UNIX” on page 265

cob2 input and output files
You can specify the following files as input file-names when you use the cob2 command.

<table>
<thead>
<tr>
<th>File name</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>file.cbl</td>
<td>COBOL source file to be compiled and linked</td>
<td>Will not be linked if you specify the cob2 option -c</td>
</tr>
<tr>
<td>file.a</td>
<td>Archive file</td>
<td>Produced by the ar command, to be used during the link-edit phase</td>
</tr>
<tr>
<td>file.o</td>
<td>Object file to be link-edited</td>
<td>Can be produced by the COBOL compiler, the C/C++ compiler, or the assembler</td>
</tr>
<tr>
<td>file.x</td>
<td>DLL definition side file</td>
<td>Used during the link-edit phase of an application that references the dynamic link library (DLL)</td>
</tr>
</tbody>
</table>

If you use the cob2 command, the following files are created in the current directory.

<table>
<thead>
<tr>
<th>File name</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>Executable module or DLL</td>
<td>Created by the linker if you specify the cob2 option -o file</td>
</tr>
</tbody>
</table>
Table 40. **Output files from the cob2 command** (continued)

<table>
<thead>
<tr>
<th>File name</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.out</td>
<td>Executable module or DLL</td>
<td>Created by the linker if you do not specify the cob2 option -o</td>
</tr>
<tr>
<td>file.adt</td>
<td>Associated data (ADATA) file corresponding to input COBOL source program file.cbl</td>
<td>Created by the compiler if you specify compiler option ADATA</td>
</tr>
<tr>
<td>file.dek</td>
<td>Extended COBOL source output from library processing</td>
<td>Created by the compiler if you specify compiler option MDECK</td>
</tr>
<tr>
<td>file.lst</td>
<td>Listing file corresponding to input COBOL source program file.cbl</td>
<td>Created by the compiler</td>
</tr>
<tr>
<td>file.o</td>
<td>Object file corresponding to input COBOL source program file.cbl</td>
<td>Created by the compiler</td>
</tr>
<tr>
<td>file.x</td>
<td>DLL definition side file</td>
<td>Created during the cob2 linking phase when creating file.dll</td>
</tr>
<tr>
<td>class.java</td>
<td>Java class definition (source)</td>
<td>Created when you compile a class definition</td>
</tr>
</tbody>
</table>

related tasks

“Compiling and linking with the cob2 command” on page 267

related references

“ADATA” on page 288
“MDECK” on page 318
“TEST” on page 341

*UNIX System Services Command Reference*

---

**Compiling using scripts**

If you use a shell script to automate cob2 tasks, you must code option syntax carefully to prevent the shell from passing invalid strings to cob2.

Code option strings in scripts as follows:

- Use an equal sign and colon rather than a left and right parenthesis, respectively, to specify compiler suboptions. For example, code `-qOPTIMIZE=1:,XREF` instead of `-qOPTIMIZE(1),XREF`.
- Use an underscore rather than an apostrophe where a compiler option requires apostrophes for delimiting a suboption.
- Do not use blanks in the option string.
Chapter 16. Compiling, linking, and running OO applications

It is recommended that you compile, link, and run object-oriented (OO) applications in the z/OS UNIX environment. However, with certain limitations explained in the related tasks, it is possible to compile, link, and run OO COBOL applications by using standard batch JCL or TSO/E commands.

related tasks
“Compiling, linking, and running OO applications under z/OS UNIX” on page 273
“Compiling, linking, and running OO applications in JCL or TSO/E” on page 277
“Using Java SDKs for z/OS” on page 280

Compiling, linking, and running OO applications under z/OS UNIX

When you compile, link, and run object-oriented applications in a z/OS UNIX environment, application components reside in the z/OS UNIX file system. You compile and link them by using shell commands, and run them at a shell command prompt or with the BPXBATCH utility from JCL or TSO/E.

related tasks
“Compiling OO applications under z/OS UNIX” on page 273
“Preparing OO applications under z/OS UNIX” on page 274
“Running OO applications under z/OS UNIX” on page 275

Compiling OO applications under z/OS UNIX

When you compile OO applications in a z/OS UNIX shell, use the cob2 command to compile COBOL client programs and class definitions, and the javac command to compile Java class definitions to produce bytecode (suffix .class).

To compile COBOL source code that contains OO syntax such as INVOKE statements or class definitions, or that uses Java services, you must use these compiler options: RENT, DLL, THREAD, and DBCS. (The RENT and DBCS options are defaults.)

A COBOL source file that contains a class definition must not contain any other class or program definitions.

When you compile a COBOL class definition, two output files are generated:

- The object file (.o) for the class definition.
- A Java source program (.java) that contains a class definition that corresponds to the COBOL class definition. Do not edit this generated Java class definition in any way. If you change the COBOL class definition, you must regenerate both the object file and the Java class definition by recompiling the updated COBOL class definition.

If a COBOL client program or class definition includes the file JNI.cpy by using a COPY statement, specify the include subdirectory of the COBOL install directory (typically /usr/lpp/cobol/include) in the search order for copybooks. You can specify the include subdirectory by using the -I option of the cob2 command or by setting the SYSLIB environment variable.

related tasks
Chapter 15, “Compiling under z/OS UNIX,” on page 265
“Preparing OO applications under z/OS UNIX” on page 274
“Running OO applications under z/OS UNIX” on page 275
“Setting and accessing environment variables” on page 436
“Accessing JNI services” on page 597
Preparing OO applications under z/OS UNIX

Use the cob2 command to link OO COBOL applications.

To prepare an OO COBOL client program for execution, link the object file with the following two DLL side files to create an executable module:

- libjvm.x, which is provided with your IBM Java Software Development Kit.
- igzcxjava.x, which is provided in the lib subdirectory of the cobol directory in the z/OS UNIX file system. The typical complete path is /usr/lpp/cobol/lib/igzcxjava.x. This DLL side file is also available as the member IGZCJAVA in the SCEELIB PDS (part of Language Environment).

To prepare a COBOL class definition for execution:

1. Link the object file using the two DLL side files mentioned above to create an executable DLL module. You must name the resulting DLL module libClassname.so, where Classname is the external class-name. If the class is part of a package and thus there are periods in the external class-name, you must change the periods to underscores in the DLL module name. For example, if class Account is part of the com.acme package, the external class-name (as defined in the REPOSITORY paragraph entry for the class) must be com.acme.Account, and the DLL module for the class must be libcom_acme_Account.so.

2. Compile the generated Java source with the Java compiler to create a class file (.class).

For a COBOL source file Classname.cbl that contains the class definition for Classname, you would use the following commands to compile and link the components of the application:

<table>
<thead>
<tr>
<th>Table 41. Commands for compiling and linking a class definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>cob2 -c -qdll,thread Classname.cbl</td>
</tr>
<tr>
<td>cob2 -bdll -o libClassname.so Classname.o /usr/lpp/java/J5.0/bin/j9vm/libjvm.x /usr/lpp/cobol/lib/igzcxjava.x</td>
</tr>
<tr>
<td>javac Classname.java</td>
</tr>
</tbody>
</table>

After you issue the cob2 and javac commands successfully, you have the executable components for the program: the executable DLL module libClassname.so and the class file Classname.class. All files from these commands are generated in the current working directory.

“Example: compiling and linking a COBOL class definition under z/OS UNIX” on page 275

related tasks
Chapter 15, “Compiling under z/OS UNIX,” on page 265
“REPOSITORY paragraph for defining a class” on page 562

related references
“cob2 syntax and options” on page 269
“Object-oriented syntax, and Java 6, Java 7, or Java 8” on page 281
Example: compiling and linking a COBOL class definition under z/OS UNIX

This example illustrates the commands that you use and the files that are produced when you compile and link a COBOL class definition, Manager.cbl, using z/OS UNIX shell commands.

Manager.cbl

```
Identification division.
Class-id Manager inherits Employee.
Environment division.
Configuration section.
Repository.
  Class Manager is "Manager"
  ...
End class Manager.
```

cob2 -c -qdll,thread Manager.cbl

Manager.java

```
javac Manager.java
```
Manager.o

```
cob2 -tdll -o libManager.so Manager.o
/usr/lp/java/35.0/bin/j9vm/l:bjvm.x
/usr/lp/cobol/lib/igzjava.x
```

Manager.class

libManager.so

The class file Manager.class and the DLL module libManager.so are the executable components of the application, and are generated in the current working directory.

Running OO applications under z/OS UNIX

It is recommended that you run object-oriented COBOL applications as z/OS UNIX applications. You must do so if an application begins with a Java program or the main factory method of a COBOL class.

Specify the directory that contains the DLLs for the COBOL classes in the LIBPATH environment variable. Specify the directory paths for the Java class files that are associated with the COBOL classes in the CLASSPATH environment variable as follows:

- For classes that are not part of a package, end the class path with the directory that contains the .class files.
- For classes that are part of a package, end the class path with the directory that contains the "root" package (the first package in the full package name).
- For a .jar file that contains .class files, end the class path with the name of the .jar file.

Separate multiple path entries with colons.

**Note:** If the CLASSPATH environment variable contains the filename wildcard (*), the wildcard cannot be expanded in the case where the JVM is initialized by the COBOL runtime.

related tasks
- “Running OO applications that start with a main method” on page 276
- “Running OO applications that start with a COBOL program” on page 276
- “Running J2EE COBOL clients” on page 276
- Chapter 23, “Running COBOL programs under z/OS UNIX,” on page 435
- “Setting and accessing environment variables” on page 436
- Chapter 32, “Writing object-oriented programs,” on page 557
- “Structuring OO applications” on page 594
Running OO applications that start with a main method
If the first routine of a mixed COBOL and Java application is the main method of a Java class or the main factory method of a COBOL class, run the application by using the java command and by specifying the name of the class that contains the main method.

The java command initializes the Java virtual machine (JVM). To customize the initialization of the JVM, specify options on the java command as in the following examples:

<table>
<thead>
<tr>
<th>Table 42. java command options for customizing the JVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
</tr>
<tr>
<td>To set a system property</td>
</tr>
<tr>
<td>To request that the JVM generate verbose messages</td>
</tr>
<tr>
<td>about garbage collection</td>
</tr>
<tr>
<td>To request that the JVM generate verbose messages</td>
</tr>
<tr>
<td>about class loading</td>
</tr>
<tr>
<td>To request that the JVM generate verbose messages</td>
</tr>
<tr>
<td>about native methods and other Java Native Interface</td>
</tr>
<tr>
<td>activity</td>
</tr>
<tr>
<td>To set the initial Java heap size to value bytes</td>
</tr>
<tr>
<td>To set the maximum Java heap size to value bytes</td>
</tr>
</tbody>
</table>

For details about the options that the JVM supports, see the output from the java -h command, or see the related references.

related references
IBM SDK for Java - Tools Documentation
WebSphere for z/OS: Applications (Java Naming and Directory Interface (JNDI))

Running OO applications that start with a COBOL program
If the first routine of a mixed COBOL and Java application is a COBOL program, run the application by specifying the program name at the command prompt. If a JVM is not already running in the process of the COBOL program, the COBOL run time automatically initializes a JVM.

To customize the initialization of the JVM, specify options by setting the COBJVMINITOPTIONS environment variable. Use blanks to separate options. For example:

```bash
export COBJVMINITOPTIONS="-Xms10000000 -Xmx20000000 -verbose:gc"
```

related tasks
“Using Java SDKs for z/OS” on page 280
Chapter 23, “Running COBOL programs under z/OS UNIX,” on page 435
“Setting and accessing environment variables” on page 436

related references
IBM SDK for Java - Tools Documentation
WebSphere for z/OS: Applications (Java Naming and Directory Interface (JNDI))

Running J2EE COBOL clients
You can use OO syntax in a COBOL program to implement a Java 2 Platform, Enterprise Edition (J2EE) client. You can, for example, invoke methods on enterprise beans that run in the WebSphere for z/OS environment.
Before you run a COBOL J2EE client, you must set the Java system property `java.naming.factory.initial` to access WebSphere naming services. For example:

```
export COBJVMINITOPTIONS
"-Djava.naming.factory.initial=com.ibm.websphere.naming.WsnInitialContextFactory"
```

“Example: J2EE client written in COBOL” on page 608

### Compiling, linking, and running OO applications in JCL or TSO/E

It is recommended that you compile, link, and run applications that use OO syntax in the z/OS UNIX environment.

However, in limited circumstances it is possible to compile, prepare, and run OO applications by using standard batch JCL or TSO/E commands. To do so, you must follow the guidelines that are in the related tasks. For example, you might follow this approach for applications that consist of a COBOL main program and subprograms that:

- Access objects that are all implemented in Java
- Access enterprise beans that run in a WebSphere server

**related tasks**

- “Compiling OO applications in JCL or TSO/E” on page 277
- “Preparing and running OO applications in JCL or TSO/E” on page 278
- “Compiling, linking, and running OO applications under z/OS UNIX” on page 273

### Compiling OO applications in JCL or TSO/E

If you use batch JCL or TSO/E to compile an OO COBOL program or class definition, the generated object file is written, as usual, to the data set that has ddname SYSLIN or SYSPUNCH. You must use compiler options RENT, DLL, THREAD, and DBCS. (RENT and DBCS are defaults.)

If the COBOL program or class definition uses the JNI environment structure to access JNI callable services, copy the file JNI.cpy from the z/OS UNIX file system to a PDS or PDSE member called JNI, identify that library with a SYSLIB DD statement, and use a COPY statement of the form COPY JNI in the COBOL source.

A COBOL source file that contains a class definition must not contain any other class or program definitions.

When you compile a COBOL class definition, a Java source program that contains a class definition that corresponds to the COBOL class definition is generated in addition to the object file. Use the SYSJAVA ddname to write the generated Java source file to a file in the z/OS UNIX file system. For example:

```
//SYSJAVA DD PATH='/u/userid/java/Classname.java',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
// PATHMODE=SIRWXU,
// FILEDATA=TEXT
```

Do not edit this generated Java class definition in any way. If you change the COBOL class definition, you must regenerate both the object file and the Java class definition by recompiling the updated COBOL class definition.

Compile Java class definitions by using the `javac` command from a z/OS UNIX shell command prompt, or by using the BPXBATCH utility.

“Example: compiling, linking, and running an OO application using JCL” on page 279

**related tasks**

- “Compiling with JCL” on page 237
- “Compiling under TSO” on page 244
Preparing and running OO applications in JCL or TSO/E

It is recommended that you run OO applications in a z/OS UNIX environment. To run OO applications from batch JCL or TSO/E, you should therefore use the BPXBATCH utility.

In limited circumstances, however, you can run an OO application by using standard batch JCL (EXEC PGM=COBPROG) or the TSO/E CALL command. To do so, follow these requirements when preparing the application:

- Structure the application to start with a COBOL program. (If an application starts with a Java program or with the main factory method of a COBOL class, you must run the application under z/OS UNIX, and the application components must reside in the z/OS UNIX file system.)

- **Link-edit considerations:** Link the program object for the COBOL program into a PDSE. COBOL programs that contain object-oriented syntax must be link-edited with AMODE 31.

- Ensure that the class files and DLLs associated with the COBOL or Java classes that are used by the application reside in the z/OS UNIX file system. You must name the class files and DLLs as described in the related task about preparing OO applications under z/OS UNIX.

- Specify INCLUDE control statements for the DLL side files libjvm.x and igzjava.x when you bind the object deck for the main program. For example:

  ```
  INCLUDE '/usr/lpp/java/J5.0/bin/j9vm/libjvm.x'
  INCLUDE '/usr/lpp/cobol/lib/igzjava.x'
  ```

- Create a file that contains the environment variable settings that are required for Java. For example, a file `/u/userid/javaenv` might contain the three lines shown below to set the PATH, LIBPATH, and CLASSPATH environment variables.

  ```
  PATH=/bin:/usr/lpp/java/IBM/J7.1/bin
  LIBPATH=/lib:/usr/lib:/usr/lpp/java/J5.0/bin:/usr/lpp/java/IBM/J7.1/bin/j9vm
  CLASSPATH=.:/u/userid/applications
  ```

  To customize the initialization of the JVM that will be used by the application, you can set the COBJVMINITOPTIONS environment variable in the same file. For example, to access enterprise beans that run in a WebSphere server, you must set the Java system property java.naming.factory.initial. For details, see the related task about running OO applications.

When you run an OO application that starts with a COBOL program by using standard batch JCL or the TSO/E CALL command, follow these guidelines:

- Use the _CEE_ENVFILE environment variable to indicate the location of the file that contains the environment variable settings required by Java. Set _CEE_ENVFILE by using the ENVAR runtime option.

- Specify the POSIX(ON) and XPLINK(ON) runtime option.

- Use DD statements to specify files in the z/OS UNIX file system for the standard input, output, and error streams for Java:
  - JAVAIN DD for the input from statements such as c=System.in.read();

---

“Specifying source libraries (SYSLIB)” on page 252
“Defining the Java-source output file (SYSJAVA)” on page 254
“Accessing JNI services” on page 597
“Compiling OO applications under z/OS UNIX” on page 273
“Preparing OO applications under z/OS UNIX” on page 274

related references
“DBCS” on page 301
“DLL” on page 303
“RENT” on page 331
“THREAD” on page 344
Appendix F, “JNI.cpy copybook,” on page 697
UNIX System Services User’s Guide (The BPXBATCH utility)
– JAVAOUT DD for the output from statements such as System.out.println(string);
– JAVAERR DD for the output from statements such as System.err.println(string);

• Ensure that the SCEERUN2 and SCEERUN load libraries are available in the system library search order, for example, by using a STEPLIB DD statement.

“Example: compiling, linking, and running an OO application using JCL” on page 279

related tasks
“Preparing OO applications under z/OS UNIX” on page 274
“Running OO applications under z/OS UNIX” on page 275
“Structuring OO applications” on page 594
UNIX System Services User’s Guide (The BPXBATCH utility)
Language Environment Programming Guide (Running an application under batch)

related references
XL C/C++ Programming Guide (_CEE_ENVFILE)
Language Environment Programming Reference (ENVAR)

Example: compiling, linking, and running an OO application using JCL

This example shows sample JCL that you could use to compile, link, and run a COBOL client that invokes a Java method.

The example shows:

• JCL to compile, link, and run an OO COBOL program, TSTHELLO
• A Java class definition, HelloJ, that contains a method that the COBOL program invokes
• A z/OS UNIX file, ENV, that contains the environment variable settings that Java requires

JCL for program TSTHELLO

```
//TSTHELLO JOB , // TIME=(1),MSGLEVEL=(1,1),MSGCLASS=H,CLASS=A,REGION=200M, // NOTIFY=&SYSUID,USER=&SYSUID // * // SET COBPRFX='IGY.V6R1M0' // SET LIBPRFX='CEE' // * //COMPILE EXEC PGM=IGYCRCTL, // SYSLIN DD DSNAME=&OBJECT(TSTHELLO),UNIT=VIO,DISP=(NEW,PASS), // SPACE=(CYL,(1,1,1)) // SYSPRINT DD SYSOUT=* //STEPLIB DD DSN=&COBPRFX..SIGYCOMP,DISP=SHR // DD DSN=&LIBPRFX..SCEERUN,DISP=SHR // DD DSN=&LIBPRFX..SCEERUN2,DISP=SHR //SYSUT1 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT2 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT3 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT4 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT5 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT6 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT7 DD UNIT=VIO,SPACE=(CYL,(1,1)) //SYSUT8 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT9 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT10 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT11 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT12 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT13 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT14 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSUT15 DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYSMDECK DD UNIT=SYSALLDA,SPACE=(CYL,(1,1)) //SYIN DD *
cbl dll,thread
Identification division.
Program-id. "TSTHELLO" recursive.
Environment division.
Configuration section.
Repository.
Class HelloJ is "HelloJ".
Data Division.
```
Procedure division.
  Display "COBOL program TSTHELLO entered"
  Invoke HelloJ "sayHello"
  Display "Returned from java sayHello to TSTHELLO"
  Goback.
End program "TSTHELLO".

Definition of class HelloJ

class HelloJ {
  public static void sayHello() {
    System.out.println("Hello World, from Java!");
  }
}

HelloJ.java is compiled with the javac command. The resulting .class file resides in the z/OS UNIX file system directory /userid/ootest/tsthello, which is specified in the CLASSPATH environment variable in the environment variable settings file.

Environment variable settings file, ENV

PATH=/bin:/usr/1pp/java/IBM/J7.1/bin.
LIBPATH=/lib:/usr/lib:/usr/1pp/java/J5.0/bin:/usr/1pp/java/IBM/J7.1/bin/j9vm
CLASSPATH=../userid/ootest/tsthello

The environment variable settings file also resides in directory /userid/ootest/tsthello, as specified in the _CEE_ENVFILE environment variable in the JCL.

Using Java SDKs for z/OS

The Java SDKs for z/OS are based on the XPLINK linkage convention defined by Language Environment.

If the application starts with a Java program or the main factory method of a COBOL class, the XPLINK environment is automatically started by the java command that starts the JVM and runs the application.

If an application starts with a COBOL program that invokes methods on COBOL or Java classes, you must specify the XPLINK(ON) runtime option so that the XPLINK environment is initialized. XPLINK(ON) is not recommended as a default setting, however; you should use XPLINK(ON) only for applications that specifically require it.
When you are running an application under z/OS UNIX, you can set the XPLINK(ON) option by using the
_CEE_RUNOPTS environment variable as follows:

```
_CEE_RUNOPTS="XPLINK(ON)"
```

Exporting `_CEE_RUNOPTS="XPLINK(ON)"` so that it is in effect for the entire z/OS UNIX shell session is
not recommended, however. Suppose for example that an OO COBOL application starts with a COBOL
program called App1Driver. One way to limit the effect of the XPLINK option to the execution of the
App1Driver application is to set the `_CEE_RUNOPTS` variable on the command-line invocation of
App1Driver as follows:

```
_CEE_RUNOPTS="XPLINK(ON)" App1Driver
```

**related tasks**

“Running OO applications under z/OS UNIX” on page 275

“Setting and accessing environment variables” on page 436

**related references**

“Object-oriented syntax, and Java 6, Java 7, or Java 8” on page 281

“Runtime environment variables” on page 437

Language Environment Programming Reference (XPLINK)

XL C/C++ Programming Guide (_CEE_RUNOPTS)

**Object-oriented syntax, and Java 6, Java 7, or Java 8**

Enterprise COBOL V5.2 and later applications that use object-oriented syntax for Java interoperability are
supported with Java 6 or Java 7.

Earlier versions of Enterprise COBOL applications that use object-oriented syntax for Java interoperability
were supported with Java SDK 1.4.2 and Java 5. To run these applications with Java 6, Java 7, or Java 8,
do these steps:

1. Recompile and relink the applications using Enterprise COBOL V5.2 or later.
2. Recompile the generated Java class that is associated with each object-oriented COBOL class using
   the `javac` command from Java 6, Java 7, or Java 8.

**related tasks**

“Preparing OO applications under z/OS UNIX” on page 274
Chapter 17. Compiler options

You can direct and control your compilation by using compiler options or by using compiler-directing statements (compiler directives).

Compiler options affect the aspects of your program that are listed in the table below. The linked-to information for each option provides the syntax for specifying the option and describes the option, its parameters, and its interaction with other parameters.

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<th>Table 43. Compiler options</th>
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<td>Date processing</td>
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<td>Maps and listings</td>
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<td>Aspect of your program</td>
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<td>Object deck generation</td>
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</table>
### Table 43. Compiler options (continued)

<table>
<thead>
<tr>
<th>Aspect of your program</th>
<th>Compiler option</th>
<th>Default</th>
<th>Option abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
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<td>4096</td>
<td>BUF</td>
</tr>
<tr>
<td></td>
<td>“DATA” on page 300</td>
<td>DATA(31)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>“DYNAM” on page 305</td>
<td>NODYNAM</td>
<td>DYN</td>
</tr>
<tr>
<td></td>
<td>“RENT” on page 331</td>
<td>RENT</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>“RMODE” on page 332</td>
<td>AUTO</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>“STGOPT” on page 340</td>
<td>NOSTGOPT</td>
<td>S0</td>
</tr>
</tbody>
</table>

### Debugging and diagnostics

|                        | “DIAGTRUNC” on page 301  | NODIAGTRUNC | DTR|NODTR |
|                        | “DUMP” on page 304       | NODUMP      | DU|NUDU  |
|                        | “FLAG” on page 308       | FLAG(I,I)  | F|NOF   |
|                        | “FLAGSTD” on page 309    | NOFLAGSTD  | None               |
|                        | “INITCHECK” on page 311  | NOINITCHECK | IC|NOIC  |
|                        | “RULES” on page 333      | NORULES    | RULES(ENDP, EVENP, LXPFRF, SLCKB)| RULES(NOENDP, NOEVENP, NOLXPRF, NOSLCKB) |
|                        | “SSRANGE” on page 339    | NOSSRANGE  | SSR(ZLEN|NOZLEN, MSG|ABD)|NOSSR |
|                        | “TEST” on page 341       | NOTEST     | None                |

### Other

|                        | “ADATA” on page 288      | NOADATA   | None                 |
|                        | “COPYLOC” on page 297    | NOCOPYLOC | CPLC                 |
|                        | “EXIT” on page 305       | NOEXIT    | NOEX|EX(INX|NOINX, LIBX|NOLIBX, PRTX|NOPRTX, ADX|NOADX, MSGX|NOMSGX) |
|                        | “MDECK” on page 318      | NOMDECK   | NOMD|MD|MD(C|NOC) |
|                        | “OPTFILE” on page 324    | None      | None                 |
|                        | “THREAD” on page 344     | NOTHREAD  | None                 |
|                        | “VSAMOPENFS” on page 348 | VSAMOPENFS(COMPAT) | VS(C|S) |

### Installation defaults:
The default compiler options that were set up when your compiler was installed are in effect for your program unless you override those options. (In some installations, certain compiler options are fixed so that you cannot override them. If you have problems with the default options, contact your system administrator.) To determine which are the default options, run a test compilation without specifying any compiler options. The output listing lists the default options in effect at your site.

### Nonoverridable options:
In some installations, certain compiler options are fixed so that you cannot override them. If you have problems with those options, contact your system administrator.

### Option specification:
Compiler options and suboptions are not case sensitive.
Performance considerations: The AFP, ARCH, ARITH, AWO, BLOCK0, DYNAM, FASTSRT, HGPR, MAXPCF, NUMCHECK, NUMPROC, OPTIMIZE, PARMCHECK, RENT, SQLCCSID, SSRANGE, STGOPT, TEST, THREAD, TRUNC, ZONECHECK, and ZONEDATA compiler options can affect runtime performance.

related tasks
Chapter 14, “Compiling under z/OS,” on page 237
“Compiling under TSO” on page 244
Chapter 15, “Compiling under z/OS UNIX,” on page 265
Chapter 36, “Tuning your program,” on page 629

related references
“Conflicting compiler options” on page 287
Chapter 18, “Compiler-directing statements,” on page 357
“Option settings for 85 COBOL Standard conformance” on page 286
“Performance-related compiler options” on page 636

Option settings for 85 COBOL Standard conformance

Compiler options and runtime options are required for conformance with the 85 COBOL Standard.

The following compiler options are required:

• ADV
• DYNAM
• NAME(ALIAS) or NAME(NOALIAS)
• NOBLOCK0
• NOCICS
• NODLL
• NOEXPORTALL
• NOFASTSRT
• NOTHREAD
• NOWORD
• NUMPROC(NOPFD)
• PGMNAME(COMPAT) or PGMNAME(LONGUPPER)
• QUALIFY(COMPAT)
• QUOTE
• TRUNC(STD)
• VLR(STANDARD)
• ZWB

You can use the FLAGSTD compiler option to flag nonconforming elements such as IBM extensions.

The following runtime options are required:

• AIXBLD
• CBLQDA(ON)
• TRAP(ON)

related references
Language Environment Programming Reference
Conflicting compiler options

The Enterprise COBOL compiler can encounter conflicting compiler options in either of two ways: both the positive and negative form of an option are specified at the same level in the hierarchy of precedence, or mutually exclusive options are specified at the same level in the hierarchy.

When conflicting options are specified at the same level in the hierarchy (such as specifying both DECK and NODECK in a PROCESS or CBL statement), the option specified last takes effect.

If you specify mutually exclusive compiler options at the same level, the compiler generates an error message and forces one of the options to a nonconflicting value. For example, if you specify both OFFSET and LIST in a PROCESS statement in any order, OFFSET takes effect and LIST is ignored.

However, options coded at a higher level of precedence override any options specified at a lower level of precedence. For example, if you code OFFSET in a JCL statement but LIST in a PROCESS statement, LIST takes effect because the options coded in the PROCESS statement and any options forced on by an option coded in the PROCESS statement have higher precedence.

<table>
<thead>
<tr>
<th>Specified</th>
<th>Ignored1</th>
<th>Forced on1</th>
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<tbody>
<tr>
<td>CICS</td>
<td>DYNAM</td>
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<td></td>
<td>NORENT</td>
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<tr>
<td>DLL</td>
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<td></td>
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<td>DYNAM</td>
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<td>RMODE(ANY)</td>
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<td>NSYMBOL(NATIONAL)</td>
<td>NODBCS</td>
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<td>OBJECT</td>
<td>DECK</td>
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<tr>
<td>OFFSET</td>
<td>LIST</td>
<td>NOLIST</td>
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<td>OPTIMIZE(0)</td>
<td>INITCHECK</td>
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<td>PGMNAME(LM</td>
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<td>NAME</td>
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<tr>
<td>TEST</td>
<td>NOOBJECT and NODECK</td>
<td>OBJECT and NODECK</td>
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<td>THREAD</td>
<td>NORENT</td>
<td>RENT</td>
</tr>
<tr>
<td>WORD</td>
<td>FLAGSTD</td>
<td>NOFLAGSTD</td>
</tr>
</tbody>
</table>

1. Unless in conflict with a fixed installation default option.

related tasks
“Specifying compiler options under z/OS” on page 254
“Specifying compiler options in a batch compilation” on page 259
“Specifying compiler options under z/OS UNIX” on page 266

related references
“OPTFILE” on page 324
ADATA

Use ADATA when you want the compiler to create a SYSADATA file that contains records of additional compilation information.

**ADATA option syntax**

```
NOADATA

ADATA
```

Default is: NOADATA

Abbreviations are: None

ADATA is required for remote compilation using an IBM Windows COBOL compiler. On z/OS, the SYSADATA file is written to ddname SYSADATA.

The size of the SYSADATA file generally grows with the size of the associated program.

**Option specification:** You cannot specify the ADATA option in a PROCESS (or CBL) statement. You can specify it only in one of the following ways:

- In the PARM parameter of JCL
- As a cob2 command option
- As an installation default
- In the COBOPT environment variable

**related references**

- “Setting environment variables under z/OS UNIX” on page 265
- “cob2 syntax and options” on page 269
- Appendix G, “COBOL SYSADATA file contents,” on page 703

ADV

ADV has meaning only if you use WRITE . . . ADVANCING in your source code. With ADV in effect, the compiler adds 1 byte to the record length to account for the printer control character.

**ADV option syntax**

```
ADV

NOADV
```

Default is: ADV

Abbreviations are: None

Use NOADV if you already adjusted record length to include 1 byte for the printer control character.
The AFP option controls the compiler usage of the Additional Floating Point (AFP) registers that are provided by z/Architecture processors.

**AFP option syntax**

AFP(VOLATILE)

Default is: AFP(VOLATILE)

Abbreviations are: None

The Enterprise COBOL compiler generates code that uses the full complement of 16 floating point registers (FPR) provided by a z/Architecture processor. These FPRs are as follows:

- Original FPRs, which are numbered 0, 2, 4, and 6
- AFP registers, which are numbered 1, 3, 5, 7, and 8-15

**Note:** If your code runs on a version of CICS Transaction Server that is earlier than V4.1, you must specify AFP(VOLATILE).

**AFP(VOLATILE)**

If you specify AFP(VOLATILE), the AFP registers 8-15 are considered volatile, which means that they might be changed by a called subprogram. Therefore, the COBOL compiler generates extra code to protect the values in these registers.

**AFP(NOVOLATILE)**

If you specify AFP(NOVOLATILE), the AFP registers 8-15 are considered nonvolatile, which means that they are known to be unchanged or preserved by every called subprogram. Therefore, the compiler can generate more efficient code sequences for programs with floating point operations. It is the normal z/OS architecture convention.

**APOST/QUOTE**

Use APOST if you want the figurative constant [ALL] QUOTE or [ALL] QUOTES to represent one or more apostrophe (’) characters. Use QUOTE if you want the figurative constant [ALL] QUOTE or [ALL] QUOTES to represent one or more quotation mark (“) characters.

**APOST/QUOTE option syntax**

Default is: QUOTE

Abbreviations are: Q|APOST

**Delimiters:** You can use either quotation marks or apostrophes as literal delimiters regardless of whether the APOST or QUOTE option is in effect. The delimiter character used as the opening delimiter for a literal must be used as the closing delimiter for that literal.
The ARCH option specifies the machine architecture for which the executable program instructions are to be generated.

**ARCH option syntax**

```
ARCH(7 8 9 10 11)
```

Default is: ARCH(7)

Abbreviations are: None

If you specify a higher ARCH level, the compiler generates code that uses newer and faster instructions. Your application might abend if it runs on a processor with an architecture level lower than what you specified with the ARCH option. Use the ARCH level that matches the lowest machine architecture where your application runs.

Current supported architecture levels and groups of models are as follows:

**7**

Produces code that uses instructions available on the 2094-xxx (IBM System z9® EC) and 2096-xxx (IBM System z9 BC) models in z/Architecture mode.

Specifically, these ARCH(7) machines and their follow-ons add instructions supported by the following facilities:

- Extended-immediate facility
- Decimal floating point facility. These instructions might be generated if decimal data is used in numeric operations.

**8**

Produces code that uses instructions available on the 2097-xxx (IBM System z10® EC) and 2098-xxx (IBM System z10 BC) models in z/Architecture mode.

Specifically, these ARCH(8) machines and their follow-ons add instructions supported by the general instruction extensions facility.

**9**

Produces code that uses instructions available on 2817-xxx (IBM zEnterprise® 196) and 2818-xxx (IBM zEnterprise 114) models in z/Architecture mode.

Specifically, these ARCH(9) machines and their follow-ons add instructions supported by the following facilities:

- High-word facility
- Interlocked access facility
- Load/store-on-condition facility
- Distinct-operands facility
- Population-count facility

**10**

Produces code that uses instructions available on the 2827-xxx (IBM zEnterprise EC12) and 2828-xxx (IBM zEnterprise BC12) models in z/Architecture mode.
Specifically, these ARCH(10) machines and their follow-ons add instructions supported by the following facilities:

- Execution-hint facility
- Load-and-trap facility
- Miscellaneous-instructions-extension facility
- Transactional-execution facility
- Enhanced decimal floating point facility that enables more efficient conversions between zoned decimal data items and decimal floating point data items. Instead of converting zoned decimal data items to packed decimal data items to perform arithmetic, the compiler converts zoned decimal data items directly to decimal floating point data items, and then back again to zoned decimal data items after the computations are complete.

### 11

Produces code that uses instructions available on 2964-xxx (IBM z13®) and 2965-xxx (IBM z13s®) models in z/Architecture mode.

Specifically, these ARCH(11) machines and their follow-ons add instructions with support of the following facilities:

- Enhanced decimal floating point facility that enables more efficient conversions between packed-decimal data items and decimal floating point intermediate result data items.
- Exploitation of the vector extension facility (SIMD) instructions for some INSPECT REPLACING and INSPECT TALLYING statements.

To use the vector extension facility (SIMD) instructions, the code must be executed on a machine running on z/OS V2.2, or z/OS V2.1 with the PTFs for APARs OA43803 and PI12412 installed.

**Note:** A higher ARCH level includes the facilities of the lower ARCH level. For example, ARCH(11) includes all the facilities of the lower ARCH levels.

For more information about these facilities, see z/Architecture Principles of Operation.

### ARITH

ARITH affects the maximum number of digits that you can code for integers, and the number of digits used in fixed-point intermediate results.

**ARITH option syntax**

```plaintext
ARITH(COMPAT | EXTEND )
```

Default is: ARITH(COMPAT)

Abbreviations are: AR(C | E)

When you specify ARITH(EXTEND):

- The maximum number of digit positions that you can specify in the PICTURE clause for packed-decimal, external-decimal, and numeric-edited data items is raised from 18 to 31.
- The maximum number of digits that you can specify in a fixed-point numeric literal is raised from 18 to 31. You can use numeric literals with large precision anywhere that numeric literals are currently allowed, including:
  - Operands of PROCEDURE DIVISION statements
  - VALUE clauses (for numeric data items with large-precision PICTURE)
  - Condition-name values (on numeric data items with large-precision PICTURE)
• The maximum number of digits that you can specify in the arguments to NUMVAL and NUMVAL-C is raised from 18 to 31.
• The maximum value of the integer argument to the FACTORIAL function is 29.
• Intermediate results in arithmetic statements use extended mode.

When you specify ARITH (COMPAT):
• The maximum number of digit positions in the PICTURE clause for packed-decimal, external-decimal, and numeric-edited data items is 18.
• The maximum number of digits in a fixed-point numeric literal is 18.
• The maximum number of digits in the arguments to NUMVAL and NUMVAL-C is 18.
• The maximum value of the integer argument to the FACTORIAL function is 28.
• Intermediate results in arithmetic statements use compatibility mode.

related concepts
Appendix A, “Intermediate results and arithmetic precision,” on page 649

AWO

If you specify AWO, an implicit APPLY WRITE-ONLY clause is activated for all QSAM files in the program that have blocked variable-length records.

AWO option syntax

AWO

Default is: NOAWO
Abbreviations are: None

related tasks
“Optimizing buffer and device space” on page 10

related references
“BLOCK0” on page 292
APPLY WRITE-ONLY clause (Enterprise COBOL for z/OS Language Reference)

BLOCK0

Use BLOCK0 to change the compiler default for QSAM files from unblocked to blocked (as if BLOCK CONTAINS 0 were specified) and thus gain the benefit of system-determined blocking for output files.

BLOCK0 option syntax

BLOCK0

Default is: NOBLOCK0
Abbreviations are: None
Specifying BLOCK0 activates an implicit BLOCK CONTAINS 0 clause for each file in the program that meets the following three criteria:

- The FILE-CONTROL paragraph either specifies ORGANIZATION SEQUENTIAL or omits the ORGANIZATION clause.
- The FD entry does not specify RECORDING MODE U.
- The FD entry does not specify a BLOCK CONTAINS clause.

Files for which the resulting BLOCK CONTAINS 0 clause is in effect have a blocking factor that is determined at run time from the data definition or from the data-set characteristics.

**Interaction of the APPLY WRITE-ONLY clause and the AWO compiler option with BLOCK0:**

- If NOBLOCK0 is in effect, and the file description of a file that meets the three criteria listed above specifies APPLY WRITE-ONLY, the compiler issues an error message because APPLY WRITE-ONLY applies only to blocked files. But if BLOCK0 is in effect, the result is that the file is blocked, and the APPLY WRITE-ONLY clause is therefore accepted.
- AWO applies to any QSAM files that have blocked variable-length records. If BLOCK0 is in effect, the result is that more files might be blocked than if NOBLOCK0 were in effect; thus AWO might apply to more files than it otherwise would.

Specifying BLOCK0 for existing programs might result in a change of behavior, and in some cases produce undesirable results for files opened as INPUT. For example:

- The OPEN INPUT statement fails for files for which no block size can be determined.
- Programs that continue after handling nonzero FILE STATUS codes for files opened as INPUT might abnormally terminate when executing subsequent I/O statements on those files.

For these reasons, after compiling with BLOCK0 you should investigate and test the effects on your program.

For recommendations about blocking, see the related reference from the Enterprise COBOL for z/OS Migration Guide (in the information about migrating from CMPR2 to NOCMPR2).

**related tasks**

“Optimizing buffer and device space” on page 10
“Setting block sizes” on page 158

**related references**

“AWO” on page 292
APPLY WRITE-ONLY clause (Enterprise COBOL for z/OS Language Reference)
BLOCK CONTAINS clause (Enterprise COBOL for z/OS Language Reference)
Enterprise COBOL for z/OS Migration Guide
(Recommendation for DCB= parameters of JCL)

**BUFSIZE**

Use BUFSIZE to allocate an amount of main storage to the buffer for each compiler work data set. Usually, a large buffer size improves the performance of the compiler.

**BUFSIZE option syntax**

```plaintext
BUFSIZE( nnnnn nnn K )
```

Default is: 4096

Abbreviations are: BUF

`nnnnn` specifies a decimal number that must be at least 256.
**CICS**

The CICS compiler option enables the integrated CICS translator and lets you specify CICS suboptions. You must use the CICS option if your COBOL source program contains EXEC CICS or EXEC DLI statements and the program has not been processed by the separate CICS translator.

The CICS option syntax

```
CICS option syntax
```

Default is: NOCICS

Abbreviations are: None

Use the CICS option only to compile CICS programs. Programs compiled with the CICS option will not run in a non-CICS environment.

If you specify the NOCICS option, any CICS statements found in the source program are diagnosed and discarded.

Use either quotation marks or apostrophes to delimit the string of CICS suboptions.

You can partition a long CICS suboption string into multiple suboption strings in multiple CBL or PROCESS statements. The CICS suboptions are concatenated in the order of their appearance. For example:

```
//STEP1 EXEC IGYWC, ...
// PARM.COBOL='CICS("string1")'
//COBOL.SYSIN DD *
  CBL CICS('string2')
  CBL CICS("string3")
  IDENTIFICATION DIVISION.
  PROGRAM-ID. DRIVER1.
  ...
```

The compiler passes the following suboption string to the integrated CICS translator:

```
"string1 string2 string3"
```

The concatenated strings are delimited with single spaces as shown. If multiple instances of the same CICS suboption are found, the last specification of that suboption in the concatenated string prevails. The compiler limits the size of the concatenated suboption string to 4 KB.

**related concepts**

“Integrated CICS translator” on page 412

**related tasks**

“Compiling with the CICS option” on page 411

“Separating CICS suboptions” on page 412

**related references**

(Developing CICS Applications)
Use CODEPAGE to specify the coded character set identifier (CCSID) for an EBCDIC code page for processing compile-time and runtime COBOL operations that are sensitive to character encoding.

**CODEPAGE option syntax**

```plaintext
CODEPAGE(ccsid)
```

Default is: CODEPAGE(1140)

Abbreviations are: CP(ccsid)

`ccsid` must be an integer that represents a valid CCSID for an EBCDIC code page.

The default CCSID 1140 is the equivalent of CCSID 37 (COM EUROPE EBCDIC), but additionally includes the euro symbol.

`ccsid` specifies these encodings:

- The encoding for alphanumeric, national, and DBCS literals in a COBOL source program
- The default encoding of the content of alphanumeric and DBCS data items at run time
- The encoding for DBCS user-defined words when processed by an XML GENERATE statement to create XML element and attribute names
- The default encoding of an XML document created by an XML GENERATE statement if the receiving data item for the document is alphanumeric
- The default encoding assumed for an XML document in an alphanumeric data item when the document is processed by an XML PARSE statement

The CODEPAGE `ccsid` is used when code-page-sensitive operations are performed at compile time or run time, and an explicit CCSID that overrides the default code page is not specified. Such operations include:

- Conversion of literal values to Unicode
- Conversion of alphanumeric data to and from national (Unicode) data as part of move operations, comparison, or the intrinsic functions DISPLAY-OF and NATIONAL-OF
- Object-oriented language such as INVOKE statements or class definitions and method definitions
- XML parsing
- XML generation
- Processing of DBCS names as part of XML generation at run time
- Processing of SQL string host variables if the SQLCCSID option is in effect
- Processing of source code for EXEC SQL statements
- Processing of source code for EXEC SQLIMS statements

However, the encoding of the following items in a COBOL source program is not affected by the CODEPAGE compiler option:

- Data items that have USAGE NATIONAL
  These items are always encoded in UTF-16 in big-endian format, CCSID 1200.
- Characters from the basic COBOL character set (see the table of these characters in the related reference below about characters)

Though the encoding of the basic COBOL characters default currency sign ($), quotation mark ("), and the lowercase Latin letters varies in different EBCDIC code pages, the compiler always interprets these characters using the EBCDIC code page 1140 encoding. In particular, the default currency sign is always the character with value X'5B' (unless changed by the CURRENCY compiler option or the
CURRENCY SIGN clause in the SPECIAL-NAMES paragraph), and the quotation mark is always the character with value X'7F'.

Some COBOL operations can override the CODEPAGE ccsid by using an explicit encoding specification, for example:

- DISPLAY-OF and NATIONAL-OF intrinsic functions that specify a code page as the second argument
- XML PARSE statements that specify the WITH ENCODING phrase
- XML GENERATE statements that specify the WITH ENCODING phrase

Additionally, you can use the CURRENCY compiler option or the CURRENCY SIGN clause in the SPECIAL-NAMES paragraph to override:

- The default currency symbol used in the PICTURE character-strings for numeric-edited data items in your source program
- The currency sign value used in the content of numeric-edited data items at run time

**DBCS code pages:**

Compile your COBOL program using the CODEPAGE option with the ccsid set to one of the EBCDIC multibyte character set (MBCS) CCSIDs shown in the table below if the program contains any of the following items:

- User-defined words formed with DBCS characters
- DBCS (USAGE DISPLAY-1) data items
- DBCS literals

All of the CCSIDs in the table below identify mixed code pages that refer to a combination of SBCS and DBCS coded character sets. These are also the CCSIDs that are supported for mixed data by DB2.

<table>
<thead>
<tr>
<th>National language</th>
<th>MBCS CCSID</th>
<th>SBCS CCSID component</th>
<th>DBCS CCSID component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese (Katakana-Kanji)</td>
<td>930</td>
<td>290</td>
<td>300</td>
</tr>
<tr>
<td>Japanese (Katakana-Kanji with euro)</td>
<td>1390</td>
<td>8482</td>
<td>16684</td>
</tr>
<tr>
<td>Japanese (Katakana-Kanji)</td>
<td>5026</td>
<td>290</td>
<td>4396</td>
</tr>
<tr>
<td>Japanese (Latin-Kanji)</td>
<td>939</td>
<td>1027</td>
<td>300</td>
</tr>
<tr>
<td>Japanese (Latin-Kanji with euro)</td>
<td>1399</td>
<td>5123</td>
<td>16684</td>
</tr>
<tr>
<td>Japanese (Latin-Kanji)</td>
<td>5035</td>
<td>1027</td>
<td>4396</td>
</tr>
<tr>
<td>Korean</td>
<td>933</td>
<td>833</td>
<td>834</td>
</tr>
<tr>
<td>Korean</td>
<td>1364</td>
<td>13121</td>
<td>4930</td>
</tr>
<tr>
<td>Simplified Chinese</td>
<td>935</td>
<td>836</td>
<td>837</td>
</tr>
<tr>
<td>Simplified Chinese</td>
<td>1388</td>
<td>13124</td>
<td>4933</td>
</tr>
<tr>
<td>Traditional Chinese</td>
<td>937</td>
<td>28709</td>
<td>835</td>
</tr>
</tbody>
</table>

Note: If you specify the TEST option, you must set the CODEPAGE option to the CCSID that is used for the COBOL source program. In particular, programs that use Japanese characters in DBCS literals or DBCS user-defined words must be compiled with the CODEPAGE option set to a Japanese codepage CCSID.

**related concepts**

“COBOL and DB2 CCSID determination” on page 422

**related tasks**

“Using currency signs” on page 62
COMPILE

Use the COMPILE option only if you want to force full compilation even in the presence of serious errors. All diagnostics and object code will be generated. Do not try to run the object code if the compilation resulted in serious errors: the results could be unpredictable or an abnormal termination could occur.

```
COMPILE option syntax
```

\[
\text{NOCOMPILE}(\text{S}) \quad \text{E} \quad \text{W} \\
\text{COMPILE} \\
\text{NOCOMPILE}
\]

Default is: NOCOMPILE(S)

Abbreviations are: C|NOC

Use NOCOMPILE without any suboption to request a syntax check (only diagnostics produced, no object code). If you use NOCOMPILE without any suboption, several compiler options will have no effect because no object code will be produced, for example: DECK, LIST, OBJECT, OFFSET, OPTIMIZE, SSRANGE, and TEST.

Use NOCOMPILE with suboption W, E, or S for conditional full compilation. Full compilation (diagnosis and object code) will stop when the compiler finds an error of the level you specify (or higher), and only syntax checking will continue.

related tasks
“Finding coding errors” on page 366

related references
“Messages and listings for compiler-detected errors” on page 262

COPYLOC

Use the COPYLOC compiler option to add either a PDSE (or PDS) dataset or z/OS UNIX directory as an additional location to be searched for copy members during the library phase. The location specified by the COPYLOC option is added to the end of the order of locations to search for copy members. For details, see COPY member search order in the Enterprise COBOL for z/OS Language Reference.

COPYLOC is introduced in Enterprise COBOL V6.1 with the PTF for APAR PI96231 installed.
COPYLOC option syntax

Default is: NOCOPYLOC

Abbreviations are: CPLC | NOCPLC

**library-name**

The library name that the copy location is to be associated with. When `library-name` is not specified, the default is SYSLIB, which is the library name assumed in COPY statements that do not include an explicit library name.

**dataset-name**

The name of a PDS or PDSE dataset in which the compiler should search for copy members when processing COPY statements that refer to library `library-name`.

**unix-directory-name**

The name of a z/OS UNIX directory in which the compiler should search for copy members when processing COPY statements that refer to library `library-name`. The specified path must not exceed 64 characters. To specify a lowercase path, which is standard for z/OS UNIX, the path should be surrounded in quotes. Otherwise, the path name will be converted to uppercase.

Multiple instances of the COPYLOC option are supported. There is no limit on the number of z/OS UNIX directories that can be specified, but there is a limit of 256 datasets that can be specified for searching. Copy locations will be searched in the order that they are specified via the COPYLOC option. This provides users the ability to mix PDSE (or PDS) locations and z/OS UNIX directories in the search.

If the NOCOPYLOC option is specified, any previous instances of the COPYLOC option are ignored.

To control the searching of copy member locations exclusively using the COPYLOC option, you should avoid using any of the existing methods for indicating copybook locations, such as, allocating datasets to a ddname in JCL, or specifying the `-I` option of the cob2 command. If the compiler is invoked from cob2, you should also avoid keeping copy members in the current directory, because the current directory will always be searched before the COPYLOC locations are being searched.

**Tip:** You might find it convenient to control searching of copy members exclusively using the COPYLOC option, especially when the compiler is invoked from the cob2 command.

When COPYLOC options are specified in CBL statements, they can be used only on the first program of a batch program. Therefore, if a file has multiple COBOL programs in it, there can be CBL statements with COPYLOC options preceding the first program, but not the other programs. The COPYLOC options specified for the first program (and COPYLOC options specified in PARM of JCL or COPYLOC options specified as cob2 command options under z/OS UNIX) apply to all programs in a file. The copy locations specified in COPYLOC options found in CBL cards will be searched after copy locations found in COPYLOC options specified as invocation parameters.

**Example**

```cobol
COPYLOC(MYLIB, DSN(USERID.COBOL.COPIYLIB1))
COPYLOC(MYLIB, PATH('/home/userid/coylib1'))
COPYLOC(MYLIB, DSN(USERID.COBOL.COPIYLIB2))
```

For COPY statements that reference library name MYLIB explicitly, if the preceding options were specified in a single invocation of the compiler and a copy member could not be found in the locations specified in JCL (or in locations indicated for a cob2 compile), additional searching for the copy member will be done in the following places sequentially:
1. USERID.COBOL.COPYLIB1 dataset
2. z/OS UNIX directory /home/userid/copylib1
3. USERID.COBOL.COPYLIB2 dataset

related references
COPY statement (Enterprise COBOL for z/OS Language Reference)
COPY member search order (Enterprise COBOL for z/OS Language Reference)
ALOWCOPYLOC (Enterprise COBOL Customization Guide)

COPYRIGHT

Use COPYRIGHT to place a string in the object module if the object module is generated. If the object is linked into a program object, the string is loaded into memory with that program object.

COPYRIGHT option syntax

```
NOCOPYRIGHT
COPYRIGHT('copyright string')
```

Default is: NOCOPYRIGHT
Abbreviations are: CPYR|NOCPYR

The copyright string is limited to 64 characters in length.

CURRENCY

You can use the CURRENCY option to provide an alternate default currency symbol to be used for a COBOL program. (The default currency symbol is the dollar sign ($).)

CURRENCY option syntax

```
NOCURRENCY
CURRENCY(literal)
```

Default is: NOCURRENCY
Abbreviations are: CURR|NOCURR

NOCURRENCY specifies that no alternate default currency symbol will be used.

To change the default currency symbol, specify CURRENCY(literal), where literal is a valid COBOL alphanumeric literal (optionally a hexadecimal literal) that represents a single character. The literal must not be from the following list:

- Digits zero (0) through nine (9)
- Uppercase alphabetic characters A B C D E G N P R S V X Z or their lowercase equivalents
- The space
- Special characters * + - / , ; ( ) " =
- A figurative constant
- A null-terminated literal
- A DBCS literal
• A national literal

If your program processes only one currency type, you can use the CURRENCY option as an alternative to the CURRENCY SIGN clause for indicating the currency symbol you will use in the PICTURE clause of your program. If your program processes more than one currency type, you should use the CURRENCY SIGN clause with the WITH PICTURE SYMBOL phrase to specify the different currency sign types.

If you use both the CURRENCY option and the CURRENCY SIGN clause in a program, the CURRENCY option is ignored. Currency symbols specified in the CURRENCY SIGN clause or clauses can be used in PICTURE clauses.

When the NOCURRENCY option is in effect and you omit the CURRENCY SIGN clause, the dollar sign ($) is used as the PICTURE symbol for the currency sign.

**Delimiter:** You can delimit the CURRENCY option literal with either quotation marks or apostrophes, regardless of the APOST|QUOTE compiler option setting.

**related tasks**

“Using currency signs” on page 62

---

**DATA**

The DATA option affects whether storage for dynamic data areas and other dynamic runtime storage is obtained from above or below the 16 MB line.

**DATA option syntax**

```
DATA(31 24)
```

Default is: DATA(31)

Abbreviations are: None

For reentrant programs, the DATA compiler option and the HEAP runtime option control whether storage for dynamic data areas (such as WORKING-STORAGE and FD record areas) is obtained from below the 16 MB line (DATA(24)) or from unrestricted storage (DATA(31)). (DATA does not affect the location of LOCAL-STORAGE data; the STACK runtime option controls that location instead, along with the AMODE of the program.)

Specify DATA(24) for programs that run in 31-bit addressing mode and that pass data arguments to programs in 24-bit addressing mode. Doing so ensures that the data will be addressable by the called program.

**External data and QSAM buffers:** The DATA option interacts with other compiler options and runtime options that affect storage and its addressability. See the related information for details.

The DATA compiler option setting influences how ALLOCATE acquires storage:

• If DATA(24) is in effect and the LOC 31 phrase of the ALLOCATE statement is not specified, ALLOCATE acquires storage from below the 16 MB line.
• If DATA(31) is in effect and the LOC 24 phrase of the ALLOCATE statement is not specified, ALLOCATE will attempt to acquire storage from above the 16 MB line.

**related concepts**

“Storage and its addressability” on page 37

**related tasks**

“Making programs reentrant” on page 460

*Language Environment Programming Guide* (Using runtime options)
related references
“Allocation of buffers for QSAM files” on page 170
“RENT” on page 331
ALLOCATE statement
(Enterprise COBOL for z/OS Language Reference)

DBCS

Using DBCS causes the compiler to recognize X'0E' (SO) and X'0F' (SI) as shift codes for the double-byte portion of an alphanumeric literal.

**DBCS option syntax**

```
DBCS

NODBCS
```

Default is: DBCS

Abbreviations are: None

With DBCS in effect, the double-byte portion of the literal is syntax-checked and the literal remains category alphanumeric.

related references
“Conflicting compiler options” on page 287

DECK

Use DECK to produce object code in the form of 80-column records. If you use the DECK option, be certain that SYSPUNCH is defined in your JCL for compilation.

**DECK option syntax**

```
NODECK

DECK
```

Default is: NODECK

Abbreviations are: D|NOD

related tasks
“Creating object code (SYSLIN or SYSPUNCH)” on page 253

DIAGTRUNC

DIAGTRUNC causes the compiler to issue a severity-4 (Warning) diagnostic message for MOVE statements that have numeric receivers when the receiving data item has fewer integer positions than the sending
data item or literal. In statements that have multiple receivers, the message is issued separately for each receiver that could be truncated.

**DIAGTRUNC option syntax**

```
{ NODIAGTRUNC }
DIAGTRUNC
```

Default is: NODIAGTRUNC

Abbreviations are: DTR|NODTR

The diagnostic message is also issued for implicit moves associated with statements such as these:

- INITIALIZE
- READ . . . INTO
- RELEASE . . . FROM
- RETURN . . . INTO
- REWRITE . . . FROM
- WRITE . . . FROM

The diagnostic message is also issued for moves to numeric receivers from alphanumeric data-names or literal senders, except when the sending field is reference modified.

There is no diagnostic message for COMP-5 receivers, nor for binary receivers when you specify the TRUNC(BIN) option.

**related concepts**

- “Formats for numeric data” on page 45
- “Reference modifiers” on page 108

**related references**

- “TRUNC” on page 345

**DISPSIGN**

The DISPSIGN option controls output formatting for DISPLAY of signed numeric items.

**DISPSIGN option syntax**

```
DISPSIGN( COMPAT SEP )
```

Default is: DISPSIGN(COMPAT)

Abbreviations are: DS(C|S)

**DISPSIGN(COMPAT)**

If you specify DISPSIGN(COMPAT), formatting for displayed values of signed numeric items is compatible with prior versions of Enterprise COBOL. Overpunch signs are generated in some cases.

**DISPSIGN(SEP)**

If you specify DISPSIGN(SEP), the displayed values for signed binary, signed packed-decimal, or overpunch signed zoned-decimal items are always formatted with a leading separate sign.
The following example shows the DISPLAY output with the DISPSIGN(COMPAT) option or the DISPSIGN(SEP) option specified:

<table>
<thead>
<tr>
<th>Data items</th>
<th>DISPLAY output with the DISPSIGN(COMPAT) option specified</th>
<th>DISPLAY output with the DISPSIGN(SEP) option specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsigned binary</td>
<td>111</td>
<td>111</td>
</tr>
<tr>
<td>Positive binary</td>
<td>111</td>
<td>+111</td>
</tr>
<tr>
<td>Negative binary</td>
<td>11J</td>
<td>-111</td>
</tr>
<tr>
<td>Unsigned packed-decimal</td>
<td>222</td>
<td>222</td>
</tr>
<tr>
<td>Positive packed-decimal</td>
<td>222</td>
<td>+222</td>
</tr>
<tr>
<td>Negative packed-decimal</td>
<td>22K</td>
<td>-222</td>
</tr>
<tr>
<td>Zoned-decimal unsigned</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>Zoned-decimal trailing positive</td>
<td>33C</td>
<td>+333</td>
</tr>
<tr>
<td>Zoned-decimal trailing negative</td>
<td>33L</td>
<td>-333</td>
</tr>
<tr>
<td>Zoned-decimal leading positive</td>
<td>C33</td>
<td>+333</td>
</tr>
<tr>
<td>Zoned-decimal leading negative</td>
<td>L33</td>
<td>-333</td>
</tr>
</tbody>
</table>

### DLL

Use DLL to instruct the compiler to generate an object module that is enabled for dynamic link library (DLL) support. DLL enablement is required if the program will be part of a DLL, will reference DLLs, or if the program contains object-oriented COBOL syntax such as INVOKE statements or class definitions.

**Note:** The DLL option can be overridden for particular CALL statements by using the CALLINTERFACE directive.

**DLL option syntax**

```
NODLL
```

Default is: NODLL

Abbreviations are: None

**Link-edit considerations:** COBOL programs that are compiled with the DLL option must be link-edited with the RENT and AMODE 31 link-edit options.

NODLL instructs the compiler to generate an object module that is not enabled for DLL usage.

**related tasks**

“Making dynamic calls” on page 448

**related references**

“Conflicting compiler options” on page 287

CALLINTERFACE (Enterprise COBOL for z/OS Language Reference)
Use DUMP to produce a system dump at compile time for an internal compiler error.

**DUMP option syntax**

```
DUMP
NODUMP
```

Default is: NODUMP

Abbreviations are: DU|NODU

**Not for general use:** The DUMP option should be used only at the request of an IBM representative.

The dump, which consists of a listing of the compiler's registers and a storage dump, is intended primarily for diagnostic personnel for determining errors in the compiler.

If you use the DUMP option, include a DD statement at compile time to define SYSABEND, SYSUDUMP, or SYSMDUMP.

With DUMP, the compiler will not issue a diagnostic message before abnormal termination processing. Instead, a user abend will be issued with an IGYppnnnn message. In general, a message IGYppnnnn corresponds to a compile-time user abend nnnn. However, both IGYpp5nnn and IGYpp1nnn messages produce a user abend of 1nnn. You can usually distinguish whether the message is really a 5nnn or a 1nnn by recompiling with the NODUMP option.

Use NODUMP if you want normal termination processing, including:

- Diagnostic messages produced so far in compilation.
- A description of the error.
- The name of the compiler phase currently executing.
- The line number of the COBOL statement being processed when the error was found. (If you compiled with OPTIMIZE(1|2), the line number might not always be correct; for some errors, it will be the last line in the program.)
- The contents of the general purpose registers.

Using the DUMP and OPTIMIZE(1|2) compiler options together could cause the compiler to produce a system dump instead of the following optimizer message:

```
"IGYOP3124-W This statement may cause a program exception at execution time."
```

This situation does not represent a compiler error. Using the NODUMP option will allow the compiler to issue message IGYOP3124-W and continue processing.

**related tasks**

*Language Environment Debugging Guide* (Understanding abend codes)

**related references**

“Conflicting compiler options” on page 287
**DYNAM**

Use DYNAM to cause nonnested, separately compiled programs invoked through the CALL literal statement to be loaded for CALL, and deleted for CANCEL, dynamically at run time.

**Note:** The DYNAM option can be overridden for particular CALL statements by using the CALLINTERFACE directive.

CALL identifier statements always result in a runtime load of the target program and are not affected by this option.

**DYNAM option syntax**

Default is: NODYNAM

Abbreviations are: DYN|NODYN

**Restriction:** The DYNAM compiler option must not be used in the following cases:

- COBOL programs that are processed by the CICS translator or the CICS compiler option
- COBOL programs that have EXEC SQL statements and are run under CICS or DB2 call attach facility (CAF)

If your COBOL program calls programs that have been linked as dynamic link libraries (DLLs), you must not use the DYNAM option. You must instead compile the program with the NODYNAM and DLL options.

**related tasks**

“Making both static and dynamic calls” on page 452

“Choosing the DYNAM or NODYNAM compiler option” on page 426

**related references**

“Conflicting compiler options” on page 287

CALLINTERFACE (*Enterprise COBOL for z/OS Language Reference*)

---

**EXIT**

Use the EXIT option to provide user-supplied modules in place of various compiler functions.

For compiler input, use the INEXIT and LIBEXIT suboptions to provide modules in place of SYSIN and SYSLIB (or copy library), respectively. For compiler output, use the PRTEXIT suboption to provide a module in place of SYSPRINT.

To provide a module that will be called for each SYSADATA record immediately after the record has been written out to the file, use the ADEXIT suboption.

To customize compiler messages (change their severity or suppress them, including converting FIPS (FLAGSTD) messages to diagnostic messages to which you assign a severity), use the MSGEXIT suboption. The module that you provide to customize the messages will be called each time the compiler issues a diagnostic message or a FIPS message.
EXIT option syntax

Default is: NOEXIT

Abbreviations are: NOEX | EX(INX | NOINX, LIBX | NOLIBX, PRTX | NOPRTX, ADX | NOADX, MSGX | NOSMGX)

You can specify the suboptions in any order, and can separate them by either commas or spaces. If you specify both the positive and negative form of a suboption, the form specified last takes effect. If you specify the same suboption more than once, the last one specified takes effect.

If you specify the EXIT option without specifying at least one suboption, NOEXIT will be in effect.

You can specify the EXIT option only at invocation in the JCL PARM field (under TSO/E, in a command argument) or at installation time. Do not specify the EXIT option in a PROCESS (CBL) statement.

INEXIT([str1,mod1])
The compiler reads source code from a user-supplied program object (where mod1 is the module name) instead of SYSIN.

LIBEXIT([str2,mod2])
The compiler obtains copybooks from a user-supplied program object (where mod2 is the module name) instead of library-name or SYSLIB. For use with either COPY or BASIS statements.

PRTEXIT([str3,mod3])
The compiler passes printer-destined output to the user-supplied program object (where mod3 is the module name) instead of SYSPRINT.

ADEXIT([str4,mod4])
The compiler passes the SYSADATA output to the user-supplied program object (where mod4 is the module name).

MSGEXIT([str5,mod5])
The compiler passes the message number, and passes the default severity of a compiler diagnostic message, or the category (as a numeric code) of a FIPS compiler message, to the user-supplied program object (where mod5 is the module name).
The names *mod1*, *mod2*, *mod3*, *mod4*, and *mod5* can refer to the same module.

The suboptions *str1*, *str2*, *str3*, *str4*, and *str5* are character strings that are passed to the program object. These strings are optional. They can be up to 64 characters in length, and you must enclose them in a pair of apostrophes ('). You can use any character in the strings, but any included apostrophes must be doubled ("'). Lowercase characters are folded to uppercase.

If one of *str1*, *str2*, *str3*, *str4*, or *str5* is specified, that string is passed to the appropriate user-exit module in the following format, where LL is a halfword (on a halfword boundary) that contains the length of the string.

```
LL string
```

“Example: MSGEXIT user exit” on page 689

Compiler exit modules that are specified on the EXIT option can be implemented either in an assembler language or in a high-level programming language such as COBOL. However, when exits are written in a Language Environment conforming programming language or Language Environment conforming assembler language, the exit must be reentrant.

The Enterprise COBOL compiler automatically manages a preinitialized Language Environment at compile time, and calls compiler exits within this environment. Therefore, the following rules apply:

- Compiler exits are run as subprograms instead of main programs.
- Compiler exits must not include logic for explicitly initializing or terminating Language Environment. In particular, exits must not use the RTEREUS runtime option, the IGZERRE callable service, or the CEEPIPI callable service for environment management.
- Compiler exits must not use the STOP RUN statement.

**related references**

“Conflicting compiler options” on page 287
“FLAGSTD” on page 309
Appendix E, “EXIT compiler option,” on page 677

**EXPORTALL**

Use EXPORTALL to instruct the compiler to automatically export the PROGRAM-ID name and each alternate entry-point name from each program definition when the object deck is link-edited to form a DLL.

```
EXPORTALL option syntax
```

```
NOEXPORTALL
```

```
EXPORTALL
```

Default is: NOEXPORTALL

Abbreviations are: EXP|NOEXP

With these symbols exported from the DLL, the exported program and entry-point names can be called from programs in the root program object, in other DLL program objects in the application, and from programs that are linked into that DLL.

Specification of the EXPORTALL option requires that the RENT linker option also be used.

NOEXPORTALL instructs the compiler to not export any symbols. In this case the programs are accessible only from other routines that are link-edited into the same program object as the COBOL program definition.
FASTSRT

Use FASTSRT to let IBM DFSORT, or an equivalent product, perform sort input and output instead of Enterprise COBOL. It applies only to sorting files by using the format 1 SORT (that is, file SORT) statement.

FASTSRT option syntax

```
NOFASTSRT
FASTSRT
```

Default is: NOFASTSRT

Abbreviations are: FSRT|NOFSRT

related tasks

“Improving sort performance with FASTSRT” on page 216

FLAG

Use FLAG(\(x\)) to produce diagnostic messages at the end of the source listing for errors of a severity level \(x\) or above.

FLAG option syntax

```
FLAG( \(x\), \(y\) )
```

NOFLAG

Default is: FLAG(I,I)

Abbreviations are: F|NOF

\(x\) and \(y\) can be either I, W, E, S, or U.

Use FLAG(\(x, y\)) to produce diagnostic messages for errors of severity level \(x\) or above at the end of the source listing, with error messages of severity \(y\) and above to be embedded directly in the source listing. The severity coded for \(y\) must not be lower than the severity coded for \(x\). To use FLAG(\(x, y\)), you must also specify the SOURCE compiler option.

Error messages in the source listing are set off by the embedding of the statement number in an arrow that points to the message code. The message code is followed by the message text. For example:

```
006413 MOVE CORR WS-DATE TO HEADER-DATE
==006413==> IGYPS2121-S "WS-DATE" was not defined as a data-name. . . .
```

When FLAG(\(x, y\)) is in effect, messages of severity \(y\) and above are embedded in the listing after the line that caused the message. (See the related reference below for information about messages for exceptions.)
Use NOFLAG to suppress error flagging. NOFLAG does not suppress error messages for compiler options.

Embedded messages

• Embedding level-U messages is not recommended. The specification of embedded level-U messages is accepted, but does not produce any messages in the source.
• The FLAG option does not affect diagnostic messages that are produced before the compiler options are processed.
• Diagnostic messages that are produced during processing of compiler options, CBL or PROCESS statements, or BASIS, COPY, or REPLACE statements are not embedded in the source listing. All such messages appear at the beginning of the compiler output.
• Messages that are produced during processing of the *CONTROL or *CBL statement are not embedded in the source listing.

related references
“Messages and listings for compiler-detected errors” on page 262

FLAGSTD

Use FLAGSTD to specify the level or subset of the 85 COBOL Standard to be regarded as conforming, and to get informational messages about the 85 COBOL Standard elements that are included in your program.

You can specify any of the following items for flagging:

• A selected Federal Information Processing Standard (FIPS) COBOL subset
• Any of the optional modules
• Obsolete language elements
• Any combination of subset and optional modules
• Any combination of subset and obsolete elements
• IBM extensions (these are flagged any time that FLAGSTD is specified, and identified as "nonconforming nonstandard")

FLAGSTD option syntax

\begin{center}
\begin{tikzpicture}
\node at (0,0) {\begin{tabular}{c}
\textbf{FLAGSTD} \\
\end{tabular}};
\node at (1,-0.5) {\begin{tabular}{c}
\textbf{x} \\
\end{tabular}};
\node at (1,-1) {\begin{tabular}{c}
\textbf{yy} \\
\end{tabular}};
\node at (1,-1.5) {\begin{tabular}{c}
\textbf{,O} \\
\end{tabular}};
\end{tikzpicture}
\end{center}

Default is: NOFLAGSTD

Abbreviations are: None

x specifies the subset of the 85 COBOL Standard to be regarded as conforming:

\textbf{M}

Language elements that are not from the minimum subset are to be flagged as "nonconforming standard."

\textbf{I}

Language elements that are not from the minimum or the intermediate subset are to be flagged as "nonconforming standard."

\textbf{H}

The high subset is being used and elements will not be flagged by subset. Elements that are IBM extensions will be flagged as "nonconforming Standard, IBM extension."
yy specifies, by a single character or combination of any two, the optional modules to be included in the subset:

D
Elements from debug module level 1 are not flagged as "nonconforming standard."

N
Elements from segmentation module level 1 are not flagged as "nonconforming standard."

S
Elements from segmentation module level 2 are not flagged as "nonconforming standard."

If S is specified, N is included (N is a subset of S).

0 (the letter) specifies that obsolete language elements are flagged as "obsolete."

The informational messages appear in the source program listing, and identify:

- The element as "obsolete," "nonconforming standard," or "nonconforming nonstandard" (a language element that is both obsolete and nonconforming is flagged as obsolete only)
- The clause, statement, or header that contains the element
- The source program line and beginning location of the clause, statement, or header that contains the element
- The subset or optional module to which the element belongs

FLAGSTD requires the standard set of reserved words.

In the following example, the line number and column where a flagged clause, statement, or header occurred are shown with the associated message code and text. After that is a summary of the total number of flagged items and their type.

<table>
<thead>
<tr>
<th>LINE.COL</th>
<th>CODE</th>
<th>FIPS MESSAGE TEXT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IGYDS8211</td>
<td>Comment lines before &quot;IDENTIFICATION DIVISION&quot;: nonconforming nonstandard, IBM extension to ANS/ISO 1985.</td>
</tr>
</tbody>
</table>

FIPS MESSAGES TOTAL          STANDARD | NONSTANDARD | OBSOLETE
3                                   1          1          1

You can convert FIPS informational messages into diagnostic messages, and can suppress FIPS messages, by using the MSGEXIT suboption of the EXIT compiler option. For details, see the related reference about the processing of MSGEXIT, and see the related task.

related tasks
“Customizing compiler-message severities” on page 687

related references
“Conflicting compiler options” on page 287
“Processing of MSGEXIT” on page 685
HGPR

The HGPR option controls the compiler usage of the 64-bit registers provided by z/Architecture processors.

**HGPR option syntax**

```plaintext
HGPR( PRESERVE  NOPRESERVE )
```

Default is: HGPR(PRESERVE)

Abbreviations are: None

The Enterprise COBOL compiler uses the 64-bit width of the z/Architecture General Purpose Registers (GPRs). HGPR stands for "High-halves of 64-bit GPRs", which means the use of native 64-bit instructions.

**HGPR(PRESERVE)**

If you specify HGPR(PRESERVE), the compiler preserves the high halves of the 64-bit GPRs that a program is using, by saving them in the prolog for the function and restoring them in the epilog. The PRESERVE suboption is necessary only if the caller of the program is not Enterprise COBOL, Enterprise PL/I, or z/OS XL C/C++ compiler-generated code.

**HGPR(NOPRESERVE)**

If you specify HGPR(NOPRESERVE), the compiler omits preserving the high-halves of the 64-bit GPRs that a program is using, which improves performance.

INITCHECK

Use the INITCHECK option to have the compiler check for uninitialized data items and issue warning messages when they are used without being initialized.

**INITCHECK option syntax**

```plaintext
INITCHECK( LAX  STRICT )
```

Default is: NOINITCHECK

Suboption default is: INITCHECK(LAX) if INITCHECK is specified with no suboption

Abbreviations are: IC  |  NOIC

**NOINITCHECK**

If NOINITCHECK is in effect, the compiler will not issue any warning messages for uninitialized data items.

**INITCHECK(LAX  |  STRICT)**

If INITCHECK or INITCHECK(LAX) is in effect, the compiler will check for uninitialized data items and issue a warning message when a data item is used without being initialized. However, if a data item is initialized on at least one logical path to a statement, no warning message will be issued.
If INITCHECK(STRICT) is in effect, the compiler will still check for uninitialized data items and issue a warning message when a data item is used without being initialized. However, unlike INITCHECK(LAX), INITCHECK(STRICT) will issue a warning message about uninitialized data for a data item used in a statement unless the data item is initialized on all logical paths to the statement.

Here is a sample program to illustrate the behavior differences between specifying INITCHECK(LAX) versus INITCHECK(STRICT). Y and Z represent some data items, with no value clauses:

```
PROCEDURE DIVISION.
IF Y > 5
  MOVE 2 TO Z
END-IF
DISPLAY Z
```

Z is initialized on one path to the DISPLAY statement but not the other, so if INITCHECK(LAX) is in effect, a warning message will be issued for Y only, while INITCHECK(STRICT) will also issue a warning message for Z.

**Restrictions:**

- The INITCHECK option analyzes data items in the WORKING-STORAGE SECTION and LOCAL-STORAGE SECTION only. In particular, it does not analyze data items in the LINKAGE SECTION or FILE SECTION.
- The INITCHECK analysis does not track external or global data items.
- The INITCHECK analysis does not track individual elements in tables independently. Instead, if one element of a table is initialized, all corresponding elements of the table are considered to be initialized. This applies to both fixed-length and variable-length tables.
- The INITCHECK analysis does not track the initialization of items if it happens through a pointer. For example, if a pointer to an uninitialized data item is created by using ADDRESS-OF, and that data item is initialized through that pointer, the INITCHECK analysis might also issue a warning message.
- For uninitialized data items being passed BY REFERENCE, no warning messages will be issued. However, the INITCHECK analysis will warn about uninitialized data items being passed BY CONTENT and BY VALUE.
- The INITCHECK option does not track individual bytes of reference-modified data items accurately. Instead, if a data item is accessed by using a reference modification, this data item is considered to be initialized.

**Notes:**

- All of the INITCHECK analyses occur at compile time only.
- The INITCHECK option has no effect on the behavior or performance of the program after it has been compiled.
- Use of the INITCHECK option might increase compile time and memory consumption.

**INLINE**

The INLINE compiler option controls whether the inlining of procedures (paragraphs or sections) referenced by PERFORM statements in the source program is allowed.

**INLINE option syntax**

```
INLINE  NOINLINE
```

Default is: INLINE

Abbreviations are: INL | NOINL
**INLINE**

Specifying INLINE causes the compiler to allow the inlining of procedures referenced by PERFORM statements in the source program when OPTIMIZE (1) or OPTIMIZE (2) is in effect. Whether to inline procedures in a specific PERFORM block or not is determined by the compiler and it can be overridden by using the >>INLINE OFF directive.

**NOINLINE**

Specifying NOINLINE causes no inlining of procedures referenced by PERFORM statements, no matter which optimization level setting is in effect. It cannot be overridden by using the >>INLINE ON directive.

**Note:**

1. The word inlining here implies that the compiler might choose to replace the PERFORM of a procedure (paragraph or section) with a copy of that procedure's code. By inserting the procedure code at the location of the PERFORM, the compiler saves the overhead of branching logic to and from the procedure.

**related references**

INLINE directive (*Enterprise COBOL for z/OS Language Reference*)

---

**INTDATE**

INTDATE(ANSI) instructs the compiler to use the 85 COBOL Standard starting date for integer dates used with date intrinsic functions. Day 1 is Jan 1, 1601. INTDATE(LILIAN) instructs the compiler to use the Language Environment Lilian starting date for integer dates used with date intrinsic functions. Day 1 is Oct 15, 1582.

**INTDATE option syntax**

```
```

Default is: INTDATE(ANSI)

Abbreviations are: None

With INTDATE(LILIAN), the date intrinsic functions return results that are compatible with the Language Environment date callable services.

**Usage note:** When INTDATE(LILIAN) is in effect, CEECBLDY is not usable because you have no way to turn an ANSI integer into a meaningful date by using either intrinsic functions or callable services. If you code a CALL literal statement with CEECBLDY as the target of the call when INTDATE(LILIAN) in effect, the compiler diagnoses this and converts the call target to CEEDAYS.

**related tasks**

“Using date callable services” on page 57

---

**LANGUAGE**

Use the LANGUAGE option to select the language in which compiler output will be printed. The information that will be printed in the selected language includes diagnostic messages, source listing page and scale headers, FIPS message headers, message summary headers, compilation summary, and headers and notations that result from the selection of certain compiler options (MAP, XREF, VBREF, and FLAGSTD).
LANGUAGEN option syntax

```
LANGUAGE( name )
```

Default is: LANGUAGE(ENGLISH)

Abbreviations are: LANG(EN|UE|JA|JP)

`name` specifies the language for compiler output messages. Possible values for the LANGUAGE option are shown in the table below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Abbreviation1</th>
<th>Output language</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGLISH</td>
<td>EN</td>
<td>Mixed-case English (the default)</td>
</tr>
<tr>
<td>JAPANESE3</td>
<td>JA, JP</td>
<td>Japanese, using the Japanese character set</td>
</tr>
<tr>
<td>UENGLISH2, 3</td>
<td>UE</td>
<td>Uppercase English</td>
</tr>
</tbody>
</table>

1. If your installation's system programmer has provided a language other than those described, you must specify at least the first two characters of this other language's name.
2. To specify a language other than UENGLISH, the appropriate language feature must be installed.
3. To change to uppercase English or Japanese compiler messages, in addition to using the LANGUAGE compiler option, you must also set the Language Environment runtime option NATLANG at compile time. We recommend using CEEOPTS DD in the compile JCL.

For example, to change messages to Japanese, use the LANGUAGE(JA) compiler option and also specify the NATLANG LE runtime option at compile time:

```
//CEEOPTS DD *
NATLANG(JPN)
/*
```

If the LANGUAGE option is changed at compile time (using CBL or PROCESS statements), some initial text will be printed using the language that was in effect at the time the compiler was started.

**NATLANG:** The NATLANG runtime option allows you to control the national language to be used for the runtime environment, including error messages, month names, and day-of-the-week names. The LANGUAGE compiler option and the NATLANG runtime option act independently of each other. You can use them together with neither taking precedence over the other.

**LINECOUNT**

Use LINECOUNT(nnn) to specify the number of lines to be printed on each page of the compilation listing, or use LINECOUNT(0) to suppress pagination.

**LINECOUNT option syntax**

```
LINECOUNT( nnn )
```

Default is: LINECOUNT(60)

Abbreviations are: LC

`nnn` must be an integer between 10 and 255, or 0.

If you specify LINECOUNT(0), no page ejects are generated in the compilation listing.
The compiler uses three lines of nnn for titles. For example, if you specify LINECOUNT(60), 57 lines of source code are printed on each page of the output listing.

**LIST**

Use the LIST compiler option to produce a listing of the assembler-language expansion of your source code.

<table>
<thead>
<tr>
<th>LIST option syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOLIST</td>
</tr>
<tr>
<td>LIST</td>
</tr>
</tbody>
</table>

Default is: NOLIST

Abbreviations are: None

These items will also be written to the output listing:

- Constant area
- Program prolog areas (PPA1, PPA2, PPA3, PPA4)
- Time stamp, compiler version, and build level information
- Compiler options and program information
- Base locator table
- External symbols dictionary
- Static maps
- Automatic maps

The output is generated if:

- You specify the COMPILEx option, or the NOCOMPILEx option is in effect and an error of level x or higher does not occur.
- You do not specify the OFFSET option.

If you want to limit the assembler listing output, use *CONTROL (or *CBL) LIST or NOLIST statements in the PROCEDURE DIVISION. Source statements that follow a *CONTROL NOLIST statement are not included in the listing until a subsequent *CONTROL LIST statement switches the output back to normal LIST format.

**related tasks**

“Getting listings” on page 370

**related references**

“Conflicting compiler options” on page 287

*CONTROL (*CBL) statement (Enterprise COBOL for z/OS Language Reference)
Use the MAP option to create a listing of the DATA DIVISION items and all implicitly declared items. You can also specify whether hexadecimal or decimal offsets are shown for MAP output in the listing.

**MAP option syntax**

```
NOMAP
MAP
HEX(DEC)
```

Default is: NOMAP

Suboption default is: MAP(HEX) if MAP is specified with no suboption

Abbreviations are: None

**HEX**

If you specify MAP(HEX), data item offsets within groups will be in hexadecimal notation.

**DEC**

If you specify MAP(DEC), data item offsets within groups will be in decimal notation.

The output includes the following items:

- DATA DIVISION map
- Nested program structure map, and program attributes
- Size of the program's WORKING-STORAGE and LOCAL-STORAGE and its location in the object code if the program is compiled with the NORENT option

If you want to limit the MAP output, use *CONTROL NOMAP or NOMAP statements in the DATA DIVISION. Source statements that follow *CONTROL NOMAP are not included in the listing until a *CONTROL MAP statement switches the output back to normal MAP format. For example:

```
*CONTROL NOMAP
  01 A
  02 B
*CONTROL MAP
*CBL MAP
```

When the MAP(HEX|DEC) option is in effect, you also get an embedded MAP report in the source code listing. The condensed MAP information is shown to the right of data-name definitions in the WORKING-STORAGE SECTION, FILE SECTION, LOCAL-STORAGE SECTION, and LINKAGE SECTION of the DATA DIVISION. When both XREF data and an embedded MAP summary are on the same line, the embedded MAP summary is listed first.

“Example: MAP output” on page 375

**related concepts**

Chapter 19, “Debugging,” on page 361

**related tasks**

“Getting listings” on page 370

**related references**

*CONTROL (*CBL) statement (Enterprise COBOL for z/OS Language Reference)
Use the MAXPCF option to specify a maximum program complexity factor value. The program complexity factor (PCF) is computed by the compiler and the computed value is in the listing file. If the PCF of your program exceeds the maximum value, the compiler will automatically reduce the optimization level to speed up the compilation and use less storage. Therefore, when you compile a suite of programs, you do not have to specify an OPTIMIZE option value for each program.

**MAXPCF option syntax**

```
MAXPCF( n )
```

Default is: MAXPCF(60000)

Abbreviations are: None

$n$ must be an integer of 0 - 999999.

The aspects of the program taken into consideration when computing the complexity factor include:

- The number of COBOL statements in the PROCEDURE DIVISION, including generated statements from the CICS, SQL or SQLIMS options, and the expansion of COPY and REPLACE statements
- Initialization operations for WORKING-STORAGE or LOCAL-STORAGE data items with value clauses
- Operations for variable-length groups or subgroups in the DATA DIVISION, which compute their size at run time

**Note:** PCF is not a metric to measure how complex a program is. It is merely a count of COBOL items that can cause problems for optimization when there are a lot of them. To measure program complexity, you should use something like the Metrics feature provided by IBM Developer for z/OS.

For large and complex programs, you can use the MAXPCF option to set a threshold on the program complexity that the compiler attempts optimize. Lower the MAXPCF value to reduce the optimization level, hence the compiler needs less memory and compilation time. Raise the MAXPCF value to attempt to optimize the programs at the cost of longer compilation time.

If you specify MAXPCF(0), no limit is enforced on the complexity of the program, and the MAXPCF option has no effect.

If you specify MAXPCF(n) and $n$ is not zero, when the program complexity factor exceeds $n$, any specification of OPTIMIZE(1) or OPTIMIZE(2) is reset to OPTIMIZE(0), and a warning message is generated.

If the COBOL source file contains a sequence of source programs (a batch compile), the MAXPCF limit is applied on a per program basis.

**Notes:**

- If the OPTIMIZE(1) or OPTIMIZE(2) option is set at installation time as a fixed, nonoverridable option, then MAXPCF($n$) with a nonzero $n$ is an option conflict. In this case, the OPTIMIZE option takes precedence and the MAXPCF(0) option is forced on.
- If you attempt to optimize a program larger than the default threshold by raising the value of MAXPCF to $n$ where $n$ is greater than the default, or by specifying MAXPCF(0), the compiler might take excessive time to compile or fail to compile because of insufficient memory.

**related references**

“OPTIMIZE” on page 325
The MDECK compiler option specifies that a copy of the updated input source after library processing (that is, the result of COPY, BASIS, REPLACE, EXEC SQL INCLUDE, and EXEC SQLIMS INCLUDE statements) is written to a file.

If Enterprise COBOL is running under z/OS UNIX, the MDECK output is written in the current directory to a file that has the same name as the COBOL source file and a suffix of .dek. For Enterprise COBOL running under TSO or batch, the MDECK output is written to the data set defined by the SYSMDECK DD allocation, which must specify an MVS data set that has RECFM F or FB and an LRECL of 80 bytes.

**Note:** When compiling under z/OS TSO or batch, the COBOL compiler requires the SYSMDECK data set allocation for all compilations, no matter if you specify the MDECK or NOMDECK option:

- If you specify the MDECK option, the SYSMDECK DD allocation must specify a permanent data set.
- If you specify the NOMDECK option, the SYSMDECK DD allocation can specify either a temporary utility data set or a permanent data set.

### MDECK option syntax

![MDECK option syntax diagram](image)

Default is: NOMDECK

Abbreviations are: NOMD | MD | MD(C | NOC)

**Option specification:**

You cannot specify the MDECK option in a PROCESS (or CBL) statement. You can specify it only in one of the following ways:

- In the PARM parameter of JCL
- As a cob2 command option
- As an installation default
- In the COBOPT environment variable

**Suboptions:**

- When MDECK(COMPILE) is in effect, compilation continues normally after library processing and generation of the MDECK output file have completed, subject to the settings of the COMPILE| NOCOMPILE, DECK|NODECK, and OBJECT|NOOBJECT compiler options.
- When MDECK(NOCOMPILE) is in effect, compilation is terminated after library processing has completed and the expanded source program file has been written. The compiler does no further syntax checking or code generation regardless of the settings of the COMPILE, DECK, and OBJECT compiler options.

If you specify MDECK with no suboption, MDECK(COMPILE) is implied.

**Contents of the MDECK output file:**

If you use the MDECK option with programs that contain EXEC CICS, EXEC SQL, or EXEC SQLIMS statements, these EXEC statements are included in the MDECK output as is. However, if you compile using the SQL or SQLIMS option, the corresponding EXEC SQL INCLUDE or EXEC SQLIMS INCLUDE statements are expanded in the MDECK output.
CBL, PROCESS, *CONTROL, and *CBL card images are passed to the MDECK output file in the proper locations.

For a batch compilation (multiple COBOL source programs in a single input file), a single MDECK output file that contains the complete expanded source is created.

Any SEQUENCE compiler-option processing is reflected in the MDECK file.

COPY statements are included in the MDECK file as comments.

related tasks
“Starting the compiler from an assembler program” on page 246
“Defining the library-processing output file (SYSMDECK)” on page 254

related references
“Conflicting compiler options” on page 287
Chapter 18, “Compiler-directing statements,” on page 357

NAME

Use NAME to generate a link-edit NAME card for each object module. You can also use NAME to generate names for each program object when you are doing batch compilations.

When NAME is specified, a NAME card is appended to each object module that is created. Program object names are formed using the rules for forming module names from PROGRAM-ID statements.

NAME option syntax

```
NAME option syntax

NONAME
NAME
(NOALIAS ALIAS)
```

Default is: NONAME, or NAME(NOALIAS) if only NAME is specified

Abbreviations are: None

If you specify NAME(ALIAS), and your program contains ENTRY statements, a link-edit ALIAS card is generated for each ENTRY statement.

related references
PROGRAM-ID paragraph (Enterprise COBOL for z/OS Language Reference)

NSYMBOL

The NSYMBOL option controls the interpretation of the N symbol used in literals and PICTURE clauses, indicating whether national or DBCS processing is assumed.

NSYMBOL option syntax

```
NSYMBOL option syntax

NSYMBOL( NATIONAL DBCS )
```

Default is: NSYMBOL(NATIONAL)

Abbreviations are: NS(NAT | DBCS)
With NSYMBOL (NATIONAL):

- Data items defined with a PICTURE clause that consists only of the symbol N without the USAGE clause are treated as if the USAGE NATIONAL clause is specified.
- Literals of the form N"..." or N'...' are treated as national literals.

With NSYMBOL (DBCS):

- Data items defined with a PICTURE clause that consists only of the symbol N without the USAGE clause are treated as if the USAGE DISPLAY-1 clause is specified.
- Literals of the form N"..." or N'...' are treated as DBCS literals.

The NSYMBOL (DBCS) option provides compatibility with previous releases of IBM COBOL, and the NSYMBOL (NATIONAL) option makes the handling of the above language elements consistent with the 2002 COBOL Standard in this regard.

NSYMBOL (NATIONAL) is recommended for applications that use Unicode data or object-oriented syntax for Java interoperability.

related references
“Conflicting compiler options” on page 287

---

**NUMBER**

Use the NUMBER compiler option if you have line numbers in your source code and want those numbers to be used in error messages and SOURCE, MAP, LIST, and XREF listings.

**NUMBER option syntax**

```
NUMBER
  NONUMBER
```

Default is: NONUMBER

Abbreviations are: NUM|NONUM

If you request NUMBER, the compiler checks columns 1 through 6 to make sure that they contain only numbers and that the numbers are in numeric collating sequence. (In contrast, SEQUENCE checks the characters in these columns according to EBCDIC collating sequence.) When a line number is found to be out of sequence, the compiler assigns to it a line number with a value one higher than the line number of the preceding statement. The compiler flags the new value with two asterisks and includes in the listing a message indicating an out-of-sequence error. Sequence-checking continues with the next statement, based on the newly assigned value of the previous line.

If you use COPY statements and NUMBER is in effect, be sure that your source program line numbers and the copybook line numbers are coordinated.

If you are doing a batch compilation and NUMBER is in effect, all programs in the batch compile will be treated as a single input file. The sequence numbers of the entire input file must be in ascending order.

Use NONUMBER if you do not have line numbers in your source code, or if you want the compiler to ignore the line numbers you do have in your source code. With NONUMBER in effect, the compiler generates line numbers for your source statements and uses those numbers as references in listings.

---

**NUMCHECK**

The NUMCHECK compiler option tells the compiler whether to generate extra code to validate data items when they are used as sending data items. For zoned decimal (numeric USAGE DISPLAY) and packed
decimal (COMP-3) data items, the compiler generates implicit numeric class tests for each sending field. For binary data items, the compiler generates SIZE ERROR checking to see whether the data item has more digits than its PICTURE clause allows.

**NUMCHECK option syntax**

![Diagram of NUMCHECK option syntax]

Default is: NONUMCHECK

Suboption defaults are:

- If no suboption is specified, defaults are ZON(ALPHNUM), PAC, BIN and MSG. For example, NUMCHECK has the same effect as NUMCHECK(ZON(ALPHNUM), PAC, BIN, MSG).
- If no datatype suboption is specified, default datatype suboptions are ZON(ALPHNUM), PAC, and BIN. For example, NUMCHECK(ABD) has the same effect as NUMCHECK(ZON(ALPHNUM), PAC, BIN, ABD).
- If only one datatype suboption is specified, defaults are NOZON, NOPAC, NOBIN, and MSG. For example, NUMCHECK(BIN) has the same effect as NUMCHECK(NOZON, NOPAC, BIN, MSG).
- If all datatype suboptions are specified with NO, then the listing will show NONUMCHECK. For example, NUMCHECK(NOZON, NOPAC, NOBIN) has the same effect as NONUMCHECK.

Abbreviations are: NONC | NC

**ZON [(ALPHNUM | NOALPHNUM)] | NOZON**

Specifying ZON or ZON(ALPHNUM) causes the compiler to generate code for an implicit numeric class test for zoned decimal (numeric USAGE DISPLAY) data items that are used as sending data items in COBOL statements.

Specifying ZON(NOALPHNUM) causes the compiler to generate code for an implicit numeric class test for zoned decimal (numeric USAGE DISPLAY) data items that are used as sending data items in COBOL statements, except when they are used in a comparison with an alphanumeric data item, alphanumeric literal or alphanumeric figurative constant.

Receivers are not checked, unless they are both a sender and a receiver, such as data item B in the following sample statements:

```
ADD A TO B

DIVIDE A INTO B
```
**COMPUTE B = A + B**

**INITIALIZE B REPLACING ALPHANUMERIC BY B**

This checking is done before the data is used in each statement:

- If the data is **NOT NUMERIC**, either a warning message for `NUMCHECK(ZON, MSG)` or a terminating message for `NUMCHECK(ZON, ABD)` is issued.
- If the data is **NUMERIC**, the external behavior of the statement is the same as `NUMCHECK(NOZON)`, other than being slower.

**PAC | NOPAC**

Specifying PAC causes the compiler to generate code for an implicit numeric class test for packed decimal (COMP-3) data items that are used as sending data items in COBOL statements. For packed decimal data items that have an even number of digits, the unused bits are checked for ones.

**Restriction:** For CALL statements, `NUMCHECK(ZON)` and `NUMCHECK(PAC)` check BY CONTENT data items that are zoned decimal or packed decimal, but they do not check BY REFERENCE parameters. (Neither zoned decimal nor packed decimal data items can be specified in a BY VALUE phrase.)

**BIN | NOBIN**

Specifying BIN causes the compiler to generate code similar to ON SIZE ERROR to test if binary data items contents are bigger than the PICTURE clause. This extra code will be generated only for binary data items that are used as sending data items, and COMP-5 data items will not get this ON SIZE ERROR code generated.

**MSG | ABD**

Determines whether the message issued for invalid data is a warning level message to continue processing or a terminating level message to cause an abend:

- If MSG is in effect, a runtime warning message with the line number, data item name, data item content, and program name is issued.
- If ABD is in effect, a terminating message is issued that causes an abend.

**Performance considerations:** `NUMCHECK` is much slower than `NONUMCHECK`, depending on how many zoned decimal (numeric USAGE DISPLAY) data items, packed decimal (COMP-3) data items, and binary data items are used in a COBOL program.

**Note:** In Enterprise COBOL V6.1 with PTF for APAR PI71625 installed, `ZONECHECK` is deprecated but is tolerated for compatibility, and it is replaced by `NUMCHECK(ZON(ALPHNUM))`.

**related tasks**

“Checking for incompatible data (numeric class test)” on page 52

**related references**

“NUMPROC” on page 322
“TRUNC” on page 345
“ZONECHECK” on page 351
“ZONEDATA” on page 353

### NUMPROC

Use NUMPROC (NOPFD) if your internal decimal and zoned decimal data might use nonpreferred signs.
Default is: NUMPROC (NOPFD)

Abbreviations are: None

The compiler accepts any valid sign configuration: X'A', X'B', X'C', X'D', X'E', or X'F'. NUMPROC (NOPFD) is the recommended option in most cases.

**Performance considerations:** NUMPROC (PFD) improves the performance of processing internal decimal and zoned decimal data. Use this option however only if your numeric data agrees exactly with the following IBM system standards:

- **Zoned decimal, unsigned:** High-order 4 bits of the sign byte contain X'F'.
- **Zoned decimal, signed overpunch:** High-order 4 bits of the sign byte contain X'C' if a number is positive or 0, and X'D' if it is not.
- **Zoned decimal, separate sign:** Separate sign contains the character '+' if a number is positive or 0, and '-' if it is not.
- **Internal decimal, unsigned:** Low-order 4 bits of the low-order byte contain X'F'.
- **Internal decimal, signed:** Low-order 4 bits of the low-order byte contain X'C' if a number is positive or 0, and X'D' if it is not.

Data produced by COBOL arithmetic statements conforms to the IBM system standards described above. However, using REDEFINES and group moves could change data so that it no longer conforms. If you use NUMPROC (PFD), use the INITIALIZE statement to initialize data fields, rather than using group moves.

Using NUMPROC (PFD) can affect class tests for numeric data. Use NUMPROC (NOPFD) if a COBOL program calls programs written in PL/I or FORTRAN.

Sign representation is affected not only by the NUMPROC option, but also by the NUMCLS installation option.

**related tasks**
“Checking for incompatible data (numeric class test)” on page 52

**related references**
“Sign representation of zoned and packed-decimal data” on page 51

---

**OBJECT**

Use OBJECT to write the generated object code to a file to be used as input for the binder.

**OBJECT option syntax**

```
OBJECT
NOOBJECT
```

Default is: OBJECT

Abbreviations are: OBJ|NOOBJ

If you specify OBJECT, include a SYSLIN DD statement in your JCL for compilation.

The only difference between DECK and OBJECT is in the routing of output to the data sets:

- **DECK** output goes to the data set associated with ddname SYSPUNCH.
- **OBJECT** output goes to the data set associated with ddname SYSLIN.

Use the option that your installation guidelines recommend.

**related references**
“Conflicting compiler options” on page 287
OFFSET

Use OFFSET to produce a condensed PROCEDURE DIVISION listing.

OFFSET option syntax

```
NOOFFSET
OFFSET
```

Default is: NOOFFSET

Abbreviations are: OFF|NOOFF

With OFFSET, the condensed PROCEDURE DIVISION listing will contain line numbers, statement references, and the location of the first instruction generated for each statement.

These items will also be written to the output listing:

- Constant area
- Program prolog areas (PPA1, PPA2, PPA3, PPA4)
- Time stamp and compiler version information
- Compiler options and program information
- Base locator table
- External symbols dictionary
- Static maps
- Automatic maps

Notes:

- The optimizer might inline paragraphs, move code around or indeed place it after the body of the program if little used, such as the error message formatting code. This might make the OFFSET report less useful than it was with previous compilers. You can refer to the LIST output instead (note that OFFSET and LIST are mutually exclusive options). For details, see “Reading LIST output” on page 381.
- Due to the out of line code used for error message formatting, Language Environment generated offsets, as indicated in "From compile unit {name} at entry point {name} at compile unit offset {offset}...", might be outside the offset range of the program. In these cases, refer to the statement number in the COBOL message (IGZnnnns) to locate the problem.

related references

“Conflicting compiler options” on page 287
“Example: OFFSET compiler output” on page 402

OPTFILE

Use OPTFILE to enable the specifying of COBOL compiler options in a data set. Using a compiler-option data set circumvents the 100-character limit on options specified in a JCL PARM string.

OPTFILE option syntax

```
OPTFILE
```

Default is: None

Abbreviations are: None
You can specify OPTFILE as a compiler invocation option or in the PROCESS or CBL statement in your COBOL source program. OPTFILE cannot be specified as an installation default.

OPTFILE is ignored if you compile using the cob2 command in the z/OS UNIX environment. (In that environment, the COBOPT environment variable provides a capability that is comparable to OPTFILE.)

If OPTFILE is in effect, compiler options are read from the data set that you identify in a SYSOPTF DD statement. A SYSOPTF data set must have RECFM F or FB and an LRECL of 80 bytes. For further details about the format of a SYSOPTF data set, see the related task below about defining a compiler-option data set.

The precedence of options in the SYSOPTF data set is determined by where you specify the OPTFILE option. For example, if you specify OPTFILE in the invocation PARM string, an option specified later in the PARM string supersedes any option specified in the SYSOPTF data set that conflicts with it.

(Conceptually, OPTFILE in an options specification is replaced with the options that are in the SYSOPTF data set; then the usual rules about precedence of compiler options and conflicting compiler options apply.)

If you start the COBOL compiler from within an assembler program, you can use the alternate ddname list to specify a ddname to be used instead of SYSOPTF to identify the compiler-option data set.

**related tasks**
- “Starting the compiler from an assembler program” on page 246
- “Defining a compiler-option data set (SYSOPTF)” on page 251
- “Specifying compiler options under z/OS” on page 254
- Chapter 15, “Compiling under z/OS UNIX,” on page 265

**related references**
- “Conflicting compiler options” on page 287

### OPTIMIZE

Use OPTIMIZE to reduce the run time of your object program. Optimization might also reduce the amount of storage your object program uses.

**OPTIMIZE option syntax**

```
OPTIMIZE (0 1 2)
```

Default is: OPTIMIZE(0)

Abbreviations are: OPT(0), OPT(1), or OPT(2)

Optimizations are performed under the assumption that the program and data are valid, given the compiler options. For example, external decimal data that has USAGE DISPLAY must be valid unless ZONEDATA(MIG|NOPFD) is used to allow invalid zone bits. Digits and sign codes must be valid no matter what options are used. If the program or data is invalid, programs might behave differently at different levels of optimization or between different versions of Enterprise COBOL.

- **OPTIMIZE(0)** specifies limited optimizations, which result in the shortest compilation time. When the TEST option is specified, full debug capabilities are available.
- **OPTIMIZE(1)** specifies optimizations that improve application runtime performance. Optimizations at this level include basic inlining, strength reduction, simplification of complex operations into equivalent simpler operations, removal of some unreachable code and block rearrangement. Also, OPTIMIZE(1) includes some intrablock optimizations such as common subexpression elimination and value propagation. When the TEST option is specified, most debug capabilities are available.
• OPTIMIZE(2) specifies further optimizations, which include more aggressive simplifications and instruction scheduling. Also, some interblock optimizations such as global value propagation and loop invariant code motion are included. When the TEST option is specified, some debug capabilities are available.

When OPTIMIZE(1) or OPTIMIZE(2) is used without the TEST compiler option, care must be taken with user-written condition handlers registered via the Language Environment service CEEHDLR. In particular, if a condition handler accesses data items that are not defined local to the condition handler program themselves (for example, data items defined in the application as EXTERNAL), such data items must be defined with the VOLATILE clause to ensure that the handler uses the latest value of the data item, or the condition handler program can be compiled with the TEST compiler option. The use of the VOLATILE clause is preferred over the use of the TEST option because the use of the TEST option can reduce optimization for the entire program, while VOLATILE localizes the reduced optimization.

For more information about the VOLATILE clause, see VOLATILE clause in the Enterprise COBOL for z/OS Language Reference.

When OPTIMIZE(1) or OPTIMIZE(2) is in effect, specifying INLINE causes the compiler to consider inlining procedures for PERFORM statements. For details, see “INLINE” on page 312.

Note: Since Enterprise COBOL V5, the NOOPTIMIZE, OPTIMIZE, OPTIMIZE(STD), and OPTIMIZE(FULL) options are removed but are tolerated for compatibility. If one of those options is specified, it is mapped to the new option or options as follows:

<table>
<thead>
<tr>
<th>Removed options</th>
<th>New options</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOOPTIMIZE</td>
<td>OPTIMIZE(0)</td>
</tr>
<tr>
<td>OPTIMIZE</td>
<td>OPTIMIZE(1)</td>
</tr>
<tr>
<td>OPTIMIZE(STD)</td>
<td>OPTIMIZE(1)</td>
</tr>
<tr>
<td>OPTIMIZE(FULL)</td>
<td>OPTIMIZE(1) and STGOPT</td>
</tr>
</tbody>
</table>

For more information about the VOLATILE clause, see VOLATILE clause in the Enterprise COBOL for z/OS Language Reference.

OUTDD

Use OUTDD to specify that you want DISPLAY output that is directed to the system logical output device to go to a specific ddname.

You can specify a file in the z/OS UNIX file system with the ddname named in OUTDD. To understand where output is directed when this ddname is not allocated, see the related task about displaying data.

<table>
<thead>
<tr>
<th>OUTDD option syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTDD( ddname )</td>
</tr>
</tbody>
</table>

OUTDD option syntax

OUTDD( ddname )
Default is: OUTDD (SYSOUT)
Abbreviations are: OUT

If the OUTDD compiler option and the Language Environment MSGFILE runtime option specify the same
ddname (both default to SYSOUT), DISPLAY output to the system logical output device is written using
Language Environment message facilities.

Restriction: The OUTDD option has no effect under CICS.

related tasks
“Displaying data on the
system logical output device” on page 34
“Coding COBOL programs to run under CICS” on page 407

related references
Language Environment Programming Reference (MSGFILE)

PARMCHECK

The PARMCHECK option tells the compiler to generate an extra data item following the last item in
WORKING-STORAGE. This buffer data item is then used at run time to check whether a called subprogram
Corrupted data beyond the end of WORKING-STORAGE.

PARMCHECK is introduced in Enterprise COBOL V6.1 with the PTF for APAR PI78089 installed.

When a calling program is compiled with PARMCHECK, the compiler generates a buffer following the last
data item in the WORKING-STORAGE section. At run time, before each call, the buffer is set to ALL 'AA'
After each call, the buffer is checked to see whether it was changed. The PARMCHECK option can help with
your migration from COBOL V4 and earlier compilers to COBOL V6 and later compilers, and can also be
used to clean up and check for good programming practices.

PARMCHECK option syntax

Default is: NOPARMCHECK
Abbreviations are: NOPC|PC

Suboption defaults are:
• If no suboption is specified, default is PARMCHECK (MSG, 100).
• If only MSG or ABD is specified, default is PARMCHECK (MSG|ABD, 100). For example,
  PC (ABD) = PC (ABD, 100).
• If only n is specified, default is PARMCHECK (MSG, n). For example, PC (5000) = PC (MSG, 5000).

MSG | ABD

Determines whether the message issued for subprogram corruption of data is a warning level
message to continue processing or a terminating level message to cause an abend:
• If MSG is in effect, a runtime warning message with the name of the parameter, the line number of
  the CALL statement, and the program name is issued.
• If ABD is in effect, a similar message is issued, but with a terminating level that causes an abend.
n
The size in bytes of the buffer to be added after the last item in WORKING-STORAGE. Must be an integer in the range of 1 to 9999.

Performance considerations: PARMCHECK will cause the compiler to generate slower code for programs with CALL statements. NOPARMCHECK should be in effect for good performance.

related references
CALL statement (Enterprise COBOL for z/OS Language Reference)

PGMNAME

The PGMNAME option controls the handling of program-names and entry-point names.

PGMNAME option syntax

```
PGMNAME( COMPAT
     LONGMIXED
     LONGUPPER )
```

Default is: PGMNAME(COMPAT)

Abbreviations are: PGMN (LM|LU|CO)

LONGUPPER can be abbreviated as UPPER, LU, or U. LONGMIXED can be abbreviated as MIXED, LM, or M.

PGMNAME controls the handling of names used in the following contexts:

- Program-names defined in the PROGRAM-ID paragraph
- Program entry-point names in the ENTRY statement
- Program-name references in:
  - CALL statements that reference nested programs, statically linked programs, or DLLs
  - SET procedure-pointer or function-pointer statements that reference statically linked programs or DLLs
  - CANCEL statements that reference nested programs

PGMNAME(COMPAT)

With PGMNAME(COMPAT), program-names are handled in a manner compatible with older versions of COBOL compilers:

- The program-name can be up to 30 characters in length.
- All the characters used in the name must be alphabetic, digits, the hyphen, or the underscore, except that if the program-name is a literal and is in the outermost program, then the literal can also contain the extension characters @, #, and $, and the first character can be an underscore.
- At least one character must be alphabetic.
- The hyphen cannot be used as the first or last character.

External program-names are processed by the compiler as follows:

- They are folded to uppercase.
- They are truncated to eight characters.
- Hyphens are translated to zero (0).
- If the first character is not alphabetic, and is not an underscore, it is converted as follows:
  - 1-9 are translated to A-I.
– Anything else is translated to J.

**PGMNAME(LONGUPPER)**

With PGMNAME (LONGUPPER), program-names that are specified in the PROGRAM-ID paragraph as COBOL user-defined words must follow the normal COBOL rules for forming a user-defined word:

- The program-name can be up to 30 characters in length.
- All the characters used in the name must be alphabetic, digits, the hyphen, or the underscore.
- At least one character must be alphabetic.
- The hyphen cannot be used as the first or last character.
- The underscore cannot be used as the first character.

When a program-name is specified as a literal, in either a definition or a reference, then:

- The program-name can be up to 160 characters in length.
- All the characters used in the name must be alphabetic, digits, the hyphen, or the underscore.
- At least one character must be alphabetic.
- The hyphen cannot be used as the first or last character.
- The underscore can be used in any position.

External program-names are processed by the compiler as follows:

- They are folded to uppercase.
- Hyphens are translated to zero (0).
- If the first character is not alphabetic, and is not an underscore, it is converted as follows:
  - 1-9 are translated to A-I.
  - Anything else is translated to J.

Names of nested programs are folded to uppercase by the compiler but otherwise are processed as is, without truncation or translation.

**PGMNAME(LONGMIXED)**

With PGMNAME (LONGMIXED), program-names are processed as is, without truncation, translation, or folding to uppercase.

If you want to use a PROGRAM-ID that is longer than eight characters, enclose it in single quotation marks or apostrophes (') and use PGMNAME (LONGMIXED).

With PGMNAME (LONGMIXED), all program-name definitions must be specified using the literal format of the program-name in the PROGRAM-ID paragraph or ENTRY statement. The literal user for a program-name can contain any character in the range X'41' - X'FE'.

**Usage notes**

- The following elements are not affected by the PGMNAME option:
  - Class-names and method-names.
  - System-names (assignment-names in SELECT ... ASSIGN, and text-names or library-names in COPY statements).
  - Dynamic calls.
  
  Dynamic calls are resolved with truncation of the program-name to eight characters, folding to uppercase, and translation of embedded hyphens or a leading digit.
  
  CANCEL of nonnested programs. Name resolution uses the same mechanism as for a dynamic call.
- **Link-edit considerations:** COBOL programs that are compiled with the PGMNAME (LONGUPPER) or PGMNAME (LONGMIXED) option must be link-edited in AMODE 31.
• Dynamic calls are not permitted to COBOL programs compiled with the PGMNAME (LONGMIXED) or PGMNAME (LONGUPPER) options unless the program-name is less than or equal to 8 bytes, and all uppercase. In addition, the name of the program must be identical to the name of the module that contains it.

• When using the extended character set supported by PGMNAME (LONGMIXED), be sure to use names that conform to the binder (linkage-editor) or system conventions that apply, depending on the mechanism used to resolve the names.

    Using characters such as commas or parentheses is not recommended, because these characters are used in the syntax of binder (linkage-editor) control statements.

related references
PROGRAM-ID paragraph (Enterprise COBOL for z/OS Language Reference)

QUALIFY

QUALIFY affects qualification rules and controls whether to extend qualification rules so that some data items that cannot be referenced under COBOL Standard rules can be referenced.

QUALIFY option syntax

```
QUALIFY( COMPAT | EXTEND )
```

Default is: QUALIFY(COMPAT)

Abbreviations are: QUA(C | E)

QUALIFY(COMPAT)

If QUALIFY(COMPAT) is in effect, references to data items must be unique.

QUALIFY(EXTEND)

If QUALIFY(EXTEND) is in effect, qualification rules are extended so that some references that are not unique by COBOL standard rules can be unique. If every level in the containing hierarchy of names is specified, the set of qualifiers is called a complete set of qualifiers. If there is only one data item with a specific complete set of qualifiers, the reference resolves to that data item, even if the same set of qualifiers can match with another reference as an incomplete set of qualifiers.

Example

```
01 A.
   02 B.
      03 C PIC X.
      03 A PIC X.
   02 C PIC X.
   .
   .
   Move space to C of A  *> Refers to 02 level C (unique only with QUALIFY(EXTEND))
   Move space to A       *> Refers to 01 level A (unique only with QUALIFY(EXTEND))
   Move space to C of B of A *> Refers to 03 level C (unique by COBOL standard rules)
   Move space to C of B  *> Refers to 03 level C (unique by COBOL standard rules)
```
RENT

A program compiled as RENT is generated as a reentrant object program. A program compiled as NORENT is generated as a nonreentrant object program.

Either a reentrant or a nonreentrant program can be invoked as a main program or as a subprogram.

RENT option syntax

```
RENT
NORENT
```

Default is: RENT

Abbreviations are: None

**DATA and RMODE settings:** The RENT option interacts with other compiler options that affect storage and its addressability. Use the DATA(24|31) option for reentrant programs to control whether dynamic data areas are allocated in unrestricted storage or in storage obtained from below 16 MB. Compile programs with RENT if they will be run in virtual storage addresses above 16 MB.

Execution of nonreentrant programs above 16 MB is not supported. Programs compiled with NORENT must be RMODE 24.

The setting of the DATA option does not affect programs compiled with NORENT.

For information about which Enterprise COBOL programs need to be reentrant, see the related task about making programs reentrant.

**Link-edit considerations:** If all programs in a program object are compiled with RENT, it is recommended that the program object be link-edited with the RENT binder (linkage-editor) option. Use the REUS binder (linkage-editor) option instead if the program object will also contain any non-COBOL programs that are only serially reusable.

If any program in a program object is not reentrant, the program object must not be link-edited with the RENT or REUS link-edit attributes. The NOREUS binder (linkage-editor) option is needed to ensure that the CANCEL statement will guarantee a fresh copy of the program on a subsequent CALL.

**related concepts**

“Storage and its addressability” on page 37

**related tasks**

“Making programs reentrant” on page 460

*DB2 Application Programming and SQL Guide* (Using reentrant code)

**related references**

“Conflicting compiler options” on page 287

“DATA” on page 300

“RMODE” on page 332
RMODE

The RMODE setting influences the RMODE (residency mode) of your generated object program.

**RMODE option syntax**

```
RMODE(AUTO 24 ANY)
```

Default is: AUTO

Abbreviations are: None

A program compiled with the RMODE (AUTO) option will have RMODE 24 if NORENT is specified, or RMODE ANY if RENT is specified. RMODE AUTO is compatible with older compilers such as VS COBOL II, which produced RMODE 24 for programs compiled with NORENT, and RMODE ANY for programs compiled with RENT.

A program compiled with the RMODE (24) option will have RMODE 24 whether NORENT or RENT is specified.

A program compiled with the RMODE (ANY) option must also be compiled with the RENT option. The program will have the RMODE ANY attribute.

If the NORENT option is specified, the RMODE (24) or RMODE (AUTO) compiler option must be specified. Overriding the module RMODE with a binder option or control statement is not supported.

**DATA and RENT:** The RMODE option interacts with other compiler options and runtime options that affect storage and its addressability. For information about passing data between programs with different modes, see the related concept about storage and its addressability.

**Link-edit considerations:** If the object code that COBOL generates has an attribute of RMODE 24, you must link-edit the code with RMODE 24. If the object code that COBOL generates has an attribute of RMODE ANY, you can link-edit the code with either RMODE ANY or RMODE 24.

**related concepts**
“Storage and its addressability” on page 37

**related references**
“Allocation of buffers for QSAM files” on page 170
“Conflicting compiler options” on page 287
You can use the RULES option to request information about your program from the compiler to improve the program by flagging certain types of source code at compile time.

### RULES option syntax

```
RULES (ENDPERIOD NOENDPERIOD EVENPACK NOEVENPACK LAXPERF NOLAXPERF SLACKBYTES NOSLACKBYTES)
```

Default is: NORULES

Abbreviations are:
- ENDP = ENDPERIOD
- EVENP = EVENPACK
- LXPRF = LAXPERF
- SLCKB = SLACKBYTES

You can specify the following suboptions for RULES:

**ENDPERIOD | NOENDPERIOD**

The default is ENDPERIOD. Specifying NOENDPERIOD causes the compiler to issue warning messages when the scope of a conditional statement is terminated by a period instead of an explicit scope terminator END-*. 

**EVENPACK | NOEVENPACK**

The default is EVENPACK. Specifying NOEVENPACK causes the compiler to issue warning messages for any USAGE PACKED-DECIMAL (COMP-3) data items that have an even number of digits because those data items whose unused bits are not zero can lead to an unexpected program behavior.

**Note:** RULES(NOEVENPACK) helps compilers to identify even-length USAGE PACKED-DECIMAL (COMP-3) data items. However, it is not necessary to change those data items to odd-length items when the related database schema uses even-length packed values.

**LAXPERF | NOLAXPERF**

The default is LAXPERF. Specifying NOLAXPERF suboption causes the compiler to issue warning messages for usage of inefficient COBOL features. These features might include USAGE DISPLAY numeric data items in arithmetic statements, large amounts of space padding in MOVE statements, inefficient compiler options, and other cases.

**SLACKBYTES | NOSLACKBYTES**

The default is SLACKBYTES. Specifying NOSLACKBYTES causes the compiler to issue warning messages for any SYNCHRONIZED data items that cause the compiler to add slack bytes, either slack bytes within records or slack bytes between records. Each data item that causes slack bytes to be added gets a compiler diagnostic.
If the RULES option is specified with no suboptions, the default is RULES(ENDPERIOD, EVENPACK, LAXPERF, SLACKBYTES).

Notes:

• It is not necessary to specify all of the suboptions for RULES. If a suboption is not specified, the default value of that suboption takes effect. For example, if you specify RULES(NOENDP, NOSLCKB), RULES(NOENDP, EVENP, LXPRF, NOSLCKB) takes effect.

• You can optionally use the RULES option with the MSGEXIT suboption of the EXIT compiler option to enforce local coding standards. For example, if you want to ensure that no programmers use periods instead of explicit scope delimiters to delimit conditional statements, you can change the severity of the ENDPERIOD message from Warning level (RC=4) to Severe level (RC=12). For a sample of how to modify the severity of this and other RULES messages, see the sample MSGEXIT in SIGYSAMP called IGYMSGXT.

related references
SYNCHRONIZED clause (Enterprise COBOL for z/OS Language Reference)

SEQUENCE

When you use SEQUENCE, the compiler examines columns 1 through 6 to check that the source statements are arranged in ascending order according to their EBCDIC collating sequence. The compiler issues a diagnostic message if any statements are not in ascending order.

Source statements with blanks in columns 1 through 6 do not participate in this sequence check and do not result in messages.

SEQUENCE option syntax

SEQUENCE

Default is: SEQUENCE
Abbreviations are: SEQ|NOSEQ

If you use COPY statements with the SEQUENCE option in effect, be sure that your source program's sequence fields and the copybook sequence fields are coordinated.

If you use NUMBER and SEQUENCE, the sequence is checked according to numeric, rather than EBCDIC, collating sequence.

If you are doing a batch compilation and SEQUENCE is in effect, all programs in the batch compilation are treated as a single input file. The sequence numbers of the entire input file must be in ascending order.

Use NOSEQUENCE to suppress this checking and the diagnostic messages.

related tasks
“Finding line sequence problems” on page 366
**SERVICE**

Use SERVICE to place a string in the object module if the object module is generated. If the object module is linked into a program object, the string is loaded into memory with this program object. If the Language Environment dump includes a traceback, this string is included in that traceback.

**SERVICE option syntax**

```
NOSERVICE
SERVICE(' service string ')```

Default is: NOSERVICE

Abbreviations are: SERV|NOSERV

The service string is limited to 64 characters in length.

**SOURCE**

Use SOURCE to get a listing of your source program. This listing will include any statements embedded by PROCESS or COPY statements.

**SOURCE option syntax**

```
SOURCE
NOSOURCE```

Default is: SOURCE

Abbreviations are: S|NOS

You must specify SOURCE if you want embedded messages in the source listing.

Use NOSOURCE to suppress the source code from the compiler output listing.

If you want to limit the SOURCE output, use *CONTROL SOURCE or NOSOURCE statements in your PROCEDURE DIVISION. Source statements that follow a *CONTROL NOSOURCE statement are not included in the listing until a subsequent *CONTROL SOURCE statement switches the output back to normal SOURCE format.

“Example: MAP output” on page 375

**related references**

*CONTROL (*CBL) statement (Enterprise COBOL for z/OS Language Reference)
**SPACE**

Use **SPACE** to select single-, double-, or triple-spacing in your source code listing.

**SPACE option syntax**

```
SPACE(1)
```

Default is: **SPACE(1)**

Abbreviations are: None

**SPACE** has meaning only when the **SOURCE** compiler option is in effect.

**related references**

“**SOURCE**” on page 335

---

**SQL**

Use the **SQL** compiler option to enable the DB2 coprocessor and to specify DB2 suboptions. You must specify the **SQL** option if a COBOL source program contains SQL statements (EXEC SQL statements) and the program has not been processed by the DB2 precompiler.

**SQL option syntax**

```
NOSQL
```

Default is: **NOSQL**

Abbreviations are: None

When you use the **SQL** option, the DB2 coprocessor writes the database request module (DBRM) to ddname DBRMLIB. DB2 must be available on the machine on which you compile.

If you specify the **NOSQL** option, any SQL statements found in the source program are diagnosed and discarded.

Use either quotation marks or apostrophes to delimit the string of DB2 suboptions.

You can partition a long suboption string into multiple suboption strings in multiple CBL statements. For example:

```
//STEP1 EXEC IGYWC, ...
// PARM.COBOLE=SQL("string1")
//COBOL.SYSIN DD *
  CBL SQL("string2")
  CBL SQL("string3")
IDENTIFICATION DIVISION.
PROGRAM-ID. DRIVER1.
...
```
The DB2 suboptions are concatenated in the order of their appearance. Thus in the example above, the compiler passes the following suboption string to the DB2 coprocessor:

"string1 string2 string3"

The concatenated strings are delimited with single spaces as shown. If multiple instances of the same DB2 option are found, the last specification of each option prevails. The compiler limits the length of the concatenated DB2 suboption string to 4 KB.

related concepts
“DB2 coprocessor” on page 417
“COBOL and DB2 CCSID determination” on page 422

related tasks
“Compiling with the SQL option” on page 421
“Separating DB2 suboptions” on page 422

related references
“Conflicting compiler options” on page 287

SQLCCSID

Use the SQLCCSID compiler option to control whether the CODEPAGE compiler option will influence the processing of SQL statements in your COBOL programs.

SQLCCSID option syntax

SQLCCSID

| NOSQLCCSID |

Default is: SQLCCSID

Abbreviations are: SQLC|NOSQLC

The SQLCCSID option has an effect only if you use the integrated DB2 coprocessor (SQL compiler option).

If SQLCCSID is in effect, the setting of the CODEPAGE compiler option will influence the processing of SQL statements within your COBOL programs when you use the integrated DB2 coprocessor.

If NOSQLCCSID is in effect:

1. The CODEPAGE compiler option will only be used as the encoding for string literals and the COBOL application source that includes converted SQL statements;
2. DB2 (character string) host variables will not be affected by the CODEPAGE compiler option. Instead, the encoding for DB2 (character string) host variables will come from the CCSID value found in the DSNHDECP file, which means DB2 (via DSNHDECP) determines the encoding of the DB2 data (host variables).

related concepts
“DB2 coprocessor” on page 417
“COBOL and DB2 CCSID determination” on page 422

related tasks
“Programming with the SQLCCSID or NOSQLCCSID option” on page 423

related references
“Code-page determination for string host variables in SQL statements” on page 423
SQLIMS

Use the SQLIMS compiler option to enable the IMS SQL coprocessor and to specify Information Management System (IMS) suboptions. You must specify the SQLIMS option if a COBOL source program contains SQLIMS statements (EXEC SQLIMS statements).

**SQLIMS option syntax**

```
NOSQLIMS

SQLIMS ("IMS-suboption-string")
```

Default: NOSQLIMS

Abbreviation: None

If you specify the NOSQLIMS option, any SQLIMS statements that are found in the source program are diagnosed and discarded.

Use either quotation marks or apostrophes to delimit the string of IMS suboptions.

You can partition a long suboption string into multiple suboption strings in multiple CBL statements. For example:

```
//STEP1 EXEC IGYWC, . . .
// PARM.COBOL='SQLIMS("string1")'
//COBOL.SYSIN DD *
    CBL SQLIMS("string2")
    CBL SQLIMS('string3')
    IDENTIFICATION DIVISION.
    PROGRAM-ID. DRIVER1.
    . . .
```

The IMS suboptions are concatenated in the order of their appearance. Thus in the proceeding example, the compiler passes the following suboption strings to the IMS SQL coprocessor:

```
"string1 string2 string3"
```

The concatenated strings are delimited with single spaces as shown. If multiple instances of the same IMS suboption are found, the last specification of each suboption takes effect. The compiler limits the length of the concatenated IMS suboption string to 4 KB.

**related concepts**

“IMS SQL coprocessor” on page 427

**related tasks**

“Compiling with the SQLIMS option” on page 429

“Separating IMS suboptions” on page 430

**related references**

“Conflicting compiler options” on page 287
SSRANGE

Use SSRANGE to generate code that checks for out-of-range storage references.

SSRANGE option syntax

![Diagram of SSRANGE option syntax]

Default is: NOSSRANGE

Suboption default is: NOZLEN, ABD if only SSRANGE is specified.

Abbreviations are: SSR|NOSSR

SSRANGE generates code that checks whether subscripts, including ALL subscripts, or indexes try to reference areas outside the region of their associated tables. Each subscript or index is not individually checked for validity. Instead, the effective address is checked to ensure that it does not reference outside the table.

If you specify SSRANGE with no suboptions, it will be accepted as a specification of SSRANGE(NOZLEN, ABD).

**Note:** If the SSRANGE option is in effect, range checks are generated by the compiler and the checks are always conducted at run time. You cannot disable the compiled-in range checks at run time by specifying the runtime option CHECK(OFF).

Variable-length items are also checked to ensure that references are within their maximum defined length.

Reference modification expressions are checked to ensure that:

- The starting position is greater than or equal to 1.
- The starting position is not greater than the current length of the subject data item.
- The length value (if specified) is greater than or equal to 1.
- The starting position and length value (if specified) do not reference an area beyond the end of the subject data item.

The ZLEN and NOZLEN suboptions control how the compiler checks reference modification lengths:
• If ZLEN is in effect, the compiler will generate code to ensure that reference modification lengths are greater than or equal to zero. Zero-length reference modification specifications will not get an SSRANGE error at run time.

• If NOZLEN is in effect, the compiler will generate code to ensure that reference modification lengths are greater than or equal to 1. Zero-length reference modification specifications will get an SSRANGE error at run time. This is compatible with how SSRANGE behaved in previous COBOL versions.

The MSG and ABD suboptions control the runtime behavior of the COBOL program when a range check fails.

• If MSG is in effect and a range check fails, a runtime warning message will be issued. This means that the program will continue executing and might potentially identify other out-of-range conditions.

• If ABD is in effect and a range check fails, the first out-of-range condition will result in a runtime error message and the program will ABEND. You can find the next potential out-of-range condition by fixing the first out-of-range condition and then recompiling and running the program again. To identify all other potential out-of-range conditions, you might need to repeat this process several times.

For unbounded groups or their subordinate items, checking is done only for reference modification expressions. Subscripted or indexed references to tables subordinate to an unbounded group are not checked.

related concepts
“Reference modifiers” on page 108

related tasks
“Checking for valid ranges” on page 366

STGOPT

The STGOPT option controls storage optimization.

STGOPT option syntax

```
+-------------+-------------+
|            | NOSTGOPT    |
|            | STGOPT      |
+-------------+-------------+
```

Default is: NOSTGOPT

Abbreviations are: SO|NOSO

If you specify STGOPT, the compiler might discard any or all of the following data items, and does not allocate storage for them.

• Unreferenced LOCAL-STORAGE and non-external WORKING-STORAGE level-77 and level-01 elementary data items
• Non-external level-01 group items if none of their subordinate items are referenced
• Unreferenced special registers

Note: The STGOPT option is ignored for data items that have the VOLATILE clause. For details, see VOLATILE clause in the Enterprise COBOL for z/OS Language Reference.

The compiler will not generate code to initialize discarded data items to the values in their VALUE clauses.

In addition, with STGOPT, data items in the LOCAL-STORAGE SECTION can be reordered in memory to optimize performance.

When NOSTGOPT is in effect, the storage for all data items, including unreferenced data items, is allocated by the compiler, data items are never reordered to improve performance, and all data items defined with a VALUE clause are guaranteed to be initialized, even if they are unreferenced.
SUPPRESS

Use the NOSUPPRESS option to ignore the SUPPRESS phrase of all COPY statements in a program so that copybook information can appear in the listing. The copybook information can be used by debuggers, tools, and so on, without users needing to modify their source code.

**SUPPRESS option syntax**

```
SUPPRESS
NOSUPPRESS
```

Default is: SUPPRESS

Abbreviations are: SUPP|NOSUPP

**NOSUPPRESS**

Ignores the SUPPRESS phrase of COPY statements.

**SUPPRESS**

Enables the SUPPRESS phrase of COPY statements.

TERMINAL

Use TERMINAL to send progress and diagnostic messages to the SYSTERM ddname.

**TERMINAL option syntax**

```
NOTERMINAL
TERMINAL
```

Default is: NOTERMINAL

Abbreviations are: TERM|NOTERM

Use NOTERMINAL if you do not want this additional output.

TEST

Use TEST to produce object code that enables debugging and problem determination tools such as Debug Tool and Fault Analyzer. With TEST, you can also enable the inclusion of symbolic variables in the formatted dumps that are produced by Language Environment.

**TEST option syntax**

```
NOTEST
NODWARF
DWARF
NOEJPD
SOURCE
EJPD
NOSOURCE
```

Option default is: NOTEST (NODWARF)
Suboption defaults are:

- NODWARF if only NOTEST is specified
- NOEJPD,SOURCE if only TEST is specified

Abbreviations are: None

Suboption abbreviation is: NOS | S

**NOTEST suboptions**

**DWARF**

If NOTEST (DWARF) is in effect, basic DWARF diagnostic information is included in the application module. This option enables the best usability for application failure analysis tools, such as CEEDUMP and IBM Fault Analyzer. With NOTEST (DWARF), the debugging information is a subset of the DWARF information that is available with TEST. The DWARF diagnostic information that is produced when NOTEST (DWARF) is in effect cannot be used with IBM Debug Tool.

Debugging information generated by the compiler is in the industry-standard DWARF format. For more information about DWARF, see About Common Debug Architecture in the DWARF/ELF Extensions Library Reference.

**NODWARF**

If NOTEST (NODWARF) is in effect, DWARF diagnostic information is not included in the application module.

**TEST suboptions**

When the TEST option is specified, DWARF debugging information is included in the application module.

The EJPD and NOEJPD suboptions control enablement of the Debug Tool commands JUMPTO and GOTO in production debugging sessions. These suboptions take effect only if you specify the TEST option and a non-zero OPTIMIZE level (OPTIMIZE(1) or OPTIMIZE(2)).

**EJPD**

If you specify TEST (EJPD) and a non-zero OPTIMIZE level:

- The JUMPTO and GOTO commands are enabled.
- The amount of program optimization is reduced. Optimization is done within statements, but most optimizations do not cross statement boundaries.

**NOEJPD**

If you specify TEST (NOEJPD) and a non-zero OPTIMIZE level:

- The JUMPTO and GOTO commands are not enabled. However, you can still use JUMPTO and GOTO if you use the SET WARNING OFF Debug Tool command. In this scenario, JUMPTO and GOTO will have unpredictable results.
- The normal amount of program optimization is done.

**SOURCE**

If you specify TEST (SOURCE), the generated DWARF debug information generated by the compiler includes the expanded source code, and the compiler listing is not needed by IBM Debug Tool.

**NOSOURCE**

If you specify TEST (NOSOURCE), the generated DWARF debugging information does not include the expanded source code, and you will not be able to use IBM Debug Tool.

**Note:** If you specify the TEST option, you must set the CODEPAGE option to the CCSID that is used for the COBOL source program. In particular, programs that use Japanese characters in DBCS literals or DBCS user-defined words must be compiled with the CODEPAGE option set to a Japanese codepage CCSID. For more information, see “CODEPAGE” on page 295.

**Performance versus debugging capability:**

You can control the amount of debugging capability that you get and so also the program performance, as follows:
For the best performance, but with some restrictions on debugging, compile using a non-zero OPTIMIZE level, STG0PT and TEST (NOEJP).

- The Debug Tool commands JUMPTO and GOTO are not supported. However, you can still use JUMPTO and GOTO if you use the SET WARNING OFF Debug Tool command. In this scenario, JUMPTO and GOTO will have unpredictable results.

- Except for the DESCRIBE ATTRIBUTES command, Debug Tool commands cannot refer to any data item that was discarded from a program by the STG0PT option.

- The Debug Tool command AT CALL entry-name is not supported.

For some reduction in program performance from the production-debugging scenario above, but to enable predictable behavior for the Debug Tool commands JUMPTO and GOTO, specify a non-zero OPTIMIZE level and TEST (EJPD).

The restrictions above about referring to items discarded by the STG0PT option, and about the AT CALL command also apply when you use a non-zero OPTIMIZE level and TEST (EJPD).

For slowest performance but maximum debugging capability, specify OPTIMIZE (0), NOSTG0PT and TEST.

The OPTIMIZE (0) option causes the compiler to generate slower code, but all Debug Tool commands are supported.

Language Environment:

The TEST option specified with any of its suboptions can improve your formatted dumps from Language Environment by adding these two features to the dumps:

- A line number that indicates the failing statement, rather than just an offset
- The values of the program variables

With NOTEST (DWARF), the dump will have program variables and the line number of the failing statement. With NOTEST (NODWARF), the dump will not have program variables nor the line number of the failing statement.

Enterprise COBOL uses the Language Environment-provided dump services to produce dumps that are consistent in content and format with those that are produced by other Language Environment-conforming member languages.

Whether Language Environment produces a dump for unhandled conditions depends on the setting of the runtime option TERMTHDACT. If you specify TERMTHDACT (DUMP), a dump is generated when a condition of severity 2 or greater goes unhandled.

related concepts
DWARF/ELF Extensions Library Reference (About Common Debug Architecture)

related tasks
“Using the debugger” on page 370
Language Environment Debugging Guide (Generating a Language Environment dump with TERMTHDACT)
z/OS Debugger User’s Guide (Special considerations while using the TEST runtime option)

related references
“Logical record length and block size” on page 250
“cob2 input and output files” on page 270
“Conflicting compiler options” on page 287
“OPTIMIZE” on page 325
Language Environment Programming Reference (TEST | NOTEST)
THREAD indicates that a COBOL program is to be enabled for execution in a Language Environment enclave that has multiple POSIX threads or PL/I tasks.

**THREAD option syntax**

```
   NOTHREAD
   
   THREAD
```

Default is: NOTHREAD

Abbreviations are: None

A program that has been compiled using the THREAD option can also be used in a nonthreaded application. However, if a COBOL program is to be run in a threaded application, all the COBOL programs in the Language Environment enclave must be compiled using the THREAD option.

NOTHREAD indicates that the COBOL program is not to be enabled for execution in an enclave that has multiple POSIX threads or PL/I tasks.

Programs that are compiled using compilers earlier than Enterprise COBOL are treated as if compiled using NOTHREAD.

If the THREAD option is in effect, the following elements are not supported. If encountered, they are diagnosed as errors:

- ALTER statement
- DEBUG-ITEM special register
- GO TO statement without procedure-name
- INITIAL phrase in PROGRAM-ID clause
- Nested programs
- RERUN
- Segmentation module
- SORT or MERGE statements
- STOP literal statement
- USE FOR DEBUGGING statement

Additionally, some language constructs have different semantics than in the nonthreaded case.

Although threaded applications are subject to a number of programming and environment restrictions, the use of a program in nonthreaded applications is not so restricted. For example, a program compiled using the THREAD option can run in the CICS and IMS environments, can run AMODE 24, and can call and be called by other programs that are not enabled for multithreading, provided that the application does not contain multiple POSIX threads or PL/I tasks at run time.

Programs compiled using the THREAD option are supported in the reusable environment that is created by calling the Language Environment preinitialization routine CEEPIPI. But a reusable environment created by using the RTEREUS runtime option is not supported for programs compiled using the THREAD option.

**Performance consideration:** If you use the THREAD option, you can expect some runtime performance degradation due to the overhead of serialization logic that is automatically generated.

**related tasks**

Chapter 27, "Preparing COBOL programs for multithreading," on page 487
TRUNC

TRUNC affects the way that binary data is truncated during moves and arithmetic operations.

**TRUNC option syntax**

```
TRUNC(STD)
TRUNC(OPT)
TRUNC(BIN)
```

Default is: TRUNC(STD)

Abbreviations are: None

TRUNC has no effect on COMP-5 data items; COMP-5 items are handled as if TRUNC(BIN) is in effect regardless of the TRUNC suboption specified.

**TRUNC(STD)**

TRUNC(STD) applies only to USAGE BINARY receiving fields in MOVE statements and arithmetic expressions. When TRUNC(STD) is in effect, the final result of an arithmetic expression, or the sending field in the MOVE statement, is truncated to the number of digits in the PICTURE clause of the BINARY receiving field.

**TRUNC(OPT)**

TRUNC(OPT) is a performance option. When TRUNC(OPT) is in effect, the compiler assumes that data conforms to PICTURE specifications in USAGE BINARY receiving fields in MOVE statements and arithmetic expressions. The results are manipulated in the most optimal way, either truncating to the number of digits in the PICTURE clause, or to the size of the binary field in storage (halfword, fullword, or doubleword).

**Tips:**

- Use the TRUNC(OPT) option only if you are sure that the data being moved into the binary areas will not have a value with larger precision than that defined by the PICTURE clause for the binary item. Otherwise, unpredictable results could occur. This truncation is performed in the most efficient manner possible; therefore, the results are dependent on the particular code sequence generated. It is not possible to predict the truncation without seeing the code sequence generated for a particular statement.

**TRUNC(BIN)**

The TRUNC(BIN) option applies to all COBOL language that processes USAGE BINARY data. When TRUNC(BIN) is in effect, all binary items (USAGE COMP, COMP-4, or BINARY) are handled as native hardware binary items, that is, as if they were each individually declared USAGE COMP-5:

- BINARY receiving fields are truncated only at halfword, fullword, or doubleword boundaries.
- BINARY sending fields are handled as halfwords, fullwords, or doublewords when the receiver is numeric; TRUNC(BIN) has no effect when the receiver is not numeric.
- The full binary content of fields is significant.
- DISPLAY will convert the entire content of binary fields with no truncation.

**Recommendations:** TRUNC(BIN) is the recommended option for programs that use binary values set by other products. Other products, such as IMS, DB2, C/C++, FORTRAN, and PL/I, might place values in COBOL binary data items that do not conform to the PICTURE clause of the data items. You can use TRUNC(OPT) with CICS programs provided that your data conforms to the PICTURE clause for your BINARY data items.
USAGE  COMP-5 has the effect of applying TRUNC(BIN) behavior to individual data items. Therefore, you can avoid the performance overhead of using TRUNC(BIN) for every binary data item by specifying COMP-5 on only some of the binary data items, such as those data items that are passed to non-COBOL programs or other products and subsystems. The use of COMP-5 is not affected by the TRUNC suboption in effect.

**Large literals in VALUE clauses:** When you use the compiler option TRUNC(BIN), numeric literals specified in VALUE clauses for binary data items (COMP, COMP-4, or BINARY) can generally contain a value of magnitude up to the capacity of the native binary representation (2, 4, or 8 bytes) rather than being limited to the value implied by the number of 9s in the PICTURE clause.

**Note:** With PH11667 installed, when TRUNC(BIN) and NUMCHECK(BIN) are both in effect and an error message or an abend is generated, if you don’t intend to switch to TRUNC(STD|OPT), you can turn off NUMCHECK(BIN) to reduce the execution time of the application and avoid an error message or an abend; if you intend to switch to TRUNC(STD|OPT) later for better performance, you must correct the data.

**TRUNC example 1**

```
01  BIN-VAR     PIC S99 USAGE BINARY.
    . . . MOVE 123451 to BIN-VAR
```

The following table shows values of the data items after the MOVE statement.

<table>
<thead>
<tr>
<th>Data item</th>
<th>Decimal</th>
<th>Hex</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sender</td>
<td>123451</td>
<td>00</td>
<td>01</td>
</tr>
<tr>
<td>Receiver TRUNC(STD)</td>
<td>51</td>
<td>00</td>
<td>33</td>
</tr>
<tr>
<td>Receiver TRUNC(OPT)</td>
<td>-7621</td>
<td>E2</td>
<td>3B</td>
</tr>
<tr>
<td>Receiver TRUNC(BIN)</td>
<td>-7621</td>
<td>E2</td>
<td>3B</td>
</tr>
</tbody>
</table>

A halfword of storage is allocated for BIN-VAR. The result of this MOVE statement if the program is compiled with the TRUNC(STD) option is 51; the field is truncated to conform to the PICTURE clause.

If you compile the program with TRUNC(BIN), the result of the MOVE statement is -7621. The reason for the unusual result is that nonzero high-order digits are truncated. Here, the generated code sequence would merely move the lower halfword quantity X'E23B' to the receiver. Because the new truncated value overflows into the sign bit of the binary halfword, the value becomes a negative number.

It is better not to compile this MOVE statement with TRUNC(OPT), because 123451 has greater precision than the PICTURE clause for BIN-VAR. With TRUNC(OPT), the results are again -7621. This is because the best performance was obtained by not doing a decimal truncation.

**TRUNC example 2**

```
01  BIN-VAR     PIC 9(6)  USAGE BINARY
    . . . MOVE 1234567891 to BIN-VAR
```

The following table shows values of the data items after the MOVE statement.

<table>
<thead>
<tr>
<th>Data item</th>
<th>Decimal</th>
<th>Hex</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sender</td>
<td>1234567891</td>
<td>49</td>
<td>96</td>
</tr>
<tr>
<td>Receiver TRUNC(STD)</td>
<td>567891</td>
<td>00</td>
<td>08</td>
</tr>
<tr>
<td>Receiver TRUNC(OPT)</td>
<td>567891</td>
<td>53</td>
<td>AA</td>
</tr>
<tr>
<td>Receiver TRUNC(BIN)</td>
<td>1234567891</td>
<td>49</td>
<td>96</td>
</tr>
</tbody>
</table>
When you specify TRUNC(STD), the sending data is truncated to six integer digits to conform to the PICTURE clause of the BINARY receiver.

When you specify TRUNC(OPT), the compiler assumes the sending data is not larger than the PICTURE clause precision of the BINARY receiver. The most efficient code sequence in this case is truncation as if TRUNC(STD) were in effect.

When you specify TRUNC(BIN), no truncation occurs because all of the sending data fits into the binary fullword allocated for BIN-VAR.

related concepts
“Formats for numeric data” on page 45

related tasks
“Compiling with the CICS option” on page 411

related references
“NUMCHECK” on page 320
VALUE clause (Enterprise COBOL for z/OS Language Reference)

VBREF
Use VBREF to get a cross-reference between all statements used in the source program and the line numbers in which they are used. VBREF also produces a summary of the number of times each statement was used in the program.

VBREF option syntax

![VBREF diagram]

Default is: NOVBREF
Abbreviations are: None
Use NOVBREF for more efficient compilation.

VLR
The VLR option affects the file status returned from READ statements for variable-length records when the length of record returned is inconsistent with the record descriptions. It eases your migration from earlier versions to Enterprise COBOL V6, if your programs have READ statements that result in a record length conflict.

VLR option syntax

![VLR diagram]

Default is: VLR(STANDARD)
Abbreviations are: VLR(C | S)
After the execution of a READ statement:
If the number of character positions in the record that is read is less than the minimum size specified by the record description entries for the file, the portion of the record area that is to the right of the last valid character read is undefined.

If the number of character positions in the record that is read is greater than the maximum size specified by the record description entries for the file, the record is truncated on the right to the maximum size.

In either of these cases, the READ statement is successful, and the file status is set to either 00 (hiding the record length conflict condition) or 04 (indicating that a record length conflict has occurred), depending on the VLR compiler option setting.

**VLR (COMPAT)**

If you specify VLR (COMPAT), you get the status value of 00 when READ statements encounter a record length conflict.

**Note:** This setting can hide I/O problems that can arise with the wrong length read situation. Use the VLR (COMPAT) option with caution, and check for correct READ statements.

**VLR (STANDARD)**

If you specify VLR (STANDARD), you get the status value of 04 when READ statements encounter a record length conflict.

You can add code to test for FS=04 to avoid accessing undefined data in a record and also avoid getting protection exceptions for attempting to reference a part of the record that was truncated.

Using VLR (STANDARD) can result in more reliable code and fewer I/O problems because the file status will tell you when a "wrong length READ" might occur. A new compiler message, MSGIGYP3178, can also help you avoid I/O problems by telling you if a program has a possibility of a "wrong length READ". This message can be used to assist with migration from VLR (COMPAT) to VLR (STANDARD) by indicating the possible "wrong length READ" that you can solve by correcting the File Definition (FD). You can also raise the severity of the message so that the program must be corrected in order to run. To do this, use the MSGEXIT suboption of the EXIT compiler option to change the severity of message MSGIGYP3178 from I (RC=0) to S (RC=12), E (RC=8), or W (RC=4). If you are not interested in seeing this message, you can suppress the message completely.

**related references**

“EXIT” on page 305

Variable length records - wrong length READ

(Enterprise COBOL Migration Guide)

---

**VSAMOPENFS**

The VSAMOPENFS option affects the user file status reported from successful VSAM OPEN statements that require verified file integrity check.

**VSAMOPENFS option syntax**

```
VSAMOPENFS(COMPAT)
```

Default is: VSAMOPENFS (COMPAT)

Abbreviations are: VS(C | S)

**COMPAT**

If you specify VSAMOPENFS (COMPAT), the statement returns the file status 97 when a VSAM OPEN statement is successfully verified. This is compatible with pre-V6 COBOL runtime behavior.
If you specify VSAMOPENFS(SUCC), the statement returns the file status 00 when a VSAM OPEN statement is successfully verified. This allows users to simply check for 0 in the first digit of the returned file status, as they usually do with other successful operations.

### WORD

Use WORD(xxxx) to specify that an alternate reserved-word table is to be used during compilation.

**WORD option syntax**

```
NOWORD

WORD( xxxx )
```

Default is: NOWORD

Abbreviations are: WD|NOWD

xxxx specifies the ending characters of the name of the reserved-word table (IGYCxxxx) to be used in your compilation. IGYC are the first four standard characters of the name, and xxxx can be one to four characters in length.

Alternate reserved-word tables provide changes to the IBM-supplied default reserved-word table. Your systems programmer might have created one or more alternate reserved-word tables for your site. See your systems programmer for the names of alternate reserved-word tables.

Enterprise COBOL provides an alternate reserved-word table (IGYCCICS) specifically for CICS applications. It is set up to flag COBOL words not supported under CICS with an error message. If you want to use this CICS reserved-word table during your compilation, specify the compiler option WORD(CICS).

**related tasks**

“Compiling with the CICS option” on page 411

**related references**

“Conflicting compiler options” on page 287
“CICS reserved-word table” on page 414

### XMLPARSE

Use XMLPARSE to select the parser to be used for processing XML input, and, therefore, the XML processing capabilities that are available to your program.

**XMLPARSE option syntax**

```
XMLPARSE(
  XMLSS
)
```

Default is: XMLSS

Abbreviations are: XP(X|C)

If you specify the XMLPARSE(XMLSS) option, XML PARSE statements are processed using the z/OS XML System Services parser. The following XML parsing capabilities are available only if you specify XMLPARSE(XMLSS):

Chapter 17. Compiler options 349
• Validation of XML input documents against an XML schema (by using the VALIDATING phrase of the XML PARSE statement)

• Enhanced namespace processing (special registers XML-NAMESPACE, XML-NAMESPACE, XML-NAMESPACE-PREFIX, and XML-NAMESPACE-PREFIX)

• Automatic conversion of document fragments to Unicode UTF-16 (by using the RETURNING NATIONAL phrase of the XML PARSE statement)

• Specification of the encoding of the input document (by using the ENCODING phrase of the XML PARSE statement)

• Direct parsing of XML documents encoded in UTF-8

• Parsing of XML documents, a buffer of XML at a time

• Offloading of XML parsing to System z Application Assist Processors (zAAPs)

If you specify the XMLPARSE(COMPAT) option, XML PARSE statements are processed using the XML parser that is a built-in component of the COBOL library. The XML PARSE statement results and operational behaviors are then compatible with those obtained with Enterprise COBOL Version 3, and also with Version 4 when XMLPARSE(COMPAT) was used, and the advanced features described above for XMLPARSE(XMLSS) are not available.

related tasks
Chapter 30, “Processing XML input,” on page 501

related references
XML PARSE statement (Enterprise COBOL for z/OS Language Reference)
z/OS XML System Services User’s Guide and Reference

XREF

Use XREF to produce a sorted cross-reference listing.

XREF option syntax

Default is: XREF (FULL)

Abbreviations are: X|NOX

You can choose XREF, XREF (FULL), or XREF (SHORT). If you specify XREF without any suboptions, XREF (FULL) will be in effect.

A section of the listing shows all the program-names, data-names, and procedure-names that are referenced in your program, and the line numbers where those names are defined. External program-names are identified.

“Example: XREF output: data-name cross-references” on page 398
“Example: XREF output: program-name cross-references” on page 399

A section is also included that cross-references COPY or BASIS statements in the program with the data sets or files from which associated copybooks were obtained.

“Example: XREF output: COPY/BASIS cross-references” on page 399
EBCDIC data-names and procedure-names are listed in alphanumeric order. DBCS data-names and procedure-names are listed based on their physical order in the program; they are shown before the EBCDIC data-names and procedure-names unless the DBCSXREF installation option is selected with a DBCS ordering program. In that case, DBCS data-names and procedure-names are in the order specified by the DBCS ordering program.

If you use XREF and SSOURCE, data-name and procedure-name cross-reference information is printed on the same line as the original source. Line-number references or other information appears on the right-hand side of the listing page. On the right of source lines that reference an intrinsic function, the letters IFN are printed with the line number of the locations where the function arguments are defined.

Information included in the embedded references lets you know if an identifier is undefined (UND) or defined more than once (DUP), if items are implicitly defined (IMP) (such as special registers or figurative constants), or if a program-name is external (EXT).

If you use XREF and NOSOURCE, you get only the sorted cross-reference listing.

XREF(SHORT) prints only the explicitly referenced data items in the cross-reference listing. XREF(SHORT) applies to DBCS data-names and procedure-names as well as to single-byte names.

NOXREF suppresses this listing.

**Usage notes**
- Group names used in a MOVE CORRESPONDING statement are in the XREF listing. The elementary names in those groups are also listed.
- In the data-name XREF listing, line numbers that are preceded by the letter M indicate that the data item is explicitly modified by a statement on that line.
- XREF listings take additional storage.
- If there is more than one data set in your SYSLIB concatenation, in some cases the COPY/BASIS cross-reference might be incomplete or missing. This loss can occur if XREF is set only in a CBL or PROCESS statement, and XREFOPT=N0 is set as an installation default or NOXREF is coded in your JCL PARM parameter.

To ensure that the COPY/BASIS cross-reference is complete, either verify with your system programmer that XREFOPT=FULL or XREFOPT=SHORT is your installation default, or code the XREF option in your JCL PARM parameter.

**related concepts**
Chapter 19, "Debugging," on page 361

**related tasks**
“Getting listings” on page 370

**related references**
Language Environment Debugging Guide (COBOL compiler options)

---

**ZONECHECK**

Use the ZONECHECK option to have the compiler generate IF NUMERIC class tests for zoned decimal data items that are used as sending data items.

**Note:** In Enterprise COBOL V6.1 with PTF for APAR PI71625 installed, ZONECHECK is deprecated but is tolerated for compatibility, and it is replaced by NUMCHECK(ZON(ALPHNUM)).
ZONECHECK option syntax

Default is: NOZONECHECK

Abbreviations are: NOZC|ZC(MSG)|ZC(ABD)

MSG

The MSG suboption requests that an IF NUMERIC test be done on every use of zoned decimal data items as senders, and if the data is invalid (for example, NOT NUMERIC), a runtime warning message with the line number, data item name, data item content, and program name is issued.

ZONECHECK(MSG) is treated as if NUMCHECK(ZON,MSG) were in effect.

ABD

The ABD suboption requests that an IF NUMERIC test be done on every use of zoned decimal data items as senders, and if the data is invalid (for example, NOT NUMERIC), a terminating message is issued that causes an abend. ZONECHECK(ABD) is treated as if NUMCHECK(ZON,ABD) were in effect.

Both ZONECHECK(MSG) and ZONECHECK(ABD) result in the compiler generating an implicit numeric class test for each zoned decimal data item that is referenced as a sender in a COBOL statement. Receivers are not checked, unless they are both a sender and a receiver, such as data item B in the following sample statements:

ADD A TO B

DIVIDE A INTO B

COMPUTE B = A + B

INITIALIZE B REPLACING ALPHANUMERIC BY B

This checking is done before the data item is used in each statement:

• If the data item is NOT NUMERIC, either a warning message for ZONECHECK(MSG) or a terminating message for ZONECHECK(ABD) is issued.

• If the data item is NUMERIC, the external behavior of the statement is the same as NOZONECHECK, other than being slower.

Restriction: For CALL statements, ZONECHECK checks BY CONTENT and BY VALUE data items that are numeric USAGE DISPLAY only, but it does not check BY REFERENCE parameters.

Performance considerations: ZONECHECK(MSG) and ZONECHECK(ABD) are much slower than NOZONECHECK, depending on how many zoned decimal data items are used in COBOL statements in a program.

related tasks
“Checking for incompatible data (numeric class test)” on page 52

related references
“NUMCHECK” on page 320
“NUMPROC” on page 322
“ZONEDATA” on page 353
The ZONEDATA option tells the compiler whether the data in USAGE DISPLAY and PACKED-DECIMAL data items is valid, and if not, what the behavior of the compiler should be.

**ZONEDATA option syntax**

```
ZONEDATA( PFD )
```

Default is: ZONEDATA(PFD)

Abbreviations are: ZD(PFD) | ZD(MIG) | ZD(NOPFD)

Each digit of a valid zoned decimal number is represented by a single byte from X'F0' through X'F9'. The 4 high-order bits of each byte are zone bits, and the 4 low-order bits of each byte contain the value of the digit. The 4 high-order bits of the low-order byte for SIGN TRAILING represent the sign of the item. The sign is in the high-order byte with SIGN LEADING, or in a separate byte for SIGN IS SEPARATE.

**ZONEDATA(PFD)**

When the ZONEDATA(PFD) option is in effect, the compiler assumes that all data in USAGE DISPLAY and PACKED-DECIMAL data items is valid, and generates the most efficient code possible to make numeric comparisons. For example, the compiler might generate a string comparison to avoid numeric conversion.

**ZONEDATA(MIG)**

When the ZONEDATA(MIG) option is in effect, the compiler generates instructions to do numeric comparisons that ignore the zone bits of each digit in zoned decimal data items. For example, the zoned decimal value is converted to packed-decimal with a PACK instruction before the comparison. The compiler will also avoid performing known optimizations that might produce a different result than COBOL V4 (or earlier versions) when a zoned decimal or packed decimal data item has invalid digits or an invalid sign code, or when a zoned decimal data item has invalid zone bits.

**ZONEDATA(NOPFD)**

When the ZONEDATA(NOPFD) option is in effect, the compiler generates instructions for numeric comparisons or an alphanumeric comparison of zoned decimal data in the same manner as COBOL V4 (or earlier versions) does when using NUMPROC(NOPFD | PFD) with COBOL V4 (or earlier versions):

- In the cases where COBOL V4 (or earlier versions) considered the zone bits, the compiler generates an alphanumeric comparison which will also consider the zone bits of each digit in zoned decimal data items. The zoned decimal value remains as zoned decimal.
- In the cases where COBOL V4 (or earlier versions) ignored the zone bits, the compiler generates numeric comparisons that ignore the zone bits of each digit in zoned decimal data items. The zoned decimal value is converted to packed-decimal with a PACK instruction before the comparison.

In order for the compiler to generate comparisons of zoned decimal data in the same way that COBOL V4 (or earlier versions) did, the NUMPROC suboption used in COBOL V6 must match the NUMPROC suboption used in COBOL V4 (or earlier versions):

- To get the COBOL V4 (or earlier versions) NUMPROC(NOPFD) behavior in COBOL V6, use ZONEDATA(NOPFD) and NUMPROC(NOPFD) in COBOL V6.
- To get the COBOL V4 (or earlier versions) NUMPROC(PFD) behavior in COBOL V6, use ZONEDATA(NOPFD) and NUMPROC(PFD) in COBOL V6.

The compiler will also avoid performing known optimizations that might produce a different result than COBOL V4 (or earlier versions) when a zoned decimal or packed decimal data item has invalid digits or an invalid sign code, or when a zoned decimal data item has invalid zone bits.
Note: The sign code must be a valid sign code according to the NUMPROC compiler option setting. In addition, the low-order byte must have a valid zone (x’F’) for unsigned and signed with either SIGN IS LEADING or SIGN IS SEPARATE.

Note: The ZONEDATA option affects the behaviour of MOVE statements, comparisons, and computations for USAGE DISPLAY or PACKED-DECIMAL data items that could contain invalid digits, an invalid sign code, or invalid zone bits.

In the following example, you can see a data item with an invalid zone bit 4 in the zone bits in the middle of data item VALUE1, forced in by REDEFINES:

```
77 VALUE0 PIC X(4) VALUE '00 0'.  *> x'F0F040F0'
77 VALUE1 REDEFINES VALUE0 PIC 9(4).
PROCEDURE DIVISION.
  IF VALUE1 = ZERO
    DISPLAY 'ZONEDATA(MIG) is in effect ' VALUE1
  ELSE
    DISPLAY 'ZONEDATA(NOPFD | PFD) is in effect '  VALUE1
  END-IF
```

In this example:

- With COBOL V4 (or earlier versions) or earlier versions, the test is true if the NUMPROC(MIG) option is used, and false for NUMPROC(NOPFD | PFD).
- With COBOL V5 or later versions:
  - When using ZONEDATA(PFD), the test is true at OPT(0) and false at OPT(1 | 2).
  - When using ZONEDATA(NOPFD), the test is false at any OPT setting.

In all, to ease your migration to COBOL V6:

- If your digits, sign code, and zone bits are valid, use ZONEDATA(PFD) and the same NUMPROC setting that you used with COBOL V4 (or earlier versions) when using COBOL V6.
- If you have invalid digits, invalid sign code, or invalid zone bits:
  - If you used NUMPROC(MIG) with COBOL V4 (or earlier versions), use ZONEDATA(MIG) and NUMPROC(NOPFD) with COBOL V6.
  - If you used NUMPROC(NOPFD) with COBOL V4 (or earlier versions), use ZONEDATA(NOPFD) and NUMPROC(NOPFD) with COBOL V6.
  - If you used NUMPROC(PFD) with COBOL V4 (or earlier versions), use ZONEDATA(NOPFD) and NUMPROC(PFD) with COBOL V6.

Note: It is not always possible to entirely match the behaviour of the old compiler even with these options when faced with clearly invalid data. For example, even for compares, ZONEDATA(NOPFD) isn't going to give the same result in all cases as COBOL V4.

Performance considerations: ZONEDATA(PFD) gives better runtime performance than ZONEDATA(NOPFD | MIG) does. ZONEDATA(NOPFD | MIG) disables some of the optimizations that NUMPROC(PFD) can give.

related tasks
“Checking for incompatible data (numeric class test)” on page 52

related references
“NUMCHECK” on page 320
“NUMPROC” on page 322
“ZONECHECK” on page 351
If you compile using ZWB, the compiler removes the sign from a signed zoned decimal (DISPLAY) field before comparing this field to an alphanumeric elementary field during execution.

**ZWB option syntax**

```
ZWB
NOZWB
```

Default is: ZWB

Abbreviations are: None

If the zoned decimal item is a scaled item (that is, it contains the symbol P in its PICTURE string), comparisons that use the decimal item are not affected by ZWB. Such items always have their sign removed before the comparison is made to an alphanumeric field.

ZWB affects how a program runs. The same COBOL program can produce different results depending on the setting of this option.

Use NOZWB if you want to test input numeric fields for SPACES.
Chapter 18. Compiler-directing statements

Several statements help you to direct the compilation of your program.

These are the compiler-directing statements:

**BASIS statement**
This extended source program library statement provides a complete COBOL program as the source for a compilation. For rules of formation and processing, see the description of *text-name* for the COPY statement.

**CALLINTERFACE directive**
The CALLINTERFACE directive specifies the interface convention for CALL and SET statements. The convention specified stays in effect until another CALLINTERFACE directive is encountered in the source.

The CALLINTERFACE directive can be used only in the procedure division and its effect is limited to the current compilation unit.

**/*CONTROL ( */CBL) statement**
This compiler-directing statement selectively suppresses or allows output to be produced. The names *CONTROL and */CBL are synonymous.

**COPY statement**

This library statement places prewritten text into a COBOL program.

Neither *text-name nor library-name need to be unique within a program. They can be identical to other user-defined words in the program, except that they cannot contain the underscore.

The uniqueness of *text-name and library-name is determined after the formation and conversion rules for a system-dependent name have been applied. If library-name is omitted, SYSLIB is assumed.

**Compiling with JCL:**

*text-name, library-name, and literal-1 and literal-2 are processed as follows:

- The name (which can be from one to 30 characters long) is truncated to eight characters. Only the first eight characters of *text-name and library-name are used as the identifying name. These eight characters must be unique within any COBOL library.
- The name is folded to uppercase.
- Hyphens that are not the first or last character are translated to zero (0), and a warning message is issued.
- If the first character is numeric, then the characters 1-9 are translated to A-I, zero (0) is converted to J, and a warning message is issued.
For example:

COPY INVOICES1Q
COPY "Company-#Employees" IN Personellib

In the IN/OF phrase, library-name is the ddname that identifies the partitioned data set to be copied from. Use a DD statement such as in the following example to define library-name:

```plaintext
//COPYLIB DD DSNAME=ABC.COB,VOLUME=SER=111111,
//           DISP=SHR,UNIT=3380
```

To specify more than one copy library, use either JCL or a combination of JCL and the IN/OF phrase. Using just JCL, concatenate data sets in your DD statement for SYSLIB. Alternatively, define multiple DD statements and include the IN/OF phrase in your COPY statements.

The maximum block size for the copy library depends on the device on which your data set resides.

### Compiling in the z/OS UNIX shell:

When you compile using the cob2 command, copybooks are included from the z/OS UNIX file system. text-name, library-name, and literal-1 and literal-2 are processed as follows:

- User-defined words are folded to uppercase. Literals are not folded. Because UNIX is case sensitive, if your file-name is lowercase or mixed case, you must specify it as a literal.
- If text-name is a literal and library-name is omitted, text-name is used directly: as a file-name, a relative path name, or an absolute path name (if the first character is /). For example:

```plaintext
COPY "MyInc"
COPY "x/MyInc"
COPY "/u/user1/MyInc"
```

- If text-name is a user-defined word, and an environment variable of that name is defined, the value of the environment variable is used as the name of the file that contains the copybook.

If an environment variable of that name is not defined, the copybook is searched for under the following names, in this order:

1. text-name.cpy
2. text-name.CPY
3. text-name.cbl
4. text-name.CBL
5. text-name.cob
6. text-name.COB
7. text-name

- If library-name is a literal, it is treated as the actual path, relative or absolute, from which to copy file text-name.
- If library-name is a user-defined word, it is treated as an environment variable. The value of the environment variable is used as the path. If the environment variable is not set, an error occurs.
- If both library-name and text-name are specified, the compiler forms the path name for the copybook by concatenating library-name and text-name with a path separator (/) inserted between the two values. For example, suppose you have the following setting for COPY MYCOPY OF MYLIB:

```plaintext
export MYCOPY=mystuff/today.cpy
export MYLIB=/u/user1
```
These settings result in:

/u/user1/mystuff/today.cpy

If library-name is an environment variable that identifies the path from which copybooks are to be copied, use an export command to define library-name, as in this example:

```
export COPYLIB=/u/mystuff/copybooks
```

The name of the environment variable must be uppercase. To specify more than one copy library, set the environment variable to multiple path names delimited by colon (:).

If library-name is omitted and text-name is not an absolute path name, the copybook is searched for in this order:

1. In the current directory
2. In the paths specified on the -I cob2 option
3. In the paths specified in the SYSLIB environment variable

For additional information about the COPY statement, for example, the rules for text replacement, see the related reference.

DELETE statement
This extended source library statement removes COBOL statements from the BASIS source program.

EJECT statement
This compiler-directing statement specifies that the next source statement is to be printed at the top of the next page.

ENTER statement
The statement is treated as a comment.

INSERT statement
This library statement adds COBOL statements to the BASIS source program.

PROCESS (CBL) statement
This statement, which you place before the IDENTIFICATION DIVISION header of an outermost program, indicates which compiler options are to be used during compilation of the program.

REPLACE statement
This statement is used to replace source program text.

SERVICE LABEL statement
This statement is generated by the CICS translator to indicate control flow, and should be used at the resume point for a call to CEE3SRP. It is not intended for general use.

SKIP1/2/3 statement
These statements indicate lines to be skipped in the source listing.

TITLE statement
This statement specifies that a title (header) should be printed at the top of each page of the source listing.

USE statement
The USE statement provides declaratives to specify these elements:

- Error-handling procedures: EXCEPTION/ERROR
- Debugging lines and sections: DEBUGGING

related tasks
“Changing the header of a source listing” on page 5
“Specifying compiler options under z/OS” on page 254
“Specifying compiler options under z/OS UNIX” on page 266
“Setting environment variables”
under z/OS UNIX” on page 265
“Eliminating repetitive coding” on page 641

related references
“cob2 syntax and options” on page 269
CALLINTERFACE (Enterprise COBOL for z/OS Language Reference)
COPY statement (Enterprise COBOL for z/OS Language Reference)
Chapter 19. Debugging

You can choose between two different approaches to determine the cause of problems in the behavior of your application: source-language debugging or interactive debugging.

For source-language debugging, COBOL provides several language elements, compiler options, and listing outputs that make debugging easier.

If the problem with your program is not easily detected and you do not have a debugger available, you might need to analyze a storage dump of your program.

For interactive debugging, you can use Debug Tool. Debug Tool offers these productivity enhancements:

- Interactive debugging (in full-screen or line mode), or debugging in batch mode
  During an interactive full-screen mode session, you can use Debug Tool’s full-screen services and session panel windows on a 3270 device to debug your program while it is running.
- COBOL-like commands
  For each high-level language supported, commands for coding actions to be taken at breakpoints are provided in a syntax similar to that programming language.
- Mixed-language debugging
  You can debug an application that contains programs written in a different language. Debug Tool automatically determines the language of the program or subprogram being run.
- COBOL-CICS debugging
  Debug Tool supports the debugging of CICS applications in both interactive and batch mode.
- Support for remote debugging
  Workstation users can use the IBM Debug Tool Plug-in for Eclipse or the IBM Problem Determination Tools with Rational Developer for System z for debugging programs that run on z/OS.

related tasks
“Debugging with source language” on page 361
“Debugging using compiler options” on page 365
“Using the debugger” on page 370
“Getting listings” on page 370
z/OS Debugger User’s Guide

related references
Debug Tool Reference and Messages
Language Environment Debugging Guide (Formatting and analyzing system dumps, Debugging example COBOL programs)

Debugging with source language

You can use several COBOL language features to pinpoint the cause of a failure in a program.

If a failing program is part of a large application that is already in production (precluding source updates), write a small test case to simulate the failing part of the program. Code debugging features in the test case to help detect these problems:

- Errors in program logic
- Input-output errors
- Mismatches of data types
- Uninitialized data
- Problems with procedures
related tasks
“Tracing program logic” on page 362
“Finding and handling input-output errors” on page 362
“Validating data” on page 363
“Moving, initializing or setting uninitialized data” on page 363
“Generating information about procedures” on page 363

related references
Source language debugging (Enterprise COBOL for z/OS Language Reference)

Tracing program logic
Trace the logic of your program by adding DISPLAY statements.

For example, if you determine that the problem is in an EVALUATE statement or in a set of nested IF statements, use DISPLAY statements in each path to see the logic flow. If you determine that the calculation of a numeric value is causing the problem, use DISPLAY statements to check the value of some interim results.

If you use explicit scope terminators to end statements in your program, the logic is more apparent and therefore easier to trace.

To determine whether a particular routine started and finished, you might insert code like this into your program:

```cobol
DISPLAY "ENTER CHECK PROCEDURE"
  . (checking procedure routine)
  . DISPLAY "FINISHED CHECK PROCEDURE"
```

After you are sure that the routine works correctly, disable the DISPLAY statements in one of two ways:

- Put an asterisk in column 7 of each DISPLAY statement line to convert it to a comment line.
- Put a D in column 7 of each DISPLAY statement to convert it to a comment line. When you want to reactivate these statements, include a WITH DEBUGGING MODE clause in the ENVIRONMENT DIVISION; the D in column 7 is ignored and the DISPLAY statements are implemented.

Before you put the program into production, delete or disable the debugging aids you used and recompile the program. The program will run more efficiently and use less storage.

related concepts
“Scope terminators” on page 18

related references
DISPLAY statement (Enterprise COBOL for z/OS Language Reference)

Finding and handling input-output errors
File status keys can help you determine whether your program errors are due to input-output errors occurring on the storage media.

To use file status keys in debugging, check for a nonzero value in the status key after each input-output statement. If the value is nonzero (as reported in an error message), look at the coding of the input-output procedures in the program. You can also include procedures to correct the error based on the value of the status key.

If you determine that a problem lies in an input-output procedure, include the USE EXCEPTION/ERROR declarative to help debug the problem. Then, when a file fails to open, the appropriate EXCEPTION/ERROR declarative is performed. The appropriate declarative might be a specific one for the file or one provided for the open attributes INPUT, OUTPUT, I-O, or EXTEND.
Code each USE AFTER STANDARD ERROR statement in a section that follows the DECLARATIVES keyword in the PROCEDURE DIVISION.

related tasks
“Coding ERROR declaratives” on page 228
“Using file status keys” on page 229

related references
File status key (Enterprise COBOL for z/OS Language Reference)

Validating data
If you suspect that your program is trying to perform arithmetic on nonnumeric data or is receiving the wrong type of data on an input record, use the class test (the class condition) to validate the type of data.

You can use the class test to check whether the content of a data item is ALPHABETIC, ALPHABETIC-LOWER, ALPHABETIC-UPPER, DBCS, KANJI, or NUMERIC. If the data item is described implicitly or explicitly as USAGE NATIONAL, the class test checks the national character representation of the characters associated with the specified character class.

You can use the UVALID intrinsic function to check whether a national data item contains valid UTF-16 encoded data, or whether an alphanumeric or alphabetic item contains valid UTF-8 encoded data.

related tasks
“Coding conditional expressions” on page 93
“Testing for valid DBCS characters” on page 144

related references
Class condition (Enterprise COBOL for z/OS Language Reference)
VALID (Enterprise COBOL for z/OS Language Reference)

Moving, initializing or setting uninitialized data
Use an INITIALIZE or SET statement to initialize a table or data item when you suspect that a problem might be caused by residual data in those fields.

If the problem happens intermittently and not always with the same data, it could be that a switch was not initialized but is generally set to the right value (0 or 1) by chance. By using a SET statement to ensure that the switch is initialized, you can determine that the uninitialized switch is the cause of the problem or remove it as a possible cause.

related references
INITIALIZE statement (Enterprise COBOL for z/OS Language Reference)
SET statement (Enterprise COBOL for z/OS Language Reference)
“INITCHECK” on page 311

Generating information about procedures
Generate information about your program or test case and how it is running by coding the USE FOR DEBUGGING declarative. This declarative lets you include statements in the program and indicate when they should be performed when you run your program.

For example, to determine how many times a procedure is run, you could include a debugging procedure in the USE FOR DEBUGGING declarative and use a counter to keep track of the number of times that control passes to that procedure. You can use the counter technique to check items such as these:

• How many times a PERFORM statement runs, and thus whether a particular routine is being used and whether the control structure is correct
• How many times a loop runs, and thus whether the loop is executing and whether the number for the loop is accurate

You can use debugging lines or debugging statements or both in your program.
Debugging lines are statements that are identified by a D in column 7. To make debugging lines in your program active, code the WITH DEBUGGING MODE clause on the SOURCE-COMPUTER line in the ENVIRONMENT DIVISION. Otherwise debugging lines are treated as comments.

Debugging statements are the statements that are coded in the DECLARATIVES section of the PROCEDURE DIVISION. Code each USE FOR DEBUGGING declarative in a separate section. Code the debugging statements as follows:

- Only in a DECLARATIVES section.
- Following the header USE FOR DEBUGGING.
- Only in the outermost program; they are not valid in nested programs. Debugging statements are also never triggered by procedures that are contained in nested programs.

To use debugging statements in your program, you must include the WITH DEBUGGING MODE clause and use the DEBUG runtime option.

Options restrictions:

- You cannot use the USE FOR DEBUGGING declarative in a program that you compile with the THREAD option.

“Example: USE FOR DEBUGGING” on page 364

related references

SOURCE-COMPUTER paragraph (Enterprise COBOL for z/OS Language Reference)
Debugging lines (Enterprise COBOL for z/OS Language Reference)
Debugging sections (Enterprise COBOL for z/OS Language Reference)
DEBUGGING declarative (Enterprise COBOL for z/OS Language Reference)

Example: USE FOR DEBUGGING

This example shows the kind of statements that are needed to use a DISPLAY statement and a USE FOR DEBUGGING declarative to test a program.

The DISPLAY statement writes information to the terminal or to an output data set. The USE FOR DEBUGGING declarative is used with a counter to show how many times a routine runs.

Environment Division.
... Data Division.
... Working-Storage Section.
... (other entries your program needs)
  01 Trace-Msg PIC X(30) Value " Trace for Procedure-Name : ".
  01 Total PIC 9(9) Value 1.
... Procedure Division.
  Declaratives.
  Debug-Declaratives Section.
  Use For Debugging On Some-Routine.
  Debug-Declaratives-Paragraph.
  Display Trace-Msg, Debug-Name, Total.
End Declaratives.

Main-Program Section.
... (source program statements)
... (source program statements)
Stop Run.
Some-Routine.
... (whatever statements you need in this paragraph)
Add 1 To Total.
Some-Routine-End.
The DISPLAY statement in the DECLARATIVES SECTION issues this message every time the procedure Some-Routine runs:

```
Trace For Procedure-Name : Some-Routine 22
```

The number at the end of the message, 22, is the value accumulated in the data item Total; it indicates the number of times Some-Routine has run. The statements in the debugging declarative are performed before the named procedure runs.

You can also use the DISPLAY statement to trace program execution and show the flow through the program. You do this by dropping Total from the DISPLAY statement and changing the USE FOR DEBUGGING declarative in the DECLARATIVES SECTION to:

```
USE FOR DEBUGGING ON ALL PROCEDURES.
```

As a result, a message is displayed before each nondebugging procedure in the outermost program runs.

### Debugging using compiler options

You can use certain compiler options to help you find errors in your program, find various elements in your program, obtain listings, and prepare your program for debugging.

You can find the following errors by using compiler options (the options are shown in parentheses):

- Syntax errors such as duplicate data-names (NOCOMPILE)
- Missing sections (SEQUENCE)
- Invalid subscript values (SSRANGE)

You can find the following elements in your program by using compiler options:

- Error messages and locations of the associated errors (FLAG)
- Program entity definitions and references; text-names and library-names from COPY or BASIS statements, and the associated data sets or files from which copybooks are obtained (XREF)
- Data items in the DATA DIVISION (MAP)
- Statement references (VBREF)

You can get a copy of your source (SOURCE) or a listing of generated code (LIST).

You prepare your program for debugging by using the TEST compiler option.

**related tasks**

- “Finding coding errors” on page 366
- “Finding line sequence problems” on page 366
- “Checking for valid ranges” on page 366
- “Selecting the level of error to be diagnosed” on page 367
- “Finding program entity definitions and references” on page 369
- “Listing data items” on page 369
- “Getting listings” on page 370

**related references**

Chapter 17, “Compiler options,” on page 283
**Finding coding errors**

Use the NOCOMPILE option to compile conditionally or to only check syntax. When used with the SOURCE option, NOCOMPILE produces a listing that will help you find coding mistakes such as missing definitions, improperly defined data items, and duplicate data-names.

If you are compiling in the TSO foreground, you can send the messages to your screen by using the TERM compiler option and defining your data set as the SYSTERM data set.

**Checking syntax only:** To only check the syntax of your program, and not produce object code, use NOCOMPILE without a suboption. If you also specify the SOURCE option, the compiler produces a listing.

When you specify NOCOMPILE, several compiler options are suppressed. See the related reference below about the COMPILE option for details.

**Compiling conditionally:** To compile conditionally, use NOCOMPILE(x), where x is one of the severity levels of errors. Your program is compiled if all the errors are of a lower severity than x. The severity levels that you can use, from highest to lowest, are S (severe), E (error), and W (warning).

If an error of level x or higher occurs, the compilation stops and your program is only checked for syntax.

**related references**

“COMPILE” on page 297

---

**Finding line sequence problems**

Use the SEQUENCE compiler option to find statements that are out of sequence. Breaks in sequence indicate that a section of a source program was moved or deleted.

When you use SEQUENCE, the compiler checks the source statement numbers to determine whether they are in ascending sequence. Two asterisks are placed beside statement numbers that are out of sequence. The total number of these statements is printed as the first line in the diagnostics after the source listing.

**related references**

“SEQUENCE” on page 334

---

**Checking for valid ranges**

Use the SSRANGE compiler option to check whether addresses fall within proper ranges.

SSRANGE causes the following addresses to be checked:

- Subscripted or indexed data references: Is the effective address of the specified table element within the maximum boundary of the containing group? (This checking is not done for UNBOUNDED tables and groups.)

- Variable-length data references (a reference to a data item that contains an OCCURS DEPENDING ON clause): Is the actual length greater than or equal to zero, and within the maximum defined length for the group data item? (This checking is not done for UNBOUNDED groups.)

- Reference-modified data references: Are the offset and length positive? Is the sum of the offset and length within the maximum length for the data item?

If the SSRANGE option is in effect, checking is performed at run time if the COBOL statement that contains the indexed, subscripted, variable-length, or reference-modified data item is executed.

If an effective address is outside the range of the data item that contains the referenced data, an error message is generated and the program stops. The message identifies the table or identifier that was referenced and the line number where the error occurred. Additional information is provided depending on the type of reference that caused the error.

If all subscripts, indices, and reference modifiers in a given data reference are literals and they result in a reference outside the data item, the error is diagnosed at compile time regardless of the setting of the SSRANGE option.
**Performance consideration:** SSRANGE can somewhat degrade performance because of the extra overhead to check each subscripted or indexed item.

**related references**
“SSRANGE” on page 339
“Performance-related compiler options” on page 636

**Selecting the level of error to be diagnosed**
Use the FLAG compiler option to specify the level of error to be diagnosed during compilation and to indicate whether error messages are to be embedded in the listing. Use FLAG(I) or FLAG(I,I) to be notified of all errors.

Specify as the first parameter the lowest severity level of the syntax-error messages to be issued. Optionally specify the second parameter as the lowest level of the syntax-error messages to be embedded in the source listing. This severity level must be the same or higher than the level for the first parameter. If you specify both parameters, you must also specify the SOURCE compiler option.

<table>
<thead>
<tr>
<th>Table 49. <strong>Severity levels of compiler messages</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity level</td>
</tr>
<tr>
<td>U (unrecoverable)</td>
</tr>
<tr>
<td>S (severe)</td>
</tr>
<tr>
<td>E (error)</td>
</tr>
<tr>
<td>W (warning)</td>
</tr>
<tr>
<td>I (informational)</td>
</tr>
</tbody>
</table>

When you specify the second parameter, each syntax-error message (except a U-level message) is embedded in the source listing at the point where the compiler had enough information to detect that error. All embedded messages (except those issued by the library compiler phase) directly follow the statement to which they refer. The number of the statement that had the error is also included with the message. Embedded messages are repeated with the rest of the diagnostic messages at the end of the source listing.

**Note:** You can suppress some error messages and change the severity of others with the MSGEXIT suboption of the EXIT option.

When you specify the NOSOURCE compiler option, the syntax-error messages are included only at the end of the listing. Messages for unrecoverable errors are not embedded in the source listing, because an error of this severity terminates the compilation.

**Example: embedded messages**
The following example shows the embedded messages generated by specifying a second parameter to the FLAG option. Some messages in the summary apply to more than one COBOL statement.

**related tasks**
“Generating a list of compiler messages” on page 261

**related references**
“Severity codes for compiler diagnostic messages” on page 263
“Messages and listings for compiler-detected errors” on page 262
“FLAG” on page 308

**Example: embedded messages**
The following example shows the embedded messages generated by specifying a second parameter to the FLAG option. Some messages in the summary apply to more than one COBOL statement.
**INITIALIZE PARAGRAPH**

Open files. Accept date, time and format header lines.

Load location-table.

100-initialize-paragraph.

move spaces to ws-transaction-record

move spaces to ws-commuter-record

move zeroes to commuter-zipcode

move zeroes to commuter-home-phone

move zeroes to commuter-work-phone

move zeroes to commuter-update-date

open input update-transaction-file

An error was found in the definition of file "LOCATION-FILE". The reference to this file was discarded.

move location-eof to true

end-read

1700 sequence errors were found in this program.

"ASSIGNN" was invalid. Scanning was resumed at the next area "A" item, level-number, or the start of the next clause.

The file definition was discarded.

An error was found in the definition of file "LOCATION-FILE". The reference to this file was discarded. Same message on line: 90684

An error was found in the definition of file "LOCATION-FILE". The reference to this file was discarded. Same message on line: 90709

Statistics for COBOL program IGYTCARA:

Source records = 1755

Procedure Division statements = 479

Generated COBOL statements = 0

Program complexity factor = 486

End of compilation 1, program IGYTCARA, highest severity 12.

Return code 12
Finding program entity definitions and references

Use the XREF (FULL) compiler option to find out where a data-name, procedure-name, or program-name is defined and referenced. Use it also to produce a cross-reference of COPY or BASIS statements to the data sets or files from which copybooks were obtained.

A sorted cross-reference includes the line number where the data-name, procedure-name, or program-name was defined and the line numbers of all references to it.

To include only the explicitly referenced data items, use the XREF (SHORT) option.

Use both the XREF (either FULL or SHORT) and the SOURCE options to print a modified cross-reference to the right of the source listing. This embedded cross-reference shows the line number where the data-name or procedure-name was defined.

For further details, see the related reference about the XREF compiler option.

“Example: XREF output: data-name cross-references” on page 398
“Example: XREF output: program-name cross-references” on page 399
“Example: XREF output: COPY/BASIS cross-references” on page 399
“Example: XREF output: embedded cross-reference” on page 401

related tasks
“Getting listings” on page 370

related references
“XREF” on page 350

Listing data items

Use the MAP (HEX|DEC) compiler option to create a listing of the DATA DIVISION items and all implicitly declared items. Use the MAP output to locate the contents of a data item in a system dump.

When you specify the MAP (HEX|DEC) option, an embedded MAP summary that contains condensed MAP information is generated to the right of the COBOL source data definition.

• If you specify MAP (HEX) or MAP with no suboption, data item offsets within groups will be in hexadecimal notation.
• If you specify MAP (DEC), data item offsets within groups will be in decimal notation.

When both XREF data and an embedded MAP summary are on the same line, the embedded summary is printed first.

You can select or inhibit parts of the MAP listing and embedded MAP summary by using *CONTROL MAP|NOMAP (or *CBL MAP|NOMAP) statements throughout the source. For example:

```
*CONTROL NOMAP
  01  A
  02  B
*CONTROL MAP
```

“Example: MAP output” on page 375

related tasks
“Getting listings” on page 370

related references
“MAP” on page 316
Using the debugger

You can use Debug Tool to debug your Enterprise COBOL programs. Use the TEST compiler option to prepare your COBOL program so that you can step through the executable program with the debugger.

For remote debugging, there is an Eclipse plugin that provides a client graphical user interface to the debugging information provided by the Debug Tool engine running under z/OS or z/OS UNIX. The IBM Debug Tool Plug-in for Eclipse is included with IBM Developer for z/OS and also with the IBM Problem Determination Tools Studio.

You can specify the TEST suboption NOSOURCE to have smaller object programs stored on disk. The loaded size does not change, the debug information is never loaded unless requested, for example, by a debugger such as Debug Tool or by LE (for CEEDUMP). With the NOSOURCE suboption, you will not be able to see the source in the Debug Tool source window.

Specify the OPTIMIZE(0), NOSTG0PT and TEST compiler options to get the most debugging function.

Specify a non-zero OPTIMIZE level, NOSTG0PT and TEST(EJP0) compiler options to get better performance with a few restrictions on debugging function.

Specify a non-zero OPTIMIZE level, STG0PT and TEST(NOJPD) compiler options to get the best performance but still be able to use Debug Tool, with some restrictions on debugging function.

For details about which compiler options to use for maximum debugging capability versus best performance, see the related reference about the TEST compiler option.

related tasks
z/OS Debugger User’s Guide (Preparing your program for debugging)

related references
“TEST” on page 341

Getting listings

Get the information that you need for debugging by requesting the appropriate compiler listing with the use of compiler options.

Attention: The listings produced by the compiler are not a programming interface and are subject to change.

<table>
<thead>
<tr>
<th>Table 50. Using compiler options to get listings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use</strong></td>
</tr>
</tbody>
</table>
| To check a list of the options in effect for the program, statistics about the content of the program, and diagnostic messages about the compilation | Short listing | • List of options in effect for the program  
• Statistics about the content of the program  
• Diagnostic messages about the compilation | NOSOURCE, NOXREF, NOVBREF, NOMAP, NOFFSET, NOLIST |
<p>| To aid in testing and debugging your program; to have a record after the program has been debugged | Source listing | Copy of your source | “SOURCE” on page 335 |</p>
<table>
<thead>
<tr>
<th>Use</th>
<th>Listing</th>
<th>Contents</th>
<th>Compiler option</th>
</tr>
</thead>
<tbody>
<tr>
<td>To find certain data items in a storage dump; to see the final storage allocation after reentrancy or optimization has been accounted for; to see where programs are defined and check their attributes</td>
<td>Map of DATA DIVISION items</td>
<td>All DATA DIVISION items and all implicitly declared items Embedded map summary (in the right margin of the listing for lines in the DATA DIVISION that contain data declarations) Nested program map (if the program contains nested programs)</td>
<td>“MAP” on page 316²</td>
</tr>
<tr>
<td>To find where a name is defined, referenced, or modified; to determine the context (such as whether a statement was used in a PERFORM block) in which a procedure is referenced; to determine the data set or file from which a copybook was obtained</td>
<td>Sorted cross-reference listing of names; sorted cross-reference listing of COPY/BASIS statements and copybook data sets or files</td>
<td>Data-names, procedure-names, and program-names; references to these names COPY/BASIS text-names and library names, and the data sets or files from which associated copybooks were obtained Embedded modified cross-reference provides line numbers where data-names and procedure-names were defined</td>
<td>“XREF” on page 350²,³</td>
</tr>
<tr>
<td>To find the failing statement in a program or the address in storage of a data item that is moved while the program is running</td>
<td>PROCEDURE DIVISION code and assembler code produced by the compiler³</td>
<td>Generated code</td>
<td>“LIST” on page 315²,⁴</td>
</tr>
<tr>
<td>To verify you still have a valid logic path after you move or add PROCEDURE DIVISION sections</td>
<td>Condensed PROCEDURE DIVISION listing</td>
<td>Condensed statement listing, global tables, WORKING-STORAGE information, and literals</td>
<td>“OFFSET” on page 324</td>
</tr>
<tr>
<td>To find an instance of a certain statement</td>
<td>Alphabetic listing of statements</td>
<td>Each statement used, number of times each statement was used, line numbers where each statement was used</td>
<td>“VBREF” on page 347</td>
</tr>
</tbody>
</table>
Table 50. Using compiler options to get listings (continued)

<table>
<thead>
<tr>
<th>Use</th>
<th>Listing</th>
<th>Contents</th>
<th>Compiler option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To eliminate messages, turn off the options (such as FLAG) that govern the level of compile diagnostic information. You can also selectively suppress messages by using the MSGEXIT suboption of the EXIT compiler option.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. To use your line numbers in the compiled program, use the NUMBER compiler option. The compiler checks the sequence of your source statement line numbers in columns 1 through 6 as the statements are read in. When it finds a line number out of sequence, the compiler assigns to it a number with a value one higher than the line number of the preceding statement. The new value is flagged with two asterisks. A diagnostic message indicating an out-of-sequence error is included in the compilation listing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The context of the procedure reference is indicated by the characters preceding the line number.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. You can control the listing of generated object code by selectively placing *CONTROL LIST and *CONTROL NOLIST (or equivalently, *CBL LIST and *CBL NOLIST) statements in your source. Note that the *CONTROL statement is different than the PROCESS (or CBL) statement.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The output is generated if:

- You specify the COMPILE option (or the NOCOMPILE(x) option is in effect and an error level x or higher does not occur).
- You do not specify the OFFSET option. OFFSET and LIST are mutually exclusive options with OFFSET taking precedence.

“Example: short listing” on page 372
“Example: SOURCE and NUMBER output” on page 375
“Example: MAP output” on page 375
“Example: embedded map summary” on page 377
“Example: nested program map” on page 380
“Example: XREF output: data-name cross-references” on page 398
“Example: XREF output: program-name cross-references” on page 399
“Example: XREF output: COPY/BASIS cross-references” on page 399
“Example: XREF output: embedded cross-reference” on page 401
“Example: OFFSET compiler output” on page 402
“Example: VBREF compiler output” on page 402

related tasks
“Generating a list of compiler messages” on page 261
“Reading LIST output” on page 381

Language Environment Debugging Guide (Debugging COBOL programs)

related references
“Messages and listings for compiler-detected errors” on page 262

Example: short listing
The parenthetical numbers shown in the listing below correspond to numbered explanations that follow the listing. For illustrative purposes, some errors that cause diagnostic messages were deliberately introduced.

Invocation parameters:  (1)
OPTFILE
PROCESS(CBL) statements:  (2)
CBL NODECK
CBL NOADV, NODYN, NONAME, NONUMBER, QUOTE, SEQ, DUMP
CBL NOSOURCE, NOXREF, NOVBREF, NOMAP, NOOFFSET, NOLIST
Options from SYSOPTF:  (3)
C, NODU, FLAG(I), X, MAP, NOLIST, RENT, OPT(1), SSR
TEST TRUNC(OPT)
Options in effect:  (4)
NOADATA
NOADV
<table>
<thead>
<tr>
<th>Line ID</th>
<th>Message ID</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>IGYDS1089-S</td>
<td>&quot;ASSIGNN&quot; was invalid. Scanning was resumed at the next area &quot;A&quot; item, level-number, or the start of the next clause.</td>
</tr>
<tr>
<td>192</td>
<td>IGYDS1050-E</td>
<td>File &quot;LOCATION-FILE&quot; contained no data record descriptions. The file definition was discarded.</td>
</tr>
<tr>
<td>192</td>
<td>IGYGR1207-S</td>
<td>The &quot;ASSIGN&quot; clause was missing or invalid in the &quot;SELECT&quot; entry for file &quot;LOCATION-</td>
</tr>
</tbody>
</table>

Chapter 19. Debugging
FILE*.

The file definition was discarded.

888  IGYPS2052-S   An error was found in the definition of file "LOCATION-FILE". The reference to this
file was discarded.

Same message on line: 979

1000  IGYPS2121-S   "WS-DATE" was not defined as a data-name. The statement was discarded.

Same message on line: 1001

1004  IGYPS2053-S   An error was found in the definition of file "LOCATION-FILE". This input/output
statement was discarded.

Same message on line: 1016

1015  IGYPS2121-S   "LOC-CODE" was not defined as a data-name. The statement was discarded.

1212  IGYPS2121-S   "WS-NUMERIC-DATE" was not defined as a data-name. The statement was discarded.

1655  IGYPG3113-W   Truncation of high-order digit positions may occur due to precision of intermediate
results exceeding 30 digits.

Messages
Printed:    Total   Informational   Warning    Error    Severe    Terminating (6)
(1)            (1)        1        1        1        1        10

* Statistics for COBOL program IGYTCARA: (7)
* Source records = 1755
* Data Division statements = 295
* Procedure Division statements = 479
* Generated COBOL statements = 0
* Program complexity factor = 486

End of compilation 1, program IGYTCARA, highest severity 12. (8)

Return code 12

---

1. Message about options passed to the compiler at compiler invocation. This message does not appear if no options were passed.

   **OPTFILE**
   Requests options from a SYSOPTF data set.

2. Options coded in the PROCESS (or CBL) statement.

   **NOOFFSET**
   Suppresses a condensed listing of the PROCEDURE DIVISION.

   **NOMAP**
   Suppresses a map report of the items defined in the DATA DIVISION.

3. Options obtained from the SYSOPTF data set (because the OPTFILE compiler option was specified).

   **NOLIST**
   Suppresses an assembler-language expansion of the source code.

   **TEST**
   The program was compiled for use with debugging and problem determination tools (such as Debug Tool and Fault Analyzer) and to get local variables listed in CEEDUMP.

4. Status of options at the start of this compilation.

5. Program diagnostics. The first message refers you to any library phase diagnostics. Diagnostics for the library phase are presented at the beginning of the listing.

6. Count of diagnostic messages in this program, grouped by severity level.

7. Program statistics for the program IGYTCARA.

8. Program statistics for the compilation unit. When you perform a batch compilation, the return code is the highest message severity level for the entire compilation.
Example: SOURCE and NUMBER output

In the portion of the listing shown below, the programmer numbered two of the statements out of sequence. The note numbers in the listing correspond to numbered explanations that follow the listing.

```
000870 /********************************************************************************
000871 *****************      D O   M A I N   L O G I C      *******************
000872 ***                                                            ***
000873 ***********************************************************
000874 procedure division.
000875 000-do-main-logic.
000876                    display "PROGRAM IGYTCARA - Beginning".
000877                    perform 050-create-vsam-master-file.                                  930
000878                    perform 100-initialize-paragraph.                                     982
000879                    read update-transaction-file into ws-transaction-record               203 338
000880                        at end
000881 1 IA4390            set transaction-eof to true                                    253
000882                end-read.
000883 IA4410     perform until transaction-eof                                         253
000884      1               perform 200-edit-update-transaction                                 1050
000885      1  IA4430       if no-errors                                                        372
000886      2                 perform 300-print-update-transaction-error                              1312
000887      1 end-if
000888      1               perform 410-re-initialize-fields                                  1373
000889      1  IA4480       read update-transaction-file into ws-transaction-record             203 338
000890      1               set transaction-eof to true                                    253
000891      1  IA4500       end-read.                                                   1373
000892      1  IA4520       perform 1100-print-i-f-headings.                              1441
000893      1  IA4540       perform 1200-print-i-f-data.                                          1481
000894      1  IA4600     if not i-o-okay                                                       241
000895      1               display '000-close'                                              230
000896      1  IA4620       move 0000 to comp-code                                              230
000897      1               perform 900-abnormal-termination                                    1432
000898      1  IA4630       end-if.                                                      1432
000899               ***********************************************************
000900               *    Paragraphs 1100 and 1200 illustrates the intrinsic *
000901               *    function computations.                                             *
000902               *                                                                       *
000903               *    Paragraphs 1100 and 1200 illustrates the intrinsic *
000904               *    function computations.                                             *
000905               *                                                                       *
000906               *                                                                       *
000907               *                                                                       *
000908               *                                                                       *
000909               *                                                                       *
000910               *                                                                       *
000911               ***********************************************************
000912               *    Paragraphs 1100 and 1200 illustrates the intrinsic *
000913               *    function computations.                                             *
000914               *                                                                       *
000915               *                                                                       *
000916               *                                                                       *
000917               *                                                                       *
000918               *                                                                       *
000919               *                                                                       *
000920               *                                                                       *
```

Example: MAP output

The following example shows output from the MAP option. The numbers used in the explanation below correspond to the numbers that annotate the output.

```
000870 /********************************************************************************
000871 *****************      D O   M A I N   L O G I C      *******************
000872 ***                                                            ***
000873 ***********************************************************
000874 procedure division.
000875 000-do-main-logic.
000876                    display "PROGRAM IGYTCARA - Beginning".
000877                    perform 050-create-vsam-master-file.                                  930
000878                    perform 100-initialize-paragraph.                                     982
000879                    read update-transaction-file into ws-transaction-record               203 338
000880                        at end
000881 1 IA4390            set transaction-eof to true                                    253
000882                end-read.
000883 IA4410     perform until transaction-eof                                         253
000884      1               perform 200-edit-update-transaction                                 1050
000885      1  IA4430       if no-errors                                                        372
000886      2                 perform 300-print-update-transaction-error                              1312
000887      1 end-if
000888      1               perform 410-re-initialize-fields                                  1373
000889      1  IA4480       read update-transaction-file into ws-transaction-record             203 338
000890      1               set transaction-eof to true                                    253
000891      1  IA4500       end-read.                                                   1373
000892      1  IA4520       perform 1100-print-i-f-headings.                              1441
000893      1  IA4540       perform 1200-print-i-f-data.                                          1481
000894      1  IA4600     if not i-o-okay                                                       241
000895      1               display '000-close'                                              230
000896      1  IA4620       move 0000 to comp-code                                              230
000897      1               perform 900-abnormal-termination                                    1432
000898      1  IA4630       end-if.                                                      1432
000899               ***********************************************************
000900               *    Paragraphs 1100 and 1200 illustrates the intrinsic *
000901               *    function computations.                                             *
000902               *                                                                       *
000903               *                                                                       *
000904               *                                                                       *
000905               *                                                                       *
000906               *                                                                       *
000907               *                                                                       *
000908               *                                                                       *
000909               *                                                                       *
000910               *                                                                       *
000911               ***********************************************************
000912               *    Paragraphs 1100 and 1200 illustrates the intrinsic *
000913               *    function computations.                                             *
000914               *                                                                       *
000915               *                                                                       *
000916               *                                                                       *
000917               *                                                                       *
000918               *                                                                       *
000919               *                                                                       *
000920               *                                                                       *
```

(1) Scale line, which labels Area A, Area B, and source-code column numbers

(2) Source-code line number assigned by the compiler

(3) Program (PL) and statement (SL) nesting level

(4) Columns 1 through 6 of program (the sequence number area)
(1) Explanations of the data definition attribute codes.

(2) Source line number where the data item was defined.

(3) Level definition or number. The compiler generates this number in the following way:
   - First level of any hierarchy is always 01. Increase 1 for each level (any item you coded as level 02 through 49).
   - Level-numbers 66, 77, and 88, and the indicators FD and SD, are not changed.

(4) Data-name that is used in the source module in source order.
Base locator used for this data item.

Hexadecimal displacement from the beginning of the containing structure if the MAP(HEX) option is in effect. If the MAP(DEC) option is in effect, decimal displacement is shown.

Pseudoassembler code showing how the data is defined. When a structure contains variable-length fields, the maximum length of the structure is shown.

Data type and usage.

Data definition attribute codes. The definitions are explained at the top of the DATA DIVISION map.

DETAILX-LINE was not referenced in the PROCEDURE DIVISION. Because STGOPT was specified, DETAILX-LINE was deleted, resulting in the base locator being set to XXXXX.

“Example: embedded map summary” on page 377
“Example: nested program map” on page 380

related references
“Terms used in MAP output” on page 378
“Symbols used in LIST and MAP output” on page 379

Example: embedded map summary
The following example shows an embedded map summary from specifying the MAP option. The summary appears in the right margin of the listing for lines in the DATA DIVISION that contain data declarations.

```
000002     Identification Division.
000003
000004     Program-id.    IGYTCARA.
000005
000006     Data division.
000007     File section.
000008
000009     FD  COMMUTER-FILE
000010     record 80 characters.
000011 01 commuter-record.                                             BLF=00001           0CL80
000012 05 commuter-key                 PIC x(16).                    BLF=00001,000000000 16C
000013 05 filler                       PIC x(64).                    BLF=00001,000000016 64C
000014
000015     Working-storage section.
000016 01 Working-storage-for-IGYCARA    pic x.                                            1C
000017 01018 77 comp-code             pic S9999 comp.                                   2C
000019 000020 01 i-f-status-area.                          value zeroes.
000021 000022 05 i-f-file-status        pic x(2).                               000000000 2C
000023           88 i-o-successful             value zeroes.
000024         05 commuter-file-status.                                                000000002 0CL6
000025           10 vsam-r15-return-code       pic 9(2) comp.                          000000002 2C
000026           10 vsam-function-code         pic 9(1) comp.                          000000004 2C
000027           10 vsam-feedback-code         pic 9(3) comp.                          000000006 2C
000028           10 update-file-status           pic xx.                                           2C
000029           77 loccode-file-status            pic xx.                                           2C
000030           77 updprint-file-status           pic xx.                                           2C
000031
000032     01 status-area.                          value zeroes.
000033 000034 000035 000036 000037 000038
000039     01 status-area.                          value zeroes.
000040 000041 000042 000043 000044 000045 000046
000047     77 update-file-status           pic xx.                                           2C
000048           77 loccode-file-status            pic xx.                                           2C
000049           77 updprint-file-status           pic xx.                                           2C
000050
000051     01 ws-commuter-record EXTERNAL.                                 BLX=00001           0CL81
000052 000053 000054 000055 000056 000057
000058     01 ws-commuter-record EXTERNAL.                                 BLX=00001           0CL81
000059 000060 000061 000062
```

Chapter 19. Debugging 377
(1) Base locator used for this data item

(2) Decimal displacement from the beginning of the containing structure. It indicates that the MAP (DEC) option is in effect. If you specified the MAP (HEX) option or MAP with no suboption, hexadecimal displacement is shown.

(3) Pseudoassembler code showing how the data is defined

related references
“Symbols used in LIST and MAP output” on page 379

Terms used in MAP output
The following table describes the terms used in the listings produced by the MAP compiler option.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHABETIC</td>
<td>DS nC</td>
<td>Alphabetic data item (PICTURE A)</td>
</tr>
<tr>
<td>ALPHA-EDIT</td>
<td>DS nC</td>
<td>Alphabetic-edited data item</td>
</tr>
<tr>
<td>AN-EDIT</td>
<td>DS nC</td>
<td>Alphanumeric-edited data item</td>
</tr>
<tr>
<td>BINARY</td>
<td>DS 1H2, 1F2, 2F2, 2C, 4C, or 8C</td>
<td>Binary data item (USAGE BINARY, COMPUTATIONAL, or COMPUTATIONAL-5)</td>
</tr>
<tr>
<td>COMP-1</td>
<td>DS 4C</td>
<td>Single-precision internal floating-point data item (USAGE COMPUTATIONAL-1)</td>
</tr>
<tr>
<td>COMP-2</td>
<td>DS 8C</td>
<td>Double-precision internal floating-point data item (USAGE COMPUTATIONAL-2)</td>
</tr>
<tr>
<td>DBCS</td>
<td>DS nC</td>
<td>DBCS data item (USAGE DISPLAY-1)</td>
</tr>
<tr>
<td>DBCS-EDIT</td>
<td>DS nC</td>
<td>DBCS-edited data item (USAGE DISPLAY-1)</td>
</tr>
<tr>
<td>DISP-FLOAT</td>
<td>DS nC</td>
<td>Display floating-point data item (USAGE DISPLAY)</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>DS nC</td>
<td>Alphanumeric data item (PICTURE X)</td>
</tr>
<tr>
<td>DISP-NUM</td>
<td>DS nC</td>
<td>Zoned decimal data item (USAGE DISPLAY)</td>
</tr>
<tr>
<td>DISP-NUM-EDIT</td>
<td>DS nC</td>
<td>Numeric-edited data item (USAGE DISPLAY)</td>
</tr>
<tr>
<td>FD</td>
<td></td>
<td>File definition</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>FUNCTION-PTR</td>
<td>DS nC</td>
<td>Function pointer (USAGE FUNCTION-POINTER)</td>
</tr>
<tr>
<td>GROUP</td>
<td>DS OCLn(^1)</td>
<td>Fixed-length alphanumeric group data item</td>
</tr>
<tr>
<td>GRP-VARLEN</td>
<td>DS OCLn(^1)</td>
<td>Variable-length alphanumeric group data item</td>
</tr>
<tr>
<td>INDEX</td>
<td>DS nC</td>
<td>Index data item (USAGE INDEX)</td>
</tr>
<tr>
<td>INDEX-NAME</td>
<td>DS nC</td>
<td>Index name</td>
</tr>
<tr>
<td>NATIONAL</td>
<td>DS nC</td>
<td>Category national data item (USAGE NATIONAL)</td>
</tr>
<tr>
<td>NAT-EDIT</td>
<td>DS nC</td>
<td>National-edited data item (USAGE NATIONAL)</td>
</tr>
<tr>
<td>NAT-FLOAT</td>
<td>DS nC</td>
<td>National floating-point data item (USAGE NATIONAL)</td>
</tr>
<tr>
<td>NAT-GROUP</td>
<td>DS OCLn(^1)</td>
<td>National group (GROUP-USAGE NATIONAL)</td>
</tr>
<tr>
<td>NAT-GRP-VARLEN</td>
<td>DS OCLn(^1)</td>
<td>National variable-length group (GROUP-USAGE NATIONAL)</td>
</tr>
<tr>
<td>NAT-NUM</td>
<td>DS nC</td>
<td>National decimal data item (USAGE NATIONAL)</td>
</tr>
<tr>
<td>NAT-NUM-EDIT</td>
<td>DS nC</td>
<td>National numeric-edited data item (USAGE NATIONAL)</td>
</tr>
<tr>
<td>OBJECT-REF</td>
<td>DS nC</td>
<td>Object-reference data item (USAGE OBJECT REFERENCE)</td>
</tr>
<tr>
<td>PACKED-DEC</td>
<td>DS nP</td>
<td>Internal decimal data item (USAGE PACKED-DECIMAL or COMPUTATIONAL-3)</td>
</tr>
<tr>
<td>POINTER</td>
<td>DS nC</td>
<td>Pointer data item (USAGE POINTER)</td>
</tr>
<tr>
<td>PROCEDURE-PTR</td>
<td>DS nC</td>
<td>Procedure pointer (USAGE PROCEDURE-POINTER)</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>Sort file definition</td>
</tr>
<tr>
<td>VSAM, QSAM, LINESEQ</td>
<td></td>
<td>File processing method</td>
</tr>
<tr>
<td>1-49, 77</td>
<td></td>
<td>Level-numbers for data descriptions</td>
</tr>
<tr>
<td>66</td>
<td></td>
<td>Level-number for RENAMES</td>
</tr>
<tr>
<td>88</td>
<td></td>
<td>Level-number for condition-names</td>
</tr>
</tbody>
</table>

1. \( n \) is the size in bytes for fixed-length groups and the maximum size in bytes for variable-length groups.
2. If the SYNCHRONIZED clause appears, these fields are used.

Symbols used in LIST and MAP output
The following table describes the symbols used in the listings produced by the LIST or MAP option.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLF(_n^1)</td>
<td>Base locator for files</td>
</tr>
<tr>
<td>BLL(_n^1)</td>
<td>Base locator for LINKAGE SECTION</td>
</tr>
<tr>
<td>BLO(_n^1)</td>
<td>Base locator for object instance data</td>
</tr>
<tr>
<td>BLT(_n^1)</td>
<td>Base locator for XML-TEXT and XML-NTEXT</td>
</tr>
<tr>
<td>BLV(_n^1)</td>
<td>Base locator for variably located data</td>
</tr>
</tbody>
</table>
Table 52. Symbols used in LIST and MAP output (continued)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLX_n(^1)</td>
<td>Base locator for external data</td>
</tr>
<tr>
<td>ODOsv_cell</td>
<td>ODO save cell number</td>
</tr>
<tr>
<td>Pf_m_cell</td>
<td>PERFORM cell number</td>
</tr>
<tr>
<td>Pfmsv_cell</td>
<td>Perform save cell number</td>
</tr>
<tr>
<td>TSN=N</td>
<td>Temporary created by the compiler</td>
</tr>
<tr>
<td>VLC_cell</td>
<td>Variable-length cell (ODO)</td>
</tr>
<tr>
<td>VN_cell</td>
<td>Variable name cell for PERFORM statement</td>
</tr>
<tr>
<td>VNGO_cell</td>
<td>Variable name cell for ALTER statement</td>
</tr>
<tr>
<td>VNI_cell</td>
<td>Variable name initialization</td>
</tr>
<tr>
<td>#Calc00000000n</td>
<td>Code to compute addresses of data that is present after an OCCURS DEPENDING ON clause</td>
</tr>
<tr>
<td>#WSVal0000000n</td>
<td>Code to initialize the WORKING-STORAGE area for a procedure</td>
</tr>
<tr>
<td>_ArgumentList</td>
<td>Outgoing arguments to a procedure</td>
</tr>
<tr>
<td>_ACON</td>
<td>Address of a symbol</td>
</tr>
<tr>
<td>_BEtempNNN</td>
<td>Temporary created by the optimizer</td>
</tr>
<tr>
<td>_CAA</td>
<td>Address of the start of the Language Environment Common Anchor Area</td>
</tr>
<tr>
<td><em>CACHED</em>$STATIC</td>
<td>Copy of the start address of the static area (for this procedure)</td>
</tr>
<tr>
<td>_CONSTANT_AREA+n</td>
<td>Offset in the Constant Area</td>
</tr>
<tr>
<td>_CRENT</td>
<td>Address of the writeable static area (for this module), from the CAA</td>
</tr>
<tr>
<td>_incomingArgumentList</td>
<td>Incoming parameters to the procedure</td>
</tr>
<tr>
<td>_parentDSA</td>
<td>For a nested procedure, it is the address of its parent's stack</td>
</tr>
<tr>
<td>_QCON</td>
<td>Offset to a symbol</td>
</tr>
<tr>
<td>_returnValue</td>
<td>Return value of the procedure</td>
</tr>
<tr>
<td>_VTS_n</td>
<td>Temporary created by the optimizer</td>
</tr>
</tbody>
</table>

1. n is the number of the entry. For base locators, it can also be XXXXX, indicating a data item that was deleted by STG0PT processing.

Example: nested program map
This example shows a map of nested procedures produced by specifying the MAP compiler option. Numbers in parentheses refer to notes that follow the example.

<table>
<thead>
<tr>
<th>Source Nesting</th>
<th>Program Nesting</th>
<th>Program Attribute codes (rightmost column) have the following meanings:</th>
<th>Program Name</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>LineID Level</td>
<td>Program Name</td>
<td>C = COMMON</td>
<td></td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>from PROGRAM-ID paragraph</td>
<td>I = INITIAL (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>U = PROCEDURE DIVISION USING...</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Source Nesting (5)</td>
<td>Program</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>NESTMAIN.</td>
<td></td>
<td>U</td>
</tr>
<tr>
<td>(2)199</td>
<td>1</td>
<td>SUBPRO1</td>
<td></td>
<td>I,C,U</td>
</tr>
</tbody>
</table>

Example:
This example shows a map of nested procedures produced by specifying the MAP compiler option. Numbers in parentheses refer to notes that follow the example.
Explanations of the program attribute codes

Source line number where the program was defined

Depth of program nesting

Program-name

Program attribute codes

Reading LIST output

Parts of the LIST compiler output might be useful to you for debugging a program.

The LIST compiler option produces several pieces of output:

- An assembler listing of the initialization code for the program (program signature information bytes) from which you can verify program characteristics such as:
  - Compiler options in effect
  - Types of data items present
  - statements used in the PROCEDURE DIVISION
- An assembler listing of the source code for the program
  From the address in storage of the instruction that was executing when an abend occurred, you can find the COBOL statement that corresponds to that instruction. After you find the address of the failing instruction, go to the assembler listing and find the statement for which that instruction was generated. The line number is in the 3rd column of the assembler listing for your program. Using the line number, you can locate the STATEMENT by looking at the corresponding line in the Source Output section of the listing.
- Information about WORKING-STORAGE. This information is contained in the Data Division Map and in the Static Map.
- A description of the writeable static area (WSA) is found in the Static Map or WSA24 Map sections of the listing. The symbols in WORKING-STORAGE area of the source are mapped into the writable static area that is shown in the Static Map.

You can use the Data Division Map along with the Static Map section to find the location of data items defined in WORKING-STORAGE. These data items reside in the Writeable Static Area (WSA or WSA24). The Static Map gives the offset of each level-1 data item relative to the beginning of the writable static area. The Data Division Map section gives the offset of the level-n data items relative to their respective level-1 member. By using both pieces of information, you can determine the offset of any data member within the writable static area.

If you compile with the DATA24 option, data items mapped below the line will appear in the WSA24 Map. You can follow the same process to determine their locations.

- Information about the constants and the literals used in the program. The Constant Area contains information about the constants and literals in the program, as well as those created by the compiler. This section contains the offset of each constant or literal within the Constant Area.
- Program prolog areas (PPA1, PPA2, PPA3, PPA4) contain information about the characteristics of the compiled program.
• Externals symbols dictionary contains the list of external symbols defined by or referred to, in your program.

• Map of the dynamic save area (DSA)

The map of the DSA (also known as the stack frame) contains information about the contents of the storage acquired each time a separately compiled procedure is entered.

You do not need to be able to program in assembler language to understand the LIST output. The comments that accompany most of the assembler code provide you with a conceptual understanding of the functions performed by the code.

“Example: Program initialization code” on page 390
“Example: MD5 signature” on page 391
“Example: Timestamp and version information” on page 391
“Example: Compiler options and program information” on page 392
“Example: Assembler code generated from source code” on page 392
“Example: Program prolog areas” on page 393
“Example: Static map” on page 394
“Example: Constant area” on page 395
“Example: Base locator table” on page 396
“Example: External symbols” on page 397

“Example: DSA memory map (Automatic map)” on page 397

related references
“Signature information bytes” on page 382
“Example: MAP output” on page 375

Language Environment Programming Guide (Stack storage overview)

Signature information bytes
The tables in this topic show program signature information that is part of the listing of program initialization code provided when you use the LIST compiler option.

Table 53. Compiler options in the INFO BYTE section

<table>
<thead>
<tr>
<th>Offset in decimal</th>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>CODEPAGE</td>
<td>CCSID value specified for EBCDIC code page</td>
</tr>
<tr>
<td>02</td>
<td>ARCH</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>03</td>
<td>OPTIMIZE</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

The INFO BYTE section of the listing also provides the following values:

• The number of DATA DIVISION statements
• The number of PROCEDURE DIVISION statements

In the following table, different signature bytes represent different information:
- Signature bytes 1-5, and 26-31 refer to compiler options
- Signature bytes 6-7 refer to DATA DIVISION items
- Signature byte 8 refers to ENVIRONMENT DIVISION items
- Signature bytes 9-25 refer to PROCEDURE DIVISION statements and items

<table>
<thead>
<tr>
<th>Offset in decimal</th>
<th>Signature byte</th>
<th>Bit</th>
<th>Item</th>
<th>On</th>
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</tr>
<tr>
<td>22</td>
<td>15</td>
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<td>USE</td>
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<td></td>
<td>1</td>
<td>WRITE</td>
<td></td>
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<tr>
<td></td>
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<td>2</td>
<td>CONTINUE</td>
<td></td>
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<td></td>
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<td>3</td>
<td>END-ADD</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>4</td>
<td>END-CALL</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>5</td>
<td>END-COMPUTE</td>
<td></td>
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<tr>
<td></td>
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<td>6</td>
<td>END-DELETE</td>
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<td>7</td>
<td>END-DIVIDE</td>
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<td></td>
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<tr>
<td>Offset in decimal</td>
<td>Signature byte</td>
<td>Bit</td>
<td>Item</td>
<td></td>
<td></td>
</tr>
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<td>------------------</td>
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<td>-----</td>
<td>-----------------------------</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>0</td>
<td>END-EVALUATE</td>
<td></td>
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<td>23</td>
<td>16</td>
<td>1</td>
<td>END-IF</td>
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<td>2</td>
<td>END-MULTIPLY</td>
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<td></td>
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<td>3</td>
<td>END-READ</td>
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<td>4</td>
<td>END-RETURN</td>
<td></td>
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<td>5</td>
<td>END-REWRITE</td>
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<td>6</td>
<td>END-SEARCH</td>
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<td>7</td>
<td>END-START</td>
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<td>24</td>
<td>17</td>
<td>0</td>
<td>END-STRING</td>
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<td>1</td>
<td>END-SUBTRACT</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2</td>
<td>END-UNSTRING</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>END-WRITE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>GOBACK</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>EVALUATE</td>
<td></td>
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</tr>
<tr>
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<td>6</td>
<td>SERVICE</td>
<td></td>
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<td></td>
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<td>25</td>
<td>18</td>
<td>0</td>
<td>END-INVOKE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>END-EXEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>XML</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>END-XML</td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>4</td>
<td>ALLOCATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>FREE</td>
<td></td>
<td></td>
</tr>
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<td>6</td>
<td>JSON</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>END-JSON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>19</td>
<td>0-7</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>20</td>
<td>0-7</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>21</td>
<td>0</td>
<td>Hexadecimal literal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Altered GO TO</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>I-O ERROR declarative</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>DEBUGGING declarative</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Program segmentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>OPEN ... EXTEND</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>EXIT PROGRAM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 54. Signature information bytes (continued)

<table>
<thead>
<tr>
<th>Offset in decimal</th>
<th>Signature byte</th>
<th>Bit</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>CALL literal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>CALL identifier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>CALL . . . ON OVERFLOW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>CALL . . . LENGTH OF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>CALL . . . ADDRESS OF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>CLOSE . . . REEL/UNIT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Exponentiation used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Floating-point items used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>COPY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>BASIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>DBCS name in program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Shift-out and Shift-in in program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>SUPPRESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>SSRANGE(ZLEN) (if bit 6 in byte 3 is on)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>SSRANGE(ABD) (if bit 6 in byte 3 is on)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>INLINE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>DBCS literal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>REPLACE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Reference modification was used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Nested program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>INITIAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>COMMON</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>SELECT . . . OPTIONAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>EXTERNAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>GLOBAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>RECORD IS VARYING</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>VOLATILE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Intrinsic function was used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Z-literal found</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>RECURSIVE</td>
</tr>
</tbody>
</table>
Check return code: A return code greater than 4 from the compiler could mean that some of the statements shown in the information bytes might have been discarded from the program.

related references
“LIST” on page 315
z/OS Language Environment Vendor Interfaces (COBOL-specific vendor interfaces)

Example: Program initialization code
A listing of the program initialization code gives you information about the characteristics of the COBOL source program. Interpret the program signature information bytes to verify characteristics of your program.

<table>
<thead>
<tr>
<th>Offset in decimal</th>
<th>Signature byte</th>
<th>Bit</th>
<th>Item</th>
<th>On</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>26</td>
<td>0</td>
<td>RMODE(ANY)</td>
<td>Not RMODE(ANY)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>INTDATE(LILIAN)</td>
<td>INTDATE(ANSI)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>27</td>
<td>0</td>
<td>PGMNAME(LONGUPPER)</td>
<td>Not PGMNAME(LONGUPPER)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>PGMNAME(LONGMIXED)</td>
<td>Not PGMNAME(LONGMIXED)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>DLL</td>
<td>NODLL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>EXPORTALL</td>
<td>NOEXPORTALL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>TEST(SOURCE)</td>
<td>Not TEST(SOURCE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>ARITH(EXTEND)</td>
<td>ARITH(COMPAT)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>THREAD</td>
<td>NOTHREAD</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>TEST(EJPD)</td>
<td>TEST(NOEJPD)</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>28</td>
<td>0-7</td>
<td>Build level info</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example: MD5 signature

The following example shows LIST output about the MD5 signature. This information is also included in the DWARF debugging data in the application module. MD5 signature is located at 16 bytes before the Timestamp and Version Information section.

Note: The MD5 signature is shown only if the TEST option is specified or if -g is specified with cob2 under z/OS UNIX.

The presence or absence of the MD5 signature is indicated by a compilation flag bit of the PPA2. If the bit is set to 1, the MD5 signature is present; if the bit is set to 0, the MD5 signature is absent. For details about PPA2, see z/OS Language Environment Vendor Interfaces.

Example: Timestamp and version information

The following example shows LIST output about the version of the compiler and the data and time of compilation.

related references

“Example: Program prolog areas” on page 393

Chapter 19. Debugging 391
Example: Compiler options and program information
The following example shows LIST output for the compiler options and program information.

<table>
<thead>
<tr>
<th>Offset (1)</th>
<th>Option (2)</th>
<th>Value (3)</th>
<th>Assembler Representation (4)</th>
<th>Explanation (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00290C</td>
<td>0030</td>
<td>=X'0030'</td>
<td>Size of Compiler Options and Program Information Section</td>
<td></td>
</tr>
<tr>
<td>00290E (+00)</td>
<td>0474</td>
<td>=X'0474'</td>
<td>UNSIGNED BINARY CODE PAGE CCSID VALUE</td>
<td></td>
</tr>
<tr>
<td>00291D (+02)</td>
<td>06</td>
<td>=X'06'</td>
<td>ARCHITECTURE LEVEL</td>
<td></td>
</tr>
<tr>
<td>00291E (+03)</td>
<td>00</td>
<td>=X'00'</td>
<td>OPTIMIZATION LEVEL</td>
<td></td>
</tr>
<tr>
<td>00291F (+04)</td>
<td>1406</td>
<td>=X'1406'</td>
<td>INFO. BYTES 28-29</td>
<td></td>
</tr>
<tr>
<td>002920 (+06)</td>
<td>0000</td>
<td>=X'0000'</td>
<td>RESERVED</td>
<td></td>
</tr>
<tr>
<td>002921 (+08)</td>
<td>A04875CC2001</td>
<td>=X'A04875CC2001'</td>
<td>INFO. BYTES 1-6</td>
<td></td>
</tr>
<tr>
<td>002922 (+14)</td>
<td>100010884909</td>
<td>=X'100010884909'</td>
<td>INFO. BYTES 7-12</td>
<td></td>
</tr>
<tr>
<td>002924 (+20)</td>
<td>002008800C00</td>
<td>=X'002008800C00'</td>
<td>INFO. BYTES 13-18</td>
<td></td>
</tr>
<tr>
<td>002926 (+26)</td>
<td>000001A000</td>
<td>=X'000001A000'</td>
<td>INFO. BYTES 19-23</td>
<td></td>
</tr>
<tr>
<td>002928 (+31)</td>
<td>0000002F</td>
<td>=X'0000002F'</td>
<td># DATA DIVISION STATEMENTS</td>
<td></td>
</tr>
<tr>
<td>00292A (+36)</td>
<td>0000005B</td>
<td>=X'0000005B'</td>
<td># PROCEDURE DIVISION STATEMENTS</td>
<td></td>
</tr>
<tr>
<td>00292C (+40)</td>
<td>18808008</td>
<td>=X'18808008'</td>
<td>INFO. BYTES 24-27</td>
<td></td>
</tr>
</tbody>
</table>

Example: Assembler code generated from source code
The following example shows a listing of the assembler code that is generated from source code when you use the LIST compiler option. You can use this listing to find the COBOL statement that corresponds to the instruction that failed.

000964: display "PROGRAM IGYTCARA - Beginning". (1)

<table>
<thead>
<tr>
<th>Offset (1)</th>
<th>Option (2)</th>
<th>Value (3)</th>
<th>Assembler Representation (4)</th>
<th>Explanation (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001EA</td>
<td>E320 3394 0171</td>
<td>000964</td>
<td>LAY R2,5012(,R3)</td>
<td>#</td>
</tr>
<tr>
<td>0001F0</td>
<td>D203 D5E8 2000</td>
<td>000964</td>
<td>MVC 1512(4,R13),0(R2)</td>
<td># $CONSTANT_AREA+5012</td>
</tr>
<tr>
<td>0001F6</td>
<td>E320 3398 0171</td>
<td>000964</td>
<td>LAY R2,5016(,R3)</td>
<td>#</td>
</tr>
<tr>
<td>000202</td>
<td>4120 39C8</td>
<td>000964</td>
<td>LA R2,2504(,R3)</td>
<td>#</td>
</tr>
<tr>
<td>000206</td>
<td>5020 D5F0</td>
<td>000964</td>
<td>ST R2,1520(,R13)</td>
<td>#</td>
</tr>
<tr>
<td>00020A</td>
<td>E320 338C 0171</td>
<td>000964</td>
<td>LAY R2,5004(,R3)</td>
<td>#</td>
</tr>
<tr>
<td>000210</td>
<td>D203 D5F4 2000</td>
<td>000964</td>
<td>MVC 1524(4,R13),0(R2)</td>
<td># $CONSTANT_AREA+5016</td>
</tr>
<tr>
<td>000216</td>
<td>4120 39C8</td>
<td>000964</td>
<td>LA R2,2504(,R3)</td>
<td>#</td>
</tr>
<tr>
<td>000222</td>
<td>0703 D5FC D5FC</td>
<td>000964</td>
<td>XC 1532(4,R13),1532(R13)</td>
<td>#</td>
</tr>
<tr>
<td>000228</td>
<td>4110 05EB</td>
<td>000964</td>
<td>LA R1,1512(,R13)</td>
<td># ArgumentList</td>
</tr>
<tr>
<td>00022C</td>
<td>03F0 31D4 0158</td>
<td>000964</td>
<td>LY R15,4564(,R3)</td>
<td># ACON</td>
</tr>
<tr>
<td>000232</td>
<td>5BC0 0080</td>
<td>000964</td>
<td>L R14,128(,R13)</td>
<td># CCA</td>
</tr>
<tr>
<td>000236</td>
<td>0DEF</td>
<td>000964</td>
<td>BASR R14,R15</td>
<td># Call &quot;IGZXDSP&quot;</td>
</tr>
</tbody>
</table>

(1) Source code interspersed with the pseudo-assembler instructions
(2) Relative location of the object code instruction in the module, in hexadecimal notation
(3) Object code instructions, in hexadecimal notation
The first two or four hexadecimal digits are the instruction, and the remaining digits are the instruction operands. Some instructions have two operands.

(4) Source line number associated with this assembler code

(5) Object code instructions, in compiler-generated pseudo assembler

(6) Explanation of the instruction and the operands used by the instructions

related references
“Symbols used in LIST and MAP output” on page 379

Example: Program prolog areas
The following example shows LIST output for the program prolog area. The Program Prologue Area (PPA) is comprised of several sections that contain information about the compiled program.

There is a PPA1 for every procedure in your program, including procedures generated by the compiler. The offset to its corresponding PPA1 is recorded at offset 12 (X'C') from the start of each procedure. The PPA1 contains information about the procedure as well as offsets to the PPA2 and PPA3 sections.

For details on how to use the program prolog areas to locate information in the listing file, see z/OS Language Environment Vendor Interfaces.

There is one PPA2 for each program. The offset to the PPA2 is recorded in each PPA1. The PPA2 contains offsets to the Time Stamp and Version Information section of the listing as well as to the PPA4 section.

If the TEST option is not in effect, the PPA2 section looks like this:

If the TEST option is in effect, the PPA2 section looks like this:

Chapter 19. Debugging 393
There is one PPA3 for each program (including each nested program) in a COBOL source file. Each entry contains offsets, relative to the PPA3 itself, to the base locator table and to the special register table. The PPA3 also contains an offset from the start of the program to the first COBOL statement.

<table>
<thead>
<tr>
<th>PPA3: Entry Point Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>001408 00000000</td>
</tr>
<tr>
<td>00144C 0000000C</td>
</tr>
<tr>
<td>001460 00000008</td>
</tr>
<tr>
<td>001460 000001B4</td>
</tr>
</tbody>
</table>

There is one PPA4 for each program. It has offsets to various compiler generated tables, such as the writable static area (the Static Map and WSA24 sections). The offset to the PPA4 is recorded in a field of the PPA2.

<table>
<thead>
<tr>
<th>PPA4: Entry Point Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>008340 08000000</td>
</tr>
<tr>
<td>008344 00020100</td>
</tr>
<tr>
<td>008348 00000000</td>
</tr>
<tr>
<td>008350 00000000</td>
</tr>
<tr>
<td>008354 00000000</td>
</tr>
<tr>
<td>008358 00000000</td>
</tr>
<tr>
<td>00835C 00000000</td>
</tr>
<tr>
<td>008360 00000000</td>
</tr>
<tr>
<td>008364 00000000</td>
</tr>
<tr>
<td>008368 0002A</td>
</tr>
<tr>
<td>00836C 00000000</td>
</tr>
<tr>
<td>008370 00000000</td>
</tr>
<tr>
<td>008374 00000000</td>
</tr>
</tbody>
</table>

1 Relative location, in hexadecimal format, of the PPA field in the object module
2 The contents of the field, in hexadecimal
3 An assembler-like syntax defining the field
4 A description of the contents of the field.

related references
z/OS Language Environment Vendor Interfaces
WORKING-STORAGE SECTION changes (Enterprise COBOL for z/OS Migration Guide)

Example: Static map

The three map sections in the listing, STATIC MAP, WORKING-STORAGE MAP, and WSA24 MAP are collectively called the static maps of a program. The storage for these areas is allocated at the start of the program and persists until the end of the run unit or until the program is canceled.

The layout of these three map sections is similar:

- The first column shows the offset of the item from a block of storage allocated by the compiler.
- The second column is the size of the symbol, including all of its sublevel members.
- The third column is the name of the area being described.

See the following STATIC MAP as an example of the layout. If the NORENT compiler option is in effect, the WORKING-STORAGE data items are mapped in the STATIC MAP section. For COBOL data items, the offset is the offset to the start of the level-01 data item from the block of storage allocated by the compiler. The starting address of this block resides in the Constant Area.

<table>
<thead>
<tr>
<th>* * * * * S T A T I C       M A P * * * * *</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFFSET (HEX)</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>
If the RENT and DATA(31) compiler options are in effect, the WORKING-Storage data items are shown under the WORKING-Storage MAP. If the RENT and DATA(24) options are in effect, the WORKING-Storage data items are shown under the WSA 24 MAP. A STATIC MAP section is also shown where compiler generated internal data items and locators are mapped.

**Example: Constant area**
The following example shows LIST output about strings and other literals from the COBOL source as well as those generated by the compiler.

The compiler generates loads from (and stores to) the Constant Area by loading the starting address of Constant Area and adding the fixed offsets to the respective constants or literals.
Offset in csect.

Offset in base 10.

8 columns containing the bytes in the Constant Area

Character representation. A dot (.) is used for non-printable characters.

**Example: Base locator table**
The following example shows LIST output for the base locator table.

<table>
<thead>
<tr>
<th>Base Locator Table</th>
<th>=X'1'</th>
<th>Table Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>008AB0 01</td>
<td></td>
<td>=X'0'</td>
</tr>
<tr>
<td>008AB1 00</td>
<td></td>
<td>=X'8'</td>
</tr>
<tr>
<td>008AB2 008</td>
<td></td>
<td>=F'16'</td>
</tr>
<tr>
<td>008AB4 00000010</td>
<td></td>
<td>=X'2A00'</td>
</tr>
<tr>
<td>008ABB 2A00</td>
<td></td>
<td>=X'14'</td>
</tr>
<tr>
<td>008ABA 00000014</td>
<td></td>
<td>=X'3'</td>
</tr>
<tr>
<td>008ABE 03</td>
<td></td>
<td>=X'0'</td>
</tr>
<tr>
<td>008ABF 0A00</td>
<td></td>
<td>=X'5'</td>
</tr>
<tr>
<td>008AC1 00000000</td>
<td></td>
<td>=X'0'</td>
</tr>
<tr>
<td>008AC5 05</td>
<td></td>
<td>=X'0'</td>
</tr>
<tr>
<td>008AC6 0000</td>
<td></td>
<td>Flags &amp; info (end of array)</td>
</tr>
</tbody>
</table>

For more information about the base locator table, see *z/OS Language Environment Vendor Interfaces*.

**related references**
*z/OS Language Environment Vendor Interfaces* (Base locator table)

**Example: Special register table**
The following example shows LIST output for the special register table. The special register table has a similar format to the base locator table.

<table>
<thead>
<tr>
<th>Special Register Table</th>
<th>=X'1'</th>
<th>Table Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>0015B0 01</td>
<td></td>
<td>=X'0'</td>
</tr>
<tr>
<td>0015B1 00</td>
<td></td>
<td>=X'8'</td>
</tr>
<tr>
<td>0015B2 008</td>
<td></td>
<td>=F'16'</td>
</tr>
<tr>
<td>0015B4 00000006</td>
<td></td>
<td>=X'2A00'</td>
</tr>
<tr>
<td>0015BB 12</td>
<td></td>
<td>=X'14'</td>
</tr>
<tr>
<td>0015BB 00000018</td>
<td></td>
<td>=X'3'</td>
</tr>
<tr>
<td>0015BD 00</td>
<td></td>
<td>=X'0'</td>
</tr>
<tr>
<td>array)</td>
<td></td>
<td>Flags &amp; info (end of array)</td>
</tr>
</tbody>
</table>

Each entry in the special register table consists of the following items:

- A byte which represents the following information:
  - Special register ID number (bits 0 - 4). ID = 1 represents the RETURN-CODE register
  - Access mode (bits 5 - 8)
    - MODE = 0; Base Address = Top of Stack
    - MODE = 1; Base Addr = NORENT Static
    - MODE = 2; Base Addr = 32-bit RENT static
    - MODE = 3; 24-bit NORENT static
  - An offset to the special register

The end of the special register table is indicated by a null byte.
Example: External symbols
The following example shows LIST output for external symbols defined by, or referred to in your program. The external symbol dictionary contains one entry per external symbol defined by or referred to in the program.

Each entry contains the address, length and symbol type. Symbol types are:

- **ED**: External Definition
- **SD**: Section Definition
- **LD**: Label Definition
- **ER**: External Reference
- **PR**: Pseudo Register

### External Symbol Dictionary

<table>
<thead>
<tr>
<th>TYPE</th>
<th>ID</th>
<th>ADDR</th>
<th>LENGTH</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>1</td>
<td>000000</td>
<td>000000</td>
<td>IGYTCARA</td>
</tr>
<tr>
<td>ED</td>
<td>2</td>
<td>000000</td>
<td>000000</td>
<td>C_CEESG003</td>
</tr>
<tr>
<td>ED</td>
<td>3</td>
<td>008AC8</td>
<td>000000</td>
<td>C_CODE</td>
</tr>
<tr>
<td>LD</td>
<td>4</td>
<td>000000</td>
<td>000000</td>
<td>IGYTCARA#C</td>
</tr>
<tr>
<td>ER</td>
<td>5</td>
<td>000000</td>
<td>000000</td>
<td>CEESTART</td>
</tr>
<tr>
<td>ER</td>
<td>6</td>
<td>000000</td>
<td>000000</td>
<td>CEEBETBL</td>
</tr>
<tr>
<td>ED</td>
<td>7</td>
<td>000000</td>
<td>000000</td>
<td>C_WSA</td>
</tr>
<tr>
<td>PR</td>
<td>8</td>
<td>002204</td>
<td>000000</td>
<td>IGYTCARA#S</td>
</tr>
<tr>
<td>ED</td>
<td>9</td>
<td>000000</td>
<td>000222</td>
<td>B_IDRL</td>
</tr>
<tr>
<td>ER</td>
<td>10</td>
<td>000000</td>
<td>000000</td>
<td>IGZXBST</td>
</tr>
<tr>
<td>ER</td>
<td>11</td>
<td>000000</td>
<td>000000</td>
<td>IGYTCARA</td>
</tr>
<tr>
<td>ER</td>
<td>12</td>
<td>000000</td>
<td>000000</td>
<td>IGZXPR5</td>
</tr>
<tr>
<td>ER</td>
<td>13</td>
<td>000000</td>
<td>000000</td>
<td>IGZXCMGS</td>
</tr>
<tr>
<td>ER</td>
<td>14</td>
<td>000000</td>
<td>000000</td>
<td>IGZXDSP</td>
</tr>
<tr>
<td>ER</td>
<td>15</td>
<td>000000</td>
<td>000000</td>
<td>IGZXVCLS</td>
</tr>
</tbody>
</table>

Example: DSA memory map (Automatic map)
The following example shows LIST output for the dynamic save area (DSA). The DSA contains information about the contents of the storage acquired when a separately compiled procedure is entered.

<table>
<thead>
<tr>
<th>OFFSET (HEX)</th>
<th>LENGTH (HEX)</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>4</td>
<td>_@CAA</td>
</tr>
<tr>
<td>C8</td>
<td>3</td>
<td>_BEtemp200</td>
</tr>
<tr>
<td>CC</td>
<td>3</td>
<td>_BEtemp204</td>
</tr>
<tr>
<td>D0</td>
<td>3</td>
<td>_BEtemp208</td>
</tr>
<tr>
<td>D4</td>
<td>3</td>
<td>_BEtemp212</td>
</tr>
<tr>
<td>D8</td>
<td>3</td>
<td>_BEtemp216</td>
</tr>
<tr>
<td>DC</td>
<td>3</td>
<td>_BEtemp220</td>
</tr>
<tr>
<td>E0</td>
<td>3</td>
<td>_BEtemp224</td>
</tr>
<tr>
<td>E4</td>
<td>3</td>
<td>_BEtemp228</td>
</tr>
<tr>
<td>E8</td>
<td>10</td>
<td>_BEtemp232</td>
</tr>
<tr>
<td>F8</td>
<td>20</td>
<td>_BEtemp248</td>
</tr>
<tr>
<td>118</td>
<td>20</td>
<td>_BEtemp250</td>
</tr>
<tr>
<td>138</td>
<td>4</td>
<td>_BEtemp312</td>
</tr>
<tr>
<td>13C</td>
<td>4</td>
<td>_BEtemp316</td>
</tr>
<tr>
<td>140</td>
<td>4</td>
<td>_BEtemp320</td>
</tr>
<tr>
<td>144</td>
<td>4</td>
<td>_BEtemp324</td>
</tr>
</tbody>
</table>
An "M" preceding a data-name reference indicates that the data-name is modified by this reference.

(4)
Context usage is indicated by the letter preceding a procedure-name reference. These letters and their meanings are:
A = ALTER (procedure-name)
D = GO TO (procedure-name) DEPENDING ON
E = End of range of (PERFORM) through (procedure-name)
G = GO TO (procedure-name)
P = PERFORM (procedure-name)
T = (ALTER) TO PROCEED TO (procedure-name)
U = USE FOR DEBUGGING (procedure-name)
Example: XREF output: program-name cross-references
The following example shows a sorted cross-reference of program-names produced by the XREF compiler option. Numbers in parentheses refer to notes that follow the example.

<table>
<thead>
<tr>
<th>(1) Defined</th>
<th>(2) Cross-reference of programs</th>
<th>(3) References</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTERNAL</td>
<td>EXTERNAL1. . . . . . . . . . . . 25</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>X. . . . . . . . . . . . . . . . 41</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>X1 . . . . . . . . . . . . . . . 33 7</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>X11. . . . . . . . . . . . . . . 25 16</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>X12. . . . . . . . . . . . . . . 32 17</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>X2 . . . . . . . . . . . . . . . 40 8</td>
<td></td>
</tr>
</tbody>
</table>

(1) Line number where the program-name was defined. If the program is external, the word EXTERNAL is displayed instead of a definition line number.

(2) Program-name.

(3) Line numbers where the program is referenced.

Example: XREF output: COPY/BASIS cross-references
The following example shows a sorted cross-reference of copybooks to the library-names and data-set names of the associated copybooks, produced by the XREF compiler option under z/OS. Numbers in parentheses refer to notes after the example.

COPY/BASIS cross-reference of text-names, library names

<table>
<thead>
<tr>
<th>(1) Text-name</th>
<th>(2) Library</th>
<th>(3) File name</th>
<th>(4) Concat</th>
<th>(5) ISPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td>(DDNAME)</td>
<td>(Data set name)</td>
<td>Level</td>
<td>Created</td>
</tr>
<tr>
<td>ACTIONS</td>
<td>OTHERLIB</td>
<td>USERID.COBOL.COPY</td>
<td>0</td>
<td>1992/07/11</td>
</tr>
<tr>
<td>ACTIONS</td>
<td>SYSLIB</td>
<td>USERID.COBOL.COPY</td>
<td>0</td>
<td>1992/07/11</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>ALTDXXY</td>
<td>USERID.COBOL.LIB3</td>
<td>0</td>
<td>2007/06/01</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>SYSLIB</td>
<td>USERID.COBOL.LIB2PDSE</td>
<td>1</td>
<td>2007/06/07</td>
</tr>
<tr>
<td>HOUSE</td>
<td>ALTDXXY</td>
<td>USERID.COBOL.LIB2</td>
<td>1</td>
<td>2007/06/07</td>
</tr>
</tbody>
</table>
Text-name and library (an abbreviation for library-name) are from the statement COPY text-name OF library-name in the source, for example, Copy ACTIONS Of OTHERLIB.

The name of the data set from which the COPY member was copied.

Abbreviation for concatenation level. Indicates how many levels deep a given data set is from the first data set in the concatenation for a given ddname.

For example, four data sets in the example above are concatenated to ddname SYSLIB:

<table>
<thead>
<tr>
<th>DDNAME</th>
<th>DSNAME</th>
<th>(concatenation level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSLIB</td>
<td>DSN=USERID.COBOL.COPY</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DSN=USERID.COBOL.LIB2PDSE</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>DSN=USERID.COBOL.LIB3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>DSN=USERID.COBOL.LIB4X</td>
<td>3</td>
</tr>
</tbody>
</table>

Thus for example member NSMAP shown in the listing above was found in data set USERID.COBOL.LIB3, which is two levels down from the first data set in the SYSLIB concatenation.

Creation date is shown if the PDSE was edited with STATS ON in ISPF.

Tip: Under z/OS, if there is more than one data set in your SYSLIB concatenation, the COPY/BASIS cross-reference might in some cases be incomplete or missing. For details, see the related reference about the XREF compiler option.

If you compile in the z/OS UNIX shell, the cross-reference looks like the excerpt shown below.

COPY/BASIS cross-reference of text-names, library names, and file names

<table>
<thead>
<tr>
<th>(5) Text-name</th>
<th>(5) Library-name</th>
<th>(6) File name</th>
</tr>
</thead>
<tbody>
<tr>
<td>'/copydir/copyM.cbl'</td>
<td>SYSLIB</td>
<td>/u/JSMITH/cobol//copydir/copyM.cbl</td>
</tr>
<tr>
<td>'/copyA.cpy'</td>
<td>SYSLIB</td>
<td>/u/JSMITH/cobol/copyA.cpy</td>
</tr>
<tr>
<td>'cobol/copyA.cpy'</td>
<td>ALTDD2</td>
<td>/u/JSMITH/cobol/copyA.cpy</td>
</tr>
<tr>
<td>'copy/stuff.cpy'</td>
<td>ALTDD2</td>
<td>/u/JSMITH/cobol/copy/stuff.cpy</td>
</tr>
<tr>
<td>'copydir/copyM.cbl'</td>
<td>SYSLIB</td>
<td>/u/JSMITH/cobol/copydir/copyM.cbl</td>
</tr>
<tr>
<td>'copydir/copyM.cbl'</td>
<td>SYSLIB (default)</td>
<td>/u/JSMITH/cobol/copydir/copyM.cbl</td>
</tr>
<tr>
<td>'stuff.cpy'</td>
<td>ALTDD</td>
<td>/u/JSMITH/cobol/copy/stuff.cpy</td>
</tr>
<tr>
<td>&quot;copyA.cpy&quot;</td>
<td>SYSLIB (default)</td>
<td>/u/JSMITH/cobol/copyA.cpy</td>
</tr>
<tr>
<td>&quot;reallyXXVeryLongLon&gt;</td>
<td>SYSLIB (default)</td>
<td>8) /JSMITH/cobol/</td>
</tr>
<tr>
<td>reallyXXVeryLongLongName.cpy</td>
<td>OTHERDD</td>
<td>/JSMITH//copy/other.cob</td>
</tr>
<tr>
<td>. . .</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Some names were truncated. > = truncated on right  < = truncated on left
From the COPY statement in the source; for example the COPY statement corresponding to the third item in the cross-reference above would be:

COPY 'cobol/copyA.cpy' Of ALTDD2

The fully qualified path of the file from which the COPY member was copied

Truncation of a long text-name or library-name on the right is marked by a greater-than sign (>).

Truncation of a long file name on the left is marked by a less-than sign (<).

related references
"XREF" on page 350

Example: XREF output: embedded cross-reference

The following example shows a modified cross-reference that is embedded in the source listing. The cross-reference is produced by the XREF compiler option.

<table>
<thead>
<tr>
<th>LineID</th>
<th>PL</th>
<th>SL</th>
<th>------A-1-B-2-C-3-D-4-E-5-F-6-G-7-H-8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>000878</td>
<td></td>
<td></td>
<td>procedure division.</td>
<td></td>
</tr>
<tr>
<td>000879</td>
<td></td>
<td></td>
<td>display &quot;PROGRAM IGYTCARA - Beginning&quot;.</td>
<td></td>
</tr>
<tr>
<td>000881</td>
<td></td>
<td></td>
<td>perform &amp;SO-create-vsm-master-file.</td>
<td>932</td>
</tr>
<tr>
<td>000882</td>
<td></td>
<td></td>
<td>perform 100-initialize-paragraph.</td>
<td>984</td>
</tr>
<tr>
<td>000883</td>
<td></td>
<td></td>
<td>read update-transaction-file into ws-transaction-record</td>
<td>204 340</td>
</tr>
<tr>
<td>000884</td>
<td></td>
<td></td>
<td>at end</td>
<td></td>
</tr>
<tr>
<td>000885</td>
<td>1</td>
<td></td>
<td>set transaction-eof to true</td>
<td>254</td>
</tr>
<tr>
<td>000886</td>
<td></td>
<td></td>
<td>end-read.</td>
<td></td>
</tr>
<tr>
<td>000984</td>
<td></td>
<td></td>
<td>100-initialize-paragraph.</td>
<td></td>
</tr>
<tr>
<td>000986</td>
<td></td>
<td></td>
<td>move spaces to ws-transaction-record</td>
<td>IMP 340</td>
</tr>
<tr>
<td>000987</td>
<td></td>
<td></td>
<td>move spaces to ws-commuter-record</td>
<td>IMP 316</td>
</tr>
<tr>
<td>000988</td>
<td></td>
<td></td>
<td>move zeroes to commuter-zipcode</td>
<td>IMP 327</td>
</tr>
<tr>
<td>000989</td>
<td></td>
<td></td>
<td>move zeroes to commuter-home-phone</td>
<td>IMP 328</td>
</tr>
<tr>
<td>000990</td>
<td></td>
<td></td>
<td>move zeroes to commuter-work-phone</td>
<td>IMP 329</td>
</tr>
<tr>
<td>000991</td>
<td></td>
<td></td>
<td>move zeroes to commuter-update-date</td>
<td>IMP 333</td>
</tr>
<tr>
<td>000992</td>
<td></td>
<td></td>
<td>open input update-transaction-file</td>
<td>204</td>
</tr>
<tr>
<td>000993</td>
<td></td>
<td></td>
<td>location-file</td>
<td>193</td>
</tr>
<tr>
<td>000994</td>
<td></td>
<td></td>
<td>i-o commuter-file</td>
<td>181</td>
</tr>
<tr>
<td>000999</td>
<td></td>
<td></td>
<td>output print-file</td>
<td>217</td>
</tr>
<tr>
<td>001443</td>
<td></td>
<td></td>
<td>1100-print-i-f-headings.</td>
<td></td>
</tr>
<tr>
<td>001444</td>
<td></td>
<td></td>
<td>open output print-file.</td>
<td>217</td>
</tr>
<tr>
<td>001445</td>
<td></td>
<td></td>
<td>move function when-compiled to when-comp.</td>
<td>IFN 698</td>
</tr>
<tr>
<td>001447</td>
<td></td>
<td></td>
<td>move when-comp (5:2) to compile-month.</td>
<td>698 640</td>
</tr>
<tr>
<td>001448</td>
<td></td>
<td></td>
<td>move when-comp (7:2) to compile-day.</td>
<td>698 642</td>
</tr>
<tr>
<td>001449</td>
<td></td>
<td></td>
<td>move when-comp (3:2) to compile-year.</td>
<td>698 644</td>
</tr>
<tr>
<td>001450</td>
<td></td>
<td></td>
<td>move function current-date (5:2) to current-month.</td>
<td>IFN 649</td>
</tr>
<tr>
<td>001452</td>
<td></td>
<td></td>
<td>move function current-date (7:2) to current-day.</td>
<td>IFN 651</td>
</tr>
<tr>
<td>001453</td>
<td></td>
<td></td>
<td>move function current-date (3:2) to current-year.</td>
<td>IFN 653</td>
</tr>
<tr>
<td>001454</td>
<td></td>
<td></td>
<td>write print-record from i-f-header-line-1</td>
<td>222 635</td>
</tr>
<tr>
<td>001456</td>
<td></td>
<td></td>
<td>after new-page.</td>
<td>130</td>
</tr>
</tbody>
</table>

(1) Line number of the definition of the data-name or procedure-name in the program

(2) Special definition symbols:

UND
The user name is undefined.

DUP
The user name is defined more than once.

IMP
Implicitly defined name, such as special registers and figurative constants.
Intrinsic function reference.

External reference.

The program-name is unresolved because the NOCOMPILE option is in effect.

Example: OFFSET compiler output

The following example shows a compiler listing that has a condensed statement listing, global tables, WORKING-STORAGE information, and literals. The listing is output from the OFFSET compiler option.

```
DATA VALIDATION AND UPDATE PROGRAM     IGYTCARA Date 03/18/2016  Time 10:48:16

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINE #</td>
<td>HEXLOC</td>
<td>VERB</td>
</tr>
<tr>
<td>000880</td>
<td>0026F0</td>
<td>DISPLAY</td>
</tr>
<tr>
<td>000934</td>
<td>002722</td>
<td>IF</td>
</tr>
<tr>
<td>001389</td>
<td>002736</td>
<td>DISPLAY</td>
</tr>
<tr>
<td>001392</td>
<td>002744</td>
<td>DISPLAY</td>
</tr>
<tr>
<td>001395</td>
<td>002772</td>
<td>DISPLAY</td>
</tr>
<tr>
<td>001398</td>
<td>002786</td>
<td>STOP</td>
</tr>
<tr>
<td>000941</td>
<td>002793</td>
<td>IF</td>
</tr>
<tr>
<td>001403</td>
<td>00283A</td>
<td>DISPLAY</td>
</tr>
<tr>
<td>001406</td>
<td>002858</td>
<td>DISPLAY</td>
</tr>
</tbody>
</table>

(1) Line number. Your line numbers or compiler-generated line numbers are listed.

(2) Offset, from the start of the program, of the code generated for this statement (in hexadecimal notation).

The statements are listed in the order in which they occur and are listed once for each time they are used.

(3) Statement used.

Notes:

- The optimizer might inline paragraphs, move code around or indeed place it after the body of the program if little used, such as the error message formatting code. This might make the OFFSET report less useful than it was with previous compilers. You can refer to the LIST output instead (note that OFFSET and LIST are mutually exclusive options). For details, see “Reading LIST output” on page 381.

- Due to the out of line code used for error message formatting, Language Environment generated offsets, as indicated in"From compile unit {name} at entry point {name} at compile unit offset {offset}...", might be outside the offset range of the program. In these cases, refer to the statement number in the COBOL message (IGZnnnns) to locate the problem.

related references

“OFFSET” on page 324

Example: VBFREF compiler output

The following example shows an alphabetic listing of all the statements in a program, and shows where each is referenced. The listing is produced by the VBFREF compiler option.

```
(1)  (2)    (3)                   (3)
2    ACCEPT . . . . . . . . . . . .  1010 1012
2    ADD. . . . . . . . . . . . . .  1290 1306
```
(1) Number of times the statement is used in the program

(2) statement

(3) Line numbers where the statement is used
Part 3. Targeting COBOL programs for certain environments
Chapter 20. Developing COBOL programs for CICS

COBOL programs that are written for CICS can run under CICS Transaction Server. CICS COBOL application programs that use CICS services must use the CICS command-level interface.

When you use the CICS compiler option, the Enterprise COBOL compiler handles both native COBOL statements and embedded CICS statements in the source program. You can still use the separate CICS translator to translate CICS statements to COBOL code, but use of the integrated CICS translator is recommended instead.

After you compile and bind your program, you need to do some other steps such as updating CICS tables before you can run the COBOL program under CICS. However, these CICS topics are beyond the scope of COBOL information. For further information, see the related tasks.

You can determine how runtime errors are handled by setting the CBLPSHPOP runtime option. For information about CICS HANDLE and CBLPSHPOP, see the related tasks.

related concepts
“Integrated CICS translator” on page 412

related tasks
“Coding COBOL programs to run under CICS” on page 407
“Compiling with the CICS option” on page 411
“Using the separate CICS translator” on page 413
“Handling errors by using CICS HANDLE” on page 415
Language Environment Programming Guide (Condition handling under CICS: using the CBLPSHPOP runtime option)
Developing CICS Applications

related references
“CICS” on page 294

Coding COBOL programs to run under CICS

To code a program to run under CICS, code CICS commands in the PROCEDURE DIVISION by using the EXEC CICS command format.

\[
\text{EXEC CICS } \text{command-name } \text{command-options} \\
\text{END-EXEC}
\]

CICS commands have the basic format shown above. Within EXEC commands, use the space as a word separator; do not use a comma or a semicolon. Do not code COBOL statements within EXEC CICS commands.

Restriction: You cannot run COBOL programs that have object-oriented syntax for Java interoperability in CICS. In addition, if you write programs to run under CICS, do not use the following code:

- FILE-CONTROL entry in the ENVIRONMENT DIVISION, unless the FILE-CONTROL entry is used for a SORT statement
- FILE SECTION of the DATA DIVISION, unless the FILE SECTION is used for a SORT statement
- User-specified parameters to the main program
- USE declaratives (except USE FOR DEBUGGING)
- These COBOL language statements:
  - ACCEPT format 1: data transfer (you can use format-2 ACCEPT to retrieve the system date and time)
  - CLOSE
If you plan to use the separate CICS translator, you must put any REPLACE statements that contain EXEC commands after the PROCEDURE DIVISION header for the program, otherwise the commands will not be translated.

**Coding file input and output:** You must use CICS commands for most input and output processing. Therefore, do not describe files or code any OPEN, CLOSE, READ, START, REWRITE, WRITE, or DELETE statements. Instead, use CICS commands to retrieve, update, insert, and delete data.

**Coding a COBOL program to run above the 16 MB line:** Under Enterprise COBOL, the following restrictions apply when you code a COBOL program to run above the 16 MB line:

- If you use IMS/ESA® without DBCTL, DL/I CALL statements are supported only if all the data passed in the call resides below the 16 MB line. Therefore, you must specify the DATA(24) compiler option. However, if you use IMS/ESA with DBCTL, you can use the DATA(31) compiler option instead and pass data that resides above the 16 MB line.
- If you use EXEC DLI instead of DL/I CALL statements, you can specify DATA(31) regardless of the level of the IMS product.
- If the receiving program is link-edited with AMODE 31, addresses that are passed must be 31 bits long, or 24 bits long with the leftmost byte set to zeros.
- If the receiving program is link-edited with AMODE 24, addresses that are passed must be 24 bits long.

**Displaying the contents of data items:** DISPLAY to the system logical output device (SYSOUT, SYSLIST, SYSLST) is supported under CICS. The DISPLAY output is written to the Language Environment message file (transient data queue CESE). DISPLAY . . . UPON CONSOLE and DISPLAY . . . UPON SYSPUNCH, however, are not allowed. You can specify the DISPSIGN option to control output formatting for DISPLAY of signed numeric items.

**related concepts**
- “Integrated CICS translator” on page 412

**related tasks**
- “Sorting under CICS” on page 222
- “Getting the system date under CICS” on page 409
- “Calling to or from COBOL programs” on page 409
- “Determining the success of ECI calls” on page 410
- “Using the separate CICS translator” on page 413

**related references**
- “CICS SORT application restrictions” on page 222
- “DISPSIGN” on page 302
Getting the system date under CICS

To retrieve the system date in a CICS program, use a format-2 ACCEPT statement or the CURRENT-DATE intrinsic function.

You can use any of these format-2 ACCEPT statements in CICS to get the system date:

- ACCEPT identifier-2 FROM DATE (two-digit year)
- ACCEPT identifier-2 FROM DATE YYYYMMDD
- ACCEPT identifier-2 FROM DAY (two-digit year)
- ACCEPT identifier-2 FROM DAY YYYYDDD
- ACCEPT identifier-2 FROM DAY-OF-WEEK (one-digit integer, where 1 represents Monday)

You can use this format-2 ACCEPT statement in CICS to get the system time:

- ACCEPT identifier-2 FROM TIME

Alternatively, you can use the CURRENT-DATE intrinsic function, which can also provide the time.

These methods work in both CICS and non-CICS environments.

Do not use a format-1 ACCEPT statement in a CICS program.

related tasks
“Assigning input from a screen or file (ACCEPT)” on page 33

related references
CURRENT-DATE (Enterprise COBOL for z/OS Language Reference)

Calling to or from COBOL programs

You can make calls to or from VS COBOL II, COBOL for MVS & VM, COBOL for OS/390 & VM, and Enterprise COBOL programs by using the CALL statement.

If you are calling a separately compiled COBOL program that was processed with either the separate CICS translator or the integrated CICS translator, you must pass DFHEIBLK and DFHCOMMAREA as the first two parameters in the CALL statement.

Called programs that are processed by the separate CICS translator or the integrated CICS translator can contain any function that is supported by CICS for the language.

Dynamic calls:

You can use COBOL dynamic calls when running under CICS. If a COBOL program contains EXEC CICS statements or contains EXEC SQL statements, the NODYNAM compiler option is required. To dynamically call a program in this case, you can use CALL identifier with the NODYNAM compiler option.

If a COBOL program contains no EXEC CICS statements and contains no EXEC SQL statements, there is no requirement to compile with NODYNAM. To dynamically call a program in this case, you can use either CALL literal with the DYNAM compiler option, or CALL identifier.

Note: END EXEC cannot be followed by a period when it is associated with EXEC CICS statements even though it is required for EXEC SQL statements.

You must define dynamically called programs in the CICS program processing table (PPT) if you are not using CICS autoinstall. Under CICS, COBOL programs do not support dynamic calls to subprograms that have the RELOAD=YES option coded in their CICS PROGRAM definition. Dynamic calls to programs that are defined with RELOAD=YES can cause a storage shortage. Use the RELOAD=NO option for programs that are to be dynamically called by COBOL.

Interlanguage communication (ILC):

Support for ILC with other high-level languages is available. Where ILC is not supported, you can use CICS LINK, XCTL, and RETURN instead.
The following table shows the calling relationship between COBOL and assembler programs. In the table, assembler programs that conform to the interface that is described in the Language Environment Programming Guide are called Language Environment-conforming assembler programs. Those that do not conform to the interface are non-Language Environment-conforming assembler programs.

<table>
<thead>
<tr>
<th>Calls between COBOL and assembler programs</th>
<th>Language Environment-conforming assembler program</th>
<th>Non-Language Environment-conforming assembler program</th>
</tr>
</thead>
<tbody>
<tr>
<td>From an Enterprise COBOL program to the assembler program?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>From the assembler program to an Enterprise COBOL program?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**Nested programs:**

When you compile with the integrated CICS translator, the translator generates the DFHEIBLK and DFHCOMMAREA control blocks with the GLOBAL clause in the outermost program. Therefore if you code nested programs, you do not have to pass these control blocks as arguments on calls to the nested programs.

If you code nested programs and you plan to use the separate CICS translator, pass DFHEIBLK and DFHCOMMAREA as parameters to the nested programs that contain EXEC commands or references to the EXEC interface block (EIB). You must pass the same parameters also to any program that forms part of the control hierarchy between such a program and its top-level program.

**related concepts**

“Integrated CICS translator” on page 412

**related tasks**

“Using the separate CICS translator” on page 413

“Choosing the DYNAM or NODYNAM compiler option” on page 426

“Handling errors when calling programs” on page 233

Language Environment Writing ILC Communication Applications (ILC under CICS)

Using EXCI with CICS

Language Environment Programming Guide

**related references**

“DYNAM” on page 305

**Determining the success of ECI calls**

After calls to the external CICS interface (ECI), the content of the RETURN-CODE special register is set to an unpredictable value. Therefore, even if your COBOL program terminates normally after successfully using the external CICS interface, the job step could end with an undefined return code.

To ensure that a meaningful return code occurs at termination, set the RETURN-CODE special register before you terminate your program. To make the job return code reflect the status of the last call to CICS, set the RETURN-CODE special register based on the response codes from the last call to the external CICS interface.

**related tasks**

Using EXCI with CICS
Compiling with the CICS option

Use the CICS compiler option to enable the integrated CICS translator and to specify CICS suboptions. If you specify the NOCICS option, the compiler diagnoses and discards any CICS statements that it finds in your source program. If you have already used the separate CICS translator, you must use NOCICS.

You can specify the CICS option in any of the compiler option sources: compiler invocation, PROCESS or CBL statements, or installation default. If the CICS option is the COBOL installation default, you cannot specify CICS suboptions. However, making the CICS option the installation default is not recommended, because the changes that are made by the integrated CICS translator are not appropriate for non-CICS applications.

All CBL or PROCESS statements must precede any comment lines, in accordance with the rules for Enterprise COBOL.

The COBOL compiler passes to the integrated CICS translator the CICS suboption string that you provide in the CICS compiler option. The compiler does not analyze the suboption string.

When you use the integrated CICS translator, you must compile with the following options:

<table>
<thead>
<tr>
<th>Compiler option</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFP</td>
<td>If your code runs on a version of CICS Transaction Server that is earlier than V4.1, you must specify AFP(VOLATILE).</td>
</tr>
<tr>
<td>CICS</td>
<td>If you specify DYNAM or NORENT, the compiler forces NODYNAM and RENT on.</td>
</tr>
<tr>
<td>NODYNAM</td>
<td>Must be in effect with CICS</td>
</tr>
<tr>
<td>RENT</td>
<td>Must be in effect with CICS</td>
</tr>
</tbody>
</table>

In addition, IBM recommends that you use the compiler option WORD(CICS) to cause the compiler to flag language elements that are not supported under CICS.

To compile your program with the integrated CICS translator, you can use the standard JCL procedural statements that are supplied with COBOL. In addition to specifying the above compiler options, you must change your JCL in two ways:

- Specify the STEPLIB override for the COBOL step.
- Add the data set that contains the integrated CICS translator services, unless these services are in the linklist.

The default name of the data set for CICS Transaction Server V6R1 is CICSTS61.CICS.SDFHLOAD, but your installation might have changed the name. For example, you might have the following line in your JCL:

```
//STEPLIB DD DSN=CICSTS61.CICS.SDFHLOAD,DISP=SHR
```

The COBOL compiler listing includes the error diagnostics (such as syntax errors in the CICS statements) that the integrated CICS translator generates. The listing reflects the input source; it does not include the COBOL statements that the integrated CICS translator generates.

**Compiling a sequence of programs:** When you use the CICS option to compile a source file that contains a sequence of COBOL programs, the order of precedence of the options from highest to lowest is:

- Options that are specified in the CBL or PROCESS card that initiates the unit of compilation
- Options that are specified when the compiler is started
- CICS default options
Separating CICS suboptions

You can partition the specification of CICS suboptions into multiple CBL statements. CICS suboptions are cumulative. The compiler concatenates them from multiple sources in the order that they are specified.

For example, suppose that a JCL file has the following code:

```cobol
//STEP1 EXEC IGYWC, . . .
//PARM.COBOL="CICS("FLAG(I)")"
//COBOL.SYSIN DD *
  CBL CICS("DEBUG")
  CBL CICS("LINKAGE")
IDENTIFICATION DIVISION.
PROGRAM-ID. COBOL1.
```

During compilation, the compiler passes the following CICS suboption string to the integrated CICS translator:

```
"FLAG(I) DEBUG LINKAGE"
```

The concatenated strings are delimited with single spaces and with a pair of quotation marks (" ") or a pair of apostrophes ( ' ' ) around the group. When the compiler finds multiple instances of the same CICS suboption, the last specification of the suboption in the concatenated string takes effect. The compiler limits the length of the concatenated CICS suboption string to 4 KB.

Related references

“CICS” on page 294
• Using nested programs that contain EXEC CICS statements is simpler. DFHCOMMAREA and DFHEIBLK are generated with the GLOBAL attribute in the outermost program. You do not need to pass them as arguments on calls to nested programs or specify them in the USING phrase of the PROCEDURE DIVISION header of nested programs.
• You can keep nested programs that contain EXEC CICS statements in separate files, and include those nested programs by using COPY statements.
• REPLACE statements can affect EXEC CICS statements.
• You can compile programs that contain CICS statements in a batch compilation (compilation of a sequence of programs).
• Because the compiler generates binary fields in CICS control blocks with format COMP-5 instead of BINARY, there is no dependency on the setting of the TRUNC compiler option. You can use any setting of the TRUNC option in CICS programs, subject only to the requirements of the application logic and use of user-defined binary fields.

Note: The CICS documentation states that the EXCI translator option is not supported for programs compiled with the integrated CICS translator, but CICS has reversed this position. You can now compile with the EXCI translator option and ignore the warning message DFH7006I.

related concepts
Developing CICS Applications (The integrated CICS translator)

related tasks
“Coding COBOL programs to run under CICS” on page 407
“Compiling with the CICS option” on page 411

related references
“CICS” on page 294
“TRUNC” on page 345

Using the separate CICS translator

To run a COBOL program under CICS, you can use the separate CICS translator to convert the CICS commands to COBOL statements, and then compile and link the program to create the executable module. However, using the CICS translator that is integrated with Enterprise COBOL is recommended. The separate CICS translator has not been updated for newer COBOL language such as floating comment delimiters, JSON GENERATE, and compiler directives. To use the latest features of the COBOL compiler, use the integrated CICS translator.

To translate CICS statements separately, use the COBOL3 translator option. This option causes the following line to be inserted:

```
CBL RENT,NODYNAM,
```

You can suppress the insertion of a CBL statement by using the CICS translator option NOCBLCARD.

After you use the separate CICS translator, use the following compiler options when you compile the program:

<table>
<thead>
<tr>
<th>Required compiler option</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENT</td>
<td>The program is translated by the CICS translator.</td>
</tr>
</tbody>
</table>

In addition, IBM recommends that you use the compiler option WORD(CICS) to cause the compiler to flag language elements that are not supported under CICS.
The following TRUNC compiler option recommendations are based on expected values for binary data items:

<table>
<thead>
<tr>
<th>Recommended compiler option</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUNC(OPT)</td>
<td>All binary data items conform to the PICTURE and USAGE clause for those data items.</td>
</tr>
<tr>
<td>TRUNC(BIN)</td>
<td>Not all binary data items conform to the PICTURE and USAGE clause for those data items.</td>
</tr>
</tbody>
</table>

For example, if you use the separate CICS translator and have a data item defined as PIC S9(8) BINARY that might receive a value greater than eight digits, use the TRUNC(BIN) compiler option, change the item to USAGE COMP-5, or change the PICTURE clause.

You might also want to avoid using these options, which have no effect:

- ADV  
- FASTSRT  
- OUTDD

The input data set for the compiler is the data set that you received as a result of translation, which is SYSPUNCH by default.

**related concepts**  
“Integrated CICS translator” on page 412

**related tasks**  
“Compiling with the CICS option” on page 411

### CICS reserved-word table

COBOL provides an alternate reserved-word table (IGYCCICS) for CICS application programs. If you use the compiler option WORD(CICS), COBOL words that are not supported under CICS are flagged with an error message.

In addition to the COBOL words restricted by the IBM-supplied default reserved-word table, the IBM-supplied CICS reserved-word table restricts the following COBOL words:

- CLOSE  
- DELETE  
- FD  
- FILE  
- FILE-CONTROL  
- INPUT-OUTPUT  
- I-O-CONTROL  
- MERGE  
- OPEN  
- READ  
- RERUN  
- REWRITE  
- SD  
- SORT
If you intend to use the SORT statement under CICS (COBOL supports an interface for the SORT statement under CICS), you must change the CICS reserved-word table to remove the words in bold above from the list of words marked as restricted.

**related tasks**
“Compiling with the CICS option” on page 411
“Sorting under CICS” on page 222

**related references**
“WORD” on page 349

### Handling errors by using CICS HANDLE

The setting of the CBLPSHPOP runtime option affects the state of the HANDLE specifications when a program calls COBOL subprograms using a CALL statement.

When CBLPSHPOP is ON and a COBOL subprogram (not a nested program) is called with a CALL statement, the following actions occur:

1. As part of program initialization, the run time suspends the HANDLE specifications of the calling program (using EXEC CICS PUSH HANDLE).
2. The default actions for HANDLE apply until the called program issues its own HANDLE commands.
3. As part of program termination, the run time reinstates the HANDLE specifications of the calling program (using EXEC CICS POP HANDLE).

If you use the CICS HANDLE CONDITION or CICS HANDLE AID commands, the LABEL specified for the CICS HANDLE command must be in the same PROCEDURE DIVISION as the CICS command that causes branching to the CICS HANDLE label. You cannot use the CICS HANDLE commands with the LABEL option to handle conditions, aids, or abends that were caused by another program invoked with the COBOL CALL statement. Attempts to perform cross-program branching by using the CICS HANDLE command with the LABEL option result in a transaction abend.

If a condition, aid, or abend occurs in a nested program, the LABEL for the condition, aid, or abend must be in the same nested program; otherwise unpredictable results occur.

**Performance considerations:** When CBLPSHPOP is OFF, the run time does not perform CICS PUSH or POP on a CALL to any COBOL subprogram. If the subprograms do not use any of the EXEC CICS condition-handling commands, you can run with CBLPSHPOP(ON), thus eliminating the overhead of the PUSH HANDLE and POP HANDLE commands. As a result, performance can be improved compared to running with CBLPSHPOP(ON).

If you are migrating an application from the VS COBOL II run time to the Language Environment run time, see the related reference for information about the CBLPSHPOP option for additional considerations.

“Example: handling errors by using CICS HANDLE” on page 416

**related tasks**
“Running efficiently with CICS, IMS, or VSAM” on page 639

**related references**
*Enterprise COBOL Migration Guide*
*Enterprise COBOL Version 6 Release 1 Performance Tuning Guide*
Example: handling errors by using CICS HANDLE

The following example shows the use of CICS HANDLE in COBOL programs.

Program A has a CICS HANDLE CONDITION command and program B has no CICS HANDLE commands. Program A calls program B; program A also calls nested program A1. A condition is handled in one of three scenarios.

1. **CBLPSHPOP(ON):** If the CICS READ command in program B causes a condition, the condition is not handled by program A (the HANDLE specifications are suspended because the run time performs a CICS PUSH HANDLE). The condition turns into a transaction abend.

2. **CBLPSHPOP(OFF):** If the CICS READ command in program B causes a condition, the condition is not handled by program A (the run time diagnoses the attempt to perform cross-program branching by using a CICS HANDLE command with the LABEL option). The condition turns into a transaction abend.

3. If the CICS READ command in nested program A1 causes a condition, the flow of control goes to label ERR-1, and unpredictable results occur.

```cobol
BEGIN PROGRAM A.
* Program A
ID DIVISION.
PROGRAM-ID. A.
PROCEDURE DIVISION.
EXEC CICS HANDLE CONDITION ERROR(ERR-1) END-EXEC.
CALL 'B' USING DFHEIBLK DFHCOMMAREA.
CALL 'A1'.
.
.
EXEC CICS RETURN END-EXEC.
ERR-1.
.
.
* Nested program A1.
ID DIVISION.
PROGRAM-ID. A1.
PROCEDURE DIVISION.
EXEC CICS READ FILE('LEDGER') INTO(RECORD) RIDFLD(ACCTNO) END-EXEC.
END PROGRAM A1.
END PROGRAM A.
*

BEGIN PROGRAM B.
* Program B
ID DIVISION.
PROGRAM-ID. B.
PROCEDURE DIVISION.
EXEC CICS READ FILE('MASTER') INTO(RECORD) RIDFLD(ACCTNO) END-EXEC.
.
.
END PROGRAM B.
```
Chapter 21. Programming for a DB2 environment

In general, the coding for a COBOL program will be the same if you want the program to access a DB2 database. However, to retrieve, update, insert, and delete DB2 data and use other DB2 services, you must use SQL statements.

To communicate with DB2, do these steps:

- Code any SQL statements that you need, delimiting them with EXEC SQL and END-EXEC statements.
- Either use the DB2 stand-alone precompiler, or compile with the SQL compiler option and use the DB2 coprocessor.

related concepts
“DB2 coprocessor” on page 417
“COBOL and DB2 CCSID determination” on page 422

related tasks
“Coding SQL statements” on page 418
“Compiling with the SQL option” on page 421
“Choosing the DYNAM or NODYNAM compiler option” on page 426

related references
“Differences in how the DB2 precompiler and coprocessor behave” on page 424

DB2 coprocessor

When you use the DB2 coprocessor (called SQL statement coprocessor by DB2), the compiler handles your source programs that contain embedded SQL statements without your having to use a separate precompile step.

To use the DB2 coprocessor, specify the SQL compiler option.

When the compiler encounters SQL statements in the source program, it interfaces with the DB2 coprocessor. All text between EXEC SQL and END-EXEC statements is passed to the coprocessor. The coprocessor takes appropriate actions for the SQL statements and indicates to the compiler which native COBOL statements to generate for them.

Although the use of a separate precompile step continues to be supported, it is recommended that you use the coprocessor instead:

- Interactive debugging with Debug Tool is enhanced when you use the coprocessor because you see the SQL statements (not the generated COBOL source) in the listing.
- The COBOL compiler listing includes the error diagnostics (such as syntax errors in the SQL statements) that the DB2 coprocessor generates.
- Certain restrictions on the use of COBOL language that apply when you use the precompile step do not apply when you use the DB2 coprocessor. With the coprocessor:
  - You can use SQL statements in any nested program. (With the precompiler, SQL statements are restricted to the outermost program.)
  - You can use SQL statements in copybooks.
  - REPLACE statements work in SQL statements.

Compiling with the DB2 coprocessor generates a DB2 database request module (DBRM) along with the usual COBOL compiler outputs such as object module and listing. The DBRM writes to the data set that you specified in the DBRMLIB DD statement in the JCL for the COBOL compile step. As input to the DB2 bind process, the DBRM data set contains information about the SQL statements and host variables in the program.
Coding SQL statements

Delimit SQL statements with EXEC SQL and END-EXEC. The EXEC SQL and END-EXEC delimiters must each be complete on one line. You cannot continue them across multiple lines. Do not code COBOL statements within EXEC SQL statements.

You also need to do these special steps:

• Code an EXEC SQL INCLUDE statement to include an SQL communication area (SQLCA) in the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION of the outermost program. LOCAL-STORAGE is recommended for recursive programs and programs that use the THREAD compiler option.

• Define all host variables that you use in SQL statements in the WORKING-STORAGE SECTION, LOCAL-STORAGE SECTION, or LINKAGE SECTION. However, you do not need to identify them with EXEC SQL BEGIN DECLARE SECTION and EXEC SQL END DECLARE SECTION.

Restriction: You cannot use SQL statements in object-oriented classes or methods.

Using SQL INCLUDE with the DB2 coprocessor

An SQL INCLUDE statement is treated identically to a native COBOL COPY statement when you use the SQL compiler option.

The following two lines are therefore treated the same way. (The period that ends the EXEC SQL INCLUDE statement is required.)

```
EXEC SQL INCLUDE name END-EXEC.
COPY "name".
```

The processing of the name in an SQL INCLUDE statement follows the same rules as those of the literal in a COPY literal-1 statement that does not have a REPLACING phrase.

The library search order for SQL INCLUDE statements is the same SYSLIB concatenation as the compiler uses to resolve COBOL COPY statements that do not specify a library-name.
Using character data in SQL statements

You can code any of the following USAGE clauses to describe host variables for character data that you use in EXEC SQL statements: USAGE DISPLAY for single-byte or UTF-8 data, USAGE DISPLAY-1 for DBCS data, or USAGE NATIONAL for UTF-16 data.

When you use the stand-alone DB2 precompiler, you must specify the code page (CCSID) in EXEC SQL DECLARE statements for host variables that are declared with USAGE NATIONAL. You must specify the code page for host variables that are declared with USAGE DISPLAY or DISPLAY-1 only if the CCSID that is in effect for the COBOL CODEPAGE compiler option does not match the CCSIDs that are used by DB2 for character and graphic data.

Consider the following code. The two highlighted statements are unnecessary when you use the integrated DB2 coprocessor (with the SQLCCSID compiler option, as detailed in the related concept below), because the code-page information is handled implicitly.

```cobol
CBL CODEPAGE(1140) NSYMBOL(NATIONAL)
WORKING-STORAGE SECTION.
EXEC SQL INCLUDE SQLCA END-EXEC.
01 INT1 PIC S9(4) USAGE COMP.
01 C1140.
  49 C1140-LEN PIC S9(4) USAGE COMP.
  49 C1140-TEXT PIC X(50).
EXEC SQL DECLARE :C1140 VARIABLE CCSID 1140 END-EXEC.
01 G1200.
  49 G1200-LEN PIC S9(4) USAGE COMP.
  49 G1200-TEXT PIC N(50) USAGE NATIONAL.
EXEC SQL DECLARE :G1200 VARIABLE CCSID 1200 END-EXEC.
...
EXEC SQL FETCH C1 INTO :INT1, :C1140, :G1200 END-EXEC.
```

If you specify EXEC SQL DECLARE variable-name VARIABLE CCSID nnnn END-EXEC, that specification overrides the implied CCSID. For example, the following code would cause DB2 to treat C1208-TEXT as encoded in UTF-8 (CCSID 1208) rather than as encoded in the CCSID in effect for the COBOL CODEPAGE compiler option:

```cobol
01 C1208.
  49 C1208-LEN PIC S9(4) USAGE COMP.
  49 C1208-TEXT PIC X(50).
EXEC SQL DECLARE :C1208 VARIABLE CCSID 1208 END-EXEC.
```

The NSYMBOL compiler option has no effect on a character literal inside an EXEC SQL statement. Character literals in an EXEC SQL statement follow the SQL rules for character constants.

related concepts
“COBOL and DB2 CCSID determination” on page 422

related tasks
DB2 Application Programming and SQL Guide (Coding SQL statements in a COBOL application)

related references
“Differences in how the DB2 precompiler and coprocessor behave” on page 424
“CODEPAGE” on page 295
DB2 SQL Reference
Using national decimal data in SQL statements

You can use national decimal host variables in EXEC SQL statements when you use either the integrated DB2 coprocessor or the DB2 precompiler. You do not need to specify the CCSID in EXEC SQL DECLARE statements in either case. CCSID 1200 is used automatically.

Any national decimal host variable that you specify in an EXEC SQL statement must have the following characteristics:

- It must be signed.
- It must be specified with the SIGN LEADING SEPARATE clause.
- USAGE NATIONAL must be in effect implicitly or explicitly.

related concepts
“Formats for numeric data” on page 45

related tasks
“Defining national numeric data items” on page 127

related references
“Differences in how the DB2 precompiler and coprocessor behave” on page 424

Using national group items in SQL statements

You can use a national group item as a host variable in an EXEC SQL statement. The national group item is treated with group semantics (that is, as shorthand for the set of host variables that are subordinate to the group item) rather than as an elementary item.

Because all subordinate items in a national group must have USAGE NATIONAL, a national group item cannot describe a variable-length string.

related tasks
“Using national groups” on page 128

Using binary items in SQL statements

For binary data items that you specify in an EXEC SQL statement, you can define the data items as either USAGE COMP-5 or as USAGE BINARY, COMP, or COMP-4.

If you define the binary data items as USAGE BINARY, COMP, or COMP-4, use the TRUNC(BIN) option. (This technique might have a larger effect on performance than using USAGE COMP-5 on individual data items.) If instead TRUNC(OPT) or TRUNC(STD) is in effect, the compiler accepts the items but the data might not be valid because of the decimal truncation rules. You need to ensure that truncation does not affect the validity of the data.

related concepts
“Formats for numeric data” on page 45

related references
“TRUNC” on page 345
Determining the success of SQL statements

When DB2 finishes executing an SQL statement, DB2 sends a return code in the SQLCA structure, with one exception, to indicate whether the operation succeeded or failed. In your program, test the return code and take any necessary action.

The exception occurs when a program runs under DSN from one of the alternate entry points of the TSO batch mode module IKJEFT01 (IKJEFT1A or IKJEFT1B). In this case, the return code is passed in register 15.

After execution of SQL statements, the content of the RETURN-CODE special register might not be valid. Therefore, even if your COBOL program terminates normally after successfully using SQL statements, the job step could end with an undefined return code. To ensure that a meaningful return code is given at termination, set the RETURN-CODE special register before terminating your program.

related tasks

DB2 Application Programming and SQL Guide (Coding SQL statements in a COBOL application)

Compiling with the SQL option

You use the SQL compiler option to enable the DB2 coprocessor and to specify DB2 suboptions.

You can specify the SQL option in any of the compiler option sources: compiler invocation, PROCESS or CBL statements, or installation default. You cannot specify DB2 suboptions when the SQL option is the COBOL installation default, but you can specify default DB2 suboptions by customizing the DB2 product installation defaults.

The DB2 suboption string that you provide in the SQL compiler option is made available to the DB2 coprocessor. Only the DB2 coprocessor views the contents of the string.

You can use standard JCL procedural statements to compile your program with the DB2 coprocessor. In addition to specifying the above compiler options, specify the following items in your JCL:

• DBRMLIB DD statement with the location for the generated database request module (DBRM).

• STEPLIB override for the COBOL step, adding the data set that contains the DB2 coprocessor services, unless these services are in the LNKLST. Typically, this data set is the data set xxxx.SDSNLOAD. For example, for DB2 9 it might be DSN910.SDSNLOAD, but your installation might have changed the name.

For example, you might have the following lines in your JCL:

```
//DBRMLIB DD DSN=PAYROLL.MONTHLY.DBRMLIB.DATA(MASTER),DISP=SHR
//STEPLIB DD DSN=DSN910.SDSNLOAD,DISP=SHR
```

Compiling a batch of programs: If you use the SQL option when compiling a source file that contains a sequence of COBOL programs (a batch compile sequence), SQL must be in effect for only the first program of the sequence. Although you can specify SQL upon compiler invocation, the option will be in effect for only the first program. If you specify SQL in a CBL or PROCESS statement for a program other than the first program in the batch, you will receive a compiler diagnostic message.

related concepts

“DB2 coprocessor” on page 417
“COBOL and DB2 CCSID determination” on page 422

related tasks

“Separating DB2 suboptions” on page 422
“Choosing the DYNAM or NODYNAM compiler option” on page 426

related references

“DYNAM” on page 305
“SQL” on page 336
DB2 Command Reference
Separating DB2 suboptions

Because of the concatenation of multiple SQL option specifications, you can separate DB2 suboptions (which might not fit in one CBL statement) into multiple CBL statements.

The options that you include in the suboption string are cumulative. The compiler concatenates these suboptions from multiple sources in the order that they are specified. For example, suppose that your source file has the following code:

```cobol
//STEP1 EXEC IGYWC, . . .  
//  PARM.COBOL="SQL("string1")'
//COBOL.SYSIN DD * 
  CBL SQL("string2")  
  CBL SQL("string3") 
IDENTIFICATION DIVISION. 
PROGRAM-ID. DRIVER1.
```

During compilation, the compiler passes the following suboption string to the DB2 coprocessor:

```
"string1 string2 string3"
```

The concatenated strings are delimited with single spaces. If the compiler finds multiple instances of the same SQL suboption, the last specification of that suboption in the concatenated string takes effect. The compiler limits the length of the concatenated DB2 suboption string to 4 KB.

COBOL and DB2 CCSID determination

All DB2 string data other than BLOB, BINARY, and VARBINARY data has an associated encoding scheme and a coded character set ID (CCSID). This is true for fixed-length and variable-length character strings, fixed-length and variable-length graphic character strings, CLOB host variables, and DBCLOB host variables.

When you use the integrated DB2 coprocessor, the determination of the code page CCSID that will be associated with the string host variables used in SQL statement processing depends on the setting of the COBOL SQLCCSID option, on the programming techniques used, and on various DB2 configuration options.

When you use the SQL and SQLCCSID COBOL compiler options, the CCSID value $nnn$ that is specified in the CODEPAGE compiler option, or that is determined from the COBOL data type of a host variable, is communicated automatically from COBOL to DB2. DB2 associates the COBOL CCSID with host variables, overriding the CCSID that would otherwise be implied by DB2 external mechanisms and defaults. This associated CCSID is used for the processing of the SQL statements that reference host variables.

When you use the SQL and NOSQLCCSID compiler options, the CCSID value $nnn$ that is specified in the CODEPAGE compiler option is used only for processing COBOL statements within the COBOL program; that CCSID is not used for the processing of SQL statements. Instead, DB2 assumes in processing SQL statements that host variable data values are encoded according to the CCSID or CCSIDs that are specified through DB2 external mechanisms and defaults.

related concepts
“DB2 coprocessor” on page 417

related tasks
“Programming with the SQLCCSID or NOSQLCCSID option” on page 423

related references
“Code-page determination for string host variables in SQL statements” on page 423
“CODEPAGE” on page 295
“SQL” on page 336
“SQLCCSID” on page 337
Code-page determination for string host variables in SQL statements

When you use the integrated DB2 coprocessor (SQL compiler option), the code page for processing string host variables in SQL statements is determined as shown below, in descending order of precedence.

- A host variable that has USAGE NATIONAL is always processed by DB2 using CCSID 1200 (Unicode UTF-16). For example:

```sql
01 hostvariable pic n(10) usage national.
```

- An alphanumeric host variable that has an explicit FOR BIT DATA declaration is set by DB2 to CCSID 66535, which indicates that the variable does not represent encoded characters. For example:

```sql
EXEC SQL DECLARE hostvariable VARIABLE FOR BIT DATA END-EXEC
```

- A BLOB, BINARY, or VARBINARY host variable has no CCSID association. These string types do not represent encoded characters.
- A host variable for which you specify an explicit CCSID override in the SQLDA is processed with that CCSID.
- A host variable that you specify in a declaration with an explicit CCSID is processed with that CCSID. For example:

```sql
EXEC SQL DECLARE hostvariable VARIABLE CCSID nnnnn END-EXEC
```

- An alphanumeric host variable, if the SQLCCSID compiler option is in effect, is processed with the CCSID nnnnn from the CODEPAGE compiler option.
- A DBCS host variable, if the SQLCCSID option is in effect, is processed with the mapped value mmmmm, which is the pure DBCS CCSID component of the mixed (MBCS) CCSID nnnnn from the CODEPAGE(nnnnn) compiler option.
- An alphanumeric or DBCS host variable, if the NOSQLCCSID option is in effect, is processed with the CCSID from the DB2 ENCODING bind option, if specified, or from the APPLICATION ENCODING set in DSNHDECP through the DB2 installation panel DSNTIPF.

related references

“CODEPAGE” on page 295
“SQLCCSID” on page 337

Programming with the SQLCCSID or NOSQLCCSID option

In general, the SQLCCSID option is recommended for new applications that use the integrated DB2 coprocessor, and as a long-term direction for existing applications. The NOSQLCCSID option is recommended as a mechanism for migrating existing precompiler-based applications to use the integrated DB2 coprocessor.

The SQLCCSID option is recommended for COBOL-DB2 applications that have any of these characteristics:

- Use COBOL Unicode support
- Use other COBOL syntax that is indirectly sensitive to CCSID encoding, such as XML support or object-oriented syntax for Java interoperability
- Process character data that is encoded in a CCSID that is different from the default CCSID assumed by DB2

The NOSQLCCSID option is recommended for applications that require the highest compatibility with the behavior of the DB2 precompiler.

For applications that use COBOL alphanumeric data items as host variables interacting with DB2 string data that is defined with the FOR BIT DATA subtype, you must either:
• Use the NOSQLCCSID compiler option
• Specify explicit FOR BIT DATA declarations for those host variables, for example:

```
EXEC SQL DECLARE hostvariable VARIABLE FOR BIT DATA END-EXEC
```

**Usage notes**

• If you use the DB2 DCLGEN command to generate COBOL declarations for a table, you can optionally create FOR BIT DATA declarations automatically. To do so, specify the DCLBIT(YES) option of the DCLGEN command.

• **Performance consideration**: Using the SQLCCSID compiler option could result in some performance overhead in SQL processing, because with SQLCCSID in effect the default DB2 CCSID association mechanism is overridden with a mechanism that works on a per-host-variable basis.

**related concepts**

“DB2 coprocessor” on page 417

**related references**

“SQLCCSID” on page 337

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**Differences in how the DB2 precompiler and coprocessor behave**

The sections that follow enumerate the differences in behavior between the stand-alone COBOL DB2 precompiler and the integrated COBOL DB2 coprocessor.

For details about the CCSID determination under the DB2 precompiler and coprocessor, see “COBOL and DB2 CCSID determination” on page 422.

**Period at the end of EXEC SQL INCLUDE statements**

**Precompiler**: The DB2 precompiler does not require that a period end each EXEC SQL INCLUDE statement. If a period is specified, the precompiler processes it as part of the statement. If a period is not specified, the precompiler accepts the statement as if a period had been specified.

**Coprocessor**: The DB2 coprocessor treats each EXEC SQL INCLUDE statement like a COPY statement, and requires that a period end the statement. For example:

```
IF A = B THEN
  EXEC SQL INCLUDE some_code_here END-EXEC.
ELSE
  . . .
END-IF
```

Note that the period does not terminate the IF statement.

**EXEC SQL and REPLACE or COPY REPLACING**

**Precompiler**: With the DB2 precompiler, COBOL REPLACE statements and the REPLACING phrase of the COPY statement act on the expanded source created from the EXEC SQL statement. COBOL rules for REPLACE and REPLACING are used.

**Coprocessor**: With the DB2 coprocessor, REPLACE and COPY . . . REPLACING statements act on the original source program, including EXEC SQL statements.

Different behavior can result, as in the following example:

```
REPLACE == ABC == By == XYZ ==.
01 G.
  02 ABC PIC X(10).
```
EXEC SQL SELECT * INTO :G.ABC FROM TABLE1 END-EXEC

With the precompiler, the reference to G.ABC will appear as ABC of G in the expanded source and will be replaced with XYZ of G. With the coprocessor, replacement will not occur, because ABC is not delimited by separators in the original source string G.ABC.

**Source code after an END-EXEC statement**

**Precompiler:** The DB2 precompiler ignores any code that follows END-EXEC statements on the same line.

**Coprocessor:** The DB2 coprocessor processes code that follows END-EXEC statements on the same line.

**Multiple definitions of host variables**

**Precompiler:** The DB2 precompiler does not require that host variable references be unique. The first definition that maps to a valid DB2 data type is used.

**Coprocessor:** The DB2 coprocessor requires that each host variable reference be unique. The coprocessor diagnoses nonunique references to host variables. You must fully qualify host variable references to make them unique.

**EXEC SQL statement continuation lines**

**Precompiler:** The DB2 precompiler requires that EXEC SQL statements start in columns 12 through 72. Continuation lines of the statements can start anywhere in columns 8 through 72.

**Coprocessor:** The DB2 coprocessor requires that all lines of an EXEC SQL statement, including continuation lines, be coded in columns 12 through 72.

**Bit-data host variables**

**Precompiler:** With the DB2 precompiler, a COBOL alphanumeric data item can be used as a host variable to hold DB2 character data that has subtype FOR BIT DATA. An explicit EXEC SQL DECLARE VARIABLE statement that declares that host variable as FOR BIT DATA is not required.

**Coprocessor:** With the DB2 coprocessor, a COBOL alphanumeric data item can be used as a host variable to hold DB2 character data that has subtype FOR BIT DATA if an explicit EXEC SQL DECLARE VARIABLE statement for that host variable is specified in the COBOL program. For example:

```sql
EXEC SQL DECLARE :HV1 VARIABLE FOR BIT DATA END-EXEC.
```

As an alternative to adding EXEC SQL DECLARE . . . FOR BIT DATA statements, you can use the NOSQLCCSID compiler option. For details, see the related reference about code-page determination below.

**SQL-INIT-FLAG**

**Precompiler:** With the DB2 precompiler, if you pass host variables that might be located at different addresses when the program is called more than once, the called program must reset SQL-INIT-FLAG. Resetting this flag indicates to DB2 that storage must be initialized when the next SQL statement runs. To reset the flag, insert the statement MOVE ZERO TO SQL-INIT-FLAG in the PROCEDURE DIVISION of the called program ahead of any executable SQL statements that use those host variables.

**Coprocessor:** With the DB2 coprocessor, the called program does not need to reset SQL-INIT-FLAG. An SQL-INIT-FLAG is automatically defined in the program to aid program portability. However, statements that modify SQL-INIT-FLAG, such as MOVE ZERO TO SQL-INIT-FLAG, have no effect on the SQL processing in the program.

**related concepts**

“DB2 coprocessor” on page 417
“COBOL and DB2 CCSID determination” on page 422
Choosing the DYNAM or NODYNAM compiler option

For COBOL programs that have EXEC SQL statements, your choice of the compiler option DYNAM or NODYNAM depends on the operating environment.

When you run under:

- TSO or IMS: You can use either the DYNAM or NODYNAM compiler option.
  
  Note that IMS and DB2 share a common alias name, DSNHLI, for the language interface module. You must concatenate your libraries as follows:
  
  - If you use IMS with the DYNAM option, concatenate the IMS library first.
  - If you run your application only under DB2, concatenate the DB2 library first.

- CICS or the DB2 call attach facility (CAF): You must use the NODYNAM compiler option.

Because stored procedures use CAF, you must also compile COBOL stored procedures with the NODYNAM option.

related tasks

“Compiling with the SQL option” on page 421

related references

“DYNAM” on page 305
Chapter 22. Developing COBOL programs for IMS

Although much of the coding of a COBOL program will be the same when running under IMS, be aware of the following recommendations and restrictions.

In COBOL, IMS message processing programs (MPPs) do not use non-IMS input or output statements such as READ, WRITE, REWRITE, OPEN, and CLOSE.

With Enterprise COBOL, you can invoke IMS facilities using the following interfaces:

• CBLTDLI call
• Language Environment callable service CEETDLI
• EXEC SQLIMS statements

CEETDLI behaves essentially the same way as CBLTDLI, except that CEETDLI enables LE condition handling to be used. There are some instances when you cannot use Language Environment condition handling when using CBLTDLI under IMS.

You can also run object-oriented COBOL programs in a Java dependent region. You can mix the object-oriented COBOL and Java languages in a single application.

related concepts
“IMS SQL coprocessor” on page 427

related tasks
“Coding SQLIMS statements” on page 428
“Compiling with the SQLIMS option” on page 429
“Compiling and linking COBOL programs for running under IMS” on page 430
“Using object-oriented COBOL and Java under IMS” on page 431
“Calling a COBOL method from a Java application under IMS” on page 431
“Building a mixed COBOL-Java application that starts with COBOL” on page 432
“Writing mixed-language IMS applications” on page 432

IMS SQL coprocessor

When you use the IMS SQL coprocessor (called SQL statement coprocessor by IMS), the compiler handles your source programs that contain embedded SQL statements.

When the compiler encounters SQLIMS statements in the source program, it interfaces with the IMS SQL coprocessor. All text between EXEC SQLIMS and END-EXEC statements is passed to the coprocessor. The coprocessor takes appropriate actions for the SQLIMS statements and indicates to the compiler what native COBOL statements to generate for them.

Notes:

• The IMS SQL coprocessor processes embedded SQLIMS statements, not embedded SQL statements.
• IMS program might contain EXEC SQL statements for accessing a DB2 SQL database, EXEC SQLIMS statements for accessing an IMS DLI databases, or both. The SQL option enables EXEC SQL statements while the SQLIMS option enables EXEC SQLIMS statements.

With the IMS SQL coprocessor, you can use statements in the following ways:

• Use EXEC SQLIMS statements in any nested program.
• Use EXEC SQLIMS statements in COPYBOOKS.
• REPLACE statements work in SQLIMS statements.

related tasks
“Coding SQLIMS statements” on page 428
Coding SQLIMS statements

Delimit SQLIMS statements with EXEC SQLIMS and END-EXEC. The EXEC SQLIMS and END-EXEC delimiters must each be complete on one line. Do not code COBOL statements within EXEC SQLIMS statements.

Code an EXEC SQLIMS INCLUDE statement to include an SQLIMS communication area (SQLCA) in the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION of the outermost program. The LOCAL-STORAGE SECTION is recommended for recursive programs and programs that use the THREAD compiler option.

Restriction: You cannot use SQLIMS statements in object-oriented classes or methods.

related tasks

“Using SQLIMS INCLUDE with the IMS SQL coprocessor” on page 428
“Using character data in SQLIMS statements” on page 428
“Using binary items in SQLIMS statements” on page 429
“Determining the success of SQLIMS statements” on page 429

Using SQLIMS INCLUDE with the IMS SQL coprocessor

An SQLIMS INCLUDE statement is treated identically to a native COBOL COPY statement when you use the SQLIMS compiler option.

The following two lines are therefore treated the same way. The period that ends the EXEC SQLIMS INCLUDE statement is required.

```cobol
EXEC SQLIMS INCLUDE name END-EXEC.
COPY "name".
```

The processing of the name in an SQLIMS INCLUDE statement follows the same rules as the literal in a COPY literal-1 statement that does not have a REPLACING phrase.

The library search order for SQLIMS INCLUDE statements is the same SYSLIB concatenation as the compiler uses to resolve COBOL COPY statements that do not specify a library-name.

related references

Chapter 18, “Compiler-directing statements,” on page 357
COPY statement (Enterprise COBOL for z/OS Language Reference)

Using character data in SQLIMS statements

Alphanumeric host data items for use in EXEC SQLIMS statements (host variables) must be defined as USAGE DISPLAY.

Note: Do not use character data items that are defined with USAGE DISPLAY-1 or USAGE NATIONAL as SQLIMS host variables.

related concepts

“IMS SQL coprocessor” on page 427

related references

“CODEPAGE” on page 295
Using binary items in SQLIMS statements

For binary data items that you specify in an EXEC SQLIMS statement, you can define the data items as either USAGE COMP-5 or as USAGE BINARY, COMP, or COMP-4.

If you define the binary data items as USAGE BINARY, COMP, or COMP-4, use the TRUNC (BIN) compiler option. Using this option might have a larger effect on performance than using USAGE COMP-5 on individual data items. If instead you use the TRUNC (OPT) or TRUNC (STD) compiler options, the compiler accepts the items but the data might not be valid because of the decimal truncation rules. You must ensure that truncation does not affect the validity of the data.

related concepts
"Formats for numeric data" on page 45

related references
"TRUNC" on page 345

Determining the success of SQLIMS statements

When IMS finishes running an SQLIMS statement, IMS sends a return code in the SQLIMSCA structure to indicate whether the operation succeeded or failed. In your program, test the return code and take any necessary action.

After execution of SQLIMS statements, the content of the RETURN-CODE special register might not be valid. Therefore, even if a program terminates normally after successfully using SQLIMS statements, the job step might end with an undefined return code. To ensure that a meaningful return code is given at termination, set the RETURN-CODE special register before you end the program.

related tasks
IMS Application Programming Guide

Compiling with the SQLIMS option

Use the SQLIMS compiler option to enable the IMS SQL coprocessor and to specify IMS suboptions.

You can specify the SQLIMS option in any of the compiler option sources: compiler invocation, PROCESS or CBL statements, or installation default. However, you cannot specify IMS suboptions when the SQLIMS option is the COBOL installation default. The IMS suboption string in the SQLIMS compiler option is only available to the IMS SQL coprocessor.

To use the IMS SQL coprocessor, you must compile with the SQLIMS option and IMS must be available on the system on which you compile.

You can use standard JCL procedural statements to compile your program with the IMS SQL coprocessor. In addition to specifying the above compiler options, specify the following item in your JCL:

STEPLIB override for the COBOL step, adding the data set that contains the IMS SQL coprocessor services, unless these services are in the LNKLIST. Typically, the data set is IMS.SDFSRESL but your installation might have changed the name.

For example, you might have the following lines in your JCL:

```bash
//STEPLIB DD DSN=IMS.SDFSRESL,DISP=SHR
```

Compiling a batch of programs:

If you use the SQLIMS option when you compile a source file that contains a sequence of COBOL programs (a batch compile sequence), SQLIMS is in effect for only the first program of the sequence. Although you can specify SQLIMS upon compiler invocation, the option is in effect for only the first program. If you specify SQLIMS in a CBL or PROCESS statement for a program other than the first program in the batch, a compiler diagnostic message is issued.
Separating IMS suboptions

Because of the concatenation of multiple SQLIMS option specifications, you can separate IMS suboptions (which might not fit in one CBL statement) into multiple CBL statements.

The options that you include in the suboption string are cumulative. The compiler concatenates these suboptions from multiple sources in the order that they are specified. For example, suppose that your source file contains the following code:

```
//STEP1 EXEC IGYWC, . . .
//  PARM.COBO='SQLIMS("string1")'
//COBOL.SYSIN DD *
   CBL SQLIMS("string2")
   CBL SQLIMS("string3")
IDENTIFICATION DIVISION.
PROGRAM-ID. DRIVER1.
```

During compilation, the compiler passes the following suboption string to the IMS SQL coprocessor:

```
"string1 string2 string3"
```

The concatenated strings are delimited with single spaces. If the compiler finds multiple instances of the same SQLIMS suboption, the last specification of that suboption in the concatenated string takes effect. The compiler limits the length of the concatenated IMS suboption string to 4 KB.

Compiling and linking COBOL programs for running under IMS

For best performance in the IMS environment, use the RENT compiler option. RENT causes COBOL to generate reentrant code. You can then run your application programs in either preloaded mode (the programs are always resident in storage) or nonpreload mode without having to recompile using different options.

Preloading can boost performance because subsequent requests for a program can be handled faster when the program is already in storage (rather than being fetched from a library each time it is needed).

For IMS programs, using the RENT compiler option is recommended. You must use the RENT compiler option for a program that is to be run preloaded or both preloaded and nonpreloaded. When you preload a program object that contains COBOL programs, all of the COBOL programs in that program object must be compiled using the RENT option.

You can place programs compiled with the RENT option in the z/OS link pack area. There they can be shared among the IMS dependent regions.

To run above the 16 MB line, an application program must be compiled with RENT. The data for IMS application programs can reside above the 16 MB line, and you can use DATA(31) RENT for programs that use IMS services.
For proper execution of COBOL programs under IMS, observe the following guidelines for the link-edit attributes:

• To link program objects that contain only COBOL programs compiled with the RENT compiler option, link as RENT.

• To link program objects that contain a mixture of COBOL RENT programs and other programs, use the link-edit attributes recommended for the other programs.

related concepts
“Storage and its addressability” on page 37

related tasks
“Choosing the DYNAM or NODYNAM compiler option” on page 426
Language Environment Programming Guide (Condition handling under IMS)

related references
“DATA” on page 300
“RENT” on page 331
Enterprise COBOL Migration Guide (IMS considerations)

Using object-oriented COBOL and Java under IMS

You can mix object-oriented COBOL and Java in an application that runs in a Java dependent region. For example, you can:

• Call a COBOL method from a Java application. You can build the messaging portion of your application in Java and call COBOL methods to access IMS databases.

• Build a mixed COBOL and Java application that starts with the main method of a COBOL class and that invokes Java routines.

You must run these applications in either a Java message processing (JMP) dependent region or a Java batch processing (JBP) dependent region. A program that reads from the message queue (regardless of the language) must run in a JMP dependent region.

related tasks
“Defining a factory section” on page 586
Chapter 32, “Writing object-oriented programs,” on page 557
Chapter 33, “Communicating with Java methods,” on page 597
Chapter 16, “Compiling, linking, and running OO applications,” on page 273
IMS Application Programming Guide

Calling a COBOL method from a Java application under IMS

You can use the object-oriented language support in Enterprise COBOL to write COBOL methods that a Java program can call under IMS.

When you define a COBOL class and compile it using Enterprise COBOL, the compiler generates a Java class definition with native methods and the object code that implements those native methods. You can then create an instance and invoke the methods of this class from a Java program that runs in a Java dependent region, just as you would use any other class.

For example, you can define a COBOL class that uses the appropriate DL/I calls to access an IMS database. To make the implementation of this class available to a Java program, do the following steps:

1. Compile the COBOL class using Enterprise COBOL.
   The compiler generates a Java source file (.java) that contains the class definition, and an object module (.o) that contains the implementation of the native methods.
2. Compile the generated Java source file using the Java compiler.
   The Java compiler creates a class file (.class).
3. Link the object code into a dynamic link library (DLL) in the z/OS UNIX file system (.so). The directory that contains the COBOL DLLs must be listed in the LIBPATH, as specified in the IMS.PROCLIB member that is indicated by the ENVIRON= parameter of the IMS region procedure.

4. Update the sharable application class path in the master JVM options member (ibm.jvm.sharable.application.class.path in the IMS.PROCLIB member that is specified by the JVMOPMAS= parameter of the IMS region procedure) to enable the JVM to access the Java class file.

A Java program cannot call procedural COBOL programs directly. To reuse existing COBOL IMS code, use one of the following techniques:

- Restructure the COBOL code as a method in a COBOL class.
- Write a COBOL class definition and method that serves as a wrapper for the existing procedural code.
  The wrapper code can use COBOL CALL statements to access procedural COBOL programs.

related tasks
Chapter 16, "Compiling, linking, and running OO applications," on page 273
"Structuring OO applications" on page 594
"Wrapping procedure-oriented COBOL programs" on page 593
IMS Application Programming Guide

Building a mixed COBOL-Java application that starts with COBOL

An application that runs in a Java dependent region must start with the main method of a class.

A COBOL class definition that has a main factory method meets this requirement; therefore, you can use a main factory method as the first routine of a mixed COBOL and Java application under IMS.

Enterprise COBOL generates a Java class with a main method, which the Java dependent region can find, instantiate, and invoke. Although you can code the entire application in COBOL, you would probably build this type of application to call a Java routine. When the COBOL run time runs within the JVM of a Java dependent region, it automatically finds and uses this JVM to invoke methods on Java classes.

The COBOL application should use DL/I calls for processing messages (GU and GN) and synchronizing transactions (CHKP).

related tasks
"Structuring OO applications" on page 594
IMS Application Programming Guide
IBM SDK for Java - Tools Documentation

Writing mixed-language IMS applications

When you write mixed-language IMS applications, you need to be aware of the effects of the STOP RUN statement. You also need to understand how to process messages and synchronize transactions, access databases, and use the application interface block (AIB).

related tasks
"Using the STOP RUN statement” on page 432
"Processing messages and synchronizing transactions” on page 433
“Accessing databases” on page 433
“Using the application interface block” on page 433

Using the STOP RUN statement

If you use the STOP RUN statement in the COBOL portion of your application, the statement terminates all COBOL and Java routines (including the JVM).

Control is returned immediately to IMS. The program and the transaction are left in a stopped state.
Processing messages and synchronizing transactions
IMS message-processing applications must do all message processing and transaction synchronization either in COBOL or Java, rather than distributing this logic between application components written in both languages.

COBOL components use CALL statements to DL/I services to process messages (GU and GN) and synchronize transactions (CHKP). Java components use Java classes for IMS to do these functions. You can use object instances of classes derived from IMSF1e1dMessage to communicate entire IMS messages between the COBOL and Java components of the application.

related tasks
IMS Application Programming Guide

related references
IMS Application Programming API Reference

Accessing databases
You can use either Java, COBOL, or a mixture of the two languages to access IMS databases.

Limitation: EXEC SQL statements for DB2 database access are not supported in COBOL routines that run in a Java dependent region.

Recommendation: Do not access the same database program communication block (PCB) from both Java and COBOL. The Java and COBOL parts of the application share the same database position. Changes in database position from calls in one part of the application affect the database position in another part of the application. (This problem occurs whether the affected parts of an application are written in the same language or in different languages.)

Suppose that a Java component of a mixed application builds an SQL SELECT clause and uses Java Database Connectivity (JDBC) to query and retrieve results from an IMS database. The Java class libraries for IMS construct the appropriate request to IMS to establish the correct position in the database. If you then invoke a COBOL method that builds a segment search argument (SSA) and issues a GU (Get Unique) request to IMS against the same database PCB, the request probably altered the position in the database for that PCB. If so, subsequent JDBC requests to retrieve more records by using the initial SQL SELECT clause are incorrect because the database position changed. If you must access the same PCB from multiple languages, reestablish the database position after an interlanguage call before you access more records in the database.

related tasks
IMS Application Programming Guide

Using the application interface block
COBOL applications that run in a Java dependent region normally must use the AIB interface because the Java dependent region does not provide PCB addresses to its application.

To use the AIB interface, specify the PCB requested for the call by placing the PCB name (which must be defined as part of the PSBGEN) in the resource name field of the AIB. (The AIB requires that all PCBs in a program specification block (PSB) definition have a name.) You do not specify the PCB address directly, and your application does not need to know the relative PCB position in the PCB list. Upon the completion of the call, the AIB returns the PCB address that corresponds to the PCB name that the application passed.

Alternatively, you can obtain PCB addresses by making an IMS INQY call using subfunction FIND, and the PCB name as the resource name. The call returns the address of the PCB, which you can then pass to a COBOL program. (This approach still requires that the PCB name be defined as part of the PSBGEN, but the application does not have to use the AIB interface.)

“Example: using the application interface block” on page 434

related tasks
IMS Application Programming Guide
Example: using the application interface block
The following example shows how you can use the AIB interface in a COBOL application.

Local-storage section.
copy AIB.
.
Linkage section.
01 IOPCB.
   05 logtterm    pic x(08).
   05           pic x(02).
   05 tpstat      pic x(02).
   05 iodate      pic s9(7)  comp-3.
   05 iotime      pic s9(7)  comp-3.
   05           pic x(02).
   05 seqnum      pic x(02).
   05 mod         pic x(08).

Procedure division.
   Move spaces to input-area
   Move spaces to AIB
   Move "DFSAIB" to AIBRID
   Move length of AIB to AIBRLLEN
   Move "IOPCB" to AIBRSNM1
   Move length of input-area to AIBOALEN
   Call "CEETDLI" using GU, AIB, input-area
   Set address of IOPCB to AIBRESA1
   If tpstat = spaces
   * . . process input message
Chapter 23. Running COBOL programs under z/OS UNIX

To run COBOL programs in the z/OS UNIX environment, compile them using Enterprise COBOL or COBOL for OS/390 & VM. The programs must be reentrant, so use the compiler and linker option RENT.

If you are going to run the programs from the z/OS UNIX file system, use the linker option AMODE 31. Any AMODE 24 program that you call from within a z/OS UNIX application must reside in an MVS PDSE.

Restrictions: The following restrictions apply to running under z/OS UNIX:

• SORT and MERGE statements are not supported.
• You cannot use the old COBOL interfaces for preinitialization (runtime option RTEREUS) to establish a reusable environment.
• You cannot run a COBOL program compiled with the NOTHREAD option in more than one thread. If you start a COBOL application in a second thread, you get a software condition from the COBOL run time. You can run NOTHREAD COBOL programs in the initial process thread (IPT) or in one non-IPT that you create from a C or PL/I routine.
• You can run a COBOL program in more than one thread if you compile all the COBOL programs in the application with the THREAD option.

You can use Debug Tool to debug z/OS UNIX programs in remote debug mode, for example, by using the Debug perspective of IBM Developer for z/OS, or in full-screen mode (MFI) using a VTAM® terminal.

related tasks
Chapter 15, “Compiling under z/OS UNIX,” on page 265
“Running OO applications under z/OS UNIX” on page 275
“Running in z/OS UNIX environments” on page 435
“Setting and accessing environment variables” on page 436
“Calling UNIX/POSIX APIs” on page 438
“Accessing main program parameters under z/OS UNIX” on page 440

Language Environment Programming Guide

related references
“RENT” on page 331

Running in z/OS UNIX environments

You can run COBOL programs in any of the z/OS UNIX execution environments, either from within a z/OS UNIX shell or from outside a shell.

• You can run programs in either the OMVS shell (OMVS) or the ISPF shell (ISHELL).

Enter the program-name at the shell prompt. The program must be in the current directory or in your search path.

You can specify runtime options only by setting the environment variable _CEE_RUNOPTS before starting the program.

You can run programs that reside in a cataloged MVS data set from a shell by using the tso utility. For example:

```
tso "call 'my.loadlib(myprog)''
```

The ISPF shell can direct stdout and stderr only to a z/OS UNIX file, not to your terminal.

• From outside a shell, you can run programs either under TSO/E or in batch.
To call a COBOL program that resides in a z/OS UNIX file from the TSO/E prompt, use the BPXBATCH utility or a spawn() syscall in a REXX exec.

To call a COBOL program that resides in a z/OS UNIX file with the EXEC JCL statement, use the BPXBATCH utility.

**related tasks**
“Running OO applications under z/OS UNIX” on page 275
“Setting and accessing environment variables” on page 436
“Calling UNIX/POSIX APIs” on page 438
“Accessing main program parameters under z/OS UNIX” on page 440
“Defining and allocating QSAM files” on page 164
“Allocating line-sequential files” on page 200
“Allocating VSAM files” on page 192
“Displaying values on a screen or in a file (DISPLAY)” on page 33
*Language Environment Programming Guide* (Running POSIX-enabled programs)

**related references**
“TEST” on page 341
*UNIX System Services User’s Guide* (The BPXBATCH utility)
*Language Environment Programming Reference*

### Setting and accessing environment variables

You can set environment variables for z/OS UNIX COBOL programs either from the shell with commands `export` and `set`, or from the program.

Although setting and resetting environment variables from the shell before you begin to run a program is a typical procedure, you can set, reset, and access environment variables from the program while it is running.

If you are running a program with BPXBATCH, you can set environment variables by using an `STDENV DD` statement.

To reset an environment variable as if it had not been set, use the z/OS UNIX shell command `unset`. To reset an environment variable from a COBOL program, call the `setenv()` function.

To see the values of all environment variables, use the `export` command with no parameters. To access the value of an environment variable from a COBOL program, call the `getenv()` function.

“Example: setting and accessing environment variables” on page 438

**related tasks**
“Running in z/OS UNIX environments” on page 435
“Setting environment variables that affect execution” on page 437
“Accessing main program parameters under z/OS UNIX” on page 440
“Running OO applications under z/OS UNIX” on page 275
“Setting environment variables under z/OS UNIX” on page 265

**related references**
“Runtime environment variables” on page 437
*Language Environment Programming Reference*
*MVS Program Management: User’s Guide and Reference*
Setting environment variables that affect execution
To set environment variables for z/OS UNIX COBOL programs from a shell, use the export or set command. To set environment variables from within the program, call POSIX functions setenv() or putenv().

For example, to set the environment variable MYFILE:

```bash
export MYFILE=/usr/mystuff/notes.txt
```

“Example: setting and accessing environment variables” on page 438

related tasks
“Calling UNIX/POSIX APIs” on page 438
“Setting environment variables under z/OS UNIX” on page 265

related references
“Runtime environment variables” on page 437

Runtime environment variables
Several runtime variables are of interest for COBOL programs.

These are the runtime environment variables:

>_CEE_ENVFILE
   Specifies a file from which to read environment variables.

>_CEE_RUNOPTS
   Specifies runtime options.

CLASSPATH
   Specifies directory paths of Java .class files required for an OO application.

COBJVMINITOPTIONS
   Specifies Java virtual machine (JVM) options to be used when COBOL initializes a JVM.

>_IGZ_SYSOUT
   Specifies where to direct DISPLAY output. stdout and stderr are the only allowable values.

LIBPATH
   Specifies directory paths of dynamic link libraries.

PATH
   Specifies directory paths of executable programs.

STEPLIB
   Specifies location of programs that are not in the LNKLST.

related tasks
“Displaying data on the system logical output device” on page 34

related references
XL C/C++ Programming Guide (_CEE_ENVFILE)
Language Environment Programming Reference
Example: setting and accessing environment variables

The following example shows how you can access and set environment variables from a COBOL program by calling the standard POSIX functions `getenv()` and `putenv()`.

Because `getenv()` and `putenv()` are C functions, you must pass arguments BY VALUE. Pass character strings as BY VALUE pointers that point to null-terminated strings. Compile programs that call these functions with the NODYNAM and PGMNAME(LONGMIXED) options.

```cobol
CBL pgmname(longmixed),nodynam
Identification division.
Program-id. "envdemo".
Data division.
Working-storage section.
 01 P pointer.
 01 PATH pic x(5) value Z"PATH".
 01 var-ptr pointer.
 01 putenv-arg pic x(14) value Z"MYVAR=ABCDEFG".
 01 rc pic 9(9) binary.
Linkage section.
 01 var pic x(5000).
Procedure division.
  * Retrieve and display the PATH environment variable
    Set P to address of PATH
    Call "getenv" using by value P returning var-ptr
    If var-ptr = null then
      Display "PATH not set"
    Else
      Set address of var to var-ptr
      Move 0 to var-len
      Inspect var tallying var-len
      for characters before initial X"00"
      Display "PATH = " var(1:var-len)
    End-if
  * Set environment variable MYVAR to ABCDEFG
    Set P to address of putenv-arg
    Call "putenv" using by value P returning rc
    If rc not = 0 then
      Display "putenv failed"
      Stop run
    End-if
  Goback.
```

Calling UNIX/POSIX APIs

You can call standard UNIX/POSIX functions from z/OS UNIX COBOL programs and from traditional z/OS COBOL programs by using the CALL literal statement. These functions are part of Language Environment.

Because these are C functions, you must pass arguments BY VALUE. Pass character strings as BY VALUE pointers that point to null-terminated strings. You must use the compiler options NODYNAM and PGMNAME(LONGMIXED) when you compile programs that call these functions.

You can call the fork(), exec(), and spawn() functions from a COBOL program or from a non-COBOL program in the same process as COBOL programs. However, be aware of these restrictions:

- From a forked process you cannot access any COBOL sequential, indexed, or relative files that were open when you issued the fork. File status code 92 is returned if you attempt such access (CLOSE, READ, WRITE, REWRITE, DELETE, or START). You can access line-sequential files that were open at the time of a fork.
- You cannot use the fork() function in a process in which any of the following conditions are true:
  - A COBOL SORT or MERGE is running.
  - A declarative is running.
  - The process has more than one Language Environment enclave (COBOL run unit).
  - The process has used any of the COBOL reusable environment interfaces.
  - The process has ever run a VS COBOL II program.
With one exception, DD allocations are not inherited from a parent process to a child process. The exception is the local spawn, which creates a child process in the same address space as the parent process. You request a local spawn by setting the environment variable _BPX_ SHAREAS=YES before you invoke the spawn() function.

The exec() and spawn() functions start a new Language Environment enclave in the new UNIX process. Therefore the target program of the exec() or spawn() function is a main program, and all COBOL programs in the process start in initial state with all files closed.

Sample code for calling some of the POSIX routines is provided in the SIGYSAMP data set.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Sample</th>
<th>Functions used</th>
</tr>
</thead>
</table>
| Shows how to use some of the file and directory routines | IGYTFL1 | • getcwd()  
|         |                      | • mkdir()  
|         |                      | • rmdir()  
|         |                      | • access()  |
| Shows how to use the iconv routines to convert data | IGYTCNV | • iconv_open()  
|         |                      | • iconv()  
|         |                      | • iconv_close()  |
| Shows the use of the exec() routine to run a new program along with other process-related routines | IGYTEXC, IGYTEXC1 | • fork()  
|         |                      | • getpid()  
|         |                      | • getppid()  
|         |                      | • execl()  
|         |                      | • perror()  
|         |                      | • wait()  |
| Shows how to get the errno value | IGYTERNO, IGYTGETE | • perror()  
|         |                      | • fopen()  |
| Shows the use of the interprocess communication message routines | IGYTMSQ, IGYTMSQ2 | • ftok()  
|         |                      | • msgget()  
|         |                      | • msgsnd()  
|         |                      | • perror()  
|         |                      | • fopen()  
|         |                      | • fclose()  
|         |                      | • msgrcv()  
|         |                      | • msgctl()  
|         |                      | • perror()  |

related tasks
“Running in z/OS UNIX environments” on page 435
“Setting and accessing environment variables” on page 436
“Accessing main program parameters under z/OS UNIX” on page 440

Language Environment Programming Guide
Accessing main program parameters under z/OS UNIX

When you run a COBOL program from the z/OS UNIX shell command line or with an exec() or spawn() function, the parameter list consists of three parameters passed by reference. You can access these parameters with standard COBOL coding.

**argument count**
A binary fullword integer that contains the number of elements in each of the arrays that are passed in the second and third parameters.

**argument length list**
An array of pointers. The \( n \)th entry in the array is the address of a fullword binary integer that contains the length of the \( n \)th entry in the argument list.

**argument list**
An array of pointers. The \( n \)th entry in the array is the address of the \( n \)th character string passed as an argument in the spawn() or exec() function or in the command invocation. Each character string is null-terminated.

This array is never empty. The first argument is the character string that represents the name of the file associated with the process being started.

“Example: accessing main program parameters under z/OS UNIX” on page 440

related tasks
“Running in z/OS UNIX environments” on page 435
“Setting and accessing environment variables” on page 436
“Calling UNIX/POSIX APIs” on page 438
“Accessing main program parameters under z/OS” on page 474

Example: accessing main program parameters under z/OS UNIX

The following example shows the three parameters that are passed by reference, and shows the coding that you can use to access them.

```
Identification division.
Program-id. "EXECED".
****************************************************************
* This sample program displays arguments received via exec()  *
* function of z/OS UNIX                                        *
****************************************************************
Data division.
Working-storage section.
 01 curr-arg-count pic 9(9) binary value zero.
Linkage section.
 01 arg-count pic 9(9) binary.  (1)
 01 arg-length-list.          (2)
    05 arg-length-addr pointer occurs 1 to 99999 depending on curr-arg-count.
 01 arg-list.                 (3)
    05 arg-addr pointer occurs 1 to 99999 depending on curr-arg-count.
 01 arg-length pic 9(9) binary.
 01 arg pic X(65536).
Procedure division using arg-count arg-length-list arg-list.
****************************************************************
* Display number of arguments received                         *
****************************************************************
  Display "Number of arguments received: " arg-count
  Display each argument passed to this program
  Display number of arguments received: arg-count
  Display each argument passed to this program
Performance arg-count times
  Add 1 to curr-arg-count
```
(1) This count contains the number of elements in the arrays that are passed in the second and third parameters.

(2) This array contains a pointer to the length of the \( n \)th entry in the argument list.

(3) This array contains a pointer to the \( n \)th character string passed as an argument in the spawn() or exec() function or in the command invocation.
Part 4. Structuring complex applications
Chapter 24. Using subprograms

Many applications consist of several separately compiled programs linked together. A run unit (the COBOL term that is synonymous with the Language Environment term enclave) includes one or more object programs and can include object programs written in other Language Environment member languages.

Language Environment provides interlanguage support that lets your Enterprise COBOL programs call and be called by programs that meet the requirements of Language Environment.

**Name prefix alert:** Do not use program-names that start with prefixes used by IBM products. If you use programs whose names start with such prefixes, CALL statements might resolve to IBM library or compiler routines rather than to the intended program. For a list of prefixes to avoid, see the related task about identifying a program.

**related concepts**

“Main programs, subprograms, and calls” on page 445

**related tasks**

“Identifying a program” on page 3

“Ending and reentering main programs or subprograms” on page 446

“Transferring control to another program” on page 447

“Making recursive calls” on page 457

“Calling to and from object-oriented programs” on page 457

“Using procedure and function pointers” on page 457

“Making programs reentrant” on page 460

“Handling COBOL limitations with multithreading” on page 492

Language Environment Writing ILC Communication Applications

**related references**

Language Environment Programming Guide (Register conventions)

Main programs, subprograms, and calls

If a COBOL program is the first program in a run unit, that COBOL program is the main program. Otherwise, it and all other COBOL programs in the run unit are subprograms. No specific source-code statements or options identify a COBOL program as a main program or subprogram.

Whether a COBOL program is a main program or subprogram can be significant for either of two reasons:

- Effect of program termination statements
- State of the program when it is reentered after returning

In the PROCEDURE DIVISION, a program can call another program (generally called a subprogram), and this called program can itself call other programs. The program that calls another program is referred to as the calling program, and the program it calls is referred to as the called program. When the processing of the called program is completed, the called program can either transfer control back to the calling program or end the run unit.

The called COBOL program starts running at the top of the PROCEDURE DIVISION.

**related tasks**

“Ending and reentering main programs or subprograms” on page 446

“Transferring control to another program” on page 447

“Making recursive calls” on page 457

**related references**

Language Environment Programming Guide
Ending and reentering main programs or subprograms

Whether a program is left in its last-used state or its initial state, and to which caller it returns, can depend on the termination statements that you use.

You can use any of three termination statements in a program, but they have different effects as shown in the following table.

<table>
<thead>
<tr>
<th>Termination statement</th>
<th>Main program</th>
<th>Subprogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXIT PROGRAM</td>
<td>No action taken</td>
<td>Return to calling program without ending the run unit. An implicit EXIT PROGRAM statement is generated if the called program has no next executable statement. In a threaded environment, the thread is not terminated unless the program is the first (oldest) one in the thread.</td>
</tr>
<tr>
<td>STOP RUN</td>
<td>Return to calling program.(^1) (Might be the operating system, and application will end.) STOP RUN terminates the run unit, and deletes all dynamically called programs in the run unit and all programs link-edited with them. (It does not delete the main program.) In a threaded environment, the entire Language Environment enclave is terminated, including all threads running within the enclave.</td>
<td>Return directly to the program that called the main program.(^2) (Might be the operating system, and application will end.) STOP RUN terminates the run unit, and deletes all dynamically called programs in the run unit and all programs link-edited with them. (It does not delete the main program.) In a threaded environment, the entire Language Environment enclave is terminated, including all threads running within the enclave.</td>
</tr>
<tr>
<td>GOBACK</td>
<td>Return to calling program.(^1) (Might be the operating system, and application will end.) GOBACK terminates the run unit, and deletes all dynamically called programs in the run unit and all programs link-edited with them. (It does not delete the main program.) In a threaded environment, the thread is terminated.(^2)</td>
<td>Return to calling program. In a threaded environment, if the program is the first program in a thread, the thread is terminated.(^2)</td>
</tr>
</tbody>
</table>

\(^1\) If the main program is called by a program written in another language that does not follow Language Environment linkage conventions, return is to this calling program.

\(^2\) If the thread is the initial thread of execution in an enclave, the enclave is terminated.

A subprogram is usually left in its last-used state when it terminates with EXIT PROGRAM or GOBACK. The next time the subprogram is called in the run unit, its internal values are as they were left, except that return values for PERFORM statements are reset to their initial values. (In contrast, a main program is initialized each time it is called.)

There are some cases in which programs will be in their initial state:
- A subprogram that is dynamically called and then canceled will be in the initial state the next time it is called.
- A program that has the INITIAL clause in the PROGRAM-ID paragraph will be in the initial state each time it is called.
- Data items defined in the LOCAL-STORAGE SECTION will be reset to the initial state specified by their VALUE clauses each time the program is called.

**related concepts**
- “Comparison of WORKING-STORAGE and LOCAL-STORAGE” on page 13

**related tasks**
- “Calling nested COBOL programs” on page 454
- “Making recursive calls” on page 457

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**Transferring control to another program**

You can use several different methods to transfer control to another program: static calls, dynamic calls, calls to nested programs, and calls to dynamic link libraries (DLLs).

In addition to making calls between Enterprise COBOL programs, you can also make static and dynamic calls between Enterprise COBOL and programs compiled with older compilers in all environments including CICS.

For restrictions about making calls with older levels of programs, see Interoperability with older levels of IBM COBOL programs in the Enterprise COBOL for z/OS Migration Guide.

Calling nested programs lets you create applications using structured programming techniques. You can use nested programs in place of PERFORM procedures to prevent unintentional modification of data items. Call nested programs using either the CALL literal or CALL identifier statement.

Calls to dynamic link libraries (DLLs) are an alternative to COBOL dynamic CALL, and are well suited to object-oriented COBOL applications, z/OS UNIX programs, and applications that interoperate with C/C++.

Under z/OS, linking two program objects together results logically in a single program with a primary entry point and an alternate entry point, each with its own name. Each name by which a subprogram is to be dynamically called must be known to the system. You must specify each such name in binder (linkage-editor) control statements as either a NAME or an ALIAS of the program object that contains the subprogram.

**related concepts**
- “AMODE switching” on page 450
- “Performance considerations of static and dynamic calls” on page 452
- “Nested programs” on page 455

**related tasks**
- “Making static calls” on page 448
- “Making dynamic calls” on page 448
- “Making both static and dynamic calls” on page 452
- “Calling nested COBOL programs” on page 454

**related references**
- Enterprise COBOL for z/OS Migration Guide
  (Interoperability with older levels of IBM COBOL programs)
Making static calls
When you use the CALL literal statement in a program that is compiled using the NODYNAM and NODLL compiler options, a static call occurs. With these options, all CALL literal calls are handled as static calls.

With static calls statement, the COBOL program and all called programs are part of the same program object. When control is transferred, the called program already resides in storage, and a branch to it takes place. Subsequent executions of the CALL statement make the called program available in its last-used state unless the called program has the INITIAL attribute. In that case, the called program and each program directly or indirectly contained within it are placed into their initial state each time the called program is called within a run unit.

If you specify alternate entry points, a static CALL statement can use any alternate entry point to enter the called subprogram.

“Examples: static and dynamic CALL statements” on page 452

related concepts
“Performance considerations of static and dynamic calls” on page 452

related tasks
“Making dynamic calls” on page 448
“Making both static and dynamic calls” on page 452
“Calling to and from object-oriented programs” on page 457

related references
“DLL” on page 303
“DYNAM” on page 305
CALL statement (Enterprise COBOL for z/OS Language Reference)

Making dynamic calls
When you use a CALL literal statement in a program that is compiled using the DYNAM and the NODLL compiler options, or when you use the CALL identifier statement in a program that is compiled using the NODLL compiler option, a dynamic call occurs.

In these forms of the CALL statement, the called COBOL subprogram is not link-edited with the main program. Instead, it is link-edited into a separate program object, and is loaded at run time only when it is required (that is, when called). The program-name in the PROGRAM-ID paragraph or ENTRY statement must be identical to the corresponding program object name or program object alias of the program object that contains the program.

Each subprogram that you call with a dynamic CALL statement can be part of a different program object that is a member of either the system link library or a private library that you supply. In either case it must be in an MVS load library; it cannot reside in the z/OS UNIX file system. When a dynamic CALL statement calls a subprogram that is not resident in storage, the subprogram is loaded from secondary storage into the region or partition that contains the main program, and a branch to the subprogram is performed.

The first dynamic call to a subprogram within a run unit obtains a fresh copy of the subprogram. Subsequent calls to the same subprogram (by either the original caller or any other subprogram within the same run unit) result in a branch to the same copy of the subprogram in its last-used state, provided the subprogram does not possess the INITIAL attribute. Therefore, the reinitialization of either of the following items is your responsibility:

• G0 TO statements that have been altered
• Data items

If you call the same COBOL program in different run units, a separate copy of WORKING- storage is allocated for each run unit.

Restrictions: You cannot make dynamic calls to:

• COBOL DLL programs
• COBOL programs compiled with the PGMNAME (LONGMIXED) option, unless the program-name is less than or equal to eight characters in length and is all uppercase

• COBOL programs compiled with the PGMNAME (LONGUPPER) option, unless the program-name is less than or equal to eight characters in length

• More than one entry point in the same COBOL program (unless an intervening CANCEL statement was executed)

“Examples: static and dynamic CALL statements” on page 452

related concepts
“When to use a dynamic call with subprograms” on page 449
“Performance considerations of static and dynamic calls” on page 452

related tasks
“Canceling a subprogram” on page 449
“Making static calls” on page 448
“Making both static and dynamic calls” on page 452

related references
“DLL” on page 303
“DYNAM” on page 305
ENTRY statement (Enterprise COBOL for z/OS Language Reference)
CALL statement (Enterprise COBOL for z/OS Language Reference)
Language Environment Programming Reference

Canceling a subprogram
When you issue a CANCEL statement for a subprogram, the storage that is occupied by the subprogram is freed. A subsequent call to the subprogram functions as though it were the first call. You can cancel a subprogram from a program other than the original caller.

If the called subprogram has more than one entry point, ensure that an intervening CANCEL statement is executed before you specify different entry points in a dynamic CALL statement to that subprogram.

After a CANCEL statement is processed for a dynamically called contained program, the program will be in its first-used state. However, the program is not loaded with the initial call, and storage is not freed after the program is canceled.

“Examples: static and dynamic CALL statements” on page 452

related concepts
“Performance considerations of static and dynamic calls” on page 452

When to use a dynamic call with subprograms
Your decision to use dynamic calls with subprograms depends on factors such as location of the program object, frequency of calls to the subprograms, size of the subprograms, ease of maintenance, the need to call subprograms in their unused state, the need for AMODE switching, and when the program-names are known.

The program object that you want to dynamically call must be in an MVS load library rather than in the z/OS UNIX file system.

If subprograms are called in only a few conditions, you can use dynamic calls to bring in the subprograms only when needed.

If the subprograms are very large or there are many of them, using static calls might require too much main storage. Less total storage might be required to call and cancel one, then call and cancel another, than to statically call both.

If you are concerned about ease of maintenance, dynamic calls can help. Applications do not have to be link-edited again when dynamically called subprograms are changed.
When you cannot use the INITIAL attribute to ensure that a subprogram is placed in its unused state each time that it is called, you can set the unused state by using a combination of dynamic CALL and CANCEL statements. When you cancel a subprogram that was first called by a COBOL program, the next call causes the subprogram to be reinitialized to its unused state.

Using the CANCEL statement to explicitly cancel a subprogram that was dynamically loaded and branched to by a non-COBOL program does not result in any action being taken to release the subprogram's storage or to delete the subprogram.

Suppose you have an AMODE 24 program in the same run unit with Enterprise COBOL programs that you want to run in 31-bit addressing mode. COBOL dynamic call processing includes AMODE switching for AMODE 24 programs that call AMODE 31 programs, and vice versa. To have this implicit AMODE switching done, the Language Environment runtime options ALL31(OFF) and STACK(,,BELOW) must be in effect.

When dynamic call is performed, control is passed from the caller to a Language Environment library routine. After the switching is performed, control passes to the called program; the save area for the library routine will be positioned between the save area for the caller program and the save area for the called program.

If you do not know the program-name to be called until run time, use the format CALL identifier, where identifier is a data item that will contain the name of the called program at run time. For example, you could use CALL identifier when the program to be called varies depending on conditional processing in your program. CALL identifier is always dynamic, even if you use the NODYNAM compiler option.

“Examples: static and dynamic CALL statements” on page 452

related concepts
“AMODE switching” on page 450
“Performance considerations of static and dynamic calls” on page 452

related tasks
“Making dynamic calls” on page 448

related references
“DYNAM” on page 305
CALL statement (Enterprise COBOL for z/OS Language Reference)
Language Environment Programming Reference

AMODE switching

When you have an application that has COBOL subprograms, some of the COBOL subprograms can be AMODE 31 and some can be AMODE 24. To have this mixed AMODE support, the calls must be dynamic and the Language Environment runtime options ALL31(OFF) and STACK(,,BELOW) must be in effect.

If your application consists of only COBOL programs, and you are using dynamic calls, each COBOL subprogram will always be entered in the proper AMODE. For example, if you are using a dynamic call from an AMODE 31 COBOL program to an AMODE 24 COBOL program, the AMODE is automatically switched.

However, if you are using procedure pointers, function pointers, or other languages that call COBOL subprograms, you must ensure that when a COBOL program is called more than once in an enclave, it is entered in the same AMODE each time that it is called. The AMODE is not automatically switched in this case.

The following scenario shows that AMODE problems can arise when procedure pointers are used to call COBOL subprograms. This scenario is not supported because the COBOL program COBOLY is not entered in the same AMODE each time that it is called.
COBOLX is AMODE 31. It uses the SET statement to set a procedure pointer to COBOLZ. COBOLZ is a reentrant program object and is AMODE 31 and RMODE 24. COBOLX calls COBOLZ using the procedure pointer. COBOLZ is entered in AMODE 31.

2. COBOLZ returns to COBOLX.

3. COBOLX dynamically calls COBOLY, passing the procedure pointer for COBOLZ. COBOLY is a reentrant program object, and is AMODE 24 and RMODE 24. COBOLY is entered in AMODE 24.

4. COBOLY calls COBOLZ using the procedure pointer. This call causes COBOLZ to be entered in AMODE 24, which is not the same AMODE in which COBOLZ was entered when it was called the first time.

The following scenario uses a mix of COBOL and assembler language. This scenario is not supported because the COBOL program COBOLB is not entered in the same AMODE each time that it is called.

1. COBOLA is AMODE 31. COBOLA dynamically calls COBOLB. COBOLB is a reentrant program object and is AMODE 31 and RMODE 24. COBOLB is entered in AMODE 31.

2. COBOLB returns to COBOLA.

3. COBOLA dynamically calls ASSEM10, which is in assembler language. ASSEM10 is a reentrant program object, and is AMODE 24 and RMODE 24. ASSEM10 is entered in AMODE 24.

4. ASSEM10 loads COBOLB. ASSEM10 does a BALR instruction to COBOLB. COBOLB is entered in AMODE 24, which is not the same AMODE in which COBOLB was entered when it was called the first time.

related concepts
“Storage and its addressability” on page 37
Performance considerations of static and dynamic calls

Because a statically called program is link-edited into the same program object as the calling program, a static call is faster than a dynamic call. A static call is the preferred method if your application does not require the services of the dynamic call.

Statically called programs cannot be deleted using CANCEL, so static calls might take more main storage. If storage is a concern, think about using dynamic calls. Storage usage of calls depends on whether:

- The subprogram is called only a few times. Regardless of whether it is called, a statically called program is loaded into storage; a dynamically called program is loaded only when it is called.
- You subsequently delete the dynamically called subprogram with a CANCEL statement.

You cannot delete a statically called program, but you can delete a dynamically called program. Using a dynamic call and then a CANCEL statement to delete the dynamically called program after it is no longer needed in the application (and not after each call to it) might require less storage than using a static call.

Making both static and dynamic calls

You can use both static and dynamic CALL statements in the same program if you compile the program with the NODYNAM compiler option.

In this case, with the CALL literal statement, the called subprogram will be link-edited with the main program into one program object. The CALL identifier statement results in the dynamic invocation of a separate program object.

When a dynamic CALL statement and a static CALL statement to the same subprogram are issued within one program, a second copy of the subprogram is loaded into storage. Because this arrangement does not guarantee that the subprogram will be left in its last-used state, results can be unpredictable.

Examples: static and dynamic CALL statements

This example shows how you can code static and dynamic calls.

The example has three parts:

- Code that uses a static call to call a subprogram
- Code that uses a dynamic call to call the same subprogram
- The subprogram that is called by the two types of calls

The following example shows how you would code static calls:

```
PROCESS NODYNAM NODLL
```
IDENTIFICATION DIVISION.
DATA DIVISION.
WORKING-STORAGE SECTION.
  01 RECORD-2                   PIC X.         (6)
  01 RECORD-1.                 (2)
    05 PAY                    PICTURE S9(5)V99.
    05 HOURLY-RATE            PICTURE S9V99.
    05 HOURS                  PICTURE S99V9.

PROCEDURE DIVISION.
CALL "SUBPROG" USING RECORD-1.  (1)
CALL "PAYMASTR" USING RECORD-1 RECORD-2.  (5)
STOP RUN.

The following example shows how you would code dynamic calls:

DATA DIVISION.
WORKING-STORAGE SECTION.
  77 PGM-NAME                   PICTURE X(8).
  01 RECORD-2                   PIC X.         (6)
  01 RECORD-1.                 (2)
    05 PAY                    PICTURE S9(5)V99.
    05 HOURLY-RATE            PICTURE S9V99.
    05 HOURS                  PICTURE S99V9.

PROCEDURE DIVISION.
  . .
  MOVE "SUBPROG" TO PGM-NAME.
  CALL PGM-NAME USING RECORD-1. (1)
  CANCEL PGM-NAME.
  MOVE "PAYMASTR" TO PGM-NAME. (4)
  CALL PGM-NAME USING RECORD-1 RECORD-2. (5)
  STOP RUN.

The following example shows a called subprogram that is called by each of the two preceding calling programs:

IDENTIFICATION DIVISION.
PROGRAM-ID. SUBPROG.
DATA DIVISION.
LINKAGE SECTION.
  01 PAYREC.                 (2)
    10 PAY                    PICTURE S9(5)V99.
    10 HOURLY-RATE            PICTURE S9V99.
    10 HOURS                  PICTURE S99V9.
  77 PAY-CODE                 PICTURE 9.  (6)
PROCEDURE DIVISION USING PAYREC. (1)
  . .
  EXIT PROGRAM.             (3)
  ENTRY "PAYMASTR" USING PAYREC PAY-CODE. (5)
  . .
  GOBACK.                  (7)

(1) Processing begins in the calling program. When the first CALL statement is executed, control is transferred to the first statement of the PROCEDURE DIVISION in SUBPROG, which is the called program.

In each of the CALL statements, the operand of the first USING option is identified as RECORD-1.

(2) When SUBPROG receives control, the values within RECORD-1 are made available to SUBPROG; however, in SUBPROG they are referred to as PAYREC.

The PICTURE character-strings within PAYREC and PAY-CODE contain the same number of characters as RECORD-1 and RECORD-2, although the descriptions are not identical.

(3) When processing within SUBPROG reaches the EXIT PROGRAM statement, control is returned to the calling program. Processing continues in that program until the second CALL statement is executed.
In the example of a dynamically called program, because the second CALL statement refers to another entry point within SUBPROG, a CANCEL statement is executed before the second CALL statement.

With the second CALL statement in the calling program, control is again transferred to SUBPROG, but this time processing begins at the statement following the ENTRY statement in SUBPROG.

The values within RECORD-1 are again made available to PAYREC. In addition, the value in RECORD-2 is now made available to SUBPROG through the corresponding USING operand, PAY-CODE.

When control is transferred the second time from the statically linked program, SUBPROG is made available in its last-used state (that is, if any values in SUBPROG storage were changed during the first execution, those changed values are still in effect). When control is transferred from the dynamically linked program, however, SUBPROG is made available in its initial state, because of the CANCEL statement that has been executed.

When processing reaches the GOBACK statement, control is returned to the calling program at the statement immediately after the second CALL statement.

In any given execution of the called program and either of the two calling programs, if the values within RECORD-1 are changed between the time of the first CALL and the second, the values passed at the time of the second CALL statement will be the changed, not the original, values. If you want to use the original values, you must save them.

**Calling nested COBOL programs**

By calling nested programs, you can create applications that use structured programming techniques. You can also call nested programs instead of PERFORM procedures to prevent unintentional modification of data items.

Use either CALL literal or CALL identifier statements to make calls to nested programs.

You can call a contained program only from its directly containing program unless you identify the contained program as COMMON in its PROGRAM-ID paragraph. In that case, you can call the common program from any program that is contained (directly or indirectly) in the same program as the common program. Only contained programs can be identified as COMMON. Recursive calls are not allowed.

Follow these guidelines when using nested program structures:

- Code an IDENTIFICATION DIVISION in each program. All other divisions are optional.
- Optionally make the name of each contained program unique. Although the names of contained programs are not required to be unique (as described in the related reference about scope of names), making the names unique could help make your application more maintainable. You can use any valid user-defined word or an alphanumeric literal as the name of a contained program.
- In the outermost program, code any CONFIGURATION SECTION entries that might be required. Contained programs cannot have a CONFIGURATION SECTION.
- Include each contained program in the containing program immediately before the END PROGRAM marker of the containing program.
- Use an END PROGRAM marker to terminate contained and containing programs.

You cannot use the THREAD option when compiling programs that contain nested programs.

**related concepts**

“Nested programs” on page 455

**related references**

“Scope of names” on page 456
Nested programs
A COBOL program can nest, or contain, other COBOL programs. The nested programs can themselves contain other programs. A nested program can be directly or indirectly contained in a program.

There are four main advantages to nesting called programs:

- Nested programs provide a method for creating modular functions and maintaining structured programming techniques. They can be used analogously to perform procedures (using the PERFORM statement), but with more structured control flow and with the ability to protect local data items.
- Nested programs let you debug a program before including it in an application.
- Nested programs enable you to compile an application with a single invocation of the compiler.
- Calls to nested programs have the best performance of all the forms of COBOL CALL statements.

The following example describes a nested structure that has directly and indirectly contained programs:

```
X is the outermost program and directly contains X1 and X2, and indirectly contains X11 and X12

X1 is directly contained in X and directly contains X11 and X12

X11 is directly contained in X1 and indirectly contained in X

X12 is directly contained in X1 and indirectly contained in X

X2 is directly contained in X
```

“Example: structure of nested programs” on page 456

related tasks
“Calling nested COBOL programs” on page 454

related references
“Scope of names” on page 456
Example: structure of nested programs
The following example shows a nested structure with some contained programs that are identified as COMMON.

The following table describes the calling hierarchy for the structure that is shown in the example above. Programs A12, A2, and A3 are identified as COMMON, and the calls associated with them differ.

<table>
<thead>
<tr>
<th>This program</th>
<th>Can call these programs</th>
<th>And can be called by these programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1, A2, A3</td>
<td>None</td>
</tr>
<tr>
<td>A1</td>
<td>A11, A12, A2, A3</td>
<td>A</td>
</tr>
<tr>
<td>A11</td>
<td>A111, A12, A2, A3</td>
<td>A1</td>
</tr>
<tr>
<td>A111</td>
<td>A12, A2, A3</td>
<td>A11</td>
</tr>
<tr>
<td>A12</td>
<td>A2, A3</td>
<td>A1, A11, A111</td>
</tr>
<tr>
<td>A2</td>
<td>A3</td>
<td>A, A1, A11, A111, A12, A3</td>
</tr>
<tr>
<td>A3</td>
<td>A2</td>
<td>A, A1, A11, A111, A12, A2</td>
</tr>
</tbody>
</table>

In this example, note that:
• A2 cannot call A1 because A1 is not common and is not contained in A2.
• A1 can call A2 because A2 is common.

Scope of names
Names in nested structures are divided into two classes: local and global. The class determines whether a name is known beyond the scope of the program that declares it. A specific search sequence locates the declaration of a name after it is referenced in a program.

Local names
Names (except the program-name) are local unless declared to be otherwise. Local names are visible or accessible only within the program in which they are declared. They are not visible or accessible to contained and containing programs.

Global names
A name that is global (indicated by using the GLOBAL clause) is visible and accessible to the program in which it is declared and to all the programs that are directly and indirectly contained in that program. Therefore, the contained programs can share common data and files from the containing program simply by referencing the names of the items.

Any item that is subordinate to a global item (including condition-names and indexes) is automatically global.
You can declare the same name with the GLOBAL clause more than one time, provided that each declaration occurs in a different program. Be aware that you can mask, or hide, a name in a nested structure by having the same name occur in different programs in the same containing structure. However, such masking could cause problems during a search for a name declaration.

*Searches for name declarations*

When a name is referenced in a program, a search is made to locate the declaration for that name. The search begins in the program that contains the reference and continues outward to the containing programs until a match is found. The search follows this process:

1. Declarations in the program are searched.
2. If no match is found, only global declarations are searched in successive outer containing programs.
3. The search ends when the first matching name is found. If no match is found, an error exists.

The search is for a global name, not for a particular type of object associated with the name such as a data item or file connector. The search stops when any match is found, regardless of the type of object. If the object declared is of a different type than that expected, an error condition exists.

**Making recursive calls**

A called program can directly or indirectly execute its caller. For example, program X calls program Y, program Y calls program Z, and program Z then calls program X. This type of call is recursive.

To make a recursive call, you must code the RECURSIVE clause in the PROGRAM-ID paragraph of the recursively called program. If you try to recursively call a COBOL program that does not have the RECURSIVE clause in the PROGRAM-ID paragraph, a condition is signaled. If the condition remains unhandled, the run unit will end.

**Related tasks**

“Identifying a program as recursive” on page 4

**Related references**

PROGRAM-ID paragraph (Enterprise COBOL for z/OS Language Reference)

**Calling to and from object-oriented programs**

When you create applications that contain object-oriented (OO) programs, the OO COBOL programs are DLL programs and can be in one or more dynamic link libraries (DLLs). Each class definition must be in a separate DLL, however.

Calls to or from COBOL DLL programs must either use DLL linkage or be static calls. COBOL dynamic calls to or from COBOL DLL programs are not supported.

If you must call a COBOL DLL program from a COBOL non-DLL program, other means to ensure that the DLL linkage mechanism is followed are available.

**Using procedure and function pointers**

You can set procedure-pointer and function-pointer data items only by using format 6 of the SET statement.

*Procedure pointers* are data items defined with the USAGE IS PROCEDURE-POINTER clause. *Function pointers* are data items defined with the USAGE IS FUNCTION-POINTER clause. In this information, “pointer” refers to either a procedure-pointer data item or a function-pointer data item. You can set either of these data items to contain entry addresses of, or pointers to, these entry points:
• Another COBOL program that is not nested. For example, to have a user-written error-handling routine take control when an exception condition occurs, you must first pass the entry address of the routine to CEEHDLR, a condition-management Language Environment callable service, so that the routine is registered.

• A program written in another language. For example, to receive the entry address of a C function, call the function with the CALL RETURNING statement. It will return a pointer that you can either use as a function pointer or convert to a procedure pointer by using a form of the SET statement.

• An alternate entry point in another COBOL program (as defined in an ENTRY statement).

The SET statement sets the pointer to refer either to an entry point in the same program object as your program, to a separate program object, or to an entry point that is exported from a DLL, depending on the DYNAM|NODYNAM and DLL|NODLL compiler options. Therefore, consider these factors when using these pointer data items:

• If you compile a program with the NODYNAM and NODLL options and set a pointer item to a literal value (to an actual name of an entry point), the value must refer to an entry point in the same program object. Otherwise the reference cannot be resolved.

• If you compile a program with the NODLL option and either set a pointer item to an identifier that will contain the name of the entry point at run time or set the pointer item to a literal and compile with the DYNAM option, then the pointer item, whether a literal or variable, must point to an entry point in a separate program object. The entry point can be either the primary entry point or an alternate entry point named in an ALIAS binder (linkage-editor) statement.

• If you compile with the NODYNAM and DLL options and set a pointer item to a literal value (the actual name of an entry point), the value must refer to an entry point in the same program object or to an entry-point name that is exported from a DLL module. In the latter case you must include the DLL side file for the target DLL module in the link-edit of your program object.

• If you compile with the NODYNAM and DLL options and set a pointer item to an identifier (a data item that contains the entry point name at run time), the identifier value must refer to the entry-point name that is exported from a DLL module. In this case the DLL module name must match the name of the exported entry point.

If you set a pointer item to an entry address in a dynamically called program object, and your program subsequently cancels that dynamically called module, then that pointer item becomes undefined. Reference to it thereafter is not reliable.

Procedure pointer and function pointer calls are supported for AMODE 24 applications. However, the addressing mode cannot be switched for these calls, so the called and calling programs must have the same addressing mode at execution time.

COBOL entry points with the AMODE ANY attribute can be entered in either AMODE 31 or AMODE 24. However, the AMODE value that is in effect when the program is entered for the first time must also be in effect for all subsequent reentries of the program during the current Language Environment enclave.

For COBOL V5 and later, procedure and function pointers point to a function descriptor rather than directly to the entry point. If you have a data-only module, a table for example, you can no longer use the technique:

```
77 DATA-FUNCTION-PTR USAGE FUNCTION-POINTER.
77 DATA-PTR REDEFINES DATA-FUNCTION-PTR USAGE POINTER.

SET DATA-FUNCTION-PTR TO ENTRY "DATAONLY"
SET ADDRESS OF DATA TO DATA_PTR
```

However, you need to do the following change:

```
77 DATA-PTR USAGE POINTER.

CALL "DATAONLY" RETURNING DATA-PTR
SET ADDRESS OF DATA TO DATA_PTR
```
with the data-only module revised to return the address of the data, and below is the LP(32) example:

```
DATAONLY CSECT
USING *,15
LA 15,DATA
BR 14

DATA DC ...
...
END
```

The revised method also works with earlier COBOLs.

Calls to procedure and function pointers must be from a module with a Language Environment stack frame, as will be the case for any high-level programming language. If such a call is to be made from an assembler module, an LE stack frame must be provided by using the CEEENTRY and CEETERM macros, along with the associated register content requirements.

related tasks
“Deciding which type of pointer to use” on page 459
“Calling alternate entry points” on page 460
“Using procedure or function pointers with DLLs” on page 482

related references
“DLL” on page 303
“DYNAM” on page 305
CANCEL statement (Enterprise COBOL for z/OS Language Reference)
Format 6: SET for procedure-pointer and function-pointer data items (Enterprise COBOL for z/OS Language Reference)
ENTRY statement (Enterprise COBOL for z/OS Language Reference)
MVS Program Management: User’s Guide and Reference

Deciding which type of pointer to use

Use procedure pointers to call other COBOL programs and to call Language Environment callable services. Use function pointers to communicate with C/C++ programs or with services provided by the Java Native Interface.

Procedure pointers are more efficient than function pointers for COBOL-to-COBOL calls, and are required for calls to Language Environment condition-handling services.

Many callable services written in C return function pointers. You can call such a C function pointer from your COBOL program by using COBOL function pointers as shown below.

```
IDENTIFICATION DIVISION.
PROGRAM-ID. DEMO.
ENVIRONMENT DIVISION.
DATA DIVISION.
*
WORKING-STORAGE SECTION.
01 FP USAGE FUNCTION-POINTER.
*
PROCEDURE DIVISION.
   CALL "c-function" RETURNING FP.
   CALL FP.
```

related tasks
“Using procedure or function pointers with DLLs” on page 482
“Accessing JNI services” on page 597
Calling alternate entry points

Static calls to alternate entry points work without restriction.

Dynamic calls to alternate entry points require the following elements:

- Either explicitly specified NAME or ALIAS binder (linkage-editor) control statements, or use of the NAME compiler option which generates them automatically.
- An intervening CANCEL for any dynamic call to the same module at a different entry point. CANCEL causes the program to be invoked in initial state when it is called at a new entry point.

You can specify another entry point at which a program will begin running by using the ENTRY label in the called program. However, this method is not recommended in a structured program.

“Examples: static and dynamic CALL statements” on page 452

dynamic calls to alternate entry points

Making programs reentrant

If more than one user will run an application program at the same time (for example, users in different address spaces accessing a program that resides in the link pack area), you must make the program reentrant by compiling with the RENT option.

You do not need to worry about multiple copies of variables. The compiler creates the necessary reentrancy controls in the object module.

The following Enterprise COBOL programs must be reentrant:

- Programs to be used with CICS
- Programs to be preloaded with IMS
- Programs to be used as DB2 stored procedures
- Programs to be run in the z/OS UNIX environment
- Programs that are enabled for DLL support
- Programs that use object-oriented syntax

For reentrant programs, use the DATA compiler option and the HEAP and ALL31 runtime options to control whether dynamic data areas, such as WORKING-STORAGE, are obtained from storage below or above the 16 MB line.

Related concepts
“Storage and its addressability” on page 37

Related tasks
“Compiling programs to create DLLs” on page 478
Chapter 16, “Compiling, linking, and running OO applications,” on page 273

Related references
“RENT” on page 331
“DATA” on page 300
Language Environment Programming Reference (ALL31, HEAP)
Chapter 25. Sharing data

If a run unit consists of several separately compiled programs that call each other, the programs must be able to communicate with each other. They also usually need access to common data.

This information describes how you can write programs that share data with other programs. In this information, a subprogram is any program that is called by another program.

related tasks
“Using data from another program” on page 15
“Sharing data with Java” on page 601
“Passing data” on page 461
“Coding the LINKAGE SECTION” on page 465
“Coding the PROCEDURE DIVISION for passing arguments” on page 466
“Passing return-code information” on page 470
“Sharing data by using the EXTERNAL clause” on page 471
“Sharing files between programs (external files)” on page 471
“Accessing main program parameters under z/OS” on page 474

Passing data

You can choose among three ways of passing data between programs: BY REFERENCE, BY CONTENT, or BY VALUE.

BY REFERENCE
The subprogram refers to and processes the data items in the storage of the calling program rather than working on a copy of the data. BY REFERENCE is the assumed passing mechanism for a parameter if none of the three ways is specified or implied for the parameter.

BY CONTENT
The calling program passes only the contents of the literal or identifier. The called program cannot change the value of the literal or identifier in the calling program, even if it modifies the data item in which it received the literal or identifier.

BY VALUE
The calling program or method passes the value of the literal or identifier, not a reference to the sending data item. The called program or invoked method can change the parameter. However, because the subprogram or method has access only to a temporary copy of the sending data item, any change does not affect the argument in the calling program.

The following figure shows the differences in values passed BY REFERENCE, BY CONTENT, and BY VALUE:
Determine which of these data-passing methods to use based on what you want your program to do with the data.

### Table 61. Methods for passing data in the CALL statement

<table>
<thead>
<tr>
<th>Code</th>
<th>Purpose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CALL . . . BY REFERENCE <code>identifier</code></td>
<td>To have the definition of the argument of the CALL statement in the calling program and the definition of the parameter in the called program share the same memory</td>
<td>Any changes made by the subprogram to the parameter affect the argument in the calling program.</td>
</tr>
<tr>
<td>CALL . . . BY REFERENCE ADDRESS OF <code>identifier</code></td>
<td>To pass the address of <code>identifier</code> to a called program, where <code>identifier</code> is an item in the LINKAGE SECTION</td>
<td>Any changes made by the subprogram to the address affect the address in the calling program.</td>
</tr>
<tr>
<td>CALL . . . BY REFERENCE <code>file-name</code></td>
<td>To pass a data control block (DCB) to assembler programs</td>
<td>The file-name must reference a QSAM sequential file.</td>
</tr>
<tr>
<td>CALL . . . BY CONTENT ADDRESS OF <code>identifier</code></td>
<td>To pass a copy of the address of <code>identifier</code> to a called program</td>
<td>Any changes to the copy of the address will not affect the address of <code>identifier</code>, but changes to <code>identifier</code> using the copy of the address will cause changes to <code>identifier</code>.</td>
</tr>
<tr>
<td>CALL . . . BY CONTENT <code>identifier</code></td>
<td>To pass a copy of the identifier to the subprogram</td>
<td>Changes to the parameter by the subprogram will not affect the caller's identifier.</td>
</tr>
<tr>
<td>CALL . . . BY CONTENT <code>literal</code></td>
<td>To pass a copy of a literal value to a called program</td>
<td></td>
</tr>
<tr>
<td>CALL . . . BY CONTENT LENGTH OF <code>identifier</code></td>
<td>To pass a copy of the length of a data item</td>
<td>The calling program passes the length of the <code>identifier</code> from its LENGTH special register.</td>
</tr>
</tbody>
</table>
Table 61. *Methods for passing data in the CALL statement* (continued)

<table>
<thead>
<tr>
<th>Code</th>
<th>Purpose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A combination of BY REFERENCE and BY CONTENT such as:</td>
<td>To pass both a data item and a copy of its length to a subprogram</td>
<td></td>
</tr>
<tr>
<td>CALL ‘ERRPROC’ USING BY REFERENCE A BY CONTENT LENGTH OF A.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CALL . . . BY VALUE identifier</td>
<td>To pass data to a program, such as a C/C++ program, that uses BY VALUE parameter linkage conventions</td>
<td>A copy of the identifier is passed directly in the parameter list.</td>
</tr>
<tr>
<td>CALL . . . BY VALUE literal</td>
<td>To pass data to a program, such as a C/C++ program, that uses BY VALUE parameter linkage conventions</td>
<td>A copy of the literal is passed directly in the parameter list.</td>
</tr>
<tr>
<td>CALL . . . BY VALUE ADDRESS OF identifier</td>
<td>To pass the address of identifier to a called program. This is the recommended way to pass data to a C/C++ program that expects a pointer to the data.</td>
<td>Any changes to the copy of the address will not affect the address of identifier, but changes to identifier using the copy of the address will cause changes to identifier.</td>
</tr>
<tr>
<td>CALL . . . RETURNING</td>
<td>To call a C/C++ function with a function return value</td>
<td></td>
</tr>
</tbody>
</table>

1. File-names as CALL operands are allowed as an IBM extension to COBOL. Any use of the extension generally depends on the specific internal implementation of the compiler. Control block field settings might change in future releases. Any changes made to the control block are the user’s responsibility and are not supported by IBM.

**related concepts**

“Storage and its addressability” on page 37

**related tasks**

“Describing arguments in the calling program” on page 464
“Describing parameters in the called program” on page 464
“Testing for OMITTED arguments” on page 465
“Specifying CALL . . . RETURNING” on page 471
“Sharing data by using the EXTERNAL clause” on page 471
“Sharing files between programs (external files)” on page 471
“Sharing data with Java” on page 601

**related references**

CALL statement (*Enterprise COBOL for z/OS Language Reference*)
The USING phrase (*Enterprise COBOL for z/OS Language Reference*)
INVOKE statement (*Enterprise COBOL for z/OS Language Reference*)
Describing arguments in the calling program

In the calling program, describe arguments in the DATA DIVISION in the same manner as other data items in the DATA DIVISION.

Storage for arguments is allocated only in the outermost program. For example, program A calls program B, which calls program C. Data items are allocated in program A. They are described in the LINKAGE SECTION of programs B and C, making the one set of data available to all three programs.

If you reference data in a file, the file must be open when the data is referenced.

Code the USING phrase of the CALL statement to pass the arguments. If you pass a data item BY VALUE, it must be an elementary item.

To pass CALL arguments from AMODE 31 programs to AMODE 24 programs, you must ensure that the arguments are in storage below the 16 MB line to be addressed by the AMODE 24 subprogram.

- For reentrant AMODE 31 programs, compile the program with the DATA(24) option, or specify the Language Environment runtime option HEAP(,,BELOW) if WORKING- STORAGE is allocated from HEAP storage. For more information about when WORKING-STORAGE is allocated from HEAP storage, see “Storage and its addressability” on page 37.
- For nonreentrant programs that are compiled with the NORENT option, compile with the RMODE(24) or RMODE(AUTO) option. Consequently, the following items are allocated below the 16 MB line, and can be passed as arguments to AMODE 24 programs:
  - WORKING-STORAGE data items without the EXTERNAL clause
  - FD record areas
  - QSAM buffers
- For mixed AMODE applications, the Language Environment runtime options ALL31(OFF) and STACK(,,BELOW) are required. Consequently, the LOCAL- STORAGE SECTION data items and data items with the EXTERNAL attributes will be allocated below the 16 MB line, and can be passed as arguments to AMODE 24 programs.

related concepts
“Storage and its addressability” on page 37

related tasks
“Coding the LINKAGE SECTION” on page 465
“Coding the PROCEDURE DIVISION for passing arguments” on page 466

related references
The USING phrase (Enterprise COBOL for z/OS Language Reference)

Describing parameters in the called program

You must know what data is being passed from the calling program and describe it in the LINKAGE SECTION of each program that is called directly or indirectly by the calling program.

Code the USING phrase after the PROCEDURE DIVISION header to name the parameters that receive the data that is passed from the calling program.

When arguments are passed to the subprogram BY REFERENCE, it is invalid for the subprogram to specify any relationship between its parameters and any fields other than those that are passed and defined in the main program. The subprogram must not:

- Define a parameter to be larger in total number of bytes than the corresponding argument.
- Use subscript references to refer to elements beyond the limits of tables that are passed as arguments by the calling program.
- Use reference modification to access data beyond the length of defined parameters.
- Manipulate the address of a parameter in order to access other data items that are defined in the calling program.
If any of the rules above are violated, unexpected results might occur.

related tasks
“Coding the LINKAGE SECTION” on page 465

related references
The USING phrase (Enterprise COBOL for z/OS Language Reference)

Testing for OMITTED arguments
You can specify that one or more BY REFERENCE arguments are not to be passed to a called program by coding the OMITTED keyword in place of those arguments in the CALL statement.

For example, to omit the second argument when calling program sub1, code this statement:

```
Call 'sub1' Using PARM1, OMITTED, PARM3
```

The arguments in the USING phrase of the CALL statement must match the parameters of the called program in number and position.

In a called program, you can test whether an argument was passed as OMITTED by comparing the address of the corresponding parameter to NULL. For example:

```
Program-ID. sub1.

Procedure Division Using RPARM1, RPARM2, RPARM3.
  If Address Of RPARM2 = Null Then
    Display 'No 2nd argument was passed this time'
  Else
    Perform Process-Parm-2
  End-If
```

related references
CALL statement (Enterprise COBOL for z/OS Language Reference)
The USING phrase (Enterprise COBOL for z/OS Language Reference)

Coding the LINKAGE SECTION
Code the same number of data-names in the identifier list of the called program as the number of arguments in the calling program. Synchronize by position, because the compiler passes the first argument from the calling program to the first identifier of the called program, and so on.

You will introduce errors if the number of data-names in the identifier list of a called program is greater than the number of arguments passed from the calling program. The compiler does not try to match arguments and parameters.

The following figure shows a data item being passed from one program to another (implicitly BY REFERENCE):
In the calling program, the code for parts (PARTCODE) and the part number (PARTNO) are distinct data items. In the called program, by contrast, the code for parts and the part number are combined into one data item (PART-ID). In the called program, a reference to PART-ID is the only valid reference to these items.

**Related tasks**

“Accessing main program parameters under z/OS” on page 474

**Coding the PROCEDURE DIVISION for passing arguments**

If you pass an argument BY VALUE, code the USING BY VALUE clause in the PROCEDURE DIVISION header of the subprogram. If you pass an argument BY REFERENCE or BY CONTENT, you do not need to indicate in the header how the argument was passed.

```cobol
PROCEDURE DIVISION USING BY VALUE . . .
PROCEDURE DIVISION USING . . .
PROCEDURE DIVISION USING BY REFERENCE . . .
```

The first header above indicates that the data items are passed BY VALUE; the second or third headers indicate that the items are passed BY REFERENCE or BY CONTENT.

**Related references**

The procedure division header (Enterprise COBOL for z/OS Language Reference)
The USING phrase (Enterprise COBOL for z/OS Language Reference)
CALL statement (Enterprise COBOL for z/OS Language Reference)

**Grouping data to be passed**

Consider grouping all the data items that you need to pass between programs and putting them under one level-01 item. If you do so, you can pass a single level-01 record.

Note that if you pass a data item BY VALUE, it must be an elementary item.

To lessen the possibility of mismatched records, put the level-01 record into a copy library and copy it into both programs. That is, copy it in the WORKING-STORAGE SECTION of the calling program and in the LINKAGE SECTION of the called program.

**Related tasks**

“Coding the LINKAGE SECTION” on page 465

**Related references**

CALL statement (Enterprise COBOL for z/OS Language Reference)
Handling null-terminated strings

COBOL supports null-terminated strings when you use string-handling statements together with null-terminated literals and the hexadecimal literal X'00'.

You can manipulate null-terminated strings (passed from a C program, for example) by using string-handling mechanisms such as those in the following code:

```
01 L        pic X(20) value z'ab'.
01 M        pic X(20) value z'cd'.
01 N        pic X(20).
01 N-Length pic 99    value zero.
01 Y        pic X(13) value 'Hello, World!'.
```

To determine the length of a null-terminated string, and display the value of the string and its length, code:

```
Inspect N tallying N-length for characters before initial X'00'
Display 'N: ' N(1:N-length) ' Length: ' N-length
```

To move a null-terminated string to an alphanumeric string, but delete the null, code:

```
Unstring N  delimited by X'00' into X
```

To create a null-terminated string, code:

```
String Y     delimited by size
  X'00' delimited by size
into N.
```

To concatenate two null-terminated strings, code:

```
String L     delimited by x'00'
 M     delimited by x'00'
 X'00' delimited by size
into N.
```

related tasks

“Manipulating null-terminated strings” on page 106

related references

Null-terminated alphanumeric literals
(Enterprise COBOL for z/OS Language Reference)

Using pointers to process a chained list

When you need to pass and receive addresses of record areas, you can use pointer data items, which are either data items that are defined with the USAGE IS POINTER clause or are ADDRESS OF special registers.

A typical application for using pointer data items is in processing a chained list, a series of records in which each record points to the next.

When you pass addresses between programs in a chained list, you can use NULL to assign the value of an address that is not valid (nonnumeric 0) to a pointer item in either of two ways:

- Use a VALUE IS NULL clause in its data definition.
- Use NULL as the sending field in a SET statement.
In the case of a chained list in which the pointer data item in the last record contains a null value, you can use this code to check for the end of the list:

```ebnf
IF PTR-NEXT-REC = NULL
  . . . (logic for end of chain)
```

If the program has not reached the end of the list, the program can process the record and move on to the next record.

The data passed from a calling program might contain header information that you want to ignore. Because pointer data items are not numeric, you cannot directly perform arithmetic on them. However, to bypass header information, you can use the `SET` statement to increment the passed address.

**Example: using pointers to process a chained list**

The following example shows how you might process a linked list, that is, a chained list of data items.

For this example, picture a chained list of data that consists of individual salary records. The following figure shows one way to visualize how the records are linked in storage. The first item in each record except the last points to the next record. The first item in the last record contains a null value (instead of a valid address) to indicate that it is the last record.

The high-level pseudocode for an application that processes these records might be:

```
Obtain address of first record in chained list from routine
Check for end of the list
Do until end of the list
  Process record
  Traverse to the next record
End
```

The following code contains an outline of the calling program, LISTS, used in this example of processing a chained list.

```
IDENTIFICATION DIVISION.
PROGRAM-ID. LISTS.
ENVIRONMENT DIVISION.
DATA DIVISION.
******
WORKING-STORAGE SECTION.
  77 PTR-FIRST         POINTER  VALUE IS NULL. (1)
  77 DEPT-TOTAL        PIC 9(4) VALUE IS 0.
******
LINKAGE SECTION.
  01 SALARY-REC.
    02 PTR-NEXT-REC    POINTER. (2)
```
02 NAME PIC X(20).
02 DEPT PIC 9(4).
02 SALARY PIC 9(6).
01 DEPT-X PIC 9(4).

******
PROCEDURE DIVISION USING DEPT-X.
******
* FOR EVERYONE IN THE DEPARTMENT RECEIVED AS DEPT-X,
* GO THROUGH ALL THE RECORDS IN THE CHAINED LIST BASED ON THE
* ADDRESS OBTAINED FROM THE PROGRAM CHAIN-ANCH
* AND ACCUMULATE THE SALARIES.
* IN EACH RECORD, PTR-NEXT-REC IS A POINTER TO THE NEXT RECORD
* IN THE LIST; IN THE LAST RECORD, PTR-NEXT-REC IS NULL.
* DISPLAY THE TOTAL.
******
CALL "CHAIN-ANCH" USING PTR-FIRST (3)
SET ADDRESS OF SALARY-REC TO PTR-FIRST (4)
******
PERFORM WITH TEST BEFORE UNTIL ADDRESS OF SALARY-REC = NULL (5)
IF DEPT = DEPT-X
THEN ADD SALARY TO DEPT-TOTAL
ELSE CONTINUE
END-IF
SET ADDRESS OF SALARY-REC TO PTR-NEXT-REC (6)
END-PERFORM
******
DISPLAY DEPT-TOTAL
GOBACK.

(1) PTR-FIRST is defined as a pointer data item with an initial value of NULL. On a successful return from the call to CHAIN-ANCH, PTR-FIRST contains the address of the first record in the chained list. If something goes wrong with the call, and PTR-FIRST never receives the value of the address of the first record in the chain, a null value remains in PTR-FIRST and, according to the logic of the program, the records will not be processed.

(2) The LINKAGE SECTION of the calling program contains the description of the records in the chained list. It also contains the description of the department code that is passed in the USING clause of the CALL statement.

(3) To obtain the address of the first SALARY-REC record area, the LISTS program calls the program CHAIN-ANCH.

(4) The SET statement bases the record description SALARY-REC on the address contained in PTR-FIRST.

(5) The chained list in this example is set up so that the last record contains an address that is not valid. This check for the end of the chained list is accomplished with a do-while structure where the value NULL is assigned to the pointer data item in the last record.

(6) The address of the record in the LINKAGE-SECTION is set equal to the address of the next record by means of the pointer data item sent as the first field in SALARY-REC. The record-processing routine repeats, processing the next record in the chained list.

To increment addresses received from another program, you could set up the LINKAGE SECTION and PROCEDURE DIVISION like this:

**LINKAGE SECTION.**
01 RECORD-A.
   02 HEADER PIC X(12).
   02 REAL-SALARY-REC PIC X(30).
.
01 SALARY-REC.
   02 PTR-NEXT-REC POINTER.
   02 NAME PIC X(20).
The address of SALARY-REC is now based on the address of REAL-SALARY-REC, or RECORD-A + 12.

related tasks
“Using pointers to process a chained list” on page 467

Passing return-code information
Use the RETURN-CODE special register to pass return codes between programs. (Methods do not return information in the RETURN-CODE special register, but they can check the register after a call to a program.)

You can also use the RETURNING phrase in the PROCEDURE DIVISION header of a method to return information to an invoking program or method. If you use PROCEDURE DIVISION . . . RETURNING with CALL . . . RETURNING, the RETURN-CODE register will not be set.

Using the RETURN-CODE special register
When a COBOL program returns to its caller, the contents of the RETURN-CODE special register are stored into register 15.

When control is returned to a COBOL program or method from a call, the contents of register 15 are stored into the RETURN-CODE special register of the calling program or method. When control is returned from a COBOL program to the operating system, the special register contents are returned as a user return code.

You might need to think about this handling of the RETURN-CODE special register when control is returned to a COBOL program from a non-COBOL program. If the non-COBOL program does not use register 15 to pass back the return code, the RETURN-CODE special register of the COBOL program might be updated with an invalid value. Unless you set this special register to a meaningful value before your Enterprise COBOL program returns to the operating system, a return code that is invalid will be passed to the system.

For equivalent function between COBOL and C programs, have your COBOL program call the C program with the RETURNING phrase. If the C program (function) correctly declares a function value, the RETURNING value of the calling COBOL program will be set.

You cannot set the RETURN-CODE special register by using the INVOKE statement.

Using PROCEDURE DIVISION RETURNING . . .
Use the RETURNING phrase in the PROCEDURE DIVISION header of a program to return information to the calling program.

PROCEDURE DIVISION RETURNING dataname2

When the called program in the example above successfully returns to its caller, the value in dataname2 is stored into the identifier that was specified in the RETURNING phrase of the CALL statement:

CALL . . . RETURNING dataname2

CEEPIPI: The results of specifying PROCEDURE DIVISION RETURNING in programs that are called with the Language Environment preinitialization service (CEEPIPI) are undefined.
**Specifying CALL . . . RETURNING**

You can specify the RETURNING phrase of the CALL statement for calls to C/C++ functions or to COBOL subroutines.

The RETURNING phrase has the following format.

```
CALL . . . RETURNING dataname2
```

The return value of the called program is stored into `dataname2`. You must define `dataname2` in the DATA DIVISION of the calling program. The data type of the return value that is declared in the target function must be identical to the data type of `dataname2`.

**Sharing data by using the EXTERNAL clause**

Use the EXTERNAL clause to enable separately compiled programs and methods (including programs in a batch sequence) to share data items. Code EXTERNAL in the level-01 data description in the WORKING-STORAGE SECTION.

The following rules apply:

- Items that are subordinate to an EXTERNAL group item are themselves EXTERNAL.
- You cannot use the name of an EXTERNAL data item as the name for another EXTERNAL item in the same program.
- You cannot code the VALUE clause for any group item or subordinate item that is EXTERNAL.

In the run unit, any COBOL program or method that has the same data description for the item as the program that contains the item can access and process that item. For example, suppose program A has the following data description:

```
01 EXT-ITEM1     EXTERNAL     PIC 99.
```

Program B can access that data item if B has the identical data description in its WORKING-STORAGE SECTION.

Any program that has access to an EXTERNAL data item can change the value of that item. Therefore do not use this clause for data items that you need to protect.

**Sharing files between programs (external files)**

To enable separately compiled programs or methods in a run unit to access a file as a common file, use the EXTERNAL clause for the file.

It is recommended that you follow these guidelines:

- Use the same data-name in the FILE STATUS clause of all the programs that check the file status code.
- For each program that checks the same file status field, code the EXTERNAL clause in the level-01 data definition for the file status field.

Using an external file has these benefits:

- Even if the main program does not contain any input or output statements, it can reference the record area of the file.
- Each subprogram can control a single input or output function, such as OPEN or READ.
- Each program has access to the file.

“Example: using external files” on page 472
Example: using external files

The following example shows the use of an external file in several programs. COPY statements ensure that each subprogram contains an identical description of the file.

The following table describes the main program and subprograms.

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ef1</td>
<td>The main program, which calls all the subprograms and then verifies the contents of a record area</td>
</tr>
<tr>
<td>ef1openo</td>
<td>Opens the external file for output and checks the file status code</td>
</tr>
<tr>
<td>ef1write</td>
<td>Writes a record to the external file and checks the file status code</td>
</tr>
<tr>
<td>ef1openi</td>
<td>Opens the external file for input and checks the file status code</td>
</tr>
<tr>
<td>ef1read</td>
<td>Reads a record from the external file and checks the file status code</td>
</tr>
<tr>
<td>ef1close</td>
<td>Closes the external file and checks the file status code</td>
</tr>
</tbody>
</table>

Each program uses three copybooks:

- **efselect** is placed in the FILE-CONTROL paragraph:

  ```cobol
  Select ef1
  Assign To ef1
  File Status Is efs1
  Organization Is Sequential.
  ```

- **effile** is placed in the FILE SECTION:

  ```cobol
  Fd ef1 Is External
  Record Contains 80 Characters
  Recording Mode F.
  01 ef-record-1.
      02 ef-item-1  Pic X(80).
  ```

- **efwrkstg** is placed in the WORKING-STORAGE SECTION:

  ```cobol
  01 efs1          Pic 99 External.
  ```

**Input/output using external files**

```cobol
IDENTIFICATION DIVISION.
  Program-Id.
    ef1.
    * This main program controls external file processing.
    *
    ENVIRONMENT DIVISION.
      Input-Output Section.
      File-Control.
        Copy efselect.
      DATA DIVISION.
        FILE SECTION.
          Copy effile.
          WORKING-STORAGE SECTION.
            Copy efwrkstg.
      PROCEDURE DIVISION.
  ```
Call "ef1openo"
Call "ef1write"
Call "ef1close"
Call "ef1openi"
* This program opens the external file for output.
* ENVIRONMENT DIVISION.
Input-Output Section.
File-Control.
  Copy efselect.
DATA DIVISION.
FILE SECTION.
  Copy effile.
WORKING-STORAGE SECTION.
  Copy efwrkstg.
PROCEDURE DIVISION.
  Open Output ef1
  If efs1 Not = 0
    Display "file status " efs1 " on open output"
    Stop Run
  End-If
  Goback.
End Program ef1openo.
IDENTIFICATION DIVISION.
Program-Id.
ef1openo.
* This program writes a record to the external file.
* ENVIRONMENT DIVISION.
Input-Output Section.
File-Control.
  Copy efselect.
DATA DIVISION.
FILE SECTION.
  Copy effile.
WORKING-STORAGE SECTION.
  Copy efwrkstg.
PROCEDURE DIVISION.
  Move "First record" to ef-record-1
  Write ef-record-1
  If efs1 Not = 0
    Display "file status " efs1 " on write"
    Stop Run
  End-If
  Goback.
End Program ef1write.
IDENTIFICATION Division.
Program-Id.
ef1write.
* This program opens the external file for input.
* ENVIRONMENT DIVISION.
Input-Output Section.
File-Control.
  Copy efselect.
DATA DIVISION.
FILE SECTION.
  Copy effile.
WORKING-STORAGE SECTION.
  Copy efwrkstg.
PROCEDURE DIVISION.
  Open Input ef1
  If efs1 Not = 0
    Display "file status " efs1 " on open input"
    Stop Run
  End-If
  Goback.
End Program ef1openi.
IDENTIFICATION Division.
Program-Id.
ef1openi.
**Accessing main program parameters under z/OS**

When you run an Enterprise COBOL program under z/OS and pass the program a parameter string, for example, by using JCL or a TSO command, the parameter list consists of a character string that has a halfword prefix that contains the string length.

You can access the parameter string by using a LINKAGE SECTION and standard COBOL coding as shown in the example referenced below:

“Example: accessing main program parameters under z/OS” on page 475

Alternatively, you can obtain the parameter string by calling either of the following Language Environment callable services, which are described in the related references below:

- CEE3PRM (query parameter string): obtain the parameter string (if not longer than 80 characters)
- CEE3PR2 (query parameter string long): obtain the parameter string and its length

In either case, the parameter string might contain program arguments, runtime options, or both. The setting of the CBLOPTS runtime option determines the relative order in which program arguments and runtime options are expected. If CBLOPTS(ON) (the default) is in effect, and program arguments and
runtime options are both passed in the parameter string, they must appear in the following order, separated by a forward slash:

```
program_arguments/runtime_options
```

For further details, see the related information referenced below.

**related tasks**

- “Coding the LINKAGE SECTION” on page 465
- “Accessing main program parameters under z/OS UNIX” on page 440
- Language Environment Programming Guide (Specifying runtime options and program arguments, Preparing your main routine to receive parameters)

**related references**

- Language Environment Customization (CBLOPTS (COBOL only))
- Language Environment Programming Reference (CEE3PRM, CEE3PR2)

**Example: accessing main program parameters under z/OS**

The following example shows how to receive a parameter string that is passed to a COBOL program that runs under z/OS, and shows the coding that you can use to access the parameter string.

```cobol
IDENTIFICATION DIVISION.
  PROGRAM-ID. "testarg".
  *
  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  *
  DATA DIVISION.
  WORKING-STORAGE SECTION.
  *
  linkage section.
  01 os-parm.
       05 parm-len         pic s999 comp.
       05 parm-string.
            10 parm-char    pic x occurs 0 to 100 times depending on parm-len.
  *
  PROCEDURE DIVISION using os-parm.
       display "parm-len=" parm-len
       display "parm-string='' parm-string ''"
       evaluate parm-string
           when "01"  display "case one"
           when "02"  display "case two"
           when "95"  display "case ninety-five"
           when other display "case unknown"
       end-evaluate
       GOBACK.
```

Suppose that the CBLOPTS(ON) runtime option is in effect, and that you pass the following argument in the JCL or TSO command that you use to run the program:

```
'95/
```

Then the resulting output is:

```
parm-len=002
parm-string='95'
case ninety-five
```
Chapter 26. Creating a DLL or a DLL application

Creating a dynamic link library (DLL) or a DLL application is similar to creating a regular COBOL application. It involves writing, compiling, and linking your source code.

Special considerations when writing a DLL or a DLL application include:

• Determining how the parts of the program object or the application relate to each other or to other DLLs
• Deciding what linking or calling mechanisms to use

Depending on whether you want to create a DLL program object or a program object that references a separate DLL, you need to use slightly different compiler and binder (linkage-editor) options.

related concepts
“Dynamic link libraries (DLLs)” on page 477

related tasks
“Creating a DLL under z/OS UNIX” on page 268
“Compiling programs to create DLLs” on page 478
“Linking DLLs” on page 478
“Using CALL identifier with DLLs” on page 480
“Using DLL linkage and dynamic calls together” on page 481
“Using COBOL DLLs with C/C++ programs” on page 484
“Using DLLs in OO COBOL applications” on page 485
“Using procedure or function pointers with DLLs” on page 482

Dynamic link libraries (DLLs)

A DLL is a program object that can be accessed from other separate program objects.

A DLL differs from a traditional program object in that it exports definitions of programs, functions, or variables to DLLs, DLL applications, or non-DLLs. Therefore, you do not need to link the target routines into the same program object as the referencing routine. When an application references a separate DLL for the first time, the system automatically loads the DLL into memory. In other words, calling a program in a DLL is similar to calling a program object with a dynamic CALL.

A DLL application is an application that references imported definitions of programs, functions, or variables.
Although some functions of z/OS DLLs overlap the functions provided by COBOL dynamic CALL statements, DLLs have several advantages over regular z/OS program objects and dynamic calls:

- DLLs are common across COBOL and C/C++, thus providing better interoperability for applications that use multiple programming languages. Reentrant COBOL and C/C++ DLLs can also interoperate smoothly.
- You can make calls to programs in separate DLL modules that have long program-names. (Dynamic call resolution truncates program-names to eight characters.) Using the COBOL option PGMNAME (LONGUPPER) or PGMNAME (LONGMIXED) and the COBOL DLL support, you can make calls between program objects with names of up to 160 characters.

DLLs are supported by IBM z/OS Language Environment, based on function provided by the z/OS program management binder. DLL support is available for applications running under z/OS in batch or in TSO, CICS, z/OS UNIX, or IMS environments.

**related references**
- “PGMNAME” on page 328
- MVS Program Management: User's Guide and Reference (Binder support for DLLs)

### Compiling programs to create DLLs

When you compile a COBOL program with the DLL option, it becomes enabled for DLL support. Applications that use DLL support must be reentrant. Therefore, you must compile them with the RENT compiler option and link them with the RENT binder option.

In an application with DLL support, use the following compiler options depending on where the programs or classes are:

<table>
<thead>
<tr>
<th>Programs or classes in:</th>
<th>Compile with:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root program object</td>
<td>DLL, RENT, NOEXPORTALL</td>
</tr>
<tr>
<td>DLL program objects used by other program objects</td>
<td>DLL, RENT, EXPORTALL</td>
</tr>
</tbody>
</table>

If a DLL program object includes some programs that are used only from within the DLL module, you can hide these routines by compiling them with NOEXPORTALL.

“Example: sample JCL for a procedural DLL application” on page 479

**related tasks**
- “Creating a DLL under z/OS UNIX” on page 268
- “Linking DLLs” on page 478
- Chapter 26, “Creating a DLL or a DLL application,” on page 477

**related references**
- “DLL” on page 303
- “EXPORTALL” on page 307
- “RENT” on page 331

### Linking DLLs

You can link DLL-enabled object modules into separate DLL program objects, or you can link them together statically. You can decide whether to package the application as one module or as several DLL modules at link time.

The DLL support in the z/OS binder is recommended for linking DLL applications. The binder can directly receive the output of COBOL compilers.
A binder-based DLL must reside in a PDSE or in a z/OS UNIX file. When using the binder to link a DLL application, use the following options:

<table>
<thead>
<tr>
<th>Type of code</th>
<th>Link using binder parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLL applications</td>
<td>DYNAM(DLL), RENT</td>
</tr>
<tr>
<td>Applications that use mixed-case exported</td>
<td>CASE(MIXED)</td>
</tr>
<tr>
<td>program-names</td>
<td></td>
</tr>
<tr>
<td>Class definitions or INVOKE statements</td>
<td></td>
</tr>
</tbody>
</table>

You must specify a SYSDEFS DD DD statement to indicate the data set in which the binder should create a DLL definition side file. This side file contains IMPORT control statements for each symbol exported by a DLL. The binder SYSLIN input (the binding code that references the DLL code) must include the DLL definition side files for DLLs that are to be referenced from the module being linked.

If there are programs in the module that you do not want to make available with DLL linkage, you can edit the definition side file to remove these programs.

“Example: sample JCL for a procedural DLL application” on page 479

related tasks
“Creating a DLL under z/OS UNIX” on page 268
Chapter 26, “Creating a DLL or a DLL application,” on page 477
“Compiling programs to create DLLs” on page 478

related references
MVS Program Management: User’s Guide and Reference (Binder support for DLLs)

Example: sample JCL for a procedural DLL application

The following example shows how to create an application that consists of a main program that calls a DLL subprogram.

The first step creates the DLL program object that contains the subprogram DemoDLLSubprogram. The second step creates the main program object that contains the program MainProgram. The third step runs the application.

```//DLLSAMP  JOB ,
//  TIME=(1),MSGLEVEL=(1,1),MSGCLASS=A,CLASS=A,
//  NOTIFY=&SYSUID,USER=&SYSUID
// SET LEPFX='SYS1'
//*---------------------------------------------------------------------
//* Compile COBOL subprogram, bind to form a DLL.
//*---------------------------------------------------------------------
//STEP1 EXEC IGYWCL,REGION=80M,GOPGM=DEMODLL,
//       PARM.COBOL='RENT,PGMN(LM),DLL,EXPORTALL',
//       PARM.LKED='RENT,LIST,XREF,LET,MAP,DYNAM(DLL),CASE(MIXED)'
//COBOL.SYSIN DD *
Identification division.
  Program-id. "DemoDLLSubprogram".
  Procedure division.
  Display "Hello from DemoDLLSubprogram!".
  End program "DemoDLLSubprogram".
/*
//LKED.SYSDEFS DD DSN=&SIDEFILE,UNIT=SYSDA,DISP=(NEW,PASS),
//             SPACE=(TRK,(1,1))
//LKED.SYSLMOD DD DSN=&GOSET(&GOPGM),DSNTYPE=LIBRARY,DISP=(MOD,PASS)
//LKED.SYSIN DD DUMMY
*="/**- Compile and bind COBOL main program */
```
Using CALL identifier with DLLs

In a COBOL program that has been compiled with the DLL option, you can use CALL identifier and CALL literal statements to make calls to DLLs. However, there are a few additional considerations for the CALL identifier case.

For the content of the identifier or for the literal, use the name of either of the following programs:

- A nested program in the same compilation unit that is eligible to be called from the program that contains the CALL identifier statement.
- A program in a separately bound DLL module. The target program-name must be exported from the DLL, and the DLL module name must match the exported name of the target program.

In the nonnested case, the runtime environment interprets the program-name in the identifier according to the setting of the PGMNAME compiler option of the program that contains the CALL statement, and interprets the program-name that is exported from the target DLL according to the setting of the PGMNAME option used when the target program was compiled.

The search for the target DLL in the z/OS UNIX file system is case sensitive. If the target DLL is a PDSE member, the DLL member name must be eight characters or less. For the purpose of the search for the DLL as a PDSE member, the run time automatically converts the name to uppercase.

If the runtime environment cannot resolve the CALL statement in either of these cases, control is transferred to the ON EXCEPTION or ON OVERFLOW phrase of the CALL statement. If the CALL statement does not specify one of these phrases in this situation, Language Environment raises a severity-3 condition.

related tasks
“Using DLL linkage and dynamic calls together” on page 481
“Compiling programs to create DLLs” on page 478
“Linking DLLs” on page 478

related references
“DLL” on page 303
“PGMNAME” on page 328
CALL statement (Enterprise COBOL for z/OS Language Reference)
“Search order for DLLs in the z/OS UNIX file system” on page 481
**Search order for DLLs in the z/OS UNIX file system**

When you use the z/OS UNIX file system, the search order for resolving a DLL reference in a CALL statement depends on the setting of the Language Environment POSIX runtime option.

If the POSIX runtime option is ON, the search order is as follows:

1. The runtime environment looks for the DLL in the z/OS UNIX file system. If the LIBPATH environment variable is set, the run time searches each directory listed. Otherwise, it searches just the current directory. The search for the DLL in the z/OS UNIX file system is case sensitive.

2. If the runtime environment does not find the DLL in the z/OS UNIX file system, it tries to load the DLL from the MVS load library search order of the caller. In this case, the DLL name must be eight characters or less. The run time automatically converts the DLL name to uppercase for this search.

If the POSIX runtime option is set to OFF, the search order is reversed:

1. The runtime environment tries to load the DLL from the search order for the load library of the caller.

2. If the runtime environment cannot load the DLL from this load library, it tries to load the DLL from the z/OS UNIX file system.

**related tasks**

“Using CALL identifier with DLLs” on page 480

**related references**

*Language Environment Programming Reference (POSIX)*

---

**Using DLL linkage and dynamic calls together**

For applications (that is, Language Environment enclaves) that are structured as multiple separately bound modules, each module can be invoked by using dynamic call linkage or DLL linkage. For a certain module, use exclusively one form of linkage to enter it. However, the caller can contain CALL statements with both linkage types, calling out to different modules.

**DLL linkage** refers to a call in a program that is compiled with the DLL and NODYNAM options, or a call with the CALLINTERFACE compiler directive that specifies DLL. In such calls, the called subprogram is resolved to an exported name in a separate module. DLL linkage can also refer to an invocation of a method that is defined in a separate module.

Within a compilation unit you can call a specific program with only one of the calling conventions: Dynamic, DLL or Static. If a program is called by using different calling conventions, the compiler diagnoses this case and force all the calls to have the same convention as the first call statement that is encountered for that program.

A program can contain CALL statements with both dynamic call linkage and DLL linkage. It can do so by using the CALLINTERFACE compiler directive to specify the linkage type of a particular call. All components of a DLL application must have the same AMODE. The automatic AMODE switching normally provided by COBOL dynamic calls is not available for DLL linkages. You cannot cancel programs that are called by using DLL linkage.

All components of a DLL application must have the same AMODE. The automatic AMODE switching normally provided by COBOL dynamic calls is not available for DLL linkages.

**related concepts**

“Dynamic link libraries (DLLs)” on page 477

**related tasks**

“Compiling programs to create DLLs” on page 478

“Linking DLLs” on page 478

“Using procedure or function pointers with DLLs” on page 482

“Calling DLLs from non-DLLs” on page 482
Using procedure or function pointers with DLLs

In run units that contain both DLLs and non-DLLs, use procedure- and function-pointer data items with care.

The SET procedure-pointer-1 TO ENTRY entry-name statement, SET function-pointer-1 TO ENTRY entry-name statement, and the CALL statement have a call linkage type that associates with them. The call linkage type is determined by the compiler options and the CALLINTERFACE directive that are in effect on that statement. In a program that is compiled with the DLL option, the default call linkage type is DLL. Otherwise, the linkage type is non-DLL. This default can be overridden by the CALLINTERFACE directive.

For a procedure-pointer or function-pointer data item that is set by a SET statement with linkage type non-DLL, it must not be used by a CALL statement with linkage type DLL. For a SET statement with linkage type DLL and the entry-name is an identifier, and if the NODYNAM option is in effect, the entry-name identifier value must refer to the entry-point name that is exported from a DLL module. The DLL module name must match the name of the exported entry point. In this case, note also that:

- The program-name that is contained in the identifier is interpreted according to the setting of the PGMNAME (COMPAT | LONGUPPER | LONGMIXED) compiler option of the program that contains the CALL statement.
- The program-name that is exported from the target DLL is interpreted according to the setting of the PGMNAME option used when compiling the target program.
- The search for the target DLL in the z/OS UNIX file system is case sensitive.
- If the target DLL is a PDSE member, the DLL member name must have eight characters or less. For the purpose of the search for the DLL as a PDSE member, the name is automatically converted to uppercase.

related tasks
“Using CALL identifier with DLLs” on page 480
“Using procedure and function pointers” on page 457
“Compiling programs to create DLLs” on page 478
“Linking DLLs” on page 478

related references
“DLL” on page 303
“EXPORTALL” on page 307
CALLINTERFACE (Enterprise COBOL for z/OS Language Reference)

Calling DLLs from non-DLLs

It is possible to call a DLL from a COBOL program that is compiled with the NODLL option, but there are restrictions.

You can use the following methods to ensure that the DLL linkage is followed:

- Put the COBOL DLL programs that you want to call from the COBOL non-DLL programs in the program object that contains the main program. Use static calls from the COBOL non-DLL programs to call the COBOL DLL programs.

The COBOL DLL programs in the program object that contains the main program can call COBOL DLL programs in other DLLs.

- Put the COBOL DLL programs in DLLs and call them from COBOL non-DLL programs with CALL function-pointer, where function-pointer is set to a function descriptor of the target program. You can obtain the
address of the function descriptor for the program in the DLL by calling a C routine that uses dllload and dllqueryfn.

“Example: calling DLLs from non-DLLs” on page 483

related tasks
“Using procedure and function pointers” on page 457

Example: calling DLLs from non-DLLs
The following example shows how a COBOL program that is not in a DLL (COBOL1) can call a COBOL program that is in a DLL (program ooc05r in DLL OOC05R).

CBL NODYNAM
IDENTIFICATION DIVISION.
PROGRAM-ID. 'COBOL1'.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
DATA DIVISION.
FILE SECTION.
WORKING-STORAGE SECTION.
01 DLL-INFO.
  03 DLL-LOADMOD-NAME PIC X(12).
  03 DLL-PROGRAM-NAME PIC X(160).
  03 DLL-PROGRAM-HANDLE FUNCTION-POINTER.
  77 DLL-RC               PIC S9(9) BINARY.
  77 DLL-STATUS           PIC X(1) VALUE 'N'.
  88 DLL-LOADED       VALUE 'Y'.
  88 DLL-NOT-LOADED   VALUE 'N'.
PROCEDURE DIVISION.
  IF DLL-NOT-LOADED
    THEN
      * Move the names in. They must be null terminated.
      MOVE Z'OOOC0SR' TO DLL-LOADMOD-NAME
      MOVE Z'ooc05r' TO DLL-PROGRAM-NAME
    END-IF
  ELSE
    * Call the C routine to load the DLL and to get the
    * function descriptor address.
    CALL 'A1CCDLGT' USING BY REFERENCE DLL-INFO
             BY REFERENCE DLL-RC
    IF DLL-RC = 0
      THEN
        SET DLL-LOADED TO TRUE
      ELSE
        DISPLAY 'A1CCLDGT failed with rc = '
                   DLL-RC
        MOVE 16 TO RETURN-CODE
        STOP RUN
      END-IF
    END-ELSE
    * Use the function pointer on the call statement to call the
    * program in the DLL.
    * Call the program in the DLL.
    CALL DLL-PROGRAM-HANDLE
  GOBACK.

#include <stdio.h>
#include <dll.h>
#pragma linkage (A1CCDLGT,COBOL)

typedef struct dll_lm {
    char         dll_loadmod_name[(12)];
    char         dll_func_name[(160)];
    void         (*fptr) (void); /* function pointer */
} dll_lm;

void A1CCDLGT (dll_lm *dll, int *rc) {
    dllhandle *handle;
void (*fptr1)(void);
*rc = 0;
/* Load the DLL */
handle = dllload(dll->dll_loadmod_name);
if (handle == NULL) {
    perror("A1CCDLGT failed on call to load DLL./n");
    *rc = 1;
    return;
}
/* Get the address of the function */
fptr1 = (void (*)(void))
dllqueryfn(handle,dll->dll_func_name);
if (fptr1 == NULL) {
    perror("A1CCDLGT failed on retrieving function./n");
    *rc = 2;
    return;
}
/* Return the function pointer */
dll->fptr = fptr1;
return;

Using COBOL DLLs with C/C++ programs

COBOL support for DLLs interoperates with the DLL support in the z/OS C/C++ products, except for COBOL EXTERNAL data. In particular, COBOL applications can call functions that are exported from C/C++ DLLs, and C/C++ applications can call COBOL programs that are exported from COBOL DLLs.

COBOL data items that are declared with the EXTERNAL attribute are independent of DLL support. These data items are accessible by name from any COBOL program in the run unit that declares them, regardless of whether the programs are in DLLs.

The COBOL options DLL, RENT, and EXPORTALL work much the same way as the C/C++ DLL, RENT, and EXPORTALL options. (The DLL option applies only to C.) However, the C/C++ compiler produces DLL-enabled code by default.

You can pass a C/C++ DLL function pointer to COBOL and use it within COBOL, receiving the C/C++ function pointer as a function-pointer data item. The following example shows a COBOL call to a C function that returns a function pointer to a service, followed by a COBOL call to the service.

Identification Division.
Program-id. Demo.
Data Division.
Working-Storage section.
01 fp usage function-pointer.
Procedure Division.
   Call "c-function" returning fp.
   Call fp.

related tasks
"Compiling programs to create DLLs" on page 478
"Linking DLLs" on page 478

related references
"DLL" on page 303
"EXPORTALL" on page 307
"RENT" on page 331
EXTERNAL clause (Enterprise COBOL for z/OS Language Reference)
CALLINTERFACE (Enterprise COBOL for z/OS Language Reference)
Using DLLs in OO COBOL applications

You must compile each COBOL class definition using the DLL, THREAD, RENT, and DBCS compiler options, and link-edit it into a separate DLL module using the RENT binder option.

**related tasks**
- Chapter 16, “Compiling, linking, and running OO applications,” on page 273
- “Compiling programs to create DLLs” on page 478
- “Linking DLLs” on page 478

**related references**
- “DLL” on page 303
- “THREAD” on page 344
- “RENT” on page 331
- “DBCS” on page 301
Chapter 27. Preparing COBOL programs for multithreading

You can run COBOL programs in multiple threads within a process under batch, TSO, IMS, or z/OS UNIX. There is no explicit COBOL language to use for multithreaded execution; rather, you compile with the THREAD compiler option.

COBOL does not directly support managing program threads. However, you can run COBOL programs that you compile with the THREAD compiler option in multithreaded application servers, in applications that use a C/C++ driver program to create the threads, in programs that interoperate with Java and use Java threads, and in applications that use PL/I tasking. In other words, other programs can call COBOL programs in such a way that the COBOL programs run in multiple threads within a process or as multiple program invocation instances within a thread. Your threaded application must run within a single Language Environment enclave.

Choosing LOCAL-STORAGE or WORKING-STORAGE: Because you must code your multithreaded programs as recursive, the persistence of data is that of any recursive program:

- Data items in the LOCAL-STORAGE SECTION are automatically allocated for each instance of a program invocation. When a program runs in multiple threads simultaneously, each invocation has a separate copy of LOCAL-STORAGE data.

- Data items in the WORKING-STORAGE SECTION are allocated once for each program and are thus available in their last-used state to all invocations of the program.

For the data that you want to isolate to an individual program invocation instance, define the data in the LOCAL-STORAGE SECTION. In general, this choice is appropriate for working data in threaded programs. If you define data in WORKING-STORAGE and your program changes the contents of the data, you must take one of the following actions:

- Structure your application so that you do not access data in WORKING-STORAGE simultaneously from multiple threads.

- If you do access data simultaneously from separate threads, write appropriate serialization code.

related concepts
“Multithreading” on page 487

related tasks
“Choosing THREAD to support multithreading” on page 488
“Transferring control to multithreaded programs” on page 489
“Ending multithreaded programs” on page 489
“Processing files with multithreading” on page 490
“Handling COBOL limitations with multithreading” on page 492

related references
“THREAD” on page 344
PROGRAM-ID paragraph (Enterprise COBOL for z/OS Language Reference)

Multithreading

To use COBOL support for multithreading, you need to understand how processes, threads, run units, and program invocation instances relate to each other.

The operating system and multithreaded applications can handle execution flow within a process, which is the course of events when all or part of a program runs. Programs that run within a process can share resources. Processes can be manipulated. For example, they can have a high or low priority in terms of the amount of time that the system devotes to running the process.

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Within a process, an application can initiate one or more threads, each of which is a stream of computer instructions that controls that thread. A multithreaded process begins with one stream of instructions (one thread) and can later create other instruction streams to perform tasks. These multiple threads can run concurrently. Within a thread, control is transferred between executing programs.

In a multithreaded environment, a COBOL run unit is the portion of the process that includes threads that have actively executing COBOL programs. The COBOL run unit continues until no COBOL program is active in the execution stack for any of the threads. For example, a called COBOL program contains a GOBACK statement and returns control to a C program. Within the run unit, COBOL programs can call non-COBOL programs, and vice versa.

Within a thread, control is transferred between separate COBOL and non-COBOL programs. For example, a COBOL program can call another COBOL program or a C program. Each separately called program is a program invocation instance. Program invocation instances of a particular program can exist in multiple threads within a given process.

The following illustration shows these relationships between processes, threads, run units, and program invocation instances.

![Diagram showing relationships between processes, threads, run units, and program invocation instances]

related concepts
Language Environment Programming Guide (Program management model, Understanding the basics: threads)

related tasks
“Choosing THREAD to support multithreading” on page 488
“Transferring control to multithreaded programs” on page 489
“Ending multithreaded programs” on page 489
“Processing files with multithreading” on page 490
“Handling COBOL limitations with multithreading” on page 492

related references
“THREAD” on page 344

Choosing THREAD to support multithreading

Use the THREAD compiler option for multithreading support. Use THREAD if your program will be called in more than one thread in a single process by an application. However, THREAD might adversely affect performance because of the serialization logic that is automatically generated.

In order to run COBOL programs in more than one thread, you must compile all of the COBOL programs in the application using the THREAD compiler option. You must also compile them with the RENT compiler option and link them with the RENT option of the binder (linkage-editor).
Use the THREAD option when you compile object-oriented (OO) clients and classes.

**Language restrictions:** When you use the THREAD option, you cannot use certain language elements. For details, see the related reference below.

**Recursion:** Before you compile a program using the THREAD compiler option, you must specify the RECURSIVE phrase in the PROGRAM-ID paragraph. If you do not do so, an error will occur.

**related tasks**
- “Sharing data in recursive or multithreaded programs” on page 15
- “Compiling OO applications under z/OS UNIX” on page 273

**related references**
- “THREAD” on page 344

---

**Transferring control to multithreaded programs**

When you write COBOL programs for a multithreaded environment, choose appropriate program linkage statements.

As in single-threaded environments, a called program is in its initial state when it is first called within a run unit and when it is first called after a CANCEL to the called program. Ensure that the program that you name on a CANCEL statement is not active on any thread. If you try to cancel an active program, a severity-3 Language Environment condition occurs.

If your threaded application requires preinitialization, use the Language Environment services (CEEPIPI interface). You cannot use the COBOL-specific interfaces for preinitialization (runtime option RTEREUS) to establish a reusable environment from any program that has been compiled with the THREAD option.

**related concepts**
- *(Language Environment Programming Guide)* (What happens during termination: enclave termination)

**related tasks**
- “Ending multithreaded programs” on page 489
- “Ending and reentering main programs or subprograms” on page 446

---

**Ending multithreaded programs**

You can end a multithreaded program by using GOBACK, EXIT PROGRAM, or STOP RUN.

Use GOBACK to return to the caller of the program. When you use GOBACK from the first program in a thread, the thread is terminated. If that thread is the initial thread in an enclave, the entire enclave is terminated.

Use EXIT PROGRAM as you would GOBACK, except from a main program where it has no effect.

Use STOP RUN to terminate the entire Language Environment enclave and to return control to the caller of the main program (which might be the operating system). All threads that are executing within the enclave are terminated.

**related concepts**
- *(Language Environment Programming Guide)* (What happens during termination: enclave termination)

**related tasks**
- “Ending and reentering main programs or subprograms” on page 446
Processing files with multithreading

In threaded applications, you can code COBOL statements for input and output in QSAM, VSAM, and line-sequential files.

Each file definition (FD) has an implicit serialization lock. This lock is used with automatic serialization logic during the input or output operation that is associated with the execution of the following statements:

- OPEN
- CLOSE
- READ
- WRITE
- REWRITE
- START
- DELETE

Automatic serialization also occurs for the implicit MOVE that is associated with the following statements:

```cobol
WRITE record-name FROM identifier
READ file-name INTO identifier
```

Automatic serialization is not applied to any statements specified within the following conditional phrases:

- AT END
- NOT AT END
- INVALID KEY
- NOT INVALID KEY
- AT END-OF-PAGE
- NOT AT END-OF-PAGE

**related concepts**
“File-definition (FD) storage” on page 490

**related tasks**
“Closing QSAM files” on page 162
“Closing VSAM files” on page 187
“Coding ERROR declaratives” on page 228
“Serializing file access with multithreading” on page 491

**File-definition (FD) storage**

On all program invocations, the storage that is associated with a file definition (such as FD records and the record area that is associated with the SAME RECORD AREA clause) is allocated and available in its last-used state.

All threads of execution share this storage. You can depend on automatic serialization for this storage during the execution of the OPEN, CLOSE, READ, WRITE, REWRITE, START, and DELETE statements, but not between uses of these statements.

**related tasks**
“Serializing file access with multithreading” on page 491
Serializing file access with multithreading

To take full advantage of automatic serialization and to avoid explicitly writing your own serialization logic, use one of the recommended file organizations and usage patterns when you access files in threaded programs.

Use one of the following file organizations:

- Sequential organization
- Line-sequential organization
- Relative organization with sequential access
- Indexed organization with sequential access

Use the following pattern for input:

```cobol
OPEN INPUT fn
READ fn INTO local-storage-item
* Process the record from the local-storage item
CLOSE fn
```

Use the following pattern for output:

```cobol
OPEN OUTPUT fn
* Construct output record in local-storage item
WRITE rec FROM local-storage-item
CLOSE fn
```

With other usage patterns, you must take one of the following actions:

- Verify the safety of your application logic. Ensure that two instances of the program are never simultaneously active on different threads.
- Code explicit serialization logic by using calls to POSIX services.

To avoid serialization problems when you access a file from multiple threads, define the data items that are associated with the file (such as file-status data items and key arguments) in the LOCAL-STORAGE SECTION.

“Example: usage patterns of file input and output with multithreading” on page 491

related tasks

“Calling UNIX/POSIX APIs” on page 438

Example: usage patterns of file input and output with multithreading

The following examples show the need for explicit serialization logic when you deviate from the recommended usage pattern for file input and output in your multithreaded applications. These examples also explain the unexpected behavior that might result if you fail to handle serialization properly.

In each example, two instances of a program that contains the sample operations are running within one run unit on two different threads.

```cobol
READ F1
REWRITE R1
```

In the example above, the second thread might execute the READ statement after the READ statement is executed on the first thread but before the REWRITE statement is executed on the first thread. The
Rewrite statement might not update the record that you intended. To ensure the results that you want, write explicit serialization logic.

```
READ F1

* Process the data in the FD record description entry for F1
```

In the example above, the second thread might execute the READ statement while the first thread is still processing a record in the FD record description entry. The second READ statement would overlay the record that the first thread is processing. To avoid this problem, use the recommended technique:

```
READ F1 INTO LOCAL-STORAGE-item
```

**Other cases:** You must give similar consideration to other usage patterns that involve a sequence of related input and output operations, such as START followed by READ NEXT, or READ followed by DELETE. Take appropriate steps to ensure the correct processing of file input and output.

## Handling COBOL limitations with multithreading

Some COBOL applications depend on subsystems or other applications. In a multithreaded environment, these dependencies and others result in some limitations on COBOL programs.

In general, you must synchronize access to resources that are visible to the application within a run unit. Exceptions to this requirement are DISPLAY and ACCEPT, which you can use from multiple threads, and supported COBOL file I/O statements that have the recommended usage pattern; all synchronization is provided for these by the runtime environment.

**CICS:** You cannot run multithreaded applications in CICS. In CICS, you can run a COBOL program that has been compiled with the THREAD option and that is part of an application that has no multiple threads or PL/I tasks.

**Recursive:** Because you must code the programs in a multithreaded application as recursive, you must adhere to all the restrictions and programming considerations that apply to recursive programs, such as not coding nested programs.

**Reentrancy:** You must compile your multithreading programs with the RENT compiler option and link them with the RENT option of the binder (linkage-editor).

**POSIX and PL/I:** If you use POSIX threads in your multithreaded application, you must specify the Language Environment runtime option POSIX(ON). If the application uses PL/I tasking, you must specify POSIX(OFF). You cannot mix POSIX threads and PL/I tasks in the same application.

**PL/I tasking:** To include COBOL programs in applications that contain multiple PL/I tasks, follow these guidelines:

- Compile all COBOL programs that you run in multiple PL/I tasks with the THREAD option. If you compile any COBOL program with the NOTHREAD option, all of the COBOL programs must run in one PL/I task.
- You can call COBOL programs compiled with the THREAD option from one or more PL/I tasks. However, calls from PL/I programs to COBOL programs cannot include the TASK or EVENT option. The PL/I tasking call must first call a PL/I program or function that in turn calls the COBOL program. This indirection is required because you cannot specify the COBOL program directly as the target of a PL/I CALL statement that includes the TASK or EVENT option.
- Be aware that issuing a STOP RUN statement from a COBOL program or a STOP statement from a PL/I program terminates the entire Language Environment enclave, including all the tasks of execution.
- Do not code explicit POSIX threading (calls to pthread_create()) in any run unit that includes PL/I tasking.
**C and Language Environment conforming assembler**: You can combine your multithreaded COBOL programs with C programs and Language Environment conforming assembler programs in the same run unit when those programs are also appropriately coded for multithreaded execution.

**AMODE**: You must run your multithreaded applications with AMODE 31. You can run a COBOL program that has been compiled with the THREAD option with AMODE 24 as part of an application that does not have multiple threads or PL/I tasks.

**Asynchronous signals**: In a threaded application your COBOL program might be interrupted by an asynchronous signal or interrupt. If your program contains logic that cannot tolerate such an interrupt, you must disable the interrupts for the duration of that logic. Call a C/C++ function to set the signal mask appropriately.

**Older COBOL programs**: To run your COBOL programs on multiple threads of a multithreaded application, you must compile them with Enterprise COBOL and use the THREAD option. Run applications that contain programs compiled by older compilers only on one thread.

**IGZETUN and IGZEOP**: Do not use the modules IGZETUN (for storage tuning) or IGZEOP (for runtime options) for applications in which the main program has been compiled with the THREAD option; these CSECTs are ignored.

**UPSI switches**: All programs and all threads in an application share a single copy of UPSI switches. If you modify switches in a threaded application, you must code appropriate serialization logic.

**related tasks**

“Making recursive calls” on page 457

“Serializing file access with multithreading” on page 491

*XL C/C++ Programming Guide* (Using threads in z/OS UNIX System Services applications)

*Language Environment Writing ILC Communication Applications*
Part 5. Using COBOL for Web Services
Chapter 28. Web Services interface

COBOL can provide or request Web Services, using architectures based on SOAP (Simple Object Access Protocol) or REST (REpresentational State Transfer). Data in the interface to such services is typically represented in JSON (JavaScript Object Notation) or XML (eXtensible Markup Language). The following information describes COBOL and other facilities that can be used to generate and consume JSON and XML.

**Processing JSON input**

The z/OS Client Web Enablement Toolkit enables applications to participate in the client/server space by providing a built-in z/OS JSON parser (provided with z/OS V2.2, or z/OS V2.1 with the PTF for APAR OA46575 installed) to consume JSON text from any source. Be aware that this parser supports JSON texts in EBCDIC codepage 1047 only, thus JSON text received by the application in another encoding format must first be converted to EBCDIC 1047 before it can be input into the parser. For details, see the description of the z/OS JSON parser in z/OS MVS Programming: Callable Services for High-Level Languages.

**related tasks**

Chapter 29, “Producing JSON output,” on page 499
Chapter 30, “Processing XML input,” on page 501
Chapter 31, “Producing XML output,” on page 541
Chapter 29. Producing JSON output

You can express COBOL data items as JSON text by using the JSON GENERATE statement, which identifies the source and output data items.

You can optionally also specify:

- A data item to receive the count of characters generated.
- Alternative names for the input data items
- Data items to be excluded from the output JSON text
- A statement to receive control if an exception occurs

The JSON text can be used to represent a resource for the interface to a Web service, and is encoded in UTF-8 if the output data item is alphanumeric, or UTF-16 if the output data item is national.

Using the JSON GENERATE statement

Consider the following example:

```cobol
01 Greeting.
  02 Msg pic x(80) value 'Hello, World!'.
  01 Jtext national pic n(80).
  01 i binary pic 99.
  ...
  JSON generate Jtext from Greeting count in i
  on exception
   display 'JSON generation error: ' json-code
  not on exception
   display function display-of(Jtext(1:i))
End-JSON
```

The above code sequence produces the following output:

```
{"Greeting":{"msg":"Hello, World!"}}
```

The following example is more complex which illustrates optional phrases that:

- Provide alternative JSON names for the included data items (NAME)
- Allow you to exclude sensitive or unwanted information from the output (SUPPRESS)

```cobol
01 GRP.
  05 Ac-No PIC AA9999 value 'SX1234'.
  05 More.
  10 Stuff PIC S99V9 OCCURS 2.
  05 SSN PIC 999/99/9999 value '987-65-4321'.
  01 d pic x(80).
  01 i binary pic 99.
  ...
  move 7.8 to stuff(1), move -9 to stuff(2)
  JSON generate d from grp count i
  NAME of stuff is 'Value' SUPPRESS ssn
  display function display-of(function national-of(d(1:i) 1208))
```

The example produces the following output:

```
{"GRP":{"Ac-No":"SX1234","More":{"Value":[7.8,-9.0]}}}
```
Chapter 30. Processing XML input

You can process XML input in a COBOL program by using the XML PARSE statement.

The XML PARSE statement is the COBOL language interface to either of two high-speed XML parsers. You use the XMLPARSE compiler option to select the appropriate parser for your application:

- **XMLPARSE(XMLSS)** selects the z/OS XML System Services parser. This option provides enhanced features such as namespace processing, validation of XML documents with respect to an XML schema, and conversion of text fragments to national character representation (Unicode UTF-16).
- **XMLPARSE(COMPAT)** selects the XML parser that is built into the COBOL library. This option provides compatibility with XML parsing in Enterprise COBOL Version 3 and Version 4.

Processing XML input involves passing control between the XML parser and a processing procedure in which you handle parser events.

Use the following COBOL facilities to process XML input:

- The XML PARSE statement to begin XML parsing and to identify the source XML document and the processing procedure.
- The following optional phrases of the XML PARSE statement:
  - ENCODING to specify the encoding of the XML document
  - VALIDATING to identify an XML schema against which the XML document is to be validated
  - The processing procedure to control the parsing, that is, receive and process XML events and associated document fragments, and return to the parser for continued processing
  - Special registers to exchange information between the parser and the processing procedure:
    - XML-CODE to receive the status of XML parsing and, in some cases, to return information to the parser
    - XML-EVENT to receive the name of each XML event from the parser
    - XML-INFORMATION provides a mechanism to easily determine whether an XML event is complete
    - XML-NTEXT to receive XML document fragments that are returned as national character data
    - XML-TEXT to receive document fragments that are returned as alphanumeric data
    - XML-NAMESPACE or XML-NNAMESPACE to receive a namespace identifier for a NAMESPACE-DECLARATION XML event, or for an element name or attribute name that is in a namespace
    - XML-NAMESPACE-PREFIX or XML-NNAMESPACE-PREFIX to receive a namespace prefix for a NAMESPACE-DECLARATION XML event, or for an element name or attribute name that is prefixed
  - The optional RETURNING NATIONAL phrase of the XML PARSE statement to indicate that the fragments of an XML document in an alphanumeric data item are to be converted to UTF-16 and returned to the processing procedure in the national special registers XML-NTEXT, XML-NNAMESPACE, and XML-NNAMESPACE-PREFIX

You can use the ENCODING, VALIDATING, and RETURNING NATIONAL phrases of the XML PARSE statement only if XMLPARSE(XMLSS) is in effect.

Link-edit consideration: COBOL programs that contain the XML PARSE statement must be link-edited with AMODE 31.

related concepts
“XML parser in COBOL” on page 502

related tasks
“Accessing XML documents” on page 503
XML parser in COBOL

Enterprise COBOL provides an event-based interface that lets you parse XML documents and transform them to COBOL data structures.

The XML parser finds fragments within the source XML document, and your processing procedure acts on those fragments. The fragments are associated with XML events; you code the processing procedure to handle each XML event.

Execution of the XML PARSE statement begins the parsing and establishes the processing procedure with the parser. The parser transfers control to the processing procedure for each XML event that it detects while processing the document. After processing the event, the processing procedure automatically returns control to the parser. Each normal return from the processing procedure causes the parser to continue analyzing the XML document to report the next event. Throughout this operation, control passes back and forth between the parser and the processing procedure.

In the XML PARSE statement, you can also specify two imperative statements to which you want control to be passed at the end of the parsing: one if a normal end occurs, and the other if an exception condition exists.

The following figure shows a high-level overview of the basic exchange of control between the parser and your COBOL program:

![Diagram showing the exchange of control between the parser and the program]

Normally, parsing continues until the entire XML document has been parsed.
The XML parser checks XML documents for most aspects of well formedness. A document is \textit{well formed} if it adheres to the XML syntax in the \textit{XML specification} and follows some additional rules such as proper use of end tags and uniqueness of attribute names.

When you parse an XML document with validation against an XML schema, the z/OS XML System Services parser additionally verifies that the XML document adheres to the content and structure prescribed in the schema. For example, the parser checks that there are no unexpected elements or attributes, that no required elements or attributes are missing, and that any values of elements or attributes are legal.

\textbf{related concepts}

“XML schemas” on page 514

“XML input document encoding” on page 519

\textbf{related tasks}

“Parsing XML documents” on page 504

“Parsing XML documents with validation” on page 512

“Handling XML PARSE exceptions” on page 523

“Terminating XML parsing” on page 527

\textbf{related references}

“The encoding of XML documents” on page 518

\textit{XML specification}

\section*{Accessing XML documents}

Before you can parse an XML document using an XML \texttt{PARSE} statement, you must make the document available to your program. Common methods of acquiring an XML document are by retrieval from a WebSphere MQ message, a CICS transient queue or communication area, or an IMS message processing queue; or by reading the document from a file.

If the XML document that you want to parse is held in a file, use ordinary COBOL facilities to place the document into a data item in your program:

- A \texttt{FILE-CONTROL} entry to define the file to your program.
- An \texttt{OPEN} statement to open the file.
- \texttt{READ} statements to read all the records from the file into a data item (either an elementary item of category alphanumeric or national, or an alphanumeric or national group). You can define the data item in the \texttt{WORKING-} \texttt{STORAGE SECTION} or the \texttt{LOCAL-} \texttt{STORAGE SECTION}.
- Optionally, the \texttt{STRING} statement to string all of the separate records together into one continuous stream, to remove extraneous blanks, and to handle variable-length records.

If the \texttt{XMLPARSE(XMLSS)} option is in effect, you can parse an XML document that is in a file by passing the parser one record (or \texttt{segment}) of text from the file at a time. This capability is useful for parsing very large XML documents.

\textbf{related tasks}

“Coding COBOL programs to run under CICS” on page 407

Chapter 22, “Developing COBOL programs for IMS,” on page 427

“Parsing XML documents one segment at a time” on page 515

\textbf{related references}

“XMLPARSE” on page 349 (compiler option)
Parsing XML documents

To parse XML documents, use the XML PARSE statement, specifying the XML document that is to be parsed and the processing procedure for handling XML events that occur during parsing, as shown in the following code fragment.

```cobol
XML PARSE xml-document
  PROCESSING PROCEDURE xml-event-handler
  ON EXCEPTION
    DISPLAY 'XML document error ' XML-CODE
    STOP RUN
  NOT ON EXCEPTION
    DISPLAY 'XML document was successfully parsed.'
END-XML
```

In the XML PARSE statement, you first identify the parse data item (xml-document in the example above) that contains the XML document character stream. In the DATA DIVISION, define the parse data item as an elementary data item of category national or as a national group item if the encoding of the document is Unicode UTF-16; otherwise, define the parse data item as an elementary alphanumeric data item or an alphanumeric group item:

- If the parse data item is national, the XML document must be encoded in UTF-16, CCSID 1200.
- If the parse data item is alphanumeric, its content must be encoded in one of the supported code pages described in the related reference about the encoding of XML documents.

Next, specify the name of the processing procedure (xml-event-handler in the example above) that is to handle the XML events that occur during parsing of the document.

If the XMLPARSE(XMLSS) compiler option is in effect, you can also use any of these optional phrases of the XML PARSE statement:

- ENCODING, to specify the CCSID of the document
- RETURNING NATIONAL, to cause the parser to automatically convert UTF-8 or single-byte characters to national characters for return to the processing procedure
- VALIDATING, to cause the parser to validate the document against an XML schema

In addition, you can specify either or both of the following optional phrases (as shown in the fragment above) to indicate the action to be taken after parsing finishes:

- ON EXCEPTION, to receive control if an unhandled exception occurs during parsing
- NOT ON EXCEPTION, to receive control otherwise

You can end the XML PARSE statement with the explicit scope terminator END-XML. Use END-XML to nest an XML PARSE statement that uses the ON EXCEPTION or NOT ON EXCEPTION phrase in a conditional statement.

The parser passes control to the processing procedure for each XML event. Control returns to the parser at the end of the processing procedure. This exchange of control between the XML parser and the processing procedure continues until one of the following events occurs:

- The entire XML document was parsed, as indicated by the END-OF-DOCUMENT event.
- If XMLPARSE(XMLSS) is in effect, either:
  - The parser detects an error in the document and signals an EXCEPTION event (regardless of the kind of exception).
  - The parser signals an END-OF-INPUT event, and the processing procedure returns to the parser with special register XML-CODE still set to zero, which indicates that no further XML data will be provided to the parser.
- If XMLPARSE(COMPAT) is in effect, either:
– The parser signals an encoding conflict EXCEPTION event, and the processing procedure does not reset special register XML-CODE to zero or to the correct CCSID before returning to the parser.

– The parser detects an error in the document and signals an EXCEPTION event (other than an encoding conflict), and the processing procedure does not reset special register XML-CODE to zero before returning to the parser.

- The parsing process is terminated deliberately by the user's code in the processing procedure that sets the XML-CODE special register to -1 before it returns to the parser.

related concepts
“XML events” on page 507
“XML-CODE” on page 508
“XML schemas” on page 514
“XML- INFORMATION” on page 510

related tasks
“Writing procedures to process XML” on page 505
“Parsing XML documents with validation” on page 512
“Parsing XML documents one segment at a time” on page 515
“Parsing XML documents encoded in UTF-8” on page 522

related references
“XMLPARSE” on page 349 (compiler option)
“The encoding of XML documents” on page 518
“XML PARSE exceptions with XMLPARSE(XMLSS) in effect” on page 665
“XML PARSE exceptions with XMLPARSE(COMPAT) in effect” on page 667
XML PARSE statement (Enterprise COBOL for z/OS Language Reference)

Writing procedures to process XML
In your processing procedure, code statements to handle XML events.

For each event that the parser encounters, the parser passes information to the processing procedure in several special registers. Use the content of those special registers to populate COBOL data structures and to control the processing.

Examine the XML-EVENT special register to determine which event the parser passed to the processing procedure. XML-EVENT contains an event name, such as 'START-OF-ELEMENT'. Obtain the text associated with the event from the XML-TEXT or XML-NTEXT special register.

If the XMLPARSE(XMLSS) option is in effect, you can use special register XML-NAMESPACE or XML-NNAMESPACE to determine the namespace identifier, if any, that is associated with the XML event, and examine the XML-NAMESPACE-PREFIX or XML-NNAMESPACE-PREFIX special register to determine the associated prefix, if any.

When used in nested programs, the XML special registers are implicitly defined as GLOBAL in the outermost program.

For additional details about the XML special registers, see the following table.

<table>
<thead>
<tr>
<th>Special register</th>
<th>Implicit definition and usage</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>XML-EVENT</td>
<td>PICTURE X(30) USAGE DISPLAY VALUE SPACE</td>
<td>The name of the XML event</td>
</tr>
</tbody>
</table>
### Table 64. Special registers used by the XML parser (continued)

<table>
<thead>
<tr>
<th>Special register</th>
<th>Implicit definition and usage</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>XML-CODE(^2)</td>
<td>PICTURE S9(9) USAGE BINARY VALUE ZERO</td>
<td>An exception code or zero for each XML event</td>
</tr>
<tr>
<td>XML-INFORMATION(^1)</td>
<td>PICTURE S9(9) USAGE BINARY VALUE 0</td>
<td>A mechanism to easily determine whether an XML EVENT is complete</td>
</tr>
<tr>
<td>XML-TEXT(^1)</td>
<td>Variable-length elementary category alphanumeric item</td>
<td>Text (corresponding to the event that the parser encountered) from the XML document if you specify an alphanumeric item for the XML PARSE identifier(^3)</td>
</tr>
<tr>
<td>XML-NTEXT(^1)</td>
<td>Variable-length elementary category national item</td>
<td>Text (corresponding to the event that the parser encountered) from the XML document if you specify a national item for the XML PARSE identifier(^3)</td>
</tr>
<tr>
<td>XML-NAMESPACE(^1, 4)</td>
<td>Variable-length elementary category alphanumeric item</td>
<td>The namespace identifier for a NAMESPACE-DECLARATION XML event or for an element or attribute name that is in a namespace, if the XML document is in an alphanumeric data item(^3)</td>
</tr>
<tr>
<td>XML-NNAMESPACE(^1, 4)</td>
<td>Variable-length elementary category national item</td>
<td>The namespace identifier for a NAMESPACE-DECLARATION XML event or for an element or attribute name that is in a namespace, if the XML document is in a national data item or the RETURNING NATIONAL phrase is specified in the XML PARSE statement</td>
</tr>
<tr>
<td>XML-NAMESPACE-PREFIX(^1, 4)</td>
<td>Variable-length elementary category national item</td>
<td>The prefix, if any, for a NAMESPACE-DECLARATION XML event or for an element or attribute name that is in a nondefault namespace, if the XML document is in an alphanumeric data item(^3)</td>
</tr>
<tr>
<td>XML-NNAMESPACE-PREFIX(^1, 4)</td>
<td>Variable-length elementary category national item</td>
<td>The prefix, if any, for a NAMESPACE-DECLARATION XML event or for an element or attribute name that is in a nondefault namespace, if the XML document is in a national data item or the RETURNING NATIONAL phrase is specified in the XML PARSE statement</td>
</tr>
</tbody>
</table>

1. You cannot use this special register as a receiving data item.
2. The XML GENERATE statement also uses XML-CODE. Therefore, if you have an XML GENERATE statement in the processing procedure, save the value of XML-CODE before the XML GENERATE statement, and restore the saved value after the XML GENERATE statement.
3. If you specify the RETURNING NATIONAL phrase in the XML PARSE statement for an alphanumeric data item, text is returned in the corresponding national special register. You can specify the RETURNING NATIONAL phrase only if the XMLPARSE(XMLSS) option is in effect.
4. The parser sets the namespace special registers only if the XMLPARSE(XMLSS) option is in effect.

**Restrictions:**

- A processing procedure must not directly execute an XML PARSE statement. However, if a processing procedure passes control to a method or outermost program by using an INVOKE or CALL statement, the target method or program can execute the same or a different XML PARSE statement. You can also execute the same XML statement or different XML statements simultaneously from a program that is running on multiple threads.
- The range of the processing procedure must not cause the execution of any GOBACK or EXIT PROGRAM statement, except to return control from a method or program to which control was passed by an INVOKE or CALL statement, respectively, that is executed in the range of the processing procedure.

You can code a STOP RUN statement in a processing procedure to end the run unit.

The compiler inserts a return mechanism after the last statement in each processing procedure.

“Example: program for processing XML” on page 528
XML events

An XML event results when the XML parser detects various conditions (such as END-OF-INPUT or EXCEPTION) or encounters document fragments (such as CONTENT-CHARACTERS or START-OF-CDATA-SECTION) while processing an XML document.

For each event that occurs during XML parsing, the parser sets the associated event name in the XML-EVENT special register, and passes the XML-EVENT special register to the processing procedure. Depending on the event, the parser sets other special registers to contain additional information about the event.

In most cases, the parser sets the XML-TEXT or XML-NTEXT special register to the XML fragment that caused the event:

- If the XMLPARSE(COMPAT) compiler option is in effect, the parser sets XML-NTEXT if the XML document is in a national data item, or if the parser finds a character reference; otherwise, the parser sets XML-TEXT.
- If XMLPARSE(XMLSS) is in effect, the parser sets XML-NTEXT if the RETURNING NATIONAL phrase is specified in the XML PARSE statement, or if the XML document is in a national data item; otherwise, the parser sets XML-TEXT.

If XMLPARSE(XMLSS) is in effect, the parser sets the namespace special registers for a NAMESPACE-DECLARATION event, or if it encounters a name that is in a namespace.

When the parser detects an encoding conflict or a well-formedness or validation error in the document, it sets XML-EVENT to 'EXCEPTION' and provides additional information about the exception in the XML-CODE special register. You can parse with validation only if XMLPARSE(XMLSS) is in effect. For further details, see the related task about parsing with validation.

For a detailed description of the set of XML events, see the related reference about XML-EVENT.

“Example: parsing a simple document” on page 527
XML-CODE
For each XML event except an EXCEPTION event, the parser sets the value of the XML-CODE special register to zero. For an EXCEPTION event, the parser sets XML-CODE to a value that identifies the specific exception.

For information about the possible exception codes, see the related references.

When the parser returns control to the XML PARSE statement from your processing procedure, XML-CODE generally contains the most recent value that was set by the parser. However, for any event other than EXCEPTION, if you set XML-CODE to -1 in your processing procedure, parsing terminates with a user-initiated exception condition when control returns to the parser, and XML-CODE retains the value -1.

For an EXCEPTION XML event when XMLPARSE (COMPAT) is in effect, your processing procedure can, in some cases, set XML-CODE to a meaningful value before control returns to the parser. (For details, see the related tasks about handling XML PARSE exceptions and handling encoding conflicts.) If you set XML-CODE to any other nonzero value or set it for any other exception, the parser resets XML-CODE to the original exception code.

For a START-OF-DOCUMENT XML event when compiler option XMLPARSE (COMPAT) is in effect, your processing procedure can set XML-CODE to 1 before control returns to the parser. This action instructs the parser to release (at the end of parsing) any Language Environment resources acquired during parsing.

The following table shows the results of setting XML-CODE to various values. The leftmost column shows the type of XML event passed to the processing procedure; the other column headings show the XML-CODE value set by the processing procedure. The cell at the intersection of each row and column shows the action that the parser takes upon return from the processing procedure for a given combination of XML event and XML-CODE value.

<table>
<thead>
<tr>
<th>XML event type</th>
<th>XML-CODE set to -1</th>
<th>XML-CODE set to 0</th>
<th>XML-CODE set to 1</th>
<th>XML-CODE set to other nonzero values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal EXCEPTION</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Ignores setting; keeps original XML-CODE value</td>
</tr>
<tr>
<td>Warning EXCEPTION</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Next event is ATTRIBUTE-NAME or START-OF-ELEMENT</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Ignores setting; keeps original XML-CODE value</td>
</tr>
<tr>
<td>Reason code 800 or 801</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-INPUT</td>
<td>Ends immediately; XML-CODE = -1(^1)</td>
<td>Next event is END-OF-DOCUMENT(^2)</td>
<td>Next event depends on input(^2)</td>
<td>Fatal runtime error (message 230S)</td>
</tr>
<tr>
<td>Normal event</td>
<td>Ends immediately; XML-CODE = -1(^1)</td>
<td>XML-CODE already 0, no change</td>
<td>Fatal runtime error (message 230S)</td>
<td>Fatal runtime error (message 230S)</td>
</tr>
</tbody>
</table>

1. See the related task about terminating XML parsing.
2. See the related task about parsing documents one segment at a time.
Table 66. Results of processing-procedure changes to XML-CODE with XMLPARSE (COMPAT) in effect

<table>
<thead>
<tr>
<th>XML event type</th>
<th>-1</th>
<th>0</th>
<th>XML-CODE-100,000</th>
<th>Other nonzero value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoding-conflict exception (exception codes 50 - 99)</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Chooses encoding depending on the specific exception code(^4)</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Ignores setting; keeps original XML-CODE value</td>
</tr>
<tr>
<td>Encoding-choice exception (exception codes &gt; 100,000)</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Parses using the CODEPAGE value(^2)</td>
<td>Parses using the difference (shown above) as the encoding value(^2)</td>
<td>Ignores setting; keeps original XML-CODE value</td>
</tr>
<tr>
<td>Other exception</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Limited continuation only for exception codes 1 - 49(^3)</td>
<td>Ignores setting; keeps original XML-CODE value</td>
<td>Ignores setting; keeps original XML-CODE value</td>
</tr>
<tr>
<td>Normal event (except START-OF-DOCUMENT)</td>
<td>Ends immediately; XML-CODE = -1(^4)</td>
<td>[No apparent change to XML-CODE]</td>
<td>Ends immediately; XML-CODE = -1</td>
<td>Ends immediately; XML-CODE = -1</td>
</tr>
</tbody>
</table>
| START-OF-DOCUMENT                                        | Ends immediately; XML-CODE = -1\(^4\)                              | [No apparent change to XML-CODE]                                 | Ends immediately; XML-CODE = -1                                                   | • XML-CODE = 1
  • Else ends immediately; XML-CODE = -1                   |

1. See the exception codes in the related reference about XML PARSE exceptions with XMLPARSE (COMPAT) in effect.
2. See the related task about handling encoding conflicts.
3. See the related task about handling XML PARSE exceptions.
4. See the related task about terminating XML parsing.

XML generation also uses the XML-CODE special register. For details, see the related task about handling XML GENERATE exceptions.

**related concepts**

“How the XML parser handles errors” on page 525

**related tasks**

“Writing procedures to process XML” on page 505

“Parsing XML documents one segment at a time” on page 515

“Handling XML PARSE exceptions” on page 523

“Terminating XML parsing” on page 527

“Handling XML GENERATE exceptions” on page 546

**related references**

“XML PARSE exceptions with XMLPARSE(XMLSS) in effect” on page 665

“XML PARSE exceptions with XMLPARSE(COMPAT) in effect” on page 667

“XML GENERATE exceptions” on page 673

XML-CODE (Enterprise COBOL for z/OS Language Reference)

XML-EVENT (Enterprise COBOL for z/OS Language Reference)
XML-INFORMATION
For most XML events, the parser sets XML-INFORMATION to indicate whether an XML EVENT is complete or whether the XML content spans multiple events.

The application program logic can use the XML-INFORMATION special register to concatenate pieces of parsed XML content together.

**related concepts**
- “XML events” on page 507
- “XML-CODE” on page 508

**related tasks**
- “Writing procedures to process XML” on page 505

**related references**
- XML-TEXT (Enterprise COBOL for z/OS Language Reference)
- XML-NTEXT (Enterprise COBOL for z/OS Language Reference)

**XML-TEXT and XML-NTEXT**
For most XML events, the parser sets XML-TEXT or XML-NTEXT to an associated document fragment.

Typically, the parser sets XML-TEXT if the XML document is in an alphanumeric data item. The parser sets XML-NTEXT if:

- The XML document is in a national data item.
- The XMLPARSE (XMLSS) option is in effect and the RETURNING NATIONAL phrase is specified in the XML PARSE statement.
- The ATTRIBUTE-NATIONAL-CHARACTER or CONTENT-NATIONAL-CHARACTER event occurs.

The special registers XML-TEXT and XML-NTEXT are mutually exclusive. When the parser sets XML-TEXT, XML-NTEXT is empty with length zero. When the parser sets XML-NTEXT, XML-TEXT is empty with length zero.

To determine the number of character encoding units in XML-NTEXT, use the LENGTH intrinsic function; for example FUNCTION LENGTH(XML-NTEXT). To determine the number of bytes in XML-NTEXT, use special register LENGTH OF XML-NTEXT. The number of character encoding units differs from the number of bytes.

To determine the number of bytes in XML-TEXT, use either special register LENGTH OF XML-TEXT or the LENGTH intrinsic function; each returns the number of bytes.

The XML-TEXT and XML-NTEXT special registers are undefined outside the processing procedure.

**related concepts**
- “XML events” on page 507
- “XML-CODE” on page 508

**related tasks**
- “Writing procedures to process XML” on page 505

**related references**
- “XMLPARSE” on page 349 (compiler option)
- XML-TEXT (Enterprise COBOL for z/OS Language Reference)
- XML-NTEXT (Enterprise COBOL for z/OS Language Reference)
XML-NAMESPACE and XML-NNAMESPACE
If the XMLPARSE (XMLSS) option is in effect, the XML parser sets the XML-NAMESPACE or XML-NNAMESPACE special register to the namespace identifier for a NAMESPACE-DECLARATION XML event, or if it encounters an element name or attribute name that is in a namespace.

The parser sets XML-NNAMESPACE if the XML document is in a national data item, or if the RETURNING NATIONAL phrase is specified in the XML PARSE statement. Otherwise, the parser sets XML-NAMESPACE.

The special registers XML-NAMESPACE and XML-NNAMESPACE are mutually exclusive: If the parser sets XML-NAMESPACE, XML-NNAMESPACE is empty with length zero. If the parser sets XML-NNAMESPACE, XML-NAMESPACE is empty with length zero.

To determine the number of character encoding units in XML-NNAMESPACE, use the LENGTH intrinsic function; for example: FUNCTION LENGTH (XML-NNAMESPACE). To determine the number of bytes in XML-NNAMESPACE, use special register LENGTH OF XML-NNAMESPACE. The number of character encoding units differs from the number of bytes.

To determine the number of bytes in XML-NAMESPACE, use either special register LENGTH OF XML-NAMESPACE or the LENGTH intrinsic function; each returns the number of bytes.

The XML namespace special registers are undefined outside the processing procedure.

related concepts
“XML events” on page 507
“XML-CODE” on page 508
“XML-NAMESPACE-PREFIX and XML-NNAMESPACE-PREFIX” on page 511
“XML-TEXT and XML-NTEXT” on page 510

related tasks
“Writing procedures to process XML” on page 505

related references
“XMLPARSE” on page 349 (compiler option)

XML-NAMESPACE-PREFIX and XML-NNAMESPACE-PREFIX
If the XMLPARSE (XMLSS) option is in effect, the XML parser sets the XML-NAMESPACE-PREFIX special register or the XML-NNAMESPACE-PREFIX special register for a NAMESPACE-DECLARATION XML event that also defines a namespace prefix, or if an element name or attribute name in a namespace is prefixed.

The parser sets XML-NNAMESPACE-PREFIX if the XML document is in a national data item, or the RETURNING NATIONAL phrase is specified in the XML PARSE statement. Otherwise, the parser sets XML-NAMESPACE-PREFIX.

The special registers XML-NAMESPACE-PREFIX and XML-NNAMESPACE-PREFIX are mutually exclusive: If the parser sets XML-NAMESPACE-PREFIX, XML-NNAMESPACE-PREFIX is empty with length zero. If the parser sets XML-NNAMESPACE-PREFIX, XML-NAMESPACE-PREFIX is empty with length zero.

To determine the number of character encoding units in XML-NNAMESPACE-PREFIX, use the LENGTH intrinsic function; for example: FUNCTION LENGTH (XML-NNAMESPACE-PREFIX). To determine the number of bytes in XML-NNAMESPACE-PREFIX, use special register LENGTH OF XML-NNAMESPACE-PREFIX. The number of character encoding units differs from the number of bytes.

To determine the number of bytes in XML-NAMESPACE-PREFIX, use either special register LENGTH OF XML-NAMESPACE-PREFIX or the LENGTH intrinsic function; each returns the number of bytes.

The XML namespace-prefix special registers are undefined outside the processing procedure.

related concepts
“XML events” on page 507
“XML-NAMESPACE and XML-NNAMESPACE” on page 511
Transforming XML text to COBOL data items

Because XML data is neither fixed length nor fixed format, you need to use special techniques when you move XML data to a COBOL data item.

For alphanumeric items, decide whether the XML data should go at the left (default) end, or at the right end, of the COBOL data item. If the data should go at the right end, specify the JUSTIFIED RIGHT clause in the definition of the item.

Give special consideration to numeric XML values, particularly “decorated” monetary values such as ‘$1,234.00’ or ‘$1234’. These two strings might mean the same thing in XML, but need quite different definitions if used as COBOL sending fields.

Use one of the following techniques when you move XML data to COBOL data items:

- If the format is reasonably regular, code a MOVE to an alphanumeric item that you redefine appropriately as a numeric-edited item. Then do the final move to a numeric (operational) item by moving from, and thus de-editing, the numeric-edited item. (A regular format would have the same number of digits after the decimal point, a comma separator for values greater than 999, and so on.)

- For simplicity and vastly increased flexibility, use the following intrinsic functions for alphanumeric XML data:
  - NUMVAL to extract and decode simple numeric values from XML data that represents plain numbers
  - NUMVAL-C to extract and decode numeric values from XML data that represents monetary quantities

However, using these functions is at the expense of performance.

Parsing XML documents with validation

Validating an XML document determines whether the structure and content of the document conform to a set of rules. In Enterprise COBOL, the rules are expressed in an XML schema, which is essentially a blueprint for a class of documents.

To validate XML documents while parsing, use the VALIDATING phrase of the XML PARSE statement. To do so, you must compile your program using the XMLPARSE(XMLSS) compiler option.

You can validate XML documents only against an XML schema.

In Enterprise COBOL, a schema used for XML validation must be in a preprocessed format known as Optimized Schema Representation, or OSR. To generate a schema in OSR format from a text-form schema, use the z/OS UNIX command xsdosrg, which invokes the OSR generator provided by z/OS System Services. (Alternatively, you can call the OSR generator programmatically. For details, see the related reference about z/OS XML System Services.)

For example, to convert the text-form schema in file item.xsd to a schema in preprocessed format in file item.osr, you can use the following z/OS UNIX command:

```bash
xsdosrg -v -o /u/HLQ/xml/item.osr /u/HLQ/xml/item.xsd
```
Use one of two forms of the VALIDATING phrase, depending on the location of the preprocessed schema:

- In one form, you use the FILE keyword and specify an XML schema name. In this case, the schema must be in an MVS data set or a z/OS UNIX file.
- In the other form, you specify the identifier of a data item that contains the schema.

If you use the FILE keyword and specify an XML schema name, the COBOL runtime library automatically retrieves the schema during execution of the XML PARSE statement. The following code fragment shows this method of specifying validation:

```cobol
XML PARSE document-item
   VALIDATING WITH FILE schema-name
   PROCESSING PROCEDURE xml-event-handler
   ON EXCEPTION
      DISPLAY 'Document has an error.'
      GOBACK
   NOT ON EXCEPTION
      DISPLAY 'Document is valid.'
END-XML
```

To associate an XML schema name with the external file that contains the schema, code the XML-SCHEMA clause in the SPECIAL-NAMES paragraph, specifying either a literal or a user-defined word to identify the file.

For example, you can associate the XML schema name `schema-name` shown in the fragment above with the ddname `DDSCHEMA` by coding the ddname as a literal in the XML-SCHEMA clause as follows:

```cobol
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SPECIAL-NAMES.
   XML-SCHEMA schema-name IS 'DDSCHEMA'.
```

For running the program, you can associate ddname `DDSCHEMA` with the z/OS UNIX file `item.osr` by coding a DD statement as follows:

```cobol
//GO.DDSCHEMA DD PATH='/u/HLQ/xml/item.osr'
```

Or you can use an analogous TSO ALLOCATE command.

Alternatively, `DDSCHEMA` in the example above could be the name of an environment variable that identifies the external file by means of a DSN option that specifies an MVS data set or a PATH option that specifies a z/OS UNIX file.

If your schema is in an MVS data set, the data set can be any sequential data set (for example, QSAM fixed blocked or variable blocked, or VSAM ESDS).

For further details about how to associate an XML schema name with the external file that contains the schema, see the related reference about the XML-SCHEMA clause.

**Restriction:** XML validation using the FILE keyword is not supported under CICS.

The automatic retrieval that occurs when you use the FILE keyword is convenient. But if you have several XML documents of the same type to validate, reading the schema into memory once and then reusing the schema for each of the documents provides better performance than automatic retrieval. In this case, you use the other form of the VALIDATING phrase, in which you specify an identifier that references an alphanumeric data item that contains the XML schema. For example:

```cobol
XML PARSE document-item
   VALIDATING WITH xmlschema
   PROCESSING PROCEDURE xml-event-handler
   ON EXCEPTION
      DISPLAY 'Document has an error.'
      GOBACK
   NOT ON EXCEPTION
```

Chapter 30. Processing XML input 513
Read the preprocessed schema into the data item, for example by using normal COBOL statements.

For more information about this form of the VALIDATING phrase, see the related reference about the XML PARSE statement.

During parsing with validation, normal XML events are returned until an exception occurs due to a validation error or well-formedness error. If an XML document is not valid, the parser signals an XML exception and passes control to the processing procedure with special register XML-EVENT containing 'EXCEPTION' and special register XML-CODE containing return code 24 in the high-order halfword and a specific validation reason code in the low-order halfword.

For information about the return code and reason code for exceptions that might occur when parsing XML documents with validation, see the related reference about exceptions with XMLPARSE(XMLSS) in effect.

“Example: parsing XML documents with validation” on page 538

related concepts
“XML-CODE” on page 508
“XML schemas” on page 514

related tasks
“Handling XML PARSE exceptions” on page 523

related references
“XMLPARSE” on page 349 (compiler option)

“XML PARSE exceptions with XMLPARSE(XMLSS) in effect” on page 665
XML PARSE statement (Enterprise COBOL for z/OS Language Reference)
XML-SCHEMA clause (Enterprise COBOL for z/OS Language Reference)
z/OS XML System Services User's Guide and Reference

XML schemas
An XML schema is a mechanism, defined by the W3C, for describing and constraining the structure and content of XML documents. An XML schema, which is itself expressed in XML, effectively defines a class of XML documents of a given type, for example, purchase orders.

For Enterprise COBOL, XML schemas used for validating XML documents must be in a preprocessed format known as Optimized Schema Representation (OSR). For information about this format, see the related reference about z/OS XML System Services.

Consider an XML document that describes an item for stock-keeping purposes:

```
<stockItem itemNumber="453-SR">
  <itemName>Stainless steel rope thimbles</itemName>
  <quantityOnHand>23</quantityOnHand>
</stockItem>
```

The example document above is both well formed and valid according to the following schema. (The numbers that precede each line are not part of the schema, but are used in the explanations after the schema.)

```
1. <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
2. 3. <xsd:element name="stockItem" type="stockItemType"/>
4. 5. <xsd:complexType name="stockItemType">
6.    7. <xsd:sequence>
8.      9. <xsd:element name="itemName" type="xsd:string" minOccurs="0"/>
10.      <xsd:element name="quantityOnHand">
11.   </xsd:complexType>
12.   </xsd:sequence>
13. </xsd:schema>
```
The schema declares (line 3) that the root element is `stockItem`, which has a mandatory `itemNumber` attribute (line 16) of type `SKU`, and includes a sequence (lines 6 - 15) of other elements:

- An optional `itemName` element of type `string` (line 7)
- A required `quantityOnHand` element that has a constrained range of 1 - 99 based on the type `nonNegativeInteger` (lines 8 - 14)

Type declarations can be inline and unnamed, as in lines 9 - 13, which include the `maxExclusive` facet to specify the legal values for the `quantityOnHand` element.

For the `itemNumber` attribute, by contrast, the named type `SKU` is declared separately in lines 19 - 23, which include a pattern facet that uses regular expression syntax to specify that the legal values for that type consist of (in order): 3 digits, a hyphen-minus, then two uppercase letters.

The example referenced below shows a program that parses documents against this schema.

“Example: parsing XML documents with validation” on page 538

related tasks
“Parsing XML documents with validation” on page 512

related references
z/OS XML System Services User's Guide and Reference

Parsing XML documents one segment at a time

You can parse XML documents by passing the parser one segment (or record) of XML text at a time. Processing very large documents, or processing XML documents that reside in a data set, are two possible major applications of this technique.

To use this feature, compile your program with the `XMLPARSE(XMLSS)` compiler option in effect.

You parse an XML document a segment at a time by initializing the parse data item to the first segment of the XML document, and then executing the XML `PARSE` statement. The parser processes the XML text and returns XML events to your processing procedure as usual.

At the end of the text segment, the parser signals an `END-OF-INPUT` XML event, with `XML-CODE` set to zero. If there is another segment of the document to process, in your processing procedure move the next segment of XML data to the parse data item, set `XML-CODE` to one, and return to the parser. To signal the end of XML segments to the parser, return to the parser with `XML-CODE` still set to zero.

The length of the parse data item is evaluated for each segment, and determines the segment length.

**Variable-length segments:** If the XML document segments are variable length, specify a variable-length item for the parse data item. For example, for variable-length XML segments, you can define the parse data item as one of the following items:

- A variable-length group item that contains an `OCCURS DEPENDING ON` clause
- A reference-modified item
- An FD record that specifies the `RECORD IS VARYING DEPENDING ON` clause, where the depending-on data item is used as the length in a reference modifier or ODO object for the FD record
When you send an XML document to the parser in multiple segments, document content is in some cases returned to the processing procedure in multiple fragments by means of multiple events, rather than as one large fragment in a single event.

For example, if the document is split into two segments with the split point in the middle of a string of content characters, the parser returns the content in two separate CONTENT-CHARACTERS events. In the processing procedure, you must reassemble the string of content as needed by the application.

Starting element tags, attribute names, namespace declarations, and ending element tags are always delivered to the processing procedure in a single event, even if those items are split between two segments of a document.

If a segment split occurs between the bytes of a multibyte character, the parser detects the split and reassembles the character for delivery in a single event.

If you are parsing an XML document with an unknown number of repetitive elements to be processed, use unbounded tables. For more information on unbounded tables, see “Working with unbounded tables and groups” on page 86.

For each such element in a given document, manage the table size using one of the following methods:

- Calculating number of elements:
  1. Count the number of elements in the document during an initial parse.
  2. Set the OCCURS DEPENDING ON object for the table to that size
  3. Allocate storage for the table
  4. Parse the document a second time to process the XML

- Incremental expansion:
  1. Set an initial size in the OCCURS DEPENDING ON object for the unbounded table
  2. Parse the document normally. For each element
     a. Check the limit and expand the unbounded table if necessary.
  3. Allocate a new, larger storage area:
  4. Copy the data from the smaller area
  5. Free the smaller area
  6. Set the table pointer to the address of the larger storage area.

**QSAM and VSAM files:** You can process XML documents stored in a QSAM or VSAM file as follows:

1. Open the file and read the first record of the XML document.
2. Execute the XML PARSE statement with the FD record as the parse data item.
3. In the processing-procedure logic for handling the END-OF-INPUT event, read the next record of the XML document into the parse data item. If not end-of-file (file status code 10), set XML-CODE to one and return to the parser. If end-of-file, return to the parser with XML-CODE still set to zero.
4. In your processing procedure logic for the END-OF-DOCUMENT event, close the file.

**Miscellaneous information after the root element:**

The root element of an XML document might be followed by zero or more occurrences of a comment or processing instruction, in any order. If you parse the document one segment at a time, the parser signals an END-OF-INPUT XML event after processing the end tag of the root element only if the last item in the segment is incomplete. If the segment ends with a complete XML item (such as the root element end tag, or after that tag, a complete comment or processing instruction), the next XML event after the event for the item itself is the END-OF-DOCUMENT XML event.

**Tip:** To provide successive segments of XML data after the end of the root element, include at least the first non-space character of an XML item at the end of each segment. Include a complete item only on the last segment that you want the parser to process.
For instance, in the following example, in which each line represents a segment of an XML document, the segment that includes the text *This comment ends this segment* is the last segment to be parsed:

```
<Tagline>
COBOL is the language of the future!
</Tagline> <
!--First comment--
> <?pi data?> <!-
-This comment ends this segment-->
<!-- This segment is not included in the parse-->    
```

“Example: parsing an XML document one segment at a time” on page 536

**related concepts**

“XML events” on page 507

“XML-CODE” on page 508

**related tasks**

“Parsing XML documents one segment at a time” on page 515

“XML-CODE” on page 508

**related references**

“XMLPARSE” on page 349 (compiler option)

**Handling splits using the XML-INFORMATION special register**

You can parse large XML documents by using the XML-INFORMATION special register.

To use this feature, compile your program with the XMLPARSE(XMLSS) compiler option in effect.

Splits in character content might occur at arbitrary points in the XML data stream, even with unsegmented input. The XML-INFORMATION special register simplifies the reassembly of content. This register may be required for any and all attribute values and element character content.

The length of the parse data item is evaluated for each segment, and determines the segment length.

The example, “Example: program for processing XML” on page 528, demonstrates various ways of assigning values obtained from the XML document to program data items for later processing.

The XML data is provided to the parser in 40-byte records, imitating the way an XML document might be acquired from an external source such as a data file. The record boundaries are designed so that all data splits but one are accommodated by the parser. For example, the sample treats as an error a split in any content except the content of the “filling” element.

In the example, the XML-INFORMATION special register is only used to simplify the reassembly of content for the “filling” element. This register could be used for any attribute values and element character content. An XML-INFORMATION value of 2 indicates that the character data for an ATTRIBUTE-CHARACTERS or CONTENT-CHARACTERS XML event is continued in a subsequent XML event, and should thus be buffered in order to accumulate the complete character string. A subsequent XML event of the same type with an XML-INFORMATION value of 1 indicates that XML-TEXT or XML-NTEXT contains the final piece of the character content, and that the complete string can be moved to the appropriate data item.

In the example, the STRING ... WITH POINTER statement accumulates and describes properly the complete character value for assignment to the “filling” identifier.

```
    String xml-text delimited by size into
        content-buffer with pointer tally
    On overflow
        Display 'content buffer (' length of content-buffer ' bytes) is too small'
        Move -1 to xml-code
    End-string
```
The encoding of XML documents

XML documents must be encoded in a supported code page.

XML documents generated in or parsed from national data items must be encoded in Unicode UTF-16 in big-endian format, CCSID 1200.

For XML GENERATE statements, documents generated in alphanumeric data items must be encoded in Unicode UTF-8 (CCSID 1208) or one of the single-byte EBCDIC encodings listed in the table below. You can use any CCSID from that table in the ENCODING phrase of the XML GENERATE statement.

For XML PARSE statements, documents in alphanumeric data items must be encoded as follows:

- If XMLPARSE(XMLSS) is in effect:
  - If the RETURNING NATIONAL phrase is specified in the XML PARSE statement, in any EBCDIC or ASCII encoding that is supported by z/OS Unicode Services for conversion to UTF-16
  - If the RETURNING NATIONAL phrase is not specified in the XML PARSE statement, in UTF-8 (CCSID 1208) or one of the single-byte EBCDIC encodings listed in the table below

- If XMLPARSE(COMPAT) is in effect: in one of the single-byte EBCDIC encodings listed in the table below

If XMLPARSE(XMLSS) is in effect, you can use any supported CCSID (as described above for XML PARSE) in the ENCODING phrase of the XML PARSE statement.

<table>
<thead>
<tr>
<th>CCSID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1208</td>
<td>UTF-8¹</td>
</tr>
<tr>
<td>1047</td>
<td>Latin 1 / Open Systems</td>
</tr>
<tr>
<td>1140, 37</td>
<td>USA, Canada, ... Euro Country Extended Code Page (ECECP), Country Extended Code Page (CECP)</td>
</tr>
<tr>
<td>1141, 273</td>
<td>Austria, Germany ECECP, CECP</td>
</tr>
<tr>
<td>1142, 277</td>
<td>Denmark, Norway ECECP, CECP</td>
</tr>
<tr>
<td>1143, 278</td>
<td>Finland, Sweden ECECP, CECP</td>
</tr>
<tr>
<td>1144, 280</td>
<td>Italy ECECP, CECP</td>
</tr>
<tr>
<td>1145, 284</td>
<td>Spain, Latin America (Spanish) ECECP, CECP</td>
</tr>
<tr>
<td>1146, 285</td>
<td>UK ECECP, CECP</td>
</tr>
<tr>
<td>1147, 297</td>
<td>France ECECP, CECP</td>
</tr>
<tr>
<td>1148, 500</td>
<td>International ECECP, CECP</td>
</tr>
<tr>
<td>1149, 871</td>
<td>Iceland ECECP, CECP</td>
</tr>
</tbody>
</table>

¹. Supported for the XML PARSE statement in the ENCODING phrase if XMLPARSE(XMLSS) is in effect

related concepts
“XML input document encoding” on page 519
**XML input document encoding**

To parse an XML document using the XML PARSE statement, the document must be encoded in a supported encoding.

The supported encodings for a given parse operation depend on:

- The category of the data item that contains the XML document
- The setting of the XMLPARSE compiler option
- The optional phrases that are specified in the XML PARSE statement

For XML documents that are contained in a national data item, the supported encoding is Unicode UTF-16 in big-endian format, CCSID 1200.

For XML documents that are contained in an alphanumeric data item, the supported encodings if the XMLPARSE(XMLSS) compiler option is in effect are as follows:

- If the RETURNING NATIONAL phrase is specified in the XML PARSE statement: UTF-8 or any EBCDIC or ASCII encoding that is supported by the z/OS Unicode Services for conversion to UTF-16
- If the RETURNING NATIONAL phrase is not specified: UTF-8 or any of the single-byte EBCDIC CCSIDs listed in the related reference about the encoding of XML documents

For XML documents that are contained in an alphanumeric data item, the supported CCSIDs if XMLPARSE(COMPAT) is in effect are those specified in the related reference about the encoding of XML documents.

To parse an XML document that is encoded in an unsupported code page, first convert the document to national character data (UTF-16) by using the NATIONAL-OF intrinsic function. You can convert the individual pieces of document text that are passed to the processing procedure in special register XML-NTEXT back to the original code page by using the DISPLAY-OF intrinsic function.

**XML declaration and white space:**

XML documents can begin with *white space* only if they do not have an XML declaration:

- If an XML document begins with an XML declaration, the first angle bracket (<) in the document must be the first character in the document.
- If an XML document does not begin with an XML declaration, the first angle bracket in the document can be preceded only by white space.

White-space characters have the hexadecimal values shown in the following table.

<table>
<thead>
<tr>
<th>White-space character</th>
<th>EBCDIC</th>
<th>Unicode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>X'40'</td>
<td>X'0020'</td>
</tr>
<tr>
<td>Horizontal tabulation</td>
<td>X'05'</td>
<td>X'0009'</td>
</tr>
<tr>
<td>Carriage return</td>
<td>X'0D'</td>
<td>X'000D'</td>
</tr>
<tr>
<td>Line feed</td>
<td>X'25'</td>
<td>X'000A'</td>
</tr>
</tbody>
</table>
### Table 68. Hexadecimal values of white-space characters (continued)

<table>
<thead>
<tr>
<th>White-space character</th>
<th>EBCDIC</th>
<th>Unicode</th>
</tr>
</thead>
<tbody>
<tr>
<td>New line / next line</td>
<td>X'15'</td>
<td>X'0085'</td>
</tr>
</tbody>
</table>

#### Determining the encoding of an input XML document

The parser must know the encoding of an XML document in order to process the document correctly.

If the specified encoding is not one of the supported coded character sets, the parser signals an XML exception event before beginning the parse operation. If the actual document encoding does not match the specified encoding, the parser signals an appropriate XML exception after beginning the parse operation.

Several sources are used in determining the encoding of an XML document:

- If the **XMLPARSE(XMLSS)** option is in effect:
  - The data type of the data item that contains the XML document
  - The ENCODING phrase (if used) of the XML PARSE statement
  - The CCSID specified in the CODEPAGE compiler option

- If the **XMLPARSE(COMPAT)** option is in effect:
  - The data type of the data item that contains the XML document
  - The actual encoding determined when the parser examines the first few bytes of the document
  - The encoding declaration specified within the XML document
  - The CCSID specified in the CODEPAGE compiler option

If **XMLPARSE(XMLSS)** is in effect:

- Any encoding declaration specified within the XML document is ignored.
- For XML documents that are contained in a national data item, the ENCODING phrase of the XML PARSE statement must be omitted or must specify CCSID 1200. The CCSID specified in the CODEPAGE compiler option is ignored. The parser signals an XML exception event if the actual document encoding is not UTF-16 in big-endian format.
- For XML documents that are contained in an alphanumeric data item, the CCSID specified in the ENCODING phrase overrides the CODEPAGE compiler option. The parser raises an XML exception event at the beginning of the parse operation if the actual document encoding is not consistent with the specified CCSID.

**related tasks**

- “Converting to or from national (Unicode) representation” on page 131
- “Specifying the encoding” on page 520
- “Parsing XML documents encoded in UTF-8” on page 522
- “Handling XML PARSE exceptions” on page 523

**related references**

- “XMLPARSE” on page 349 (compiler option)
- “The encoding of XML documents” on page 518
- “EBCDIC code-page-sensitive characters in XML markup” on page 521

#### Specifying the encoding

You can choose how to specify the encoding for parsing an XML document that is in an alphanumeric data item.

The preferred way is to omit the encoding declaration from the document and to specify the encoding using one of the following means:
• If XMLPARSE(XMLSS) is in effect: the ENCODING phrase of the XML PARSE statement, or the CODEPAGE compiler option
• If XMLPARSE(COMPAT) is in effect: the CODEPAGE compiler option

Omitting the encoding declaration makes it possible to more easily transmit an XML document between heterogeneous systems. (If you included an encoding declaration, you would need to update it to reflect any code-page translation imposed by the transmission process.)

For XMLPARSE (COMPAT):
You can instead specify an encoding declaration in the XML declaration with which most XML documents begin. For example:

```xml
<?xml version="1.0" encoding="ibm-1140"?>
```

Note that the XML parser generates an exception if it encounters an XML declaration that does not begin in the first byte of an XML document.

If you specify an encoding declaration, do so in one of the following ways:

• Specify the CCSID number (with or without any number of leading zeros) prefixed by one of the following strings in any mixture of uppercase and lowercase letters:
  – IBM-
  – IBM_
  – CCSID-
  – CCSID_

• Use one of the aliases listed in the following table. You can code the aliases in any mixture of uppercase and lowercase letters.

<table>
<thead>
<tr>
<th>CCSID</th>
<th>Supported aliases</th>
</tr>
</thead>
<tbody>
<tr>
<td>037</td>
<td>EBCDIC-CP-US, EBCDIC-CP-CA, EBCDIC-CP-WT, EBCDIC-CP-NL</td>
</tr>
<tr>
<td>500</td>
<td>EBCDIC-CP-BE, EBCDIC-CP-CH</td>
</tr>
<tr>
<td>1200</td>
<td>UTF-16</td>
</tr>
<tr>
<td>1208</td>
<td>UTF-8</td>
</tr>
</tbody>
</table>

For more information about the CCSIDs that are supported for XML parsing, see the related reference about the encoding of XML documents.

related concepts
“XML input document encoding” on page 519

related tasks
“Parsing XML documents encoded in UTF-8” on page 522
“Handling encoding conflicts” on page 526

related references
“The encoding of XML documents” on page 518

EBCDIC code-page-sensitive characters in XML markup
Several special characters that are used in XML markup have different hexadecimal representations in different EBCDIC code pages.

The following table shows those special characters and their hexadecimal values for various EBCDIC CCSIDs.
Table 70. Hexadecimal values of special characters for various EBCDIC CCSIDs

<table>
<thead>
<tr>
<th>Character</th>
<th>1047</th>
<th>1140</th>
<th>1141</th>
<th>1142</th>
<th>1143</th>
<th>1144</th>
<th>1145</th>
<th>1146</th>
<th>1147</th>
<th>1148</th>
<th>1149</th>
</tr>
</thead>
<tbody>
<tr>
<td>[</td>
<td>X'AD'</td>
<td>X'BA'</td>
<td>X'63'</td>
<td>X'9E'</td>
<td>X'B5'</td>
<td>X'90'</td>
<td>X'4A'</td>
<td>X'B1'</td>
<td>X'90'</td>
<td>X'4A'</td>
<td>X'AE'</td>
</tr>
<tr>
<td>]</td>
<td>X'BD'</td>
<td>X'BB'</td>
<td>X'FC'</td>
<td>X'9F'</td>
<td>X'9F'</td>
<td>X'51'</td>
<td>X'5A'</td>
<td>X'B5'</td>
<td>X'5A'</td>
<td>X'9E'</td>
<td></td>
</tr>
<tr>
<td>!</td>
<td>X'5A'</td>
<td>X'5A'</td>
<td>X'4F'</td>
<td>X'4F'</td>
<td>X'4F'</td>
<td>X'4F'</td>
<td>X'B5'</td>
<td>X'5A'</td>
<td>X'9E'</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X'4F'</td>
<td>X'4F'</td>
<td>X'BB'</td>
<td>X'BB'</td>
<td>X'BB'</td>
<td>X'4F'</td>
<td>X'4F'</td>
<td>X'B5'</td>
<td>X'5A'</td>
<td>X'9E'</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>X'7B'</td>
<td>X'7B'</td>
<td>X'7B'</td>
<td>X'4A'</td>
<td>X'63'</td>
<td>X'B1'</td>
<td>X'69'</td>
<td>X'7B'</td>
<td>X'B1'</td>
<td>X'7B'</td>
<td>X'7B'</td>
</tr>
</tbody>
</table>

Parsing XML documents encoded in UTF-8

If the XMLPARSE(XMLSS) compiler option is in effect, you can parse XML documents that are encoded in Unicode UTF-8 in a manner similar to parsing other XML documents. However, some additional requirements apply.

To parse a UTF-8 XML document, you must specify CCSID 1208 in the ENCODING phrase of the XML PARSE statement, as shown in the following code fragment:

```
XML PARSE xml-document
  WITH ENCODING 1208
  PROCESSING PROCEDURE xml-event-handler
END-XML
```

You define xml-document as an alphanumeric data item or alphanumeric group item in WORKING-STORAGE or LOCAL-STORAGE.

If you do not code the RETURNING NATIONAL phrase in the XML PARSE statement, the parser returns the XML document fragments in the alphanumeric special registers XML-TEXT, XML-NAMESPACE, and XML-NAMESPACE-PREFIX.

UTF-8 characters are encoded using a variable number of bytes per character. Most COBOL operations on alphanumeric data assume a single-byte encoding, in which each character is encoded in 1 byte. When you operate on UTF-8 characters as alphanumeric data, you must ensure that the data is processed correctly. Avoid operations (such as reference modification and moves that involve truncation) that can split a multibyte character between bytes. You cannot reliably use statements such as INSPECT to process multibyte characters in alphanumeric data.

You can more reliably process UTF-8 document fragments by specifying the RETURNING NATIONAL phrase in the XML PARSE statement. If you use the RETURNING NATIONAL phrase, XML document fragments are efficiently converted to UTF-16 encoding and are returned to the application in the national special registers XML-NTEXT, XML-NNAMESPACE, and XMLNNAMESPACE-PREFIX. Then you can process the XML text fragments in national data items. (The UTF-16 encoding in national data items greatly facilitates Unicode processing in COBOL.)

The following code fragment illustrates the use of both the ENCODING phrase and the RETURNING NATIONAL phrase for parsing a UTF-8 XML document:

```
XML PARSE xml-document
  WITH ENCODING 1208 RETURNING NATIONAL
  PROCESSING PROCEDURE xml-event-handler
ON EXCEPTION
  DISPLAY 'XML document error ' XML-CODE
  STOP RUN
NOT ON EXCEPTION
  DISPLAY 'XML document was successfully parsed.'
END-XML
```

related concepts

“XML-TEXT and XML-NTEXT” on page 510
Handling XML PARSE exceptions

If the XML parser encounters an anomaly or error during parsing, it sets an exception code in the XML-CODE special register and signals an XML exception event. The specific exception codes that can occur and the subsequent actions that you can take differ depending on the setting of the XMLPARSE compiler option.

For XMLPARSE(XMLSS):

**Return code and reason code:** The exception code is formed from the return code and the reason code that the parser generates. The return code and the reason code are each a halfword binary value. The value in XML-CODE is a concatenation of these two values.

As an example, the following XML document is not well formed because the element end tag `<mmsg>` does not match the element start tag `<msg>`:

```xml
<msg>Hello</mmsg>
```

The return code is hexadecimal 000C (XRC_NOT_WELL_FORMED), and the reason code is hexadecimal 3035 (XRSN_ENDTAG_NAME_MISMATCH), if you parse the document without validation. The concatenation of these two values, hexadecimal 000C3035, is returned to the processing procedure in the XML-CODE special register.

If you parse a document with validation, the values returned in XML-CODE for any well-formedness errors differ from the values returned for the same errors when you parse without validation. The return code generated by the z/OS XML System Services parser for any validation error is 24 (hexadecimal 0018).

For more information about the return codes and reason codes that can be generated, see the related reference about exceptions with XMLPARSE(XMLSS) in effect.

If XMLPARSE(XMLSS) is in effect, processing procedures cannot handle exception events and cannot cause parsing to resume. When a processing procedure returns to the parser from an exception event, the parser does not signal any further events. The parser transfers control to the statement that is specified in the ON EXCEPTION phrase of the XMLPARSE statement. If you did not code an ON EXCEPTION phrase, control is passed to the end of the XMLPARSE statement. XML-CODE contains the original exception code set by the parser.

If no exception occurs during parsing, control is passed to the statement specified in the NOT ON EXCEPTION phrase. If you did not code a NOT ON EXCEPTION phrase, control is passed to the end of the XMLPARSE statement. XML-CODE contains zero.

For XMLPARSE(COMPAT):

If the exception code is within a certain range, you might be able to handle the exception event within your processing procedure, and resume parsing.

To handle an exception in the processing procedure, follow these steps:

1. Check the contents of XML-CODE.
2. Handle the exception appropriately.
3. Set XML-CODE to zero to indicate that you handled the exception.
4. Return control to the parser.

The exception condition no longer exists.

You can handle exceptions in this way only if the exception code that is passed in XML-CODE is within one of the following ranges, which indicates that an encoding conflict was detected:

- 50 - 99
- 100,001 - 165,535

**Exception codes 1 - 49:** In the processing procedure, you can do limited handling of exceptions for which the exception code is within the range 1 - 49. After an exception in this range occurs, the parser does not signal any further normal events, except the END-OF-DOCUMENT event, even if you set XML-CODE to zero before returning. If you set XML-CODE to zero, the parser continues parsing the document and signals any exceptions that it finds. (Doing so can provide a useful way to discover multiple errors in the document.)

**Restriction:** The compatibility-mode COBOL XML parser might not signal all additional exception events. The number of exceptions is limited to the remaining space in the XML PARSE event token array, probably 8192 events.

At the end of parsing after an exception that has an exception code in the range 1 - 49, control is passed to the statement specified in the ON EXCEPTION phrase. If you did not code an ON EXCEPTION phrase, control is passed to the end of the XML PARSE statement. XML-CODE contains the code set by the parser for the most recent exception.

For all exceptions other than those having an exception code within one of the ranges described above, the parser does not signal any further events, but passes control to the statement specified in the ON EXCEPTION phrase. XML-CODE contains the original exception code even if you set XML-CODE in the processing procedure before returning control to the parser.

If you do not want to handle an exception, return control to the parser without changing the value of XML-CODE. The parser transfers control to the statement specified in the ON EXCEPTION phrase. If you did not code an ON EXCEPTION phrase, control is transferred to the end of the XML PARSE statement.

If no unhandled exceptions occur before the end of parsing, control is passed to the statement specified in the NOT ON EXCEPTION phrase. If you did not code a NOT ON EXCEPTION phrase, control is transferred to the end of the XML PARSE statement. XML-CODE contains zero.

**related concepts**
- “XML-CODE” on page 508
- “XML input document encoding” on page 519
- “How the XML parser handles errors” on page 525

**related tasks**
- “Writing procedures to process XML” on page 505
- “Parsing XML documents with validation” on page 512
- “Handling encoding conflicts” on page 526

**related references**
- “XMLPARSE” on page 349 (compiler option)
- “The encoding of XML documents” on page 518
- “XML PARSE exceptions with XMLPARSE(XMLSS) in effect” on page 665
- “XML PARSE exceptions with XMLPARSE(COMPAT) in effect” on page 667
- z/OS XML System Services User's Guide and Reference
How the XML parser handles errors
When the XML parser detects an error in an XML document, it generates an XML exception event and passes control to your processing procedure.

The parser passes the following information in special registers to the processing procedure:

- **XML-EVENT** contains 'EXCEPTION'.
- **XML-CODE** contains a numeric exception code.

The exception codes are described in the related references about XML PARSE exceptions.

- For fatal exceptions, **XML-TEXT** or **XML-NTEXT** contains the document text up to and including the point where the exception was detected.
- For the warning exceptions issued for using an undeclared prefix, **XML-TEXT** or **XML-NTEXT** contains the fully qualified attribute name or element name. That is, the name includes the undeclared prefix and the separator colon (:).
- If **XMLPARSE(COMPAT)** is in effect, **XML-TEXT** or **XML-NTEXT** contains the document text up to and including the point where the exception was detected.
- If **XMLPARSE(XMLSS)** is in effect, **XML-TEXT** or **XML-NTEXT** contains the document text up to the point where the error or anomaly was detected. If you process the XML document one segment at a time, the applicable special register contains only the current segment.

All other XML special registers are empty with length zero.

**For XMLPARSE(XMLSS):**
Parsing cannot continue after a fatal exception even if you set **XML-CODE** to zero in the processing procedure. Upon return to the parser from the processing procedure, the parser transfers control to the ON EXCEPTION phrase, if specified; otherwise the parser transfers control to the end of the XML PARSE statement. **XML-CODE** contains the original exception code set by the parser.

**For XMLPARSE(COMPAT):**
The processing procedure might be able to handle an exception so that parsing continues if the exception code is within one of the following ranges:

- 1 - 99
- 100,001 - 165,535

If the exception code has any other nonzero value, parsing cannot continue.

**Encoding conflicts:** The exceptions for encoding conflicts (50 - 99 and 300 - 399) are signaled before the parsing of the document begins. For these exceptions, **XML-TEXT** or **XML-NTEXT** is either length zero or contains only the encoding declaration value from the document.

**Exception codes 1 - 49:** An exception for which the exception code is in the range 1 - 49 is a fatal error according to the XML specification. Therefore, the parser does not continue normal parsing even if the processing procedure handles the exception. However, the parser does continue scanning for further errors until it reaches the end of the document, or until the existing XML EVENT token array is exhausted. For these exceptions, the parser does not signal any further normal events except the END-OF-DOCUMENT event.

related concepts
“XML events” on page 507
“XML-CODE” on page 508
“XML input document encoding” on page 519

related tasks
“Parsing XML documents one segment at a time” on page 515
“Handling XML PARSE exceptions” on page 523
“Handling encoding conflicts” on page 526

“Terminating XML parsing” on page 527

Chapter 30. Processing XML input 525
Handling encoding conflicts

The way that you handle encoding-conflict exceptions depends on the setting of the XMLPARSE compiler option.

**For XMLPARSE(XMLSS):**

The parser does not continue after an encoding-conflict exception or after any other type of exception. Any changes that you make in the processing procedure to the value of XML-CODE are ignored. The value in XML-CODE when the parser returns to the XML PARSE statement is the original exception code that the parser set.

**For XMLPARSE(COMPAT):**

Your processing procedure might be able to handle exceptions for document encoding conflicts. Exception events in which the parse data item is alphanumeric and the exception code in XML-CODE is within the range 100,001 - 165,535 indicate that the code page of the document (as specified by its encoding declaration) conflicts with the external code-page information.

In this special case, you can choose to parse using the code page of the document by subtracting 100,000 from the value in XML-CODE. For instance, if XML-CODE contains 101,140, the code page of the document is 1140. Alternatively, you can choose to parse using the external code page by setting XML-CODE to zero before returning to the parser.

The parser takes one of three actions after returning from a processing procedure for an encoding-conflict exception event:

- If you set XML-CODE to zero, the parser uses the external code page: the value of the CODEPAGE compiler option.
- If you set XML-CODE to the code page of the document (that is, the original XML-CODE value minus 100,000), the parser uses the code page of the document. This is the only case in which the parser continues when XML-CODE has a nonzero value upon returning from a processing procedure.
- Otherwise, the parser stops processing the document and returns control to the XML PARSE statement with an exception condition. XML-CODE contains the exception code that was originally passed with the exception event.
Terminating XML parsing

You can terminate parsing immediately, without processing any remaining XML text, by setting XML-CODE to -1 in your processing procedure before the procedure returns to the parser from any normal XML event (that is, any event other than EXCEPTION).

You can use this technique when the processing procedure has examined enough of the document or has detected some irregularity in the document that precludes further meaningful processing.

If you terminate parsing in this way, the parser does not signal any further XML events, including the exception event. Control transfers to the ON EXCEPTION phrase of the XML PARSE statement, if that phrase was specified.

In the imperative statement of the ON EXCEPTION phrase, you can determine whether parsing was deliberately terminated by testing whether XML-CODE contains -1. If you do not specify the ON EXCEPTION phrase, control transfers to the end of the XML PARSE statement.

If the XMLPARSE(COMPAT) compiler option is in effect, you can also terminate parsing after any XML EXCEPTION event by returning to the parser from the processing procedure without changing the value in XML-CODE. The result is similar to the result of deliberate termination, except that the parser returns to the XML PARSE statement with XML-CODE containing the original exception code.

If the XMLPARSE(XMLSS) option is in effect, parsing always terminates after any exception event.

related concepts
"XML-CODE" on page 508
"How the XML parser handles errors" on page 525

related tasks
"Writing procedures to process XML" on page 505
"Handling XML PARSE exceptions" on page 523

XML PARSE examples

The examples that are referenced below illustrate various uses of the XML PARSE statement.

Use these examples to understand the basic use of XML PARSE and for XMLPARSE(XMLSS), specialized uses such as parsing documents that include namespaces, parsing documents one segment at a time, and parsing documents with validation against a schema.

"Example: parsing a simple document" on page 527
"Example: program for processing XML" on page 528
"Example: parsing an XML document that uses namespaces" on page 532
"Example: parsing an XML document one segment at a time" on page 536
"Example: parsing XML documents with validation" on page 538

Example: parsing a simple document

This example shows the flow of events and the contents of special register XML-TEXT that result from the parsing of a simple XML document.

Assume that the COBOL program contains the following XML document in data item Doc:

```
<?xml version="1.0"?><msg type="short">Hello, World!</msg>
```
The following code fragment shows an XML PARSE statement for parsing Doc, and a processing procedure, P, for handling the XML events:

```
XML Parse Doc
Processing procedure P
P. Display XML-Event XML-Text.
```

The processing procedure displays the content of XML-EVENT and XML-TEXT for each event that the parser signals during parsing. The following table shows the events and the text.

<table>
<thead>
<tr>
<th>XML-EVENT</th>
<th>XML-TEXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>START-OF-DOCUMENT</td>
<td></td>
</tr>
<tr>
<td>VERSION-INFORMATION</td>
<td>1.0</td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>msg</td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>type</td>
</tr>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>short</td>
</tr>
<tr>
<td>CONTENT-CHARACTERS</td>
<td>Hello, World!</td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>msg</td>
</tr>
<tr>
<td>END-OF-DOCUMENT</td>
<td></td>
</tr>
</tbody>
</table>

related concepts
“XML events” on page 507
“XML-TEXT and XML-NTEXT” on page 510

Example: program for processing XML

This example shows the parsing of an XML document, and a processing procedure that reports the various XML events and their associated text fragments.

The XML document is shown in the program source to make it easier to follow the flow of the parsing. The output of the program with XMLPARSE(XMLSS) and with XMLPARSE(COMPAT) in effect is shown after the example.

To understand the interaction of the parser and the processing procedure, and to match events to document fragments, compare the XML document to the output of the program.

```
Process codepage(1047)
Identification division.
  Program-id. XMLSAMPL.
  Data division.
    Working-storage section.
      XML document data, encoded as initial values of data items.*
      1 xml-document-data.
        2 pic x(39) value '<?xml version="1.0" encoding="IBM-1047"'>.'.
        2 pic x(19) value ' standalone="yes"'>.'.
        2 pic x(39) value '<--This document is just an example-->'.'.
        2 pic x(10) value '<sandwich>'.'.
        2 pic x(33) value '<bread type="baker\'s best"/>'.'.
        2 pic x(36) value '<?spread We\'ll use real mayonnaise?/>'.'.
        2 pic x(29) value '<meat>Ham & turkey</meat>'.'.
        2 pic x(34) value '<filling>Cheese, lettuce, tomato, '</.
        2 pic x(32) value 'and that\'s all, Folks!</filling>'.'.
        2 pic x(25) value '<![CDATA[We should add a ']'.
        2 pic x(28) value '<relish> element!!]]>'.'.
        2 pic x(28) value '<listprice>$4.99</listprice>'.'.
        2 pic x(25) value '<discount>0.10</discount>'.'.
        2 pic x(31) value '</sandwich>'.'.
```
XML document, represented as fixed-length records.

Sample data definitions for processing numeric XML content.

```
1 xml-document redefines xml-document-data.
  2 xml-segment pic x(40) occurs 10 times.
  1 xml-segment-no comp pic s9(4).
  1 content-buffer pic x(100).
  1 current-element-stack.
  2 current-element pic x(30) occurs 10 times.

Procedure division.
Mainline section.
  Move 1 to xml-segment-no
  Display 'Initial segment {' xml-segment(xml-segment-no) '}'
  XML parse xml-segment(xml-segment-no)
  processing procedure XML-handler
On exception
  Display 'XML processing error, XML-Code=' XML-Code '.
  Move 16 to return-code
  Goback
Not on exception
  Display 'XML document successfully parsed.'
End-XML

Process the transformed content and calculate promo price.

```
Chapter 30. Processing XML input 529
subtract 1 from tally
move content-buffer(1:tally) to filling
Display ' Element "filling" data (' tally ' bytes) is now complete:'
Display ' {' filling(1:tally) '}
End-evaluate
When 'listprice'
* ==> Using function NUMVAL-C...
  Move XML-Text to content-buffer
  Compute list-price = function numval-c(content-buffer)
When 'discount'
* ==> Using de-editing of a numeric edited item...
  Move XML-Text to off-ed
  Move off-ed-1 to discount
End-evaluate
When 'END-OF-ELEMENT'
  Display 'End element tag: {' XML-Text '}'
  Subtract 1 from element-depth
When 'END-OF-INPUT'
  Display 'End of input'
  Add 1 to xml-segment-no
  Display ' Next segment: {' xml-segment(xml-segment-no) '}
  Display ' '  Move 1 to xml-code
When 'START-OF-DOCUMENT'
  Display 'Start of document'
  Move 0 to element-depth
  Move 1 to tally
When 'END-OF-DOCUMENT'
  Display 'End of document.'
When 'VERSION-INFORMATION'
  Display 'Version: {' XML-Text '}'
When 'ENCODING-DECLARATION'
  Display 'Encoding: {' XML-Text '}'
When 'STANDALONE-DECLARATION'
  Display 'Standalone: {' XML-Text '}'
When 'ATTRIBUTE-NAME'
  Display 'Attribute name: {' XML-Text '}'
When 'ATTRIBUTE-CHARACTERS'
  Display 'Attribute value characters: {' XML-Text '}'
When 'ATTRIBUTE-CHARACTER'
  Display 'Attribute value character: {' XML-Text '}'
When 'START-OF-CDATA-SECTION'
  Display 'Start of CData section'
When 'END-OF-CDATA-SECTION'
  Display 'End of CData section'
When 'CONTENT-CHARACTER'
  Display 'Content character: {' XML-Text '}'
When 'PROCESSING-INSTRUCTION-TARGET'
  Display 'PI target: {' XML-Text '}'
When 'PROCESSING-INSTRUCTION-DATA'
  Display 'PI data: {' XML-Text '}'
When 'COMMENT'
  Display 'Comment: {' XML-Text '}'
When 'EXCEPTION'
  Compute tally = function length (XML-Text)
  Display 'Exception ' XML-Code ' at offset ' tally '.'
When other
  Display 'Unexpected XML event: ' XML-Event '.'
End-evaluate
End program XMSAMP.

Output from parsing with XMLPARSE (XMLSS)

From the following output you can see which fragments of the document were associated with the events that occurred during parsing:

Initial segment {<?xml version="1.0" encoding="ibm-1047" }  
Start of document  
End of input  
  Next segment: {standalone="yes"?><!--This document is j}  
Version: {1.0}  
Encoding: {ibm-1047}  
Standalone: {yes}
Comment: {This document is just an example---><sandwich><bread type="baker's best"/><?spread We'll use real mayonnaise?><meat>Ham & turkey</>}

Start element tag: {sandwich}
End of input

Start element tag: {bread}
Attribute name: {type}
Attribute value characters: {baker's best}
End element tag: {bread}
PI target: {spread}
PI data: {We'll use real mayonnaise}\<meat>Ham & turkey</>

Start element tag: {bread}
Attribute name: {type}
Attribute value characters: {baker's best}
End element tag: {bread}
PI target: {spread}
PI data: {We'll use real mayonnaise}
Content characters: {Ham & turkey}
End of input

Start element tag: {meat}
Content characters: {Ham & turkey}
End element tag: {meat}
Content characters: {Ham & turkey}
End of input

Start element tag: {filling}
Content characters: {Cheese, lettuce, tomato, a}
End element tag: {filling}
End of input

Start element tag: {meat}
Content characters: {Ham & turkey}
End element tag: {meat}
Content characters: {Ham & turkey}
End of input

Start element tag: {filling}
Content characters: {Cheese, lettuce, tomato, a}
End element tag: {filling}
End of input

Start element tag: {meat}
Content characters: {Ham & turkey}
End element tag: {meat}
Content characters: {Ham & turkey}
End of input

End element tag: {filling}
End element tag: {meat}
End element tag: {bread}
End element tag: {sandwich}
End of document.

Output from parsing with XMLPARSE(COMPAT)

From the following output you can see which fragments of the document were associated with the events that occurred during parsing:

Start of document
Version: {1.0}
Encoding: {IBM-1047}
Standalone: {yes}
Comment: {This document is just an example}
Start element tag: {sandwich}
Content characters: { }
Start element tag: {bread}
related concepts
“XML events” on page 507

related tasks
“Handling splits using the XML-INFORMATION special register” on page 517

related references
“XMLPARSE” on page 349 (compiler option)
XML-EVENT (Enterprise COBOL for z/OS Language Reference)

Example: parsing an XML document that uses namespaces

This example shows the parsing of a document that uses namespaces and namespace prefixes. The program must be compiled using the XMLPARSE(XMLSS) compiler option.

Namespace identifiers and namespace prefixes are used in the program to qualify element names and attribute names. This qualification makes it possible to use the same name in more than one context: title is used both as an author’s title (Mr) and as a book title (Writing COBOL for Fun and Profit).

Sample XML document

The following XML document contains several namespace declarations: a default namespace; then three namespace identifiers with prefixes (bk, pi, and isbn). Notice that the default namespace is set to the empty string for the element comment (xmlns=’’). This setting "undeclares" the default namespace, with the result that there is no default namespace.
Results from parsing

The following table shows the sequence of events that the processing procedure receives from the parser, and shows the content of the associated XML special registers.

Table 72. XML events and special registers

<table>
<thead>
<tr>
<th>XML-EVENT</th>
<th>XML-TEXT</th>
<th>XML-NAMESPACE-PREFIX</th>
<th>XML-NAMESPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>START-OF-DOCUMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>section</td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>NAMESPACE-DECLARATION</td>
<td></td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>NAMESPACE-DECLARATION</td>
<td></td>
<td>bk</td>
<td>urn:loc.gov:books</td>
</tr>
<tr>
<td>NAMESPACE-DECLARATION</td>
<td>title</td>
<td>pi</td>
<td>urn:personalInformation</td>
</tr>
<tr>
<td>NAMESPACE-DECLARATION</td>
<td>isbn</td>
<td></td>
<td>urn:ISBN:0-395-36341-6</td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>title</td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>CONTENT-CHARACTERS</td>
<td>Book-Signing Event</td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>title</td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>signing</td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>author</td>
<td>bk</td>
<td>urn:loc.gov:books</td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>title</td>
<td>pi</td>
<td>urn:personalInformation</td>
</tr>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>Mr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>name</td>
<td>pi</td>
<td>urn:personalInformation</td>
</tr>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>Jim Ross</td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>author</td>
<td>bk</td>
<td>urn:loc.gov:books</td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>title</td>
<td>bk</td>
<td>urn:loc.gov:books</td>
</tr>
</tbody>
</table>
### XML PARSE example with an undeclared namespace prefix

The following XML document contains undeclared namespace prefixes:

```cobol
Identification division.
  Program-id. XMLup.
  Data division.
    Working-storage section.
      1 d.
      2 pic x(40) value '<pfx0:root xmlns:pfx1="http://whatever">'.
      2 pic x(19) value '<pfx1:localElName1>'.
      2 pic x(20) value '<pfx2:localElName2/>'.
      2 pic x(40) value '<pfx3:localElName3 pfx4:localAtName4="">'.
      2 pic x(02) value 'c1'.
      2 pic x(41) value '<pfx5:localElName5 pfx6:localAtName6="/">'.
      2 pic x(24) value 'c2<pfx3:localElName3>c3'.
      2 pic x(32) value '</pfx1:localElName1></pfx0:root>'.
Procedure division.
  main.
    display 'XML document:  ' d
    display ' ' xml parse d processing procedure h goback.
    h.
      if xml-event = 'EXCEPTION'
        display ' '.
      end-if
      display xml-event xml-code '|' xml-text '|' xml-namespace-prefix '|' xml-namespace
      if xml-event = 'EXCEPTION' and xml-code = 264192 or 264193
        move 0 to xml-code
      end-if
    '.
  End program XMLup.
```

---

**Table 72. XML events and special registers (continued)**

<table>
<thead>
<tr>
<th>XML-EVENT</th>
<th>XML-TEXT</th>
<th>XML-NAMESPACE-PREFIX</th>
<th>XML-NAMESPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>Writing COBOL for Fun and Profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>number</td>
<td>isbn</td>
<td>urn:ISBN:0-395-36341-6</td>
</tr>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>0426070806</td>
<td></td>
<td></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>comment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAMESPACE-DECLARATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTENT-CHARACTERS</td>
<td>What a great issue!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>comment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>signing</td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>section</td>
<td></td>
<td><a href="http://www.ibm.com/events">http://www.ibm.com/events</a></td>
</tr>
<tr>
<td>END-OF-DOCUMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results from parsing XML document with an undeclared namespace prefix

The following table lists the sequence of events that the processing procedure receives from the parser, and shows the content of the associated XML special registers.

<table>
<thead>
<tr>
<th>XML-EVENT</th>
<th>XML-CODE</th>
<th>XML-TEXT</th>
<th>XML-NAMESPACE-PREFIX</th>
<th>XML-NAMESPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>START-OF-DOCUMENT</td>
<td>000000000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>000264193</td>
<td>pfx0:root</td>
<td></td>
<td></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>000000000</td>
<td>root</td>
<td>pfx0</td>
<td></td>
</tr>
<tr>
<td>NAMESPACE-DECLARATION</td>
<td>000000000</td>
<td></td>
<td>pfx1</td>
<td><a href="http://whatever">http://whatever</a></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName1</td>
<td>pfx1</td>
<td><a href="http://whatever">http://whatever</a></td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>000264193</td>
<td>pfx2:localElName2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName2</td>
<td>pfx2</td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName2</td>
<td>pfx2</td>
<td></td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>000264193</td>
<td>pfx3:localElName3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName3</td>
<td>pfx3</td>
<td></td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>000264192</td>
<td>pfx4:localAtName4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>000000000</td>
<td>localAtName4</td>
<td>pfx4</td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>000000000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTENT-CHARACTERS</td>
<td>000000000</td>
<td>c1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>000264193</td>
<td>pfx5:localElName5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>START-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName5</td>
<td>pfx5</td>
<td></td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>000264192</td>
<td>pfx6:localAtName6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTE-NAME</td>
<td>000000000</td>
<td>localAtName6</td>
<td>pfx6</td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTE-CHARACTERS</td>
<td>000000000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName5</td>
<td>pfx5</td>
<td></td>
</tr>
<tr>
<td>CONTENT-CHARACTERS</td>
<td>000000000</td>
<td>c2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>000000000</td>
<td>localElName3</td>
<td>pfx3</td>
<td></td>
</tr>
<tr>
<td>CONTENT-CHARACTERS</td>
<td>000000000</td>
<td>c3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 73. **XML events and special registers from parsing XML document with an undeclared namespace prefix** (continued)

<table>
<thead>
<tr>
<th>XML-EVENT</th>
<th>XML-CODE</th>
<th>XML-TEXT</th>
<th>XML-NAMESPACE-PREFIX</th>
<th>XML-NAMESPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>END-OF-ELEMENT</td>
<td>0000000000</td>
<td>localElName1</td>
<td>pfx1</td>
<td><a href="http://whatever">http://whatever</a></td>
</tr>
<tr>
<td>END-OF-ELEMENT</td>
<td>0000000000</td>
<td>root</td>
<td>pfx0</td>
<td></td>
</tr>
<tr>
<td>END-OF-DOCUMENT</td>
<td>0000000000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For a detailed description of the set of XML events, see the related reference about XML-EVENT.

**related concepts**
- “XML events” on page 507
- “XML-TEXT and XML-NTEXT” on page 510
- “XML-NAMESPACE and XML-NNAMESPACE” on page 511
- “XML-NAMESPACE-PREFIX and XML-NNAMESPACE-PREFIX” on page 511

**related references**
- “XMLPARSE” on page 349 (compiler option)
- XML-EVENT (*Enterprise COBOL for z/OS Language Reference*)

**Example: parsing an XML document one segment at a time**

This example shows the parsing of a document one segment at a time. The program must be compiled using the XMLPARSE (XMLSS) compiler option.

The example shows the XML content of a file, the program that reads and submits XML text to the parser, and the sequence of events that results from parsing the input records.

**Content of infile**

The XML document that will be parsed a segment at a time is contained in file infile, shown below.

```xml
<?xml version='1.0'?><Tagline>COBOL is the language of the future!</Tagline>
```

**Program PARSESEG**

Program PARSESEG reads a segment (a record) of the XML document from file infile, then passes the record to the parser using the XML PARSE statement. The parser processes the XML text and transfers control to the processing procedure for each XML event. The processing procedure handles each event and returns to the parser.

At the end of the segment, the parser sets XML-EVENT to END-OF-INPUT, sets XML-CODE to zero, and transfers control to the processing procedure. The processing procedure reads the next XML record into the parse data item, sets XML-CODE to one, and returns to the parser.

The exchange between the processing procedure and the parser continues until the READ statement returns the end-of-file status code. The processing procedure returns to the parser with XML-CODE still set to zero to indicate the end of segment processing.
File status is Input-XML-status.
Data division.
File section.
FD Input-XML
  Record is varying from 1 to 255 depending on Rec-length
  Recording mode V.
  1 fdrec.
  2 pic X occurs 1 to 255 depending on Rec-length.
Working-storage section.
  1 Event-number comp pic 99.
  1 Rec-length comp-5 pic 9(4).
  1 Input-XML-status pic 99.
Procedure division.
  Open input Input-XML
  If Input-XML-status not = 0
    Display 'Open failed, file status: ' Input-XML-status
    Goback
  End-if
  Read Input-XML
  If Input-XML-status not = 0
    Display 'Read failed, file status: ' Input-XML-status
    Goback
  End-if
  Move 0 to Event-number
  Display 'Starting with: ' fdrec
  Display 'Event number and name    Content of XML-text'
  XML parse fdrec processing procedure Handle-parse-events
  Close Input-XML
  Goback

Handle-parse-events.
  Add 1 to Event-number
  Display 'Event-number ': Event-number ': ' XML-event '{' XML-text '}'
  Evaluate XML-event
    When 'END-OF-INPUT'
      Read Input-XML
      Evaluate Input-XML-status
      When 0
        Move 1 to XML-code
        Display 'Continuing with: ' fdrec
        When 10
          Display 'At EOF; no more input.'
        End-when
      End-when
      Display 'Read failed, file status: ' Input-XML-status
      Goback
    End-when
    When other
      Display 'Read failed, file status: ' Input-XML-status
      Goback
    End-when
    Continue
End-evaluate
End program PARSESEG.

Results from parsing

To show parsing results, the processing procedure displayed each record of input, followed by the sequence of XML events and any associated text fragments in XML-TEXT. The content of XML-TEXT is displayed in braces ({}); empty braces signify that XML-TEXT is empty.

Notice the extra zero-length CONTENT-CHARACTERS XML event at event number 08. (Such anomalies are typical when supplying XML text piecemeal.)

Starting with:  <?xml version='1.0'?>
  Event number and name    Content of XML-TEXT
  01: START-OF-DOCUMENT    {}
  02: VERSION-INFORMATION  {1.0}
  03: END-OF-INPUT         {}
Continuing with:  <Tagline>
  04: START-OF-ELEMENT     {Tagline}
  05: END-OF-INPUT         {}
Continuing with:  COBOL is the language of the future!
  06: CONTENT-CHARACTERS   {COBOL is the language of the future!}
  07: END-OF-INPUT         {}
Continuing with:  </Tagline>
  08: CONTENT-CHARACTERS   {}
  09: END-OF-ELEMENT       {Tagline}
  10: END-OF-DOCUMENT      {"}
Example: parsing XML documents with validation

This example shows the parsing of several XML documents with validation against a schema, and a processing procedure that captures the return code and reason code that the parser generates after parsing each document. All of the XML documents are well formed but not necessarily valid.

The program must be compiled using the XMLPARSE (XMLSS) compiler option.

The example uses the schema that was described in the related concept about XML schemas.

Assume that file item.xsd contains the schema in text format, and that the preprocessed schema was generated in file item.osr by means of the following z/OS UNIX command:

```
xdosrg -v -o /u/HLQ/xml/item.osr /u/HLQ/xml/item.xsd
```

The example uses the XML-SCHEMA clause to associate the XML schema name schema with the ddname ddschema. The following DD statement associates the ddname with the external z/OS UNIX file that contains the schema:

```
//GO.DDSCHEMA DD PATH='/u/HLQ/xml/item.osr'
```

Program ValidCk

```
Identification division.
  Program-id. ValidCk.
Environment division.
  Configuration section.
    Special-names.
      xml-schema schema is 'ddschema'.
Data division.
  Working-storage section.
    1 xml-decode.
    2 rtn comp pic 9(2).
    2 rsn comp-5 pic 9(4).
    1 hv pic x(16) value '0123456789ABCDEF'.
    1 T pic 999 COMP.
    1 xml-document-1.
      2 pic x(52) value '<!--Valid: the "itemName" element can be omitted-->'.
      2 pic x(31) value '<stockItem itemNumber="123-AB">'.
      2 pic x(36) value '  <quantityOnHand>1</quantityOnHand>'.
      2 pic x(12) value '</stockItem>'.
    1 xml-document-2.
      2 pic x(44) value '<!--Invalid: missing attribute itemNumber-->'.
      2 pic x(11) value '<stockItem>.
      2 pic x(30) value '  <itemName>No name</itemName>'.
      2 pic x(36) value '  <quantityOnHand>1</quantityOnHand>'.
      2 pic x(12) value '</stockItem>'.
    1 xml-document-3.
      2 pic x(47) value '<!--Invalid: unexpected attribute warehouse-->'.
      2 pic x(46) value '  <stockItem itemNumber="074-UN" warehouse="NJ">'.
      2 pic x(37) value '  <quantityOnHand>10</quantityOnHand>'.
      2 pic x(32) value '  <itemName>Not here!</itemName>'.
      2 pic x(12) value '</stockItem>'.
    1 xml-document-4.
      2 pic x(46) value '<!--Invalid: illegal attribute value 123-Ab-->'.
      2 pic x(31) value '<stockItem itemNumber="123-Ab">'.
      2 pic x(33) value '  <itemName>Paintbrush</itemName>'.
      2 pic x(37) value '  <quantityOnHand>10</quantityOnHand>'.
```
Output from program ValidCk

In the following output, you can see which XML documents in the source program failed validation against the schema.

For those documents that were not valid, the parser signaled an XML exception and passed control to the processing procedure with special register XML-EVENT containing ‘EXCEPTION’ and special-register XML-CODE containing the return code and a specific reason code.

Valid: the "itemName" element can be omitted
Document successfully parsed.

Invalid: missing attribute itemNumber
RC=24, reason=x’8613’

Invalid: unexpected attribute warehouse
RC=24, reason=x’8612’
Invalid: illegal attribute value 123-Ab
RC=24, reason=x'8809'

Invalid: missing element quantityOnHand
RC=24, reason=x'8611'

Invalid: unexpected element comment
RC=24, reason=x'8607'

Invalid: out-of-range element value 100
RC=24, reason=x'8803'

related concepts
“XML-CODE” on page 508
“XML schemas” on page 514

related tasks
“Parsing XML documents with validation” on page 512
“Handling XML PARSE exceptions” on page 523

related references
“XML PARSE exceptions with XMLPARSE(XMLSS) in effect” on page 665
Chapter 31. Producing XML output

You can produce XML output from a COBOL program by using the XML GENERATE statement. In the XML GENERATE statement, you identify the source and the output data items. You can optionally also identify:

- A field to receive a count of the XML characters generated
- A code page in which the generated XML document is to be encoded
- A namespace for the generated document
- A namespace prefix to qualify the start and end tag of each element, if you specify a namespace
- A user-defined element or attribute name in the generated XML document
- Attributes or elements to be suppressed according to some specified conditions
- Particular items to be specified as attributes, elements or content in the generated XML output.
- A statement to receive control if an exception occurs

Optionally, you can generate an XML declaration for the document, and can cause eligible source data items to be expressed as attributes in the output rather than as elements.

You can use the XML-CODE special register to determine the status of XML generation.

After you transform COBOL data items to XML, you can use the resulting XML output in various ways, such as deploying it in a web service, passing it as a message to WebSphere MQ, or transmitting it for subsequent conversion to a CICS communication area.

**Link-edit considerations:** COBOL programs that contain the XML GENERATE statement must be link-edited with AMODE 31.

**related tasks**
- “Generating XML output” on page 541
- “Controlling the encoding of generated XML output” on page 546
- “Handling XML GENERATE exceptions” on page 546
- “Enhancing XML output” on page 551

**related references**
- Extensible Markup Language (XML)
- XML GENERATE statement (Enterprise COBOL for z/OS Language Reference)

**Generating XML output**

To transform COBOL data to XML, use the XML GENERATE statement as in the example below.

```cobol
XML GENERATE XML-OUTPUT FROM SOURCE-REC
    COUNT IN XML-CHAR-COUNT
ON EXCEPTION
    DISPLAY 'XML generation error' XML-CODE
    STOP RUN
NOT ON EXCEPTION
    DISPLAY 'XML document was successfully generated.'
END-XML
```

In the XML GENERATE statement, you first identify the data item (XML-OUTPUT in the example above) that is to receive the XML output. Define the data item to be large enough to contain the generated XML output, typically five to 10 times the size of the COBOL source data depending on the length of its data-name or data-names.
In the DATA DIVISION, you can define the receiving identifier as alphanumeric (either an alphanumeric group item or an elementary item of category alphanumeric) or as national (either a national group item or an elementary item of category national).

Next you identify the source data item that is to be transformed to XML format (SOURCE-REC in the example). The source data item can be an alphanumeric group item, national group item, or elementary data item of class alphanumeric or national.

Some COBOL data items are not transformed to XML, but are ignored. Subordinate data items of an alphanumeric group item or national group item that you transform to XML are ignored if they:

- Specify the REDEFINES clause, or are subordinate to such a redefining item
- Specify the RENAMES clause

These items in the source data item are also ignored when you generate XML:

- Elementary FILLER (or unnamed) data items
- Slack bytes inserted for SYNCHRONIZED data items

No extra white space (for example, new lines or indentation) is inserted to make the generated XML more readable.

Optionally, you can code the COUNT IN phrase to obtain the number of XML character encoding units that are filled during generation of the XML output. If the receiving identifier has category national, the count is in UTF-16 character encoding units. For all other encodings (including UTF-8), the count is in bytes.

You can use the count field as a reference modification length to obtain only that portion of the receiving data item that contains the generated XML output. For example, XML-OUTPUT(1:XML-CHAR-COUNT) references the first XML-CHAR-COUNT character positions of XML-OUTPUT.

Consider the following program excerpt:

```
01 doc pic x(512).
01 docSize pic 9(9) binary.
01 G.
   05 A pic x(3) value "aaa".
   05 B.
      10 C pic x(3) value "ccc".
      10 D pic x(3) value "ddd".
   05 E pic x(3) value "eee".
```

The code above generates the following XML document, in which A, B, and E are expressed as child elements of element G, and C and D become child elements of element B:

```
<G><A>aaa</A><B><C>ccc</C><D>ddd</D></B><E>eee</E></G>
```

Alternatively, you can specify the ATTRIBUTES phrase of the XML GENERATE statement. The ATTRIBUTES phrase causes every eligible data item included in the generated XML document to be expressed as an attribute of the containing XML element, rather than as a child element of the containing XML element. To be eligible, the data item must be elementary, must have a name other than FILLER, and must not have an OCCURS clause in its data description entry. The containing XML element corresponds to the group data item that is immediately superordinate to the elementary data item.

Optionally, you can specify more precise control of which data items should be expressed as attributes or elements by using the TYPE OF phrase.

For example, suppose that the XML GENERATE statement in the program excerpt above had instead been coded as follows:

```
XML Generate Doc from G with attributes
```

Alternatively, you can specify the ATTRIBUTES phrase of the XML GENERATE statement. The ATTRIBUTES phrase causes every eligible data item included in the generated XML document to be expressed as an attribute of the containing XML element, rather than as a child element of the containing XML element. To be eligible, the data item must be elementary, must have a name other than FILLER, and must not have an OCCURS clause in its data description entry. The containing XML element corresponds to the group data item that is immediately superordinate to the elementary data item. Optionally, you can specify more precise control of which data items should be expressed as attributes or elements by using the TYPE OF phrase.

For example, suppose that the XML GENERATE statement in the program excerpt above had instead been coded as follows:

```
XML Generate Doc from G with attributes
```
The code would then generate the following XML document, in which A and E are expressed as attributes of element G, and C and D become attributes of element B:

```xml
<G A="aaa" E="eee"><B C="ccc" D="ddd"></B></G>
```

Optionally, you can code the ENCODING phrase of the XML GENERATE statement to specify the CCSID of the generated XML document. If you do not use the ENCODING phrase, the document encoding is determined by the category of the receiving data item and by the CODEPAGE compiler option. For further details, see the related task below about controlling the encoding of generated XML output.

Optionally, you can code the XML-DECLARATION phrase to cause the generated XML document to have an XML declaration that includes version information and an encoding declaration. If the receiving data item is of category:

- National: The encoding declaration has the value UTF-16 (encoding="UTF-16").
- Alphanumeric: The encoding declaration is derived from the ENCODING phrase, if specified, or from the CODEPAGE compiler option in effect for the program if the ENCODING phrase is not specified.

For example, the program excerpt below specifies the XML-DECLARATION phrase of XML GENERATE, and specifies encoding with CCSID 1208 (UTF-8):

```sql
01  Greeting.
   05  msg  pic x(80)  value 'Hello, world!'.
   XML Generate Doc from Greeting
   with Encoding 1208
   with XML-declaration
   End-XML
```

The code above generates the following XML document:

```xml
<?xml version="1.0" encoding="UTF-8"?><Greeting><msg>Hello, world!</msg></Greeting>
```

If you do not code the XML-DECLARATION phrase, an XML declaration is not generated.

Optionally, you can code the NAMESPACE phrase to specify a namespace for the generated XML document. The namespace value must be a valid Uniform Resource Identifier (URI), for example, a URL (Uniform Resource Locator); for further details, see the related concept about URI syntax below.

Specify the namespace in an identifier or literal of either category national or alphanumeric.

If you specify a namespace, but do not specify a namespace prefix (described below), the namespace becomes the default namespace for the document. That is, the namespace define on the root element applies by default to each element name in the document, including the root element.

For example, consider the following data definitions and XML GENERATE statement:

```sql
01  Greeting.
   05  msg  pic x(80)  value 'Hello, world!'.
   01  NS   pic x(20)   value 'http://example'.
   XML Generate Doc from Greeting
   namespace is NS
```

The resulting XML document has a default namespace (http://example), as follows:

```xml
<Greeting xmlns="http://example"><msg>Hello, world!</msg></Greeting>
```

If you do not specify a namespace, the element names in the generated XML document are not in any namespace.

Optionally, you can code the NAMESPACE-PREFIX phrase to specify a prefix to be applied to the start and end tag of each element in the generated document. You can specify a prefix only if you have specified a namespace as described above.
When the XML GENERATE statement is executed, the prefix value must be a valid XML name, but without the colon (:); see the related reference below about namespaces for details. The value can have trailing spaces, which are removed before the prefix is used.

Specify the namespace prefix in an identifier or literal of either category national or alphanumeric.

It is recommended that the prefix be short, because it qualifies the start and end tag of each element.

For example, consider the following data definitions and XML GENERATE statement:

```cobol
01 Greeting.
   05 msg pic x(80) value 'Hello, world!'.
01 NS pic x(20) value 'http://example'.
01 NP pic x(5) value 'pre'.
   ...  
XML Generate Doc from Greeting
namespace is NS
namespace-prefix is NP
```

The resulting XML document has an explicit namespace (http://example), and the prefix pre is applied to the start and end tag of the elements Greeting and msg, as follows:

```xml
<pre:Greeting xmlns:pre="http://example"><pre:msg>Hello, world!</pre:msg></pre:Greeting>
```

Optionally, you can code the NAME phrase to specify attribute and element names in the generated XML document. The attribute and element names must be alphanumeric or national literals and must be legal names according to the XML 1.0 standard.

For example, consider the following data structure and XML GENERATE statement:

```cobol
01 Msg.
   02 Msg-Severity pic 9 value 1.
   02 Msg-Date pic 9999/99/99 value "2012/04/12".
   02 Msg-Text pic X(50) value "Sell everything!".
01 Doc pic X(500).
XML Generate Doc from Msg
With attributes
   Name of Msg is "Message"
   Msg-Severity is "Severity"
   Msg-Date is "Date"
   Msg-Text is "Text"
End-XML
```

The resulting XML document is as follows:

```xml
<Message Severity="1" Date="2012/04/12" Text="Sell everything!"></Message>
```

Optionally, you can code the SUPPRESS phrase to specify whether individual data items are generated based on whether or not they meet certain criteria.

For example, consider the following data structure and XML GENERATE statement to suppress spaces and zeros:

```cobol
01 G.
   02 SensitiveInfo.
      03 SSN pic x(11) value '123-45-6789'.
      03 HomeAddress pic x(50) value '123 Main St, Anytown, USA'.
   02 Aarray value spaces.
      03 A pic AAA occurs 5.
   02 Barray value spaces.
      03 B pic XXX occurs 5.
   02 Carray value zeros.
      03 C pic 999 occurs 5.
   Move 'abc' to A(1)
   Move 123 to C(3)
XML Generate Doc from G
Suppress SensitiveInfo
   every nonnumeric element when space
```

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The resulting XML document is as follows:

```xml
<G>
  <Aarray><A>abc</A></Aarray>
  <Carray><C>123</C></Carray>
</G>
```

Optionally, you can use the TYPE OF phrase to specify whether individual data items are expressed as attributes, elements or content.

For example, consider the following data structure and XML GENERATE statement:

```coบอล
01 Msg.
  02 Msg-Severity pic 9 value 1.
  02 Msg-Date pic 9999/99/99 value "2012/04/12".
  02 Msg-Text pic X(50) value "Sell everything!".
  01 Doc pic X(500).
  XML Generate Doc from Msg
    With attributes
    Type of Msg-Severity is attribute
    Msg-Date     is attribute
    Msg-Text     is element
End-XML
```

The resulting XML document is as follows:

```xml
<Msg Msg-Severity="1" Msg-Date="2012/04/12">
  <Msg-Text>Sell everything!</Msg-Text></Msg>
```

In addition, you can specify either or both of the following phrases to receive control after generation of the XML document:

- ON EXCEPTION, to receive control if an error occurs during XML generation
- NOT ON EXCEPTION, to receive control if no error occurs

You can end the XML GENERATE statement with the explicit scope terminator END-XML. Code END-XML to nest an XML GENERATE statement that has the ON EXCEPTION or NOT ON EXCEPTION phrase in a conditional statement.

XML generation continues until either the COBOL source record has been transformed to XML or an error occurs. If an error occurs, the results are as follows:

- The XML-CODE special register contains a nonzero exception code.
- Control is passed to the ON EXCEPTION phrase, if specified, otherwise to the end of the XML GENERATE statement.

If no error occurs during XML generation, the XML-CODE special register contains zero, and control is passed to the NOT ON EXCEPTION phrase if specified or to the end of the XML GENERATE statement otherwise.

“Example: generating XML” on page 547

**related concepts**

*Uniform Resource Identifier (URI): Generic Syntax*

**related tasks**

- “Controlling the encoding of generated XML output” on page 546
- “Handling XML GENERATE exceptions” on page 546
- “Processing UTF-8 data” on page 134

**related references**

XML GENERATE statement (Enterprise COBOL for z/OS Language Reference)
Controlling the encoding of generated XML output

When you generate XML output by using the XML GENERATE statement, you can control the encoding of the output by the category of the data item that receives the output, and by identifying the code page using the WITH ENCODING phrase of the XML GENERATE statement.

If you specify the WITH ENCODING codepage phrase to designate the coded character set identifier (CCSID) of the output document, codepage must specify an unsigned integer data item or unsigned integer literal that identifies one of the code pages supported for COBOL XML processing as described in the related reference below about the encoding of XML documents:

• If the data item that receives the generated XML is of category national, the WITH ENCODING phrase must specify 1200, the CCSID for Unicode UTF-16.
• If the receiving identifier is of category alphanumeric, the WITH ENCODING phrase must specify CCSID 1208 or the CCSID of a supported EBCDIC code page.

If you do not code the WITH ENCODING phrase, the generated XML output is encoded as shown in the table below.

<table>
<thead>
<tr>
<th>If you define the receiving XML identifier as:</th>
<th>The generated XML output is encoded in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphanumeric</td>
<td>The code page specified by the CODEPAGE compiler option in effect when the source was compiled</td>
</tr>
<tr>
<td>National</td>
<td>UTF-16 big-endian (UTF-16BE, CCSID 1200)</td>
</tr>
</tbody>
</table>

A byte order mark is not generated.

For details about how data items are converted to XML and how the XML element names and attributes names are formed from the COBOL data-names, see the related reference below about the operation of the XML GENERATE statement.

related references
“CODEPAGE” on page 295
“The encoding of XML documents” on page 518
XML GENERATE statement (Enterprise COBOL for z/OS Language Reference)
Operation of XML GENERATE (Enterprise COBOL for z/OS Language Reference)

Handling XML GENERATE exceptions

When an error is detected during generation of XML output, an exception condition exists. You can write code to check the XML-CODE special register, which contains a numeric exception code that indicates the error type.

To handle errors, use either or both of the following phrases of the XML GENERATE statement:

• ON EXCEPTION
• COUNT IN

If you code the ON EXCEPTION phrase in the XML GENERATE statement, control is transferred to the imperative statement that you specify. You might code an imperative statement, for example, to display the XML-CODE value. If you do not code an ON EXCEPTION phrase, control is transferred to the end of the XML GENERATE statement.
When an error occurs, one problem might be that the data item that receives the XML output is not large enough. In that case, the XML output is not complete, and the XML-CODE special register contains error code 400.

You can examine the generated XML output by doing these steps:

1. Code the COUNT IN phrase in the XML GENERATE statement.

   The count field that you specify holds a count of the XML character encoding units that are filled during XML generation. If you define the XML output as national, the count is in UTF-16 character encoding units; for all other encodings (including for UTF-8), the count is in bytes.

2. Use the count field as a reference modification length to refer to the substring of the receiving data item that contains the XML characters that were generated until the point when the error occurred.

   For example, if XML-OUTPUT is the data item that receives the XML output, and XML-CHAR-COUNT is the count field, then XML-OUTPUT(1:XML-CHAR-COUNT) references the XML output.

Use the contents of XML-CODE to determine what corrective action to take. For a list of the exceptions that can occur during XML generation, see the related reference below.

related tasks
“Referring to substrings of data items” on page 107

related references
“XML GENERATE exceptions” on page 673
XML-CODE (Enterprise COBOL for z/OS Language Reference)

Example: generating XML

The following example simulates the building of a purchase order in a group data item, and generates an XML version of that purchase order.

Program XGFX uses XML GENERATE to produce XML output in elementary data item xmlPO from the source record, group data item purchaseOrder. Elementary data items in the source record are converted to character format as necessary, and the characters are inserted as the values of XML attributes whose names are derived from the data-names in the source record.

XGFX calls program Pretty, which uses the XML PARSE statement with processing procedure p to format the XML output with new lines and indentation so that the XML content can more easily be verified.

Program XGFX

Identification division.
  Program-id. XGFX.
  Data division.
  Working-storage section.
    01 numItems pic 99 global.
    01 purchaseOrder global.
    05 orderDate pic x(10).
    05 shipTo.
      10 country pic xx value 'US'.
      10 name pic x(30).
      10 street pic x(30).
      10 city pic x(30).
      10 state pic xx.
      10 zip pic x(10).
    05 billTo.
      10 country pic xx value 'US'.
      10 name pic x(30).
      10 street pic x(30).
      10 city pic x(30).
      10 state pic xx.
      10 zip pic x(10).
    05 orderComment pic x(80).
    05 items occurs 0 to 20 times depending on numItems.
      10 item.
15 partNum pic x(6).
15 productName pic x(50).
15 quantity pic 99.
15 USPrice pic 999v99.
15 shipDate pic x(10).
15 itemComment pic x(40).
01 numChars comp pic 999.
01 xmlPO pic x(999).

Procedure division.
   m.
   Move 20 to numItems
   Move spaces to purchaseOrder
   Move '1999-10-20' to orderDate
   Move 'US' to country of shipTo
   Move 'Alice Smith' to name of shipTo
   Move '123 Maple Street' to street of shipTo
   Move 'Mill Valley' to city of shipTo
   Move 'CA' to state of shipTo
   Move '90952' to zip of shipTo
   Move 'US' to country of billTo
   Move 'Robert Smith' to name of billTo
   Move '8 Oak Avenue' to street of billTo
   Move 'Old Town' to city of billTo
   Move 'PA' to state of billTo
   Move '95819' to zip of billTo
   Move 'Hurry, my lawn is going wild!' to orderComment
   Move 0 to numItems
   Call 'addFirstItem'
   Call 'addSecondItem'
   Move space to xmlPO
   Xml generate xmlPO from purchaseOrder count in numChars
      with xml-declaration with attributes
      namespace 'http://www.example.com' namespace-prefix 'po'
   Call 'pretty' using xmlPO value numChars
   Goback.

Identification division.
   Program-id. 'addFirstItem'.
   Procedure division.
       Add 1 to numItems
       Move '872-AA' to partNum(numItems)
       Move 'Lawnmower' to productName(numItems)
       Move 1 to quantity(numItems)
       Move 148.95 to USPrice(numItems)
       Move 'Confirm this is electric' to itemComment(numItems)
       Goback.
   End program 'addFirstItem'.

Identification division.
   Program-id. 'addSecondItem'.
   Procedure division.
       Add 1 to numItems
       Move '926-AA' to partNum(numItems)
       Move 'Baby Monitor' to productName(numItems)
       Move 1 to quantity(numItems)
       Move 39.98 to USPrice(numItems)
       Move '1999-05-21' to shipDate(numItems)
       Goback.
   End program 'addSecondItem'.

End program XGFX.

Program Pretty

Process xmlparse(xmlss), codepage(37)
Identification division.
   Program-id. Pretty.
Data division.
   Working-storage section.
      01 prettyPrint.
         05 pose pic 999.
         05 posd pic 999.
         05 depth pic 99.
         05 inx pic 999.
Chapter 31. Producing XML output
with pointer posd
Else
    String '" ' delimited by size into buffer
    with pointer posd
End-if
If xml-namespace-prefix = space
    String 'xmlns="" xml-namespace delimited by size into buffer with pointer posd
Else
    String 'xmlns: ' xml-namespace-prefix '='" xml-namespace delimited by size into buffer with pointer posd
End-if
Set attribute to true
When 'ATTRIBUTE-CHARACTERS'
    String xml-text delimited by size into buffer
    with pointer posd
When 'ATTRIBUTE-CHARACTER'
    String xml-text delimited by size into buffer
    with pointer posd
When 'CONTENT-CHARACTERS'
    Evaluate true
    When element
        String '>'; delimited by size into buffer
        with pointer posd
    When attribute
        String '?'; delimited by size into buffer
        with pointer posd
    End-evaluate
    String xml-text delimited by size into buffer
    with pointer posd
Set charcontent to true
When 'CONTENT-CHARACTER'
    Evaluate true
    When element
        String '>'; delimited by size into buffer
        with pointer posd
    When attribute
        String '?'; delimited by size into buffer
        with pointer posd
    End-evaluate
    String xml-text delimited by size into buffer
    with pointer posd
Set charcontent to true
When 'END-OF-ELEMENT'
    Move space to elementName
    Evaluate true
    When element
        String '/>'; delimited by size into buffer
        with pointer posd
    When attribute
        String '/?'; delimited by size into buffer
        with pointer posd
    When other
        If xml-namespace-prefix = space
            String '</'; xml-text '>'; delimited by size into buffer with pointer posd
        Else
            String '</'; xml-namespace-prefix ':' xml-text '>'; delimited by size into buffer with pointer posd
        End-if
    End-evaluate
    Set unknown to true
    Perform printline
    Subtract 1 from depth
    Move 1 to posd
    When other
        Continue
    End-evaluate
    printline.
    Compute inx = function max(0 2 * depth - 2) + posd - 1
    If inx > 120
        compute inx = 117 - function max(0 2 * depth - 2)
    If depth > 1
        Display indent(1:2 * depth - 2) buffer(1:inx) '...
    Else
        Display buffer(1:inx) '...
    End-if
Else
    If depth > 1
        Display indent(1:2 * depth - 2) buffer(1:posd - 1)
    Else

Enhancing XML output

It might happen that the information that you want to express in XML format already exists in a group item in the DATA DIVISION, but you are unable to use that item directly to generate an XML document because of one or more factors.

For example:

- In addition to the required data, the item has subordinate data items that contain values that are irrelevant to the XML output document.
- The names of the required data items are unsuitable for external presentation, and are possibly meaningful only to programmers.
- The required data items are broken up into too many components, and should be output as the content of the containing group.

There are various ways that you can deal with such situations. One possible technique is to define a new data item that has the appropriate characteristics, and move the required data to the appropriate fields of this new data item. However, this approach is somewhat laborious and requires careful maintenance to keep the original and new data items synchronized.

A superior approach that addresses most such problems is to use the new optional phrases of the XML GENERATE statement in order to:

- Provide more meaningful and appropriate names for the selected elementary items and for the group items that contain them.
- Exclude irrelevant data items from the generated XML by suppressing them based on their values.

The example that is referenced below shows a way to do so.

related references
Operation of XML GENERATE (Enterprise COBOL for z/OS Language Reference)
Example: enhancing XML output

The following example shows how you can modify XML output.

Consider the following data structure. The XML that is generated from the structure suffers from several problems that can be corrected.

```
01 CDR-LIFE-BASE-VALUES-BOX.
15 CDR-LIFE-BASE-VAL-DATE PIC X(08).
15 CDR-LIFE-BASE-VALUE-LINE OCCURS 2 TIMES.
20 CDR-LIFE-BASE-DESC.
25 CDR-LIFE-BASE-DESC1 PIC X(15).
25 FILLER PIC X(01).
25 CDR-LIFE-BASE-LIT PIC X(08).
25 CDR-LIFE-BASE-DTE PIC X(08).
20 CDR-LIFE-BASE-PRICE.
25 CDR-LIFE-BP-SPACE PIC 9(08).
25 CDR-LIFE-BP-DASH PIC X.
25 CDR-LIFE-BP-SPACE1 PIC X(02).
20 CDR-LIFE-BASE-QTY.
25 CDR-LIFE-QTY-SPACE PIC X(08).
25 CDR-LIFE-QTY-DASH PIC X.
25 CDR-LIFE-QTY-SPACE1 PIC X(03).
25 FILLER PIC X(02).
20 CDR-LIFE-BASE-VALUE PIC $9.99 BLANK WHEN ZERO.
15 CDR-LIFE-BASE-TOT-VALUE PIC X(15)
```

When this data structure is populated with some sample values, and XML is generated directly from it and then formatted using program Pretty (shown in “Example: generating XML” on page 547), the result is as follows:

```
<CDR-LIFE-BASE-VALUES-BOX>
  <CDR-LIFE-BASE-VAL-DATE>01/02/03</CDR-LIFE-BASE-VAL-DATE>
  <CDR-LIFE-BASE-VALUE-LINE>
    <CDR-LIFE-BASE-DESC>
      <CDR-LIFE-BASE-DESC1>First</CDR-LIFE-BASE-DESC1>
      <CDR-LIFE-BASE-LIT></CDR-LIFE-BASE-LIT>
      <CDR-LIFE-BASE-DTE>01/01/01</CDR-LIFE-BASE-DTE>
    </CDR-LIFE-BASE-DESC>
    <CDR-LIFE-BASE-PRICE>
      <CDR-LIFE-BP-SPACE>23</CDR-LIFE-BP-SPACE>
      <CDR-LIFE-BP-DASH>.</CDR-LIFE-BP-DASH>
      <CDR-LIFE-BP-SPACE1>00</CDR-LIFE-BP-SPACE1>
    </CDR-LIFE-BASE-PRICE>
    <CDR-LIFE-BASE-QTY>
      <CDR-LIFE-QTY-SPACE>123</CDR-LIFE-QTY-SPACE>
      <CDR-LIFE-QTY-DASH>./</CDR-LIFE-QTY-DASH>
      <CDR-LIFE-QTY-SPACE1>000</CDR-LIFE-QTY-SPACE1>
    </CDR-LIFE-BASE-QTY>
    <CDR-LIFE-BASE-VALUE>$765.00</CDR-LIFE-BASE-VALUE>
  </CDR-LIFE-BASE-VALUE-LINE>
  <CDR-LIFE-BASE-VALUE-LINE>
    <CDR-LIFE-BASE-DESC>
      <CDR-LIFE-BASE-DESC1>Second</CDR-LIFE-BASE-DESC1>
      <CDR-LIFE-BASE-LIT></CDR-LIFE-BASE-LIT>
      <CDR-LIFE-BASE-DTE>02/02/02</CDR-LIFE-BASE-DTE>
    </CDR-LIFE-BASE-DESC>
    <CDR-LIFE-BASE-PRICE>
      <CDR-LIFE-BP-SPACE>34</CDR-LIFE-BP-SPACE>
      <CDR-LIFE-BP-DASH>./</CDR-LIFE-BP-DASH>
      <CDR-LIFE-BP-SPACE1>00</CDR-LIFE-BP-SPACE1>
    </CDR-LIFE-BASE-PRICE>
    <CDR-LIFE-BASE-QTY>
      <CDR-LIFE-QTY-SPACE>234</CDR-LIFE-QTY-SPACE>
      <CDR-LIFE-QTY-DASH>./</CDR-LIFE-QTY-DASH>
      <CDR-LIFE-QTY-SPACE1>000</CDR-LIFE-QTY-SPACE1>
    </CDR-LIFE-BASE-QTY>
    <CDR-LIFE-BASE-VALUE>$654.00</CDR-LIFE-BASE-VALUE>
  </CDR-LIFE-BASE-VALUE-LINE>
  <CDR-LIFE-BASE-TOT-VALUE>Very high!</CDR-LIFE-BASE-TOT-VALUE>
</CDR-LIFE-BASE-VALUES-BOX>
```

This generated XML suffers from several problems:
• The element names are long and not very meaningful. There may also be an XML schema that specifies required tag names.
• The XML schema may require some tag names that are COBOL reserved words such as DATE/TIME.
• Some fields that are elements should be attributes such as, CDR-LIFE-BASE-VAL-DATE and CDR-LIFE-BASE-DESC1.
• There is unwanted data, for example, CDR-LIFE-BASE-LIT and CDR-LIFE-BASE-DTE.
• Other required fields are split into too many subcomponents. For example, CDR-LIFE-BASE-PRICE has three subcomponents for one amount.

These and other characteristics of the XML output can be remedied by using additional phrases of the XML GENERATE statement as follows:

• Use the NAME OF phrase to provide appropriate tag or attribute names.
• Use the TYPE OF … IS ATTRIBUTE phrase to select the fields which should be XML attributes rather than elements.
• Use the TYPE OF … IS CONTENT phrase to suppress tags for excessive subcomponents.
• Use the SUPPRESS … WHEN phrase to exclude fields that contain uninteresting values.

Here is an example of the XML GENERATE statement to address those problems:

```
XML generate Doc from CDR-LIFE-BASE-VALUES-BOX
Count in tally
Name of
  CDR-LIFE-BASE-VALUES-BOX
    is 'Base_Values'
    CDR-LIFE-BASE-VAL-DATE
      is 'Date'
    CDR-LIFE-BASE-DTE
      is 'Date'
    CDR-LIFE-BASE-VALUE-LINE
      is 'BaseValueLine'
    CDR-LIFE-BASE-PRICE
      is 'BasePrice'
    CDR-LIFE-BASE-QTY
      is 'BaseQuantity'
    CDR-LIFE-BASE-VALUE
      is 'BaseValue'
    CDR-LIFE-BASE-TOT-VALUE
      is 'TotalValue'
Type of
  CDR-LIFE-BASE-VAL-DATE is attribute
  CDR-LIFE-BASE-DESC1 is attribute
  CDR-LIFE-BP-SPACE is content
  CDR-LIFE-BP-DASH is content
  CDR-LIFE-BP-SPACE1 is content
  CDR-LIFE-QTY-SPACE is content
  CDR-LIFE-QTY-DASH is content
  CDR-LIFE-QTY-SPACE1 is content
Suppress every nonnumeric when space
  every numeric when zero
```

The result of generating and formatting XML from the statement shown above is more usable:

```
<Base_Values Date="01/02/03">
  <BaseValueLine Description="First">
    <Date>01/01/01</Date>
    <BasePrice>23.00</BasePrice>
    <BaseQuantity>123.000</BaseQuantity>
    <BaseValue>$765.00</BaseValue>
  </BaseValueLine>
  <BaseValueLine Description="Second">
    <Date>02/02/02</Date>
    <BasePrice>34.00</BasePrice>
    <BaseQuantity>234.000</BaseQuantity>
    <BaseValue>$654.00</BaseValue>
  </BaseValueLine>
  <TotalValue>Very high!</TotalValue>
</Base_Values>
```
Note that the COBOL reserved word DATE can now be used as an XML tag name in the output. Characters such as accented letters and period . that are illegal in single-byte data names can also be used.

related references
Operation of XML GENERATE (Enterprise COBOL for z/OS Language Reference)
REPLACE statement (Enterprise COBOL for z/OS Language Reference)
Part 6. Developing object-oriented programs
Chapter 32. Writing object-oriented programs

When you write an object-oriented (OO) program, you have to determine what classes you need and the methods and data that the classes need to do their work.

OO programs are based on objects (entities that encapsulate state and behavior) and their classes, methods, and data. A class is a template that defines the state and the capabilities of an object. Usually a program creates and works with multiple object instances (or simply, instances) of a class, that is, multiple objects that are members of that class. The state of each instance is stored in data known as instance data, and the capabilities of each instance are called instance methods. A class can define data that is shared by all instances of the class, known as factory or static data, and methods that are supported independently of any object instance, known as factory or static methods.

Using Enterprise COBOL, you can:
- Define classes, with methods and data implemented in COBOL.
- Create instances of Java and COBOL classes.
- Invoke methods on Java and COBOL objects.
- Write classes that inherit from Java classes or other COBOL classes.
- Define and invoke overloaded methods.

In Enterprise COBOL programs, you can call the services provided by the Java Native Interface (JNI) to obtain Java-oriented capabilities in addition to the basic OO capabilities available directly in the COBOL language.

In Enterprise COBOL classes, you can code CALL statements to interface with procedural COBOL programs. Thus COBOL class definition syntax can be especially useful for writing wrapper classes for procedural COBOL logic, enabling existing COBOL code to be accessed from Java.

Java code can create instances of COBOL classes, invoke methods of these classes, and can extend COBOL classes.

It is recommended that you develop and run OO COBOL programs and Java programs in the z/OS UNIX environment.

Restrictions:
- COBOL class definitions and methods cannot contain EXEC SQL statements and cannot be compiled using the SQL compiler option.
- COBOL class definitions and methods cannot contain EXEC SQLIMS statements and cannot be compiled using the SQLIMS compiler option.
- COBOL programs that use object-oriented syntax for Java interoperability cannot contain EXEC CICS statements, and cannot be run in CICS. They cannot be compiled using the CICS compiler option.

“Example: accounts” on page 558

related tasks
- “Defining a class” on page 560
- “Defining a class instance method” on page 564
- “Defining a client” on page 572
- “Defining a subclass” on page 582
- “Defining a factory section” on page 586

Chapter 16, “Compiling, linking, and running OO applications,” on page 273

Upgrading IBM COBOL source programs
(Enterprise COBOL Migration Guide)

related references
- The Java Language Specification
Example: accounts

Consider the example of a bank in which customers can open accounts and make deposits to and withdrawals from their accounts. You could represent an account by a general-purpose class, called Account. Because there are many customers, multiple instances of the Account class could exist simultaneously.

After you determine the classes that you need, the next step is to determine the methods that the classes need to do their work. An Account class must provide the following services:

- Open the account.
- Get the current balance.
- Deposit to the account.
- Withdraw from the account.
- Report account status.

The following methods for an Account class meet those needs:

- **init**
  - Open an account and assign it an account number.

- **getBalance**
  - Return the current balance of the account.

- **credit**
  - Deposit a given sum to the account.

- **debit**
  - Withdraw a given sum from the account.

- **print**
  - Display account number and account balance.

As you design an Account class and its methods, you discover the need for the class to keep some instance data. Typically, an Account object needs the following instance data:

- Account number
- Account balance
- Customer information: name, address, home phone, work phone, social security number, and so forth

To keep the example simple, however, it is assumed that the account number and account balance are the only instance data that the Account class needs.

Diagrams are helpful when you design classes and methods. The following diagram depicts a first attempt at a design of the Account class:

```
Account
(AccountNumber)
(AccountBalance)
1: init
2: getBalance
3: credit
4: debit
5: print
```

The words in parentheses in the diagrams are the names of the instance data, and the words that follow a number and colon are the names of the instance methods.

The structure below shows how the classes relate to each other, and is known as the inheritance hierarchy. The Account class inherits directly from the class java.lang.Object.
Subclasses

In the account example, Account is a general-purpose class. However, a bank could have many different types of accounts: checking accounts, savings accounts, mortgage loans, and so forth, all of which have all the general characteristics of accounts but could have additional characteristics not shared by all types of accounts.

For example, a CheckingAccount class could have, in addition to the account number and account balance that all accounts have, a check fee that applies to each check written on the account. A CheckingAccount class also needs a method to process checks (that is, to read the amount, debit the payer, credit the payee, and so forth). So it makes sense to define CheckingAccount as a subclass of Account, and to define in the subclass the additional instance data and instance methods that the subclass needs.

As you design the CheckingAccount class, you discover the need for a class that models checks. An instance of class Check needs, at a minimum, instance data for payer, payee, and the check amount. Many additional classes (and database and transaction-processing logic) would need to be designed in a real-world OO account system, but have been omitted to keep the example simple. The updated inheritance diagram is shown below.

A number and colon with no method-name following them indicate that the method with that number is inherited from the superclass.
Multiple inheritance: You cannot use *multiple inheritance* in OO COBOL applications. All classes that you define must have exactly one parent, and java.lang.Object must be at the root of every inheritance hierarchy. The class structure of any object-oriented system defined in an OO COBOL application is thus a tree.

“Example: defining a method” on page 570

related tasks
“Defining a class” on page 560
“Defining a class instance method” on page 564
“Defining a subclass” on page 582

Defining a class

A COBOL class definition consists of an IDENTIFICATION DIVISION and ENVIRONMENT DIVISION, followed by an optional factory definition and optional object definition, followed by an END CLASS marker.

<table>
<thead>
<tr>
<th>Table 75. Structure of class definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section</strong></td>
</tr>
<tr>
<td>IDENTIFICATION DIVISION (required)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>ENVIRONMENT DIVISION (required)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Factory definition (optional)</td>
</tr>
<tr>
<td>Object definition (optional)</td>
</tr>
</tbody>
</table>
If you specify the SOURCE-COMPUTER, OBJECT-COMPUTER, or SPECIAL-NAMES paragraphs in a class CONFIGURATION SECTION, they apply to the entire class definition including all methods that the class introduces.

A class CONFIGURATION SECTION can consist of the same entries as a program CONFIGURATION SECTION, except that a class CONFIGURATION SECTION cannot contain an INPUT-OUTPUT SECTION. You define an INPUT-OUTPUT SECTION only in the individual methods that require it rather than defining it at the class level.

As shown above, you define instance data and methods in the DATA DIVISION and PROCEDURE DIVISION, respectively, within the OBJECT paragraph of the class definition. In classes that require data and methods that are to be associated with the class itself rather than with individual object instances, define a separate DATA DIVISION and PROCEDURE DIVISION within the FACTORY paragraph of the class definition.

Each COBOL class definition must be in a separate source file.

"Example: defining a class" on page 564

related tasks
"WORKING-STORAGE SECTION for defining class instance data" on page 563
"Defining a class instance method" on page 564
"Defining a subclass" on page 582
"Defining a factory section" on page 586
"Describing the computing environment" on page 5
Chapter 16, “Compiling, linking, and running OO applications,” on page 273

related references
COBOL class definition structure (Enterprise COBOL for z/OS Language Reference)

CLASS-ID paragraph for defining a class

Use the CLASS-ID paragraph in the IDENTIFICATION DIVISION to name a class and provide inheritance information for it.

Identification Division. Required
Class-id. Account inherits Base. Required

Use the CLASS-ID paragraph to identify these classes:

• The class that you are defining (Account in the example above).

• The immediate superclass from which the class that you are defining inherits its characteristics. The superclass can be implemented in Java or COBOL.

In the example above, inherits Base indicates that the Account class inherits methods and data from the class known within the class definition as Base. It is recommended that you use the name Base in your OO COBOL programs to refer to java.lang.Object.

A class-name must use single-byte characters and must conform to the normal rules of formation for a COBOL user-defined word.

Use the REPOSITORY paragraph in the CONFIGURATION SECTION of the ENVIRONMENT DIVISION to associate the superclass name (Base in the example) with the name of the superclass as it is known externally (java.lang.Object for Base). You can optionally also specify the name of the class that you are defining (Account in the example) in the REPOSITORY paragraph and associate it with its corresponding external class-name.

You must derive all classes directly or indirectly from the java.lang.Object class.

related tasks
“REPOSITORY paragraph for defining a class” on page 562
REPOSITORY paragraph for defining a class

Use the REPOSITORY paragraph to declare to the compiler that the specified words are class-names when you use them within a class definition, and to optionally relate the class-names to the corresponding external class-names (the class-names as they are known outside the compilation unit).

External class-names are case sensitive and must conform to Java rules of formation. For example, in the Account class definition you might code this:

<table>
<thead>
<tr>
<th>Environment Division.</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration Section.</td>
<td>Required</td>
</tr>
<tr>
<td>Repository.</td>
<td>Required</td>
</tr>
<tr>
<td>Class Base is &quot;java.lang.Object&quot;</td>
<td>Required</td>
</tr>
<tr>
<td>Class Account is &quot;Account&quot;.</td>
<td>Optional</td>
</tr>
</tbody>
</table>

The REPOSITORY paragraph entries indicate that the external class-names of the classes referred to as Base and Account within the class definition are java.lang.Object and Account, respectively.

In the REPOSITORY paragraph, you must code an entry for each class-name that you explicitly reference in the class definition. For example:

- Base
- A superclass from which the class that you are defining inherits
- The classes that you reference in methods within the class definition

In a REPOSITORY paragraph entry, you must specify the external class-name if the name contains non-COBOL characters. You must also specify the external class-name for any referenced class that is part of a Java package. For example, the Object class is part of the java.lang package, so specify its external name as java.lang.Object as shown above.

An external class-name that you specify in the REPOSITORY paragraph must be an alphanumeric literal that conforms to the rules of formation for a fully-qualified Java class-name.

If you do not include the external class-name in a REPOSITORY paragraph entry, the external class-name is formed from the class-name in the following manner:

- The class-name is converted to uppercase.
- Each hyphen is changed to zero.
- The first character, if a digit, is changed:
  - 1-9 are changed to A-I.
  - 0 is changed to J.
- Underscores are not changed.

In the example above, class Account is known externally as Account (in mixed case) because the external name is spelled using mixed case.

You can optionally include in the REPOSITORY paragraph an entry for the class that you are defining (Account in this example). You must include an entry for the class that you are defining if the external class-name contains non-COBOL characters, or to specify a fully package-qualified class-name if the class is to be part of a Java package.

“Example: external class-names and Java packages” on page 563

related tasks
“Declaring arrays and strings for Java” on page 602
related references
REPOSITORY paragraph (Enterprise COBOL for z/OS Language Reference)
The Java Language Specification (Identifiers)
The Java Language Specification (Packages)

Example: external class-names and Java packages
The following example shows how external class-names are determined from entries in a REPOSITORY paragraph.

Environment division.
  Configuration section.
  Repository.
    Class Employee is "com.acme.Employee"
    Class JavaException is "java.lang.Exception"
    Class Orders.

The local class-names (the class-names as used within the class definition), the Java packages that contain the classes, and the associated external class-names are as shown in the table below.

<table>
<thead>
<tr>
<th>Local class-name</th>
<th>Java package</th>
<th>External class-name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employee</td>
<td>com.acme</td>
<td>com.acme.Employee</td>
</tr>
<tr>
<td>JavaException</td>
<td>java.lang</td>
<td>java.lang.Exception</td>
</tr>
<tr>
<td>Orders</td>
<td>(unnamed)</td>
<td>ORDERS</td>
</tr>
</tbody>
</table>

The external class-name (the name after the class-name and optional IS in the REPOSITORY paragraph entry) is composed of the fully qualified name of the package (if any) followed by a period, followed by the simple name of the class.

related tasks
“REPOSITORY paragraph for defining a class” on page 562

related references
REPOSITORY paragraph (Enterprise COBOL for z/OS Language Reference)

WORKING-STORAGE SECTION for defining class instance data
Use the WORKING-STORAGE SECTION in the DATA DIVISION of the OBJECT paragraph to describe the instance data that a COBOL class needs, that is, the data to be allocated for each instance of the class.

The OBJECT keyword, which you must immediately precede with an IDENTIFICATION DIVISION declaration, indicates the beginning of the definitions of the instance data and instance methods for the class. For example, the definition of the instance data for the Account class might look like this:

```
IDENTIFICATION DIVISION.
  Object.
    DATA DIVISION.
      WORKING-STORAGE SECTION.
        01 AccountNumber pic 9(6).
        01 AccountBalance pic S9(9) value zero.
    End Object.
```

The instance data is allocated when an object instance is created, and exists until garbage collection of the instance by the Java run time.

You can initialize simple instance data by using VALUE clauses as shown above. You can initialize more complex instance data by coding customized methods to create and initialize instances of classes.

COBOL instance data is equivalent to Java private nonstatic member data. No other class or subclass (nor factory method in the same class, if any) can reference COBOL instance data directly. Instance data is
global to all instance methods that the OBJECT paragraph defines. If you want to make instance data accessible from outside the OBJECT paragraph, define attribute (get or set) instance methods for doing so.

The syntax of the WORKING-STORAGE SECTION for instance data definition is generally the same as in a program, with these exceptions:

- You cannot use the EXTERNAL attribute.
- You can use the GLOBAL attribute, but it has no effect.

related tasks
“Creating and initializing instances of classes” on page 580
“Freeing instances of classes” on page 581
“Defining a factory method” on page 587
“Coding attribute (get and set) methods” on page 569

Example: defining a class
The following example shows a first attempt at the definition of the Account class, excluding method definitions.

cbl dll,thread,pgmname(longmixed)
IDENTIFICATION DIVISION.
Class-id. Account inherits Base.
ENVIRONMENT DIVISION.
Configuration section.
Repository.
  Class Base is "java.lang.Object"
  Class Account is "Account".
* IDENTIFICATION DIVISION.
Object.
DATA DIVISION.
WORKING-STORAGE SECTION.
  01 AccountNumber pic 9(6).
  01 AccountBalance pic S9(9) value zero.
* PROCEDURE DIVISION.
* (Instance method definitions here)
* End Object.
* End class Account.

related tasks
Chapter 16, “Compiling, linking, and running OO applications,” on page 273
“Defining a client” on page 572

Defining a class instance method

Define COBOL instance methods in the PROCEDURE DIVISION of the OBJECT paragraph of a class definition. An instance method defines an operation that is supported for each object instance of a class.

A COBOL instance method definition consists of four divisions (like a COBOL program), followed by an END METHOD marker.
### Table 76. **Structure of instance method definitions**

<table>
<thead>
<tr>
<th>Division</th>
<th>Purpose</th>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDENTIFICATION (required)</td>
<td>Name a method.</td>
<td>“METHOD-ID paragraph for defining a class instance method” on page 565 (required)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AUTHOR paragraph (optional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INSTALLATION paragraph (optional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DATE-WRITTEN paragraph (optional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DATE-COMPILED paragraph (optional)</td>
</tr>
<tr>
<td>ENVIRONMENT (optional)</td>
<td>Relate the file-names used in a method to the corresponding file-names known to the operating system.</td>
<td>“INPUT-OUTPUT SECTION for defining a class instance method” on page 566 (optional)</td>
</tr>
<tr>
<td>DATA (optional)</td>
<td>Define external files. Allocate a copy of the data.</td>
<td>“DATA DIVISION for defining a class instance method” on page 566 (optional)</td>
</tr>
<tr>
<td>PROCEDURE (optional)</td>
<td>Code the executable statements to complete the service provided by the method.</td>
<td>“PROCEDURE DIVISION for defining a class instance method” on page 567 (optional)</td>
</tr>
</tbody>
</table>

**Definition:** The *signature* of a method consists of the name of the method and the number and type of its formal parameters. (You define the formal parameters of a COBOL method in the USING phrase of the method’s PROCEDURE DIVISION header.)

Within a class definition, you do not need to make each method-name unique, but you do need to give each method a unique signature. (You overload methods by giving them the same name but a different signature.)

COBOL instance methods are equivalent to Java public nonstatic methods.

“Example: defining a method” on page 570

**related tasks**

- “PROCEDURE DIVISION for defining a class instance method” on page 567
- “Overloading an instance method” on page 569
- “Overriding an instance method” on page 568
- “Invoking methods (INVOKE)” on page 576
- “Defining a subclass instance method” on page 584
- “Defining a factory method” on page 587

**METHOD-ID paragraph for defining a class instance method**

Use the METHOD-ID paragraph to name an instance method. Immediately precede the METHOD-ID paragraph with an IDENTIFICATION DIVISION declaration to indicate the beginning of the method definition.

For example, the definition of the `credit` method in the `Account` class begins like this:

```cobol
Identification Division.
Method-id. "credit".
```

Code the method-name as an alphanumeric or national literal. The method-name is processed in a case-sensitive manner and must conform to the rules of formation for a Java method-name.

Other Java or COBOL methods or programs (that is, clients) use the method-name to invoke a method.
INPUT-OUTPUT SECTION for defining a class instance method

The ENVIRONMENT DIVISION of an instance method can have only one section, the INPUT-OUTPUT SECTION. This section relates the file-names used in a method definition to the corresponding file-names as they are known to the operating system.

For example, if the Account class defined a method that read information from a file, the Account class might have an INPUT-OUTPUT SECTION that is coded like this:

```
Environment Division.
  Input-Output Section.
    File-Control.
      Select account-file Assign AcctFile.
```

The syntax for the INPUT-OUTPUT SECTION of a method is the same as the syntax for the INPUT-OUTPUT SECTION of a program.

related references
INPUT-OUTPUT section (Enterprise COBOL for z/OS Language Reference)

DATA DIVISION for defining a class instance method

The DATA DIVISION of an instance method consists of any of the following four sections: FILE SECTION, LOCAL-STORAGE SECTION, WORKING-STORAGE SECTION, and LINKAGE SECTION.

FILE SECTION
The same as a program FILE SECTION, except that a method FILE SECTION can define EXTERNAL files only.

LOCAL-STORAGE SECTION
A separate copy of the LOCAL-STORAGE data is allocated for each invocation of the method, and is freed on return from the method. The method LOCAL-STORAGE SECTION is similar to a program LOCAL-STORAGE SECTION.

If you specify the VALUE clause on a data item, the item is initialized to that value on each invocation of the method.

WORKING-STORAGE SECTION
A single copy of the WORKING-STORAGE data is allocated. The data persists in its last-used state until the run unit ends. The same copy of the data is used whenever the method is invoked, regardless of the invoking object or thread. The method WORKING-STORAGE SECTION is similar to a program WORKING-STORAGE SECTION.

If you specify the VALUE clause on a data item, the item is initialized to that value on the first invocation of the method. You can specify the EXTERNAL clause for the data items.

LINKAGE SECTION
The same as a program LINKAGE SECTION.
If you define a data item with the same name in both the DATA DIVISION of an instance method and the DATA DIVISION of the OBJECT paragraph, a reference in the method to that data-name refers only to the method data item. The method DATA DIVISION takes precedence.

**related tasks**

“Describing the data” on page 10
“Sharing data by using the EXTERNAL clause” on page 471

**related references**

DATA DIVISION overview (Enterprise COBOL for z/OS Language Reference)

**PROCEDURE DIVISION for defining a class instance method**

Code the executable statements to implement the service that an instance method provides in the PROCEDURE DIVISION of the instance method.

You can code most COBOL statements in the PROCEDURE DIVISION of a method that you can code in the PROCEDURE DIVISION of a program. You cannot, however, code the following statements in a method:

- ENTRY
- EXIT PROGRAM
- The following obsolete elements of the 85 COBOL Standard:
  - ALTER
  - GOTO without a specified procedure-name
  - SEGMENT-LIMIT
  - USE FOR DEBUGGING

Additionally, because you must compile all COBOL class definitions with the THREAD compiler option, you cannot use SORT or MERGE statements in a COBOL method.

You can code the EXIT METHOD or GOBACK statement in an instance method to return control to the invoking client. Both statements have the same effect. If you specify the RETURNING phrase upon invocation of the method, the EXIT METHOD or GOBACK statement returns the value of the data item to the invoking client.

An implicit EXIT METHOD is generated as the last statement in the PROCEDURE DIVISION of each method.

You can specify STOP RUN in a method; doing so terminates the entire run unit including all threads executing within it.

You must terminate a method definition with an END METHOD marker. For example, the following statement marks the end of the credit method:

```
End method "credit".
```

**USING phrase for obtaining passed arguments:** Specify the formal parameters to a method, if any, in the USING phrase of the method's PROCEDURE DIVISION header. You must specify that the arguments are passed BY VALUE. Define each parameter as a level-01 or level-77 item in the method's LINKAGE SECTION. The data type of each parameter must be one of the types that are interoperable with Java.

**RETURNING phrase for returning a value:** Specify the data item to be returned as the method result, if any, in the RETURNING phrase of the method's PROCEDURE DIVISION header. Define the data item as a level-01 or level-77 item in the method's LINKAGE SECTION. The data type of the return value must be one of the types that are interoperable with Java.

**related tasks**

“Coding interoperable data types in COBOL and Java” on page 601
Overriding an instance method

An instance method that is defined in a subclass is said to override an inherited instance method that would otherwise be accessible in the subclass if the two methods have the same signature.

To override a superclass instance method m1 in a COBOL subclass, define an instance method m1 in the subclass that has the same name and whose PROCEDURE DIVISION USING phrase (if any) has the same number and type of formal parameters as the superclass method has. (If the superclass method is implemented in Java, you must code formal parameters that are interoperable with the data types of the corresponding Java parameters.) When a client invokes m1 on an instance of the subclass, the subclass method rather than the superclass method is invoked.

For example, the Account class defines a method debit whose LINKAGE SECTION and PROCEDURE DIVISION header look like this:

```
Linkage section.
01 inDebit   pic S9(9) binary.
Procedure Division using by value inDebit.
```

If you define a CheckingAccount subclass and want it to have a debit method that overrides the debit method defined in the Account superclass, define the subclass method with exactly one input parameter also specified as pic S9(9) binary. If a client invokes debit using an object reference to a CheckingAccount instance, the CheckingAccount debit method (rather than the debit method in the Account superclass) is invoked.

The presence or absence of a method return value and the data type of the return value used in the PROCEDURE DIVISION RETURNING phrase (if any) must be identical in the subclass instance method and the overridden superclass instance method.

An instance method must not override a factory method in a COBOL superclass nor a static method in a Java superclass.

“Example: defining a method” on page 570

related tasks
“PROCEDURE DIVISION for defining a class instance method” on page 567
“Coding interoperable data types in COBOL and Java” on page 601
“Invoking methods (INVOKE)” on page 576
“Invoking overridden superclass methods” on page 579
“Defining a subclass” on page 582
“Hiding a factory or static method” on page 588

related references
The Java Language Specification (Inheritance, overriding, and hiding)
Overloading an instance method

Two methods that are supported in a class (whether defined in the class or inherited from a superclass) are said to be *overloaded* if they have the same name but different signatures.

You overload methods when you want to enable clients to invoke different versions of a method, for example, to initialize data using different sets of parameters.

To overload a method, define a method whose `PROCEDURE DIVISION USING` phrase (if any) has a different number or type of formal parameters than an identically named method that is supported in the same class. For example, the Account class defines an instance method `init` that has exactly one formal parameter. The `LINKAGE SECTION` and `PROCEDURE DIVISION` header of the `init` method look like this:

```cobol
Linkage section.
  01 inAccountNumber pic S9(9) binary.
  Procedure Division using by value inAccountNumber.
```

Clients invoke this method to initialize an Account instance with a given account number (and a default account balance of zero) by passing exactly one argument that matches the data type of `inAccountNumber`.

But the Account class could define, for example, a second instance method `init` that has an additional formal parameter that allows the opening account balance to also be specified. The `LINKAGE SECTION` and `PROCEDURE DIVISION` header of this `init` method could look like this:

```cobol
Linkage section.
  01 inAccountNumber pic S9(9) binary.
  01 inBalance       pic S9(9) binary.
  Procedure Division using by value inAccountNumber
                     inBalance.
```

Clients could invoke either `init` method by passing arguments that match the signature of the required method.

The presence or absence of a method return value does not have to be consistent in overloaded methods, and the data type of the return value given in the `PROCEDURE DIVISION RETURNING` phrase (if any) does not have to be identical in overloaded methods.

You can overload factory methods in exactly the same way that you overload instance methods.

The rules for overloaded method definition and resolution of overloaded method invocations are based on the corresponding rules for Java.

**related tasks**

"Invoking methods (INVOKE)" on page 576
"Defining a factory method" on page 587

**related references**

*The Java Language Specification* (Overloading)

**Coding attribute (get and set) methods**

You can provide access to an instance variable `X` from outside the class in which `X` is defined by coding accessor (get) and mutator (set) methods for `X`.

Instance variables in COBOL are *private*: the class that defines instance variables fully encapsulates them, and only the instance methods defined in the same `OBJECT` paragraph can access them directly. Normally a well-designed object-oriented application does not need to access instance variables from outside the class.

COBOL does not directly support the concept of a public instance variable as defined in Java and other object-oriented languages, nor the concept of a class attribute as defined by CORBA. (A CORBA *attribute* is an instance variable that has an automatically generated get method for accessing the value of the
variable, and an automatically generated set method for modifying the value of the variable if the variable is not read-only.)

“Example: coding a get method” on page 570

related tasks
“WORKING-STORAGE SECTION for defining class instance data” on page 563
“Processing the data” on page 16

Example: coding a get method
The following example shows the definition in the Account class of an instance method, getBalance, to return the value of the instance variable AccountBalance to a client. getBalance and AccountBalance are defined in the OBJECT paragraph of the Account class definition.

```cobol
Identification Division.
Class-id. Account inherits Base.
*  (ENVIRONMENT DIVISION not shown)
*  (FACTORY paragraph not shown)
*
Identification division.
Object.
Data division.
WORKING-STORAGE SECTION.
  01 AccountBalance pic S9(9) value zero.
  * (Other instance data not shown)
  *
Procedure Division.
*
  Identification Division.
  Method-id. "getBalance".
  Data division.
  Linkage section.
  01 outBalance pic S9(9) binary.
  *
  Procedure Division returning outBalance.
  Move AccountBalance to outBalance.
  End method "getBalance".
  *
  * (Other instance methods not shown)
  End Object.
  *
End class Account.
```

Example: defining a method
The following example adds to the previous example the instance method definitions of the Account class, and shows the definition of the Java Check class.

(The previous example was “Example: defining a class” on page 564.)

Account class

```cobol
  cbl dll,thread,pgmname(longmixed)
Identification Division.
Class-id. Account inherits Base.
Environment Division.
Configuration section.
Repository.
  Class Base is "java.lang.Object"
  Class Account is "Account".
  *
  (FACTORY paragraph not shown)
  *
Identification division.
Object.
Data division.
Working-storage section.
  01 AccountNumber pic 9(6).
  01 AccountBalance pic S9(9) value zero.
  *
  Procedure Division.
```
* init method to initialize the account:
  Identification Division.
  Method-id. "init".
  Data division.
  Linkage section.
  01 inAccountNumber pic S9(9) binary.
  Procedure Division using by value inAccountNumber.
  Move inAccountNumber to AccountNumber.
  End method "init".
* getBalance method to return the account balance:
  Identification Division.
  Method-id. "getBalance".
  Data division.
  Linkage section.
  01 outBalance pic S9(9) binary.
  Procedure Division returning outBalance.
  Move AccountBalance to outBalance.
  End method "getBalance".
* credit method to deposit to the account:
  Identification Division.
  Method-id. "credit".
  Data division.
  Linkage section.
  01 inCredit   pic S9(9) binary.
  Procedure Division using by value inCredit.
  Add inCredit to AccountBalance.
  End method "credit".
* debit method to withdraw from the account:
  Identification Division.
  Method-id. "debit".
  Data division.
  Linkage section.
  01 inDebit    pic S9(9) binary.
  Procedure Division using by value inDebit.
  Subtract inDebit from AccountBalance.
  End method "debit".
* print method to display formatted account number and balance:
  Identification Division.
  Method-id. "print".
  Data division.
  Local-storage section.
  01 PrintableAccountNumber  pic ZZZZZZ999999.
  01 PrintableAccountBalance pic $$$$,$$$,$$9CR.
  Procedure Division.
  Move AccountNumber  to PrintableAccountNumber
  Move AccountBalance to PrintableAccountBalance
  Display " Account: " PrintableAccountNumber
  End method "print".
* End Object.
* End class Account.

Check class

/**
* A Java class for check information
*/
public class Check {
    private CheckingAccount payer;
    private Account payee;
    private int amount;

    public Check(CheckingAccount inPayer, Account inPayee, int inAmount) {
        payer=inPayer;
        payee=inPayee;
        amount=inAmount;
    }

    public int getAmount() {
        return amount;
    }
}
public Account getPayee() {
    return payee;
}

related tasks
Chapter 16, “Compiling, linking, and running OO applications,” on page 273

Defining a client

A program or method that requests services from one or more methods in a class is called a client of that class.

In a COBOL or Java client, you can:

- Create object instances of Java and COBOL classes.
- Invoke instance methods on Java and COBOL objects.
- Invoke COBOL factory methods and Java static methods.

In a COBOL client, you can also call services provided by the Java Native Interface (JNI).

A COBOL client program consists of the usual four divisions:

<table>
<thead>
<tr>
<th>Table 77. Structure of COBOL clients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division</td>
</tr>
<tr>
<td>----------</td>
</tr>
</tbody>
</table>
| IDENTIFICATION (required) | Name a client. | Code as usual, except that a client program must be:  
• Recursive (declared RECURSIVE in the PROGRAM-ID paragraph)  
• Thread-enabled (compiled with the THREAD option, and conforming to the coding guidelines for threaded applications) |
| ENVIRONMENT (required) | Describe the computing environment. Relate class-names used in the client to the corresponding external class-names known outside the compilation unit. | CONFIGURATION SECTION (required)  
“REPOSITORY paragraph for defining a client” on page 573 (required) |
| DATA (optional) | Describe the data that the client needs. | “DATA DIVISION for defining a client” on page 574 (optional) |
| PROCEDURE (optional) | Create instances of classes, manipulate object reference data items, and invoke methods. | Code using INVOKE, IF, and SET statements. |

Because you must compile all COBOL programs that contain object-oriented syntax or that interoperate with Java with the THREAD compiler option, you cannot use the following language elements in a COBOL client:

- SORT or MERGE statements
- Nested programs

Any programs that you compile with the THREAD compiler option must be recursive. You must specify the RECURSIVE clause in the PROGRAM-ID paragraph of each OO COBOL client program.
REPOSITORY paragraph for defining a client

Use the REPOSITORY paragraph to declare to the compiler that the specified words are class-names when you use them in a COBOL client, and to optionally relate the class-names to the corresponding external class-names (the class-names as they are known outside the compilation unit).

External class-names are case sensitive, and must conform to Java rules of formation. For example, in a client program that uses the Account and Check classes you might code this:

```
Environment division.
Configuration section.
  Required
  Source-Computer.  IBM-390.
  Required
  Object-Computer.  IBM-390.
Repository.  Required
  Class Account is "Account".
  Class Check is "Check".
```

The REPOSITORY paragraph entries indicate that the external class-names of the classes referred to as Account and Check within the client are Account and Check, respectively.

In the REPOSITORY paragraph, you must code an entry for each class-name that you explicitly reference in the client. In a REPOSITORY paragraph entry, you must specify the external class-name if the name contains non-COBOL characters.

You must specify the external class-name for any referenced class that is part of a Java package. For such a class, specify the external class-name as the fully qualified name of the package, followed by period (.), followed by the simple name of the Java class.

An external class-name that you specify in the REPOSITORY paragraph must be an alphanumeric literal that conforms to the rules of formation for a fully qualified Java class-name.

If you do not include the external class-name in a REPOSITORY paragraph entry, the external class-name is formed from the class-name in the same manner as it is when an external class-name is not included in a REPOSITORY paragraph entry in a class definition. In the example above, class Account and class Check are known externally as Account and Check (in mixed case), respectively, because the external names are spelled using mixed case.

The SOURCE-COMPUTER, OBJECT-COMPUTER, and SPECIAL-NAMES paragraphs of the CONFIGURATION SECTION are optional.

related tasks
“REPOSITORY paragraph for defining a class” on page 562

related references
REPOSITORY paragraph (Enterprise COBOL for z/OS Language Reference)
DATA DIVISION for defining a client

You can use any of the sections of the DATA DIVISION to describe the data that the client needs.

```
Data Division.
Local-storage section.
  01 anAccount    usage object reference Account.
  01 aCheckingAccount usage object reference CheckingAccount.
  01 aCheck      usage object reference Check.
  01 payee       usage object reference Account.
```

Because a client references classes, it needs one or more special data items called object references, that is, references to instances of those classes. All requests to instance methods require an object reference to an instance of a class in which the method is supported (that is, either defined or available by inheritance). You code object references to refer to instances of Java classes using the same syntax as you use to refer to instances of COBOL classes. In the example above, the phrase usage object reference indicates an object reference data item.

All four object references in the code above are called typed object references because a class-name appears after the OBJECT REFERENCE phrase. A typed object reference can refer only to an instance of the class named in the OBJECT REFERENCE phrase or to one of its subclasses. Thus anAccount can refer to instances of the Account class or one of its subclasses, but cannot refer to instances of any other class. Similarly, aCheck can refer only to instances of the Check class or any subclasses that it might have.

Another type of object reference, not shown above, does not have a class-name after the OBJECT REFERENCE phrase. Such a reference is called a universal object reference, which means that it can refer to instances of any class. Avoid coding universal object references, because they are interoperable with Java in only very limited circumstances (when used in the RETURNING phrase of the INVOKE class-name NEW . . . statement).

You must define, in the REPOSITORY paragraph of the CONFIGURATION SECTION, class-names that you use in the OBJECT REFERENCE phrase.

related tasks
“Choosing LOCAL-STORAGE or WORKING-STORAGE” on page 574
“Coding interoperable data types in COBOL and Java” on page 601
“Invoking methods (INVOKE)” on page 576
“REPOSITORY paragraph for defining a client” on page 573

related references
RETURNING phrase (Enterprise COBOL for z/OS Language Reference)

Choosing LOCAL-STORAGE or WORKING-STORAGE

You can in general use the WORKING-STORAGE SECTION to define working data that a client program needs. However, if the program could simultaneously run on multiple threads, you might instead want to define the data in the LOCAL-STORAGE SECTION.

Each thread has access to a separate copy of LOCAL-STORAGE data but shares access to a single copy of WORKING-STORAGE data. If you define the data in the WORKING-STORAGE SECTION, you need to synchronize access to the data or ensure that no two threads can access it simultaneously.

related tasks
Chapter 27, “Preparing COBOL programs for multithreading,” on page 487
Comparing and setting object references

You can compare object references by coding conditional statements or a call to the JNI service IsSameObject, and you can set object references by using the SET statement.

For example, code either IF statement below to check whether the object reference anAccount refers to no object instance:

```
If anAccount = Null . . .
If anAccount = Nulls . . .
```

You can code a call to IsSameObject to check whether two object references, object1 and object2, refer to the same object instance or whether each refers to no object instance. To ensure that the arguments and return value are interoperable with Java and to establish addressability to the callable service, code the following data definitions and statements before the call to IsSameObject:

```
Local-storage Section.
   01  is-same Pic X.
      88 is-same-false Value X'00'.
      88 is-same-true  Value X'01' Through X'FF'.
Linkage Section.
   Copy JNI.
Procedure Division.
   Set Address Of JNIEnv To JNIEnvPtr
   Set Address Of JNINativeInterface To JNIEnv
   Call IsSameObject Using By Value JNIEnvPtr object1 object2
   Returning is-same
   If is-same-true . . .
```

Within a method you can check whether an object reference refers to the object instance on which the method was invoked by coding a call to IsSameObject that compares the object reference and SELF.

You can instead invoke the Java equals method (inherited from java.lang.Object) to determine whether two object references refer to the same object instance.

You can make an object reference refer to no object instance by using the SET statement. For example:

```
Set anAccount To Null.
```

You can also make one object reference refer to the same instance as another object reference does by using the SET statement. For example:

```
Set anotherAccount To anAccount.
```

This SET statement causes anotherAccount to refer to the same object instance as anAccount does. If the receiver (anotherAccount) is a universal object reference, the sender (anAccount) can be either a universal or a typed object reference. If the receiver is a typed object reference, the sender must be a typed object reference bound to the same class as the receiver or to one of its subclasses.

Within a method you can make an object reference refer to the object instance on which the method was invoked by setting it to SELF. For example:

```
Set anAccount To Self.
```

related tasks

“Coding interoperable data types in COBOL and Java” on page 601
“Accessing JNI services” on page 597

related references

The Java Native Interface (IsSameObject)
**Invoking methods (INVOKE)**

In a Java client, you can create object instances of classes that were implemented in COBOL and invoke methods on those objects using standard Java syntax. In a COBOL client, you can invoke methods that are defined in Java or COBOL classes by coding the INVOKE statement.

```plaintext
Invoke Account "createAccount"
    using by value 123456
    returning anAccount
Invoke anAccount "credit" using by value 500.
```

The first example INVOKE statement above uses the class-name Account to invoke a method called createAccount. This method must be either defined or inherited in the Account class, and must be one of the following types:

- A Java static method
- A COBOL factory method

The phrase using by value 123456 indicates that 123456 is an input argument to the method, and is passed by value. The input argument 123456 and the returned data item anAccount must conform to the definition of the formal parameters and return type, respectively, of the (possibly overloaded) createAccount method.

The second INVOKE statement uses the returned object reference anAccount to invoke the instance method credit, which is defined in the Account class. The input argument 500 must conform to the definition of the formal parameters of the (possibly overloaded) credit method.

Code the name of the method to be invoked either as a literal or as an identifier whose value at run time matches the method-name in the signature of the target method. The method-name must be an alphanumeric or national literal or a category alphabetic, alphanumeric, or national data item, and is interpreted in a case-sensitive manner.

When you code an INVOKE statement using an object reference (as in the second example statement above), the statement begins with one of the following two forms:

```plaintext
Invoke objRef "literal-name" . . .
Invoke objRef identifier-name . . .
```

When the method-name is an identifier, you must define the object reference (objRef) as USAGE OBJECT REFERENCE with no specified type, that is, as a universal object reference.

If an invoked method is not supported in the class to which the object reference refers, a severity-3 Language Environment condition is raised at run time unless you code the ON EXCEPTION phrase in the INVOKE statement.

You can use the optional scope terminator END-INVOKE with the INVOKE statement.

The INVOKE statement does not set the RETURN-CODE special register.

**related tasks**

- “USING phrase for passing arguments” on page 577
- “RETURNING phrase for obtaining a returned value” on page 578
- “PROCEDURE DIVISION for defining a class instance method” on page 567
- “Coding interoperable data types in COBOL and Java” on page 601
- “Invoking overridden superclass methods” on page 579
- “Invoking factory or static methods” on page 588
INVOKING A METHOD

If you pass arguments to a method, specify the arguments in the USING phrase of the \texttt{INVOKE} statement. Code the data type of each argument so that it conforms to the type of the corresponding formal parameter in the intended target method.

### Table 78. Conformance of arguments in a COBOL client

<table>
<thead>
<tr>
<th>Programming language of the target method</th>
<th>Is the argument an object reference?</th>
<th>Then code the DATA DIVISION definition of the argument as:</th>
<th>Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>COBOL</td>
<td>No</td>
<td>The same as the definition of the corresponding formal parameter</td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td>No</td>
<td>Interoperable with the corresponding Java parameter</td>
<td></td>
</tr>
<tr>
<td>COBOL or Java</td>
<td>Yes</td>
<td>An object reference that is typed to the same class as the corresponding parameter in the target method</td>
<td>In a COBOL client (unlike in a Java client), the class of an argument cannot be a subclass of the class of the corresponding parameter.</td>
</tr>
</tbody>
</table>

See the example referenced below for a way to make an object-reference argument conform to the type of a corresponding formal parameter by using the \texttt{SET} statement or the \texttt{REDEFINES} clause.

“Example: passing conforming object-reference arguments from a COBOL client” on page 577

If the target method is overloaded, the data types of the arguments are used to select from among the methods that have the same name.

You must specify that the arguments are passed \texttt{BY VALUE}. In other words, the arguments are not affected by any change to the corresponding formal parameters in the invoked method.

The data type of each argument must be one of the types that are interoperable with Java.

### related tasks

- “PROCEDURE DIVISION for defining a class instance method” on page 567
- “Overloading an instance method” on page 569
- “Coding interoperable data types in COBOL and Java” on page 601
- “Passing data” on page 461

### related references

- INVOKE statement (\textit{Enterprise COBOL for z/OS Language Reference})
- SET statement (\textit{Enterprise COBOL for z/OS Language Reference})
- REDEFINES clause (\textit{Enterprise COBOL for z/OS Language Reference})

### Example: passing conforming object-reference arguments from a COBOL client

The following example shows a way to make an object-reference argument in a COBOL client conform to the expected class of the corresponding formal parameter in an invoked method.

Class C defines a method M that has one parameter, a reference to an object of class \texttt{java.lang.Object}:

```
Class-id. C inherits Base.
Repository.
```

To invoke method M, a COBOL client must pass an argument that is a reference to an object of class java.lang.Object. The client below defines a data item aString, which cannot be passed as an argument to M because aString is a reference to an object of class java.lang.String. The client first uses a SET statement to assign aString to a data item, anObj, that is a reference to an object of class java.lang.Object. (This SET statement is legal because java.lang.String is a subclass of java.lang.Object.) The client then passes anObj as the argument to M.

Instead of using a SET statement to obtain anObj as a reference to an object of class java.lang.Object, the client could define aString and anObj with the REDEFINES clause as follows:

After the client assigns a value to data item aString (that is, a valid reference to an object of class java.lang.String), anObj can be passed as the argument to M. For an example of the use of the REDEFINES clause to obtain argument conformance, see the example referenced below.

“Example: J2EE client written in COBOL” on page 608

related tasks
“Coding interoperable data types in COBOL and Java” on page 601
“PROCEDURE DIVISION for defining a class instance method” on page 567

related references
INVOKE statement (Enterprise COBOL for z/OS Language Reference)
SET statement (Enterprise COBOL for z/OS Language Reference)
REDEFINES clause (Enterprise COBOL for z/OS Language Reference)

RETURNING phrase for obtaining a returned value
If a data item is to be returned as the method result, specify the item in the RETURNING phrase of the INVOKE statement. Define the returned item in the DATA DIVISION of the client.

The item that you specify in the RETURNING phrase of the INVOKE statement must conform to the type returned by the target method, as shown in the table below.
Table 79. Conformance of the returned data item in a COBOL client

<table>
<thead>
<tr>
<th>Programming language of the target method</th>
<th>Is the returned item an object reference?</th>
<th>Then code the DATA DIVISION definition of the returned item as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>COBOL</td>
<td>No</td>
<td>The same as the definition of the RETURNING item in the target method</td>
</tr>
<tr>
<td>Java</td>
<td>No</td>
<td>Interoperable with the returned Java data item</td>
</tr>
<tr>
<td>COBOL or Java</td>
<td>Yes</td>
<td>An object reference that is typed to the same class as the object reference that is returned by the target method</td>
</tr>
</tbody>
</table>

In all cases, the data type of the returned value must be one of the types that are interoperable with Java.

**related tasks**
“Coding interoperable data types in COBOL and Java” on page 601

**related references**
INVOKE statement (Enterprise COBOL for z/OS Language Reference)

**Invoking overridden superclass methods**
Sometimes within a class you need to invoke an overridden superclass method instead of invoking a method that has the same signature and is defined in the current class.

For example, suppose that the CheckingAccount class overrides the debit instance method defined in its immediate superclass, Account. You could invoke the Account debit method within a method in the CheckingAccount class by coding this statement:

```
Invoke Super "debit" Using By Value amount.
```

You would define amount as PIC S9(9) BINARY to match the signature of the debit methods.

The CheckingAccount class overrides the print method that is defined in the Account class. Because the print method has no formal parameters, a method in the CheckingAccount class could invoke the superclass print method with this statement:

```
Invoke Super "print".
```

The keyword SUPER indicates that you want to invoke a superclass method rather than a method in the current class. (SUPER is an implicit reference to the object used in the invocation of the currently executing method.)

“Example: accounts” on page 558

**related tasks**
“Overriding an instance method” on page 568

**related references**
INVOKE statement (Enterprise COBOL for z/OS Language Reference)
Creating and initializing instances of classes

Before you can use the instance methods that are defined in a Java or COBOL class, you must first create an instance of the class.

To create a new instance of class class-name and to obtain a reference object-reference to the created object, code a statement of the following form, where object-reference is defined in the DATA DIVISION of the client:

```
INVOKEx class-name NEW . . . RETURNING object-reference
```

When you code the INVOKE . . . NEW statement within a method, and the use of the returned object reference is not limited to the duration of the method invocation, you must convert the returned object reference to a global reference by calling the JNI service NewGlobalRef:

```
Call NewGlobalRef using by value JNIEnvPtr object-reference
    returning object-reference
```

If you do not call NewGlobalRef, the returned object reference is only a local reference, which means that it is automatically freed after the method returns.

**related tasks**

“Instantiating Java classes” on page 580
“Instantiating COBOL classes” on page 581
“Accessing JNI services” on page 597
“Managing local and global references” on page 599
“DATA DIVISION for defining a client” on page 574
“Invoking methods (INVOKE)” on page 576
“Coding interoperable data types in COBOL and Java” on page 601

**related references**

INVOKEx statement (Enterprise COBOL for z/OS Language Reference)

Instantiating Java classes

To instantiate a Java class, invoke any parameterized constructor that the class supports by coding the USING phrase in the INVOKE . . . NEW statement immediately before the RETURNING phrase, passing BY VALUE the number and types of arguments that match the signature of the constructor.

The data type of each argument must be one of the types that are interoperable with Java. To invoke the default (parameterless) constructor, omit the USING phrase.

For example, to create an instance of the Check class, initialize its instance data, and obtain reference aCheck to the Check instance created, you could code this statement in a COBOL client:

```
Invoke Check New
    using by value aCheckingAccount, payee, 125
    returning aCheck
```

**related tasks**

“Invoking methods (INVOKE)” on page 576
“Coding interoperable data types in COBOL and Java” on page 601

**related references**

VALUE clause (Enterprise COBOL for z/OS Language Reference)
INVOKEx statement (Enterprise COBOL for z/OS Language Reference)
Instantiating COBOL classes
To instantiate a COBOL class, you can specify either a typed or universal object reference in the RETURNING phrase of the INVOKE . . . NEW statement. However, you cannot code the USING phrase: the instance data is initialized as specified in the VALUE clauses in the class definition.

Thus the INVOKE . . . NEW statement is useful for instantiating COBOL classes that have only simple instance data. For example, the following statement creates an instance of the Account class, initializes the instance data as specified in VALUE clauses in the WORKING-STORAGE SECTION of the OBJECT paragraph of the Account class definition, and provides reference outAccount to the new instance:

```
Invoke Account New returning outAccount
```

To make it possible to initialize COBOL instance data that cannot be initialized using VALUE clauses alone, when designing a COBOL class you must define a parameterized creation method in the FACTORY paragraph and a parameterized initialization method in the OBJECT paragraph:

1. In the parameterized factory creation method, do these steps:
   a) Code INVOKE class-name NEW RETURNING objectRef to create an instance of class-name and to give initial values to the instance data items that have VALUE clauses.
   b) Invoke the parameterized initialization method on the instance (objectRef), passing BY VALUE the arguments that were supplied to the factory method.

2. In the initialization method, code logic to complete the instance data initialization using the values supplied through the formal parameters.

To create an instance of the COBOL class and properly initialize it, the client invokes the parameterized factory method, passing BY VALUE the required arguments. The object reference returned to the client is a local reference. If the client code is within a method, and the use of the returned object reference is not limited to the duration of that method, the client code must convert the returned object reference to a global reference by calling the JNI service NewGlobalRef.

"Example: defining a factory (with methods)" on page 589

related tasks
“Accessing JNI services” on page 597
“Managing local and global references” on page 599
“Invoking methods (INVOKE)” on page 576
“Defining a factory section” on page 586

related references
VALUE clause (Enterprise COBOL for z/OS Language Reference)
INVOKE statement (Enterprise COBOL for z/OS Language Reference)

Freeing instances of classes
You do not need to take any action to free individual object instances of any class. No syntax is available for doing so. The Java runtime system automatically performs garbage collection, that is, it reclaims the memory for objects that are no longer in use.

There could be times, however, when you need to explicitly free local or global references to objects within a native COBOL client in order to permit garbage collection of the referenced objects to occur.

related tasks
“Managing local and global references” on page 599

Example: defining a client
The following example shows a small client program of the Account class.

The program does this:
- Invokes a factory method createAccount to create an Account instance with a default balance of zero
• Invokes the instance method `credit` to deposit $500 to the new account
• Invokes the instance method `print` to display the account status

(The Account class was shown in “Example: defining a method” on page 570.)

cbl dll,thread,pgmname(longmixed)
Identification division.
  Program-id. "TestAccounts" recursive.
  Environment division.
  Configuration section.
  Repository.
  Class Account is "Account".
Data Division.
  * Working data is declared in LOCAL-STORAGE instead of
  * WORKING-STORAGE so that each thread has its own copy:
  Local-storage section.
    01 anAccount usage object reference Account.
  *
  Procedure division.
  Test-Account-section.
    Display "Test Account class"
    * Create account 123456 with 0 balance:
      Invoke Account "createAccount"
      using by value 123456
      returning anAccount
    * Deposit 500 to the account:
      Invoke anAccount "credit" using by value 500
      Invoke anAccount "print"
    Display space
    *
    Stop Run.
End program "TestAccounts".

“Example: defining a factory (with methods)” on page 589

related tasks
“Defining a factory method” on page 587
“Invoking factory or static methods” on page 588
Chapter 16, “Compiling, linking, and running OO applications,” on page 273

Defining a subclass

You can make a class (called a subclass, derived class, or child class) a specialization of another class (called a superclass, base class, or parent class).

A subclass inherits the methods and instance data of its superclasses, and is related to its superclasses by an is-a relationship. For example, if subclass P inherits from superclass Q, and subclass Q inherits from superclass S, then an instance of P is an instance of Q and also (by transitivity) an instance of S. An instance of P inherits the methods and data of Q and S.

Using subclasses has several advantages:

• Reuse of code: Through inheritance, a subclass can reuse methods that already exist in a superclass.
• Specialization: In a subclass you can add new methods to handle cases that the superclass does not handle. You can also add new data items that the superclass does not need.
• Change in action: A subclass can override a method that it inherits from a superclass by defining a method of the same signature as that in the superclass. When you override a method, you might make only a few minor changes or completely change what the method does.

Restriction: You cannot use multiple inheritance in your COBOL programs. Each COBOL class that you define must have exactly one immediate superclass that is implemented in Java or COBOL, and each class must be derived directly or indirectly from java.lang.Object. The semantics of inheritance are as defined by Java.
The structure and syntax of a subclass definition are identical to those of a class definition: Define instance data and methods in the DATA DIVISION and PROCEDURE DIVISION, respectively, within the OBJECT paragraph of the subclass definition. In subclasses that require data and methods that are to be associated with the subclass itself rather than with individual object instances, define a separate DATA DIVISION and PROCEDURE DIVISION within the FACTORY paragraph of the subclass definition.

COBOL instance data is private. A subclass can access the instance data of a COBOL superclass only if the superclass defines attribute (get or set) instance methods for doing so.

“Example: accounts” on page 558
“Example: defining a subclass (with methods)” on page 585

related tasks
“Defining a class” on page 560
“Overriding an instance method” on page 568
“Coding attribute (get and set) methods” on page 569
“Defining a subclass instance method” on page 584
“Defining a factory section” on page 586

related references
The Java Language Specification (Inheritance, overriding, and hiding)
COBOL class definition structure (Enterprise COBOL for z/OS Language Reference)

CLASS-ID paragraph for defining a subclass

Use the CLASS-ID paragraph to name the subclass and indicate from which immediate Java or COBOL superclass it inherits its characteristics.

Identification Division. Required
Class-id. CheckingAccount inherits Account. Required

In the example above, CheckingAccount is the subclass being defined. CheckingAccount inherits all the methods of the class known within the subclass definition as Account. CheckingAccount methods can access Account instance data only if the Account class provides attribute (get or set) methods for doing so.

You must specify the name of the immediate superclass in the REPOSITORY paragraph in the CONFIGURATION SECTION of the ENVIRONMENT DIVISION. You can optionally associate the superclass name with the name of the class as it is known externally. You can also specify the name of the subclass that you are defining (here, CheckingAccount) in the REPOSITORY paragraph and associate it with its corresponding external class-name.

related tasks
“CLASS-ID paragraph for defining a class” on page 561
“Coding attribute (get and set) methods” on page 569
“REPOSITORY paragraph for defining a subclass” on page 583

REPOSITORY paragraph for defining a subclass

Use the REPOSITORY paragraph to declare to the compiler that the specified words are class-names when you use them within a subclass definition, and to optionally relate the class-names to the corresponding external class-names (the class-names as they are known outside the compilation unit).

For example, in the CheckingAccount subclass definition, these REPOSITORY paragraph entries indicate that the external class-names of the classes referred to as CheckingAccount, Check, and Account within the subclass definition are CheckingAccount, Check, and Account, respectively.
In the REPOSITORY paragraph, you must code an entry for each class-name that you explicitly reference in the subclass definition. For example:

- A user-defined superclass from which the subclass that you are defining inherits
- The classes that you reference in methods within the subclass definition

The rules for coding REPOSITORY paragraph entries in a subclass are identical to those for coding REPOSITORY paragraph entries in a class.

**related tasks**

“REPOSITORY paragraph for defining a class” on page 562

**related references**

REPOSITORY paragraph (Enterprise COBOL for z/OS Language Reference)

**WORKING-STORAGE SECTION for defining subclass instance data**

Use the WORKING-STORAGE SECTION in the DATA DIVISION of the subclass OBJECT paragraph to describe any instance data that the subclass needs in addition to the instance data defined in its superclasses. Use the same syntax that you use to define instance data in a class.

For example, the definition of the instance data for the CheckingAccount subclass of the Account class might look like this:

```cobol
IDENTIFICATION DIVISION.
Object.
DATA DIVISION.
WORKING-STORAGE SECTION.
  01 CheckFee pic S9(9) value 1.
End Object.
```

**related tasks**

“WORKING-STORAGE SECTION for defining class instance data” on page 563

**Defining a subclass instance method**

A subclass inherits the methods of its superclasses. In a subclass definition, you can override any instance method that the subclass inherits by defining an instance method with the same signature as the inherited method. You can also define new methods that the subclass needs.

The structure and syntax of a subclass instance method are identical to those of a class instance method. Define subclass instance methods in the PROCEDURE DIVISION of the OBJECT paragraph of the subclass definition.

“Example: defining a subclass (with methods)” on page 585

**related tasks**

“Defining a class instance method” on page 564
“Overriding an instance method” on page 568
“Overloading an instance method” on page 569
Example: defining a subclass (with methods)
The following example shows the instance method definitions for the CheckingAccount subclass of the Account class.

The processCheck method invokes the Java instance methods getAmount and getPayee of the Check class to get the check data. It invokes the credit and debit instance methods inherited from the Account class to credit the payee and debit the payer of the check.

The print method overrides the print instance method defined in the Account class. It invokes the overridden print method to display account status, and also displays the check fee. CheckFee is an instance data item defined in the subclass.

(The Account class was shown in “Example: defining a method” on page 570.)

CheckingAccount class (subclass of Account)

cbl dll,thread,pgmname(longmixed)
Identification Division.
Class-id. CheckingAccount inherits Account.
Environment Division.
Configuration section.
Repository.
   Class CheckingAccount is "CheckingAccount"
   Class Check           is "Check"
   Class Account         is "Account".
*   (FACTORY paragraph not shown)
*   Identification division.
   Object.
   Data division.
   Working-storage section.
01 CheckFee pic S9(9) value 1.
Procedure Division.
   *   processCheck method to get the check amount and payee,
   *   add the check fee, and invoke inherited methods debit
   *   to debit the payer and credit to credit the payee:
   Identification Division.
   Method-id. "processCheck".
   Data division.
   Local-storage section.
01 amount pic S9(9) binary.
01 payee usage object reference Account.
   Linkage section.
01 aCheck usage object reference Check.
   *   Procedure Division using by value aCheck.
      Invoke aCheck "getAmount" returning amount
      Invoke aCheck "getPayee" returning payee
      Invoke payee "credit" using by value amount
      Add checkFee to amount
      Invoke self "debit"  using by value amount.
   End method "processCheck".
   *   print method override to display account status:
   Identification Division.
   Method-id. "print".
   Data division.
   Local-storage section.
01 printableFee pic $$,$$$,$$9.
   Procedure Division.
      Invoke super "print"
      Move CheckFee to printableFee
      Display " Check fee: " printableFee.
   End method "print".
*   End Object.
*   End class CheckingAccount.

related tasks
Chapter 16, “Compiling, linking, and running OO applications,” on page 273
“Invoking methods (INVOKE)” on page 576

Chapter 32. Writing object-oriented programs 585
Defining a factory section

Use the FACTORY paragraph in a class definition to define data and methods that are to be associated with the class itself rather than with individual object instances.

COBOL *factory data* is equivalent to Java private static data. A single copy of the data is instantiated for the class and is shared by all object instances of the class. You most commonly use factory data when you want to gather data from all the instances of a class. For example, you could define a factory data item to keep a running total of the number of instances of the class that are created.

COBOL *factory methods* are equivalent to Java public static methods. The methods are supported by the class independently of any object instance. You most commonly use factory methods to customize object creation when you cannot use VALUE clauses alone to initialize instance data.

By contrast, you use the OBJECT paragraph in a class definition to define data that is created for each object instance of the class, and methods that are supported for each object instance of the class.

A factory definition consists of three divisions, followed by an END FACTORY statement:

<table>
<thead>
<tr>
<th>Table 80. Structure of factory definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Division</strong></td>
</tr>
<tr>
<td>IDENTIFICATION (required)</td>
</tr>
<tr>
<td>DATA (optional)</td>
</tr>
<tr>
<td>PROCEDURE (optional)</td>
</tr>
</tbody>
</table>

**WORKING-STORAGE SECTION for defining factory data**

Use the WORKING-STORAGE SECTION in the DATA DIVISION of the FACTORY paragraph to describe the *factory data* that a COBOL class needs, that is, statically allocated data to be shared by all object instances of the class.

The FACTORY keyword, which you must immediately precede with an IDENTIFICATION DIVISION declaration, indicates the beginning of the definitions of the factory data and factory methods for the class. For example, the definition of the factory data for the Account class might look like this:

```
IDENTIFICATION DIVISION.
Factory.
DATA DIVISION.
WORKING-STORAGE SECTION.
```
You can initialize simple factory data by using VALUE clauses as shown above.

COBOL factory data is equivalent to Java private static data. No other class or subclass (nor instance method in the same class, if any) can reference COBOL factory data directly. Factory data is global to all factory methods that the FACTORY paragraph defines. If you want to make factory data accessible from outside the FACTORY paragraph, define factory attribute (get or set) methods for doing so.

related tasks
“Coding attribute (get and set) methods” on page 569
“Instantiating COBOL classes” on page 581

Defining a factory method

Define COBOL factory methods in the PROCEDURE DIVISION of the FACTORY paragraph of a class definition. A factory method defines an operation that is supported by a class independently of any object instance of the class. COBOL factory methods are equivalent to Java public static methods.

You typically define factory methods for classes whose instances require complex initialization, that is, to values that you cannot assign by using VALUE clauses alone. Within a factory method you can invoke instance methods to initialize the instance data. A factory method cannot directly access instance data.

You can code factory attribute (get and set) methods to make factory data accessible from outside the FACTORY paragraph, for example, to make the data accessible from instance methods in the same class or from a client program. For example, the Account class could define a factory method getNumberOfAccounts to return the current tally of the number of accounts.

You can use factory methods to wrap procedure-oriented COBOL programs so that they are accessible from Java programs. You can code a factory method called main to enable you to run an OO application by using the java command, and to structure your applications in keeping with standard Java practice. See the related tasks for details.

In defining factory methods, you use the same syntax that you use to define instance methods. A COBOL factory method definition consists of four divisions (like a COBOL program), followed by an END METHOD marker:

<table>
<thead>
<tr>
<th>Division</th>
<th>Purpose</th>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDENTIFICATION (required)</td>
<td>Same as for a class instance method</td>
<td>Same as for a class instance method (required)</td>
</tr>
<tr>
<td>ENVIRONMENT (optional)</td>
<td>Same as for a class instance method</td>
<td>Same as for a class instance method</td>
</tr>
<tr>
<td>DATA (optional)</td>
<td>Same as for a class instance method</td>
<td>Same as for a class instance method</td>
</tr>
<tr>
<td>PROCEDURE (optional)</td>
<td>Same as for a class instance method</td>
<td>Same as for a class instance method</td>
</tr>
</tbody>
</table>

Within a class definition, you do not need to make each factory method-name unique, but you do need to give each factory method a unique signature. You can overload factory methods in exactly the same way that you overload instance methods. For example, the CheckingAccount subclass provides two versions of the factory method createCheckingAccount: one that initializes the account to have a default balance of zero, and one that allows the opening balance to be passed in. Clients can invoke either createCheckingAccount method by passing arguments that match the signature of the intended method.
If you define a data item with the same name in both the DATA DIVISION of a factory method and the DATA DIVISION of the FACTORY paragraph, a reference in the method to that data-name refers only to the method data item. The method DATA DIVISION takes precedence.

“Example: defining a factory (with methods)” on page 589

related tasks
“Structuring OO applications” on page 594
“Wrapping procedure-oriented COBOL programs” on page 593
“Instantiating COBOL classes” on page 581
“Defining a class instance method” on page 564
“Coding attribute (get and set) methods” on page 569
“Overloading an instance method” on page 569
“Hiding a factory or static method” on page 588
“Invoking factory or static methods” on page 588
“Using object-oriented COBOL and Java under IMS” on page 431

Hiding a factory or static method
A factory method defined in a subclass is said to hide an inherited COBOL or Java method that would otherwise be accessible in the subclass if the two methods have the same signature.

To hide a superclass factory method fi1 in a COBOL subclass, define a factory method fi1 in the subclass that has the same name and whose PROCEDURE DIVISION USING phrase (if any) has the same number and type of formal parameters as the superclass method has. (If the superclass method is implemented in Java, you must code formal parameters that are interoperable with the data types of the corresponding Java parameters.) When a client invokes fi1 using the subclass name, the subclass method rather than the superclass method is invoked.

The presence or absence of a method return value and the data type of the return value used in the PROCEDURE DIVISION RETURNING phrase (if any) must be identical in the subclass factory method and the hidden superclass method.

A factory method must not hide an instance method in a Java or COBOL superclass.

“Example: defining a factory (with methods)” on page 589

related tasks
“Coding interoperable data types in COBOL and Java” on page 601
“Overriding an instance method” on page 568
“Invoking methods (INVOKE)” on page 576

related references
The Java Language Specification (Inheritance, overriding, and hiding)
The procedure division header (Enterprise COBOL for z/OS Language Reference)

Invoking factory or static methods
To invoke a COBOL factory method or Java static method in a COBOL method or client program, code the class-name as the first operand of the INVOKE statement.

For example, a client program could invoke one of the overloaded CheckingAccount factory methods called createCheckingAccount to create a checking account with account number 777777 and an opening balance of $300 by coding this statement:

```
Invoke CheckingAccount "createCheckingAccount"
    using by value 777777 300
    returning aCheckingAccount
```

To invoke a factory method from within the same class in which you define the factory method, you also use the class-name as the first operand in the INVOKE statement.
Code the name of the method to be invoked either as a literal or as an identifier whose value at run time is the method-name. The method-name must be an alphanumeric or national literal or a category alphabetic, alphanumeric, or national data item, and is interpreted in a case-sensitive manner.

If an invoked method is not supported in the class that you name in the INVOKE statement, a severity-3 Language Environment condition is raised at run time unless you code the ON EXCEPTION phrase in the INVOKE statement.

The conformance requirements for passing arguments to a COBOL factory method or Java static method in the USING phrase, and receiving a return value in the RETURNING phrase, are the same as those for invoking instance methods.

“Example: defining a factory (with methods)” on page 589

related tasks
“Invoking methods (INVOKE)” on page 576
“Using national data (Unicode) in COBOL” on page 124
“Coding interoperable data types in COBOL and Java” on page 601

related references
INVOKE statement (Enterprise COBOL for z/OS Language Reference)

Example: defining a factory (with methods)
The following example updates the previous examples to show the definition of factory data and methods.

These updates are shown:

• The Account class adds factory data and a parameterized factory method, createAccount, which allows an Account instance to be created using an account number that is passed in.

• The CheckingAccount subclass adds factory data and an overloaded parameterized factory method, createCheckingAccount. One implementation of createCheckingAccount initializes the account with a default balance of zero, and the other allows the opening balance to be passed in. Clients can invoke either method by passing arguments that match the signature of the required method.

• The TestAccounts client invokes the services provided by the factory methods of the Account and CheckingAccount classes, and instantiates the Java Check class.

• The output from the TestAccounts client program is shown.

(The previous examples were “Example: defining a method” on page 570, “Example: defining a client” on page 581, and “Example: defining a subclass (with methods)” on page 585.)

You can also find the complete source code for this example in the cobol/demo/oosample subdirectory in the z/OS UNIX file system. Typically the complete path for the source is /usr/lpp/cobol/demo/oosample. You can use the makefile there to compile and link the code.

Account class

```
cbl dll,thread,pgmname(longmixed)  
Identification Division.  
Class-id. Account inherits Base.  
Environment Division.  
Configuration section.  
Repository.  
  Class Base is "java.lang.Object"  
  Class Account is "Account".  
*  
Identification division.  
Factory.  
Data division.  
Working-storage section.  
01 NumberOfAccounts pic 9(6) value zero.  
*  
Procedure Division.  
*  
```
* createAccount method to create a new Account instance, then invoke the OBJECT paragraph’s init method on the instance to initialize its instance data:
  * Identification Division.
  * Method-id. "createAccount".
  * Data division.
  * Linkage section.
  * 01 inAccountNumber  pic S9(6) binary.
  * 01 outAccount object reference Account.
  * Facilitate access to JNI services:
    Copy JNI.
  * Procedure Division using by value inAccountNumber
    returning outAccount.
    * Establish addressability to JNI environment structure:
      Set address of JNIEnv to JNIEnvPtr
      Set address of JNINativeInterface to JNIEnv
      Invoke Account New returning outAccount
      Invoke outAccount "init" using by value inAccountNumber
    Add 1 to NumberOfAccounts.
  * End method "createAccount".
* End Factory.
* Identification division.
* Object.
* Data division.
  * Working-storage section.
  * 01 AccountNumber  pic 9(6).
  * 01 AccountBalance pic S9(9) value zero.
* Procedure Division.
  * init method to initialize the account:
    * Identification Division.
    * Method-id. "init".
    * Data division.
    * Linkage section.
    * 01 inAccountNumber pic S9(9) binary.
    * Procedure Division using by value inAccountNumber.
      Move inAccountNumber to AccountNumber.
    * End method "init".
* getBalance method to return the account balance:
  * Identification Division.
  * Method-id. "getBalance".
  * Data division.
  * Linkage section.
  * 01 outBalance pic S9(9) binary.
  * Procedure Division returning outBalance.
    Move AccountBalance to outBalance.
  * End method "getBalance".
* credit method to deposit to the account:
  * Identification Division.
  * Method-id. "credit".
  * Data division.
  * Linkage section.
  * 01 inCredit   pic S9(9) binary.
  * Procedure Division using by value inCredit.
    Add inCredit to AccountBalance.
  * End method "credit".
* debit method to withdraw from the account:
  * Identification Division.
  * Method-id. "debit".
  * Data division.
  * Linkage section.
  * 01 inDebit    pic S9(9) binary.
  * Procedure Division using by value inDebit.
    Subtract inDebit from AccountBalance.
  * End method "debit".
* print method to display formatted account number and balance:
  * Identification Division.
  * Method-id. "print".
  * Data division.
  * Local-storage section.
  * 01 PrintableAccountNumber  pic ZZZZZ999999.
  * 01 PrintableAccountBalance pic $$ $$ $$ $$ $$9CR.
  * Procedure Division.
    Move AccountNumber to PrintableAccountNumber
    Move AccountBalance to PrintableAccountBalance
Display "Account: " PrintableAccountNumber
End method "print".

End Object.

End class Account.

**CheckingAccount class (subclass of Account)**

cbl dll,thread,pgmname(longmixed)
Identification Division.
Class-id. CheckingAccount inherits Account.
Environment Division.
Configuration section.
Repository.
    Class CheckingAccount is "CheckingAccount"
    Class Check           is "Check"
    Class Account         is "Account".

Identification division.
Factory.
    Data division.
    Working-storage section.
    01 NumberOfCheckingAccounts pic 9(6) value zero.

Procedure Division.

* createCheckingAccount overloaded method to create a new
  CheckingAccount instance with a default balance, invoke
  inherited instance method init to initialize the account
  number, and increment factory data tally of checking accounts:
    Identification Division.
    Method-id. "createCheckingAccount".
    Data division.
    Linkage section.
    01 inAccountNumber  pic S9(6) binary.
    01 outCheckingAccount object reference CheckingAccount.
    * Facilitate access to JNI services:
      Copy JNI.
      Procedure Division using by value inAccountNumber
      returning outCheckingAccount.
      * Establish addressability to JNI environment structure:
        Set address of JNIEnv to JNIEnvPtr
        Set address of JNI NativeInterface to JNIEnv
        Invoke CheckingAccount New returning outCheckingAccount
        Invoke outCheckingAccount "init"
        using by value inAccountNumber
        Add 1 to NumberOfCheckingAccounts.
      End method "createCheckingAccount".

* createCheckingAccount overloaded method to create a new
  CheckingAccount instance, invoke inherited instance methods
  init to initialize the account number and credit to set the
  balance, and increment factory data tally of checking accounts:
    Identification Division.
    Method-id. "createCheckingAccount".
    Data division.
    Linkage section.
    01 inAccountNumber  pic S9(6) binary.
    01 inInitialBalance pic S9(9) binary.
    01 outCheckingAccount object reference CheckingAccount.
    Copy JNI.
    Procedure Division using by value inAccountNumber
    inInitialBalance
    returning outCheckingAccount.
    * Set address of JNIEnv to JNIEnvPtr
    * Set address of JNI NativeInterface to JNIEnv
    * Invoke CheckingAccount New returning outCheckingAccount
      using by value inAccountNumber
    * Invoke outCheckingAccount "credit"
      using by value inInitialBalance
    Add 1 to NumberOfCheckingAccounts.
    End method "createCheckingAccount".

End Factory.

* Identification division.

Chapter 32. Writing object-oriented programs  591
Object.
   Data division.
   Working-storage section.
   01 CheckFee pic S9(9) value 1.
   Procedure Division.
   *   processCheck method to get the check amount and payee,
   *   add the check fee, and invoke inherited methods debit
   *   to debit the payer and credit to credit the payee:
      Identification Division.
      Method-id. "processCheck".
      Data division.
      Local-storage section.
      01 amount pic S9(9) binary.
      01 payee usage object reference Account.
      Linkage section.
      01 aCheck usage object reference Check.
      Procedure Division using by value aCheck.
      Invoke aCheck "getAmount" returning amount
      Invoke aCheck "getPayee" returning payee
      Invoke payee "credit" using by value amount
      Add checkFee to amount
      Invoke self "debit" using by value amount.
      End method "processCheck".
   *
   *   print method override to display account status:
      Identification Division.
      Method-id. "print".
      Data division.
      Local-storage section.
      01 printableFee pic $$,$$$,$$9.
      Procedure Division.
      Invoke super "print"
      Move CheckFee to printableFee
      Display " Check fee: " printableFee.
      End method "print".
   *
   End Object.
   *
   End class CheckingAccount.

Check class

/**
 * A Java class for check information
 */
public class Check {
   private CheckingAccount payer;
   private Account payee;
   private int amount;
   public Check(CheckingAccount inPayer, Account inPayee, int inAmount) {
      payer=inPayer;
      payee=inPayee;
      amount=inAmount;
   }
   public int getAmount() {
      return amount;
   }
   public Account getPayee() {
      return payee;
   }
}

TestAccounts client program

cbl dll,thread,pgmname(longmixed)
Identification division.
Program-id. "TestAccounts" recursive.
Environment division.
Configuration section.
Repository.
   Class Account is "Account"
   Class CheckingAccount is "CheckingAccount"
Class Check is "Check".

Data Division.
* Working data is declared in Local-storage
  * so that each thread has its own copy:

Local-storage section.
01 anAccount usage object reference Account.
01 aCheckingAccount usage object reference CheckingAccount.
01 aCheck usage object reference Check.
01 payee usage object reference Account.

* Procedure division.
  Test-Account-section.
  Display "Test Account class"
  * Create account 123456 with 0 balance:
  Invoke Account "createAccount" using by value 123456
  returning anAccount
  * Deposit 500 to the account:
  Invoke anAccount "credit" using by value 500
  Invoke anAccount "print"
  Display space

  * Display "Test CheckingAccount class"
  * Create checking account 777777 with balance of 300:
  Invoke CheckingAccount "createCheckingAccount" using by value 777777 300
  returning aCheckingAccount
  * Set account 123456 as the payee:
  Set payee to anAccount
  * Initialize check for 125 to be paid by account 777777 to payee:
  Invoke Check New using by value aCheckingAccount, payee, 125
  returning aCheck
  * Debit the payer, and credit the payee:
  Invoke aCheckingAccount "processCheck" using by value aCheck
  Invoke aCheckingAccount "print"
  Invoke anAccount "print"

* Stop Run.
End program "TestAccounts".

Output produced by the TestAccounts client program

Test Account class
Account:    123456
Balance:    $500

Test CheckingAccount class
Account:    777777
Balance:    $174
Check fee:  $1
Account:    123456
Balance:    $625

related tasks
"Creating and initializing instances of classes" on page 580
"Defining a factory method" on page 587
"Invoking factory or static methods" on page 588
Chapter 16, "Compiling, linking, and running OO applications," on page 273

Wrapping procedure-oriented COBOL programs

A wrapper is a class that provides an interface between object-oriented code and procedure-oriented code. Factory methods provide a convenient means for writing wrappers for existing procedural COBOL code to make it accessible from Java programs.

To wrap COBOL code, do these steps:
1. Create a simple COBOL class that contains a FACTORY paragraph.
2. In the FACTORY paragraph, code a factory method that uses a CALL statement to call the procedural program.

A Java program can invoke the factory method by using a static method invocation expression, thus invoking the COBOL procedural program.

related tasks
“Defining a class” on page 560
“Defining a factory section” on page 586
“Defining a factory method” on page 587

Structuring OO applications

You can structure applications that use object-oriented COBOL syntax in one of three ways.

An OO application can begin with:

- A COBOL program, which can have any name.
  Under z/OS UNIX, you can run the application by specifying the name of the linked module (which should match the program name) at the command prompt. You can also bind the program as a module in a PDSE and run it in JCL using the EXEC PGM statement.
- A Java class definition that contains a method called main. Declare main as public, static, and void, with a single parameter of type String[]. You can run the application with the java command, specifying the name of the class that contains main, and zero or more strings as command-line arguments.
- A COBOL class definition that contains a factory method called main. Declare main with no RETURNING phrase and a single USING parameter, an object reference to a class that is an array with elements of type java.lang.String. (Thus main is in effect public, static, and void, with a single parameter of type String[].) You can run the application with the java command, specifying the name of the class that contains main, and zero or more strings as command-line arguments.

Structure an OO application this way if you want to:
- Run the application by using the java command.
- Run the application in an environment where applications must start with the main method of a Java class (such as a Java dependent region).
- Follow standard Java programming practice.

“Examples: COBOL applications that run using the java command” on page 594

related tasks
Chapter 16, “Compiling, linking, and running OO applications,” on page 273
“Defining a factory method” on page 587
“Declaring arrays and strings for Java” on page 602
Chapter 22, “Developing COBOL programs for IMS,” on page 427

Examples: COBOL applications that run using the java command
The following examples show COBOL class definitions that contain a factory method called main.

In each case, main has no RETURNING phrase and has a single USING parameter, an object reference to a class that is an array with elements of type java.lang.String. You can run these applications by using the java command.
**Displaying a message**

cbl dll,thread
Identification Division.
Class-id. CBLmain inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base is "java.lang.Object"
    Class stringArray is "jobjectArray:java.lang.String"
    Class CBLmain is "CBLmain".
*
Identification Division.
Factory.
Procedure division.
*
Identification Division.
Method-id. "main".
Data division.
    Linkage section.
        01 SA usage object reference stringArray.
    Procedure division using by value SA.
        Display " >> COBOL main method entered"
    End method "main".
End factory.
End class CBLmain.

**Echoing the input strings**

cbl dll,thread,pgmname(longmixed),ssrange
Identification Division.
Class-id. Echo inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base is "java.lang.Object"
    Class stringArray is "jobjectArray:java.lang.String"
    Class jstring is "java.lang.String"
    Class Echo is "Echo".
*
Identification Division.
Factory.
Procedure division.
*
Identification Division.
Method-id. "main".
Data division.
    Linkage section.
        01 SAlen        pic s9(9) binary.
        01 I            pic s9(9) binary.
        01 SAelement    object reference jstring.
        01 SAelementlen pic s9(9) binary.
        01 Sbuffer      pic X(65535).
        01 P            pointer.
    Procedure division using by value SA.
        Copy "JNI.cpy" suppress.
        Procedure division using by value SA.
            Set address of JNIEnv to JNIEnvPtr
            Set address of JNINativeInterface to JNIEnv
            Call GetArrayLength using by value JNIEnvPtr SA
            returning SAlen
            Display "Input string array length: " SAlen
            Display "Input strings:"
            Perform varying I from 0 by 1 until I = SAlen
            Call GetObjectArrayElement
                using by value JNIEnvPtr SA I
                returning SAelement
            Call "GetStringPlatformLength"
                using by value JNIEnvPtr
                SAelement
                address of SAelementlen
                0
            Call "GetStringPlatform"
                using by value JNIEnvPtr

Chapter 32. Writing object-oriented programs  595
SAelement
address of Sbuffer
length of Sbuffer
0
Display Sbuffer(1:SAelementlen)
End-perform
.
End method "main".
End factory.
End class Echo.

related tasks
Chapter 16, “Compiling, linking, and running OO applications,” on page 273
“Defining a factory method” on page 587
Chapter 33, “Communicating with Java methods,” on page 597
Chapter 33. Communicating with Java methods

To achieve interlanguage interoperability with Java, you need to follow certain rules and guidelines for using services in the Java Native Interface (JNI), coding data types, and compiling COBOL programs.

You can invoke methods that are written in Java from COBOL programs, and you can invoke methods that are written in COBOL from Java programs. You need to code COBOL object-oriented language for basic Java object capabilities. For additional Java capabilities, you can call JNI services.

Because Java programs might be multithreaded and use asynchronous signals, compile COBOL programs with the THREAD option.

“Example: J2EE client written in COBOL” on page 608

related tasks
Chapter 16, “Compiling, linking, and running OO applications,” on page 273
“Accessing JNI services” on page 597
“Sharing data with Java” on page 601
Chapter 32, “Writing object-oriented programs,” on page 557
Chapter 27, “Preparing COBOL programs for multithreading,” on page 487

related references
JDK 5.0 Documentation

Accessing JNI services

The Java Native Interface (JNI) provides many callable services that you can use when you develop applications that mix COBOL and Java. To facilitate access to these services, copy JNI.cpy into the LINKAGE SECTION of your COBOL program.

The JNI.cpy copybook contains these definitions:

• COBOL data definitions that correspond to the Java JNI types
• JNINativeInterface, the JNI environment structure that contains function pointers for accessing the callable service functions

You obtain the JNI environment structure by two levels of indirection from the JNI environment pointer, as the following illustration shows:

Use the special register JNIEnvPtr to reference the JNI environment pointer to obtain the address for the JNI environment structure. JNIEnvPtr is implicitly defined as USAGE POINTER; do not use it as a receiving data item. Before you reference the contents of the JNI environment structure, you must code the following statements to establish its addressability:

Linkage section.
COPY JNI
Procedure division.
   Set address of JNIEnv to JNIEnvPtr
   Set address of JNINativeInterface to JNIEnv

The code above sets the addresses of the following items:

- JNIEnv, a pointer data item that JNI . cpy provides. JNIEnvPtr is the COBOL special register that contains the environment pointer.
- JNINativeInterface, the COBOL group structure that JNI . cpy contains. This structure maps the JNI environment structure, which contains an array of function pointers for the JNI callable services.

After you code the statements above, you can access the JNI callable services with CALL statements that reference the function pointers. You can pass the JNIEnvPtr special register as the first argument to the services that require the environment pointer, as shown in the following example:

```
01 InputArrayObj usage object reference jlongArray.
01 ArrayLen pic S9(9) comp-5.
   . . Call GetArrayLength using by value JNIEnvPtr InputArrayObj
       returning ArrayLen
```

**Important:** Pass all arguments to the JNI callable services by value.

Some JNI callable services require a Java class-object reference as an argument. To obtain a reference to the class object that is associated with a class, use one of the following JNI callable services:

- GetObjectClass
- FindClass

**Restriction:** The JNI environment pointer is thread specific. Do not pass it from one thread to another.

**related tasks**
- “Managing local and global references” on page 599
- “Handling Java exceptions” on page 598
- “Coding interoperable data types in COBOL and Java” on page 601
- “Defining a client” on page 572

**related references**
Appendix F, “JNI . cpy copybook,” on page 697
*The Java Native Interface*

### Handling Java exceptions

Use JNI services to throw and catch Java exceptions.

**Throwing an exception:** Use one of the following services to throw a Java exception from a COBOL method:

- Throw
- ThrowNew

You must make the thrown object an instance of a subclass of java.lang.Throwable.

The Java virtual machine (JVM) does not recognize and process the thrown exception until the method that contains the call has completed and returned to the JVM.

**Catching an exception:** After you invoke a method that might have thrown a Java exception, you can do these steps:

1. Test whether an exception occurred.
2. If an exception occurred, process the exception.
3. Clear the exception, if clearing is appropriate.
Use the following JNI services:

- ExceptionOccurred
- ExceptionCheck
- ExceptionDescribe
- ExceptionClear

To do error analysis, use the methods supported by the exception object that is returned. This object is an instance of the java.lang.Throwable class.

“Example: handling Java exceptions” on page 599

**Example: handling Java exceptions**

The following example shows the use of JNI services for catching an exception from Java and the use of the printStackTrace method of java.lang.Throwable for error analysis.

```java
// Repository.
Class JavaException is "java.lang.Exception".
...
// Local-storage section.
01 ex usage object reference JavaException.
Linkage section.
COPY "JNI.cpy".
// Procedure division.
  Set address of JNIEnv to JNIEnvPtr
  Set address of JNINativeInterface to JNIEnv
  ...
  // Invoke anObj "someMethod"
  Perform ErrorCheck
  ...
// ErrorCheck.
  Call ExceptionOccurred using by value JNIEnvPtr
  returning ex
  If ex not = null then
    Call ExceptionClear using by value JNIEnvPtr
    Display "Caught an unexpected exception"
    Invoke ex "printStackTrace"
    Stop run
  End-if
```

**Managing local and global references**

The Java virtual machine tracks the object references that you use in native methods, such as COBOL methods. This tracking ensures that the objects are not prematurely released during garbage collection.

There are two classes of such references:

**Local references**

- Local references are valid only while the method that you invoke runs. Automatic freeing of the local references occurs after the native method returns.

**Global references**

- Global references remain valid until you explicitly delete them. You can create global references from local references by using the JNI service NewGlobalRef.

The following object references are always local:

- Object references that are received as method parameters
- Object references that are returned as the method RETURNING value from a method invocation
- Object references that are returned by a call to a JNI function
- Object references that you create by using the INVOKE . . . NEW statement

You can pass either a local reference or a global reference as an object reference argument to a JNI service.
You can code methods to return either local or global references as RETURNING values. However, in either case, the reference that is received by the invoking program is a local reference.

You can pass either local or global references as USING arguments in a method invocation. However, in either case, the reference that is received by the invoked method is a local reference.

Local references are valid only in the thread in which you create them. Do not pass them from one thread to another.

related tasks
“Accessing JNI services” on page 597
“Deleting, saving, and freeing local references” on page 600

Deleting, saving, and freeing local references
You can manually delete local references at any point within a method. Save local references only in object references that you define in the LOCAL-STORAGE SECTION of a method.

Use a SET statement to convert a local reference to a global reference if you want to save a reference in any of these data items:
- An object instance variable
- A factory variable
- A data item in the WORKING-STORAGE SECTION of a method
Otherwise, an error occurs. These storage areas persist when a method returns; therefore a local reference is no longer valid.

In most cases you can rely on the automatic freeing of local references that occurs when a method returns. However, in some cases you should explicitly free a local reference within a method by using the JNI service DeleteLocalRef. Here are two situations where explicit freeing is appropriate:
- In a method you access a large object, thereby creating a local reference to the object. After extensive computations, the method returns. Free the large object if you do not need it for the additional computations, because the local reference prevents the object from being released during garbage collection.
- You create a large number of local references in a method, but do not use all of them at the same time. Because the Java virtual machine requires space to keep track of each local reference, you should free those that you no longer need. Freeing the local references helps prevent the system from running out of memory.

For example, in a COBOL method you loop through a large array of objects, retrieve the elements as local references, and operate on one element at each iteration. You can free the local reference to the array element after each iteration.

Use the following callable services to manage local references and global references.

<table>
<thead>
<tr>
<th>Table 82. JNI services for local and global references</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Service</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
</tbody>
</table>
| NewGlobalRef | • The JNI environment pointer  
• A local or global object reference | The global reference, or NULL if the system is out of memory | To create a new global reference to the object that the input object reference refers to |
| DeleteGlobalRef | • The JNI environment pointer  
• A global object reference | None | To delete a global reference to the object that the input object reference refers to |
Table 82. JNI services for local and global references (continued)

<table>
<thead>
<tr>
<th>Service</th>
<th>Input arguments</th>
<th>Return value</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeleteLocalRef</td>
<td>• The JNI environment pointer</td>
<td>None</td>
<td>To delete a local reference to the object that the input object reference refers to</td>
</tr>
<tr>
<td></td>
<td>• A local object reference</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

related tasks
“Accessing JNI services” on page 597

Java access controls

The Java access modifiers protected and private are not enforced when you use the Java Native Interface. Therefore a COBOL program could invoke a protected or private Java method that is not invocable from a Java client. This usage is not recommended.

Sharing data with Java

You can share the COBOL data types that have Java equivalents. (Some COBOL data types have Java equivalents, but others do not.)

Share data items with Java in these ways:
• Pass them as arguments in the USING phrase of an INVOKE statement.
• Receive them as parameters in the USING phrase from a Java method.
• Receive them as the RETURNING value in an INVOKE statement.
• Return them as the value in the RETURNING phrase of the PROCEDURE DIVISION header in a COBOL method.

To pass or receive arrays and strings, declare them as object references:
• Declare an array as an object reference that contains an instance of one of the special array classes.
• Declare a string as an object reference that contains an instance of the jstring class.

related tasks
“Coding interoperable data types in COBOL and Java” on page 601
“Declaring arrays and strings for Java” on page 602
“Manipulating Java arrays” on page 603
“Manipulating Java strings” on page 606
“Invoking methods (INVOKE)” on page 576
Chapter 25, “Sharing data,” on page 461

Coding interoperable data types in COBOL and Java

Your COBOL program can use only certain data types when communicating with Java.

Table 83. Interoperable data types in COBOL and Java

<table>
<thead>
<tr>
<th>Primitive Java data type</th>
<th>Corresponding COBOL data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean</td>
<td>PIC X followed by exactly two condition-names of this form:</td>
</tr>
<tr>
<td></td>
<td>level-number data-name PIC X.</td>
</tr>
<tr>
<td></td>
<td>88 data-name-false value X'00'.</td>
</tr>
<tr>
<td></td>
<td>88 data-name-true value X'01' through X'FF'.</td>
</tr>
<tr>
<td>byte</td>
<td>Single-byte alphanumeric: PIC X or PIC A</td>
</tr>
</tbody>
</table>
Table 83. Interoperable data types in COBOL and Java (continued)

<table>
<thead>
<tr>
<th>Primitive Java data type</th>
<th>Corresponding COBOL data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>USAGE BINARY, COMP, COMP-4, or COMP-5, with PICTURE clause of the form S9(n), where 1 &lt;= n &lt;= 4</td>
</tr>
<tr>
<td>int</td>
<td>USAGE BINARY, COMP, COMP-4, or COMP-5, with PICTURE clause of the form S9(n), where 5 &lt;= n &lt;= 9</td>
</tr>
<tr>
<td>long</td>
<td>USAGE BINARY, COMP, COMP-4, or COMP-5, with PICTURE clause of the form S9(n), where 10 &lt;= n &lt;= 18</td>
</tr>
<tr>
<td>float²</td>
<td>USAGE COMP-1</td>
</tr>
<tr>
<td>double²</td>
<td>USAGE COMP-2</td>
</tr>
<tr>
<td>char</td>
<td>Single-character elementary national: PIC N USAGE NATIONAL. (Cannot be a national group.)</td>
</tr>
<tr>
<td>class types (object references)</td>
<td>USAGE OBJECT REFERENCE class-name</td>
</tr>
</tbody>
</table>

1. You must distinguish boolean from byte, because they each correspond to PIC X. PIC X is interpreted as boolean only if you define an argument or a parameter with the two condition-names as shown. Otherwise, a PIC X data item is interpreted as the Java byte type.

2. Java floating-point data is formatted according to the *IEEE Standard for Binary Floating Point Arithmetic*. Enterprise COBOL, however, uses hexadecimal floating-point representation. When you pass floating-point arguments by using an INVOKE statement, or you receive floating-point data from a Java method, the arguments and data are automatically converted as needed.

related tasks
“Using national data (Unicode) in COBOL” on page 124

Declaring arrays and strings for Java
When you communicate with Java, declare arrays by using the special array classes, and declare strings by using jstring. Code the COBOL data types shown in the table below.

Table 84. Interoperable arrays and strings in COBOL and Java

<table>
<thead>
<tr>
<th>Java data type</th>
<th>Corresponding COBOL data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean[]</td>
<td>object reference jbooleanArray</td>
</tr>
<tr>
<td>byte[]</td>
<td>object reference jbyteArray</td>
</tr>
<tr>
<td>short[]</td>
<td>object reference jshortArray</td>
</tr>
<tr>
<td>int[]</td>
<td>object reference jintArray</td>
</tr>
<tr>
<td>long[]</td>
<td>object reference jlongArray</td>
</tr>
<tr>
<td>char[]</td>
<td>object reference jcharArray</td>
</tr>
<tr>
<td>Object[]</td>
<td>object reference jobjectArray</td>
</tr>
<tr>
<td>String</td>
<td>object reference jstring</td>
</tr>
</tbody>
</table>
To use one of these classes for interoperability with Java, you must code an entry in the REPOSITORY paragraph. For example:

```
Configuration section.
Repository.
    Class jbooleanArray is "jbooleanArray".
```

The REPOSITORY paragraph entry for an object array type must specify an external class-name in one of these forms:

```
"jobjectArray"
"jobjectArray:external-classname-2"
```

In the first case, the REPOSITORY entry specifies an array class in which the elements of the array are objects of type java.lang.Object. In the second case, the REPOSITORY entry specifies an array class in which the elements of the array are objects of type `external-classname-2`. Code a colon as the separator between the specification of the jobjectArray type and the external class-name of the array elements.

The following example shows both cases. In the example, oa defines an array of elements that are objects of type java.lang.Object. aDepartment defines an array of elements that are objects of type com.acme.Employee.

```
Environment Division.
Configuration Section.
Repository.
    Class jobjectArray is "jobjectArray"
    Class Employee is "com.acme.Employee"
    Class Department is "jobjectArray:com.acme.Employee".

Linkage section.
01 oa  usage object reference jobjectArray.
01 aDepartment usage object reference Department.
...
Procedure division using by value aDepartment.
...
```

"Examples: COBOL applications that run using the java command" on page 594

The following Java array types are currently not supported for interoperation with COBOL programs.

<table>
<thead>
<tr>
<th>Java data type</th>
<th>Corresponding COBOL data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>float[]</td>
<td>object reference jfloatArray</td>
</tr>
<tr>
<td>double[]</td>
<td>object reference jdoubleArray</td>
</tr>
</tbody>
</table>

**related tasks**

"REPOSITORY paragraph for defining a class" on page 562

**Manipulating Java arrays**

To represent an array in a COBOL program, code a group item that contains a single elementary item that is of the data type that corresponds to the Java type of the array. Specify an OCCURS or OCCURS DEPENDING ON clause that is appropriate for the array.

For example, the following code specifies a structure to receive 500 or fewer integer values from a jlongArray object:

```
01  longArray.
  02  x pic 9(10) comp-5 occurs 1 to 500 times depending on N.
```
To operate on objects of the special Java-array classes, call the services that the JNI provides. You can use services to access and set individual elements of an array and for the following purposes, using the services cited:

<table>
<thead>
<tr>
<th>Table 86. JNI array services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Service</strong></td>
</tr>
</tbody>
</table>
| GetArrayLength               | • The JNI environment pointer  
|                               | • The array object reference  | The array length as a binary fullword integer | To get the number of elements in a Java array object |
| NewBooleanArray, NewByteArray, NewCharArray, NewShortArray, NewIntArray, NewLongArray | • The JNI environment pointer  
|                               | • The number of elements in the array, as a binary fullword integer | The array object reference, or NULL if the array cannot be constructed | To create a new Java array object |
| GetBooleanArrayElements, GetByteArrayElements, GetCharArrayElements, GetShortArrayElements, GetIntArrayElements, GetLongArrayElements | • The JNI environment pointer  
|                               | • The array object reference  | A pointer to the storage buffer | To extract the array elements from a Java array into a storage buffer. The services return a pointer to the storage buffer, which you can use as the address of a COBOL group data item defined in the LINKAGE SECTION. |
| ReleaseBooleanArrayElements, ReleaseByteArrayElements, ReleaseCharArrayElements, ReleaseShortArrayElements, ReleaseIntArrayElements, ReleaseLongArrayElements | • The JNI environment pointer  
|                               | • The array object reference  
|                               | • A pointer to the storage buffer  
|                               | • The release mode, as a binary fullword integer. See Java JNI documentation for details. (Recommendation: Specify 0 to copy back the array content and free the storage buffer.) | None; the storage for the array is released. | To release the storage buffer that contains elements that have been extracted from a Java array, and conditionally map the updated array values back into the array object |
| NewObjectArray               | • The JNI environment pointer  
|                               | • The number of elements in the array, as a binary fullword integer  
|                               | • An object reference for the array element class  
|                               | • An object reference for the initial element value. All array elements are set to this value. | The array object reference, or NULL if the array cannot be constructed | To create a new Java object array |
### Table 86. JNI array services (continued)

<table>
<thead>
<tr>
<th>Service</th>
<th>Input arguments</th>
<th>Return value</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| GetObjectArrayElement        | • The JNI environment pointer  
• The array object reference  
• An array element index, as a binary fullword integer using origin zero | An object reference \(^2\) | To return the element at a given index within an object array                                         |
| SetObjectArrayElement        | • The JNI environment pointer  
• The array object reference  
• The array element index, as a binary fullword integer using origin zero  
• The object reference for the new value | None \(^3\)           | To set an element within an object array                                                             |

1. NewObjectArray throws an exception if the system runs out of memory.
2. GetObjectArrayElement throws an exception if the index is not valid.
3. SetObjectArrayElement throws an exception if the index is not valid or if the new value is not a subclass of the element class of the array.

---

**“Examples: COBOL applications that run using the java command” on page 594**  
**“Example: processing a Java integer array” on page 605**

**related tasks**  
“Coding interoperable data types in COBOL and Java” on page 601
“Declaring arrays and strings for Java” on page 602
“Accessing JNI services” on page 597

**Example: processing a Java integer array**  
The following example shows the use of the Java-array classes and JNI services to process a Java integer array in COBOL.

```cobol
CBL THREAD DLL
IDENTIFICATION DIVISION.
CLASS-ID. OOAARRAY inherits Base.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
REPOSITORY.
CLASS Base is "java.lang.Object"
CLASS jintArray is "jintArray".
IDENTIFICATION DIVISION.
OBJECT.
PROCEDURE DIVISION.
IDENTIFICATION DIVISION.
METHOD-ID. "ProcessArray".
DATA DIVISION.
LOCAL-STORAGE SECTION.
01 intArrayPtr pointer.
01 intArrayLen pic S9(9) COMP-5.
LINKAGE SECTION.
COPY JNI.
01 inIntArrayObj usage object reference jintArray.
01 intArrayGroup.
  02 x pic S9(9) COMP-5 OCCURS 1 TO 1000 TIMES DEPENDING ON intArrayLen.
PROCEDURE DIVISION USING BY VALUE inIntArrayObj.
  SET ADDRESS OF JNIEnv TO JNIEnvPtr
```
Manipulating Java strings

COBOL represents Java String data in Unicode. To represent a Java String in a COBOL program, declare the string as an object reference of the jstring class. Then use JNI services to set or extract COBOL alphanumeric or national (Unicode) data from the object.

**Services for Unicode:** Use the following standard services to convert between jstring object references and COBOL USAGE NATIONAL data items. Use these services for applications that you intend to be portable between the workstation and the mainframe. Access these services by using function pointers in the JNINativeInterface environment structure.

<table>
<thead>
<tr>
<th>Service</th>
<th>Input arguments</th>
<th>Return value</th>
</tr>
</thead>
</table>
| NewString            | • The JNI environment pointer  
                      • A pointer to a Unicode string, such as a COBOL national data item  
                      • The number of characters in the string; binary fullword | jstring object reference                                |
| GetStringLength      | • The JNI environment pointer  
                      • A jstring object reference | The number of Unicode characters in the jstring object reference; binary fullword |
| GetStringChars       | • The JNI environment pointer  
                      • A jstring object reference  
                      • A pointer to a boolean data item, or NULL | • A pointer to the array of Unicode characters extracted from the jstring object, or NULL if the operation fails. The pointer is valid until it is released with ReleaseStringChars.  
                      • If the pointer to the boolean data item is not null, the boolean value is set to true if a copy is made of the string and to false if no copy is made. |
| ReleaseStringChars   | • The JNI environment pointer  
                      • A jstring object reference  
                      • A pointer to the array of Unicode characters that was returned from GetStringChars | None; the storage for the array is released. |

1. This service throws an exception if the system runs out of memory.

**Services for EBCDIC:** Use the following z/OS services, an extension of the JNI, to convert between jstring object references and COBOL alphanumeric data (PIC X(n)).
<table>
<thead>
<tr>
<th>Service</th>
<th>Input arguments</th>
<th>Return value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NewStringPlatform</td>
<td>• The JNI environment pointer&lt;br&gt;• Pointer to the null-terminated EBCDIC character string that you want to convert to a jstring object&lt;br&gt;• Pointer to the jstring object reference in which you want the result&lt;br&gt;• Pointer to the Java encoding name for the string, represented as a null-terminated EBCDIC character string¹</td>
<td>Return code as a binary fullword integer:&lt;br&gt;0&lt;br&gt;Success.&lt;br&gt;-1&lt;br&gt;Malformed input or illegal input character.&lt;br&gt;-2&lt;br&gt;Unsupported encoding; the jstring object reference pointer is set to NULL.</td>
</tr>
<tr>
<td>GetStringPlatformLength</td>
<td>• The JNI environment pointer&lt;br&gt;• jstring object reference for which you want the length&lt;br&gt;• Pointer to a binary fullword integer for the result&lt;br&gt;• Pointer to the Java encoding name for the string, represented as a null-terminated EBCDIC character string¹</td>
<td>Return code as a binary fullword integer:&lt;br&gt;0&lt;br&gt;Success.&lt;br&gt;-1&lt;br&gt;Malformed input or illegal input character.&lt;br&gt;-2&lt;br&gt;Unsupported encoding; the jstring object reference pointer is set to NULL. Returns, in the third argument, the needed length in bytes of the output buffer to hold the converted Java string, including the terminating null byte referenced by the second argument.</td>
</tr>
<tr>
<td>GetStringPlatform</td>
<td>• The JNI environment pointer&lt;br&gt;• jstring object reference that you want to convert to a null-terminated string&lt;br&gt;• Pointer to the output buffer in which you want the converted string&lt;br&gt;• Length of the output buffer as a binary fullword integer&lt;br&gt;• Pointer to the Java encoding name for the string, represented as a null-terminated EBCDIC character string¹</td>
<td>Return code as a binary fullword integer:&lt;br&gt;0&lt;br&gt;Success.&lt;br&gt;-1&lt;br&gt;Malformed input or illegal input character.&lt;br&gt;-2&lt;br&gt;Unsupported encoding; the output string is set to a null string.&lt;br&gt;-3&lt;br&gt;Conversion buffer is full.</td>
</tr>
</tbody>
</table>

¹ If the pointer is NULL, the encoding from the Java file.encoding property is used.

These EBCDIC services are packaged as a DLL that is part of your IBM Java Software Development Kit. For details about the services, see jni_convert.h in the IBM Java Software Development Kit.

Use CALL literal statements to call the services. The calls are resolved through the libjvm.x DLL side file, which you must include in the link step of any COBOL program that uses object-oriented language.
For example, the following code creates a Java String object from the EBCDIC string 'MyConverter'. (This code fragment is from the J2EE client program, which is shown in full in “Example: J2EE client written in COBOL” on page 608.)

```cobol
Move 'MyConverter' to stringBuf
Call "NewStringPlatform"
    using by value JNIEnvPtr
        address of stringBuf
        address of jstring1
    0
returning rc
```

If the EBCDIC services are the only JNI services that you call from a COBOL program, you do not need to copy the JNI . cpy copybook. You also do not need to establish addressability with the JNI environment pointer.

**Services for UTF-8:** The Java Native Interface also provides services for conversion between jstring object references and UTF-8 strings. These services are not recommended for use in COBOL programs due to the difficulty in handling UTF-8 character strings on the z/OS platform.

**related tasks**
- “Accessing JNI services” on page 597
- “CODing interoperable data types in COBOL and Java” on page 601
- “Declaring arrays and strings for Java” on page 602
- “Using national data (Unicode) in COBOL” on page 124
- Chapter 16, “Compiling, linking, and running OO applications,” on page 273

---

**Example: J2EE client written in COBOL**

The following example shows a COBOL client program that can access enterprise beans that run on a J2EE-compliant EJB server.

The COBOL client is equivalent to the J2EE client program in the Getting Started section of the Java 2 Enterprise Edition Developer's Guide. For your convenience in comparing implementations, the second example shows the equivalent Java client from the guide. (The enterprise bean is the Java implementation of the simple currency-converter enterprise bean, and is in the same guide.)

You can find an alternate version of the Java enterprise bean and client code in The Java EE 5 Tutorial, referenced below.

**COBOL client (ConverterClient.cbl)**

```cobol
Process pgmname(longmixed),dll,thread
******************************************************************************
** Demo J2EE client written in COBOL.                                      **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** Based on the sample J2EE client written in Java, which is               **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** given in the "Getting Started" chapter of "The Java(TM) 2               **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** The client:                                                            **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** - Locates the home interface of a session enterprise bean               **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** (a simple currency converter bean)                                    **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** - Creates an enterprise bean instance                                  **
** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
** - Invokes a business method (currency conversion)                      **
******************************************************************************
Identification division.
Program-id. "ConverterClient" is recursive.
Environment Division.
Configuration section.
Repository.
    Class InitialContext is "javax.naming.InitialContext"
    Class PortableRemoteObject is "javax.rmi.PortableRemoteObject"
    Class JavaObject is "java.lang.Object"
```
Class JavaClass is "java.lang.Class"
Class JavaException is "java.lang.Exception"
Class jstring is "jstring"
Class Converter is "Converter"
Class ConverterHome is "ConverterHome".

Data division.
Working-storage section.
01 initialCtx object reference InitialContext.
01 obj object reference JavaObject.
01 classObj object reference JavaClass.
01 ex object reference JavaException.
01 currencyConverter object reference Converter.
01 home object reference ConverterHome.
01 homeObject redefines home object reference JavaObject.
01 jstring1 object reference jstring.
01 stringBuf pic X(500) usage display.
01 len pic s9(9) comp-5.
01 rc pic s9(9) comp-5.
01 amount comp-2.

Linkage section.
Copy JNI.

Procedure division.
Set address of JNIenv to JNIEnvPtr
Set address of JNINativeInterface to JNIenv

*****************************************************************
* Create JNDI naming context.                                    *
*****************************************************************
Invoke InitialContext New returning initialCtx
Perform JavaExceptionCheck

*****************************************************************
* Create a jstring object for the string "MyConverter" for use  *
* as argument to the lookup method.                              *
*****************************************************************
Move z"MyConverter" to stringBuf
Call "NewStringPlatform"
   using by value JNIEnvPtr
   address of stringBuf
   address of jstring1
   0
   returning rc
If rc not = zero then
   Display "Error occurred creating jstring object"
   Stop run
End-if

*****************************************************************
* Use the lookup method to obtain a reference to the home       *
* object bound to the name "MyConverter". (This is the JNDI      *
* name specified when deploying the J2EE application.)          *
*****************************************************************
Invoke initialCtx "lookup" using by value jstring1
   returning obj
Perform JavaExceptionCheck

*****************************************************************
* Narrow the home object to be of type ConverterHome.          *
* First obtain class object for the ConverterHome class, by     *
* passing the null-terminated ASCII string "ConverterHome" to    *
* the FindClass API. Then use this class object as the          *
* argument to the static method "narrow".                       *
*****************************************************************
Move z"ConverterHome" to stringBuf
Call "__etoa"
   using by value address of stringBuf
   returning len
If len = -1 then
   Display "Error occurred on ASCII conversion"
   Stop run
End-if
Call FindClass
   using by value JNIEnvPtr
   address of stringBuf
   returning classObj
If classObj = null
   Display "Error occurred locating ConverterHome class"
   Stop run
End-if
Invoke PortableRemoteObject "narrow"
   using by value obj
   classObj
returning homeObject
Perform JavaExceptionCheck
*****************************************************************
* Create the ConverterEJB instance and obtain local object     *
* reference for its remote interface                          *
*****************************************************************
Invoke home "create" returning currencyConverter
Perform JavaExceptionCheck
*****************************************************************
* Invoke business methods                                     *
*****************************************************************
Invoke currencyConverter "dollarToYen"
using by value +100.00E+0
returning amount
Perform JavaExceptionCheck
Display amount
Invoke currencyConverter "yenToEuro"
using by value +100.00E+0
returning amount
Perform JavaExceptionCheck
Display amount
*****************************************************************
* Remove the object and return.                               *
*****************************************************************
Invoke currencyConverter "remove"
Perform JavaExceptionCheck
Goback

*****************************************************************
* Check for thrown Java exceptions                            *
*****************************************************************
JavaExceptionCheck.
Call ExceptionOccurred using by value JNIEnvPtr
returning ex
If ex not = null then
Call ExceptionClear using by value JNIEnvPtr
Display "Caught an unexpected exception"
Invoke ex "printStackTrace"
Stop run
End-if
End program "ConverterClient".

Java client (ConverterClient.java)

/*
 * Copyright 2000 Sun Microsystems, Inc. All Rights Reserved.
 * This software is the proprietary information of Sun Microsystems, Inc.
 * Use is subject to license terms.
 */
import javax.naming.Context;
import javax.naming.InitialContext;
import javax.rmi.PortableRemoteObject;
import Converter;
import ConverterHome;
public class ConverterClient {
    public static void main(String[] args) {
        try {
            Context initial = new InitialContext();
            Object objref = initial.lookup("MyConverter");
            ConverterHome home = (ConverterHome)PortableRemoteObject.narrow(objref,
                                  ConverterHome.class);
            // Further code...
        } catch (Exception e) { /* Handle exceptions */ }
    }
}
Converter currencyConverter = home.create();
double amount = currencyConverter.dollarToYen(100.00);
System.out.println(String.valueOf(amount));
amount = currencyConverter.yenToEuro(100.00);
System.out.println(String.valueOf(amount));
currencyConverter.remove();
}
}

} catch (Exception ex) {
    System.err.println("Caught an unexpected exception!");
ex.printStackTrace();
}
Part 7. Specialized processing
Chapter 34. Interrupts and checkpoint/restart

When programs run for an extended period of time, interruptions might halt processing before the end of a job. The checkpoint/restart functions of z/OS let an interrupted program be restarted at the beginning of a job step or at a checkpoint that you have set.

Because the checkpoint/restart functions cause a lot of extra processing, use them only when you anticipate interruptions caused by machine malfunctions, input or output errors, or intentional operator intervention.

The checkpoint routine starts from the COBOL program object that contains your program. While your program is running, the checkpoint routine creates records at points that you have designated using the COBOL RERUN clause. A checkpoint record contains a snapshot of the information in the registers and main storage when the program reached the checkpoint.

The restart routine restarts an interrupted program. You can perform a restart at any time after the program was interrupted: either immediately (automatic restart), or later (deferred restart).

related tasks
“Setting checkpoints” on page 615
“Restarting programs” on page 618
“Resubmitting jobs for restart” on page 620
z/OS DFSMS: Checkpoint/Restart

related references
“DD statements for defining checkpoint data sets” on page 616
“Messages generated during checkpoint” on page 618
“Formats for requesting deferred restart” on page 619

Setting checkpoints

To set checkpoints, use job control statements and use the RERUN clause in the ENVIRONMENT DIVISION. Associate each RERUN clause with a particular COBOL file.

The RERUN clause indicates that a checkpoint record is to be written to a checkpoint data set whenever a specified number of records in the COBOL file have been processed or when END OF VOLUME is reached. You cannot use the RERUN clause with files that are defined with the EXTERNAL attribute.

You can write checkpoint records from several COBOL files to one checkpoint data set, but you must use a separate data set exclusively for checkpoint records. You cannot embed checkpoint records in one of your program data sets.

Restrictions: A checkpoint data set must have sequential organization. You cannot write checkpoints in VSAM data sets or in data sets that are allocated to extended-format QSAM data sets. Also, a checkpoint cannot be taken if any program in the run unit has an extended-format QSAM data set that is open.

Checkpoint records are written in the checkpoint data set defined by a DD statement. In the DD statement, you also choose the checkpoint method:

Single (store single checkpoints)
Only one checkpoint record exists at any given time. After the first checkpoint record is written, any succeeding checkpoint record overlays the previous one.

This method is acceptable for most programs. You save space in the checkpoint data set, and you can restart your program at the latest checkpoint.

Multiple (store multiple contiguous checkpoints)
Checkpoints are recorded and numbered sequentially. Each checkpoint is saved.

Use this method if you want to restart a program at a checkpoint other than the latest one taken.
You must use the multiple checkpoint method for complete compliance with the 85 COBOL Standard. Checkpoints during sort operations have the following requirements:

- If checkpoints are to be taken during a sort operation, add a DD statement for SORTCKPT in the job control procedure for execution.
- You can take checkpoint records on ASCII-collated sorts, but the system-name that indicates the checkpoint data set must not specify an ASCII file.

**related tasks**
- “Using checkpoint/restart with DFSORT” on page 221
- “Designing checkpoints” on page 616
- “Testing for a successful checkpoint” on page 616

**related references**
- “DD statements for defining checkpoint data sets” on page 616

**Designing checkpoints**
Design your checkpoints at critical points in your program so that data can be easily reconstructed. Do not change the contents of files between the time of a checkpoint and the time of the restart.

In a program that uses disk files, design the program so that you can identify previously processed records. For example, consider a disk file that contains loan records that are periodically updated for interest due. If a checkpoint is taken, records are updated, and then the program is interrupted, you would want to test that the records that are updated after the last checkpoint are not updated again when the program is restarted. To do this, set up a date field in each record, and update the field each time the record is processed. Then, after the restart, test the field to determine whether the record was already processed.

For efficient repositioning of a print file, take checkpoints on the file only after printing the last line of a page.

**Testing for a successful checkpoint**
After each input or output statement that issues a checkpoint, the RETURN-CODE special register is updated with the return code from the checkpoint routine. Therefore, you can test whether the checkpoint was successful and decide whether conditions are right to allow a restart.

If the return code is greater than 4, an error has occurred in the checkpoint. Check the return code to prevent a restart that could cause incorrect output.

**related references**
- z/OS DFSMS: Checkpoint/Restart (Return codes)

**DD statements for defining checkpoint data sets**
To define checkpoint data sets, use DD statements.

**For tape**:

```cobol
//ddname DD DSN=ds-name,
// [VOLUME=SER=ser],UNIT=device-type,
// DISP=(NEW,MOD),KEEP)
```

**For direct-access devices**:

```cobol
//ddname DD DSN=ds-name,
// [VOLUME=(PRIVATE,RETAIN,SER=ser),]
// UNIT=device-type,SPACE=(subparms),
// DISP=(NEW,MOD),KEEP)
```
**ddname**
Provides a link to the DD statement. The same as the ddname portion of the assignment-name used in the COBOL RERUN clause.

**data-set-name**
Identifies the checkpoint data set to the restart procedure. The name given to the data set used to record checkpoint records.

**volser**
Identifies the volume by serial number.

**device-type**
Identifies the device.

**subparms**
Specifies the amount of track space needed for the data set.

**MOD**
Specifies the multiple contiguous checkpoint method.

**NEW**
Specifies the single checkpoint method.

**PASS**
Prevents deletion of the data set at successful completion of the job step, unless the job step is the last in the job. If it is the last step, the data set is deleted.

**KEEP**
Keeps the data set if the job step abnormally ends.

**Examples: defining checkpoint data sets**
The following examples show the JCL and COBOL coding you can use to define checkpoint data sets.

**Writing single checkpoint records, using tape:**

```
//CHECKPT DD DSNAME=CHECK1,VOLUME=SER=ND0003,
//            UNIT=TAPE,DISP=(NEW,KEEP),LABEL=(,NL)
```

**Writing single checkpoint records, using disk:**

```
//CHEK DD DSNAME=CHECK2,
//       VOLUME=(PRIVATE,RETAIN,SER=DB0030),
//       UNIT=3380,DISP=(NEW,KEEP),SPACE=(CYL,5)
```

**Writing multiple contiguous checkpoint records, using tape:**

```
//CHECKPT DD DSNAME=CHECK3,VOLUME=SER=111111,
//            UNIT=TAPE,DISP=(MOD,PASS),LABEL=(,NL)
```

---

Chapter 34. Interrupts and checkpoint/restart 617
Messages generated during checkpoint

The system checkpoint routine advises the operator of the status of the checkpoints taken by displaying informative messages on the console.

Each time a checkpoint is successfully completed, a message is displayed that associates the jobname (ddname, unit, volser) with the checkpoint taken (checkid).

The control program assigns checkid as an eight-character string. The first character is the letter C, followed by a decimal number that indicates the checkpoint. For example, the following message indicates the fourth checkpoint taken in the job step:

checkid C0000004

Restarting programs

The system restart routine retrieves the information recorded in a checkpoint record, restores the contents of main storage and all registers, and restarts the program.

You can begin the restart routine in one of two ways:

- Automatically at the time an interruption stopped the program
- At a later time as a deferred restart

The RD parameter of the job control language determines the type of restart. You can use the RD parameter on either the JOB or the EXEC statement. If coded on the JOB statement, the parameter overrides any RD parameters on the EXEC statement.

To suppress both restart and writing checkpoints, code RD=NC.

Restriction: If you try to restart at a checkpoint taken by a COBOL program during a SORT or MERGE operation, an error message is issued and the restart is canceled. Only checkpoints taken by DFSORT are valid.

Data sets that have the SYSOUT parameter coded in their DD statements are handled in various ways depending on the type of restart.

If the checkpoint data set is multivolume, include in the VOLUME parameter the sequence number of the volume on which the checkpoint entry was written. If the checkpoint data set is on a 7-track tape with nonstandard labels or no labels, the SYSCHK DD statement must contain DCB=(TRTCH=C, . . . ).

related tasks

“Using checkpoint/restart with DFSORT” on page 221
“Requesting automatic restart” on page 618
“Requesting deferred restart” on page 619

Requesting automatic restart

Automatic restart occurs only at the latest checkpoint taken. If no checkpoint was taken before interruption, automatic restart occurs at the beginning of the job step.

Whenever automatic restart is to occur, the system repositions all devices except unit-record devices.

If you want automatic restart, code RD=R or RD=RNC:

- RD=R indicates that restart is to occur at the latest checkpoint. Code the RERUN clause for at least one data set in the program in order to record checkpoints. If no checkpoint is taken before interruption, restart occurs at the beginning of the job step.
- RD=RNC indicates that no checkpoint is to be written, and that any restart is to occur at the beginning of the job step. In this case, RERUN clauses are unnecessary; if any are present, they are ignored.

If you omit the RD parameter, the CHKPT macro instruction remains active, and checkpoints can be taken during processing. If an interrupt occurs after the first checkpoint, automatic restart will occur.
To restart automatically, a program must satisfy the following conditions:

- In the program you must request restart by using the RD parameter or by taking a checkpoint.
- An abend that terminated the job must return a code that allows restart.
- The operator must authorize the restart.

“Example: requesting a step restart” on page 620

**Requesting deferred restart**

Deferred restart can occur at any checkpoint, not necessarily the latest one taken. You can restart your program at a checkpoint other than at the beginning of the job step.

When a deferred restart has been successfully completed, the system displays a message on the console stating that the job has been restarted. Control is then given to your program.

If you want deferred restart, code the RD parameter as RD=NR. This form of the parameter suppresses automatic restart but allows a checkpoint record to be written provided that a RERUN clause was coded.

Request a deferred restart by using the RESTART parameter on the JOB card and a SYSCHK DD statement to identify the checkpoint data set. If a SYSCHK DD statement is present in a job and the JOB statement does not contain the RESTART parameter, the SYSCHK DD statement is ignored. If a RESTART parameter without the CHECKID subparameter is included in a job, a SYSCHK DD statement must not appear before the first EXEC statement for the job.

“Example: restarting a job at a specific checkpoint step” on page 620

**related references**

“Formats for requesting deferred restart” on page 619

**Formats for requesting deferred restart**

The formats for the RESTART parameter of the JOB statement and the SYSCHK DD statements are as shown below.

```plaintext
//jobname JOB MSGLEVEL=1,RESTART=(request[,checkid])
//SYSCHK DD DSNAME=data-set-name,
//       DISP=OLD[,UNIT=device-type,
//       VOLUME=SER=volser]
```

**MSGLEVEL=1 (or MSGLEVEL=(1,y))**

MSGLEVEL is required.

**RESTART=(request,[checkid])**

Identifies the particular checkpoint at which restart is to occur.

**request**

Takes one of the following forms:

* Indicates restart at the beginning of the job.

**stepname**

Indicates restart at the beginning of a job step.

**stepname,processtep**

Indicates restart at a procedure step within the job step.

**checkid**

Indicates the checkpoint where restart is to occur.

**SYSCHK**

The ddname used to identify a checkpoint data set to the control program. The SYSCHK DD statement must immediately precede the first EXEC statement of the resubmitted job, and must follow any JOBLIB statement.
**data-set-name**
Identifies the checkpoint data set. It must be the same name that was used when the checkpoint was taken.

**device-type and volser**
Identify the device type and the serial number of the volume that contains the checkpoint data set.

“Example: requesting a deferred restart” on page 620

**Example: requesting a deferred restart**
This example shows JCL to restart the GO step of an IGYWCLG procedure at checkpoint identifier (CHECKID) C00000003.

```cobol
//jobname  JOB  MSGLEVEL=1,RESTART=(stepname.GO,C00000003)
//SYSCK    DD  DSNAME=CHEKPT,
//           DISP=OLD[,UNIT=3380,VOLUME=SER=111111]
```

**Resubmitting jobs for restart**
When you resubmit a job for restart, be careful with any DD statements that might affect the execution of the restarted job step. The restart routine uses information from DD statements in the resubmitted job to reset files for use after restart.

If you want a data set to be deleted at the end of a job step, give it a conditional disposition of PASS or KEEP (rather than DELETE). This disposition allows the data set to be available if an interruption forces a restart. If you want to restart a job at the beginning of a step, you must first discard any data set created (defined as NEW in a DD statement) in the previous run, or change the DD statement to mark the data set as OLD.

The system automatically repositions input data sets that are on tape or disk.

“Example: resubmitting a job for a step restart” on page 621
“Example: resubmitting a job for a checkpoint restart” on page 621

**Example: restarting a job at a specific checkpoint step**
This example shows a sequence of job control statements for restarting a job at a specific step.

```cobol
//PAYROLL  JOB  MSGLEVEL=1,REGION=80K,
//          RESTART=(STEP1,CHECKPT4)
//JOBLIB    DD  DSNAME=PRIV.LIB3,DISP=OLD
//SYSCK     DD  DSNAME=CHKPTLIB,
//           [UNIT=TAPE,VOL=SER=456789,]
//           DISP=(OLD,KEEP)
//STEP1     EXEC PGM=PROG4,TIME=5
```

**Example: requesting a step restart**
This example shows the use of the RD parameter, which requests step restart for any abnormally terminated job step.

```cobol
//J1234    JOB  386,SMITH,MSGLEVEL=1,RD=R
//S1       EXEC PGM=MYPROG
//INDATA   DD  DSNAME=INVENT[,UNIT=TAPE],DISP=OLD,
//         [VOLUME=SER=91468,]
//         LABEL=RETPD=14
//REPORT   DD  SYSOUT=A
//WORK     DD  DSNAME=T91468,DISP=(,KEEP),
//         UNIT=SYSDA,SPACE=(3000,(5000,500)),
//         VOLUME=(PRIVATE,RETAIN,,6)
```

620  Enterprise COBOL for z/OS: Enterprise COBOL for z/OS, V6.1 Programming Guide
The DDCKPNT DD statement defines a checkpoint data set. For this step, after a RERUN clause is performed, only automatic checkpoint restart can occur unless a CHKPT cancel is issued.

**Example: resubmitting a job for a step restart**

This example shows the changes that you might make to the JCL before you resubmit a job for step restart.

```
//J3412 JOB  386,SMITH,MSGLEVEL=1,RD=R,RESTART=*
//S1 EXEC PGM=MYPROG
//INDATA DD DSNAME=INVENT[,UNIT=TAPE],DISP=OLD,
//          [VOLUME=SER=91468,]LABEL=RETPD=14
//REPORT DD SYSOUT=A
//WORK DD DSNAME=S91468,
//        DISP=(,KEEP),UNIT=SYSDA,
//        SPACE=(3000,(5000,500)),
//        VOLUME=(PRIVATE,RETAIN,,6)
//DDCHKPNT DD UNIT=TAPE,DISP=(MOD,KEEP,CATLG),
//           DSNAME=R91468,LABEL=(,NL)
```

The following changes were made in the example above:

- The job name has been changed (from J1234 to J3412) to distinguish the original job from the restarted job.
- The RESTART parameter has been added to the JOB statement, and indicates that restart is to begin with the first job step.
- The WORK DD statement was originally assigned a conditional disposition of KEEP for this data set:
  - If the step terminated normally in the previous run of the job, the data set was deleted, and no changes need to be made to this statement.
  - If the step abnormally terminated, the data set was kept. In that case, define a new data set (S91468 instead of T91468, as shown), or change the status of the data set to OLD before resubmitting the job.
- A new data set (R91468 instead of C91468) has also been defined as the checkpoint data set.

“Example: requesting a step restart” on page 620

**Example: resubmitting a job for a checkpoint restart**

This example shows the changes that you might make to JCL before you resubmit a job for checkpoint restart.

```
//J3412 JOB  386,SMITH,MSGLEVEL=1,RD=R,RESTART=(*,C0000002)
//SYSCHK DD DSNAME=C91468,DISP=OLD
//S1 EXEC PGM=MYPROG
//INDATA DD DSNAME=INVENT,UNIT=TAPE,DISP=OLD,
//          VOLUME=SER=91468,LABEL=RETPD=14
//REPORT DD SYSOUT=A
//WORK DD DSNAME=T91468,DISP=(,KEEP),
//        UNIT=SYSDA,SPACE=(3000,(5000,500)),
//        VOLUME=(PRIVATE,RETAIN,,6)
//DDCHKPNT DD UNIT=TAPE,DISP=(MOD,PASS,CATLG),
//           DSNAME=C91468,LABEL=(,NL)
```

The following changes were made in the example above:

- The job name has been changed (from J1234 to J3412) to distinguish the original job from the restarted job.
- The RESTART parameter has been added to the JOB statement, and indicates that restart is to begin with the first step at the checkpoint entry named C0000002.
• The DD statement DDCKPNT was originally assigned a conditional disposition of CATLG for the checkpoint data set:
  – If the step terminated normally in the previous run of the job, the data set was kept. In that case, the SYSCHK DD statement must contain all of the information necessary for retrieving the checkpoint data set.
  – If the job abnormally terminated, the data set was cataloged. In that case, the only parameters required on the SYSCHK DD statement are DSNAME and DISP as shown.

If a checkpoint is taken in a job that is running when V=R is specified, the job cannot be restarted until adequate nonpageable dynamic storage becomes available.
Chapter 35. Using zlib compression from a COBOL program

Refer to the following example including instructions and tricks about using zlib compression from a COBOL program.

```cobol
//PROCLIB JCLLIB ORDER=IGYV6R10.SIGYPROC
//EXAMPLE1 EXEC IGYWCLG
//COBOL STEPLIB DD DISP=SHR,DSNAME=IGYV6R10.SIGYCOMP
//SYSADATA DD SYSOUT=* 
//COBOL SYSIN DD * 
CBL PGMNAME(LONGMIXED) * 
****************************************************************** 
* This is a sample testcase to show how you can call zlib. * 
* It initializes compression (deflate) and then deflates some * 
* data, then initializes decompression (inflate) and inflates * 
* the same data. * 
* 
* Some of the key differences from 'typical' COBOL are: * 
* - Compiler option PGMNAME(LONGMIXED) is required. * 
* - This means that the Program-Id name has to be a literal * 
* - This program uses COMP-5 data items so that the program * 
* can work with any setting of the TRUNC compiler option * 
* - Rather than passing the zstream structure by REFERENCE like * 
* most COBOL programs, we pass the ADDRESS OF using the * 
* BY VALUE phrase to avoid high-order bit getting set * 
* - This sample has DISPLAY statements to tell you if it was * 
* successful or not, and they should be removed for production* 
* - The binder (linkage editor) needs to have LIBRARY * 
* statements in order to access the functions in the * 
* /usr/lpp/hzc/lib/libzz.a archive file. See the sample * 
* LKED.SYSIN statements below * 
* 
****************************************************************** 
Id Division. 
Program-id. 'ZLIB'. 
* 
Data Division. 
Working-Storage Section. **> Memory for tests. 'data' to be compressed 
01 zinput pic X(65536) value x'00'. 
01 zoutput pic X(65536) value x'00'. 
01 z. 
* 
  02 next_in is a Pointer to zstring 
  02 avail_in Pic S9(9) Comp-5. 
  02 total_in Pic S9(9) Comp-5. 
* 
  02 next_out is a Pointer to zstring 
  02 avail_out Pic S9(9) Comp-5. 
  02 total_out Pic S9(9) Comp-5. 
* 
  02 msg is a Pointer to zstring 
  02 state Pointer. 
  02 zalloc Function-pointer. 
  02 zfree Function-pointer. 
  02 opaque Function-pointer. 
  02 data_type Pic S9(9) Comp-5. 
  02 adler Pic S9(9) Comp-5. 
  02 reserved Pic S9(9) Comp-5. 
01 y. 
* 
  02 next_in is a Pointer to zstring 
  02 avail_in Pic S9(9) Comp-5. 
  02 total_in Pic S9(9) Comp-5. 
* 
  02 next_out is a Pointer to zstring 
  02 avail_out Pic S9(9) Comp-5. 
  02 total_out Pic S9(9) Comp-5. 
* 
  02 msg is a Pointer to zstring 
  02 state Pointer. 
```

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02  zalloc Function-pointer.
02  zfree  Function-pointer.
02  opaque Function-pointer.
02  data_type Pic S9(9) Comp-5.
02  adler  Pic S9(9) Comp-5.
02  reserved Pic S9(9) Comp-5.

77  rc-disp  Pic S9(9) Display Sign leading separate.

Linkage Section.
77  zstring Pic x(1000).
77  rc       Pic S9(9) Comp-5.

Procedure Division returning rc.

**>***********************************************************/
**>                                                            */
**> Setup the z_stream structure with defaults                 */
**>                                                            */
**>***********************************************************/
Set zalloc of z to Null
Set zfree  of z to Null
Set opaque of z to Null

*     *>***********************************************************/
*     *>                                                       */
*     *> Call deflateInit to initialize the deflate stream     */
*     *> service using a GZIP wrapper                          */
*     *>                                                       */
*     *>***********************************************************/
Call 'DEIN2' Using By Value Address of z,
   By Value   -1, 8, 31, 8,  0,
   By Content '1.2.7',
   By Value  Length Of z
returning rc

If rc NOT = 0  Then
   Move rc to rc-disp
   Display 'Error: deflateInit failed with Return Code ' rc-disp
If  msg of z NOT = Null Then
   Set Address of zstring to msg of z
   Display 'Message = ' zstring
Else
   Display 'Message pointer is NULL '
End-if
Move -1 To Return-code rc
Goback
Else
   Display 'deflateInit Successful ! '
End-if

************************************************************************
* Initialize available input, output, total in for deflate
************************************************************************
Compute avail_in of z  = 65536
Compute avail_out of z = 65536
Compute total_in of z = 0

************************************************************************
* Set input and output pointers
************************************************************************
Set next_out of z to Address of zoutput
Set next_in of z  to Address of zinput

*     *>***********************************************************/
*     *>                                                       */
*     *> Call deflate to compress the data. We only call it     */
*     *> once with a flush mode of Z_FINISH (4) which indicates */
*     *> to end the stream                                       */
*     *>                                                       */
*     *>***********************************************************/
Call 'deflate' Using By Value Address of z
   BY Value 4 Returning rc
If rc NOT = 1  Then
   Move rc to rc-disp
   Display 'Error: deflate returned ' rc-disp
If  msg of z NOT = Null Then
   Set Address of zstring to msg of z
   Display zstring
End-if
Display "avail_in of z= " avail_in of z
Display "total_in of z= " total_in of z
Display "avail_out of z= " avail_out of z
Display "total_out of z= " total_out of z

Call 'DEEND' Using By Value address of z returning rc

Move -1 To Return-code rc
Goback
Else
  Display 'deflate Successful ! '
End-if

Display 'After deflate '
Display 'avail_in of z= ' avail_in of z
Display 'total_in of z= ' total_in of z
Display 'avail_out of z= ' avail_out of z
Display 'total_out of z= ' total_out of z

*******************************************************************************
*/
/* Now that we are done , call deflateEnd to cleanup the */
/* deflate internal state. */
*/
*******************************************************************************
Call 'DEEND' Using By Value Address of z returning rc
If rc NOT = 0 Then
  Move rc to rc-disp
  Display 'Error: deflateEnd returned ' rc-disp
  If msg of z NOT = Null Then
    Move -1 To Return-code rc
    Goback
  End-if
Else
  Display 'deflateEnd Successful ! '
End-if

*******************************************************************************
*/
/* Inflate the data we just deflated. Call inflateInit to */
/* initialize the inflate stream */
*/
*******************************************************************************
Set zalloc of y to Null
Set zfree of y to Null
Set opaque of y to Null
Call 'ININ2' Using By Value Address of y,
    By Value 31,
    By Content '1.2.7',
    By VALUE Length Of y
    returning rc
If rc NOT = 0 Then
  Move rc to rc-disp
  Display 'Error: inflateInit failed with Return Code ' rc-disp
  If msg of y NOT = Null Then
    Set Address of zstring to msg of y
    Display zstring
  End-if
  Move -1 To Return-code rc
  Goback
Else
  Display 'inflateInit Successful ! '
End-if

*******************************************************************************
*/
/* Set the amount of input based on what deflate returned */
/* and what we expect the output size to be. */
*/
*******************************************************************************
Compute avail_in of y = total_out of z
Compute avail_out of y = 65536
Compute total_in of y = 0
Set next_out of y to Address of zinput
Set next_in of y to Address of zoutput

* /*******************************************************************************/
* /* Call inflate to decompress the data. Note that we expect */
* /* this to end with a Z_STREAM_END (1) since we provided the */
* /* full stream above. */
* /* */
* /*****************************************************************************/
Call 'inflate' Using By Value Address of y
By Value 0 Returning rc

If rc Not = 1 Then
  Move rc to rc-disp
  Display 'Error: inflate returned ' rc-disp
  If msg of z NOT = Null Then
    Set Address of zstring to msg of z
    Display zstring
  End-if
  Display "avail_in of y= " avail_in of y
  Display "total_in of y= " total_in of y
  Display "avail_out of y= " avail_out of y
  Display "total_out of y= " total_out of y

Call 'INEND' Using By Value Address of y Returning rc
  Move -1 To Return-code rc
  Goback
Else
  Display 'inflate Successful !'
End-if

Display 'After inflate'
Display 'avail_in of y= ' avail_in of y
Display 'total_in of y= ' total_in of y
Display 'avail_out of y= ' avail_out of y
Display 'total_out of y= ' total_out of y

* /*****************************************************************************/
* /* Now that we are done call inflateEnd to cleanup the */
* /* internal inflate state of the stream. */
* /* */
* /*****************************************************************************/
Call 'INEND' Using By Value Address of y Returning rc
  If rc Not = 0 Then
    If rc Not = 0 Then
      Move rc to rc-disp
      Display 'Error: inflateEnd returned ' rc-disp
      If msg of z NOT = Null Then
        Move -1 To Return-code rc
        Goback
      End-if
    Else
      Display 'inflateEnd Successful !'
    End-if
  Else
    Move zero to return-code rc
  End-if
  Goback.

/*
//LKED.SYSIN DD *
LIBRARY ‘/usr/lpp/hzc/lib/libzz.a’
/*
//LKED.SYSLIB DD DSN=CEE2240.SCEE,DISP=SHR
//LKED.SYSLMOD DD DSN=MYLOAD.COBOL.LOAD(ZLIB),DISP=SHR
//GO.STEPLIB DD DSNNAME=CEEV240.CEERUN,DISP=SHR
//GO.SYSUDUMP DD DUMMY
//GO.SYSSORT DD DUMMY
//GO.SYSOUT DD SYSOUT=* */
Part 8. Improving performance and productivity
When a program is comprehensible, you can assess its performance. A tangled control flow makes a program difficult to understand and maintain, and inhibits the optimization of its code.

To improve the performance of your program, examine at least these aspects:

- Underlying algorithms: For best performance, using sound algorithms is essential. For example:
  - A sophisticated algorithm for sorting a million items might be hundreds of thousands of times faster than a simple algorithm.
  - If the program frequently accesses data, reduce the number of steps to access the data.
- Data structures: Using data structures that are appropriate for the algorithms is essential.

You can write programs that result in better generated code sequences and use system services more efficiently. These additional aspects can affect performance:

- Coding techniques: Use a programming style that enables the optimizer to choose efficient data types and handle tables efficiently.
- Optimization: You can optimize code by using the OPTIMIZE compiler option.
- Compiler options and USE FOR DEBUGGING ON ALL PROCEDURES: Some compiler options and language affect program efficiency.
- Runtime environment: Consider your choice of runtime options.
- Running under CICS, IMS, or VSAM: Heeding various tips can help make these programs run more efficiently.

related concepts
“Optimization” on page 634

related tasks
“Using an optimal programming style” on page 629
“Choosing efficient data types” on page 630
“Handling tables efficiently” on page 632
“Optimizing your code” on page 634
“Choosing compiler features to enhance performance” on page 635
“Running efficiently with CICS, IMS, or VSAM” on page 639

Language Environment Programming Guide (Specifying runtime options)

related references
“Performance-related compiler options” on page 636
Language Environment Programming Guide (Storage performance considerations)

Using an optimal programming style

The coding style you use can affect how the optimizer handles your code. You can improve optimization by using structured programming techniques, factoring expressions, using symbolic constants, and grouping constant and duplicate computations.

related tasks
“Using structured programming” on page 630
“Factoring expressions” on page 630
“Using symbolic constants” on page 630
Using structured programming
Using structured programming statements, such as EVALUATE and inline PERFORM, makes your program more comprehensible and generates a more linear control flow. As a result, the optimizer can operate over larger regions of the program, which gives you more efficient code.

Use top-down programming constructs. Out-of-line PERFORM statements are a natural means of doing top-down programming. Out-of-line PERFORM statements can often be as efficient as inline PERFORM statements, because the optimizer can simplify or remove the linkage code.

Avoid using the following constructs:
• ALTER statements
• Explicit GO TO statements
• PERFORM procedures that involve irregular control flow (such as preventing control from passing to the end of the procedure and returning to the PERFORM statement)

Factoring expressions
By factoring expressions in your programs, you can potentially eliminate a lot of unnecessary computation.

For example, the first block of code below is more efficient than the second block of code:

```
MOVE ZERO TO TOTAL
PERFORM VARYING I FROM 1 BY 1 UNTIL I = 10
  COMPUTE TOTAL = TOTAL + ITEM(I)
END-PERFORM

COMPUTE TOTAL = TOTAL * DISCOUNT
```

```
MOVE ZERO TO TOTAL
PERFORM VARYING I FROM 1 BY 1 UNTIL I = 10
  COMPUTE TOTAL = TOTAL + ITEM(I) * DISCOUNT
END-PERFORM
```

The optimizer does not factor expressions.

Using symbolic constants
To have the optimizer recognize a data item as a constant throughout the program, initialize it with a VALUE clause and do not change it anywhere in the program.

If you pass a data item to a subprogram BY REFERENCE, the optimizer treats it as an external data item and assumes that it is changed at every subprogram call.

Choosing efficient data types
Using the SYNCHRONIZED clause can produce more efficient code.

Consistent data types can reduce the need for conversions during operations on data items. You can also improve program performance by carefully determining when to use fixed-point and floating-point data types.

related concepts
“Formats for numeric data” on page 45

related tasks
“Choosing efficient computational data items” on page 631
“Using consistent data types” on page 631
“Making arithmetic expressions efficient” on page 631
“Making exponentiations efficient” on page 631
Choosing efficient computational data items

When you use a data item mainly for arithmetic or as a subscript, code USAGE BINARY on the data description entry for the item. The operations for manipulating binary data are faster than those for manipulating decimal data.

However, if a fixed-point arithmetic statement has intermediate results with a large precision (number of significant digits), the compiler uses decimal arithmetic anyway, after converting the operands to packed-decimal form. For fixed-point arithmetic statements, the compiler normally uses binary arithmetic for simple computations with binary operands if the precision is eight or fewer digits. Above 18 digits, the compiler always uses decimal arithmetic. With a precision of nine to 18 digits, the compiler uses either form.

To produce the most efficient code for a BINARY data item, ensure that it has:

- A sign (an S in its PICTURE clause)
- Eight or fewer digits

For a data item that is larger than eight digits or is used with DISPLAY or NATIONAL data items, use PACKED-DECIMAL. The code generated for PACKED-DECIMAL data items can be as fast as that for BINARY data items in some cases, especially if the statement is complicated or specifies rounding.

To produce the most efficient code for a PACKED-DECIMAL data item, ensure that it has:

- A sign (an S in its PICTURE clause)
- An odd number of digits (9s in the PICTURE clause), so that it occupies an exact number of bytes without a half byte left over
- 15 or fewer digits in the PICTURE specification on ARCH(7) machines. If a PACKED-DECIMAL data item has more than 31 digits, library routines are used. For a PACKED-DECIMAL data item with 16-31 digits on ARCH (8) or higher level machines, the compiler uses instructions that are more efficient than library calls, but not as fast as if the data item has 15 or fewer digits.

Using consistent data types

In operations on operands of different types, one of the operands must be converted to the same type as the other. Each conversion requires several instructions. For example, one of the operands might need to be scaled to give it the appropriate number of decimal places.

You can largely avoid conversions by using consistent data types and by giving both operands the same usage and also appropriate PICTURE specifications. That is, you should ensure that two numbers to be compared, added, or subtracted not only have the same usage but also the same number of decimal places (9s after the V in the PICTURE clause).

Making arithmetic expressions efficient

Computation of arithmetic expressions that are evaluated in floating point is most efficient when the operands need little or no conversion. Use operands that are COMP-1 or COMP-2 to produce the most efficient code.

Define integer items as BINARY or PACKED-DECIMAL with nine or fewer digits to afford quick conversion to floating-point data. Also, conversion from a COMP-1 or COMP-2 item to a fixed-point integer with nine or fewer digits, without SIZE ERROR in effect, is efficient when the value of the COMP-1 or COMP-2 item is less than 1,000,000,000.

Making exponentiations efficient

Use floating point for exponentiations for large exponents to achieve faster evaluation and more accurate results.

For example, the first statement below is computed more quickly and accurately than the second statement:

```plaintext
COMPUTE fixed-point1 = fixed-point2 ** 100000.E+00
```
A floating-point exponent causes floating-point arithmetic to be used to compute the exponentiation.

**Using VOLATILE clauses efficiently**

Optimization of data items that are defined with the VOLATILE clause is significantly restricted. Therefore, use the VOLATILE clause only when appropriate.

In particular, it is important to understand that when the VOLATILE clause is used on a group item, the compiler treats all data items subordinate to the group item as volatile, and all higher-level group items that contain the volatile group item are treated as volatile, too. If a particular member of a group needs to be treated as volatile, specify the VOLATILE clause on the data description entry for that item only, where possible.

At present, the primary reason to use the VOLATILE clause is for data items that are set or referenced inside an LE condition handler but are defined outside the LE condition handler program. The VOLATILE clause guarantees that such items are handled correctly by the optimizer. For more information on when to use VOLATILE, see VOLATILE clause in the Enterprise COBOL for z/OS Language Reference.

**Handling tables efficiently**

You can use several techniques to improve the efficiency of table-handling operations, and to influence the optimizer. The return for your efforts can be significant, particularly when table-handling operations are a major part of an application.

The following two guidelines affect your choice of how to refer to table elements:

- **Use indexing rather than subscripting.**
  
  Although the compiler can eliminate duplicate indexes and subscripts, the original reference to a table element is more efficient with indexes (even if the subscripts were BINARY). The value of an index has the element size factored into it, whereas the value of a subscript must be multiplied by the element size when the subscript is used. The index already contains the displacement from the start of the table, and this value does not have to be calculated at run time. However, subscripting might be easier to understand and maintain.

- **Use relative indexing.**
  
  Relative index references (that is, references in which an unsigned numeric literal is added to or subtracted from the index-name) are executed at least as fast as direct index references, and sometimes faster. There is no merit in keeping alternative indexes with the offset factored in.

Whether you use indexes or subscripts, the following coding guidelines can help you get better performance:

- **Specify the element length so that it matches that of related tables.**
  
  When you index or subscript tables, it is most efficient if all the tables have the same element length. That way, the stride for the last dimension of the tables is the same, and the optimizer can reuse the rightmost index or subscript computed for one table. If both the element lengths and the number of occurrences in each dimension are equal, then the strides for dimensions other than the last are also equal, resulting in greater commonality between their subscript computations. The optimizer can then reuse indexes or subscripts other than the rightmost.

- **Avoid errors in references by coding index and subscript checks into your program.**
  
  If you need to validate indexes and subscripts, it might be faster to code your own checks than to use the SSRANGE compiler option.

You can also improve the efficiency of tables by using these guidelines:

- **Use binary data items for all subscripts.**
When you use subscripts to address a table, use a BINARY signed data item with eight or fewer digits. In some cases, using four or fewer digits for the data item might also improve processing time.

- Use binary data items for variable-length table items.

For tables with variable-length items, you can improve the code for OCCURS DEPENDING ON (ODO). To avoid unnecessary conversions each time the variable-length items are referenced, specify BINARY for OCCURS . . . DEPENDING ON objects.

- Use fixed-length data items whenever possible.

Copying variable-length data items into a fixed-length data item before a period of high-frequency use can reduce some of the overhead associated with using variable-length data items.

- Organize tables according to the type of search method used.

If the table is searched sequentially, put the data values most likely to satisfy the search criteria at the beginning of the table. If the table is searched using a binary search algorithm, put the data values in the table sorted alphabetically on the search key field.

related concepts
“Optimization of table references” on page 633

related tasks
“Referring to an item in a table” on page 68
“Choosing efficient data types” on page 630

related references
“SSRANGE” on page 339

Optimization of table references

The COBOL compiler optimizes table references in several ways.

For the table element reference ELEMENT(S1 S2 S3), where S1, S2, and S3 are subscripts, the compiler evaluates the following expression:

```
comp_s1 * d1 + comp_s2 * d2 + comp_s3 * d3 + base_address
```

Here comp_s1 is the value of S1 after conversion to binary, comp_s2 is the value of S2 after conversion to binary, and so on. The strides for each dimension are d1, d2, and d3. The stride of a given dimension is the distance in bytes between table elements whose occurrence numbers in that dimension differ by 1 and whose other occurrence numbers are equal. For example, the stride d2 of the second dimension in the above example is the distance in bytes between ELEMENT(S1 1 S3) and ELEMENT(S1 2 S3).

Index computations are similar to subscript computations, except that no multiplication needs to be done. Index values have the stride factored into them. They involve loading the indexes into registers, and these data transfers can be optimized, much as the individual subscript computation terms are optimized.

**Optimization of variable-length items**

A group item that contains a subordinate OCCURS DEPENDING ON data item has a variable length. The program must perform special code every time a variable-length data item is referenced.

Because this code is out-of-line, it might interrupt optimization. Furthermore, the code to manipulate variable-length data items is much less efficient than that for fixed-size data items and can significantly increase processing time. For instance, the code to compare or move a variable-length data item might involve calling a library routine and is much slower than the same code for fixed-length data items.

**Comparison of direct and relative indexing**

Relative index references are as fast as or faster than direct index references.
The direct indexing in ELEMENT (I5, J3, K2) requires this preprocessing:

```
SET I5 TO I
SET I5 UP BY 5
SET J3 TO J
SET J3 DOWN BY 3
SET K2 TO K
SET K2 UP BY 2
```

This processing makes the direct indexing less efficient than the relative indexing in ELEMENT (I + 5, J - 3, K + 2).

related concepts
“Optimization” on page 634

related tasks
“Handling tables efficiently” on page 632

### Optimizing your code

When your program is ready for final testing, specify the OPTIMIZE(1|2) compiler option so that the tested code and the production code are identical.

If you frequently run a program without recompiling it during development, you might also want to use OPTIMIZE(1|2). However, if you recompile frequently, the overhead for OPTIMIZE(1|2) might outweigh its benefits unless you are using the assembler language expansion (LIST compiler option) to fine-tune the program.

For unit-testing a program, you will probably find it easier to debug code that has not been optimized.

To see how the optimizer works on a program, compile it with different levels of optimization and compare the generated code. (Use the LIST compiler option to request the assembler listing of the generated code.)

related concepts
“Optimization” on page 634

related references
“LIST” on page 315
“OPTIMIZE” on page 325

### Optimization

To improve the efficiency of the generated code, you can use the OPTIMIZE(1) or OPTIMIZE(2) compiler option.

OPTIMIZE(1) causes the COBOL optimizer to do the following optimizations:

- Eliminate unnecessary transfers of control and inefficient branches, including those generated by the compiler that are not evident from looking at the source program.
- Simplify the compiled code for a PERFORM statement. The compiler replicates the PERFORM a number of times to avoid linkage code.
- Eliminate duplicate computations (such as subscript computations and repeated statements) that have no effect on the results of the program.
- Eliminate constant computations by performing them when the program is compiled.
- Eliminate constant conditional expressions.
- Aggregate moves of contiguous items (such as those that often occur with the use of MOVE CORRESPONDING) into a single move. Both the source and target must be contiguous for the moves to be aggregated.
• Delete from the program, and identify with a warning message, code that can never be performed (unreachable code elimination).
• Discard unreferenced data items from the DATA DIVISION, and suppress generation of code to initialize these data items to their VALUE clauses. (The optimizer takes this action only when you use the STGOPT option.)

OPTIMIZE(2) causes the COBOL optimizer to do further optimizations:
• Simplify operations more aggressively and schedule instructions.
• Do interblock optimizations such as global value propagation and loop invariant code motion.

**Contained program procedure integration**
In contained program procedure integration, the contained program code replaces a CALL to a contained program. The resulting program runs faster without the overhead of CALL linkage and with more linear control flow.

**Program size:** If several CALL statements call contained programs and these programs replace each such statement, the containing program can become large. The optimizer then chooses the next best optimization for the CALL statement.

**Related concepts**
“PERFORM procedure integration” on page 635

**Related references**
“OPTIMIZE” on page 325

**PERFORM procedure integration**
PERFORM procedure integration is the process whereby a PERFORM statement is replaced by its performed procedures. The advantage is that the resulting program runs faster without the overhead of PERFORM linkage and with more orderly control flow.

**Program size:** If the performed procedures are invoked by several PERFORM statements and replace each such statement, the program could become large. The optimizer limits this increase, after which it no longer integrates these procedures.

**Related references**
“INLINE” on page 312
INLINE directive (Enterprise COBOL for z/OS Language Reference)

**Choosing compiler features to enhance performance**

Your choice of performance-related compiler options and your use of the USE FOR DEBUGGING ON ALL PROCEDURES statement can affect how well your program is optimized.

You might have a customized system that requires certain options for optimum performance. Do these steps:

1. To see what your system defaults are, get a short listing for any program and review the listed option settings.
2. Determine which options are fixed as nonoverridable at your installation by checking with your system programmer.
3. For the options not fixed at installation, select performance-related options for compiling your programs.

**Important:** Confer with your system programmer about how to tune COBOL programs. Doing so will ensure that the options you choose are appropriate for programs at your site.

Another compiler feature to consider is the USE FOR DEBUGGING ON ALL PROCEDURES statement. It can greatly affect the compiler optimizer. The ON ALL PROCEDURES option generates extra code at each
transfer to a procedure name. Although very useful for debugging, it can make the program significantly larger and inhibit optimization substantially.

Although COBOL allows segmentation language, you will not improve storage allocation by using it, because COBOL does not perform overlay.

related concepts
“Optimization” on page 634

related tasks
“Optimizing your code” on page 634
“Getting listings” on page 370

related references
“Performance-related compiler options” on page 636

Performance-related compiler options
In the table below you can see a description of the purpose of each option, its performance advantages and disadvantages, and usage notes where applicable.

<table>
<thead>
<tr>
<th>Compiler option</th>
<th>Purpose</th>
<th>Performance advantages</th>
<th>Performance disadvantages</th>
<th>Usage notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFP( NOVOLATILE)</td>
<td>To control the compiler usage of the Additional Floating Point (AFP) registers that are provided by z/Architecture processors</td>
<td>AFP( NOVOLATILE) lets the compiler generate more efficient code sequences for programs with floating point operations.</td>
<td>None</td>
<td>Poorly behaved assembler code might not adhere to the standard calling convention and might fail to correctly preserve values in Floating Point registers. With AFP( NOVOLATILE), COBOL programs can safely call such routines.</td>
</tr>
<tr>
<td>ARCH</td>
<td>To specify the machine architecture for which the executable program instructions are to be generated</td>
<td>If you specify a higher ARCH level, the machine generates code that uses newer and faster instructions instead of the sequences of common instructions.</td>
<td>None</td>
<td>Your application might abend if it runs on a processor with an architecture level lower than that specified for the ARCH option.</td>
</tr>
<tr>
<td>ARITH(EXTEND)</td>
<td>To increase the maximum number of digits allowed for decimal numbers</td>
<td>None</td>
<td>ARITH(EXTEND) causes some degradation in performance for all decimal data types because of larger intermediate results.</td>
<td>The amount of degradation that you experience depends directly on the amount of decimal data that you use.</td>
</tr>
<tr>
<td>AWO</td>
<td>To get optimum use of buffer and device space for QSAM files</td>
<td>Can result in performance savings, because this option results in fewer calls to data management services to handle input and output</td>
<td>None</td>
<td>If you use AWO, the APPLY WRITE-ONLY clause is in effect for all QSAM files in the program that have V-mode records.</td>
</tr>
<tr>
<td>BLOCK0</td>
<td>To take advantage of system-determined block size for QSAM output files</td>
<td>Can result in enhanced processing speed and minimized storage requirements for QSAM output files</td>
<td>None</td>
<td>If you use BLOCK0, a BLOCK CONTAINS 0 clause is activated for all QSAM files in the program that specify neither BLOCK CONTAINS nor RECORDING MODE U in the file description entry.</td>
</tr>
<tr>
<td>DATA(31)</td>
<td>To have DFSMS allocate QSAM buffers above the 16 MB line (by using the RENT and DATA(31) compiler options)</td>
<td>Because extended-format QSAM data sets can require many buffers, allocating the buffers in unrestricted storage avoids virtual storage constraint problems.</td>
<td>None</td>
<td>On a z/OS system with DFSMS, if your application processes striped extended-format QSAM data sets, use the RENT and DATA(31) compiler options to have the input-output buffers for your QSAM files allocated from storage above the 16 MB line.</td>
</tr>
</tbody>
</table>
### Table 89. Performance-related compiler options (continued)

<table>
<thead>
<tr>
<th>Compiler option</th>
<th>Purpose</th>
<th>Performance advantages</th>
<th>Performance disadvantages</th>
<th>Usage notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAM</td>
<td>To have subprograms (called through the CALL statement) dynamically loaded at run time</td>
<td>Subprograms are easier to maintain, because the application does not have to be link-edited again if a subprogram is changed.</td>
<td>There is a slight performance penalty, because the call must go through a Language Environment routine.</td>
<td>To free virtual storage that is no longer needed, issue the CANCEL statement.</td>
</tr>
<tr>
<td>FASTSRT</td>
<td>To specify that the IBM DFSORT product (or equivalent) will handle all of the input and output</td>
<td>Eliminates the overhead of returning to Enterprise COBOL after each record is processed</td>
<td>None</td>
<td>FASTSRT is recommended if direct work files are used for the sort work files. Not all sorts are eligible for this option.</td>
</tr>
<tr>
<td>HGPR</td>
<td>To control the compiler usage of the 64-bit registers provided by z/Architecture processors.</td>
<td>If you specify HGPR (NOPRESERVE), the compiler omits preserving the high-halves of the 64-bit GPRs that a program is using, which improves performance.</td>
<td>None</td>
<td>If your program modifies and does not save the high-halves of the registers, but calling programs depend on the unchanged values, the application might give incorrect results. <strong>Exception:</strong> It does not apply if the caller of this program is Enterprise COBOL, Enterprise PL/I or z/OS XL C/C++ programs.</td>
</tr>
<tr>
<td>INLINE</td>
<td>To control the compiler usage of inlining procedures (paragraphs or sections) referenced by PERFORM statements in the source program.</td>
<td>Specifying INLINE allows the compiler to decide whether to inline procedures referenced by PERFORM statements. This typically improves performance when the application contains commonly occurring and often-executed procedures.</td>
<td>Specifying INLINE usually increases the size of the module. For commonly occurring but rarely executed procedures, you can use the &gt;&gt;INLINE OFF directive to prevent the compiler from inlining that procedure and increasing the module size.</td>
<td>You can use the INLINE compiler option to indicate that a procedure should be considered eligible for inlining, but the decision whether to inline a procedure in a specific PERFORM statement or not is made by the compiler.</td>
</tr>
<tr>
<td>MAXPCF</td>
<td>To reduce optimization in programs that require excessive compilation time or excessive storage requirements because of large sizes or complexity.</td>
<td>None</td>
<td>If you specify MAXPCF(n) and n is not zero, when the program complexity factor exceeds n, any specification of OPTIMIZE(1) or OPTIMIZE(2) is reset to OPTIMIZE(0), and a warning message is generated.</td>
<td>None</td>
</tr>
<tr>
<td>NUMPROC (PFD)</td>
<td>To have invalid sign processing bypassed for numeric operations</td>
<td>Generates significantly more efficient code for numeric comparisons</td>
<td>For most references to COMP-3 and DISPLAY numeric data items, NUMPROC (PFD) inhibits extra code from being generated to “fix up” signs. This extra code might also inhibit some other types of optimizations. The extra code is generated with NUMPROC (NOPFD).</td>
<td>If you use NUMPROC (PFD), the compiler assumes and requires that all decimal items contain the preferred sign values and bypasses the sign “fix-up” process. However, because not all external data files contain the proper signs for COMP-3 or DISPLAY numeric data, and programs might use REDEFINES, group moves, or parameter passing in ways that do not ensure preferred signs, the NUMPROC (PFD) might not be appropriate for many programs.</td>
</tr>
<tr>
<td>OPTIMIZE(0</td>
<td>1</td>
<td>2)</td>
<td>To optimize generated code for better performance</td>
<td>Generally results in more efficient runtime code</td>
</tr>
<tr>
<td>Compiler option</td>
<td>Purpose</td>
<td>Performance advantages</td>
<td>Performance disadvantages</td>
<td>Usage notes</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
<td>------------------------</td>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>STGOPT</td>
<td>To optimize storage allocation in DATA DIVISION</td>
<td>Generally results in less storage usage</td>
<td>None</td>
<td>STGOPT deletes unused data items, which might be undesirable in the case of time stamps or data items that are used only as markers for dump reading.</td>
</tr>
<tr>
<td>RENT</td>
<td>To generate a reentrant program</td>
<td>Enables the program to be placed in shared storage (LPA/ELPA) for faster execution</td>
<td>Generates additional code to ensure that the program is reentrant</td>
<td>None</td>
</tr>
<tr>
<td>RMODE (ANY)</td>
<td>To let the program be loaded anywhere</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SSRANGE</td>
<td>To verify that all table references and reference modification expressions are in proper bounds</td>
<td>SSRANGE generates additional code for verifying table references. Using NOSSRANGE causes that code not to be generated.</td>
<td>With SSRANGE specified, checks for valid ranges do affect compiler performance.</td>
<td>In general, if you need to verify the table references only a few times instead of at every reference, coding your own checks might be faster than using SSRANGE. For performance-sensitive applications, NOSSRANGE is recommended.</td>
</tr>
<tr>
<td>TEST</td>
<td>To get full debugging capability when using Debug Tool and to get a symbolic dump of the data items in CEEDUMP. You can also get a symbolic dump of the data items in CEEDUMP with NOTEST (DWARF).</td>
<td>None</td>
<td>Some reduction in optimization occurs when the TEST option is used. More reduction in optimization occurs when the EJPD suboption of TEST is used.</td>
<td>For production runs, using NOTEST or TEST (NOEJPD) is recommended. If during a production run, you want a symbolic dump of the data items in a formatted dump if the program abends, compile using TEST or with NOTEST (DWARF).</td>
</tr>
<tr>
<td>THREAD</td>
<td>To enable programs for execution in a Language Environment enclave that has multiple POSIX threads or PL/I tasks</td>
<td>None</td>
<td>There is a slight performance penalty because of the overhead of serialization logic.</td>
<td>A slight performance penalty occurs in either a threaded or nonthreaded environment.</td>
</tr>
<tr>
<td>TRUNC (OPT)</td>
<td>To avoid having code generated to truncate the receiving fields of arithmetic operations</td>
<td>Does not generate extra code and generally improves performance</td>
<td>Both TRUNC (BIN) and TRUNC (STD) generate extra code whenever a BINARY data item is changed. TRUNC (BIN) is usually the slowest of these options.</td>
<td>TRUNC (STD) conforms to the 85 COBOL Standard, but TRUNC (BIN) and TRUNC (OPT) do not. With TRUNC (OPT), the compiler assumes that the data conforms to the PICTURE and USAGE specifications. TRUNC (OPT) is recommended where possible.</td>
</tr>
</tbody>
</table>

related concepts
“Optimization” on page 634
“Storage and its addressability” on page 37

related tasks
“Generating a list of compiler messages” on page 261
“Evaluating performance” on page 639
“Choosing compiler features to enhance performance” on page 635
“Improving sort performance with FASTSRT” on page 216
“Using striped extended-format QSAM data sets” on page 169
“Handling tables efficiently” on page 632

related references
“Sign representation of zoned and packed-decimal data” on page 51
“Allocation of buffers for QSAM files” on page 170
Evaluating performance

Fill in the following worksheet to help you evaluate the performance of your program. If you answer yes to each question, you are probably improving the performance.

In thinking about the performance tradeoff, be sure you understand the function of each option as well as the performance advantages and disadvantages. You might prefer function over increased performance in many instances.

Table 90. Performance-tuning worksheet

<table>
<thead>
<tr>
<th>Compiler option</th>
<th>Consideration</th>
<th>Yes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH</td>
<td>Do you use the highest architecture level possible for all environments in which your programs will run? For example, if the lowest level architecture you have including your disaster recovery machines is z10, are you using ARCH(8)?</td>
<td></td>
</tr>
<tr>
<td>AWO</td>
<td>Do you use the AWO option when possible?</td>
<td></td>
</tr>
<tr>
<td>BLOCK0</td>
<td>Do you use BLOCK0 for QSAM files?</td>
<td></td>
</tr>
<tr>
<td>DATA</td>
<td>When you use QSAM striped data sets, do you use the RENT and DATA(31) options? Is the program object AMODE 31? Are you running with ALL31(ON)?</td>
<td></td>
</tr>
<tr>
<td>DYNAM</td>
<td>Can you use NODYNAM? Consider the performance tradeoffs.</td>
<td></td>
</tr>
<tr>
<td>FASTSRT</td>
<td>When you use direct work files for the sort work files, did you use the FASTSRT option?</td>
<td></td>
</tr>
<tr>
<td>NUMPROC</td>
<td>Do you use NUMPROC(PFD) when possible?</td>
<td></td>
</tr>
<tr>
<td>OPTIMIZE</td>
<td>Do you use a non-zero OPTIMIZE level for production runs?</td>
<td></td>
</tr>
<tr>
<td>SSRANGE</td>
<td>Do you use NOSSRANGE for production runs?</td>
<td></td>
</tr>
<tr>
<td>TEST</td>
<td>Do you use NOTEST or TEST(NOEJPD) for production runs?</td>
<td></td>
</tr>
<tr>
<td>TRUNC</td>
<td>Do you use TRUNC(OPT) when possible?</td>
<td></td>
</tr>
<tr>
<td>ZONEDATA</td>
<td>Do you use ZONEDATA (PFD) when possible?</td>
<td></td>
</tr>
</tbody>
</table>

related concepts
“Storage and its addressability” on page 37

related tasks
“Choosing compiler features to enhance performance” on page 635

related references
“Performance-related compiler options” on page 636

Running efficiently with CICS, IMS, or VSAM

You can improve performance for online programs running under CICS or IMS, or programs that use VSAM, by following these tips.

**CICS**: If your application runs under CICS, convert EXEC CICS LINK commands to COBOL CALL statements to improve transaction response time.
**IMS:** If your application runs under IMS, preloading the application program and the library routines can help reduce the overhead of loading and searching. It can also reduce the input-output activity.

For better system performance, use the RENT compiler option and preload the applications and library routines when possible. You can also use the Language Environment library routine retention (LRR) function to improve performance in IMS/TM regions.

**VSAM:** When you use VSAM files, increase the number of data buffers for sequential access or index buffers for random access. Also, select a control interval size (CISZ) that is appropriate for the application. A smaller CISZ results in faster retrieval for random processing at the expense of inserts. A larger CISZ is more efficient for sequential processing.

For better performance, access the records sequentially and avoid using multiple alternate indexes when possible. If you use alternate indexes, access method services builds them more efficiently than the AIXBLD runtime option.

**related tasks**
- “Coding COBOL programs to run under CICS” on page 407
- Chapter 22, “Developing COBOL programs for IMS,” on page 427
- “Improving VSAM performance” on page 195

**Language Environment Customization**

**related references**
- *Language Environment Programming Guide* (Specifying runtime options)

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**Choosing static or dynamic calls**

If you can arrange your modules, and the programs that frequently call each other are in one module, static calls are faster than dynamic calls.

For more information, see “Performance considerations of static and dynamic calls” on page 452.

**related concepts**
- “Performance considerations of static and dynamic calls” on page 452
Chapter 37. Simplifying coding

You can use coding techniques to improve your productivity. By using the COPY statement, the format 2 SORT statement, COBOL intrinsic functions, and Language Environment callable services, you can avoid repetitive coding and having to code many arithmetic calculations or other complex tasks.

If your program contains frequently used code sequences (such as blocks of common data items, input-output routines, error routines, or even entire COBOL programs), write the code sequences once and put them in a COBOL copy library. You can use the COPY statement to retrieve these code sequences and have them included in your program at compile time. Using copybooks in this manner eliminates repetitive coding.

To sort a table, you can use the format 2 SORT statement to simplify coding. It provides a much simpler way compared to the format 1 SORT statement.

COBOL provides various capabilities for manipulating strings and numbers. These capabilities can help you simplify your coding.

The Language Environment date and time callable services store dates as fullword binary integers and store time stamps as long (64-bit) floating-point values. These formats let you do arithmetic calculations on date and time values simply and efficiently. You do not need to write special subroutines that use services outside the language library to perform such calculations.

related tasks
“Using numeric intrinsic functions” on page 55
“Using math-oriented callable services” on page 56
“Using date callable services” on page 57
“Eliminating repetitive coding” on page 641
“Converting data items (intrinsic functions)” on page 112
“Evaluating data items (intrinsic functions)” on page 114
“Using Language Environment callable services” on page 643

related references
“Using the format 2 SORT statement to sort a table” on page 646

Eliminating repetitive coding

To include stored source statements in a program, use the COPY statement in any program division and at any code sequence level. You can nest COPY statements to any depth.

To specify more than one copy library, use either multiple system definitions or a combination of multiple definitions and the IN/OF phrase (IN/OF library-name):

MVS batch
Use JCL to concatenate data sets in your SYSLIB DD statement. Alternatively, define multiple DD statements and use the IN/OF phrase of the COPY statement.

TSO
Use the ALLOCATE command to concatenate data sets for SYSLIB. Alternatively, issue multiple ALLOCATE statements and use the IN/OF phrase of the COPY statement.

z/OS UNIX
Use the SYSLIB environment variable to define multiple paths to your copybooks. Alternatively, use multiple environment variables and use the IN/OF phrase of the COPY statement.
For example:

```
COPY MEMBER1 OF COPYLIB
```

If you omit this qualifying phrase, the default is SYSLIB.

**COPY and debugging line:** In order for the text copied to be treated as debug lines, for example, as if there were a D inserted in column 7, put the D on the first line of the COPY statement. A COPY statement cannot itself be a debugging line; if it contains a D, and WITH DEBUGGING mode is not specified, the COPY statement is nevertheless processed.

“Example: using the COPY statement” on page 642

**related references**
Chapter 18, “Compiler-directing statements,” on page 357

**Example: using the COPY statement**

These examples show how you can use the COPY statement to include library text in a program.

Suppose the library entry CFILEA consists of the following FD entries:

```
BLOCK CONTAINS 20 RECORDS
RECORD CONTAINS 120 CHARACTERS
LABEL RECORDS ARE STANDARD
DATA RECORD IS FILE-OUT.
01 FILE-OUT PIC X(120).
```

You can retrieve the text-name CFILEA by using the COPY statement in a source program as follows:

```
FD FILEA
COPY CFILEA.
```

The library entry is copied into your program, and the resulting program listing looks like this:

```
FD FILEA
COPY CFILEA.
C    BLOCK CONTAINS 20 RECORDS
C    RECORD CONTAINS 120 CHARACTERS
C    LABEL RECORDS ARE STANDARD
C    DATA RECORD IS FILE-OUT.
C    01 FILE-OUT   PIC X(120).
```

In the compiler source listing, the COPY statement prints on a separate line. C precedes copied lines.

Assume that a copybook with the text-name DOWORK is stored by using the following statements:

```
COMPUTE QTY-ON-HAND = TOTAL-USED-NUMBER-ON-HAND
MOVE QTY-ON-HAND to PRINT-AREA
```

To retrieve the copybook identified as DOWORK, code:

```
paragraph-name.
COPY DOWORK.
```

The statements that are in the DOWORK procedure will follow `paragraph-name`.

If you use the EXIT compiler option to provide a LIBEXIT module, your results might differ from those shown here.

**Note:** To save compile time, you might group related items in a copybook, but not necessarily have a single large copybook with unrelated items in it.
Using Language Environment callable services

Language Environment callable services make many types of programming tasks easier. You call them by using the \texttt{CALL} statement.

Language Environment services help you with the following tasks:

- **Handling conditions**
  
  The Language Environment condition-handling facilities enable COBOL applications to react to unexpected errors. You can use language constructs or runtime options to select the level at which to handle each condition. For example, you can handle a particular error in your COBOL program, let Language Environment take care of it, or have the operating system handle it.

  In support of Language Environment condition handling, COBOL provides procedure-pointer data items.

- **Managing dynamic storage**
  
  These services enable you to get, free, and reallocate storage. You can also create your own storage pools.

- **Calculating dates and times**
  
  If you use the date and time services, you can get the current local time and date in several formats, and perform date and time conversions. Two callable services, CEEQCENC and CEESCENC, provide a predictable way to handle two-digit years, such as 91 for 1991 or 09 for 2009.

- **Making math calculations**
  
  Calculations that are easy to perform with mathematical callable services include logarithmic, exponential, trigonometric, square root, and integer functions.

  COBOL also supports a set of intrinsic functions that include some of the same mathematical and date functions as those provided by the callable services. The Language Environment callable services and intrinsic functions provide equivalent results, with a few exceptions. You should be familiar with these differences before deciding which to use.

- **Handling messages**
  
  Message-handling services include services for getting, dispatching, and formatting messages. Messages for non-CICS applications can be directed to files or printers. CICS messages are directed to a CICS transient data queue. Language Environment splits messages to accommodate the record length of the destination, and presents messages in the correct national language such as Japanese or English.

- **Supporting national languages**
  
  These services make it easy for your applications to support the language that application users want. You can set the language and country, and obtain default date, time, number, and currency formats. For example, you might want dates to appear as 23 June 09 or as 6,23,09.

- **General services such as starting Debug Tool and obtaining a Language Environment formatted dump**
  
  Debug Tool provides advanced debugging functions for COBOL applications, including both batch and interactive debugging of CICS programs. Debug Tool enables you to debug a COBOL application from the host or, in conjunction with the Debug Perspective of IBM Developer for z/OS, from a Windows-based workstation.

  Depending on the options that you select, the Language Environment formatted dump might contain the names and values of data items, and information about conditions, program tracebacks, control blocks, storage, and files. All Language Environment dumps have a common, well-labeled, easy-to-read format.
Sample list of Language Environment callable services

The following table shows some examples of the callable services that are available with Language Environment. Many more services are available than those listed.

<table>
<thead>
<tr>
<th>Function type</th>
<th>Service</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition handling</td>
<td>CEEHDLR</td>
<td>To register a user condition handler</td>
</tr>
<tr>
<td></td>
<td>CEESGL</td>
<td>To raise or signal a condition</td>
</tr>
<tr>
<td></td>
<td>CEEMRCR</td>
<td>To indicate where the program will resume running after the condition handler has finished</td>
</tr>
<tr>
<td>Dynamic storage</td>
<td>CEEGTST</td>
<td>To get storage</td>
</tr>
<tr>
<td></td>
<td>CEECZST</td>
<td>To change the size of a previously allocated storage block</td>
</tr>
<tr>
<td></td>
<td>CEEFRST</td>
<td>To free storage</td>
</tr>
<tr>
<td>Date and time</td>
<td>CEECBLDY</td>
<td>To convert a string that represents a date into COBOL integer date format, which represents a date as the number of days since 31 December 1600</td>
</tr>
<tr>
<td></td>
<td>CEEQCEN, CEESCN</td>
<td>To query and set the Language Environment century window, which is valuable when a program uses two digits to express a year</td>
</tr>
<tr>
<td></td>
<td>CEEGMTO</td>
<td>To calculate the difference between the local system time and Greenwich Mean Time</td>
</tr>
<tr>
<td></td>
<td>CEELOCT</td>
<td>To get the current local time in your choice of three formats</td>
</tr>
<tr>
<td>Math</td>
<td>CEESIABS</td>
<td>To calculate the absolute value of an integer</td>
</tr>
<tr>
<td></td>
<td>CESSNWN</td>
<td>To calculate the nearest whole number for a single-precision floating-point number</td>
</tr>
<tr>
<td></td>
<td>CESSCOS</td>
<td>To calculate the cosine of an angle</td>
</tr>
<tr>
<td>Message handling</td>
<td>CEEMOUT</td>
<td>To dispatch a message</td>
</tr>
<tr>
<td></td>
<td>CEEMGET</td>
<td>To retrieve a message</td>
</tr>
<tr>
<td>National language support</td>
<td>CEE3LNG</td>
<td>To change or query the current national language</td>
</tr>
<tr>
<td></td>
<td>CEE3CTY</td>
<td>To change or query the current national country</td>
</tr>
<tr>
<td></td>
<td>CEE3MCS</td>
<td>To obtain the default currency symbol for a given country</td>
</tr>
</tbody>
</table>
### Table 91. Language Environment callable services (continued)

<table>
<thead>
<tr>
<th>Function type</th>
<th>Service</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>CEE3DMP</td>
<td>To obtain a Language Environment formatted dump</td>
</tr>
<tr>
<td></td>
<td>CEETEST</td>
<td>To start a debugging tool, such as Debug Tool</td>
</tr>
</tbody>
</table>

**related references**

*Language Environment Programming Reference*

### Calling Language Environment services

To invoke a Language Environment service, use a CALL statement with the correct parameters for that service. Define the variables for the CALL statement in the DATA DIVISION with the definitions that are required by that service.

```cobol
77  argument        comp-1.
77  feedback-code   pic  x(12)  display.
77  result          comp-1.

CALL "CEESSSQT" using argument, feedback-code, result
```

In the example above, Language Environment service CEESSSQT calculates the value of the square root of the variable argument and returns this value in the variable result.

You can choose whether to specify the feedback code parameter. If you specify it, the value returned in feedback-code indicates whether the service completed successfully. If you specify OMITTED instead of the feedback code, and the service is not successful, a Language Environment condition is automatically signaled to the Language Environment condition manager. You can handle such a condition by recovery logic implemented in a user-written condition handler, or let the default Language Environment processing for unhandled conditions occur. In either case, you avoid having to write logic to check the feedback code explicitly after each call.

If you call a Language Environment callable service and specify OMITTED for the feedback code, the RETURN-CODE special register is set to 0 if the service is successful. It is not altered if the service is unsuccessful. If you do not specify OMITTED for the feedback code, the RETURN-CODE special register is always set to 0 regardless of whether the service completed successfully.

“Example: Language Environment callable services” on page 645

**related concepts**

*Language Environment Programming Guide* (General callable services)

**related references**

*Language Environment Programming Reference* (General callable services)

**CALL statement** *(Enterprise COBOL for z/OS Language Reference)*

### Example: Language Environment callable services

This example shows a COBOL program that uses the Language Environment services CEEDAYS and CEEDATE to format and display a date from the results of a COBOL ACCEPT statement.

Using CEEDAYS and CEEDATE reduces the coding that would be required without Language Environment.

```cobol
ID DIVISION.
PROGRAM-ID. HOHOHO.

* FUNCTION: DISPLAY TODAY'S DATE IN THE FOLLOWING FORMAT: *
*           WWWWWWWW, MMMMMMMM DD, YYYY               *
*           For example: TUESDAY, SEPTEMBER 15, 2009   *
*                                                        *
ENVIRONMENT DIVISION.
DATA DIVISION.
```
Using the format 2 SORT statement to sort a table

It is recommended to use the format 2 SORT statement to sort a table. It provides the following benefits when compared to the format 1 SORT statement.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Format 1 SORT statements</th>
<th>Format 2 SORT statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be used to sort a file or a table</td>
<td>Yes</td>
<td>No, it is for tables only</td>
</tr>
<tr>
<td>Requires DFSORT or equivalent sorting program</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Supported in CICS</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Supported in UNIX System Services</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Supported in programs that are compiled with the THREAD option</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Table can be sorted by using a single SORT statement, which simplifies coding</td>
<td>No, it requires the SELECT clauses, SD entries with record descriptions, and input and output procedures</td>
<td>Yes</td>
</tr>
<tr>
<td>Keys for sorting can be specified as part of the table definition, which can also be used in the SEARCH ALL statement</td>
<td>No, keys must be specified in the SORT statement. If the table is to be searched by using SEARCH ALL as well, the keys must also be redundantly specified as part of the table definition.</td>
<td>Yes, and it also supports specifying keys in the SORT statement if needed</td>
</tr>
</tbody>
</table>

Table 92. Comparison of format 1 and format 2 SORT statements

646 Enterprise COBOL for z/OS: Enterprise COBOL for z/OS, V6.1 Programming Guide
### Table 92. Comparison of format 1 and format 2 SORT statements (continued)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Format 1 SORT statements</th>
<th>Format 2 SORT statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can filter or preprocess table elements during the sorting process</td>
<td>Yes, using input and output procedures</td>
<td>No, all of the table elements are passed to SORT as-is</td>
</tr>
<tr>
<td>Uses special registers that include SORT-CONTROL, SORT-CORE-SIZE, SORT-FILE-SIZE, SORT-MESSAGE, SORT-MODE-SIZE, and SORT-RETURN</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Can be executed within the range of an input or output procedure</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Note:** Do not use the format 2 SORT with large tables in an environment where storage is constrained, because the format 2 SORT uses heap storage to do the sort.

**related references**
SORT statement (*Enterprise COBOL for z/OS Language Reference*)
Appendix A. Intermediate results and arithmetic precision

The compiler handles arithmetic statements as a succession of operations performed according to operator precedence, and sets up intermediate fields to contain the results of those operations. The compiler uses algorithms to determine the number of integer and decimal places to reserve.

Intermediate results are possible in the following cases:

• In an ADD or SUBTRACT statement that contains more than one operand immediately after the verb
• In a COMPUTE statement that specifies a series of arithmetic operations or multiple result fields
• In an arithmetic expression contained in a conditional statement or in a reference-modification specification
• In an ADD, SUBTRACT, MULTIPLY, or DIVIDE statement that uses the GIVING option and multiple result fields
• In a statement that uses an intrinsic function as an operand
• In a statement that contains the ROUNDED phrase

“Example: calculation of intermediate results” on page 650

The precision of intermediate results depends on whether you compile using the default option ARITH(COMPAT) (referred to as compatibility mode) or using ARITH(EXTEND) (referred to as extended mode).

In compatibility mode, evaluation of arithmetic operations is unchanged from that in releases of IBM COBOL before COBOL for OS/390 & VM Version 2 Release 2:

• A maximum of 30 digits is used for fixed-point intermediate results.
• Floating-point intrinsic functions return long-precision (64-bit) floating-point results.
• Expressions that contain floating-point operands, fractional exponents, or floating-point intrinsic functions are evaluated as if all operands that are not in floating point are converted to long-precision floating point and floating-point operations are used to evaluate the expression.
• Floating-point literals and external floating-point data items are converted to long-precision floating point for processing.

In extended mode, evaluation of arithmetic operations has the following characteristics:

• A maximum of 31 digits is used for fixed-point intermediate results.
• Floating-point intrinsic functions return extended-precision (128-bit) floating-point results.
• Expressions that contain floating-point operands, fractional exponents, or floating-point intrinsic functions are evaluated as if all operands that are not in floating point are converted to extended-precision floating point and floating-point operations are used to evaluate the expression.
• Floating-point literals and external floating-point data items are converted to extended-precision floating point for processing.

related concepts
“Formats for numeric data” on page 45
“Fixed-point contrasted with floating-point arithmetic” on page 60

related references
“Fixed-point data and intermediate results” on page 651
“Floating-point data and intermediate results” on page 656
“Arithmetic expressions in nonarithmetic statements” on page 657
“ARITH” on page 291
Terminology used for intermediate results

To understand this information about intermediate results, you need to understand the following terminology.

\( i \)
The number of integer places carried for an intermediate result. (If you use the ROUNDED phrase, one more integer place might be carried for accuracy if necessary.)

\( d \)
The number of decimal places carried for an intermediate result. (If you use the ROUNDED phrase, one more decimal place might be carried for accuracy if necessary.)

\( d_{\text{max}} \)
In a particular statement, the largest of the following items:
- The number of decimal places needed for the final result field or fields
- The maximum number of decimal places defined for any operand, except divisors or exponents
- The outer-\( d_{\text{max}} \) for any function operand

\( \text{inner-} d_{\text{max}} \)
In reference to a function, the largest of the following items:
- The number of decimal places defined for any of its elementary arguments
- The \( d_{\text{max}} \) for any of its arithmetic expression arguments
- The outer-\( d_{\text{max}} \) for any of its embedded functions

\( \text{outer-} d_{\text{max}} \)
The number of decimal places that a function result contributes to operations outside of its own evaluation (for example, if the function is an operand in an arithmetic expression, or an argument to another function).

\( \text{op1} \)
The first operand in a generated arithmetic statement (in division, the divisor).

\( \text{op2} \)
The second operand in a generated arithmetic statement (in division, the dividend).

\( i_1, i_2 \)
The number of integer places in \( \text{op1} \) and \( \text{op2} \), respectively.

\( d_1, d_2 \)
The number of decimal places in \( \text{op1} \) and \( \text{op2} \), respectively.

\( \text{ir} \)
The intermediate result when a generated arithmetic statement or operation is performed. (Intermediate results are generated either in registers or storage locations.)

\( \text{ir}_1, \text{ir}_2 \)
Successive intermediate results. (Successive intermediate results might have the same storage location.)

related references
ROUNDED phrase (Enterprise COBOL for z/OS Language Reference)

Example: calculation of intermediate results

The following example shows how the compiler performs an arithmetic statement as a succession of operations, storing intermediate results as needed.

```
COMPUTE Y = A + B * C - D / E + F ** G
```
The result is calculated in the following order:
1. Exponentiate $F$ by $G$ yielding $ir1$.
3. Divide $E$ into $D$ yielding $ir3$.
4. Add $A$ to $ir2$ yielding $ir4$.
5. Subtract $ir3$ from $ir4$ yielding $ir5$.
6. Add $ir5$ to $ir1$ yielding $Y$.

**related tasks**
“Using arithmetic expressions” on page 54

**related references**
“Terminology used for intermediate results” on page 650

### Fixed-point data and intermediate results

The compiler determines the number of integer and decimal places in an intermediate result.

#### Addition, subtraction, multiplication, and division

The following table shows the precision theoretically possible as the result of addition, subtraction, multiplication, or division.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Integer places</th>
<th>Decimal places</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ or -</td>
<td>$(i1 \text{ or } i2) + 1$, whichever is greater</td>
<td>$d1 \text{ or } d2$, whichever is greater</td>
</tr>
<tr>
<td>*</td>
<td>$i1 + i2$</td>
<td>$d1 + d2$</td>
</tr>
<tr>
<td>/</td>
<td>$i2 + d1$</td>
<td>$(d2 - d1) \text{ or } dmax$, whichever is greater</td>
</tr>
</tbody>
</table>

You must define the operands of any arithmetic statements with enough decimal places to obtain the accuracy you want in the final result.

The following table shows the number of places the compiler carries for fixed-point intermediate results of arithmetic operations that involve addition, subtraction, multiplication, or division in *compatibility mode* (that is, when the default compiler option ARITH(COMPAT) is in effect):

<table>
<thead>
<tr>
<th>Value of $i + d$</th>
<th>Value of $d$</th>
<th>Value of $i + dmax$</th>
<th>Number of places carried for $ir$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt;30 \text{ or } =30$</td>
<td>Any value</td>
<td>Any value</td>
<td>$i$ integer and $d$ decimal places</td>
</tr>
<tr>
<td>$&gt;30$</td>
<td>$&lt;dmax \text{ or } =dmax$</td>
<td>Any value</td>
<td>$30-d$ integer and $d$ decimal places</td>
</tr>
<tr>
<td></td>
<td>$&gt;dmax$</td>
<td>$&lt;30 \text{ or } =30$</td>
<td>$i$ integer and $30-i$ decimal places</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$&gt;30$</td>
<td>$30-dmax$ integer and $dmax$ decimal places</td>
</tr>
</tbody>
</table>

The following table shows the number of places the compiler carries for fixed-point intermediate results of arithmetic operations that involve addition, subtraction, multiplication, or division in *extended mode* (that is, when the compiler option ARITH(EXTEND) is in effect):

<table>
<thead>
<tr>
<th>Value of $i + d$</th>
<th>Value of $d$</th>
<th>Value of $i + dmax$</th>
<th>Number of places carried for $ir$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt;31 \text{ or } =31$</td>
<td>Any value</td>
<td>Any value</td>
<td>$i$ integer and $d$ decimal places</td>
</tr>
</tbody>
</table>
Exponentiation

Exponentiation is represented by the expression \( op1 \times op2 \). Based on the characteristics of \( op2 \), the compiler handles exponentiation of fixed-point numbers in one of three ways:

- When \( op2 \) is expressed with decimals, floating-point instructions are used.
- When \( op2 \) is an integral literal or constant, the value \( d \) is computed as

\[
d = d1 \times |op2|
\]

and the value \( i \) is computed based on the characteristics of \( op1 \):

- When \( op1 \) is a data-name or variable,

\[
i = i1 \times |op2|
\]

- When \( op1 \) is a literal or constant, \( i \) is set equal to the number of integers in the value of \( op1 \times |op2| \).

In compatibility mode (compilation using \( \text{ARITH(COMPAT)} \)), the compiler having calculated \( i \) and \( d \) takes the action indicated in the table below to handle the intermediate results \( ir \) of the exponentiation.

<table>
<thead>
<tr>
<th>Value of ( i + d )</th>
<th>Other conditions</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;30)</td>
<td>Any</td>
<td>( i ) integer and ( d ) decimal places are carried for ( ir ).</td>
</tr>
<tr>
<td>(=30)</td>
<td>( op1 ) has an odd number of digits.</td>
<td>( i ) integer and ( d ) decimal places are carried for ( ir ).</td>
</tr>
<tr>
<td></td>
<td>( op1 ) has an even number of digits.</td>
<td>Same action as when ( op2 ) is an integral data-name or variable (shown below). Exception: for a 30-digit integer raised to the power of literal 1, ( i ) integer and ( d ) decimal places are carried for ( ir ).</td>
</tr>
<tr>
<td>(&gt;30)</td>
<td>Any</td>
<td>Same action as when ( op2 ) is an integral data-name or variable (shown below)</td>
</tr>
</tbody>
</table>

In extended mode (compilation using \( \text{ARITH(EXTEND)} \)), the compiler having calculated \( i \) and \( d \) takes the action indicated in the table below to handle the intermediate results \( ir \) of the exponentiation.

<table>
<thead>
<tr>
<th>Value of ( i + d )</th>
<th>Other conditions</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;31)</td>
<td>Any</td>
<td>( i ) integer and ( d ) decimal places are carried for ( ir ).</td>
</tr>
<tr>
<td>(=31 \text{ or } &gt;31)</td>
<td>Any</td>
<td>Same action as when ( op2 ) is an integral data-name or variable (shown below). Exception: for a 31-digit integer raised to the power of literal 1, ( i ) integer and ( d ) decimal places are carried for ( ir ).</td>
</tr>
</tbody>
</table>

If \( op2 \) is negative, the value of 1 is then divided by the result produced by the preliminary computation. The values of \( i \) and \( d \) that are used are calculated following the division rules for fixed-point data already shown above.
When `op2` is an integral data-name or variable, `dmax` decimal places and `30-dmax` (compatibility mode) or `31-dmax` (extended mode) integer places are used. `op1` is multiplied by itself `(|op2| - 1)` times for nonzero `op2`.

If `op2` is equal to 0, the result is 1. Division-by-0 and exponentiation SIZE ERROR conditions apply. Fixed-point exponents with more than nine significant digits are always truncated to nine digits. If the exponent is a literal or constant, an E-level compiler diagnostic message is issued; otherwise, an informational message is issued at run time.

“Example: exponentiation in fixed-point arithmetic” on page 653

related references
“Terminology used for intermediate results” on page 650
“Truncated intermediate results” on page 653
“Binary data and intermediate results” on page 654
“Floating-point data and intermediate results” on page 656
“Intrinsic functions evaluated in fixed-point arithmetic” on page 654
“ARITH” on page 291
SIZE ERROR phrases (Enterprise COBOL for z/OS Language Reference)

Example: exponentiation in fixed-point arithmetic
The following example shows how the compiler performs an exponentiation to a nonzero integer power as a succession of multiplications, storing intermediate results as needed.

```
COMPUTE Y = A ** B
```

If `B` is equal to 4, the result is computed as shown below. The values of `i` and `d` that are used are calculated according to the multiplication rules for fixed-point data and intermediate results (referred to below).

1. Multiply `A` by `A` yielding an internal intermediate result `iir1`.
2. Multiply `iir1` by `A` yielding an internal intermediate result `iir2`.
3. Multiply `iir2` by `A` yielding an internal intermediate result `iir3`.
   `ir4` has `dmax` decimal places. Because `B` is positive, `ir4` is moved to `Y`. If `B` were equal to -4, however, an additional fifth step would be performed:
5. Divide `ir4` into 1 yielding `ir5`.
   `ir5` has `dmax` decimal places, and would then be moved to `Y`.

**Note:** The internal intermediate results (`iir1`, `iir2`, and `iir3`) obtained by the internal library routine performing the exponential calculation in steps 1, 2, and 3 above do not use the same decimal precision as `ir4` and `ir5` above. Instead, those intermediate results are much more precise, ensuring the most accurate result possible in `ir4` or `ir5`.

related references
“Terminology used for intermediate results” on page 650
“Fixed-point data and intermediate results” on page 651

Truncated intermediate results
Whenever the number of digits in an intermediate result exceeds 30 in compatibility mode or 31 in extended mode, the compiler truncates to 30 (compatibility mode) or 31 (extended mode) digits and issues a warning. If truncation occurs at run time, a message is issued and the program continues running.

If you want to avoid the truncation of intermediate results that can occur in fixed-point calculations, use floating-point operands (COMP-1 or COMP-2) instead.
Binary data and intermediate results

If an operation that involves binary operands requires intermediate results longer than 18 digits, the compiler converts the operands to internal decimal before performing the operation. If the result field is binary, the compiler converts the result from internal decimal to binary.

Binary operands are most efficient when intermediate results will not exceed nine digits.

Intrinsic functions evaluated in fixed-point arithmetic

The compiler determines the inner-dmax and outer-dmax values for an intrinsic function from the characteristics of the function.

Integer functions

Integer intrinsic functions return an integer; thus their outer-dmax is always zero. For those integer functions whose arguments must all be integers, the inner-dmax is thus also always zero.

The following table summarizes the inner-dmax and the precision of the function result.

<table>
<thead>
<tr>
<th>Function</th>
<th>Inner-dmax</th>
<th>Digit precision of function result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE-OF-INTEGER</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>DATE-TO-YYYYMMDD</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>DAY-OF-INTEGER</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>DAY-TO-YYYYDDD</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>FACTORIAL</td>
<td>0</td>
<td>30 in compatibility mode, 31 in extended mode</td>
</tr>
<tr>
<td>INTEGER-OF-DATE</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>INTEGER-OF-DAY</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>LENGTH</td>
<td>n/a</td>
<td>9</td>
</tr>
<tr>
<td>MOD</td>
<td>0</td>
<td>(\min(i1, i2))</td>
</tr>
<tr>
<td>ORD</td>
<td>n/a</td>
<td>3</td>
</tr>
<tr>
<td>ORD-MAX</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>ORD-MIN</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>YEAR-TO-YYYY</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>INTEGER</td>
<td></td>
<td>For a fixed-point argument: one more digit than in the argument. For a floating-point argument: 30 in compatibility mode, 31 in extended mode.</td>
</tr>
</tbody>
</table>
### Mixed functions

A *mixed* intrinsic function is a function whose result type depends on the type of its arguments. A mixed function is fixed point if all of its arguments are numeric and none of its arguments is floating point. (If any argument of a mixed function is floating point, the function is evaluated with floating-point instructions and returns a floating-point result.) When a mixed function is evaluated with fixed-point arithmetic, the result is integer if all of the arguments are integer; otherwise, the result is fixed point.

For the mixed functions MAX, MIN, RANGE, REM, and SUM, the outer-dmax is always equal to the inner-dmax (and both are thus zero if all the arguments are integer). To determine the precision of the result returned for these functions, apply the rules for fixed-point arithmetic and intermediate results (as referred to below) to each step in the algorithm.

**MAX**

1. Assign the first argument to the function result.
2. For each remaining argument, do the following steps:
   a. Compare the algebraic value of the function result with the argument.
   b. Assign the greater of the two to the function result.

**MIN**

1. Assign the first argument to the function result.
2. For each remaining argument, do the following steps:
   a. Compare the algebraic value of the function result with the argument.
   b. Assign the lesser of the two to the function result.

**RANGE**

1. Use the steps for MAX to select the maximum argument.
2. Use the steps for MIN to select the minimum argument.
3. Subtract the minimum argument from the maximum.
4. Assign the difference to the function result.

**REM**

1. Divide argument one by argument two.
2. Remove all noninteger digits from the result of step 1.
3. Multiply the result of step 2 by argument two.
4. Subtract the result of step 3 from argument one.
5. Assign the difference to the function result.

**SUM**

1. Assign the value 0 to the function result.
2. For each argument, do the following steps:
   a. Add the argument to the function result.
   b. Assign the sum to the function result.

### related references

“Terminology used for intermediate results” on page 650
“Fixed-point data and intermediate results” on page 651
Floating-point data and intermediate results

If any operation in an arithmetic expression is computed in floating-point arithmetic, the entire expression is computed as if all operands were converted to floating point and the operations were performed using floating-point instructions.

Floating-point instructions are used to compute an arithmetic expression if any of the following conditions is true of the expression:

- A receiver or operand is COMP-1, COMP-2, external floating point, or a floating-point literal.
- An exponent contains decimal places.
- An exponent is an expression that contains an exponentiation or division operator, and $dmax$ is greater than zero.
- An intrinsic function is a floating-point function.

In compatibility mode, if an expression is computed in floating-point arithmetic, the precision used to evaluate the arithmetic operations is determined as follows:

- Single precision is used if all receivers and operands are COMP-1 data items and the expression contains no multiplication or exponentiation operations.
- In all other cases, long precision is used.

Whenever long-precision floating point is used for one operation in an arithmetic expression, all operations in the expression are computed as if long floating-point instructions were used.

In extended mode, if an expression is computed in floating-point arithmetic, the precision used to evaluate the arithmetic operations is determined as follows:

- Single precision is used if all receivers and operands are COMP-1 data items and the expression contains no multiplication or exponentiation operations.
- Long precision is used if all receivers and operands are COMP-1 or COMP-2 data items, at least one receiver or operand is a COMP-2 data item, and the expression contains no multiplication or exponentiation operations.
- In all other cases, extended precision is used.

Whenever extended-precision floating point is used for one operation in an arithmetic expression, all operations in the expression are computed as if extended-precision floating-point instructions were used.

**Alert:** If a floating-point operation has an intermediate result field in which exponent overflow occurs, the job is abnormally terminated.

Exponentiations evaluated in floating-point arithmetic

In compatibility mode, floating-point exponentiations are always evaluated using long floating-point arithmetic. In extended mode, floating-point exponentiations are always evaluated using extended-precision floating-point arithmetic.

The value of a negative number raised to a fractional power is undefined in COBOL. For example, $(-2)^{**}3$ is equal to -8, but $(-2)^{**}(3.000001)$ is undefined. When an exponentiation is evaluated in floating point and there is a possibility that the result is undefined, the exponent is evaluated at run time to determine if it has an integral value. If not, a diagnostic message is issued.

Intrinsic functions evaluated in floating-point arithmetic

In compatibility mode, floating-point intrinsic functions always return a long (64-bit) floating-point value. In extended mode, floating-point intrinsic functions always return an extended-precision (128-bit) floating-point value.
Mixed functions that have at least one floating-point argument are evaluated using floating-point arithmetic.

**related references**
“Terminology used for intermediate results” on page 650
“ARITH” on page 291

---

**Arithmetic expressions in nonarithmetic statements**

Arithmetic expressions can appear in contexts other than arithmetic statements. For example, you can use an arithmetic expression with the IF or EVALUATE statement.

In such statements, the rules for intermediate results with fixed-point data and for intermediate results with floating-point data apply, with the following changes:

- Abbreviated IF statements are handled as though the statements were not abbreviated.
- In an explicit relation condition where at least one of the comparands is an arithmetic expression, \( d_{max} \) is the maximum number of decimal places for any operand of either comparand, excluding divisors and exponents. The rules for floating-point arithmetic apply if any of the following conditions is true:
  - Any operand in either comparand is COMP-1, COMP-2, external floating point, or a floating-point literal.
  - An exponent contains decimal places.
  - An exponent is an expression that contains an exponentiation or division operator, and \( d_{max} \) is greater than zero.

For example:

```
IF operand-1 = expression-1 THEN . . .
```

If `operand-1` is a data-name defined to be COMP-2, the rules for floating-point arithmetic apply to `expression-1` even if it contains only fixed-point operands, because it is being compared to a floating-point operand.

- When the comparison between an arithmetic expression and another data item or arithmetic expression does not use a relational operator (that is, there is no explicit relation condition), the arithmetic expression is evaluated without regard to the attributes of its comparand. For example:

```
EVALUATE expression-1
  WHEN expression-2 THRU expression-3
  WHEN expression-4
  . . .
END-EVALUATE
```

In the statement above, each arithmetic expression is evaluated in fixed-point or floating-point arithmetic based on its own characteristics.

**related concepts**
“Fixed-point contrasted with floating-point arithmetic” on page 60

**related references**
“Terminology used for intermediate results” on page 650
“Fixed-point data and intermediate results” on page 651
“Floating-point data and intermediate results” on page 656
IF statement *(Enterprise COBOL for z/OS Language Reference)*
EVALUATE statement *(Enterprise COBOL for z/OS Language Reference)*
Conditional expressions *(Enterprise COBOL for z/OS Language Reference)*
Appendix B. Converting double-byte character set (DBCS) data

The Language Environment service routines IGZCA2D and IGZCD2A were intended for converting alphanumeric data items that contain DBCS data to and from pure DBCS data items in order to reliably perform operations such as STRING, UNSTRING, and reference modification.

These service routines continue to be provided for compatibility; however, using national data items and the national conversion operations is now recommended instead for this purpose.

The service routines do not support a code-page argument and are not sensitive to the code page specified by the CODEPAGE compiler option. The DBCS compiler option does not affect their operation.

related tasks
“Converting to or from national (Unicode) representation” on page 131
“Processing alphanumeric data items that contain DBCS data” on page 144

related references
“DBCS notation” on page 659
“Alphanumeric to DBCS data conversion (IGZCA2D)” on page 659
“DBCS to alphanumeric data conversion (IGZCD2A)” on page 661
“CODEPAGE” on page 295

DBCS notation

The symbols shown below are used in the DBCS data conversion examples to describe DBCS items.

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; and &gt;</td>
<td>Shift-out (SO) and shift-in (SI), respectively</td>
</tr>
<tr>
<td>D0, D1, D2, . . ., Dn</td>
<td>Any DBCS character except for double-byte EBCDIC characters that correspond to single-byte EBCDIC characters</td>
</tr>
<tr>
<td>.A, .B, .C, . . .</td>
<td>Any double-byte EBCDIC character that corresponds to a single-byte EBCDIC character. The period (.) represents the value X'42'.</td>
</tr>
<tr>
<td>A single letter, such as A, B, or s</td>
<td>Any single-byte EBCDIC character</td>
</tr>
</tbody>
</table>

Alphanumeric to DBCS data conversion (IGZCA2D)

The Language Environment IGZCA2D service routine converts alphanumeric data that contains double-byte characters to pure DBCS data.

IGZCA2D syntax

To use the IGZCA2D service routine, pass the following four parameters to the routine by using the CALL statement:

parameter-1
   The sending field for the conversion, handled as an alphanumeric data item.

parameter-2
   The receiving field for the conversion, handled as a DBCS data item.

You cannot use reference modification with parameter-2.
**parameter-3**

The number of bytes in `parameter-1` to be converted.

It can be the LENGTH OF special register of `parameter-1`, or a 4-byte USAGE IS BINARY data item containing the number of bytes of `parameter-1` to be converted. Shift codes count as 1 byte each.

**parameter-4**

The number of bytes in `parameter-2` that will receive the converted data.

It can be the LENGTH OF special register of `parameter-2`, or a 4-byte USAGE IS BINARY data item containing the number of bytes of `parameter-2` to receive the converted data.

**Usage notes**

- You can pass `parameter-1`, `parameter-3`, and `parameter-4` to the routine BY REFERENCE or BY CONTENT, but you must pass `parameter-2` BY REFERENCE.
- The compiler does not perform syntax checking on these parameters. Ensure that the parameters are correctly set and passed in the CALL statement to the conversion routine. Otherwise, results are unpredictable.
- When creating `parameter-2` from `parameter-1`, IGZCA2D makes these changes:
  - Removes the shift codes, leaving the DBCS data unchanged
  - Converts the single-byte (nonspace) EBCDIC character X'nn' to a character represented by X'42nn'
  - Converts the single-byte space (X'40') to DBCS space (X'4040'), instead of X'4240'
- IGZCA2D does not change the contents of `parameter-1`, `parameter-3`, or `parameter-4`.
- The valid range for the contents of `parameter-3` and for the contents of `parameter-4` is 1 to 134,217,727.

“Example: IGZCA2D” on page 661

**related references**

“IGZCA2D return codes” on page 660

**IGZCA2D return codes**

IGZCA2D sets the RETURN-CODE special register to reflect the status of the conversion.

<table>
<thead>
<tr>
<th>Return code</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><code>parameter-1</code> was converted and the results were placed in <code>parameter-2</code>.</td>
</tr>
<tr>
<td>2</td>
<td><code>parameter-1</code> was converted and the results were placed in <code>parameter-2</code>. <code>parameter-2</code> was padded on the right with DBCS spaces.</td>
</tr>
<tr>
<td>4</td>
<td><code>parameter-1</code> was converted and the results were placed in <code>parameter-2</code>. The DBCS data placed in <code>parameter-2</code> was truncated on the right.</td>
</tr>
<tr>
<td>6</td>
<td><code>parameter-1</code> was converted and the results were placed in <code>parameter-2</code>. A single-byte character in the range X'00' to X'3F' or X'FF' was encountered. The valid single-byte character was converted into an out-of-range DBCS character.</td>
</tr>
<tr>
<td>8</td>
<td><code>parameter-1</code> was converted and the results were placed in <code>parameter-2</code>. A single-byte character in the range X'00' to X'3F' or X'FF' was encountered. The valid single-byte character was converted into an out-of-range DBCS character. <code>parameter-2</code> was padded on the right with DBCS spaces.</td>
</tr>
<tr>
<td>Return code</td>
<td>Explanation</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>10</td>
<td>A single-byte character in the range X'00' to X'3F' or X'FF' was encountered. The valid single-byte character was converted into an out-of-range DBCS character. The DBCS data in parameter-2 was truncated on the right.</td>
</tr>
<tr>
<td>12</td>
<td>An odd number of bytes was found between paired shift codes in parameter-1. No conversion occurred.</td>
</tr>
<tr>
<td>13</td>
<td>Unpaired or nested shift codes were found in parameter-1. No conversion occurred.</td>
</tr>
<tr>
<td>14</td>
<td>parameter-1 and parameter-2 were overlapping. No conversion occurred.</td>
</tr>
<tr>
<td>15</td>
<td>The value provided for parameter-3 or parameter-4 was out of range. No conversion occurred.</td>
</tr>
<tr>
<td>16</td>
<td>An odd number of bytes was coded in parameter-4. No conversion occurred.</td>
</tr>
</tbody>
</table>

Example: IGZCA2D

This example CALL statement converts the alphanumeric data in alpha-item to DBCS data. The results of the conversion are placed in dbcs-item.

```
CALL "IGZCA2D" USING BY REFERENCE alpha-item dbcs-item
BY CONTENT LENGTH OF alpha-item LENGTH OF dbcs-item
```

Suppose the contents of alpha-item and dbcs-item and the lengths before the conversion are:

```
alpha-item = AB<D1D2D3>CD
dbcs-item  = D4D5D6D7D8D9D0
```

LENGTH OF alpha-item = 12
LENGTH OF dbcs-item  = 14

Then after the conversion, alpha-item and dbcs-item will contain:

```
alpha-item = AB<D1D2D3>CD
dbcs-item  = .A.BD1D2D3.C.D
```

The content of the RETURN-CODE register is 0.

**related references**

“DBCS notation” on page 659

---

**DBCS to alphanumeric data conversion (IGZCD2A)**

The Language Environment IGZCD2A routine converts pure DBCS data to alphanumeric data that can contain double-byte characters.

**IGZCD2A syntax**

To use the IGZCD2A service routine, pass the following four parameters to the routine using the CALL statement:

- **parameter-1**
  The sending field for the conversion, handled as a DBCS data item.
**parameter-2**
The receiving field for the conversion, handled as an alphanumeric data item.

**parameter-3**
The number of bytes in **parameter-1** to be converted.

It can be the LENGTH OF special register of **parameter-1**, or a 4-byte USAGE IS BINARY data item containing the number of bytes of **parameter-1** to be converted.

**parameter-4**
The number of bytes in **parameter-2** that will receive the converted data.

It can be the LENGTH OF special register of **parameter-2**, or a 4-byte USAGE IS BINARY data item containing the number of bytes of **parameter-2** to receive the converted data. Shift codes count as 1 byte each.

**Usage notes**

- You can pass **parameter-1**, **parameter-3**, and **parameter-4** to the routine **BY REFERENCE** or **BY CONTENT**, but you must pass **parameter-2** **BY REFERENCE**.
- The compiler does not perform syntax checking on these parameters. Ensure that the parameters are correctly set and passed to the conversion routine. Otherwise, results are unpredictable.
- When creating **parameter-2** from **parameter-1**, IGZCD2A makes these changes:
  - Inserts shift codes around DBCS characters that do not correspond to single-byte EBCDIC characters
  - Converts DBCS characters to single-byte characters when the DBCS characters correspond to single-byte EBCDIC characters
  - Converts the DBCS space (X'4040') to a single-byte space (X'40')
- IGZCD2A does not change the contents of **parameter-1**, **parameter-3**, or **parameter-4**.
- If the converted data contains double-byte characters, shift codes are counted in the length of **parameter-2**.
- The valid range for the contents of **parameter-3** and for the contents of **parameter-4** is 1 to 134,217,727.

“Example: IGZCD2A” on page 663

**related references**

“IGZCD2A return codes” on page 662

**IGZCD2A return codes**

IGZCD2A sets the RETURN-CODE special register to reflect the status of the conversion.

<table>
<thead>
<tr>
<th>Return code</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>parameter-1</strong> was converted and the results were placed in <strong>parameter-2</strong>.</td>
</tr>
<tr>
<td>2</td>
<td><strong>parameter-1</strong> was converted and the results were placed in <strong>parameter-2</strong>. <strong>parameter-2</strong> was padded on the right with single-byte spaces.</td>
</tr>
<tr>
<td>4</td>
<td><strong>parameter-1</strong> was converted and the results were placed in <strong>parameter-2</strong>. <strong>parameter-2</strong> was truncated on the right.¹</td>
</tr>
<tr>
<td>14</td>
<td><strong>parameter-1</strong> and <strong>parameter-2</strong> were overlapping. No conversion occurred.</td>
</tr>
<tr>
<td>15</td>
<td>The value of <strong>parameter-3</strong> or <strong>parameter-4</strong> was out of range. No conversion occurred.</td>
</tr>
<tr>
<td>16</td>
<td>An odd number of bytes was coded in <strong>parameter-3</strong>. No conversion occurred.</td>
</tr>
</tbody>
</table>
### Table 94. IGZCD2A return codes (continued)

<table>
<thead>
<tr>
<th>Return code</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If a truncation occurs within the DBCS characters, the truncation is on an even-byte boundary and a shift-in (SI) is inserted. If necessary, the alphanumeric data is padded with a single-byte space after the shift-in.</td>
<td></td>
</tr>
</tbody>
</table>

**Example: IGZCD2A**

This example CALL statement converts the DBCS data in `dbcs-item` to alphanumeric data with double-byte characters. The results of the conversion are placed in `alpha-item`.

```
CALL "IGZCD2A" USING BY REFERENCE dbcs-item alpha-item
   BY CONTENT LENGTH OF dbcs-item LENGTH OF alpha-item
```

Suppose the contents of `dbcs-item` and `alpha-item` and the lengths before the conversion are:

```
dbcs-item = .A.BD1D2D3.C.D
alpha-item = sssssssssss
```

LENGTH OF `dbcs-item` = 14
LENGTH OF `alpha-item` = 12

Then after the conversion, `dbcs-item` and `alpha-item` will contain:

```
dbcs-item = .A.BD1D2D3.C.D
alpha-item = AB<D1D2D3>CD
```

The content of the RETURN-CODE register is 0.

**related references**

“DBCS notation” on page 659
Appendix C. XML reference material

The following information describes the XML exception codes that might be returned during XML parsing or XML generation.

related references
“XML PARSE exceptions with XMLPARSE(XMLSS) in effect” on page 665
“XML PARSE exceptions with XMLPARSE(COMPAT) in effect” on page 667
“XML GENERATE exceptions” on page 673
XML specification

XML PARSE exceptions with XMLPARSE(XMLSS) in effect

When the z/OS XML System Services parser passes control to your processing procedure for an exception event, the XML - CODE special register contains the exception code, which is formed from a return code and a reason code.

The return code and reason code are each a halfword binary value. The exception code is the concatenation of those two values: the return code in the high-order halfword, and the reason code in the low-order halfword.

The return codes and reason codes are documented as hexadecimal values in the z/OS XML System Services User’s Guide and Reference, referenced below, and in Table 95 on page 665 below.

After most exception events, the parser does not continue processing; the value in XML - CODE at the end of the XML PARSE statement is the original exception code set by the parser.

When the processing procedure returns to the parser after the exception event, control transfers to the statement specified in the ON EXCEPTION phrase, or to the end of the XML PARSE statement if you did not code an ON EXCEPTION phrase.

Validation exceptions:

If you code an XML PARSE statement that contains the VALIDATING phrase, and the z/OS XML System Services parser determines that the document is not valid, the parser generates return code 24 (hexadecimal 18, XRC_NOT_VALID).

Exceptions that are unique to Enterprise COBOL:

Some exceptions are unique to Enterprise COBOL and thus are not documented in the z/OS XML System Services User’s Guide and Reference, for example, errors that occur during XML schema retrieval. The return code for exceptions with reason codes in the hexadecimal range 800 to 899 is 4 (hexadecimal 0004, XRC_WARNING). For other exceptions, the return code is 16 (hexadecimal 0010, XRC_FATAL). The exception code (the value in special register XML - CODE), is formed from this return code concatenated with one of the reason codes shown in the following table.

<table>
<thead>
<tr>
<th>Reason code (hexadecimal)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>700</td>
<td>VALIDATING WITH FILE is not supported under CICS.</td>
</tr>
<tr>
<td>701</td>
<td>The optimized XML schema that was read in was too short, or the file was empty.</td>
</tr>
<tr>
<td>702</td>
<td>The file identifier for the schema was not a ddname or environment-variable name.</td>
</tr>
<tr>
<td>703</td>
<td>The DSN value contained a space character in a position where a space is not allowed.</td>
</tr>
<tr>
<td>Reason code (hexadecimal)</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>704</td>
<td>The DSN value specified a temporary data set.</td>
</tr>
<tr>
<td>705</td>
<td>The PATH value contained an unescaped space character.</td>
</tr>
<tr>
<td>706</td>
<td>The PATH value contained a path name that was not an absolute path.</td>
</tr>
<tr>
<td>707</td>
<td>Memory allocation for the XML schema buffer failed.</td>
</tr>
<tr>
<td>708</td>
<td>The environment variable was null or contained only spaces.</td>
</tr>
<tr>
<td>709</td>
<td>The environment variable contained an invalid keyword.</td>
</tr>
<tr>
<td>710</td>
<td>The DSN value contained an invalid character after the member name.</td>
</tr>
<tr>
<td>711</td>
<td>The DSN value did not specify a member name.</td>
</tr>
<tr>
<td>712</td>
<td>The DSN value did not specify a data set name, or parentheses were not specified correctly.</td>
</tr>
<tr>
<td>713</td>
<td>The PATH value did not specify a path name, or parentheses were not specified correctly.</td>
</tr>
<tr>
<td>714</td>
<td>The DSN value contained an extra parenthesis.</td>
</tr>
<tr>
<td>715</td>
<td>The PATH value contained an extra parenthesis.</td>
</tr>
<tr>
<td>716</td>
<td>The DSN value was missing the closing parenthesis.</td>
</tr>
<tr>
<td>717</td>
<td>The PATH value was missing the closing parenthesis.</td>
</tr>
<tr>
<td>718</td>
<td>The DSN value contained an escape character.</td>
</tr>
<tr>
<td>720</td>
<td>A character reference for an unrepresentable character was not resolved.</td>
</tr>
<tr>
<td>721</td>
<td>An unrepresentable character reference in the document type declaration is not supported.</td>
</tr>
<tr>
<td>800</td>
<td>The attribute name used an undeclared prefix.</td>
</tr>
<tr>
<td>801</td>
<td>The START-OF-ELEMENT name used an undeclared prefix. (The END-OF-ELEMENT name must match, so using the same undeclared prefix does not cause another exception.)</td>
</tr>
<tr>
<td>900</td>
<td>Internal error. Report the error to your service representative.</td>
</tr>
</tbody>
</table>

For any of the reason codes except 900, correct the error and then retry your program.

related concepts
“XML-CODE” on page 508
“XML events” on page 507

related tasks
“Handling XML PARSE exceptions” on page 523

related references
“XMLPARSE” on page 349 (compiler option)
XML PARSE statement (Enterprise COBOL for z/OS Language Reference)
z/OS XML System Services User's Guide and Reference
XML PARSE exceptions with XMLPARSE(COMPAT) in effect

When an exception event occurs, the XML parser that is provided with the Enterprise COBOL library sets special register XML-CODE to a value that identifies the exception. Depending on the value in XML-CODE, the parser might or might not be able to continue processing after the exception, as detailed in the information referenced below.

related references
“XML PARSE exceptions that allow continuation” on page 667
“XML PARSE exceptions that do not allow continuation” on page 670

XML PARSE exceptions that allow continuation

If the XMLPARSE (COMPAT) compiler option is in effect, whether the XML parser can continue processing after an exception event depends upon the value of the exception code.

The parser can continue processing if the exception code, which is in special register XML-CODE, is within one of the following ranges:

- 1 - 99
- 100,001 - 165,535

The following table describes each exception, and identifies the actions that the parser takes if you request that it continue after the exception. Some of the descriptions use the following terms:

- Actual document encoding
- Document encoding declaration

For definitions of the terms, see the related concept about XML input document encoding.

<table>
<thead>
<tr>
<th>Exception code (decimal)</th>
<th>Description</th>
<th>Parser action on continuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The parser found an invalid character while scanning white space outside element content. For further information about white space, see the related concept about XML input document encoding.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>2</td>
<td>The parser found an invalid start of a processing instruction, element, comment, or document type declaration outside element content.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>3</td>
<td>The parser found a duplicate attribute name.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>4</td>
<td>The parser found the markup character <code>&lt;</code> in an attribute value.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>Exception code (decimal)</td>
<td>Description</td>
<td>Parser action on continuation</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5</td>
<td>The start and end tag names of an element did not match.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>6</td>
<td>The parser found an invalid character in element content.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>7</td>
<td>The parser found an invalid start of an element, comment, processing instruction, or CDATA section in element content.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>8</td>
<td>The parser found in element content the CDATA closing character sequence <code>]]&gt;']]&gt;' without the matching opening character sequence </code>&lt;![CDATA['.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>9</td>
<td>The parser found an invalid character in a comment.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>10</td>
<td>The parser found in a comment the character sequence '- - ' (two hyphens) not followed by '&gt;'.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>11</td>
<td>The parser found an invalid character in a processing instruction data segment.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>12</td>
<td>The XML declaration was not at the beginning of the document.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>13</td>
<td>The parser found an invalid digit in a hexadecimal character reference (of the form <code>&amp;#xd3dd;</code>).</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
</tbody>
</table>
Table 96. XML PARSE exceptions that allow continuation (continued)

<table>
<thead>
<tr>
<th>Exception code (decimal)</th>
<th>Description</th>
<th>Parser action on continuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>The parser found an invalid digit in a decimal character reference (of the form &amp;###dd).</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>15</td>
<td>The encoding declaration value in the XML declaration did not begin with lowercase or uppercase A through Z.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>16</td>
<td>A character reference did not refer to a legal XML character.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>17</td>
<td>The parser found an invalid character in an entity reference name.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>18</td>
<td>The parser found an invalid character in an attribute value.</td>
<td>The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.</td>
</tr>
<tr>
<td>70</td>
<td>The actual document encoding was EBCDIC, and the CODEPAGE compiler option specified a supported EBCDIC code page, but the document encoding declaration did not specify a supported EBCDIC code page.</td>
<td>The parser uses the encoding specified by the CODEPAGE compiler option.</td>
</tr>
<tr>
<td>71</td>
<td>The actual document encoding was EBCDIC, and the document encoding declaration specified a supported EBCDIC encoding, but the CODEPAGE compiler option did not specify a supported EBCDIC code page.</td>
<td>The parser uses the encoding specified by the document encoding declaration.</td>
</tr>
<tr>
<td>72</td>
<td>The actual document encoding was EBCDIC, the CODEPAGE compiler option did not specify a supported EBCDIC code page, and the document did not contain an encoding declaration.</td>
<td>The parser uses EBCDIC code page 1140 (USA, Canada, ... Euro Country Extended Code Page).</td>
</tr>
</tbody>
</table>
Table 96. XML PARSE exceptions that allow continuation (continued)

<table>
<thead>
<tr>
<th>Exception code (decimal)</th>
<th>Description</th>
<th>Parser action on continuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>The actual document encoding was EBCDIC, but neither the CODEPAGE compiler option nor the document encoding declaration specified a supported EBCDIC code page.</td>
<td>The parser uses EBCDIC code page 1140 (USA, Canada, . . . Euro Country Extended Code Page).</td>
</tr>
<tr>
<td>82</td>
<td>The actual document encoding was ASCII, but the document did not contain an encoding declaration.</td>
<td>The parser uses ASCII code page 819 (ISO-8859-1 Latin 1/Open Systems).</td>
</tr>
<tr>
<td>83</td>
<td>The actual document encoding was ASCII, but the document encoding declaration did not specify code page 813, 819, or 920.</td>
<td>The parser uses ASCII code page 819 (ISO-8859-1 Latin 1/Open Systems).</td>
</tr>
<tr>
<td>92</td>
<td>The document data item was alphanumeric, but the actual document encoding was Unicode UTF-16.</td>
<td>The parser uses code page 1200 (Unicode UTF-16).</td>
</tr>
<tr>
<td>100,001 - 165,535</td>
<td>The CODEPAGE compiler option and the document encoding declaration specified different supported EBCDIC code pages. XML-CODE contains the code page CCSID for the encoding declaration plus 100,000.</td>
<td>If you set XML-CODE to zero before returning from the EXCEPTION event, the parser uses the encoding specified by the CODEPAGE compiler option. If you set XML-CODE to the CCSID for the document encoding declaration (by subtracting 100,000), the parser uses this encoding.</td>
</tr>
</tbody>
</table>

related concepts
“XML-CODE” on page 508
“XML input document encoding” on page 519

related tasks
“Handling XML PARSE exceptions” on page 523

related references
“XMLPARSE” on page 349 (compiler option)

XML PARSE exceptions that do not allow continuation
If the XMLPARSE(COMPAT) compiler option is in effect, the XML parser cannot continue processing if any of the exceptions described below occurs.

No further events are returned from the parser for any of these exceptions even if the processing procedure sets XML-CODE to zero before passing control back to the parser. The parser transfers control to the statement in the ON EXCEPTION phrase, if specified, otherwise to the end of the XML PARSE statement.

Table 97. XML PARSE exceptions that do not allow continuation (for XMLPARSE(COMPAT))

<table>
<thead>
<tr>
<th>Exception code (decimal)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>The parser reached the end of the document while scanning the start of the XML declaration.</td>
</tr>
<tr>
<td>Exception code (decimal)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>101</td>
<td>The parser reached the end of the document while looking for the end of the XML declaration.</td>
</tr>
<tr>
<td>102</td>
<td>The parser reached the end of the document while looking for the root element.</td>
</tr>
<tr>
<td>103</td>
<td>The parser reached the end of the document while looking for the version information in the XML declaration.</td>
</tr>
<tr>
<td>104</td>
<td>The parser reached the end of the document while looking for the version information value in the XML declaration.</td>
</tr>
<tr>
<td>106</td>
<td>The parser reached the end of the document while looking for the encoding declaration value in the XML declaration.</td>
</tr>
<tr>
<td>108</td>
<td>The parser reached the end of the document while looking for the standalone declaration value in the XML declaration.</td>
</tr>
<tr>
<td>109</td>
<td>The parser reached the end of the document while scanning an attribute name.</td>
</tr>
<tr>
<td>110</td>
<td>The parser reached the end of the document while scanning an attribute value.</td>
</tr>
<tr>
<td>111</td>
<td>The parser reached the end of the document while scanning a character reference or entity reference in an attribute value.</td>
</tr>
<tr>
<td>112</td>
<td>The parser reached the end of the document while scanning an empty element tag.</td>
</tr>
<tr>
<td>113</td>
<td>The parser reached the end of the document while scanning the root element name.</td>
</tr>
<tr>
<td>114</td>
<td>The parser reached the end of the document while scanning an element name.</td>
</tr>
<tr>
<td>115</td>
<td>The parser reached the end of the document while scanning character data in element content.</td>
</tr>
<tr>
<td>116</td>
<td>The parser reached the end of the document while scanning a processing instruction in element content.</td>
</tr>
<tr>
<td>117</td>
<td>The parser reached the end of the document while scanning a comment or CDATA section in element content.</td>
</tr>
<tr>
<td>118</td>
<td>The parser reached the end of the document while scanning a comment in element content.</td>
</tr>
<tr>
<td>119</td>
<td>The parser reached the end of the document while scanning a CDATA section in element content.</td>
</tr>
<tr>
<td>120</td>
<td>The parser reached the end of the document while scanning a character reference or entity reference in element content.</td>
</tr>
<tr>
<td>121</td>
<td>The parser reached the end of the document while scanning after the close of the root element.</td>
</tr>
<tr>
<td>122</td>
<td>The parser found a possible invalid start of a document type declaration.</td>
</tr>
<tr>
<td>123</td>
<td>The parser found a second document type declaration.</td>
</tr>
<tr>
<td>124</td>
<td>The first character of the root element name was not a letter, '_', or ':' .</td>
</tr>
<tr>
<td>125</td>
<td>The first character of the first attribute name of an element was not a letter, '_', or ':' .</td>
</tr>
<tr>
<td>126</td>
<td>The parser found an invalid character either in or following an element name.</td>
</tr>
<tr>
<td>127</td>
<td>The parser found a character other than '=' following an attribute name.</td>
</tr>
<tr>
<td>Exception code (decimal)</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>128</td>
<td>The parser found an invalid attribute value delimiter.</td>
</tr>
<tr>
<td>130</td>
<td>The first character of an attribute name was not a letter, ',', or ':'.</td>
</tr>
<tr>
<td>131</td>
<td>The parser found an invalid character either in or following an attribute name.</td>
</tr>
<tr>
<td>132</td>
<td>An empty element tag was not terminated by a '&gt;' following the '/'.</td>
</tr>
<tr>
<td>133</td>
<td>The first character of an element end tag name was not a letter, ',', or ':'.</td>
</tr>
<tr>
<td>134</td>
<td>An element end tag name was not terminated by a '&gt;'.</td>
</tr>
<tr>
<td>135</td>
<td>The first character of an element name was not a letter, ',', or ':'.</td>
</tr>
<tr>
<td>136</td>
<td>The parser found an invalid start of a comment or CDATA section in element content.</td>
</tr>
<tr>
<td>137</td>
<td>The parser found an invalid start of a comment.</td>
</tr>
<tr>
<td>138</td>
<td>The first character of a processing instruction target name was not a letter, ',', or ':'.</td>
</tr>
<tr>
<td>139</td>
<td>The parser found an invalid character in or following a processing instruction target name.</td>
</tr>
<tr>
<td>140</td>
<td>A processing instruction was not terminated by the closing character sequence '?&gt;'.</td>
</tr>
<tr>
<td>141</td>
<td>The parser found an invalid character following '&amp;' in a character reference or entity reference.</td>
</tr>
<tr>
<td>142</td>
<td>The version information was not present in the XML declaration.</td>
</tr>
<tr>
<td>143</td>
<td>'version' in the XML declaration was not followed by '='.</td>
</tr>
<tr>
<td>144</td>
<td>The version declaration value in the XML declaration is either missing or improperly delimited.</td>
</tr>
<tr>
<td>145</td>
<td>The version information value in the XML declaration specified a bad character, or the start and end delimiters did not match.</td>
</tr>
<tr>
<td>146</td>
<td>The parser found an invalid character following the version information value closing delimiter in the XML declaration.</td>
</tr>
<tr>
<td>147</td>
<td>The parser found an invalid attribute instead of the optional encoding declaration in the XML declaration.</td>
</tr>
<tr>
<td>148</td>
<td>'encoding' in the XML declaration was not followed by '='.</td>
</tr>
<tr>
<td>149</td>
<td>The encoding declaration value in the XML declaration is either missing or improperly delimited.</td>
</tr>
<tr>
<td>150</td>
<td>The encoding declaration value in the XML declaration specified a bad character, or the start and end delimiters did not match.</td>
</tr>
<tr>
<td>151</td>
<td>The parser found an invalid character following the encoding declaration value closing delimiter in the XML declaration.</td>
</tr>
<tr>
<td>152</td>
<td>The parser found an invalid attribute instead of the optional standalone declaration in the XML declaration.</td>
</tr>
<tr>
<td>153</td>
<td>standalone in the XML declaration was not followed by '='.</td>
</tr>
<tr>
<td>154</td>
<td>The standalone declaration value in the XML declaration is either missing or improperly delimited.</td>
</tr>
<tr>
<td>155</td>
<td>The standalone declaration value was neither 'yes' nor 'no' only.</td>
</tr>
</tbody>
</table>
Table 97. XML PARSE exceptions that do not allow continuation (for XMLPARSE(COMPAT)) (continued)

<table>
<thead>
<tr>
<th>Exception code (decimal)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>156</td>
<td>The standalone declaration value in the XML declaration specified a bad character, or the start and end delimiters did not match.</td>
</tr>
<tr>
<td>157</td>
<td>The parser found an invalid character following the standalone declaration value closing delimiter in the XML declaration.</td>
</tr>
<tr>
<td>158</td>
<td>The XML declaration was not terminated by the proper character sequence ‘?&gt;’, or contained an invalid attribute.</td>
</tr>
<tr>
<td>159</td>
<td>The parser found the start of a document type declaration after the end of the root element.</td>
</tr>
<tr>
<td>160</td>
<td>The parser found the start of an element after the end of the root element.</td>
</tr>
<tr>
<td>315</td>
<td>The actual document encoding was UTF-16 little-endian, which the parser does not support on this platform.</td>
</tr>
<tr>
<td>316</td>
<td>The actual document encoding was UCS4, which the parser does not support.</td>
</tr>
<tr>
<td>317</td>
<td>The parser cannot determine the document encoding. The document might be damaged.</td>
</tr>
<tr>
<td>318</td>
<td>The actual document encoding was UTF-8, which the parser does not support.</td>
</tr>
<tr>
<td>320</td>
<td>The document data item was national, but the actual document encoding was EBCDIC.</td>
</tr>
<tr>
<td>321</td>
<td>The document data item was national, but the actual document encoding was ASCII.</td>
</tr>
<tr>
<td>500 - 599</td>
<td>Internal error. Report the error to your service representative.</td>
</tr>
</tbody>
</table>

related concepts
“XML-CODE” on page 508

related tasks
“Handling XML PARSE exceptions” on page 523

XML GENERATE exceptions

One of several exception codes might be returned in the XML-CODE special register during XML generation. If one of these exceptions occurs, control is passed to the statement in the ON EXCEPTION phrase, or to the end of the XML GENERATE statement if you did not code an ON EXCEPTION phrase.

Table 98. XML GENERATE exceptions

<table>
<thead>
<tr>
<th>Exception code (decimal)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>The receiver was too small to contain the generated XML document. The COUNT IN data item, if specified, contains the count of character positions that were actually generated.</td>
</tr>
<tr>
<td>401</td>
<td>A DBCS data-name contained a character that, when converted to Unicode, was not valid in an XML element or attribute name.</td>
</tr>
<tr>
<td>402</td>
<td>The first character of a DBCS data-name, when converted to Unicode, was not valid as the first character of an XML element or attribute name.</td>
</tr>
<tr>
<td>403</td>
<td>The value of an OCCURS DEPENDING ON variable exceeded 16,777,215.</td>
</tr>
<tr>
<td>Exception code (decimal)</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>410</td>
<td>The CCSID page specified by the CODEPAGE compiler option is not supported for conversion to Unicode.</td>
</tr>
<tr>
<td>411</td>
<td>The CCSID specified by the CODEPAGE compiler option is not a supported single-byte EBCDIC CCSID.</td>
</tr>
<tr>
<td>414</td>
<td>The CCSID specified for the XML document was invalid or was not supported.</td>
</tr>
<tr>
<td>415</td>
<td>The receiver was national, but the encoding specified for the document was not UTF-16.</td>
</tr>
<tr>
<td>416</td>
<td>The XML namespace identifier contained invalid XML characters.</td>
</tr>
<tr>
<td>417</td>
<td>Element character content or an attribute value contained characters that are illegal in XML content. XML generation has continued, with the element tag name or the attribute name prefixed with 'hex.' and the original data value represented in the document in hexadecimal. Any TYPE IS CONTENT specification is ignored, and the item is treated as an element.</td>
</tr>
<tr>
<td>418</td>
<td>Substitution characters were generated by encoding conversion.</td>
</tr>
<tr>
<td>419</td>
<td>The XML namespace prefix was invalid.</td>
</tr>
<tr>
<td>420</td>
<td>The receiver was alphanumeric and the input included national or DBCS data or names, but the encoding specified for the document was not 1208.</td>
</tr>
<tr>
<td>600-699</td>
<td>Internal error. Report the error to your service representative.</td>
</tr>
</tbody>
</table>

**related tasks**

“Handling XML GENERATE exceptions” on page 546
Appendix D. JSON GENERATE exceptions

One of several exception codes might be returned in the JSON-CODE special register during JSON generation. If one of these exceptions occurs, control is passed to the statement in the ON EXCEPTION phrase, or to the end of the JSON GENERATE statement if you did not code an ON EXCEPTION phrase.

<table>
<thead>
<tr>
<th>Table 99. JSON GENERATE exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exception code (decimal)</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>500 - 599</td>
</tr>
</tbody>
</table>
Appendix E. EXIT compiler option

You can use the EXIT compiler option to provide user-supplied modules in place of various compiler functions. For details about processing of each exit module, error handling for exit modules, or using the EXIT option with CICS, SQL and SQLIMS statements, see the following topics.

related tasks
“Using the user-exit work area” on page 677
“Calling from exit modules” on page 678
Using the EXIT compiler option with CICS, SQL and SQLIMS statements

related references
“EXIT” on page 305
“Processing of INEXIT” on page 678
“Processing of LIBEXIT” on page 679
“Processing of PRTEXIT” on page 682
“Processing of ADEXIT” on page 684
“Processing of MSGEXIT” on page 685
“Error handling for exit modules” on page 694

Using the user-exit work area

When you use one of the user exits, the compiler provides a work area in which you can save the address of GETMAIN storage obtained by the exit module. Having such a work area lets the module be reentrant.

The user-exit work area consists of 6 fullwords that reside on a fullword boundary. These fullwords are initialized to binary zeros before the first exit routine is invoked. The address of the work area is passed to the exit module in a parameter list. After initialization, the compiler makes no further reference to the work area.

The words in the user-exit work area are used by the individual exit modules as shown in the following table.

Table 100. Layout of the user-exit work area

<table>
<thead>
<tr>
<th>Word number</th>
<th>Used by module:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INEXIT</td>
</tr>
<tr>
<td>2</td>
<td>LIBEXIT</td>
</tr>
<tr>
<td>3</td>
<td>PRTEXIT</td>
</tr>
<tr>
<td>4</td>
<td>ADEXIT</td>
</tr>
<tr>
<td>5</td>
<td>(Reserved)</td>
</tr>
<tr>
<td>6</td>
<td>MSGEXIT</td>
</tr>
</tbody>
</table>

related references
“Processing of INEXIT” on page 678
“Processing of LIBEXIT” on page 679
“Processing of PRTEXIT” on page 682
“Processing of ADEXIT” on page 684
“Processing of MSGEXIT” on page 685
Calling from exit modules

To call COBOL programs or library routines within your exit modules, use standard COBOL linkage. You need to be aware of the register conventions in order to trace the call chain correctly.

When a call is made to a program or to a routine in an exit module, the registers are set up as follows:

- **R1**
  - Points to the parameter list passed to the called program or library routine

- **R13**
  - Points to the register save area provided by the calling program or routine

- **R14**
  - Holds the return address of the calling program or routine

- **R15**
  - Holds the address of the called program or routine

Exit modules must have RMODE attribute 24 and AMODE attribute ANY.

related concepts
“Storage and its addressability” on page 37

Processing of INEXIT

The INEXIT exit module is used to read source code from a user-supplied program object in place of SYSIN.

<table>
<thead>
<tr>
<th>Table 101. INEXIT processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action by compiler</strong></td>
</tr>
<tr>
<td>Loads the exit module (mod1) during initialization</td>
</tr>
<tr>
<td>Calls the exit module with an OPEN operation code (op code)</td>
</tr>
<tr>
<td>Calls the exit module with a GET op code when a source statement is needed</td>
</tr>
</tbody>
</table>

INEXIT parameters

The compiler uses 10 parameters, passed by reference, to communicate with the exit module. The return code, data length, and data parameters are set by the exit module for return to the compiler; the other items are passed from the compiler to the exit module.

<table>
<thead>
<tr>
<th>Table 102. INEXIT parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter number</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Parameter number</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

**related tasks**

"Using the user-exit work area" on page 677
"Calling from exit modules" on page 678
Using the EXIT compiler option with CICS, SQL and SQLIMS statements

**Processing of LIBEXIT**

The LIBEXIT exit module is used in place of the SYSLIB, or library-name, data set. Calls are made to the module by the compiler to obtain copybooks whenever COPY or BASIS statements are encountered.

<table>
<thead>
<tr>
<th>Table 103. LIBEXIT processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action by compiler</strong></td>
</tr>
<tr>
<td>Loads the exit module (mod2) during initialization</td>
</tr>
</tbody>
</table>
### Table 103. **LIBEXIT processing** (continued)

<table>
<thead>
<tr>
<th>Action by compiler</th>
<th>Action by exit module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calls the exit module with a FIND op code if the library-name was successfully opened</td>
<td>Establishes positioning at the requested text-name (or basis-name) in the specified library-name; this place becomes the active copybook. Passes an appropriate return code to the compiler when positioning is complete.</td>
</tr>
<tr>
<td>Calls the exit module with a GET op code</td>
<td>Passes the compiler either the length and address of the record to be copied from the active copybook or the end-of-data indicator</td>
</tr>
<tr>
<td>Calls the exit module with a CLOSE op code when the end-of-data is presented</td>
<td>Releases any resources that are related to its input</td>
</tr>
</tbody>
</table>

### Processing of LIBEXIT with nested COPY statements

Any record from the active copybook can contain a COPY statement.

You cannot make recursive calls to text-name. That is, a copybook can be named only once in a set of nested COPY statements until the end-of-data for that copybook is reached.

The following table shows how the processing of LIBEXIT changes when there are one or more valid COPY statements that are not nested.

### Table 104. **LIBEXIT processing with nonnested COPY statements**

<table>
<thead>
<tr>
<th>Action by compiler</th>
<th>Action by exit module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loads the exit module (mod2) during initialization</td>
<td></td>
</tr>
<tr>
<td>Calls the exit module with an OPEN operation code (op code)</td>
<td>Prepares the specified library-name for processing. Passes the status of the OPEN request to the compiler.</td>
</tr>
<tr>
<td>Calls the exit module with a FIND op code if the library-name was successfully opened</td>
<td>Establishes positioning at the requested text-name (or basis-name) in the specified library-name; this place becomes the active copybook. Passes an appropriate return code to the compiler when positioning is complete.</td>
</tr>
<tr>
<td>Calls the exit module with a CLOSE op code when the end-of-data is presented</td>
<td>Releases any resources that are related to its input</td>
</tr>
<tr>
<td>Calls the exit module with a FIND op code if the library-name was successfully opened</td>
<td>Reestablishes positioning at the previous active copybook. Passes an appropriate return code to the compiler when positioning is complete.</td>
</tr>
<tr>
<td>Calls the exit module with a GET op code. Verifies that the same record was passed.</td>
<td>Passes the compiler the same record as was passed previously from this copybook. After verification, passes either the length and address of the record to be copied from the active copybook or the end-of-data indicator.</td>
</tr>
</tbody>
</table>

The following table shows how the processing of LIBEXIT changes when the compiler encounters a valid nested COPY statement.
Table 105. LIBEXIT processing with nested COPY statements

<table>
<thead>
<tr>
<th>Action by compiler</th>
<th>Action by exit module</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the requested library-name from the nested COPY statement was not previously</td>
<td>Pushes its control information about the active copybook onto a stack. Completes the requested action (OPEN). The newly requested text-name (or basis-name) becomes the active copybook.</td>
</tr>
<tr>
<td>opened, calls the exit module with an OPEN op code</td>
<td></td>
</tr>
<tr>
<td>Calls the exit module with a FIND op code for the requested new text-name</td>
<td>Pushes its control information about the active copybook onto a stack. Completes the requested action (FIND). The newly requested text-name (or basis-name) becomes the active copybook.</td>
</tr>
<tr>
<td>Calls the exit module with a GET op code</td>
<td>Passes the compiler either the length and address of the record to be copied from the active copybook or the end-of-data indicator. At end-of-data, pops its control information from the stack.</td>
</tr>
</tbody>
</table>

LIBEXIT parameters

The compiler uses 10 parameters, passed by reference, to communicate with the exit module. The return code, data length, and data parameters are set by the exit module for return to the compiler; the other items are passed from the compiler to the exit module.

Table 106. LIBEXIT parameters

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter item</th>
<th>Description of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User-exit type</td>
<td>Halfword that identifies which user exit is to perform the operation. 2=LIBEXIT</td>
</tr>
<tr>
<td>2</td>
<td>Operation code</td>
<td>Halfword that indicates the type of operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0=OPEN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1=CLOSE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 2=GET</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 4=FIND</td>
</tr>
<tr>
<td>3</td>
<td>Return code</td>
<td>Fullword, set by the exit module, that indicates the success of the requested operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0=Operation was successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 4=End-of-data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 12=Operation failed</td>
</tr>
<tr>
<td>4</td>
<td>User-exit work area</td>
<td>Six-fullword work area provided by the compiler for use by the user-exit module. Second word: for use by LIBEXIT</td>
</tr>
<tr>
<td>5</td>
<td>Data length</td>
<td>Fullword, set by the exit module, that specifies the length of the record being returned by the GET operation (must be 80)</td>
</tr>
</tbody>
</table>
Table 106. LIBEXIT parameters (continued)

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter item</th>
<th>Description of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Data or str2</td>
<td>Fullword, set by the exit module, that contains the address of the record in a user-owned buffer, for the GET operation. str2 applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string.</td>
</tr>
<tr>
<td>7</td>
<td>System library-name</td>
<td>Eight-character area that contains the library-name from the COPY statement. Processing and conversion rules for a program-name are applied. Padded with blanks if required. Applies to OPEN, CLOSE, and FIND.</td>
</tr>
<tr>
<td>8</td>
<td>System text-name</td>
<td>Eight-character area that contains the text-name from the COPY statement (basis-name from BASIS statement). Processing and conversion rules for a program-name are applied. Padded with blanks if required. Applies only to FIND.</td>
</tr>
<tr>
<td>9</td>
<td>Library-name</td>
<td>Thirty-character area that contains the full library-name from the COPY statement. Padded with blanks if required, and used as is (not folded to uppercase). Applies to OPEN, CLOSE, and FIND.</td>
</tr>
<tr>
<td>10</td>
<td>Text-name</td>
<td>Thirty-character area that contains the full text-name from the COPY statement. Padded with blanks if required, and used as is (not folded to uppercase). Applies only to FIND.</td>
</tr>
</tbody>
</table>

related tasks
“Using the user-exit work area” on page 677
“Calling from exit modules” on page 678
Using the EXIT compiler option with CICS, SQL and SQLIMS statements

### Processing of PRTEXIT

The PRTEXIT exit module is used in place of the SYSPRINT data set.

Table 107. PRTEXIT processing

<table>
<thead>
<tr>
<th>Action by compiler</th>
<th>Action by exit module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loads the exit module (mod3) during initialization</td>
<td>Prepares its output destination for processing. Passes the status of the OPEN request to the compiler.</td>
</tr>
<tr>
<td>Calls the exit module with an OPEN operation code (op code)</td>
<td>Passes the status of the PUT request to the compiler by a return code. The first byte of the record to be printed contains an ANSI printer control character.</td>
</tr>
<tr>
<td>Calls the exit modules with a PUT op code when a line is to be printed, supplying the address and length of the record that is to be printed</td>
<td>Releases any resources that are related to its output destination</td>
</tr>
</tbody>
</table>
PRTEXIT parameters

The compiler uses 10 parameters, passed by reference, to communicate with the exit module. The return code, data length, and data buffer parameters are set by the exit module for return to the compiler; the other items are passed from the compiler to the exit module.

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter item</th>
<th>Description of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User-exit type</td>
<td>Halfword that identifies which user exit is to perform the operation. 3=PRTEXIT</td>
</tr>
<tr>
<td>2</td>
<td>Operation code</td>
<td>Halfword that indicates the type of operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0=OPEN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1=CLOSE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 3=PUT</td>
</tr>
<tr>
<td>3</td>
<td>Return code</td>
<td>Fullword, set by the exit module, that indicates the success of the requested operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0=Operation was successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 12=Operation failed</td>
</tr>
<tr>
<td>4</td>
<td>User-exit work area</td>
<td>Six-fullword work area provided by the compiler for use by the user-exit module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Third word: for use by PRTEXIT</td>
</tr>
<tr>
<td>5</td>
<td>Data length</td>
<td>Fullword that specifies the length of the record being supplied by the PUT operation (the compiler sets this value to 133)</td>
</tr>
<tr>
<td>6</td>
<td>Data buffer or str3</td>
<td>Data buffer where the compiler has placed the record to be printed by the PUT operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>str3 applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string.</td>
</tr>
<tr>
<td>7</td>
<td>Not used</td>
<td>(Used only by LIBEXIT and MSGEXIT)</td>
</tr>
<tr>
<td>8</td>
<td>Not used</td>
<td>(Used only by LIBEXIT)</td>
</tr>
<tr>
<td>9</td>
<td>Not used</td>
<td>(Used only by LIBEXIT)</td>
</tr>
<tr>
<td>10</td>
<td>Not used</td>
<td>(Used only by LIBEXIT)</td>
</tr>
</tbody>
</table>

related tasks

“Using the user-exit work area” on page 677
“Calling from exit modules” on page 678
Using the EXIT compiler option with CICS, SQL and SQLIMS statements
Processing of ADEXIT

The ADEXIT module is called for each SYSADATA record immediately after the record has been written out to the file.

To use an ADEXIT module, you must compile using the ADATA option to produce SYSADATA output, and code the SYSADATA DD statement.

<table>
<thead>
<tr>
<th>Table 109. ADEXIT processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action by compiler</strong></td>
</tr>
<tr>
<td>Loads the exit module ((mod4)) during initialization</td>
</tr>
<tr>
<td>Calls the exit module with an OPEN operation code ((op\ code))</td>
</tr>
<tr>
<td>Calls the exit module with a PUT op code when the compiler has written a SYSADATA record, supplying the address and length of the SYSADATA record</td>
</tr>
<tr>
<td>Calls the exit module with a CLOSE op code when the end-of-data is presented</td>
</tr>
</tbody>
</table>

ADEXIT parameters

The compiler uses 10 parameters, passed by reference, to communicate with the exit module. The return code, data length, and data buffer parameters are set by the exit module for return to the compiler; the other items are passed from the compiler to the exit module.

<table>
<thead>
<tr>
<th>Table 110. ADEXIT parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter number</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>
Table 110. ADEXIT parameters (continued)

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter item</th>
<th>Description of item</th>
</tr>
</thead>
</table>
| 6                | Data buffer or str4 | Fullword that contains the address of the data buffer where the compiler has placed the record to be printed by the PUT operation.  
not applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string. |
| 7                | Not used            | (Used only by LIBEXIT and MSGEXIT)                                                  |
| 8                | Not used            | (Used only by LIBEXIT)                                                              |
| 9                | Not used            | (Used only by LIBEXIT)                                                              |
| 10               | Not used            | (Used only by LIBEXIT)                                                              |

related tasks
“Using the user-exit work area” on page 677
“Calling from exit modules” on page 678
Using the EXIT compiler option with CICS, SQL and SQLIMS statements

related references
“ADATA” on page 288

Processing of MSGEXIT

The MSGEXIT module is used to customize compiler diagnostic messages and FIPS messages. The module can customize a message either by changing its severity or suppressing it.

If the MSGEXIT module assigns a severity to a FIPS message, the message is converted into a diagnostic message. (The message is shown in the summary of diagnostic messages in the listing.)

A MSGEXIT summary at the end of the compiler listing shows how many messages were changed in severity and how many messages were suppressed.

Table 111. MSGEXIT processing

<table>
<thead>
<tr>
<th>Action by compiler</th>
<th>Action by exit module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loads the exit module (mod5) during initialization</td>
<td></td>
</tr>
<tr>
<td>Calls the exit module with an OPEN operation code (op code)</td>
<td>Optionally processes str5 and passes the status of the OPEN request to the compiler</td>
</tr>
</tbody>
</table>
| Calls the exit module with a MSGSEV operation code (op code) when the compiler is about to issue a diagnostic message or FIPS message | One of the following actions:  
  • Indicates no customization of the message (by setting return code to 0)  
  • Specifies a new severity for (or suppression of) the message, and sets return code to 4  
  • Indicates that the operation failed (by setting return code to 12) |
| Calls the exit module with a CLOSE op code                                        | Optionally frees storage and passes the status of the CLOSE request to the compiler |
### MSGEXIT processing (continued)

<table>
<thead>
<tr>
<th>Action by compiler</th>
<th>Action by exit module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deletes the exit module (mod5) during compiler termination</td>
<td></td>
</tr>
</tbody>
</table>

### MSGEXIT parameters

The compiler uses 10 parameters, passed by reference, to communicate with the exit module. The return code and user-requested severity parameters are set by the exit module for return to the compiler; the other items are passed from the compiler to the exit module.

#### Table 112. MSGEXIT parameters

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter item</th>
<th>Description of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User-exit type</td>
<td>Halfword that identifies which user exit is to perform the operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6=MSGEXIT</td>
</tr>
<tr>
<td>2</td>
<td>Operation code</td>
<td>Halfword that indicates the type of operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0=OPEN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1=CLOSE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 5=MSGSEV: customize message severity</td>
</tr>
<tr>
<td>3</td>
<td>Return code</td>
<td>Fullword, set by the exit module, that indicates the success of the requested operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For op code MSGSEV:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0=Message not customized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 4=Message found and customized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 12=Operation failed</td>
</tr>
<tr>
<td>4</td>
<td>User-exit work area</td>
<td>Six-fullword work area provided by the compiler for use by the user-exit module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sixth word: for use by MSGEXIT</td>
</tr>
<tr>
<td>5</td>
<td>Not used</td>
<td>(Used by the other exits)</td>
</tr>
<tr>
<td>6</td>
<td>Message exit data</td>
<td>Three-halfword area (on a halfword boundary).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• First halfword: the message number of the message to be customized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Second halfword: for a diagnostic message, the default severity; for a FIPS message, the FIPS category as a numeric code</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Third halfword: the user-requested severity for the message (-1 to indicate suppression)</td>
</tr>
<tr>
<td>7</td>
<td>str5</td>
<td>First halfword (on a halfword boundary): the length of the string, followed by the string</td>
</tr>
<tr>
<td>8</td>
<td>Not used</td>
<td>(Used only by LIBEXIT)</td>
</tr>
<tr>
<td>9</td>
<td>Not used</td>
<td>(Used only by LIBEXIT)</td>
</tr>
</tbody>
</table>
Table 112. MSGEXIT parameters (continued)

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter item</th>
<th>Description of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Not used</td>
<td>(Used only by LIBEXIT)</td>
</tr>
</tbody>
</table>

“Example: MSGEXIT user exit” on page 689

related tasks
“Using the user-exit work area” on page 677
“Calling from exit modules” on page 678
“Customizing compiler-message severities” on page 687
Using the EXIT compiler option with CICS, SQL and SQLIMS statements

Customizing compiler-message severities
To change the severities of compiler messages or suppress compiler messages (including FIPS messages), do the steps described below.

1. Code and compile a COBOL program named ERRMSG. The program needs only a PROGRAM-ID paragraph, as described in the related task.
2. Review the ERRMSG listing, which contains a complete list of compiler messages with their message numbers, severities, and message text.
3. Decide which messages you want to customize.
   To understand the customizations that are possible, see the related reference about customizable compiler-message severities.
4. Code a MSGEXIT module to implement the customizations:
   a. Verify that the operation-code parameter indicates message-severity customization.
   b. Check the two input values in the message-exit-data parameter: the message number; and the default severity for a diagnostic message or the FIPS category for a FIPS message.
      The FIPS category is expressed as numeric code. For details, see the related reference about customizable compiler-message severities.
   c. For a message that you want to customize, set the user-requested severity in the message-exit-data parameter to indicate either:
      • A new message severity, by coding severity 0, 4, 8, or 12
      • Message suppression, by coding severity -1
   d. Set the return code to one of the following values:
      • 0, to indicate that the message was not customized
      • 4, to indicate that the message was found and customized
      • 12, to indicate that the operation failed and that compilation should be terminated
5. Compile and link your MSGEXIT module.
6. Add the data set that contains your MSGEXIT module to the compiler concatenation by using a STEPLIB or JOBLIB DD statement.
7. Recompile program ERRMSG, but use compiler option EXIT(MSGEXIT(msgmod)), where msgmod is the name of your MSGEXIT module.
8. Review the listing and check for:
   • Updated message severities
   • Suppressed messages (indicated by XX in place of the severity)
Unsupported severity changes or unsupported message suppression (indicated by a severity-U diagnostic message, and compiler termination with return code 16)

related tasks
“Generating a list of compiler messages” on page 261

related references
“Severity codes for compiler diagnostic messages” on page 263
“Customizable compiler-message severities” on page 688
“Effect of message customization on compilation return code” on page 689
“Error handling for exit modules” on page 694

Customizable compiler-message severities
To customize compiler-message severities, you need to understand the possible severities of compiler diagnostic messages, the levels or categories of FIPS messages, and the permitted customizations of message severities.

The possible severity codes for compiler diagnostic messages are described in the related reference about severity codes.

The eight categories of FIPS (FLAGSTD) messages are shown in the following table. The category of any given FIPS message is passed as a numeric code to the MSGEXIT module. Those numeric codes are shown in the second column.

<table>
<thead>
<tr>
<th>FIPS level or category</th>
<th>Numeric code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>81</td>
<td>Debug module level 1</td>
</tr>
<tr>
<td>E</td>
<td>82</td>
<td>Extension (IBM)</td>
</tr>
<tr>
<td>H</td>
<td>83</td>
<td>High level</td>
</tr>
<tr>
<td>I</td>
<td>84</td>
<td>Intermediate level</td>
</tr>
<tr>
<td>N</td>
<td>85</td>
<td>Segmentation module level 1</td>
</tr>
<tr>
<td>O</td>
<td>86</td>
<td>Obsolete elements</td>
</tr>
<tr>
<td>Q</td>
<td>87</td>
<td>High-level and obsolete elements</td>
</tr>
<tr>
<td>S</td>
<td>88</td>
<td>Segmentation module level 2</td>
</tr>
</tbody>
</table>

FIPS messages have an implied severity of zero (severity I).

Permitted message-severity customizations:
You can change the severity of a compiler message in the following ways:

- Severity-I and severity-W compiler diagnostic messages, and FIPS messages, can be changed to have any severity from I through S.
  Assigning a severity to a FIPS message converts the FIPS message to a diagnostic message of the assigned severity.
  As examples, you can:
  - Lower an optimizer warning to severity I.
  - Disallow REDEFINING a smaller item with a larger item by raising the severity of message 1154.
  - Disallow complex OCCURS DEPENDING ON by changing FIPS message 8235 from a category-E FIPS message to a severity-S compiler diagnostic message.
- Severity-E messages can be raised to severity S, but not lowered to severity I or W, because an error condition has occurred in the program.
- Severity-S and severity-U messages cannot be changed to have a different severity.
You can request suppression of compiler messages as follows:

- I, W, and FIPS messages can be suppressed.
- E and S messages cannot be suppressed.

**related references**
- “Severity codes for compiler diagnostic messages” on page 263
- “FLAGSTD” on page 309
- “Effect of message customization on compilation return code” on page 689

**Effect of message customization on compilation return code**
If you use a MSGEXIT module, the final return code from the compilation of a program could be affected as described below.

If you change the severity of a message, the return code from the compilation might also be changed. For example, if a compilation produces one diagnostic message, and it is a severity-E message, the compilation return code would normally be 8. But if the MSGEXIT module changes the severity of that message to severity S, then the return code from compilation would be 12.

If you suppress a message, the return code from the compilation is no longer affected by the severity of that message. For example, if a compilation produces one diagnostic message, and it is a severity-W message, the compilation return code would normally be 4. But if the MSGEXIT module suppresses that message, then the return code from compilation would be 0.

**related tasks**
- “Customizing compiler-message severities” on page 687

**related references**
- “Severity codes for compiler diagnostic messages” on page 263

**Example: MSGEXIT user exit**
The following example shows a MSGEXIT user-exit module that changes message severities and suppresses messages.

For helpful tips about using a message-exit module, see the comments within the code.

```cobol
******************************************************************
* IGYMSGXT - Sample COBOL program for MSGEXIT                   *
******************************************************************
*                                                                *
* IBM Enterprise COBOL for z/OS                                  *
*     Version 6 Release 1 Modification 0                          *
*                                                                *
* LICENSED MATERIALS - PROPERTY OF IBM.                           *
*                                                                *
* 5655-EC6  COPYRIGHT IBM CORP. 2016                             *
*     ALL RIGHTS RESERVED                                         *
*                                                                *
* US GOVERNMENT USERS RESTRICTED RIGHTS - USE,                    *
*     DUPLICATION OR DISCLOSURE RESTRICTED BY GSA                *
*     ADP SCHEDULE CONTRACT WITH IBM CORP.                        *
*                                                                *
******************************************************************
******************************************************************
* Function:  This is a SAMPLE user exit for the MSGEXIT          *
* suboption of the EXIT compiler option.  This exit            *
* can be used to customize the severity of or                   *
* suppress compiler diagnostic messages and FIPS                *
* messages.  This example program includes several               *
* sample customizations to show how customizations              *
* are done.  If you do not want the sample                       *
* customizations then either delete the unwanted                 *
* lines of code or comment them out with a comment              *
* indicator in column 7 (*).                                     *
*                                                                *
*---------------------------------------------------------------*
*                                                                *
* USAGE NOTE: To use this user exit program, make the            *
*             link-edited load module available to your          *
*```
compiles that will use the MSGEXIT suboption of the EXIT compiler option. Also, the name should be changed, since IBM recommends that you avoid having programs with names that start with IGY. Sample steps to take:
1) Make your customizations
2) Change program name (E.G. MYEXIT)
3) Compile and link into a dataset
4) Include that dataset in your compile JCL concatenation for the compile step.
If you link into USER.COBOLLIB:

//COBOL.STEPLIB DD DSNAME=SYS1.SIGYCOMP,DISP=SHR
// DD DSNAME=USER.COBOLLIB,DISP=SHR

5) Finally, compile your programs with the EXIT compiler option, E.G:
EXIT(MSGEXIT(MYEXIT))

** COMPILTE NOTE: Compile this program with NOEXIT.**

*****************************************************************
Id Division.
Program-id. IGYMSGXT.
Data Division.

Working-Storage Section.

*****************************************************************
* Local variables. *
* *
*****************************************************************
77 EXIT-TYPEN PIC 9(4).
77 EXIT-DEFAULT-SEV-FIPS PIC X.

*****************************************************************
Definition of the User-Exit Parameter List, which is passed from the COBOL compiler to the user-exit module.

*****************************************************************
Linkage Section.
01 EXIT-TYPE PIC 9(4) COMP.
01 EXIT-OPERATION PIC 9(4) COMP.
01 EXIT-RETURNCODE PIC 9(9) COMP.
01 EXIT-WORK-AREA.
   02 EXIT-WORK-AREA-PTR OCCURS 6 POINTER.
01 EXIT-DUMMY  POINTER.
01 EXIT-MESSAGE-PARMS.
   02 EXIT-MESSAGE-NUM PIC 9(4) COMP.
   02 EXIT-DEFAULT-SEV PIC 9(4) COMP.
   02 EXIT-USER-SEV PIC S9(4) COMP.
01 EXIT-STRING.
   02 EXIT-STR-LEN PIC 9(4) COMP.
   02 EXIT-STR-TXT PIC X(64).

*****************************************************************
Begin PROCEDURE DIVISION
*
* Check parameters and perform the operation requested. *
*
*****************************************************************

Procedure Division Using EXIT-TYPE EXIT-OPERATION
EXIT-RETURNCODE EXIT-WORK-AREA
EXIT-DUMMY EXIT-MESSAGE-PARMS
EXIT-STRING EXIT-DUMMY
EXIT-DUMMY EXIT-DUMMY.

Compute EXIT-RETURNCODE = 0
Evaluate TRUE

*****************************************************************
Handle a bad invocation of this exit by the compiler.
*****************************************************************
This could happen if this routine was used for one of the other EXITs, such as INEXIT, PRTEXIT or LIBEXIT.

When EXIT-TYPE Not = 6
  Move EXIT-TYPE to EXIT-TYPEN
  Display '*** Invalid exit routine identifier'
  Display '*** EXIT TYPE = ' EXIT-TYPE
  Compute EXIT-RETURNCODE = 16

*****************************************************************

When EXIT-TYPE Not = 6
  Move EXIT-TYPE to EXIT-TYPEN
  Display '*** Invalid exit routine identifier'
  Display '*** EXIT TYPE = ' EXIT-TYPE
  Compute EXIT-RETURNCODE = 16

*****************************************************************

* Handle the OPEN call to this exit by the compiler
  * Display the exit string (str5 in syntax diagram) from
  * the EXIT(MSGEXIT('str5',mod5)) option specification.
  *
  When EXIT-OPERATION = 0
  * Display 'Opening MSGEXIT'
  * If EXIT-STR-LEN Not Zero Then
  *   Display ' str5 len = ' EXIT-STR-LEN
  *   Display ' str5 = ' EXIT-STR-TXT(1:EXIT-STR-LEN)
  * End-If
  * Continue

*****************************************************************

When EXIT-OPERATION = 1
  Display 'Closing MSGEXIT'
  Goback

*****************************************************************

* Handle the CLOSE call to this exit by the compiler
  *
  When EXIT-OPERATION = 5
  * Display 'MSGEXIT called with MSGSEV'
  If EXIT-MESSAGE-NUM < 8000 Then
    Perform Error-Messages-Severity
  Else
    Perform FIPS-Messages-Severity
  End-If

  * If EXIT-RETURNCODE = 4 Then
  *   Display ' >>>> Customizing message ' EXIT=MESSAGE-NUM
  *   ' with new severity ' EXIT-USER-SEV ' <<<<'
  *   If EXIT-MESSAGE-NUM > 8000 Then
  *     Display 'FIPS sev = ' EXIT-DEFAULT-SEV-FIPS '<<<<'
  *   End-If
  * End-If

*****************************************************************

* Handle a bad invocation of this exit by the compiler. The compiler should not invoke this exit with EXIT-TYPE = 6 and an opcode other than 0, 1, or 5. This should not happen and IBM service should be contacted if it does.

When Other
  Display '*** Invalid MSGEXIT routine operation'
  Display '*** EXIT OPCODE = ' EXIT-OPERATION
  Compute EXIT-RETURNCODE = 16

End-Evaluate

Goback.

*****************************************************************

* ERROR MESSAGE PROCESSOR
  *
  Error-Messages-Severity.
  *
  Assume message severity will be customized...
  Compute EXIT-RETURNCODE = 4

Evaluate EXIT-MESSAGE-NUM

*****************************************************************

* Change severity of message 1154(W) to 12 ('S')
* This is the case of redefining a large item
* with a smaller item, IBM Req # MR0904063236

When(1154)
  Compute EXIT-USER-SEV = 12
Modify the severity of RULES messages to enforce coding standards or highlight coding that you want to avoid.

Here are the message numbers and what they flag:

- 1348 RULES(NOEVENPACK) Even digit packed-decimal items
- 1353 RULES(NOSLACKBYTES) Slack bytes within records
- 1379 RULES(NOSLACKBYTES) Slack bytes between records
- 2159 RULES(NOENDPERIOD) Cond stmt terminated by period
- 2224 RULES(NOLAXPERF) Ineff. type for PERFORM VARYING
- 2246 RULES(NOLAXPERF) Ineff. type for subscript
- 2247 RULES(NOLAXPERF) Compiler option NOAWO in effect
- 2248 RULES(NOLAXPERF) Compiler option ARITH(EXTEND) in effect
- 2249 RULES(NOLAXPERF) Option NOBLOCK0 in effect
- 2250 RULES(NOLAXPERF) Option NOSRANGE in effect
- 2252 RULES(NOLAXPERF) Option OPTIMIZE(0) in effect
- 2253 RULES(NOLAXPERF) Option SS RANGE in effect
- 2254 RULES(NOLAXPERF) Option THREAD in effect
- 2255 RULES(NOLAXPERF) Option TRUNC(STD) in effect
- 2256 RULES(NOLAXPERF) Option TRUNC(BIN) in effect
- 3084 RULES(NOLAXPERF) Ineff. type for arith sender
- 3123 RULES(NOLAXPERF) Lots of padding in alph MOVE

When(1348) => Disallow even-digit Comp-3
When(1353) When(1379) => Disallow slack bytes
When(2159) => Disallow period-termination of conditional stmts

Highlight poorly performing COBOL features

When(2224) => Ineff. type for PERFORM VARYING
When(2246) => Ineff. type for subscript
When(2247) => Compiler option NOAWO in effect
When(2248) => Compiler option ARITH(EXTEND) in effect
When(2249) => Option NOBLOCK0 in effect
When(2250) => Option NOFASTSRT in effect
When(2251) => Option NUMPROC(NOPFD) in effect
When(2252) => Option OPTIMIZE(0) in effect
When(2253) => Option S RANGE in effect
When(2254) => Option THREAD in effect
When(2255) => Option TRUNC(STD) in effect
When(2256) => Option TRUNC(BIN) in effect
When(3084) => Ineff. type for arith sender
When(3123) => Lots of padding in alph MOVE

When(3178) Compute EXIT-USER-SEV = 8

Change severity of messages 3178(I) to highlight File Definitions that could lead to wrong-length read conditions.
Message 3178 is issued when the length of the shortest record description is less than the FROM integer in the RECORD IS VARYING clause, and when the length of the longest record description is greater than the TO integer in the RECORD IS VARYING clause.

When(3188) When(3189) Compute EXIT-USER-SEV = 12

Change severity of 'optimization' messages to suppress them so that compilation Return Code can be zero (RC=0).
7300: The code from lines &2 in program '&1' can never be executed and was therefore discarded.
7301: A zero base was raised to a zero power in a numeric literal exponentiation. The result was set to 1.
7302: A zero base was raised to a negative power in a numeric literal exponentiation. The result was set to 0.
* 7304: An exception "&1" occurred while processing numeric literals. The result of the operation was set to zero.
* 7307: This statement may cause a program exception at execution time.
* 7309: There may be a loop from the "PERFORM" statement at "PERFORM (line &1)" to itself.

******************************************************************************
When(7300) When(7301) When(7302) When(7304)
When(7307) When(7309)
Compute EXIT-USER-SEV = -1  => Suppress the messages

******************************************************************************
* Message severity Not customized
******************************************************************************
When Other
Compute EXIT-RETURNCODE = 0
End-Evaluate

******************************************************************************
* FIPS MESSAGE PROCESSOR  *
******************************************************************************
Fips-Messages-Severity.
*  Assume message severity will be customized...
Compute EXIT-RETURNCODE = 4
*  Convert numeric FIPS(FLAGSTD) 'category' to character
*  See the Programming Guide for description of FIPS category
EVALUATE EXIT-DEFAULT-SEV
  When 81
    MOVE 'D' To EXIT-DEFAULT-SEV-FIPS
  When 82
    MOVE 'E' To EXIT-DEFAULT-SEV-FIPS
  When 83
    MOVE 'H' To EXIT-DEFAULT-SEV-FIPS
  When 84
    MOVE 'I' To EXIT-DEFAULT-SEV-FIPS
  When 85
    MOVE 'N' To EXIT-DEFAULT-SEV-FIPS
  When 86
    MOVE 'O' To EXIT-DEFAULT-SEV-FIPS
  When 87
    MOVE 'Q' To EXIT-DEFAULT-SEV-FIPS
  When 88
    MOVE 'S' To EXIT-DEFAULT-SEV-FIPS
  When Other
    Continue
End-Evaluate

******************************************************************************
* Example of using FIPS category to force coding restrictions. This is not a recommendation!
*  Change severity of all OBSOLETE item FIPS messages to 'S'
******************************************************************************
*  If EXIT-DEFAULT-SEV-FIPS = 'O' Then
*    Display '>>>> Default customizing FIPS category 'EXIT-DEFAULT-SEV-FIPS' msg 'EXIT-MESSAGE-NUM' <<<<'
*    Compute EXIT-USER-SEV = 12
*  End-If

Evaluate EXIT-MESSAGE-NUM
******************************************************************************
*  Change severity of message 8862(O) to 8 ('E')
*  8862 = GO TO without proc name
******************************************************************************
When(8862)
  Compute EXIT-USER-SEV = 8
******************************************************************************
*  Change severity of message 8193(E) to 8 ('I')
*  8193 = GOBACK
******************************************************************************
When(8193)
  Compute EXIT-USER-SEV = 0
******************************************************************************
*  Change severity of message 8235(E) to 8 (Error)
*  to disallow Complex Occurs Depending On
*  8235 = Complex Occurs Depending On
**Error handling for exit modules**

The conditions described below can occur during processing of the user exits.

**Exit load failure:**
Message IGYSI5207-U is written to the operator if a LOAD request for any of the user exits fails:

An error occurred while attempting to load user exit exit-name.

**Exit open failure:**
Message IGYSI5208-U is written to the operator if an OPEN request for any of the user exits fails:

An error occurred while attempting to open user exit exit-name.

**PRTEXIT PUT failure:**
- Message IGYSI5203-U is written to the listing:

A PUT request to the PRTEXIT user exit failed with return code nn.

- Message IGYSI5217-U is written to the operator:

An error occurred in PRTEXIT user exit exit-name. Compiler terminated.

**SYNIN GET failures:**
The following messages might be written to the listing:

- IGYSI5204-U:

The record address was not set by the exit-name user exit.

- IGYSI5205-U:

A GET request from the INEXIT user exit failed with return code nn.

- IGYSI5206-U:

The record length was not set by the exit-name user exit.
• Message IGYSI5225-U is written to the operator:

An error occurred in ADEXIT user exit `exit-name`. Compiler terminated.

• Message IGYSI5226-U is written to the listing:

A PUT request to the ADEXIT user exit failed with return code `nn`.

**MSGEXIT failures:**

**Customization failure:** Message IGYPP5293-U is written to the listing if an unsupported severity change or unsupported message suppression is attempted:

MSGEXIT user exit `exit-name` specified a message severity customization that is not supported. The message number, default severity, and user-specified severity were: `mm`, `ds`, `us`. Change MSGEXIT user exit `exit-name` to correct this error.

**General failure:** Message IGYPP5064-U is written to the listing if the MSGEXIT module sets the return code to a nonzero value other than 4:

A call to the MSGEXIT user exit routine `exit-name` failed with return code `nn`.

In the MSGEXIT messages, the two characters `PP` indicate the phase of the compiler that issued the message that resulted in a call to the MSGEXIT module.

**related tasks**

“Customizing compiler-message severities” on page 687

**Using the EXIT compiler option with CICS, SQL and SQLIMS statements**

When you compile using suboptions of the EXIT compiler option, and your program contains EXEC CICS, EXEC SQL, or EXEC SQLIMS statements, the actions that you can take in the exit modules depend on whether you use the separate CICS translator and DB2 precompiler, or the integrated CICS translator and DB2 coprocessor.

If the program contains EXEC SQLIMS statements, the actions that you can take in the exit modules are the actions that are listed for the integrated translator.

The following table shows which actions you can take in the exit modules depending on whether you use the integrated or separate translators.

<table>
<thead>
<tr>
<th>Compile with suboption</th>
<th>Translated with integrated or separate CICS and DB2 translators?</th>
<th>Possible actions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>INEXIT</td>
<td>Integrated</td>
<td>Can process EXEC CICS, EXEC SQL, and EXEC SQLIMS statements in the INEXIT module</td>
<td>The INEXIT module does not get control of the COBOL statements that are generated for the EXEC statements.</td>
</tr>
<tr>
<td></td>
<td>Separate</td>
<td>Can process the COBOL statements that are generated for the EXEC statements in the INEXIT module</td>
<td>You can change the generated statements in the INEXIT module, but doing so is not supported by IBM.</td>
</tr>
</tbody>
</table>
Table 114. Actions possible in exit modules for CICS, SQL and SQLIMS statements (continued)

<table>
<thead>
<tr>
<th>Compile with suboption</th>
<th>Translated with integrated or separate CICS and DB2 translators?</th>
<th>Possible actions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIBEXIT</td>
<td>Integrated</td>
<td>Can process in the LIBEXIT module the statements that are brought in by the EXEC SQL INCLUDE and EXEC SQLIMS INCLUDE statements. Can process EXEC CICS source statements in the LIBEXIT module.</td>
<td>EXEC SQL INCLUDE and EXEC SQLIMS INCLUDE statements are processed like COBOL COPY statements.</td>
</tr>
<tr>
<td></td>
<td>Separate</td>
<td>Can process the COBOL statements that are generated for the EXEC CICS statements in the LIBEXIT module.</td>
<td>You can process the input statements that are brought in by the EXEC SQL INCLUDE and SQLIMS INCLUDE statements only by using the INEXIT suboption.</td>
</tr>
<tr>
<td>PRTEXIT</td>
<td>Integrated</td>
<td>Can process the EXEC CICS, EXEC SQL, and EXEC SQLIMS source statements from the SOURCE listing in the PRTEXIT module.</td>
<td>The PRTEXIT module does not have access to the COBOL statements that are generated.</td>
</tr>
<tr>
<td></td>
<td>Separate</td>
<td>Can process the COBOL SOURCE listing statements that are generated for the EXEC statements in the PRTEXIT module.</td>
<td></td>
</tr>
<tr>
<td>ADEXIT</td>
<td>Integrated</td>
<td>Can process the EXEC CICS, EXEC SQL, and EXEC SQLIMS source statements in the ADEXIT module.</td>
<td>The ADEXIT module does not have access to the COBOL statements that are generated.</td>
</tr>
<tr>
<td></td>
<td>Separate</td>
<td>Can process the COBOL SYSADATA statements that are generated for the EXEC statements in the ADEXIT module.</td>
<td></td>
</tr>
<tr>
<td>MSGEXIT</td>
<td>Integrated</td>
<td>Can process CICS and DB2 messages in the MSGEXIT module.</td>
<td>Messages from CICS are shown in the separate CICS translator listing; messages from DB2 are shown in the DB2 precompiler listing.</td>
</tr>
<tr>
<td></td>
<td>Separate</td>
<td>Cannot process CICS and DB2 messages in the MSGEXIT module.</td>
<td></td>
</tr>
</tbody>
</table>

related concepts
“Integrated CICS translator” on page 412
“DB2 coprocessor” on page 417

related tasks
“Compiling with the CICS option” on page 411
“Compiling with the SQL option” on page 421

related references
“Processing of INEXIT” on page 678
“Processing of LIBEXIT” on page 679
“Processing of PRTEXIT” on page 682
“Processing of ADEXIT” on page 684
“Processing of MSGEXIT” on page 685
Appendix F. JNI.cpy copybook

This listing shows the JNI.cpy copybook, which you can use to access the Java Native Interface (JNI) services from your COBOL programs.

JNI.cpy contains sample COBOL data definitions that correspond to the Java JNI types, and contains JNINativeInterface, the JNI environment structure that contains function pointers for accessing the JNI callable services.

JNI.cpy is in the /OS UNIX file system in the include subdirectory of the COBOL install directory (typically /usr/lpp/cobol/include). JNI.cpy is analogous to the header file jni.h that C programmers use to access the JNI.

*****************************************************************
* COBOL declarations for Java native method interoperation      *
*                                                               *
* To use the Java Native Interface callable services from a     *
* COBOL program:                                                *
* 1) Use a COPY statement to include this file into the        *
*    the Linkage Section of the program, e.g.                  *
*    Linkage Section.                                          *
*    Copy JNI                                                 *
* 2) Code the following statements at the beginning of the     *
*    Procedure Division:                                       *
*    Set address of JNIEnv to JNIEnvPtr                       *
*    Set address of JNINativeInterface to JNIEnv              *
*****************************************************************

* Sample JNI type definitions in COBOL

*01 jboolean1 pic X.
  88 jboolean1-true  value X'01' through X'FF'.
  88 jboolean1-false value X'00'.

*01 jbyte1 pic X.

*01 jchar1 pic N usage national.

*01 jshort1 pic s9(4)  comp-5.
*01 jint1   pic s9(9)  comp-5.
*01 jlong1  pic s9(18) comp-5.

*01 jfloat1  comp-1.
*01 jdouble1 comp-2.

*01 jobject1 object reference.
*01 jclass1  object reference.
*01 jstring1 object reference jstring.
*01 jarray1  object reference jarray.

*01 jbooleanArray1 object reference jbooleanArray.
*01 jbyteArray1 object reference jbyteArray.
*01 jcharArray1 object reference jcharArray.
*01 jshortArray1 object reference jshortArray.
*01 jintArray1 object reference jintArray.
*01 jlongArray1 object reference jlongArray.
*01 jfloatArray1 object reference jfloatArray.
*01 jdoubleArray1 object reference jdoubleArray.
*01 jobjectArray1 object reference jobjectArray.

* Possible return values for JNI functions.
*01 JNI-RC pic S9(9) comp-5.
* success
  88 JNI-OK        value 0.
* unknown error
  88 JNI-ERR       value -1.
* thread detached from the VM
  88 JNI-EDETACHED value -2.
* JNI version error
  88 JNI-EVERSION value -3.
* not enough memory
  88 JNI-ENOMEM    value -4.
* VM already created
  88 JNI-EEXIST value -5.
* invalid arguments
  88 JNI-EINVAL value -6.

* Used in ReleaseScalarArrayElements
01 releaseMode pic s9(9) comp-5.
  88 JNI-COMMIT value 1.
  88 JNI-ABORT value 2.

01 JNIenv pointer.

* JNI Native Method Interface - environment structure.
01 JNINativeInterface.
 02 pointer.
 02 pointer.
 02 pointer.
 02 pointer.
 02 GetVersion function-pointer.
 02 DefineClass function-pointer.
 02 FindClass function-pointer.
 02 FromReflectedMethod function-pointer.
 02 FromReflectedField function-pointer.
 02 ToReflectedMethod function-pointer.
 02 GetSuperclass function-pointer.
 02 IsAssignableFrom function-pointer.
 02 ToReflectedField function-pointer.
 02 Throw function-pointer.
 02 ThrowNew function-pointer.
 02 ExceptionOccurred function-pointer.
 02 ExceptionDescribe function-pointer.
 02 ExceptionClear function-pointer.
 02 FatalError function-pointer.
 02 PushLocalFrame function-pointer.
 02 PopLocalFrame function-pointer.
 02 NewGlobalRef function-pointer.
 02 DeleteGlobalRef function-pointer.
 02 DeleteLocalRef function-pointer.
 02 IsSameObject function-pointer.
 02 NewLocalRef function-pointer.
 02 EnsureLocalCapacity function-pointer.
 02 AllocObject function-pointer.
 02 NewObject function-pointer.
 02 NewObjectV function-pointer.
 02 NewObjectA function-pointer.
 02 GetObjectClass function-pointer.
 02 IsInstanceOf function-pointer.
 02 GetMethodID function-pointer.
 02 CallObjectMethod function-pointer.
 02 CallObjectMethodV function-pointer.
 02 CallObjectMethodA function-pointer.
 02 CallBooleanMethod function-pointer.
 02 CallBooleanMethodV function-pointer.
 02 CallBooleanMethodA function-pointer.
 02 CallByteMethod function-pointer.
 02 CallByteMethodV function-pointer.
 02 CallByteMethodA function-pointer.
 02 CallCharMethod function-pointer.
 02 CallCharMethodV function-pointer.
 02 CallCharMethodA function-pointer.
 02 CallShortMethod function-pointer.
 02 CallShortMethodV function-pointer.
 02 CallShortMethodA function-pointer.
 02 CallIntMethod function-pointer.
 02 CallIntMethodV function-pointer.
 02 CallIntMethodA function-pointer.
 02 CallLongMethod function-pointer.
 02 CallLongMethodV function-pointer.
 02 CallLongMethodA function-pointer.
 02 CallFloatMethod function-pointer.
 02 CallFloatMethodV function-pointer.
 02 CallFloatMethodA function-pointer.
 02 CallDoubleMethod function-pointer.
 02 CallDoubleMethodV function-pointer.
 02 CallDoubleMethodA function-pointer.
 02 CallVoidMethod function-pointer.
 02 CallVoidMethodV function-pointer.
 02 CallVoidMethodA function-pointer.
 02 CallNonvirtualObjectMethod function-pointer.
 02 CallNonvirtualObjectMethodV function-pointer.
 02 CallNonvirtualObjectMethodA function-pointer.
 02 CallNonvirtualBooleanMethod function-pointer.
<table>
<thead>
<tr>
<th>Function Pointer Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CallNonvirtualBooleanMethod</td>
<td>CallNonvirtualBooleanMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualByteMethod</td>
<td>CallNonvirtualByteMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualCharMethod</td>
<td>CallNonvirtualCharMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualShortMethod</td>
<td>CallNonvirtualShortMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualIntMethod</td>
<td>CallNonvirtualIntMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualLongMethod</td>
<td>CallNonvirtualLongMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualFloatMethod</td>
<td>CallNonvirtualFloatMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualDoubleMethod</td>
<td>CallNonvirtualDoubleMethod function-pointer.</td>
</tr>
<tr>
<td>CallNonvirtualVoidMethod</td>
<td>CallNonvirtualVoidMethod function-pointer.</td>
</tr>
<tr>
<td>GetFieldID</td>
<td>GetFieldID function-pointer.</td>
</tr>
<tr>
<td>GetObjectField</td>
<td>GetObjectField function-pointer.</td>
</tr>
<tr>
<td>GetBooleanField</td>
<td>GetBooleanField function-pointer.</td>
</tr>
<tr>
<td>GetByteField</td>
<td>GetByteField function-pointer.</td>
</tr>
<tr>
<td>GetCharField</td>
<td>GetCharField function-pointer.</td>
</tr>
<tr>
<td>GetShortField</td>
<td>GetShortField function-pointer.</td>
</tr>
<tr>
<td>GetIntField</td>
<td>GetIntField function-pointer.</td>
</tr>
<tr>
<td>GetLongField</td>
<td>GetLongField function-pointer.</td>
</tr>
<tr>
<td>GetFloatField</td>
<td>GetFloatField function-pointer.</td>
</tr>
<tr>
<td>SetObjectField</td>
<td>SetObjectField function-pointer.</td>
</tr>
<tr>
<td>SetBooleanField</td>
<td>SetBooleanField function-pointer.</td>
</tr>
<tr>
<td>SetByteField</td>
<td>SetByteField function-pointer.</td>
</tr>
<tr>
<td>SetCharField</td>
<td>SetCharField function-pointer.</td>
</tr>
<tr>
<td>SetShortField</td>
<td>SetShortField function-pointer.</td>
</tr>
<tr>
<td>SetIntField</td>
<td>SetIntField function-pointer.</td>
</tr>
<tr>
<td>SetLongField</td>
<td>SetLongField function-pointer.</td>
</tr>
<tr>
<td>SetFloatField</td>
<td>SetFloatField function-pointer.</td>
</tr>
<tr>
<td>GetStaticMethodID</td>
<td>GetStaticMethodID function-pointer.</td>
</tr>
<tr>
<td>CallStaticObjectMethod</td>
<td>CallStaticObjectMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticObjectMethodV</td>
<td>CallStaticObjectMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticObjectMethodA</td>
<td>CallStaticObjectMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticBooleanMethod</td>
<td>CallStaticBooleanMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticBooleanMethodV</td>
<td>CallStaticBooleanMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticBooleanMethodA</td>
<td>CallStaticBooleanMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticByteMethod</td>
<td>CallStaticByteMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticByteMethodV</td>
<td>CallStaticByteMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticByteMethodA</td>
<td>CallStaticByteMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticCharMethod</td>
<td>CallStaticCharMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticCharMethodV</td>
<td>CallStaticCharMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticCharMethodA</td>
<td>CallStaticCharMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticShortMethod</td>
<td>CallStaticShortMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticShortMethodV</td>
<td>CallStaticShortMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticShortMethodA</td>
<td>CallStaticShortMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticIntMethod</td>
<td>CallStaticIntMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticIntMethodV</td>
<td>CallStaticIntMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticIntMethodA</td>
<td>CallStaticIntMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticLongMethod</td>
<td>CallStaticLongMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticLongMethodV</td>
<td>CallStaticLongMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticLongMethodA</td>
<td>CallStaticLongMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticFloatMethod</td>
<td>CallStaticFloatMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticFloatMethodV</td>
<td>CallStaticFloatMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticFloatMethodA</td>
<td>CallStaticFloatMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticDoubleMethod</td>
<td>CallStaticDoubleMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticDoubleMethodV</td>
<td>CallStaticDoubleMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticDoubleMethodA</td>
<td>CallStaticDoubleMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticVoidMethod</td>
<td>CallStaticVoidMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticVoidMethodV</td>
<td>CallStaticVoidMethod function-pointer.</td>
</tr>
<tr>
<td>CallStaticVoidMethodA</td>
<td>CallStaticVoidMethod function-pointer.</td>
</tr>
<tr>
<td>GetStaticFieldID</td>
<td>GetStaticFieldID function-pointer.</td>
</tr>
<tr>
<td>GetStaticObjectField</td>
<td>GetStaticObjectField function-pointer.</td>
</tr>
<tr>
<td>GetStaticBooleanField</td>
<td>GetStaticBooleanField function-pointer.</td>
</tr>
<tr>
<td>GetStaticByteField</td>
<td>GetStaticByteField function-pointer.</td>
</tr>
<tr>
<td>GetStaticCharField</td>
<td>GetStaticCharField function-pointer.</td>
</tr>
<tr>
<td>GetStaticShortField</td>
<td>GetStaticShortField function-pointer.</td>
</tr>
<tr>
<td>Function Pointer</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>GetStaticIntField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStaticLongField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStaticFloatField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStaticDoubleField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticObjectField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticBooleanField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticByteField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticCharField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticShortField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticIntField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticLongField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticFloatField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetStaticDoubleField</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewString</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringLength</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringChars</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseStringChars</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewStringUTF</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringUTFLength</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringUTFChars</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseStringUTFChars</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetArrayLength</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewObjectArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetObjectArrayElement</td>
<td>function-pointer</td>
</tr>
<tr>
<td>SetObjectArrayElement</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewBooleanArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewByteArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewCharArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewShortArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewIntArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewLongArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewFloatArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewDoubleArray</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetBooleanArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetByteArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetCharArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetShortArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetIntArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetLongArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetFloatArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetDoubleArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseBooleanArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseByteArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseCharArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseShortArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseIntArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseLongArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseFloatArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseDoubleArrayElements</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetBooleanArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetByteArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetCharArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetShortArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetIntArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetLongArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetFloatArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetDoubleArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetBooleanArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetCharArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetShortArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetIntArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetLongArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetFloatArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetDoubleArrayRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>RegisterNatives</td>
<td>function-pointer</td>
</tr>
<tr>
<td>UnregisterNatives</td>
<td>function-pointer</td>
</tr>
<tr>
<td>MonitorEnter</td>
<td>function-pointer</td>
</tr>
<tr>
<td>MonitorExit</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetJavaVM</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringUTFRegion</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetPrimitiveArrayCritical</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleasePrimitiveArrayCritical</td>
<td>function-pointer</td>
</tr>
<tr>
<td>GetStringCritical</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ReleaseStringCritical</td>
<td>function-pointer</td>
</tr>
<tr>
<td>NewWeakGlobalRef</td>
<td>function-pointer</td>
</tr>
<tr>
<td>DeleteWeakGlobalRef</td>
<td>function-pointer</td>
</tr>
<tr>
<td>ExceptionCheck</td>
<td>function-pointer</td>
</tr>
</tbody>
</table>
related tasks
“Compiling OO applications under z/OS UNIX” on page 273
“Accessing JNI services” on page 597
Appendix G. COBOL SYSADATA file contents

When you use the ADATA compiler option, the compiler produces a file, the SYSADATA file, that contains additional program data. You can use this file instead of the compiler listing to extract information about the program. For example, you can extract information about the program for symbolic debugging tools or cross-reference tools.

“Example: SYSADATA” on page 705

related references

“ADATA” on page 288
“Compiler options that affect the SYSADATA file” on page 703
“SYSADATA record types” on page 704
“SYSADATA record descriptions” on page 706

Compiler options that affect the SYSADATA file

Several compiler options could affect the contents of the SYSADATA file.

**COMPILE**

NOCOMPILE (W|E|S) might stop compilation prematurely, resulting in the loss of specific messages.

**EXIT**

INEXIT prohibits identification of the compilation source file.

**LANGUAGE**

LANGUAGE controls the message text (Uppercase English, Mixed-Case English, or Japanese). Selection of Japanese could result in DBCS characters written to Error Identification records.

**NUM**

NUM causes the compiler to use the contents of columns 1-6 in the source records for line numbering, rather than using generated sequence numbers. Any invalid (nonnumeric) or out-of-sequence numbers are replaced with a number one higher than that of the previous record.

**TEST**

TEST causes additional object text records to be created that also affect the contents of the SYSADATA file.

The SYSADATA fields shown in the following table contain line numbers whose contents differ depending on the NUM|NONUM setting.

<table>
<thead>
<tr>
<th>Type</th>
<th>Field</th>
<th>Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>0020</td>
<td>AE_LINE</td>
<td>External Symbol record</td>
</tr>
<tr>
<td>0030</td>
<td>ATOK_LINE</td>
<td>Token record</td>
</tr>
<tr>
<td>0032</td>
<td>AF_STMT</td>
<td>Source Error record</td>
</tr>
<tr>
<td>0038</td>
<td>AS_STMT</td>
<td>Source record</td>
</tr>
<tr>
<td>0039</td>
<td>AS_REP_EXP_SLIN</td>
<td>COPY REPLACING record</td>
</tr>
<tr>
<td>0039</td>
<td>AS_REP_EXP_ELIN</td>
<td>COPY REPLACING record</td>
</tr>
<tr>
<td>0042</td>
<td>ASY_STMT</td>
<td>Symbol record</td>
</tr>
<tr>
<td>0044</td>
<td>AX_DEFN</td>
<td>Symbol Cross Reference record</td>
</tr>
<tr>
<td>0044</td>
<td>AX_STMT</td>
<td>Symbol Cross Reference record</td>
</tr>
<tr>
<td>0046</td>
<td>AN_STMT</td>
<td>Nested Program record</td>
</tr>
</tbody>
</table>
The Type 0038 Source record contains two fields that relate to line numbers and record numbers:

- **AS_STMT** contains the compiler line number in both the NUM and NONUM cases.
- **AS_CUR_REC#** contains the physical source record number.

These two fields can always be used to correlate the compiler line numbers, used in all the above fields, with physical source record numbers.

The remaining compiler options have no direct effect on the SYSADATA file, but might trigger generation of additional error messages associated with the specific option, such as FLAGSTD or SSRANGE.

“Example: SYSADATA” on page 705

**related references**

“SYSADATA record types” on page 704
“COMPILE” on page 297
“EXIT” on page 305
“LANGUAGE” on page 313
“NUMBER” on page 320
“TEST” on page 341

**SYSADATA record types**

The SYSADATA file contains records classified into different record types. Each type of record provides information about the COBOL program being compiled.

Each record consists of two parts:

- A 12-byte header section, which has the same structure for all record types, and contains the record code that identifies the type of record
- A variable-length data section, which varies by record type

<table>
<thead>
<tr>
<th><strong>Record type</strong></th>
<th><strong>What it does</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>“Job identification record: X'0000'” on page 709</td>
<td>Provides information about the environment used to process the source data</td>
</tr>
<tr>
<td>“ADATA identification record: X'0001'” on page 710</td>
<td>Provides common information about the records in the SYSADATA file</td>
</tr>
<tr>
<td>“Compilation unit start</td>
<td>end record: X'0002'” on page 710</td>
</tr>
<tr>
<td>“Options record: X'0010'” on page 711</td>
<td>Describes the compiler options used for the compilation</td>
</tr>
<tr>
<td>“External symbol record: X'0020'” on page 721</td>
<td>Describes all external names in the program, definitions, and references</td>
</tr>
<tr>
<td>“Parse tree record: X'0024'” on page 722</td>
<td>Defines a node in the parse tree of the program</td>
</tr>
<tr>
<td>“Token record: X'0030'” on page 742</td>
<td>Defines a source token</td>
</tr>
<tr>
<td>“Source error record: X'0032'” on page 757</td>
<td>Describes errors in source program statements</td>
</tr>
<tr>
<td>“Source record: X'0038'” on page 757</td>
<td>Describes a single source line</td>
</tr>
<tr>
<td>“COPY REPLACING record: X'0039'” on page 758</td>
<td>Describes an instance of text replacement as a result of a match of COPY . . .REPLACING operand-1 with text in the copybook</td>
</tr>
</tbody>
</table>

“Example: SYSADATA” on page 705
Table 115. **SYSADATA record types** (continued)

<table>
<thead>
<tr>
<th>Record type</th>
<th>What it does</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Symbol record: X’0042’” on page 759</td>
<td>Describes a single symbol defined in the program. There is one symbol record for each symbol defined in the program.</td>
</tr>
<tr>
<td>“Symbol cross-reference record: X’0044’” on page 771</td>
<td>Describes references to a single symbol</td>
</tr>
<tr>
<td>“Nested program record: X’0046’” on page 773</td>
<td>Describes the name and nesting level of a program</td>
</tr>
<tr>
<td>“Library record: X’0060’” on page 773</td>
<td>Describes the library files and members used from each library</td>
</tr>
<tr>
<td>“Statistics record: X’0090’” on page 774</td>
<td>Describes the statistics about the compilation</td>
</tr>
<tr>
<td>“EVENTS record: X’0120’” on page 775</td>
<td>EVENTS records provide compatibility with COBOL/370. The record format is identical with that in COBOL/370, with the addition of the standard ADATA header at the beginning of the record and a field indicating the length of the EVENTS record data.</td>
</tr>
</tbody>
</table>

**Example: SYSADATA**

The following sample shows part of the listing of a COBOL program. If this COBOL program were compiled with the ADATA option, the records produced in the associated data file would be in the sequence shown in the table below.

```
000001 IDENTIFICATION DIVISION.
000002 PROGRAM-ID. AD04202.
000003 ENVIRONMENT DIVISION.
000004 DATA DIVISION.
000005 WORKING-STORAGE SECTION.
000006 77 COMP3-FLD2 pic S9(3)v9.
000007 PROCEDURE DIVISION.
000008 STOP RUN.
```

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X’0120’</td>
<td>EVENTS Timestamp record</td>
</tr>
<tr>
<td>X’0120’</td>
<td>EVENTS Processor record</td>
</tr>
<tr>
<td>X’0120’</td>
<td>EVENTS File-ID record</td>
</tr>
<tr>
<td>X’0120’</td>
<td>EVENTS Program record</td>
</tr>
<tr>
<td>X’0001’</td>
<td>ADATA Identification record</td>
</tr>
<tr>
<td>X’0000’</td>
<td>Job Identification record</td>
</tr>
<tr>
<td>X’0010’</td>
<td>Options record</td>
</tr>
<tr>
<td>X’0038’</td>
<td>Source record for statement 1</td>
</tr>
<tr>
<td>X’0038’</td>
<td>Source record for statement 2</td>
</tr>
<tr>
<td>X’0038’</td>
<td>Source record for statement 3</td>
</tr>
<tr>
<td>X’0038’</td>
<td>Source record for statement 4</td>
</tr>
<tr>
<td>X’0038’</td>
<td>Source record for statement 5</td>
</tr>
<tr>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>X'0038'</td>
<td>Source record for statement 6</td>
</tr>
<tr>
<td>X'0038'</td>
<td>Source record for statement 7</td>
</tr>
<tr>
<td>X'0038'</td>
<td>Source record for statement 8</td>
</tr>
<tr>
<td>X'0020'</td>
<td>External Symbol record for AD04202</td>
</tr>
<tr>
<td>X'0044'</td>
<td>Symbol Cross Reference record for STOP</td>
</tr>
<tr>
<td>X'0044'</td>
<td>Symbol Cross Reference record for COMP3-FLD2</td>
</tr>
<tr>
<td>X'0044'</td>
<td>Symbol Cross Reference record for AD04202</td>
</tr>
<tr>
<td>X'0042'</td>
<td>Symbol record for AD04202</td>
</tr>
<tr>
<td>X'0042'</td>
<td>Symbol record for COMP3-FLD2</td>
</tr>
<tr>
<td>X'0090'</td>
<td>Statistics record</td>
</tr>
<tr>
<td>X'0120'</td>
<td>EVENTS FileEnd record</td>
</tr>
</tbody>
</table>

related references
“SYSADATA record descriptions” on page 706

SYSADATA record descriptions

The formats of the records written to the associated data file are shown in the related references below.

In the fields described in each of the record types, these symbols occur:

- **C**: Indicates character (EBCDIC or ASCII) data
- **H**: Indicates 2-byte binary integer data
- **F**: Indicates 4-byte binary integer data
- **A**: Indicates 4-byte binary integer address and offset data
- **X**: Indicates hexadecimal (bit) data or 1-byte binary integer data

No boundary alignments are implied by any data type, and the implied lengths above might be changed by the presence of a length indicator (Ln). All integer data is in big-endian or little-endian format depending on the indicator bit in the header flag byte. Big-endian format means that bit 0 is always the most significant bit and bit n is the least significant bit. Little-endian refers to “byte-reversed” integers as seen on Intel processors.

All undefined fields and unused values are reserved.

related references
“Common header section” on page 707
“Job identification record: X'0000'” on page 709
“ADATA identification record: X'0001'” on page 710
“Compilation unit start | end record: X'0002'” on page 710
“Options record: X'0010'” on page 711
“External symbol record: X'0020'” on page 721
“Parse tree record: X'0024'” on page 722
“Token record: X'0030'” on page 742
“Source error record: X'0032'” on page 757
Common header section

The table below shows the format of the header section that is common for all record types. For MVS and VSE, each record is preceded by a 4-byte RDW (record-descriptor word) that is normally used only by access methods and stripped off by download utilities.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language code</td>
<td>XL1</td>
<td>16 High Level Assembler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 COBOL on all platforms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 PL/I on supported platforms</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Record type</td>
<td>HL2</td>
<td>The record type, which can be any of the following ones:</td>
</tr>
</tbody>
</table>
|                             |      | X'0000'  
|                             |      | Job Identification record                                                                                                                 |
|                             |      | X'0001'  
|                             |      | ADATA Identification record                                                                                                                |
|                             |      | X'0002'  
|                             |      | Compilation unit start/end record                                                                                                          |
|                             |      | X'0010'  
|                             |      | Options record                                                                                                                             |
|                             |      | X'0020'  
|                             |      | External Symbol record                                                                                                                    |
|                             |      | X'0024'  
|                             |      | Parse Tree record                                                                                                                          |
|                             |      | X'0030'  
|                             |      | Token record                                                                                                                               |
|                             |      | X'0032'  
|                             |      | Source Error record                                                                                                                        |
|                             |      | X'0038'  
|                             |      | Source record                                                                                                                              |
|                             |      | X'0039'  
|                             |      | COPY REPLACING record                                                                                                                      |
|                             |      | X'0042'  
|                             |      | Symbol record                                                                                                                              |
|                             |      | X'0044'  
|                             |      | Symbol Cross-Reference record                                                                                                               |
|                             |      | X'0046'  
|                             |      | Nested Program record                                                                                                                      |
|                             |      | X'0060'  
|                             |      | Library record                                                                                                                             |
|                             |      | X'0090'  
|                             |      | Statistics record                                                                                                                          |
|                             |      | X'0120'  
|                             |      | EVENTS record                                                                                                                              |
| Associated data architecture level | XL1  | 3  
|                             |      | Definition level for the header structure                                                                                                   |
| Flag                        | XL1  | . . . . 1.  
|                             |      | ADATA record integers are in little-endian (Intel) format                                                                                   |
|                             |      | . . . . 1  
|                             |      | This record is continued in the next record                                                                                                 |
|                             |      | 1111  
|                             |      | Used for future use                                                                                                                        |
|                             |      | 11 . .  
| Associated data record edition level | XL1  | Used to indicate a new format for a specific record type, usually 0                                                                      |
| Reserved                    | CL4  | Reserved for future use                                                                                                                    |
**Table 116. SYSADATA common header section (continued)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated data field length</td>
<td>HL2</td>
<td>The length in bytes of the data following the header</td>
</tr>
</tbody>
</table>

1. When a batch compilation (sequence of programs) is run with the ADATA option, there will be multiple Job Identification, Options, and Statistics records for each compilation.

The mapping of the 12-byte header does not include the area used for the variable-length record-descriptor word required by the access method on MVS and VSE.

**Job identification record: X'0000'**

The following table shows the contents of the job identification record.

**Table 117. SYSADATA job identification record**

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>CL8</td>
<td>The date of the compilation in the format YYYYMMDD</td>
</tr>
<tr>
<td>Time</td>
<td>CL4</td>
<td>The time of the compilation in the format HHMM</td>
</tr>
<tr>
<td>Product number</td>
<td>CL8</td>
<td>The product number of the compiler that produced the associated data file</td>
</tr>
<tr>
<td>Product version</td>
<td>CL8</td>
<td>The version number of the product that produced the associated data file, in the form V.R,M</td>
</tr>
<tr>
<td>BLD Level</td>
<td>CL8</td>
<td>The build level information (of the form PYYMMDD) of the product that produced the associated data file</td>
</tr>
<tr>
<td>System ID</td>
<td>CL24</td>
<td>The system identification of the system on which the compilation was run</td>
</tr>
<tr>
<td>Job name</td>
<td>CL8</td>
<td>The MVS job name of the compilation job</td>
</tr>
<tr>
<td>Step name</td>
<td>CL8</td>
<td>The MVS step name of the compilation step</td>
</tr>
<tr>
<td>Proc step</td>
<td>CL8</td>
<td>The MVS procedure step name of the compilation procedure</td>
</tr>
<tr>
<td>Number of input files(^2)</td>
<td>HL2</td>
<td>The number of input files recorded in this record. The following group of seven fields will occur (n) times depending on the value in this field.</td>
</tr>
<tr>
<td>...Input file number</td>
<td>HL2</td>
<td>The assigned sequence number of the file</td>
</tr>
<tr>
<td>...Input file name length</td>
<td>HL2</td>
<td>The length of the following input file name</td>
</tr>
<tr>
<td>...Volume serial number length</td>
<td>HL2</td>
<td>The length of the volume serial number</td>
</tr>
<tr>
<td>...Member name length</td>
<td>HL2</td>
<td>The length of the member name</td>
</tr>
<tr>
<td>...Input file name</td>
<td>CL(n)</td>
<td>The name of the input file for the compilation</td>
</tr>
<tr>
<td>...Volume serial number</td>
<td>CL(n)</td>
<td>The volume serial number of the (first) volume on which the input file resides</td>
</tr>
<tr>
<td>...Member name</td>
<td>CL(n)</td>
<td>Where applicable, the name of the member in the input file</td>
</tr>
</tbody>
</table>
1. Where the number of input files would exceed the record size for the associated data file, the record is continued on the next record. The current number of input files (for that record) is stored in the record, and the record is written to the associated data file. The next record contains the rest of the input files. The count of the number of input files is a count for the current record.

**ADATA identification record: X'0001'**

The following table shows the contents of the ADATA identification record.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (binary)</td>
<td>XL8</td>
<td>Universal Time (UT) as a binary number of microseconds since midnight Greenwich Mean Time, with the low-order bit representing 1 microsecond. This time can be used as a time-zone-independent time stamp. On Windows and AIX systems, only bytes 5-8 of the field are used as a fullword binary field that contains the time.</td>
</tr>
<tr>
<td>CCSID¹</td>
<td>XL2</td>
<td>Coded Character Set Identifier</td>
</tr>
<tr>
<td>Character-set flags</td>
<td>XL1</td>
<td>X'80' EBCDIC (IBM-037)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'40' ASCII (IBM-1252)</td>
</tr>
<tr>
<td>Code-page name length</td>
<td>XL2</td>
<td>Length of the code-page name that follows</td>
</tr>
<tr>
<td>Code-page name</td>
<td>CL(n)</td>
<td>Name of the code page</td>
</tr>
</tbody>
</table>

1. The appropriate CCS flag will always be set. If the CCSID is set to nonzero, the code-page name length will be zero. If the CCSID is set to zero, the code-page name length will be nonzero and the code-page name will be present.

**Compilation unit start | end record: X'0002'**

The following table shows the contents of the compilation unit start|end record.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>HL2</td>
<td>Compilation unit type, which is one of the following options: X'0000'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start compilation unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'0001' End compilation unit</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL2</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Reserved</td>
<td>FL4</td>
<td>Reserved for future use</td>
</tr>
</tbody>
</table>
The following table shows the contents of the options record.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option byte 0</td>
<td>XL1</td>
<td>1111 1111 Reserved for future use</td>
</tr>
<tr>
<td>Option byte 1</td>
<td>XL1</td>
<td>1... ..... Bit 1 = DECK, Bit 0 = NODECK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... ..... Bit 1 = ADATA, Bit 0 = NOADATA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... ..... Bit 1 = COLSEQ (EBCDIC), Bit 0 = COLSEQ (LOCALE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.....1..... Bit 1 = SEPOBJ, Bit 0 = NOSEPOBJ (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... 1... Bit 1 = NAME, Bit 0 = NONAME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..... .1.. Bit 1 = OBJECT, Bit 0 = NOOBJECT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..... ..1. Bit 1 = SQL, Bit 0 = NOSQL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..... ...1 Bit 1 = CICS, Bit 0 = NOCICS</td>
</tr>
<tr>
<td>Option byte 2</td>
<td>XL1</td>
<td>1... ..... Bit 1 = OFFSET, Bit 0 = NOOFFSET</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... ..... Bit 1 = MAP, Bit 0 = NOMAP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... ..... Bit 1 = LIST, Bit 0 = NOLIST</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... 1... Bit 1 = DBCSXREF, Bit 0 = NODBCSXREF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... 1... Bit 1 = XREF (SHORT), Bit 0 = not XREF (SHORT). This flag should be used in combination with the flag at bit 7. XREF (FULL) is indicated by this flag being off and the flag at bit 7 being on.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..... .1.. Bit 1 = SOURCE, Bit 0 = NOSOURCE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..... ..1. Bit 1 = VBREF, Bit 0 = NOVBREF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..... ...1 Bit 1 = XREF, Bit 0 = not XREF. See also flag at bit 4 above.</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Option byte 3</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1.   Bit 1 = FLAG imbedded diagnostics level specified (a value y is specified as in FLAG(x,y))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. 1...   Bit 1 = FLAGSTD, Bit 0 = NOFLAGSTD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. 1...   Bit 1 = NUM, Bit 0 = NONUM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = SEQUENCE, Bit 0 = NOSEQUENCE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = SOSI, Bit 0 = NOSOSI (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = NSYMBOL (NATIONAL), Bit 0 = NSYMBOL (DBCS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = PROFILE, Bit 0 = NOPROFILE (AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = WORD, Bit 0 = NOWORD</td>
</tr>
<tr>
<td>Option byte 4</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = ADV, Bit 0 = NOADV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = APOST, Bit 0 = QUOTE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = DYNAM, Bit 0 = NODYNAM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = AWO, Bit 0 = NOAWO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = RMODE specified, Bit 0 = RMODE (AUTO)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = RENT, Bit 0 = NORENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = RES: this flag will always be set on for COBOL.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 1... Bit 1 = RMODE (24), Bit 0 = RMODE (ANY)</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Option byte 5 | XL1  | 1...       
|               |      | Bit 1 = SQLCCSID, Bit 0 = NOSQLCCSID                                        |
|               |      | .1...      
|               |      | Bit 1 = OPT(1|2), Bit 0 = OPT(0)                                              |
|               |      | ..1...     
|               |      | Bit 1 = SQLIMS, Bit 0 = NOSQLIMS                                            |
|               |      | ...1...    
|               |      | Bit 1 = DBCS, Bit 0 = NODBCS                                                |
|               |      | .... 1...  
|               |      | Bit 1 = AFP(VOLATILE), Bit 0 = AFP(NOVOATILE)                              |
|               |      | .... .1... 
|               |      | Bit 1 = SSRANGE, Bit 0 = NOSSRANGE                                          |
|               |      | .... ...1. 
|               |      | Bit 1 = TEST, Bit 0 = NOTEST                                                |
|               |      | .... ....1 
|               |      | Bit 1 = PROBE, Bit 0 = NOPROBE (Windows only)                              |
| Option byte 6 | XL1  | 1...       
|               |      | Bit 1 = SRCFORMAT(EXTEND), Bit 0 = SRCFORMAT(COMPAT)                        |
|               |      | .1...      
|               |      | Bit 1 = NUMPROC(PFD), Bit 0 = NUMPROC(NOPFD)                                |
|               |      | ..1...     
|               |      | Bit 1 = NUMCLS(ALT), Bit 0 = NUMCLS(PRIM)                                  |
|               |      | .... .1... 
|               |      | Bit 1 = BINARY(S390), Bit 0 = BINARY(NATIVE) (Windows and AIX only)        |
|               |      | .... ...1. 
|               |      | Bit 1 = TRUNC(STD), Bit 0 = TRUNC(OPT)                                      |
|               |      | .... ....1 
|               |      | Bit 1 = ZWB, Bit 0 = NOZWB                                                  |
|               |      | 1... 1...   
|               |      | Reserved for future use                                                     |
| Option byte 7 | XL1  | 1...       
|               |      | Bit 1 = ALOWCBL, Bit 0 = NOALOWCBL                                          |
|               |      | .1...      
|               |      | Bit 1 = TERM, Bit 0 = NOTERM                                                |
|               |      | ..1...     
|               |      | Bit 1 = DUMP, Bit 0 = NODUMP                                                |
|               |      | .... .1... 
|               |      | Bit 1 = CURRENCY, Bit 0 = NOCURRENCY                                         |
|               |      | ...1 11.1  
|               |      | Reserved for future use                                                     |
Table 120. **SYSADATA options record** (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option byte 8</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1... .</strong> Bit 1 = RULES, Bit 0 = NORULES</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.1...</strong> Bit 1 = OPTFILE, Bit 0 = not OPTFILE</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>..1...</strong> Bit 1 = ADDR(64), Bit 0 = ADDR(32) (AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.... 1...</strong> Bit 1 = BLOCK0, Bit 0 = NOBLOCK0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.... ..1...</strong> Bit 1 = DISPSIGN(SEP), Bit 0 = DISPSIGN(COMPAT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.... ....1</strong> Bit 1 = STGOPT, Bit 0 = NOSTGOPT</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1... .1...</strong> Reserved for future use</td>
</tr>
<tr>
<td>Option byte 9</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1... .</strong> Bit 1 = DATA(24), Bit 0 = DATA(31)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.1... .</strong> Bit 1 = FASTSRT, Bit 0 = NOFASTSRT</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.... .1...</strong> Bit 1 = THREAD, Bit 0 = NOTHREAD</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>11 111</strong> Reserved for future use</td>
</tr>
<tr>
<td>Option byte A</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1... .</strong> Bit 1 = HGPR(PRESERVE), Bit 0 = HGPR(NOPRESERVE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.1... .</strong> Bit 1 = XMLPARSE(XMLSS), Bit 0 = XMLPARSE(COMPAT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>..1... .</strong> Bit 1 = MAP(DEC), Bit 0 = MAP(HEX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>....1...</strong> Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.... 1...</strong> Bit 1 = SUPRESS, Bit 0 = NOSUPPRESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>....11</strong> Bit 1 = VSAMOPENFS(SUCC), Bit 0 = VSAMOPENFS(COMPAT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>....11</strong> Reserved for future use</td>
</tr>
<tr>
<td>Option byte B</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1111 1111</strong> Reserved for future use</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Option byte C</td>
<td>XL1</td>
<td>1... 6... Bit 1 = NCOLLSEQ(LOCALE) (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... 6... Reserved for future use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... 6... Bit 1 = INTDATE(LILIAN), Bit 0 = INTDATE(ANSI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = NCOLLSEQ(BINARY) (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = CHAR(EBDIC), Bit 0 = CHAR(NATIVE) (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = FLOAT(HEX), Bit 0 = FLOAT(NATIVE) (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = COLLSEQ(BINARY) (Windows and AIX only)</td>
</tr>
<tr>
<td>Option byte D</td>
<td>XL1</td>
<td>1... 6... Bit 1 = DLL, Bit 0 = NODLL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... 6... Bit 1 = EXPORTALL, Bit 0 = NOEXPORTALL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... 6... Bit 1 = CODEPAGE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = SOURCEFORMAT(EXTEND), Bit 0 = SOURCEFORMAT(COMPAT) (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = WSCLEAR, Bit 0 = NOWSCLEAR (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = BEOPT, Bit 0 = NOBEOPT (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Reserved for future use</td>
</tr>
<tr>
<td>Option byte E</td>
<td>XL1</td>
<td>1... 6... Bit 1 = VLR(COMPAT), Bit 0 = VLR(STANDARD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... 6... Bit 1 = DIAGTRUNC, Bit 0 = NODIAGTRUNC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... 6... Bit 1 = LSTFILE(UTF-8), Bit 0 = LSTFILE(LOCALE) (Windows and AIX only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = MDECK, Bit 0 = NOMDECK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... 6... Bit 1 = MDECK(NOCOMPILE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..11... 6... Reserved for future use</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Option byte F</td>
<td>XL1</td>
<td><strong>1... .....</strong>&lt;br&gt;Bit 1 = DIVIDE(S390), Bit 0 = DIVIDE(NATIVE) (AIX Only)&lt;br&gt;<strong>.1... .....</strong>&lt;br&gt;Bit 1 = COPYRIGHT, Bit 0 = NOCOPYRIGHT&lt;br&gt;<strong>..1... .....</strong>&lt;br&gt;Bit 1 = QUALIFY(EXTEND), Bit 0 = QUALIFY(COMPAT)&lt;br&gt;<strong>...1... .....</strong>&lt;br&gt;Bit 1 = SERVICE, Bit 0 = NOSERVICE&lt;br&gt;<strong>.... 1... .....</strong>&lt;br&gt;Bit 1 = ZONEDATA(MIG)&lt;br&gt;<strong>.... .1... .....</strong>&lt;br&gt;Bit 1 = ZONEDATA(NOPFD)&lt;br&gt;<strong>.... ..1... .....</strong>&lt;br&gt;Bit 1 = NUMCHECK(ZON</td>
</tr>
<tr>
<td>Option byte G</td>
<td>XL1</td>
<td><strong>1... .....</strong>&lt;br&gt;Bit 1 = NUMCHECK(ZON), Bit 0 = NUMCHECK(NOZON)&lt;br&gt;<strong>.1... .....</strong>&lt;br&gt;Bit 1 = NUMCHECK(PAC), Bit 0 = NUMCHECK(NOPAC)&lt;br&gt;<strong>..1... .....</strong>&lt;br&gt;Bit 1 = NUMCHECK(BIN), Bit 0 = NUMCHECK(NOBIN)&lt;br&gt;<strong>...1... .....</strong>&lt;br&gt;Bit 1 = NUMCHECK(MSG), Bit 0 = NUMCHECK(ABD)&lt;br&gt;<strong>.... 1... .....</strong>&lt;br&gt;Bit 1 = NUMCHECK(ZON(NOALPHNUM)), Bit 0 = NUMCHECK(ZON(ALPHNUM))&lt;br&gt;<strong>.... .111... .....</strong>&lt;br&gt;Reserved for future use</td>
</tr>
<tr>
<td>Option byte H</td>
<td>XL1</td>
<td><strong>1... .....</strong>&lt;br&gt;Bit 1 = PARMCHECK(ABD), Bit 0 = PARMCHECK(MSG) (if PARMCHECK in effect)&lt;br&gt;<strong>.1... .....</strong>&lt;br&gt;Reserved for future use</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Flag level</td>
<td>XL1</td>
<td><code>X'00'</code> Flag(I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'04'</code> Flag(W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'08'</code> Flag(E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'0C'</code> Flag(S)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'10'</code> Flag(U)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'FF'</code> Noflag</td>
</tr>
<tr>
<td>Imbedded diagnostic level</td>
<td>XL1</td>
<td><code>X'00'</code> Flag(I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'04'</code> Flag(W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'08'</code> Flag(E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'0C'</code> Flag(S)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'10'</code> Flag(U)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>X'FF'</code> Noflag</td>
</tr>
<tr>
<td>FLAGSTD (FIPS) specification</td>
<td>XL1</td>
<td>1... Minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... Intermediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... IBM extensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... 1... Level-1 segmentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... .1... Level-2 segmentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ..1... Debugging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ...1... Obsolete</td>
</tr>
<tr>
<td>Reserved for flagging</td>
<td>XL1</td>
<td>1111 1111 Reserved for future use</td>
</tr>
</tbody>
</table>
### Table 120. SYSADATA options record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compiler mode</strong></td>
<td>XL1</td>
<td>- <strong>X'00'</strong> Unconditional Nocompile, Nocompile(I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>X'04'</strong> Nocompile(W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>X'08'</strong> Nocompile(E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>X'0C'</strong> Nocompile(S)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>X'FF'</strong> Compile</td>
</tr>
<tr>
<td><strong>Space value</strong></td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td><strong>Data for 3-valued options</strong></td>
<td>XL1</td>
<td>- <strong>1...</strong> NAME(ALIAS) specified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> Reserved for future use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> TRUNC(BIN) specified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> PARMCHECK(ABD) (if PARMCHECK in effect)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> INITCHECK(STRICT) specified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>111</strong> Reserved for future use</td>
</tr>
<tr>
<td><strong>TEST suboptions</strong></td>
<td>XL1</td>
<td>- <strong>1...</strong> TEST(EJPD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> TEST(SOURCE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reserved for TEST suboptions</td>
</tr>
<tr>
<td><strong>OUTDD name length</strong></td>
<td>HL2</td>
<td>Length of OUTDD name</td>
</tr>
<tr>
<td><strong>RWT ID Length</strong></td>
<td>HL2</td>
<td>Length of Reserved Word Table identifier</td>
</tr>
<tr>
<td><strong>BLD LEVEL</strong></td>
<td>CL8</td>
<td>Product build level information (of the form PYYMMDD)</td>
</tr>
<tr>
<td><strong>PGMNAME suboptions</strong></td>
<td>XL1</td>
<td>- <strong>1...</strong> Bit 1 = PGMNAME(COMPAT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> Bit 1 = PGMNAME(LONGUPPER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>1...</strong> Bit 1 = PGMNAME(LONGMIXED)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>111</strong> Reserved for future use</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Entry interface suboptions | XL1  | 1... ....  
|                        |      | Bit 1 = EntryInterface(System) (Windows only)  
|                        |      | .1... ....  
|                        |      | Bit 1 = EntryInterface(OptLink) (Windows only)  
|                        |      | ..11 1111  
|                        |      | Reserved for future use  |
| CALLINTERFACE suboptions | XL1  | 1... ....  
|                        |      | Bit 1 = CALLINTERFACE(DLL)  
|                        |      | .1... ....  
|                        |      | Bit 1 = CALLINTERFACE(DYNAMIC)  
|                        |      | ..11 1111  
|                        |      | Reserved for future use  |
| ARITH suboption       | XL1  | 1... ....  
|                        |      | Bit 1 = ARITH(COMPAT)  
|                        |      | .1... ....  
|                        |      | Bit 1 = ARITH(EXTEND)  
|                        |      | ..11 1111  
<p>|                        |      | Reserved for future use  |
| DBCS Req               | FL4  | DBCS XREF storage requirement  |
| DBCS ORDPGM length     | HL2  | Length of name of DBCS Ordering Program  |
| DBCS ENCTBL length     | HL2  | Length of name of DBCS Encode Table  |
| DBCS ORD TYPE          | CL2  | DBCS Ordering type  |
| Reserved               | CL5  | Reserved for future use  |
| Optimize level         | XL1  | Optimization level 0 &lt;= n &lt;= 2  |
| Converted SO           | CL1  | Converted SO hexadecimal value  |
| Converted SI           | CL1  | Converted SI hexadecimal value  |
| Language ID            | CL2  | This field holds the two-character abbreviation (one of EN, UE, JA, or JP) from the LANGUAGE option.  |
| Reserved               | CL8  | Reserved for future use  |
| INEXIT name length     | HL2  | Length of SYSIN user-exit name  |
| PRTEXIT name length    | HL2  | Length of SYSPRINT user-exit name  |
| LIBEXIT name length    | HL2  | Length of Libraryuser-exit name  |
| ADEXIT name length     | HL2  | Length of ADATA user-exit name  |
| CURR0PT                | CL5  | CURRENCY option value  |
| ARCH                   | XL1  | ARCH level number  |
| Reserved               | CL2  | Reserved for future use  |
| CODEPAGE               | HL2  | CODEPAGE CCSID option value  |
| Reserved               | CL50 | Reserved for future use  |</p>
<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
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<td>LINECOUNT value</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL2</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>BUFSIZE</td>
<td>FL4</td>
<td>BUFSIZE option value</td>
</tr>
<tr>
<td>Reserved</td>
<td>FL4</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Phase residence bits</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>byte 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCLIBR in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCSCAN in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCDSCN in user region</td>
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<tr>
<td></td>
<td></td>
<td>...1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCGROU in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>....1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCPSCN in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... .1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCPANA in user region</td>
</tr>
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<td></td>
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<td>.... ..1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCFGEN in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ...1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCPGEN in user region</td>
</tr>
<tr>
<td>Phase residence bits</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>byte 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCLSTR in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCREF in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCDMAP in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ..1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCDIA in user region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ...1.. 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1 = IGYCDGEN in user region</td>
</tr>
<tr>
<td>Phase residence bits</td>
<td>XL2</td>
<td></td>
</tr>
<tr>
<td>bytes 3 and 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... 11..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL8</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>OUTDD name</td>
<td>CL(n)</td>
<td>OUTDD name</td>
</tr>
<tr>
<td>RWT</td>
<td>CL(n)</td>
<td>Reserved word table identifier</td>
</tr>
<tr>
<td>DBCS ORDPGM</td>
<td>CL(n)</td>
<td>DBCS Ordering program name</td>
</tr>
<tr>
<td>DBCS ENCTBL</td>
<td>CL(n)</td>
<td>DBCS Encode table name</td>
</tr>
<tr>
<td>INEXIT name</td>
<td>CL(n)</td>
<td>SYSIN user-exit name</td>
</tr>
<tr>
<td>PRTEEXIT name</td>
<td>CL(n)</td>
<td>SYSPRINT user-exit name</td>
</tr>
</tbody>
</table>
Table 120.SYSADATA options record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIBEXIT name</td>
<td>CL(n)</td>
<td>Library user-exit name</td>
</tr>
<tr>
<td>AEXIT name</td>
<td>CL(n)</td>
<td>ADATA user-exit name</td>
</tr>
</tbody>
</table>

External symbol record: X'0020'

The following table shows the contents of the external symbol record.

Table 121. SYSADATA external symbol record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Section type</td>
<td>XL1</td>
<td>X'00' PROGRAM-ID name (main entry point name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'01' ENTRY name (secondary entry point name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'02' External reference (referenced external entry point)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'04' Not applicable for COBOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'05' Not applicable for COBOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'06' Not applicable for COBOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'0A' Not applicable for COBOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'12' Internal reference (referenced internal subprogram)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'C0' External class-name (OO COBOL class definition)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'C1' METHOD-ID name (OO COBOL method definition)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'C6' Method reference (OO COBOL method reference)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'FF' Not applicable for COBOL</td>
</tr>
<tr>
<td>Flags</td>
<td>XL1</td>
<td>Not applicable for COBOL</td>
</tr>
<tr>
<td>Reserved</td>
<td>HL2</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Symbol-ID</td>
<td>FL4</td>
<td>Symbol-ID of program that contains the reference (only for types x'02' and x'12')</td>
</tr>
<tr>
<td>Line number</td>
<td>FL4</td>
<td>Line number of statement that contains the reference (only for types x'02' and x'12')</td>
</tr>
<tr>
<td>Section length</td>
<td>FL4</td>
<td>Not applicable for COBOL</td>
</tr>
<tr>
<td>LD ID</td>
<td>FL4</td>
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</tr>
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</table>
Table 121. SYSADATA external symbol record (continued)

<table>
<thead>
<tr>
<th>Field</th>
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<th>Description</th>
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<tbody>
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<td>Reserved</td>
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</tr>
<tr>
<td>External name length</td>
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<td>Number of characters in the external name</td>
</tr>
<tr>
<td>Alias name length</td>
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<td>Not applicable for COBOL</td>
</tr>
<tr>
<td>External name</td>
<td>CL(n)</td>
<td>The external name</td>
</tr>
<tr>
<td>Alias section name</td>
<td>CL(n)</td>
<td>Not applicable for COBOL</td>
</tr>
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</table>

Parse tree record: X'0024'

The following table shows the contents of the parse tree record.

Table 122. SYSADATA parse tree record

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<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node number</td>
<td>FL4</td>
<td>The node number generated by the compiler, starting at 1</td>
</tr>
<tr>
<td>Node type</td>
<td>HL2</td>
<td>The type of the node:</td>
</tr>
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<td></td>
<td></td>
<td>001 Program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>002 Class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>003 Method</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101 IDENTIFICATION DIVISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>102 ENVIRONMENT DIVISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>103 DATA DIVISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>104 PROCEDURE DIVISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>105 End Program/Method/Class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>201 Declaratives body</td>
</tr>
<tr>
<td></td>
<td></td>
<td>202 Nondeclaratives body</td>
</tr>
<tr>
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<td></td>
<td>301 Section</td>
</tr>
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<td></td>
<td></td>
<td>302 Procedure section</td>
</tr>
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<td>Field</td>
<td>Size</td>
<td>Description</td>
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<td>401</td>
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<td>Paragraph</td>
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<td>Procedure paragraph</td>
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<td>501</td>
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<td>Sentence</td>
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<td>File definition</td>
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<td>Sort file definition</td>
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<td>Program-name</td>
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<td>Program attribute</td>
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<td>ENVIRONMENT DIVISION clause</td>
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<td>509</td>
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<td>CLASS attribute</td>
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<td>510</td>
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<td>METHOD attribute</td>
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<td>511</td>
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<td>USE statement</td>
</tr>
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<td>601</td>
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<td>Statement</td>
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<td>Data description clause</td>
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<td>Data entry</td>
</tr>
<tr>
<td>604</td>
<td></td>
<td>File description clause</td>
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<td>Data entry level</td>
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<tr>
<td>607</td>
<td></td>
<td>EXEC entry</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
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<td>------</td>
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<td>EVALUATE subject phrase</td>
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<td>EVALUATE WHEN phrase</td>
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<td>703</td>
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<td>EVALUATE WHEN OTHER phrase</td>
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<tr>
<td>704</td>
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<td>SEARCH WHEN phrase</td>
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<td>INSPECT CONVERTING phrase</td>
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<td>706</td>
<td></td>
<td>INSPECT REPLACING phrase</td>
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<tr>
<td>707</td>
<td></td>
<td>INSPECT TALLYING phrase</td>
</tr>
<tr>
<td>708</td>
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<td>PERFORM UNTIL phrase</td>
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<tr>
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<td>PERFORM VARYING phrase</td>
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<td>PERFORM AFTER phrase</td>
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<tr>
<td>711</td>
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<td>Statement block</td>
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<td>Scope terminator</td>
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<tr>
<td>713</td>
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<td>INITIALIZE REPLACING phrase</td>
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<tr>
<td>714</td>
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<td>EXEC CICS Command</td>
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<td>INITIALIZE WITH FILLER</td>
</tr>
<tr>
<td>716</td>
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<td>INITIALIZE TO VALUE</td>
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<td>717</td>
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<td>INITIALIZE TO DEFAULT</td>
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<td>ALLOCATE INITIALIZED</td>
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<td>THEN phrase</td>
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<tr>
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<td>ELSE phrase</td>
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Node subtype HL2

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- 0002 INPUT-OUTPUT Section
- 0003 FILE SECTION
- 0004 WORKING-STORAGE SECTION
- 0005 LINKAGE SECTION
- 0006 LOCAL-STORAGE SECTION
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<td>0004 THRU</td>
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<td>For Procedure-name type:</td>
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<td>Description</td>
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<td>For Reserved word at identifier level type:</td>
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<tr>
<td>0009</td>
<td></td>
<td>TIME</td>
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Table 122. **SYSADATA parse tree record** (continued)

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<td>For Arithmetic Operator type:</td>
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<tr>
<td></td>
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<td>0001    PLUS</td>
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<td>0002    MINUS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0003    TIMES</td>
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<td>0004    DIVIDE</td>
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<td></td>
<td></td>
<td>0005    DIVIDE REMAINDER</td>
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<tr>
<td></td>
<td></td>
<td>0006    EXPONENTIATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0007    NEGATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For Relational Operator type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0008    LESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0009    LESS OR EQUAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0010    EQUAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0011    NOT EQUAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0012    GREATER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0013    GREATER OR EQUAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0014    AND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0015    OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0016    CLASS CONDITION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0017    NOT CLASS CONDITION</td>
</tr>
<tr>
<td>Parent node number</td>
<td>FL4</td>
<td>The node number of the parent of the node</td>
</tr>
<tr>
<td>Left sibling node number</td>
<td>FL4</td>
<td>The node number of the left sibling of the node, if any. If none, the value is zero.</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Symbol ID</td>
<td>FL4</td>
<td>The Symbol ID of the node, if it is a user-name of one of the following types:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Data entry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Identifier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• File-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Index-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Procedure-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Condition-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mnemonic-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This value corresponds to the Symbol ID in a Symbol (Type 42) record, except for procedure-names where it corresponds to the Paragraph ID.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For all other node types this value is zero.</td>
</tr>
<tr>
<td>Section Symbol ID</td>
<td>FL4</td>
<td>The Symbol ID of the section containing the node, if it is a qualified paragraph-name reference. This value corresponds to the Section ID in a Symbol (Type 42) record.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For all other node types this value is zero.</td>
</tr>
<tr>
<td>First token number</td>
<td>FL4</td>
<td>The number of the first token associated with the node</td>
</tr>
<tr>
<td>Last token number</td>
<td>FL4</td>
<td>The number of the last token associated with the node</td>
</tr>
<tr>
<td>Reserved</td>
<td>FL4</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Flags</td>
<td>CL1</td>
<td>Information about the node:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'80' Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'40' Generated node, no tokens</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL3</td>
<td>Reserved for future use</td>
</tr>
</tbody>
</table>

**Token record: X'0030'**

The compiler does not generate token records for any lines that are treated as comment lines, which include, but are not limited to, items in the following list.

- Comment lines, which are source lines that have an asterisk (*) or a slash (/) in column 7
- The following compiler-directing statements:
  - *CBL (*CONTROL)
  - BASIS
  - COPY
  - DELETE
  - EJECT
  - INSERT
  - REPLACE
– SKIP1
– SKIP2
– SKIP3
– TITLE

• Debugging lines, which are source lines that have a D in column 7, if WITH DEBUGGING MODE is not specified

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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Token number</td>
<td>FL4</td>
<td>The token number within the source file generated by the compiler, starting at 1. Any copybooks have already been included in the source.</td>
</tr>
</tbody>
</table>
Table 123. SYSADATA token record (continued)

<table>
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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Token code</td>
<td>HL2</td>
<td>The type of token (user-name, literal, reserved word, and so forth).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For reserved words, the compiler reserved-word table values are used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For PICTURE strings, the special code 0000 is used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For each piece (other than the last) of a continued token, the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>special code 3333 is used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Otherwise, the following codes are used:</td>
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<td>0001                          ACCEPT</td>
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<tr>
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<td></td>
<td>0002                          ADD</td>
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<td></td>
<td>0003                          ALTER</td>
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<td>0004                          CALL</td>
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<tr>
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<td>0005                          CANCEL</td>
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<td>0007                          CLOSE</td>
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<td>0009                          COMPUTE</td>
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<td>0019                          ENTER</td>
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<tr>
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<td>Description</td>
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<tr>
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<td>0716</td>
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<td>0733</td>
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<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
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</tr>
<tr>
<td>0801</td>
<td>ARE</td>
<td>IS</td>
</tr>
<tr>
<td>0802</td>
<td>ASCENDING</td>
<td></td>
</tr>
<tr>
<td>0803</td>
<td>AT</td>
<td></td>
</tr>
<tr>
<td>0804</td>
<td>BY</td>
<td></td>
</tr>
<tr>
<td>0805</td>
<td>CHARACTERS</td>
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<td>COUNT</td>
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</tr>
<tr>
<td>0809</td>
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<td></td>
</tr>
<tr>
<td>0810</td>
<td>DEPENDING</td>
<td></td>
</tr>
<tr>
<td>0811</td>
<td>DESCENDING</td>
<td></td>
</tr>
<tr>
<td>0812</td>
<td>DIVISION</td>
<td></td>
</tr>
<tr>
<td>0814</td>
<td>FOR</td>
<td></td>
</tr>
<tr>
<td>0815</td>
<td>ORDER</td>
<td></td>
</tr>
<tr>
<td>0816</td>
<td>INPUT</td>
<td></td>
</tr>
<tr>
<td>0817</td>
<td>REPLACE</td>
<td></td>
</tr>
<tr>
<td>0818</td>
<td>KEY</td>
<td></td>
</tr>
<tr>
<td>0819</td>
<td>LINE</td>
<td>LINES</td>
</tr>
<tr>
<td>0820</td>
<td>XML-INFORMATION</td>
<td></td>
</tr>
<tr>
<td>0821</td>
<td>OF</td>
<td></td>
</tr>
<tr>
<td>0822</td>
<td>ON</td>
<td></td>
</tr>
<tr>
<td>0823</td>
<td>OUTPUT</td>
<td></td>
</tr>
<tr>
<td>0825</td>
<td>RECORD</td>
<td></td>
</tr>
<tr>
<td>0826</td>
<td>RECORDS</td>
<td></td>
</tr>
<tr>
<td>0827</td>
<td>REEL</td>
<td></td>
</tr>
</tbody>
</table>
Table 123. **SYSADATA token record** (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0837</td>
<td></td>
<td>USING</td>
</tr>
<tr>
<td>0838</td>
<td></td>
<td>WHEN</td>
</tr>
<tr>
<td>0839</td>
<td></td>
<td>WITH</td>
</tr>
<tr>
<td>0840</td>
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<td>SQLIMS</td>
</tr>
<tr>
<td>0841</td>
<td></td>
<td>DEFAULT</td>
</tr>
<tr>
<td>0901</td>
<td></td>
<td>PROCEDURE</td>
</tr>
<tr>
<td>0902</td>
<td></td>
<td>DECLARATIVES</td>
</tr>
<tr>
<td>0903</td>
<td></td>
<td>END</td>
</tr>
<tr>
<td>1001</td>
<td></td>
<td>DATA</td>
</tr>
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<td>1002</td>
<td></td>
<td>FILE</td>
</tr>
<tr>
<td>1003</td>
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<td>FD</td>
</tr>
<tr>
<td>1004</td>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>1005</td>
<td></td>
<td>WORKING-STORAGE</td>
</tr>
<tr>
<td>1006</td>
<td></td>
<td>LOCAL-STORE</td>
</tr>
<tr>
<td>1007</td>
<td></td>
<td>LINKAGE</td>
</tr>
<tr>
<td>1101</td>
<td></td>
<td>ENVIRONMENT</td>
</tr>
<tr>
<td>1102</td>
<td></td>
<td>CONFIGURATION</td>
</tr>
<tr>
<td>1103</td>
<td></td>
<td>SOURCE-COMPUTER</td>
</tr>
<tr>
<td>1104</td>
<td></td>
<td>OBJECT-COMPUTER</td>
</tr>
<tr>
<td>1105</td>
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<td>SPECIAL-NAMES</td>
</tr>
<tr>
<td>1106</td>
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<td>REPOSITORY</td>
</tr>
<tr>
<td>1107</td>
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<td>INPUT-OUTPUT</td>
</tr>
<tr>
<td>1108</td>
<td></td>
<td>FILE-CONTROL</td>
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<tr>
<td>1109</td>
<td></td>
<td>I-O-CONTROL</td>
</tr>
<tr>
<td>1201</td>
<td></td>
<td>ID</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>1212</td>
<td>2020</td>
<td>OBJECT</td>
</tr>
<tr>
<td>2046</td>
<td>SUPPRESS</td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>DATADEF</td>
<td></td>
</tr>
<tr>
<td>3001</td>
<td>F-NAME</td>
<td></td>
</tr>
<tr>
<td>3002</td>
<td>UPSI-SWITCH</td>
<td></td>
</tr>
<tr>
<td>3003</td>
<td>CONDNAME</td>
<td></td>
</tr>
<tr>
<td>3004</td>
<td>CONDVAR</td>
<td></td>
</tr>
<tr>
<td>3005</td>
<td>BLOB</td>
<td></td>
</tr>
<tr>
<td>3006</td>
<td>CLOB</td>
<td></td>
</tr>
<tr>
<td>3007</td>
<td>DBCLOB</td>
<td></td>
</tr>
<tr>
<td>3008</td>
<td>BLOB-LOCATOR</td>
<td></td>
</tr>
<tr>
<td>3009</td>
<td>CLOB-LOCATOR</td>
<td></td>
</tr>
<tr>
<td>3010</td>
<td>DBCLOB-LOCATOR</td>
<td></td>
</tr>
<tr>
<td>3011</td>
<td>BLOB-FILE</td>
<td></td>
</tr>
<tr>
<td>3012</td>
<td>CLOB-FILE</td>
<td></td>
</tr>
<tr>
<td>3013</td>
<td>DBCLOB-FILE</td>
<td></td>
</tr>
<tr>
<td>3014</td>
<td>DFHRESP</td>
<td></td>
</tr>
<tr>
<td>5001</td>
<td>PARSE</td>
<td></td>
</tr>
<tr>
<td>5002</td>
<td>AUTOMATIC</td>
<td></td>
</tr>
<tr>
<td>5003</td>
<td>PREVIOUS</td>
<td></td>
</tr>
<tr>
<td>5004</td>
<td>ENCODING</td>
<td></td>
</tr>
<tr>
<td>5005</td>
<td>NAMESPACE</td>
<td></td>
</tr>
<tr>
<td>5006</td>
<td>NAMESPACE-PREFIX</td>
<td></td>
</tr>
<tr>
<td>5007</td>
<td>XML-DECLARATION</td>
<td></td>
</tr>
</tbody>
</table>
Table 123. SYSADATA token record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Token length</td>
<td>HL2</td>
<td>The length of the token</td>
</tr>
<tr>
<td>Token column</td>
<td>FL4</td>
<td>The starting column number of the token in the source listing</td>
</tr>
<tr>
<td>Token line</td>
<td>FL4</td>
<td>The line number of the token in the source listing</td>
</tr>
<tr>
<td>Flags</td>
<td>CL1</td>
<td>Information about the token:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'80' Token is continued</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'40' Last piece of continued token</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note that for PICTURE strings, even if the source token is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>continued, there will be only one Token record generated. It will</td>
</tr>
<tr>
<td></td>
<td></td>
<td>have a token code of 0000, the token column and line of the first</td>
</tr>
<tr>
<td></td>
<td></td>
<td>piece, the length of the complete string, no continuation flags set,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and the token text of the complete string.</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL7</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Token text</td>
<td>CL(n)</td>
<td>The actual token string</td>
</tr>
</tbody>
</table>

Source error record: X'0032'

The following table shows the contents of the source error record.

Table 124. SYSADATA source error record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement number</td>
<td>FL4</td>
<td>The statement number of the statement in error</td>
</tr>
<tr>
<td>Error identifier</td>
<td>CL16</td>
<td>The error message identifier (left-justified and padded with blanks)</td>
</tr>
<tr>
<td>Error severity</td>
<td>HL2</td>
<td>The severity of the error</td>
</tr>
<tr>
<td>Error message length</td>
<td>HL2</td>
<td>The length of the error message text</td>
</tr>
<tr>
<td>Line position</td>
<td>XL1</td>
<td>The line position indicator provided in FIPS messages</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL7</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Error message</td>
<td>CL(n)</td>
<td>The error message text</td>
</tr>
</tbody>
</table>

Source record: X'0038'

The following table shows the contents of the source record.

Table 125. SYSADATA source record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line number</td>
<td>FL4</td>
<td>The listing line number of the source record</td>
</tr>
<tr>
<td>Input record number</td>
<td>FL4</td>
<td>The input source record number in the current input file</td>
</tr>
</tbody>
</table>
### Table 125. SYSADATA source record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary file number</td>
<td>HL2</td>
<td>The input file's assigned sequence number if this record is from the primary input file. (Refer to the Input file n field in the Job identification record).</td>
</tr>
<tr>
<td>Library file number</td>
<td>HL2</td>
<td>The library input file's assigned sequence number if this record is from a COPY/BASIS input file. (Refer to the Member File ID n field in the Library record.)</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL8</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Parent record number</td>
<td>FL4</td>
<td>The parent source record number. This will be the record number of the COPY/BASIS statement.</td>
</tr>
<tr>
<td>Parent primary file number</td>
<td>HL2</td>
<td>The parent file's assigned sequence number if the parent of this record is from the primary input file. (Refer to the Input file n field in the Job Identification Record.)</td>
</tr>
<tr>
<td>Parent library assigned file number</td>
<td>HL2</td>
<td>The parent library file's assigned sequence number if this record's parent is from a COPY/BASIS input file. (Refer to the COPY/BASIS Member File ID n field in the Library record.)</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL8</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Length of source record</td>
<td>HL2</td>
<td>The length of the actual source record following</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL10</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Source record</td>
<td>CL(n)</td>
<td></td>
</tr>
</tbody>
</table>

### COPY REPLACING record: X'0039'

One COPY REPLACING type record will be emitted each time a REPLACING action takes place. That is, whenever operand-1 of the REPLACING phrase is matched with text in the copybook, a COPY REPLACING TEXT record will be written.

The following table shows the contents of the COPY REPLACING record.

### Table 126. SYSADATA COPY REPLACING record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting line number of replaced string</td>
<td>FL4</td>
<td>The listing line number of the start of the text that resulted from REPLACING</td>
</tr>
<tr>
<td>Starting column number of replaced string</td>
<td>FL4</td>
<td>The listing column number of the start of the text that resulted from REPLACING</td>
</tr>
<tr>
<td>Ending line number of replaced string</td>
<td>FL4</td>
<td>The listing line number of the end of the text that resulted from REPLACING</td>
</tr>
<tr>
<td>Ending column number of replaced string</td>
<td>FL4</td>
<td>The listing column number of the end of the text that resulted from REPLACING</td>
</tr>
<tr>
<td>Starting line number of original string</td>
<td>FL4</td>
<td>The source file line number of the start of the text that was changed by REPLACING</td>
</tr>
<tr>
<td>Starting column number of original string</td>
<td>FL4</td>
<td>The source file column number of the start of the text that was changed by REPLACING</td>
</tr>
</tbody>
</table>
### Table 126. SYSADATA COPY REPLACING record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ending line number of original string</td>
<td>FL4</td>
<td>The source file line number of the end of the text that was changed by REPLACING</td>
</tr>
<tr>
<td>Ending column number of original string</td>
<td>FL4</td>
<td>The source file column number of the end of the text that was changed by REPLACING</td>
</tr>
</tbody>
</table>

### Symbol record: X'0042'

The following table shows the contents of the symbol record.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol ID</td>
<td>FL4</td>
<td>Unique ID of symbol</td>
</tr>
<tr>
<td>Line number</td>
<td>FL4</td>
<td>The listing line number of the source record in which the symbol is defined or declared</td>
</tr>
<tr>
<td>Level</td>
<td>XL1</td>
<td>True level-number of symbol (or relative level-number of a data item within a structure). For COBOL, this can be in the range 01-49, 66 (for RENAMES items), 77, or 88 (for condition items).</td>
</tr>
<tr>
<td>Qualification indicator</td>
<td>XL1</td>
<td>X'00' Unique name; no qualification needed. X'01' This data item needs qualification. The name is not unique within the program. This field applies only when this data item is not the level-01 name.</td>
</tr>
<tr>
<td>Symbol type</td>
<td>XL1</td>
<td>X'68' Class-name (Class-ID) X'58' Method-name X'40' Data-name X'20' Procedure-name X'10' Mnemonic-name X'08' Program-name X'81' Reserved The following ORed are into the above types, when applicable: X'04' External X'02' Global</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Symbol attribute</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'01' Numeric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'02' Elementary character of one of these classes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alphabetic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alphanumeric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• DBCS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• National</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'03' Group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'04' Pointer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'05' Index data item</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'06' Index-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'07' Condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'0F' File</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'10' Sort file</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'17' Class-name (repository)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'18' Object reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'19' Currency-sign symbol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'1A' XML schema name</td>
</tr>
</tbody>
</table>
Table 127. **SYSADATA symbol record** (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clauses</td>
<td>XL1</td>
<td>Clauses specified in symbol definition.</td>
</tr>
<tr>
<td></td>
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<td>For symbols that have a symbol attribute of Numeric (X’01’),</td>
</tr>
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<td>Elementary character (X’02’), Group (X’03’), Pointer (X’04’),</td>
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<td></td>
<td>Index data item (X’05’), or Object reference (X’18’):</td>
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<td>Clauses Specified in Symbol definition</td>
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<td>Occurs Depending On</td>
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<td>Same record area</td>
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<td>Record</td>
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<tr>
<td>Field</td>
<td>Size</td>
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<td>C12</td>
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<td>S03</td>
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<td>18</td>
<td>S</td>
<td>S05</td>
</tr>
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<td>20</td>
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<td>SYSIPT</td>
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<td>22</td>
<td>SYSOUT</td>
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<td>Field</td>
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<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Data flags 1</td>
<td>XL1</td>
<td>For file types, and for symbols that have a symbol attribute of Numeric (‘X’01’), Elementary character (‘X’02’), Group (‘X’03’), Pointer (‘X’04’), Index data item (‘X’05’), or Object reference (‘X’18’):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... .... Redefined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... .... Renamed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... .... Synchronized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... .... Implicitly redefined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... 1... Volatile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... .1... Implicitly redefines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ..1... FILLER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ....1 Level 77</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Data flags 2</td>
<td>XL1</td>
<td>For symbols that have a symbol attribute of Numeric (X'01'):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... .... Binary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... .... External floating point (of USAGE DISPLAY or USAGE NATIONAL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..1... .... Internal floating point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...1... .... Packed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... 1... External decimal (of USAGE DISPLAY or USAGE NATIONAL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ..1... Scaled negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... .1... Numeric edited (of USAGE DISPLAY or USAGE NATIONAL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.... ...1 Reserved for future use</td>
</tr>
<tr>
<td>For symbols that have a symbol attribute of Elementary character (X'02') or Group (X'03'):</td>
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<td></td>
</tr>
<tr>
<td>1... .... Alphabetic</td>
<td></td>
<td></td>
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<tr>
<td>.1... .... Alphanumeric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>..1... .... Alphanumeric edited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...1... .... Group contains its own ODO object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.... 1... DBCS item</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.... .1... Group variable length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.... ..1... EGCS item</td>
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<td></td>
</tr>
<tr>
<td>.... ...1 EGCS edited</td>
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<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
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<td>-------------</td>
</tr>
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<td></td>
<td></td>
<td>For file types:</td>
</tr>
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<td>1... .....</td>
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<td>Object of ODO in record</td>
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<td>.1... .....</td>
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<td>Subject of ODO in record</td>
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<td>..1... .....</td>
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<td></td>
<td>Sequential access</td>
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<tr>
<td></td>
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<td>...1... .....</td>
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<td>Random access</td>
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<td>.... 1...</td>
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<td>Dynamic access</td>
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<td>.... .1..</td>
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<td>Locate mode</td>
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<td></td>
<td>.... ..1.</td>
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<td>Record area</td>
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<td></td>
<td>.... ....1</td>
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<td></td>
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<td>Reserved for future use</td>
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<td></td>
<td>XL1</td>
<td>1... .....</td>
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<td>All records are the same length</td>
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<td>.1... .....</td>
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<td>Fixed length</td>
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<td>..1... .....</td>
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<td>Variable length</td>
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<td>Spanned</td>
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<td></td>
<td>.... .1..</td>
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<td>Blocked</td>
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<td>.... ..1.</td>
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<td></td>
<td>Apply write only</td>
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<td>.... ....1</td>
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<td>Same sort merge area</td>
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<td>Description</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>File organization and</td>
<td>XL1</td>
<td><strong>1</strong>... ....Physical sequential (on host, QSAM)</td>
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<tr>
<td>attributes</td>
<td></td>
<td><strong>.1</strong>... ....ASCII</td>
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<td></td>
<td><strong>...1</strong>... ....Standard label</td>
</tr>
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<td></td>
<td><strong>...1</strong>... ....User label</td>
</tr>
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<td></td>
<td><strong>.... 1...</strong> Sequential organization</td>
</tr>
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<td></td>
<td></td>
<td><strong>.... .1...</strong> Indexed organization</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>.... ..1.</strong> Relative organization</td>
</tr>
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<td></td>
<td></td>
<td><strong>.... ...1</strong> Line sequential</td>
</tr>
<tr>
<td>USAGE clause</td>
<td>FL1</td>
<td>X'00'                         USAGE IS DISPLAY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'01'                         USAGE IS COMP-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'02'                         USAGE IS COMP-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'03'                         USAGE IS PACKED-DECIMAL or USAGE IS COMP-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'04'                         USAGE IS BINARY, USAGE IS COMP, USAGE IS COMP-4, or USAGE IS COMP-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'05'                         USAGE IS DISPLAY-1</td>
</tr>
<tr>
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<td>X'06'                         USAGE IS POINTER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'07'                         USAGE IS INDEX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'08'                         USAGE IS PROCEDURE-POINTER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'09'                         USAGE IS OBJECT-REFERENCE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'0A'                         FUNCTION-POINTER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'0B'                         NATIONAL</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Sign clause  | FL1  | **X'00'**
No SIGN clause

**X'01'**
SIGN IS LEADING

**X'02'**
SIGN IS LEADING SEPARATE CHARACTER

**X'03'**
SIGN IS TRAILING

**X'04'**
SIGN IS TRAILING SEPARATE CHARACTER

| Indicators   | FL1  | **X'01'**
Has JUSTIFIED clause. Right-justified attribute is in effect.

**X'02'**
Has BLANK WHEN ZERO clause.

<table>
<thead>
<tr>
<th>Size</th>
<th>FL4</th>
<th>The size of this data item. The actual number of bytes this item occupies in storage. If a DBCS item, the number is in bytes, not characters. For variable-length items, this field will reflect the maximum size of storage reserved for this item by the compiler. Also known as the “Length attribute.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision</td>
<td>FL1</td>
<td>The precision of a fixed or float data item</td>
</tr>
<tr>
<td>Scale</td>
<td>FL1</td>
<td>The scale factor of a fixed data item. This is the number of digits to the right of the decimal point.</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Storage type</td>
<td>FL1</td>
<td><strong>00</strong> Not applicable</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>01</strong> Files</td>
</tr>
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<td></td>
<td></td>
<td><strong>02</strong> Working-Storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>03</strong> Linkage Section</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>05</strong> Special registers</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>07</strong> Indexed by variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>10</strong> UPSI switch</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>13</strong> Variably located items</td>
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<td></td>
<td><strong>14</strong> External data</td>
</tr>
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<td></td>
<td></td>
<td><strong>15</strong> Alphanumeric FUNC</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>16</strong> Alphanumeric EVAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>17</strong> Object data</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>19</strong> Local-Storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>20</strong> Factory data</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>21</strong> XML-TEXT and XML-NTEXT</td>
</tr>
<tr>
<td>Date format</td>
<td>FL1</td>
<td>Reserved for future use</td>
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Table 127. **SYSADATA symbol record** (continued)

<table>
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<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
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<tbody>
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<td>Data flags 4</td>
<td>XL1</td>
<td>For symbols that have a symbol attribute of Numeric (X'01'):</td>
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<tr>
<td></td>
<td></td>
<td>1... ......................... Numeric national</td>
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<td></td>
<td>For symbols that have a symbol attribute of Elementary character (X'02'):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... ......................... National</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... ....................... National edited</td>
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<tr>
<td></td>
<td></td>
<td>For symbols that have a symbol attribute of Group (X'03'):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... ......................... Group-Usage National</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1... ....................... Unbounded length group</td>
</tr>
<tr>
<td>Data flags 5</td>
<td>XL1</td>
<td>OCCURS flags:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1... ......................... UNBOUNDED</td>
</tr>
<tr>
<td>Base locator Cell</td>
<td>FL2</td>
<td>Base locator cell number</td>
</tr>
<tr>
<td>Symbol Identifier</td>
<td>FL4</td>
<td>Number identifying the symbol</td>
</tr>
<tr>
<td>Structure displacement</td>
<td>AL4</td>
<td>Offset of symbol within structure. This offset is set to 0 for variably</td>
</tr>
<tr>
<td></td>
<td></td>
<td>located items.</td>
</tr>
<tr>
<td>Parent displacement</td>
<td>AL4</td>
<td>Byte offset from immediate parent of the item being defined.</td>
</tr>
<tr>
<td>Parent ID</td>
<td>FL4</td>
<td>The symbol ID of the immediate parent of the item being defined.</td>
</tr>
<tr>
<td>Redefined ID</td>
<td>FL4</td>
<td>The symbol ID of the data item that this item redefines, if applicable.</td>
</tr>
<tr>
<td>Start-renamed ID</td>
<td>FL4</td>
<td>If this item is a level-66 item, the symbol ID of the starting COBOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>data item that this item renames. If not a level-66 item, this field is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>set to 0.</td>
</tr>
<tr>
<td>End-renamed ID</td>
<td>FL4</td>
<td>If this item is a level-66 item, the symbol ID of the ending COBOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>data item that this item renames. If not a level-66 item, this field is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>set to 0.</td>
</tr>
<tr>
<td>Program-name symbol</td>
<td>FL4</td>
<td>ID of the program-name of the program or the class-name of the class</td>
</tr>
<tr>
<td>ID</td>
<td></td>
<td>where this symbol is defined.</td>
</tr>
<tr>
<td>OCCURS minimum</td>
<td>FL4</td>
<td>Minimum value for OCCURS</td>
</tr>
<tr>
<td>Paragraph ID</td>
<td></td>
<td>Proc-name ID for a paragraph-name</td>
</tr>
<tr>
<td>OCCURS maximum</td>
<td>FL4</td>
<td>Maximum value for OCCURS</td>
</tr>
<tr>
<td>Section ID</td>
<td></td>
<td>Proc-name ID for a section-name</td>
</tr>
<tr>
<td>Dimensions</td>
<td>FL4</td>
<td>Number of dimensions</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>Case bit vector</td>
<td>XL4</td>
<td>The case of the characters in the symbol name is represented with one bit per character. Each bit has the following meaning: 0 Uppercase 1 Lowercase Bit 0 represents the case of the first character, bit 1 represents the case of the second character, and so forth.</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL8</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Value pairs count</td>
<td>HL2</td>
<td>Count of value pairs</td>
</tr>
<tr>
<td>Symbol name length</td>
<td>HL2</td>
<td>Number of characters in the symbol name</td>
</tr>
<tr>
<td>Picture data length for data-name or Assignment-name length for file-name</td>
<td>HL2</td>
<td>Number of characters in the picture data; zero if symbol has no associated PICTURE clause. (Length of the PICTURE field.) Length represents the field as it is found in the source input. This length does not represent the expanded field for PICTURE items that contain a replication factor. The maximum COBOL length for a PICTURE string is 50 bytes. Zero in this field indicates no PICTURE specified. Number of characters in the external file-name if this is a file-name. This is the DD name part of the assignment-name. Zero if file-name and ASSIGN USING specified.</td>
</tr>
<tr>
<td>Initial Value length for data-name External class-name length for CLASS-ID</td>
<td>HL2</td>
<td>Number of characters in the symbol value; zero if symbol has no initial value Number of characters in the external class-name for CLASS-ID</td>
</tr>
<tr>
<td>ODO symbol name ID for data-name ID of ASSIGN data-name if file-name</td>
<td>FL4</td>
<td>If data-name, ID of the ODO symbol name; zero if ODO not specified If file-name, Symbol-ID for ASSIGN USING data-name; zero if ASSIGN TO specified</td>
</tr>
<tr>
<td>Keys count</td>
<td>HL2</td>
<td>The number of keys defined</td>
</tr>
<tr>
<td>Index count</td>
<td>HL2</td>
<td>Count of Index symbol IDs; zero if none specified</td>
</tr>
<tr>
<td>Symbol name</td>
<td>CL(n)</td>
<td></td>
</tr>
<tr>
<td>Picture data string for data-name or Assignment-name for file-name</td>
<td>CL(n)</td>
<td>The PICTURE character string exactly as the user types it in. The character string includes all symbols, parentheses, and replication factor. The external file-name if this is a file-name. This is the DD name part of the assignment-name.</td>
</tr>
<tr>
<td>Index ID list</td>
<td>(n)FL4</td>
<td>ID of each index symbol name</td>
</tr>
<tr>
<td>Keys</td>
<td>(n)XL8</td>
<td>This field contains data describing keys specified for an array. The following three fields are repeated as many times as specified in the 'Keys count' field.</td>
</tr>
</tbody>
</table>
### Table 127. SYSADATA symbol record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>...Key Sequence</td>
<td>FL1</td>
<td>Ascending or descending indicator.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'00' DESCENDING</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'01' ASCENDING</td>
</tr>
<tr>
<td>...Filler</td>
<td>CL3</td>
<td>Reserved</td>
</tr>
<tr>
<td>...Key ID</td>
<td>FL4</td>
<td>The symbol ID of the data item that is the key field in the array</td>
</tr>
<tr>
<td>Initial Value data for data-name</td>
<td>CL(n)</td>
<td>This field contains the data specified in the INITIAL VALUE clause for this symbol. The following four subfields are repeated according to the count in the 'Value pairs count' field. The total length of the data in this field is contained in the 'Initial value length' field. The external class-name for CLASS-ID.</td>
</tr>
<tr>
<td>External class-name for CLASS-ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...1st value length</td>
<td>HL2</td>
<td>Length of first value</td>
</tr>
<tr>
<td>...1st value data</td>
<td>CL(n)</td>
<td>1st value. This field contains the literal (or figurative constant) as it is specified in the VALUE clause in the source file. It includes any beginning and ending delimiters, embedded quotation marks, and SHIFT IN and SHIFT OUT characters. If the literal spans multiple lines, the lines are concatenated into one long string. If a figurative constant is specified, this field contains the actual reserved word, not the value associated with that word.</td>
</tr>
<tr>
<td>...2nd value length</td>
<td>HL2</td>
<td>Length of second value, zero if not a THRU value pair</td>
</tr>
<tr>
<td>...2nd value data</td>
<td>CL(n)</td>
<td>2nd value. This field contains the literal (or figurative constant) as it is specified in the VALUE clause in the source file. It includes any beginning and ending delimiters, embedded quotation marks, and SHIFT IN and SHIFT OUT characters. If the literal spans multiple lines, the lines are concatenated into one long string. If a figurative constant is specified, this field contains the actual reserved word, not the value associated with that word.</td>
</tr>
</tbody>
</table>

### Symbol cross-reference record: X'0044'

The following table shows the contents of the symbol cross-reference record.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol length</td>
<td>HL2</td>
<td>The length of the symbol</td>
</tr>
<tr>
<td>Statement definition</td>
<td>FL4</td>
<td>The statement number where the symbol is defined or declared</td>
</tr>
<tr>
<td>For STATEMENT XREF only:</td>
<td></td>
<td>Statement count - total number of references to this statement.</td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Number of references¹</td>
<td>HL2</td>
<td>The number of references in this record to the symbol following</td>
</tr>
<tr>
<td>Cross-reference type</td>
<td>XL1</td>
<td>X'01'  Program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'02'  Procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'03'  statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'04'  Symbol or data-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'05'  Method</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X'06'  Class</td>
</tr>
<tr>
<td>Reserved</td>
<td>CL7</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Symbol name</td>
<td>CL(n)</td>
<td>The symbol. Variable length.</td>
</tr>
<tr>
<td>...Reference flag</td>
<td>CL1</td>
<td>For symbol or data-name references:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C''                           Blank means reference only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'M'                           Modification reference flag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For Procedure type symbol references:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'A'                           ALTER (procedure-name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'D'                           GO TO (procedure-name) DEPENDING ON</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'E'                           End of range of (PERFORM) through (procedure-name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'G'                           GO TO (procedure-name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'P'                           PERFORM (procedure-name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'T'                           (ALTER) TO PROCEED TO (procedure-name)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C'U'                           Use for debugging (procedure-name)</td>
</tr>
<tr>
<td>...Statement number</td>
<td>XL4</td>
<td>The statement number on which the symbol or statement is referenced</td>
</tr>
</tbody>
</table>
Table 128. SYSADATA symbol cross-reference record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The reference flag field</td>
<td></td>
<td>and the statement number field occur as many times as the number of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>references field dictates. For example, if there is a value of 10 in the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>number of references field, there will be 10 occurrences of the reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flag and statement number pair for data-name, procedure, or program symbols,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 10 occurrences of the statement number for statements. Where the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>number of references would exceed the record size for the SYSADATA file,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the record is continued on the next record. The continuation flag is set in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the common header section of the record.</td>
</tr>
</tbody>
</table>

Nested program record: X'0046'

The following table shows the contents of the nested program record.

Table 129. SYSADATA nested program record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement definition</td>
<td>FL4</td>
<td>The statement number where the symbol is defined or declared</td>
</tr>
<tr>
<td>Nesting level</td>
<td>XL1</td>
<td>Program nesting level</td>
</tr>
<tr>
<td>Program attributes</td>
<td>XL1</td>
<td>1... ..... Initial 1... ..... Common 1... ..... PROCEDURE DIVISION using 1 1111 Reserved for future use</td>
</tr>
<tr>
<td>Reserved</td>
<td>XL1</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Program-name length</td>
<td>XL1</td>
<td>Length of the following field</td>
</tr>
<tr>
<td>Program-name</td>
<td>CL(n)</td>
<td>The program-name</td>
</tr>
</tbody>
</table>

Library record: X'0060'

The following table shows the contents of the SYSADATA library record.

Table 130. SYSADATA library record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of members(^3)</td>
<td>HL2</td>
<td>Count of the number of COPY/INCLUDE code members described in this record</td>
</tr>
<tr>
<td>Library name length</td>
<td>HL2</td>
<td>The length of the library name</td>
</tr>
<tr>
<td>Library volume length</td>
<td>HL2</td>
<td>The length of the library volume ID</td>
</tr>
<tr>
<td>Concatenation number</td>
<td>XL2</td>
<td>Concatenation number of the library</td>
</tr>
<tr>
<td>Library ddname length</td>
<td>HL2</td>
<td>The length of the library ddname</td>
</tr>
</tbody>
</table>
Table 130. SYSADATA library record (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserved</td>
<td>CL4</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>Library name</td>
<td>CL(n)</td>
<td>The name of the library from which the COPY/INCLUDE member was retrieved</td>
</tr>
<tr>
<td>Library volume</td>
<td>CL(n)</td>
<td>The volume identification of the volume where the library resides</td>
</tr>
<tr>
<td>Library ddname</td>
<td>CL(n)</td>
<td>The ddname (or equivalent) used for this library</td>
</tr>
<tr>
<td>...COPY/BASIS member file ID²</td>
<td>HL2</td>
<td>The library file ID of the name following</td>
</tr>
<tr>
<td>...COPY/BASIS name length</td>
<td>HL2</td>
<td>The length of the name following</td>
</tr>
<tr>
<td>...COPY/BASIS name</td>
<td>CL(n)</td>
<td>The name of the COPY/BASIS member that has been used</td>
</tr>
</tbody>
</table>

1. If 10 COPY members are retrieved from a library, the "Number of members" field will contain 10 and there will be 10 occurrences of the "COPY/BASIS member file ID" field, the "COPY/BASIS name length" field, and the "COPY/BASIS name" field.

2. If COPY/BASIS members are retrieved from different libraries, a library record is written to the SYSADATA file for each unique library.

Statistics record: X'0090'

The following table shows the contents of the statistics record.

Table 131. SYSADATA statistics record

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source records</td>
<td>FL4</td>
<td>The number of source records processed</td>
</tr>
<tr>
<td>DATA DIVISION statements</td>
<td>FL4</td>
<td>The number of DATA DIVISION statements processed</td>
</tr>
<tr>
<td>PROCEDURE DIVISION statements</td>
<td>FL4</td>
<td>The number of PROCEDURE DIVISION statements processed</td>
</tr>
<tr>
<td>Compilation number</td>
<td>HL2</td>
<td>Batch compilation number</td>
</tr>
<tr>
<td>Error severity</td>
<td>XL1</td>
<td>The highest error message severity</td>
</tr>
<tr>
<td>Flags</td>
<td>XL1</td>
<td>1... .... End of Job indicator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.1.. .... Class definition indicator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>..11 1111 Reserved for future use</td>
</tr>
<tr>
<td>EOJ severity</td>
<td>XL1</td>
<td>The maximum return code for the compile job</td>
</tr>
<tr>
<td>Program-name length</td>
<td>XL1</td>
<td>The length of the program-name</td>
</tr>
<tr>
<td>Program-name</td>
<td>CL(n)</td>
<td>Program-name</td>
</tr>
</tbody>
</table>
EVENTS record: X'0120'

Events records are included in the ADATA file to provide compatibility with previous levels of the compiler.

Events records are of the following types:

- Time stamp
- Processor
- File end
- Program
- File ID
- Error

<p>| Table 132. SYSADATA EVENTS TIMESTAMP record layout |</p>
<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>CL12</td>
<td>Standard ADATA record header</td>
</tr>
<tr>
<td>Record length</td>
<td>HL2</td>
<td>Length of following EVENTS record data (excluding this halfword)</td>
</tr>
<tr>
<td>EVENTS record type</td>
<td>CL12</td>
<td>C'TIMESTAMP'</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Revision level</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>XL8</td>
<td>YYYYMMDD</td>
</tr>
<tr>
<td>Hour</td>
<td>XL2</td>
<td>HH</td>
</tr>
<tr>
<td>Minutes</td>
<td>XL2</td>
<td>MI</td>
</tr>
<tr>
<td>Seconds</td>
<td>XL2</td>
<td>SS</td>
</tr>
</tbody>
</table>

<p>| Table 133. SYSADATA EVENTS PROCESSOR record layout |</p>
<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>CL12</td>
<td>Standard ADATA record header</td>
</tr>
<tr>
<td>Record length</td>
<td>HL2</td>
<td>Length of following EVENTS record data (excluding this halfword)</td>
</tr>
<tr>
<td>EVENTS record type</td>
<td>CL9</td>
<td>C'PROCESSOR'</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Revision level</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Output file ID</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Line-class indicator</td>
<td>XL1</td>
<td></td>
</tr>
</tbody>
</table>
### Table 134. *SYSADATA EVENTS FILE END* record layout

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>CL12</td>
<td>Standard ADATA record header</td>
</tr>
<tr>
<td>Record length</td>
<td>HL2</td>
<td>Length of following EVENTS record data (excluding this halfword)</td>
</tr>
<tr>
<td>EVENTS record type</td>
<td>CL7</td>
<td>C'FILEEND'</td>
</tr>
<tr>
<td>FILE END record</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Revision level</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Input file ID</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Expansion indicator</td>
<td>XL1</td>
<td></td>
</tr>
</tbody>
</table>

### Table 135. *SYSADATA EVENTS PROGRAM* record layout

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>CL12</td>
<td>Standard ADATA record header</td>
</tr>
<tr>
<td>Record length</td>
<td>HL2</td>
<td>Length of following EVENTS record data (excluding this halfword)</td>
</tr>
<tr>
<td>EVENTS record type</td>
<td>CL7</td>
<td>C'PROGRAM'</td>
</tr>
<tr>
<td>PROGRAM record</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Revision level</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Output file ID</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Program input record number</td>
<td>XL1</td>
<td></td>
</tr>
</tbody>
</table>

### Table 136. *SYSADATA EVENTS FILE ID* record layout

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>CL12</td>
<td>Standard ADATA record header</td>
</tr>
<tr>
<td>Record length</td>
<td>HL2</td>
<td>Length of following EVENTS record data (excluding this halfword)</td>
</tr>
<tr>
<td>EVENTS record type</td>
<td>CL7</td>
<td>C'FILEID'</td>
</tr>
<tr>
<td>FILE ID record</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Revision level</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Input source file ID</td>
<td>XL1</td>
<td>File ID of source file</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
</tbody>
</table>
### Table 136. SYSDATA EVENTS FILE ID record layout (continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference indicator</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Source file name length</td>
<td>H2</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Source file name</td>
<td>CL(n)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 137. SYSDATA EVENTS ERROR record layout

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>CL12</td>
<td>Standard ADATA record header</td>
</tr>
<tr>
<td>Record length</td>
<td>HL2</td>
<td>Length of following EVENTS record data (excluding this halfword)</td>
</tr>
<tr>
<td>EVENTS record type</td>
<td>CL5</td>
<td>C’ERROR’</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Revision level</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Input source file ID</td>
<td>XL1</td>
<td>File ID of source file</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Annot class</td>
<td>XL1</td>
<td>Annot-class message placement</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error input record number</td>
<td>XL10</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error start line number</td>
<td>XL10</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error token start number</td>
<td>XL1</td>
<td>Column number of error token start</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error end line number</td>
<td>XL10</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error token end number</td>
<td>XL1</td>
<td>Column number of error token end</td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error message ID number</td>
<td>XL9</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error message severity</td>
<td>XL1</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Field</td>
<td>Size</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>Error message severity level number</td>
<td>XL2</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error message length</td>
<td>HL3</td>
<td></td>
</tr>
<tr>
<td>Blank separator</td>
<td>CL1</td>
<td></td>
</tr>
<tr>
<td>Error message text</td>
<td>CL(n)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix H. Using sample programs

The sample programs, which are included on your product tape, demonstrate many language elements and concepts of COBOL.

This information contains the following items:

• Overview of the programs, including program charts for two of the samples
• Format and sample of the input data
• Sample of reports produced
• Information about how to run the programs
• List of the language elements and concepts that are illustrated

Pseudocode and other comments about the programs are included in the program prolog, which you can obtain in a program listing.

There are three sample programs:

• IGYTCARA is an example of using QSAM files and VSAM indexed files, and shows how to use many COBOL intrinsic functions.
• IGYTCARB is an example of using IBM Interactive System Product Facility (ISPF).
• IGYTSALE is an example of using several of the features of the Language Environment callable services.

related concepts
“IGYTCARA: batch application” on page 779
“IGYTCARB: interactive program” on page 783
“IGYTSALE: nested program application” on page 785

IGYTCARA: batch application

A company that has several local offices wants to establish employee carpools. Application IGYTCARA validates the transaction-file entries (QSAM sequential file processing) and updates a master file (VSAM indexed file processing).

This batch application does two tasks:

• Produces reports of employees who can share rides from the same home location to the same work location
• Updates the carpool data:
  – Adds data for new employees
  – Changes information for participating employees
  – Deletes employee records
  – Lists update requests that are not valid

The following diagram shows the parts of the application and how they are organized:
Input data for IGYTCARA

As input to the program, the company collected information from interested employees, coded the information, and produced an input file. Here is an example of the format of the input file (spaces between fields are left out, as they would be in your input file) with an explanation of each item.

```
A10111ROBERTS AB1021 CRYSTAL COURTSAN FRANCISCOC0CA9990141555550:9041555551387W1W1D
```

1. Transaction code
2. Shift
3. Home code
4. Work code
5. Commuter name
6. Home address  
7. Home phone  
8. Work phone  
9. Home location code  
10. Work location code  
11. Driving status code

This sample below shows a section of the input file:

<table>
<thead>
<tr>
<th>TRANS. CODE</th>
<th>RE-TRANS. CODE</th>
<th>CORD TYPE</th>
<th>HOME ADDRESS</th>
<th>HOME PHONE</th>
<th>HOME LOCATION CODE</th>
<th>STA-TRANS. CODE</th>
<th>TRANS. ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A10111</td>
<td>ROBERTS</td>
<td>AB1021</td>
<td>CRYSTAL COURTS</td>
<td>SAN FRANCISCO CA 99901</td>
<td>(415) 555-0190</td>
<td>RODNEY/CRYSTAL</td>
<td>D</td>
</tr>
<tr>
<td>A20212</td>
<td>KAHN</td>
<td>DE789</td>
<td>EMILY LANE</td>
<td>SAN FRANCISCO CA 99921</td>
<td>(415) 555-1890</td>
<td>COYOTE</td>
<td>D</td>
</tr>
</tbody>
</table>

Report produced by IGYTCARA

The following sample shows the first page of the output report produced by IGYTCARA. Your actual output might vary slightly in appearance, depending on your system.
Preparing to run IGYTCARA

All files required by the IGYTCARA program (IGYTCARA, IGYTCODE, and IGYTRANX) are supplied on the product installation tape. These files are located in the IGY.V6R1M0.SIGYSAMP data set.

Data-set and procedure names might be changed at installation time. Check with your system programmer to verify these names.

Do not change these options on the CBL statement in the source file for IGYTCARA:

• NOADV
• NODYNAM
• NONAME
• NONUMBER
• QUOTE
• SEQUENCE

With these options in effect, the program will not cause any diagnostic messages to be issued. You can use the sequence number string in the source file to search for the language elements used.

related concepts
“IGYTCARA: batch application” on page 779

related tasks
“Running IGYTCARA” on page 782

related references
“Input data for IGYTCARA” on page 780
“Report produced by IGYTCARA” on page 781
“Language elements and concepts that are illustrated” on page 793

Running IGYTCARA

The following procedure compiles, link-edits, and runs the IGYTCARA program. If you want only to compile or only to compile and link-edit the program, you must change the IGYWCLG cataloged procedure.

To run IGYTCARA under z/OS, use JCL to define a VSAM cluster and compile the program. Insert the information specific to your system and installation (accounting information, volume serial number, unit name, cluster prefix) in the fields that are shown in lowercase letters. These examples use the name IGYTCAR.MASTFILE; you can use another name if you want to.

1. Use this JCL to create the required VSAM cluster:

```cobol
//CREATE JOB (acct-info), 'IGYTCAR CREATE VSAM', MSGLEVEL=(1,1),
// TIME=(0,29)
//CREATE EXEC PGM=IDCAMS
//VOL1 DD VOL=SER=your-volume-serial,UNIT=your-unit,DISP=SHR
//SYSPRINT DD SYSOUT=A
//SYSIN DD SYSIN=
DELETE your-prefix.IGYTCAR.MASTFILE -
FILE(VOL1) -
PURGE
DEFINE CLUSTER -
(NAME(your-prefix.IGYTCAR.MASTFILE) -
VOLUME(your-volume-serial) -
FILE(VOL1) -
INDEXED -
RECSZ(80 80) -
KEYS((16 8) -
CYLINDERS(2)) -
/*

To remove any existing cluster, a DELETE is issued before the VSAM cluster is created.

2. Use the following JCL to compile, link-edit, and run the IGYTCARA program:
related tasks
Chapter 10, “Processing VSAM files,” on page 173

related references
“Compile, link-edit, and run procedure (IGYWCLG)” on page 241

IGYTCARB: interactive program

IGYTCARB contains an interactive program for entering carpool data by using IBM Interactive System Productivity Facility (ISPF) to invoke Dialog Manager and Enterprise COBOL. IGYTCARB creates a file that can be used as input for a carpool listing or matching program such as IGYTCARA.

The input data for IGYTCARB is the same as that for IGYTCARA. IGYTCARB lets you append to the information in your input file by using an ISPF panel. An example of the panel used by IGYTCARB is shown below:

```
--------------------------- CARPOOL DATA ENTRY -------------------------------
New Data Entry                                Previous Entry
Type =======> -                               A, R, or D    A
Shift ======> -                               1, 2, or 3    1
Home Code ==> --                              2 Chars      01
Work Code ==> --                              2 Chars      11
Name =======> ---------                       9 Chars      POPOWICH
Initials ===> --                              2 Chars      AD
Address ====> ------------------              18 Chars      134 SIXTH AVENUE
City =======> -------------                   13 Chars      SAN FRANCISCO
State ======> --                              2 Chars      CA
Zip Code ===> -----                           5 Chars      99903
Home Phone => ----------                      10 Chars      4155553390
Work Phone => ----------                      10 Chars      4155557855
Home Jnc code > --                            2 Chars      H3
Work Jnc Code > --                            2 Chars      W7
Commuter Stat > -                             D, R or blank
```

related tasks
“Preparing to run IGYTCARB” on page 783

Preparing to run IGYTCARB

Run the IGYTCARB program under Interactive System Productivity Facility (ISPF). All files required by IGYTCARB (IGYTCARB, IGYTRANB, and IGYTPNL) are supplied on the product installation tape in the IGY.V6R1M0.SIGYSAMP data set.

Data-set names and procedure-names might be changed at installation time. Check with your system programmer to verify the names.

Do not change the following options in the CBL statement in the source file for IGYTCARB:

- NONUMBER
- QUOTE
- SEQUENCE

With these options in effect, the program will not cause any diagnostic messages to be issued. You can use the sequence number string in the source file to search for language elements.
Running IGYTCARB

The following procedure compiles, link-edits, and runs the IGYTCARB program. If you want only to compile or only to compile and link-edit the program, you must change the procedure.

To run IGYTCARB under z/OS, do the following steps:

1. Using the ISPF editor, change the ISPF/PDF Primary Option Panel (ISR@PRIM) or some other panel to include the IGYTCARB invocation. Panel ISR@PRIM is in your site's PDF panel data set (normally ISRPLIB).

   The following example shows an ISR@PRIM panel modified, in two identified locations, to include the IGYTCARB invocation. If you add or change an option in the upper portion of the panel definition, you must also add or change the corresponding line on the lower portion of the panel.

   %----------------------  ISPF/PDF PRIMARY OPTION PANEL  ------------------------
   %OPTION  ===>_ZCMD +USERID   - &ZUSER
   %                                                           +TIME     - &ZTIME
   %   0 +ISPF PARMS - Specify terminal and user parameters +TERMINAL - &ZTERM
   %   1 +BROWSE - Display source data or output listings +PF KEYS - &ZKEYS
   %   2 +EDIT - Create or change source data
   %   3 +UTILITIES - Perform utility functions
   %   4 +FOREGROUND - Invoke language processors in foreground
   %   5 +BATCH - Submit to batch for language processing
   %   6 +COMMAND - Enter TSO or Workstation commands
   %   7 +DIALOG TEST - Perform dialog testing
   %   8 +LM UTILITIES- Perform library management utility functions
   %   C +IGYTCARB - Run IGYTCARB UPDATE TRANSACTION PROGRAM (1)
   %   T +TUTORIAL - Display information about ISPF/PDF
   %   X +EXIT - Terminate using console, log, and list defaults
   %
   +Enter%END+command to terminate ISPF.
   %
   )INIT
   .HELP = ISR00003
   &ZPRIM = YES /* ALWAYS A PRIMARY OPTION MENU */
   &ZTOP = ISR00003 /* TUTORIAL TABLE OF CONTENTS */
   &ZHINDEX = ISR91000 /* TUTORIAL INDEX - 1ST PAGE */
   VPUT (ZHTOP,ZHINDEX) PROFILE
   )PROC
   &Z1 = TRUNC(&ZCMD,1)
   IF (&Z1 &notsym.= '.')
     &ZSEL = TRANS( TRUNC( &ZCMD,’’)
       0,’PANEL(ISPOPTA)’
       1,’PGM(ISBBRO) PARM(ISBBRO01)’
       2,’PGM(ISREDIT) PARM(P,ISREDM01)’
       3,’PANEL(ISRUTIL)’
       4,’PANEL(ISRFPFA)’
       5,’PGM(ISRJBI) PARM(ISRJPA) NOCHECK’
       6,’PGM(ISRPCC)’
       7,’PGM(ISRYXDR) NOCHECK’
       8,’PANEL(ISRLPRIM)’
       9,’PANEL(ISRIGYTCARB)’
     T,’PGM(ISPTUTOR) PARM(ISR000000)’
   X,’EXIT’
   +.’’
   )TRAAIL = .TRAIL
   IF (&Z1 = ‘.’) .msg = ISP0141
   )END
As indicated by (1) in this example, you add IGYTCARB to the upper portion of the panel by entering:

```
%   C +IGYTCARB    - Run IGYTCARB UPDATE TRANSACTION PROGRAM
```

You add the corresponding line on the lower portion of the panel, indicated by (2), by entering:

```
C, 'PGM(IGYTCARB)'  
```

2. Place ISR@PRIM (or your other modified panel) and IGYTPNL in a library and make this library the first library in the ISPPLIB concatenation.

3. Comment sequence line IB2200 and uncomment sequence line IB2210 in IGYTCARB. (The OPEN EXTEND statement is supported under z/OS.)

4. Compile and link-edit IGYTCARB and place the resulting program object in your LOADLIB.

5. Allocate ISPLLIB by using the following command:

```
ALLOCATE FILE(ISPLLIB) DATASET( DSN1, SYS1.COBLIB, DSN2) SHR REUSE
```

Here DSN1 is the library name of the LOADLIB from step 4. DSN2 is your installed ISPLLIB.

6. Allocate the input and output data sets by using the following command:

```
ALLOCATE FILE(UPDTRANS) DA('IGY.V6R1M0.SIGYSAMP(IGYTRANB)') SHR REUSE
```

7. Allocate ISPPLIB by using the following command:

```
ALLOCATE FILE(ISPPLIB) DATASET(DSN3, DSN4) SHR REUSE
```

Here DSN3 is the library containing the modified panels. DSN4 is the ISPF panel library.

8. Invoke IGYTCARB by using your modified panel.

**related references**

*ISPF Dialog Developer's Guide and Reference*

---

**IGYTSALE: nested program application**

Application IGYTSALE tracks product sales and sales commissions for a sporting-goods distributor.

This nested program application does the following tasks:

1. Keeps a record of the product line, customers, and number of salespeople. This data is stored in a file called IGYTABLE.

2. Maintains a file that records valid transactions and transaction errors. All transactions that are not valid are flagged, and the results are printed in a report. Transactions to be processed are in a file called IGYTRANA.

3. Processes transactions and report sales by location.

4. Records an individual's sales performance and commission, and prints the results in a report.

5. Reports the sale and shipment dates in local time and UTC (Universal Time Coordinate), and calculates the response time.

The following diagram shows the parts of the application as a hierarchy:
related tasks
“Preparing to run IGYTSALE” on page 792

related references
“Input data for IGYTSALE” on page 786
“Reports produced by IGYTSALE” on page 788
“Language elements and concepts that are illustrated” on page 793

Input data for IGYTSALE

As input to our program, the distributor collected information about its customers, salespeople, and products, coded the information, and produced an input file.

This input file, called IGYTABLE, is loaded into three separate tables for use during transaction processing. The format of the file is as follows, with an explanation of the items below:
1. Record type  
2. Customer code  
3. Customer name  
4. Product code  
5. Product description  
6. Product unit price  
7. Salesperson number  
8. Salesperson name  
9. Date of hire  
10. Commission rate  

The value of field 1 (C, P, or S) determines the format of the input record. The following sample shows a section of IGYTABLE:

<table>
<thead>
<tr>
<th>Record Type</th>
<th>Customer Code</th>
<th>Customer Name</th>
<th>Product Code</th>
<th>Product Description</th>
<th>Product Unit Price</th>
<th>Salesperson Code</th>
<th>Salesperson Name</th>
<th>Date of Hire</th>
<th>Commission Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1111</td>
<td>Eddy Phillips</td>
<td>062484042327</td>
<td>S01</td>
<td>Footballs</td>
<td>0000620</td>
<td>S11</td>
<td>Chris Preston</td>
<td>12269833333333</td>
<td></td>
</tr>
<tr>
<td>S1122</td>
<td>Chuck Morgan</td>
<td>052780084425</td>
<td>P02</td>
<td>Football Equipment</td>
<td>0032080</td>
<td>S12</td>
<td>Art Tung</td>
<td>052780084425</td>
<td></td>
</tr>
<tr>
<td>S1133</td>
<td>Art Tung</td>
<td>022882661728</td>
<td>P03</td>
<td>Football Uniform</td>
<td>0049011</td>
<td>S13</td>
<td>Billy Jim Bob</td>
<td>082721211150</td>
<td></td>
</tr>
<tr>
<td>S1144</td>
<td>Billy Jim Bob</td>
<td>012168333333</td>
<td>P04</td>
<td>Basketballs</td>
<td>0002220</td>
<td>S14</td>
<td>Chris Preston</td>
<td>12269833333333</td>
<td></td>
</tr>
<tr>
<td>S1155</td>
<td>Chris Preston</td>
<td>111276100000</td>
<td>P05</td>
<td>Basketballs Rim/Board</td>
<td>0000880</td>
<td>S15</td>
<td>Al Willie Roz</td>
<td>111276100000</td>
<td></td>
</tr>
<tr>
<td>C01</td>
<td>L. A. Sports</td>
<td>0004220</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C02</td>
<td>Gear Up</td>
<td>0000620</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C03</td>
<td>Play Outdoors</td>
<td>0032080</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C04</td>
<td>Sports 4 You</td>
<td>0049011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C05</td>
<td>Sports R US</td>
<td>0002220</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C06</td>
<td>Stay Active</td>
<td>0000880</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C07</td>
<td>Sport Shop</td>
<td>0004220</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C08</td>
<td>Stay Sporty</td>
<td>0000620</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C09</td>
<td>Hot Sports</td>
<td>0032080</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C10</td>
<td>The Sportsman</td>
<td>0049011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C11</td>
<td>Playing Ball</td>
<td>0002220</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C12</td>
<td>Sports Play</td>
<td>0000880</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition, the distributor collected information about sales transactions. Each transaction represents an individual salesperson's sales to a particular customer. The customer can purchase from one to five items during each transaction. The transaction information is coded and put into an input file, called IGYTRAN. The format of this file is as follows, with an explanation of the items below:
1. Sales order number
2. Invoiced items (number of different items ordered)
3. Date of sale (year month day hour minutes seconds)
4. Sales area
5. Salesperson number
6. Customer code
7. Date of shipment (year month day hour minutes seconds)
8. Product code
9. Quantity sold

Fields 8 and 9 occur one to eight times depending on the number of different items ordered (field 2). The following sample shows a section of IGYTRAN:

```
A00001119900227010101CNTRL VALLEY11442019900228259999
A00004119900310100530CNTRL VALLEY11441219900403150099
A00006119900523151010CNTRL VALLEY11442019900623250004
4199903245195155SAN DIEGO 11615 68206132208116522045160
B11114419901111003303SAN DIEGO 11661519901142620031220116522041109
A00007119901115003205CNTRL VALLEY1133201990117126023
B11116419901211011522013721SF BAY AREA 113315199012066620811220250522145111
B111116419901202132011522013721SF BAY AREA 113315199012066620811220250522145112
B111173199012010708335SAN Diego 11656199812633306201322016522041109
B1111841990122191544SAN SAN DIEGO 1166149962123162001422001395220468309
B111194199012211544SAN SAN DIEGO 1122121996121496020815220166522056569
B111204199012060616SAN SAN DIEGO 112204199612086020815220166522056569
B11121419901201131544SAN SAN DIEGO 113302199612031202081122014652225100
B111224199012073312SAN SAN DIEGO 11221619961131002080162202652225100
B11123919901110123314SAN SAN DIEGO 116609919011426208270500116522250100140010
B1112421990131510008SAN SAN DIEGO 1166111 1028042200120a22141109
B1112541990121501258SAN SAN DIEGO 11661519901216182081622013052214111
B111261419901111000634SAN SAN DIEGO 112315199011326022
B111271199011015410SAN SAN DIEGO 112221299611312200
B1112841990110175001SAN SAN DIEGO 11661519901132602081322001605210411104
```

Reports produced by IGYTSALE

The figures referenced below are samples of IGYTSALE output.

The program records the following data in reports:

- Transaction errors
- Sales by product and area
- Individual sales performance and commissions
- Response time between the sale date and the date the sold products are shipped

Your output might vary slightly in appearance, depending on your system.

“Example: IGYTSALE transaction errors” on page 789
“Example: IGYTSALE sales analysis by product by area” on page 789
“Example: IGYTSALE sales and commissions” on page 791
“Example: IGYTSALE response time from sale to ship” on page 792
Example: IGYTSALE transaction errors
The following sample of IGYTSALE output shows transaction errors in the last column.

<table>
<thead>
<tr>
<th>Day of Report: Tuesday</th>
<th>COBOL SPORTS</th>
<th>11/24/2003 03:12</th>
<th>Page: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Order</td>
<td>Inv. Sales</td>
<td>Sales</td>
<td>Area</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>4</td>
<td>19990324591515</td>
<td>SAN DIEGO</td>
<td>116</td>
</tr>
</tbody>
</table>

Error Descriptions
- Sales order number is missing
- Date of sale time stamp is invalid
- Salesperson number not numeric
- Product code not in product-table
- Date of ship time stamp is invalid

<table>
<thead>
<tr>
<th>Sales Order</th>
<th>Inv. Sales</th>
<th>Sales</th>
<th>Area</th>
<th>Cus. Product And Quantity Sold</th>
<th>Ship Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>199901201070833</td>
<td>3</td>
<td>SAN DIEGO</td>
<td>116</td>
<td>66</td>
<td>330280132200120522041100</td>
</tr>
</tbody>
</table>

Error Descriptions
- Sales area not in area-table
- Salesperson not in sales-person-table
- Customer code not in customer-table
- Product code not in product-table
- Quantity sold not numeric
- Invoiced items is invalid
- Product and quantity not checked
- Date of sale time stamp is invalid
- Product code is invalid
- Date of ship time stamp is invalid

Example: IGYTSALE sales analysis by product by area
The following sample of IGYTSALE output shows sales by product and area.

<table>
<thead>
<tr>
<th>Day of Report: Tuesday</th>
<th>COBOL SPORTS</th>
<th>11/24/2003 03:12</th>
<th>Page: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Analysis By Product By Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Areas of Sale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CNTRL COAST</td>
<td>CNTRL VALLEY</td>
<td>LOS ANGELES</td>
</tr>
<tr>
<td>Product Codes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Number</th>
<th>04</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Basketball</td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>433</td>
<td></td>
</tr>
<tr>
<td>Unit Price</td>
<td>22.20</td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td>$9,612.60</td>
<td></td>
</tr>
<tr>
<td>$113,264.40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Number</th>
<th>05</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Basketball Rim/Board</td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>9900</td>
<td></td>
</tr>
<tr>
<td>Unit Price</td>
<td>88.30</td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td>$874,170.00</td>
<td></td>
</tr>
<tr>
<td>$238,410.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix H. Using sample programs 789
<table>
<thead>
<tr>
<th>Product Number</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basketball Uniform</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>1390</td>
<td></td>
<td></td>
<td>990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
<td></td>
<td>42.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$41,778.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$8,440.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$8,440.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$58,658.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Number</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseball Cage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>7031</td>
<td>45</td>
<td></td>
<td>3450</td>
<td>16</td>
<td>200</td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
<td></td>
<td>890.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$40,050.00</td>
<td>$3,070,500.00</td>
<td>$14,240.00</td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$178,000.00</td>
<td>$2,954,800.00</td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$6,257,590.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$6,257,590.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Number</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseball Uniform</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>19249</td>
<td>10003</td>
<td></td>
<td>3578</td>
<td></td>
<td>2922</td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
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<td>45.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$457,137.10</td>
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<td>$133,535.40</td>
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<td><strong>Total</strong></td>
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<td>12</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Softballs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
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<td>10</td>
<td></td>
<td>137</td>
<td>2564</td>
<td>13</td>
</tr>
<tr>
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<td></td>
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<td>Amount of Sale</td>
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<td></td>
<td></td>
<td>$14.00</td>
<td>$191.80</td>
<td>$3,589.60</td>
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<td></td>
<td>$18.20</td>
<td></td>
<td></td>
</tr>
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<td></td>
<td>$13,860.00</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td>$13,860.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Product Number</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Softball Bats</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>14083</td>
<td>3227</td>
<td></td>
<td>3300</td>
<td>1998</td>
<td>5444</td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
<td></td>
<td>12.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$40,660.20</td>
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<td>$25,174.80</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>$68,594.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$1,247.40</td>
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<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$177,256.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Number</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Softball Gloves</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>13395</td>
<td>1155</td>
<td></td>
<td>136</td>
<td>3119</td>
<td>3833</td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
<td></td>
<td>12.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$13,860.00</td>
<td>$1,632.00</td>
<td>$37,428.00</td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$45,996.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$61,824.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$61,824.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Number</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Softball Cage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>5496</td>
<td>997</td>
<td></td>
<td>99</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
<td></td>
<td>890.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$887,338.00</td>
<td>$88,110.00</td>
<td>$1,780,000.00</td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$2,136,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$2,136,000.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Number</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Softball Uniform</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>6890</td>
<td>44</td>
<td></td>
<td>465</td>
<td>16</td>
<td>6165</td>
</tr>
<tr>
<td>Unit Price</td>
<td></td>
<td></td>
<td></td>
<td>45.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$2,010.80</td>
<td>$21,250.50</td>
<td>$731.20</td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$281,740.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Sale</td>
<td></td>
<td></td>
<td></td>
<td>$9,140.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$314,873.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Number</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Racketballs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>21823</td>
<td>1001</td>
<td></td>
<td>10083</td>
<td>1108</td>
<td>8989</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following sample of IGYTSALE output shows sales performance and commissions by salesperson.

<table>
<thead>
<tr>
<th>Unit Price</th>
<th>0.60</th>
<th>0.60</th>
<th>0.60</th>
<th>0.60</th>
<th>0.60</th>
<th>0.60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of Sale</td>
<td>$606.60</td>
<td>$6,081.80</td>
<td>$664.80</td>
<td>$5,393.40</td>
<td>$120.00</td>
<td>$313.20</td>
</tr>
<tr>
<td>$13,093.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Number</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racketball Rackets</td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>21</td>
</tr>
<tr>
<td>Unit Price</td>
<td>12.70</td>
</tr>
<tr>
<td>Amount of Sale</td>
<td>$266.70</td>
</tr>
<tr>
<td>$26,060.40</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Total Units Sold</th>
<th>16503</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sales</td>
<td>$1,441,929.40</td>
</tr>
<tr>
<td>$14,267,748.80</td>
<td></td>
</tr>
</tbody>
</table>

Example: IGYTSALE sales and commissions

The following sample of IGYTSALE output shows sales performance and commissions by salesperson.

|------------------------|----------|----------------------------------------|------------|--------|--------|

Salesperson: Billy Jim Bob
Customers: Number of Orders
Products Ordered
Total for Order
Discount (if any)
Discount Amount
Earned Commission

<table>
<thead>
<tr>
<th>Sports Stop</th>
<th>3</th>
<th>10117</th>
<th>$6,161.40</th>
<th>2.25%</th>
<th>$138.63</th>
<th>$746.45</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Sportsman</td>
<td>1</td>
<td>9999</td>
<td>$44,418.00</td>
<td>5.86%</td>
<td>$2,569.97</td>
<td>$10,924.52</td>
</tr>
<tr>
<td>Sports Play</td>
<td>1</td>
<td>9900</td>
<td>$874,170.00</td>
<td>7.59%</td>
<td>$66,349.50</td>
<td>$105,905.69</td>
</tr>
<tr>
<td>Totals: 5</td>
<td>20116</td>
<td>$968,441.40</td>
<td>$70,946.49</td>
<td>$117,326.66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Salesperson: Willie Al Roz
Customers: Number of Orders
Products Ordered
Total for Order
Discount (if any)
Discount Amount
Earned Commission

<table>
<thead>
<tr>
<th>Winners Club</th>
<th>4</th>
<th>13998</th>
<th>$1,572,775.90</th>
<th>7.59%</th>
<th>$119,373.69</th>
<th>$157,277.59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winning Sports</td>
<td>1</td>
<td>3222</td>
<td>$48,777.20</td>
<td>3.38%</td>
<td>$1,648.66</td>
<td>$4,877.72</td>
</tr>
<tr>
<td>The Sportsman</td>
<td>1</td>
<td>1747</td>
<td>$27,415.50</td>
<td>3.38%</td>
<td>$926.64</td>
<td>$2,741.55</td>
</tr>
<tr>
<td>Play Outdoors</td>
<td>1</td>
<td>2510</td>
<td>$18,579.60</td>
<td>3.38%</td>
<td>$627.99</td>
<td>$1,857.96</td>
</tr>
<tr>
<td>Totals: 7</td>
<td>21331</td>
<td>$3,381,986.00</td>
<td>$225,615.23</td>
<td>$208,763.21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Salesperson: Art Tung
Customers: Number of Orders
Products Ordered
Total for Order
Discount (if any)
Discount Amount
Earned Commission

<table>
<thead>
<tr>
<th>Sports Stop</th>
<th>1</th>
<th>23</th>
<th>$32.20</th>
<th>2.25%</th>
<th>$1.38</th>
<th>$1.98</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winners Club</td>
<td>2</td>
<td>16857</td>
<td>$2,278,885.00</td>
<td>7.59%</td>
<td>$172,663.77</td>
<td>$410,124.10</td>
</tr>
<tr>
<td>Gear Up</td>
<td>1</td>
<td>3022</td>
<td>$107,146.00</td>
<td>7.59%</td>
<td>$8,132.22</td>
<td>$6,613.78</td>
</tr>
<tr>
<td>Sports Club</td>
<td>1</td>
<td>22</td>
<td>$279.40</td>
<td>2.25%</td>
<td>$6.28</td>
<td>$7.24</td>
</tr>
<tr>
<td>Sports Fans Shop</td>
<td>1</td>
<td>1044</td>
<td>$2,597.30</td>
<td>3.38%</td>
<td>$86.91</td>
<td>$2,597.30</td>
</tr>
<tr>
<td>L.A. Sports</td>
<td>1</td>
<td>1163</td>
<td>$97,906.40</td>
<td>7.59%</td>
<td>$7,722.87</td>
<td>$60,443.94</td>
</tr>
<tr>
<td>Totals: 7</td>
<td>21577</td>
<td>$1,667,948.20</td>
<td>$122,576.98</td>
<td>$166,754.82</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Salesperson: Chuck Morgan
Customers: Number of Orders
Products Ordered
Total for Order
Discount (if any)
Discount Amount
Earned Commission

<table>
<thead>
<tr>
<th>Sports Play</th>
<th>1</th>
<th>742</th>
<th>$3,817,245.40</th>
<th>7.59%</th>
<th>$289,728.92</th>
<th>$322,270.94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports 4 You</td>
<td>1</td>
<td>3022</td>
<td>$398,335.40</td>
<td>7.59%</td>
<td>$30,233.65</td>
<td>$33,629.46</td>
</tr>
<tr>
<td>The Sportsman</td>
<td>1</td>
<td>3022</td>
<td>$285,239.40</td>
<td>7.59%</td>
<td>$21,689.91</td>
<td>$24,080.49</td>
</tr>
<tr>
<td>Sports 4 Winners</td>
<td>1</td>
<td>1100</td>
<td>$68,509.40</td>
<td>5.06%</td>
<td>$3,466.57</td>
<td>$5,783.90</td>
</tr>
<tr>
<td>Sports Club</td>
<td>1</td>
<td>12027</td>
<td>$1,324,256.10</td>
<td>7.59%</td>
<td>$100,511.03</td>
<td>$111,800.32</td>
</tr>
<tr>
<td>Totals: 7</td>
<td>26593</td>
<td>$5,893,575.70</td>
<td>$445,589.08</td>
<td>$497,565.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Salesperson: Chris Preston
Customers: Number of Orders
Products Ordered
Total for Order
Discount (if any)
Discount Amount
Earned Commission

<table>
<thead>
<tr>
<th>Playing Ball</th>
<th>1</th>
<th>5535</th>
<th>$1,939,219.10</th>
<th>7.59%</th>
<th>$147,186.72</th>
<th>$203,509.69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Play Sports</td>
<td>1</td>
<td>5675</td>
<td>$253,229.40</td>
<td>7.59%</td>
<td>$21,689.91</td>
<td>$24,080.49</td>
</tr>
<tr>
<td>Winners Club</td>
<td>1</td>
<td>631</td>
<td>$14,669.78</td>
<td>2.25%</td>
<td>$316.56</td>
<td>$750.99</td>
</tr>
<tr>
<td>The Jock Shop</td>
<td>1</td>
<td>2332</td>
<td>$28,716.60</td>
<td>3.38%</td>
<td>$926.64</td>
<td>$2,741.55</td>
</tr>
<tr>
<td>Totals: 4</td>
<td>14173</td>
<td>$2,207,136.20</td>
<td>$165,561.32</td>
<td>$117,810.28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Salesperson: Edyth Phillips
Customers: Number of Orders
Products Ordered
Total for Order
Discount (if any)
Discount Amount
Earned Commission

<table>
<thead>
<tr>
<th>Sports Play</th>
<th>2</th>
<th>3575</th>
<th>$92,469.90</th>
<th>5.06%</th>
<th>$4,675.94</th>
<th>$3,911.43</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winning Sports</td>
<td>1</td>
<td>11945</td>
<td>$2,651.40</td>
<td>5.06%</td>
<td>$133.17</td>
<td>$2,651.40</td>
</tr>
</tbody>
</table>

Appendix H. Using sample programs 791
Example: IGYTSALE response time from sale to ship
The following sample of IGYTSALE output shows response time between the sale date in the United States and the date the sold products are shipped to Europe.

<table>
<thead>
<tr>
<th>Prod</th>
<th>Code</th>
<th>Units</th>
<th>Sale Date/Time(PST)</th>
<th>Ship Date</th>
<th>Ship Day</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>YYYYMMDD HHMMSS</td>
<td>YYYYMMDD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>9999</td>
<td>9999</td>
<td>19900226 010101</td>
<td>19900228</td>
<td>WED</td>
<td>.95</td>
</tr>
<tr>
<td>15</td>
<td>99</td>
<td>99</td>
<td>19900310 100530</td>
<td>19900419</td>
<td>THU</td>
<td>.86</td>
</tr>
<tr>
<td>05</td>
<td>9900</td>
<td>22</td>
<td>19900610 151010</td>
<td>19900623</td>
<td>SAT</td>
<td>30.36</td>
</tr>
<tr>
<td>04</td>
<td>1100</td>
<td>3</td>
<td>19900111 063011</td>
<td>19900114</td>
<td>WED</td>
<td>2.97</td>
</tr>
<tr>
<td>12</td>
<td>23</td>
<td>000</td>
<td>19900111 003205</td>
<td>19900117</td>
<td>SAT</td>
<td>1.97</td>
</tr>
<tr>
<td>14</td>
<td>5111</td>
<td>19</td>
<td>19900112 191544</td>
<td>19900123</td>
<td>SUN</td>
<td>1.19</td>
</tr>
<tr>
<td>04</td>
<td>5102</td>
<td>19</td>
<td>19900112 121544</td>
<td>19900123</td>
<td>SUN</td>
<td>2.34</td>
</tr>
<tr>
<td>04</td>
<td>300</td>
<td>19</td>
<td>19900112 191544</td>
<td>19900123</td>
<td>SUN</td>
<td>1.19</td>
</tr>
<tr>
<td>05</td>
<td>500</td>
<td>19</td>
<td>19900112 211544</td>
<td>19900124</td>
<td>FRI</td>
<td>3.11</td>
</tr>
<tr>
<td>04</td>
<td>100</td>
<td>19</td>
<td>19900112 000816</td>
<td>19900112</td>
<td>THU</td>
<td>.99</td>
</tr>
<tr>
<td>25</td>
<td>100</td>
<td>19</td>
<td>19900112 131544</td>
<td>19900123</td>
<td>MON</td>
<td>1.44</td>
</tr>
<tr>
<td>25</td>
<td>100</td>
<td>1971</td>
<td>073012</td>
<td>19900113</td>
<td>TUE</td>
<td>.68</td>
</tr>
<tr>
<td>14</td>
<td>1111</td>
<td>1971</td>
<td>012510</td>
<td>19900116</td>
<td>SUN</td>
<td>.94</td>
</tr>
<tr>
<td>26</td>
<td>22</td>
<td>1971</td>
<td>000034</td>
<td>19900111</td>
<td>TUE</td>
<td>1.99</td>
</tr>
<tr>
<td>12</td>
<td>2060</td>
<td>19</td>
<td>151000</td>
<td>19900113</td>
<td>TUE</td>
<td>2.34</td>
</tr>
<tr>
<td>04</td>
<td>1184</td>
<td>19</td>
<td>175001</td>
<td>19900113</td>
<td>TUE</td>
<td>2.25</td>
</tr>
<tr>
<td>12</td>
<td>114</td>
<td>19</td>
<td>115522</td>
<td>19900123</td>
<td>SUN</td>
<td>.58</td>
</tr>
<tr>
<td>15</td>
<td>2060</td>
<td>19</td>
<td>190113</td>
<td>19900114</td>
<td>WED</td>
<td>3.29</td>
</tr>
<tr>
<td>10</td>
<td>1440</td>
<td>19</td>
<td>001500</td>
<td>19900115</td>
<td>THU</td>
<td>1.98</td>
</tr>
<tr>
<td>25</td>
<td>1184</td>
<td>1971</td>
<td>120101</td>
<td>19900119</td>
<td>MON</td>
<td>.49</td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>1971</td>
<td>110030</td>
<td>19900119</td>
<td>MON</td>
<td>.54</td>
</tr>
<tr>
<td>12</td>
<td>144</td>
<td>1971</td>
<td>010510</td>
<td>19900119</td>
<td>MON</td>
<td>3.95</td>
</tr>
<tr>
<td>14</td>
<td>112</td>
<td>1971</td>
<td>010101</td>
<td>19900112</td>
<td>THU</td>
<td>1.95</td>
</tr>
<tr>
<td>26</td>
<td>321</td>
<td>1971</td>
<td>173945</td>
<td>19900119</td>
<td>MON</td>
<td>1.26</td>
</tr>
<tr>
<td>13</td>
<td>1221</td>
<td>1971</td>
<td>135133</td>
<td>19900119</td>
<td>MON</td>
<td>.42</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>19901029 210000</td>
<td>19901030</td>
<td>TUE</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>9005</td>
<td>19901021 050505</td>
<td>19901012</td>
<td>WED</td>
<td>.78</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>999</td>
<td>19900511 214409</td>
<td>19900515</td>
<td>TUE</td>
<td>3.89</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1998</td>
<td>19900712 150100</td>
<td>19900716</td>
<td>MON</td>
<td>3.37</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>31</td>
<td>19901816 185559</td>
<td>19901011</td>
<td>THU</td>
<td>.21</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>30</td>
<td>19901210 195500</td>
<td>19901212</td>
<td>WED</td>
<td>1.17</td>
<td></td>
</tr>
</tbody>
</table>

Preparing to run IGYTSALE
All files required by the IGYTSALE program (IGYTSALE, IGYTCRC, IGYTPRC, IGYTSRC, IGYTABLE, and IGYTRANA) are on the product installation tape in the IGY.V6R1M0.SIGYSAMP data set.

You can change data-set names and procedure-names at installation time. Check with your system programmer to verify these names.

Do not change these options in the CBL statement in the source file for IGYTSALE:

- NONUMBER
- SEQUENCE
- NONUMBER
- QUOTE

With these options in effect, the program might not cause any diagnostic messages to be issued. You can use the sequence number string in the source file to search for the language elements used.

When you run IGYTSALE, the following messages are printed to the SYSOUT data set:

```
Program IGYTSALE Begins
There were 00041 records processed in this program
Program IGYTSALE Normal End
```
related concepts
“IGYTSALE: nested program application” on page 785

related tasks
“Running IGYTSALE” on page 793

related references
“Input data for IGYTSALE” on page 786
“Reports produced by IGYTSALE” on page 788
“Language elements and concepts that are illustrated” on page 793

Running IGYTSALE
Use the following JCL to compile, link-edit, and run the IGYTSALE program. If you want only to compile or only to compile and link-edit the program, change the IGYWCLG cataloged procedure.

Insert the accounting information for your system or installation in the fields that are shown in lowercase letters.

```
//IGYTSALE JOB (acct-info), 'IGYTSALE', MSGLEVEL=(1,1), TIME=(0,29)
//TEST  EXEC IGYWCLG
//COBOL.SYSLIB DD DSN=IGY.V6R1M0.SIGYSAMP, DISP=SHR
//COBOL.SYSIN  DD DSN=IGY.V6R1M0.SIGYSAMP(IGYTSALE), DISP=SHR
//GO.SYSOUT   DD SYSOUT=A
//GO.IGYTABLE  DD DSN=IGY.V6R1M0.SIGYSAMP(IGYTSALE), DISP=SHR
//GO.IGYTRANS  DD DSN=IGY.V6R1M0.SIGYSAMP(IGYTRANA), DISP=SHR
//GO.IGYPRT2   DD SYSOUT=A, DCB=BLKSIZE=133
```

Language elements and concepts that are illustrated

The sample programs illustrate several COBOL language elements and concepts.

To find the applicable language element for a sample program, locate the abbreviation for that program in the sequence string:

<table>
<thead>
<tr>
<th>Sample program</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGYTCARA</td>
<td>IA</td>
</tr>
<tr>
<td>IGYTCARB</td>
<td>IB</td>
</tr>
<tr>
<td>IGYTSALE</td>
<td>IS</td>
</tr>
</tbody>
</table>

The following table lists the language elements and programming concepts that the sample programs illustrate. The language element or concept is described, and the sequence string is shown. The sequence string is the special character string that appears in the sequence field of the source file. You can use this string as a search argument for locating the elements in the listing.

<table>
<thead>
<tr>
<th>Language element or concept</th>
<th>Sequence string</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCEPT . . . FROM DAY-OF-WEEK</td>
<td>IS0900</td>
</tr>
<tr>
<td>ACCEPT . . . FROM DATE</td>
<td>IS0901</td>
</tr>
<tr>
<td>ACCEPT . . . FROM TIME</td>
<td>IS0902</td>
</tr>
<tr>
<td>ADD . . . TO</td>
<td>IS4550</td>
</tr>
<tr>
<td>AFTER ADVANCING</td>
<td>IS2700</td>
</tr>
<tr>
<td>AFTER PAGE</td>
<td>IS2600</td>
</tr>
<tr>
<td>ALL</td>
<td>IS4200</td>
</tr>
<tr>
<td>Language element or concept</td>
<td>Sequence string</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>ASSIGN</td>
<td>IS1101</td>
</tr>
<tr>
<td>AUTHOR</td>
<td>IA0040</td>
</tr>
<tr>
<td>CALL</td>
<td>IS0800</td>
</tr>
<tr>
<td>Callable services (Language Environment):</td>
<td></td>
</tr>
<tr>
<td>1. CEEDATM: format date or time output</td>
<td>1. IS0875, IS2575</td>
</tr>
<tr>
<td>2. CEEDCOD: feedback code check</td>
<td>2. IS0905</td>
</tr>
<tr>
<td>3. CEEGMTO: UTC offset from local time</td>
<td>3. IS0904</td>
</tr>
<tr>
<td>4. CEELOCT: local date and time</td>
<td>4. IS0850</td>
</tr>
<tr>
<td>5. CEESECS: convert time stamp to seconds</td>
<td>5. IS2350, IS2550</td>
</tr>
<tr>
<td>CLOSE files</td>
<td>IS1900</td>
</tr>
<tr>
<td>Comma, semicolon, and space interchangeable</td>
<td>IS3500, IS3600</td>
</tr>
<tr>
<td>COMMON statement for nested programs</td>
<td>IS4600</td>
</tr>
<tr>
<td>Complex OCCURS DEPENDING ON</td>
<td>IS0700, IS3700</td>
</tr>
<tr>
<td>COMPUTE</td>
<td>IS4501</td>
</tr>
<tr>
<td>COMPUTE ROUNDED</td>
<td>IS4500</td>
</tr>
<tr>
<td>CONFIGURATION SECTION</td>
<td>IA0970</td>
</tr>
<tr>
<td>CONFIGURATION SECTION (optional)</td>
<td>IS0200</td>
</tr>
<tr>
<td>CONTINUE statement</td>
<td>IA5310, IA5380</td>
</tr>
<tr>
<td>COPY statement</td>
<td>IS0500</td>
</tr>
<tr>
<td>DATA DIVISION (optional)</td>
<td>IS5100</td>
</tr>
<tr>
<td>Data validation</td>
<td>IA5130-6190</td>
</tr>
<tr>
<td>Do-until (PERFORM . . . TEST AFTER)</td>
<td>IA4900-5010, IA7690-7770</td>
</tr>
<tr>
<td>Do-while (PERFORM . . . TEST BEFORE)</td>
<td>IS1660</td>
</tr>
<tr>
<td>END-ADD</td>
<td>IS2900</td>
</tr>
<tr>
<td>END-COMPUTE</td>
<td>IS4510</td>
</tr>
<tr>
<td>END-EVALUATE</td>
<td>IA6590, IS2450</td>
</tr>
<tr>
<td>END-IF</td>
<td>IS1680</td>
</tr>
<tr>
<td>END-MULTIPLY</td>
<td>IS3100</td>
</tr>
<tr>
<td>END-PERFORM</td>
<td>IS1700</td>
</tr>
<tr>
<td>END PROGRAM</td>
<td>IA9990</td>
</tr>
<tr>
<td>END-READ</td>
<td>IS1800</td>
</tr>
<tr>
<td>END-SEARCH</td>
<td>IS3400</td>
</tr>
<tr>
<td>ENVIRONMENT DIVISION (optional)</td>
<td>IS0200</td>
</tr>
<tr>
<td>Error handling, termination of program</td>
<td>IA4620, IA5080, IA7800-7980</td>
</tr>
<tr>
<td>EVALUATE statement</td>
<td>IA6270-6590</td>
</tr>
<tr>
<td>EVALUATE . . . ALSO</td>
<td>IS2400</td>
</tr>
<tr>
<td>Language element or concept</td>
<td>Sequence string</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>EXIT PROGRAM not only statement in paragraph</td>
<td>IS2000</td>
</tr>
<tr>
<td>Exponentiation</td>
<td>IS4500</td>
</tr>
<tr>
<td>EXTERNAL clause</td>
<td>IS1200</td>
</tr>
<tr>
<td>FILE-CONTROL entry for sequential file</td>
<td>IA1190-1300</td>
</tr>
<tr>
<td>FILE-CONTROL entry for VSAM indexed file</td>
<td>IA1070-1180</td>
</tr>
<tr>
<td>FILE SECTION (optional)</td>
<td>IS0200</td>
</tr>
<tr>
<td>FILE_STATUS code check</td>
<td>IA4600-4630, IA4760-4790</td>
</tr>
<tr>
<td>FILLER (optional)</td>
<td>IS0400</td>
</tr>
<tr>
<td>Flags, level-88, definition</td>
<td>IA1730-1800, IA2440-2480, IA2710</td>
</tr>
<tr>
<td>Flags, level-88, testing</td>
<td>IA4430, IA5200-5250</td>
</tr>
<tr>
<td>FLOATING POINT</td>
<td>IS4400</td>
</tr>
<tr>
<td>GLOBAL statement</td>
<td>IS0300</td>
</tr>
<tr>
<td>INITIAL statement for nested programs</td>
<td>IS2300</td>
</tr>
<tr>
<td>INITIALIZE</td>
<td>IS2500</td>
</tr>
<tr>
<td>Initializing a table in the DATA DIVISION</td>
<td>IA2920-4260</td>
</tr>
<tr>
<td>Inline PERFORM statement</td>
<td>IA4410-4520</td>
</tr>
<tr>
<td>I-O-CONTROL paragraphs (optional)</td>
<td>IS0200</td>
</tr>
<tr>
<td>INPUT-OUTPUT SECTION (optional)</td>
<td>IS0200</td>
</tr>
<tr>
<td>Intrinsic functions:</td>
<td></td>
</tr>
<tr>
<td>1. CURRENT-DATE</td>
<td>IA9005</td>
</tr>
<tr>
<td>2. MAX</td>
<td>IA9235</td>
</tr>
<tr>
<td>3. MEAN</td>
<td>IA9215</td>
</tr>
<tr>
<td>4. MEDIAN</td>
<td>IA9220</td>
</tr>
<tr>
<td>5. MIN</td>
<td>IA9240</td>
</tr>
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Appendix I. Accessibility features for Enterprise COBOL for z/OS

Accessibility features assist users who have a disability, such as restricted mobility or limited vision, to use information technology content successfully. The accessibility features in z/OS provide accessibility for Enterprise COBOL for z/OS.

Accessibility features
z/OS includes the following major accessibility features:

- Interfaces that are commonly used by screen readers and screen-magnifier software
- Keyboard-only navigation
- Ability to customize display attributes such as color, contrast, and font size

z/OS uses the latest W3C Standard, WAI-ARIA 1.0 (http://www.w3.org/TR/wai-aria/), to ensure compliance to US Section 508 (http://www.access-board.gov/guidelines-and-standards/communications-and-it/about-the-section-508-standards/section-508-standards) and Web Content Accessibility Guidelines (WCAG) 2.0 (http://www.w3.org/TR/WCAG20/). To take advantage of accessibility features, use the latest release of your screen reader in combination with the latest web browser that is supported by this product.

The Enterprise COBOL for z/OS online product documentation in IBM Knowledge Center is enabled for accessibility. The accessibility features of IBM Knowledge Center are described at http://www.ibm.com/support/knowledgecenter/en/about/releaseNotes.html.

Keyboard navigation

Users can access z/OS user interfaces by using TSO/E or ISPF.

Users can also access z/OS services by using IBM Rational Developer for System z.

For information about accessing these interfaces, see the following publications:

- z/OS TSO/E Primer (http://publib.boulder.ibm.com/cgi-bin/bookmgr/BOOKS/ikj4p120)

These guides describe how to use TSO/E and ISPF, including the use of keyboard shortcuts or function keys (PF keys). Each guide includes the default settings for the PF keys and explains how to modify their functions.

Interface information

The Enterprise COBOL for z/OS online product documentation is available in IBM Knowledge Center, which is viewable from a standard web browser.

PDF files have limited accessibility support. With PDF documentation, you can use optional font enlargement, high-contrast display settings, and can navigate by keyboard alone.

To enable your screen reader to accurately read syntax diagrams, source code examples, and text that contains period or comma PICTURE symbols, you must set the screen reader to speak all punctuation.
Assistive technology products work with the user interfaces that are found in z/OS. For specific guidance information, see the documentation for the assistive technology product that you use to access z/OS interfaces.

**Related accessibility information**

In addition to standard IBM help desk and support websites, IBM has established a TTY telephone service for use by deaf or hard of hearing customers to access sales and support services:

TTY service 800-IBM-3383 (800-426-3383) (within North America)

**IBM and accessibility**

For more information about the commitment that IBM has to accessibility, see [IBM Accessibility](www.ibm.com/able).
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Glossary

The terms in this glossary are defined in accordance with their meaning in COBOL. These terms might or might not have the same meaning in other languages.

This glossary includes terms and definitions from the following publications:


American National Standard definitions are preceded by an asterisk (*).

A

* abbreviated combined relation condition
  The combined condition that results from the explicit omission of a common subject or a common subject and common relational operator in a consecutive sequence of relation conditions.

abend
  Abnormal termination of a program.

above the 16 MB line
  Storage above the so-called 16 MB line (or boundary) but below the 2 GB bar. This storage is addressable only in 31-bit mode. Before IBM introduced the MVS/XA architecture in the 1980s, the virtual storage for a program was limited to 16 MB. Programs that have been compiled with a 24-bit mode can address only 16 MB of space, as though they were kept under an imaginary storage line. Since VS COBOL II, a program that has been compiled with a 31-bit mode can be above the 16 MB line.

* access mode
  The manner in which records are to be operated upon within a file.

* actual decimal point
  The physical representation, using the decimal point characters period (.) or comma (,), of the decimal point position in a data item.

actual document encoding
  For an XML document, one of the following encoding categories that the XML parser determines by examining the first few bytes of the document:
  • ASCII
  • EBCDIC
  • UTF-8
  • UTF-16, either big-endian or little-endian
  • Other unsupported encoding
  • No recognizable encoding

* alphabet-name
  A user-defined word, in the SPECIAL-Names paragraph of the ENVIRONMENT DIVISION, that assigns a name to a specific character set or collating sequence or both.

* alphabetic character
  A letter or a space character.

alphabetic data item
  A data item that is described with a PICTURE character string that contains only the symbol A. An alphabetic data item has USAGE DISPLAY.

* alphanumeric character
  Any character in the single-byte character set of the computer.
alphanumeric data item
   A general reference to a data item that is described implicitly or explicitly as USAGE DISPLAY, and
   that has category alphanumeric, alphanumeric-edited, or numeric-edited.

alphanumeric-edited data item
   A data item that is described by a PICTURE character string that contains at least one instance of the
   symbol A or X and at least one of the simple insertion symbols B, 0, or / . An alphanumeric-edited data
   item has USAGE DISPLAY.

* alphanumeric function
   A function whose value is composed of a string of one or more characters from the alphanumeric
   character set of the computer.

alphanumeric group item
   A group item that is defined without a GROUP-USAGE NATIONAL clause. For operations such as
   INSPECT, STRING, and UNSTRING, an alphanumeric group item is processed as though all its content
   were described as USAGE DISPLAY regardless of the actual content of the group. For operations that
   require processing of the elementary items within a group, such as MOVE CORRESPONDING, ADD
   CORRESPONDING, or INITIALIZE, an alphanumeric group item is processed using group semantics.

alphanumeric literal
   A literal that has an opening delimiter from the following set: ', " , X' , X" , Z' , or Z" . The string of
   characters can include any character in the character set of the computer.

* alternate record key
   A key, other than the prime record key, whose contents identify a record within an indexed file.

ANSI (American National Standards Institute)
   An organization that consists of producers, consumers, and general-interest groups and establishes
   the procedures by which accredited organizations create and maintain voluntary industry standards in
   the United States.

argument
   (1) An identifier, a literal, an arithmetic expression, or a function-identifier that specifies a value to be
   used in the evaluation of a function. (2) An operand of the USING phrase of a CALL or INVOKE
   statement, used for passing values to a called program or an invoked method.

* arithmetic expression
   An identifier of a numeric elementary item, a numeric literal, such identifiers and literals separated by
   arithmetic operators, two arithmetic expressions separated by an arithmetic operator, or an
   arithmetic expression enclosed in parentheses.

* arithmetic operation
   The process caused by the execution of an arithmetic statement, or the evaluation of an arithmetic
   expression, that results in a mathematically correct solution to the arguments presented.

* arithmetic operator
   A single character, or a fixed two-character combination that belongs to the following set:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
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<td>/</td>
<td>Division</td>
</tr>
<tr>
<td>**</td>
<td>Exponentiation</td>
</tr>
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</table>

* arithmetic statement
   A statement that causes an arithmetic operation to be executed. The arithmetic statements are ADD,
   COMPUTE, DIVIDE, MULTIPLY, and SUBTRACT.

array
   An aggregate that consists of data objects, each of which can be uniquely referenced by subscripting.
   An array is roughly analogous to a COBOL table.
* ascending key
   A key upon the values of which data is ordered, starting with the lowest value of the key up to the highest value of the key, in accordance with the rules for comparing data items.

ASCII
   American National Standard Code for Information Interchange. The standard code uses a coded character set that is based on 7-bit coded characters (8 bits including parity check). The standard is used for information interchange between data processing systems, data communication systems, and associated equipment. The ASCII set consists of control characters and graphic characters.
   IBM has defined an extension to ASCII (characters 128-255).

assignment-name
   A name that identifies the organization of a COBOL file and the name by which it is known to the system.

* assumed decimal point
   A decimal point position that does not involve the existence of an actual character in a data item. The assumed decimal point has logical meaning but no physical representation.

AT END condition
   A condition that is caused during the execution of a READ, RETURN, or SEARCH statement under certain conditions:
   • A READ statement runs on a sequentially accessed file when no next logical record exists in the file, or when the number of significant digits in the relative record number is larger than the size of the relative key data item, or when an optional input file is not available.
   • A RETURN statement runs when no next logical record exists for the associated sort or merge file.
   • A SEARCH statement runs when the search operation terminates without satisfying the condition specified in any of the associated WHEN phrases.

B

big-endian
   The default format that the mainframe and the AIX workstation use to store binary data and UTF-16 characters. In this format, the least significant byte of a binary data item is at the highest address and the least significant byte of a UTF-16 character is at the highest address. Compare with little-endian.

binary item
   A numeric data item that is represented in binary notation (on the base 2 numbering system). The decimal equivalent consists of the decimal digits 0 through 9, plus an operational sign. The leftmost bit of the item is the operational sign.

binary search
   A dichotomizing search in which, at each step of the search, the set of data elements is divided by two; some appropriate action is taken in the case of an odd number.

* block
   A physical unit of data that is normally composed of one or more logical records. For mass storage files, a block can contain a portion of a logical record. The size of a block has no direct relationship to the size of the file within which the block is contained or to the size of the logical records that are either contained within the block or that overlap the block. Synonymous with physical record.

breakpoint
   A place in a computer program, usually specified by an instruction, where external intervention or a monitor program can interrupt the program as it runs.

buffer
   A portion of storage that is used to hold input or output data temporarily.

built-in function
   See intrinsic function.

business method
   A method of an enterprise bean that implements the business logic or rules of an application. (Oracle)
byte
A string that consists of a certain number of bits, usually eight, treated as a unit, and representing a character or a control function.

byte order mark (BOM)
A Unicode character that can be used at the start of UTF-16 or UTF-32 text to indicate the byte order of subsequent text; the byte order can be either big-endian or little-endian.

bytecode
Machine-independent code that is generated by the Java compiler and executed by the Java interpreter. (Oracle)

C

callable services
In Language Environment, a set of services that a COBOL program can invoke by using the conventional Language Environment-defined call interface. All programs that share the Language Environment conventions can use these services.

called program
A program that is the object of a CALL statement. At run time the called program and calling program are combined to produce a run unit.

* calling program
A program that executes a CALL to another program.

case structure
A program-processing logic in which a series of conditions is tested in order to choose between a number of resulting actions.

cataloged procedure
A set of job control statements that are placed in a partitioned data set called the procedure library (SYS1.PROCLIB). You can use cataloged procedures to save time and reduce errors in coding JCL.

CCSID
See coded character set identifier.

century window
A 100-year interval within which any two-digit year is unique. Several types of century window are available to COBOL programmers:

• For the windowing intrinsic functions DATE-TO-YYYYMMDD, DAY-TO-YYYYDDD, and YEAR-TO-YYYY, you specify the century window with argument-2.
• For Language Environment callable services, you specify the century window in CEESCEN.

* character
The basic indivisible unit of the language.

character encoding unit
A unit of data that corresponds to one code point in a coded character set. One or more character encoding units are used to represent a character in a coded character set. Also known as encoding unit.

For USAGE NATIONAL, a character encoding unit corresponds to one 2-byte code point of UTF-16.
For USAGE DISPLAY, a character encoding unit corresponds to a byte.
For USAGE DISPLAY-1, a character encoding unit corresponds to a 2-byte code point in the DBCS character set.

character position
The amount of physical storage or presentation space required to hold or present one character. The term applies to any class of character. For specific classes of characters, the following terms apply:

• Alphanumeric character position, for characters represented in USAGE DISPLAY
• DBCS character position, for DBCS characters represented in USAGE DISPLAY-1
• National character position, for characters represented in USAGE NATIONAL; synonymous with character encoding unit for UTF-16

character set
A collection of elements that are used to represent textual information, but for which no coded representation is assumed. See also coded character set.

character string
A sequence of contiguous characters that form a COBOL word, a literal, a PICTURE character string, or a comment-entry. A character string must be delimited by separators.

checkpoint
A point at which information about the status of a job and the system can be recorded so that the job step can be restarted later.

* class
The entity that defines common behavior and implementation for zero, one, or more objects. The objects that share the same implementation are considered to be objects of the same class. Classes can be defined hierarchically, allowing one class to inherit from another.

* class condition
The proposition (for which a truth value can be determined) that the content of an item is wholly alphabetic, is wholly numeric, is wholly DBCS, is wholly Kanji, or consists exclusively of the characters that are listed in the definition of a class-name.

* class definition
The COBOL source unit that defines a class.

class hierarchy
A tree-like structure that shows relationships among object classes. It places one class at the top and one or more layers of classes below it. Synonymous with inheritance hierarchy.

* class identification entry
An entry in the CLASS-ID paragraph of the IDENTIFICATION DIVISION; this entry contains clauses that specify the class-name and assign selected attributes to the class definition.

class-name (object-oriented)
The name of an object-oriented COBOL class definition.

* class-name (of data)
A user-defined word that is defined in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION; this word assigns a name to the proposition (for which a truth value can be defined) that the content of a data item consists exclusively of the characters that are listed in the definition of the class-name.

class object
The runtime object that represents a class.

* clause
An ordered set of consecutive COBOL character strings whose purpose is to specify an attribute of an entry.

client
In object-oriented programming, a program or method that requests services from one or more methods in a class.

COBOL character set
The set of characters used in writing COBOL syntax. The complete COBOL character set consists of these characters:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,1,...,9</td>
<td>Digit</td>
</tr>
<tr>
<td>A,B,...,Z</td>
<td>Uppercase letter</td>
</tr>
<tr>
<td>a,b,...,z</td>
<td>Lowercase letter</td>
</tr>
<tr>
<td></td>
<td>Space</td>
</tr>
<tr>
<td>Character</td>
<td>Meaning</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>+</td>
<td>Plus sign</td>
</tr>
<tr>
<td>-</td>
<td>Minus sign (hyphen)</td>
</tr>
<tr>
<td>*</td>
<td>Asterisk</td>
</tr>
<tr>
<td>/</td>
<td>Slant (forward slash)</td>
</tr>
<tr>
<td>=</td>
<td>Equal sign</td>
</tr>
<tr>
<td>$</td>
<td>Currency sign</td>
</tr>
<tr>
<td>,</td>
<td>Comma</td>
</tr>
<tr>
<td>;</td>
<td>Semicolon</td>
</tr>
<tr>
<td>.</td>
<td>Period (decimal point, full stop)</td>
</tr>
<tr>
<td>“</td>
<td>Quotation mark</td>
</tr>
<tr>
<td>'</td>
<td>Apostrophe</td>
</tr>
<tr>
<td>(</td>
<td>Left parenthesis</td>
</tr>
<tr>
<td>)</td>
<td>Right parenthesis</td>
</tr>
<tr>
<td>&gt;</td>
<td>Greater than</td>
</tr>
<tr>
<td>&lt;</td>
<td>Less than</td>
</tr>
<tr>
<td>:</td>
<td>Colon</td>
</tr>
<tr>
<td>_</td>
<td>Underscore</td>
</tr>
</tbody>
</table>

* COBOL word
See word.

code page
An assignment of graphic characters and control function meanings to all code points. For example, one code page could assign characters and meanings to 256 code points for 8-bit code, and another code page could assign characters and meanings to 128 code points for 7-bit code. For example, one of the IBM code pages for English on the workstation is IBM-1252 and on the host is IBM-1047. A coded character set.

code point
A unique bit pattern that is defined in a coded character set (code page). Graphic symbols and control characters are assigned to code points.

coded character set
A set of unambiguous rules that establish a character set and the relationship between the characters of the set and their coded representation. Examples of coded character sets are the character sets as represented by ASCII or EBCDIC code pages or by the UTF-16 encoding scheme for Unicode.

coded character set identifier (CCSID)
An IBM-defined number in the range 1 to 65,535 that identifies a specific code page.

* collating sequence
The sequence in which the characters that are acceptable to a computer are ordered for purposes of sorting, merging, comparing, and for processing indexed files sequentially.

* column
A byte position within a print line or within a reference format line. The columns are numbered from 1, by 1, starting at the leftmost position of the line and extending to the rightmost position of the line. A column holds one single-byte character.

* combined condition
A condition that is the result of connecting two or more conditions with the AND or the OR logical operator. See also condition and negated combined condition.
comment-entry
An entry in the IDENTIFICATION DIVISION that is used for documentation and has no effect on execution.

calendar line
A source program line represented by an asterisk (*) in the indicator area of the line or by an asterisk followed by greater-than sign (≻) as the first character string in the program text area (Area A plus Area B), and any characters from the character set of the computer that follow in Area A and Area B of that line. A comment line serves only for documentation. A special form of comment line represented by a slant (/) in the indicator area of the line and any characters from the character set of the computer in Area A and Area B of that line causes page ejection before the comment is printed.

common program
A program that, despite being directly contained within another program, can be called from any program directly or indirectly contained in that other program.

compile
(1) To translate a program expressed in a high-level language into a program expressed in an intermediate language, assembly language, or a computer language. (2) To prepare a machine-language program from a computer program written in another programming language by making use of the overall logic structure of the program, or generating more than one computer instruction for each symbolic statement, or both, as well as performing the function of an assembler.

compile time
The time at which COBOL source code is translated, by a COBOL compiler, to a COBOL object program.

compiler
A program that translates source code written in a higher-level language into machine-language object code.

compiler-directing statement
A statement that causes the compiler to take a specific action during compilation. The standard compiler-directing statements are COPY, REPLACE, and USE.

complex condition
A condition in which one or more logical operators act upon one or more conditions. See also condition, negated simple condition, and negated combined condition.

complex ODO
Certain forms of the OCCURS DEPENDING ON clause:

- Variably located item or group: A data item described by an OCCURS clause with the DEPENDING ON option is followed by a nonsubordinate data item or group. The group can be an alphanumeric group or a national group.
- Variably located table: A data item described by an OCCURS clause with the DEPENDING ON option is followed by a nonsubordinate data item described by an OCCURS clause.
- Table with variable-length elements: A data item described by an OCCURS clause contains a subordinate data item described by an OCCURS clause with the DEPENDING ON option.
- Index name for a table with variable-length elements.
- Element of a table with variable-length elements.

component
(1) A functional grouping of related files. (2) In object-oriented programming, a reusable object or program that performs a specific function and is designed to work with other components and applications. JavaBeans is Oracle’s architecture for creating components.

* computer-name
A system-name that identifies the computer where the program is to be compiled or run.

condition (exception)
An exception that has been enabled, or recognized, by Language Environment and thus is eligible to activate user and language condition handlers. Any alteration to the normal programmed flow of an
application. Conditions can be detected by the hardware or the operating system and result in an interrupt. They can also be detected by language-specific generated code or language library code.

**condition (expression)**
A status of data at run time for which a truth value can be determined. Where used in this information in or in reference to "condition" (condition-1, condition-2, . . .) of a general format, the term refers to a conditional expression that consists of either a simple condition optionally parenthesized or a combined condition (consisting of the syntactically correct combination of simple conditions, logical operators, and parentheses) for which a truth value can be determined. See also simple condition, complex condition, negated simple condition, combined condition, and negated combined condition.

**conditional expression**
A simple condition or a complex condition specified in an EVALUATE, IF, PERFORM, or SEARCH statement. See also simple condition and complex condition.

**conditional phrase**
A phrase that specifies the action to be taken upon determination of the truth value of a condition that results from the execution of a conditional statement.

**conditional statement**
A statement that specifies that the truth value of a condition is to be determined and that the subsequent action of the object program depends on this truth value.

**conditional variable**
A data item one or more values of which has a condition-name assigned to it.

**condition-name**
A user-defined word that assigns a name to a subset of values that a conditional variable can assume; or a user-defined word assigned to a status of an implementor-defined switch or device.

**condition-name condition**
The proposition (for which a truth value can be determined) that the value of a conditional variable is a member of the set of values attributed to a condition-name associated with the conditional variable.

**CONFIGURATION SECTION**
A section of the ENVIRONMENT DIVISION that describes overall specifications of source and object programs and class definitions.

**CONSOLE**
A COBOL environment-name associated with the operator console.

**contained program**
A COBOL program that is nested within another COBOL program.

**contiguous items**
Items that are described by consecutive entries in the DATA DIVISION, and that bear a definite hierarchic relationship to each other.

**copybook**
A file or library member that contains a sequence of code that is included in the source program at compile time using the COPY statement. The file can be created by the user, supplied by COBOL, or supplied by another product. Synonymous with copy file.

**counter**
A data item used for storing numbers or number representations in a manner that permits these numbers to be increased or decreased by the value of another number, or to be changed or reset to zero or to an arbitrary positive or negative value.

**cross-reference listing**
The portion of the compiler listing that contains information on where files, fields, and indicators are defined, referenced, and modified in a program.

**currency-sign value**
A character string that identifies the monetary units stored in a numeric-edited item. Typical examples are $, USD, and EUR. A currency-sign value can be defined by either the CURRENCY compiler option or the CURRENCY SIGN clause in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION. If the CURRENCY SIGN clause is not specified and the NOCURRENCY
compiler option is in effect, the dollar sign ($) is used as the default currency-sign value. See also *currency symbol*.

**currency symbol**
A character used in a PICTURE clause to indicate the position of a currency sign value in a numeric-edited item. A currency symbol can be defined by either the CURRENCY compiler option or the CURRENCY SIGN clause in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION. If the CURRENCY SIGN clause is not specified and the NOCURRENCY compiler option is in effect, the dollar sign ($) is used as the default currency sign value and currency symbol. Multiple currency symbols and currency sign values can be defined. See also *currency sign value*.

* current record
In file processing, the record that is available in the record area associated with a file.

* current volume pointer
A conceptual entity that points to the current volume of a sequential file.

D

* data clause
A clause, appearing in a data description entry in the DATA DIVISION of a COBOL program, that provides information describing a particular attribute of a data item.

* data description entry
An entry in the DATA DIVISION of a COBOL program that is composed of a level-number followed by a data-name, if required, and then followed by a set of data clauses, as required.

**DATA DIVISION**
The division of a COBOL program or method that describes the data to be processed by the program or method: the files to be used and the records contained within them; internal WORKING-STORAGE records that will be needed; data to be made available in more than one program in the COBOL run unit.

* data item
A unit of data (excluding literals) defined by a COBOL program or by the rules for function evaluation.

data set
Synonym for *file*.

* data-name
A user-defined word that names a data item described in a data description entry. When used in the general formats, data-name represents a word that must not be reference-modified, subscripted, or qualified unless specifically permitted by the rules for the format.

**DBCS**
See *double-byte character set (DBCS)*.

**DBCS character**
Any character defined in IBM’s double-byte character set.

**DBCS character position**
See *character position*.

**DBCS data item**
A data item that is described by a PICTURE character string that contains at least one symbol G, or, when the NSYMBOL (DBCS) compiler option is in effect, at least one symbol N. A DBCS data item has USAGE DISPLAY-1.

* debugging line
Any line with a D in the indicator area of the line.

* debugging section
A section that contains a USE FOR DEBUGGING statement.

* declarative sentence
A compiler-directing sentence that consists of a single USE statement terminated by the separator period.
declaratives
A set of one or more special-purpose sections, written at the beginning of the PROCEDURE DIVISION, the first of which is preceded by the key word DECLARATIVE and the last of which is followed by the key words END DECLARATIVES. A declarative is composed of a section header, followed by a USE compiler-directing sentence, followed by a set of zero, one, or more associated paragraphs.

de-edit
The logical removal of all editing characters from a numeric-edited data item in order to determine the unedited numeric value of the item.

delimited scope statement
Any statement that includes its explicit scope terminator.

delimiter
A character or a sequence of contiguous characters that identify the end of a string of characters and separate that string of characters from the following string of characters. A delimiter is not part of the string of characters that it delimits.

dependent region
In IMS, the MVS virtual storage region that contains message-driven programs, batch programs, or online utilities.

descending key
A key upon the values of which data is ordered starting with the highest value of key down to the lowest value of key, in accordance with the rules for comparing data items.

digit
Any of the numerals from 0 through 9. In COBOL, the term is not used to refer to any other symbol.

digit position
The amount of physical storage required to store a single digit. This amount can vary depending on the usage specified in the data description entry that defines the data item.

direct access
The facility to obtain data from storage devices or to enter data into a storage device in such a way that the process depends only on the location of that data and not on a reference to data previously accessed.

display floating-point data item
A data item that is described implicitly or explicitly as USAGE DISPLAY and that has a PICTURE character string that describes an external floating-point data item.

division
A collection of zero, one, or more sections or paragraphs, called the division body, that are formed and combined in accordance with a specific set of rules. Each division consists of the division header and the related division body. There are four divisions in a COBOL program: Identification, Environment, Data, and Procedure.

division header
A combination of words followed by a separator period that indicates the beginning of a division. The division headers are:

- IDENTIFICATION DIVISION.
- ENVIRONMENT DIVISION.
- DATA DIVISION.
- PROCEDURE DIVISION.

DLL
See dynamic link library (DLL).

DLL application
An application that references imported programs, functions, or variables.
**DLL linkage**
A CALL in a program that has been compiled with the DLL and NODYNAM options; the CALL resolves to an exported name in a separate module, or to an INVOKE of a method that is defined in a separate module.

**do construct**
In structured programming, a DO statement is used to group a number of statements in a procedure. In COBOL, an inline PERFORM statement functions in the same way.

**do-until**
In structured programming, a do-until loop will be executed at least once, and until a given condition is true. In COBOL, a TEST AFTER phrase used with the PERFORM statement functions in the same way.

**do-while**
In structured programming, a do-while loop will be executed if, and while, a given condition is true. In COBOL, a TEST BEFORE phrase used with the PERFORM statement functions in the same way.

**document type declaration**
An XML element that contains or points to markup declarations that provide a grammar for a class of documents. This grammar is known as a document type definition, or DTD.

**document type definition (DTD)**
The grammar for a class of XML documents. See document type declaration.

**double-byte character set (DBCS)**
A set of characters in which each character is represented by 2 bytes. Languages such as Japanese, Chinese, and Korean, which contain more symbols than can be represented by 256 code points, require double-byte character sets. Because each character requires 2 bytes, entering, displaying, and printing DBCS characters requires hardware and supporting software that are DBCS-capable.

**DWARF**
DWARF was developed by the UNIX International Programming Languages Special Interest Group (SIG). It is designed to meet the symbolic, source-level debugging needs of different languages in a unified fashion by supplying language-independent debugging information. A DWARF file contains debugging data organized into different elements. For more information, see DWARF program information in the DWARF/ELF Extensions Library Reference.

* **dynamic access**
An access mode in which specific logical records can be obtained from or placed into a mass storage file in a nonsequential manner and obtained from a file in a sequential manner during the scope of the same OPEN statement.

**dynamic CALL**
A CALL literal statement in a program that has been compiled with the DYNAM option and the NODLL option, or a CALL identifier statement in a program that has been compiled with the NODLL option.

**dynamic link library (DLL)**
A file that contains executable code and data that are bound to a program at load time or run time, rather than during linking. Several applications can share the code and data in a DLL simultaneously. Although a DLL is not part of the executable file for a program, it can be required for an executable file to run properly.

**dynamic storage area (DSA)**
Dynamically acquired storage composed of a register save area and an area available for dynamic storage allocation (such as program variables). A DSA is allocated upon invocation of a program or function and persists for the duration of the invocation instance. DSAs are generally allocated within stack segments managed by Language Environment.

* **EBCDIC (Extended Binary-Coded Decimal Interchange Code)**
A coded character set based on 8-bit coded characters.

**EBCDIC character**
Any one of the symbols included in the EBCDIC (Extended Binary-Coded-Decimal Interchange Code) set.
**edited data item**
A data item that has been modified by suppressing zeros or inserting editing characters or both.

**editing character**
A single character or a fixed two-character combination belonging to the following set:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Zero</td>
</tr>
<tr>
<td>+</td>
<td>Plus</td>
</tr>
<tr>
<td>-</td>
<td>Minus</td>
</tr>
<tr>
<td>CR</td>
<td>Credit</td>
</tr>
<tr>
<td>DB</td>
<td>Debit</td>
</tr>
<tr>
<td>Z</td>
<td>Zero suppress</td>
</tr>
<tr>
<td>*</td>
<td>Check protect</td>
</tr>
<tr>
<td>$</td>
<td>Currency sign</td>
</tr>
<tr>
<td>,</td>
<td>Comma (decimal point)</td>
</tr>
<tr>
<td>.</td>
<td>Period (decimal point)</td>
</tr>
<tr>
<td>/</td>
<td>Slant (forward slash)</td>
</tr>
</tbody>
</table>

**EJB**
See *Enterprise JavaBeans.*

**EJB container**
A container that implements the EJB component contract of the J2EE architecture. This contract specifies a runtime environment for enterprise beans that includes security, concurrency, life cycle management, transaction, deployment, and other services. An EJB container is provided by an EJB or J2EE server. (Oracle)

**EJB server**
Software that provides services to an EJB container. An EJB server can host one or more EJB containers. (Oracle)

**element (text element)**
One logical unit of a string of text, such as the description of a single data item or verb, preceded by a unique code identifying the element type.

**elementary item**
A data item that is described as not being further logically subdivided.

**encapsulation**
In object-oriented programming, the technique that is used to hide the inherent details of an object. The object provides an interface that queries and manipulates the data without exposing its underlying structure. Synonymous with *information hiding.*

**enclave**
When running under Language Environment, an enclave is analogous to a run unit. An enclave can create other enclaves by using LINK and by using the system() function in C.

**encoding unit**
See *character encoding unit.*

**end class marker**
A combination of words, followed by a separator period, that indicates the end of a COBOL class definition. The end class marker is:
**end method marker**
A combination of words, followed by a separator period, that indicates the end of a COBOL method definition. The end method marker is:

```
END METHOD method-name.
```

* **end of PROCEDURE DIVISION**
The physical position of a COBOL source program after which no further procedures appear.

* **end program marker**
A combination of words, followed by a separator period, that indicates the end of a COBOL source program. The end program marker is:

```
END PROGRAM program-name.
```

**enterprise bean**
A component that implements a business task and resides in an EJB container. (Oracle)

**Enterprise JavaBeans**
A component architecture defined by Oracle for the development and deployment of object-oriented, distributed, enterprise-level applications.

* **entry**
Any descriptive set of consecutive clauses terminated by a separator period and written in the IDENTIFICATION DIVISION, ENVIRONMENT DIVISION, or DATA DIVISION of a COBOL program.

* **environment clause**
A clause that appears as part of an ENVIRONMENT DIVISION entry.

**ENVIRONMENT DIVISION**
One of the four main component parts of a COBOL program, class definition, or method definition. The ENVIRONMENT DIVISION describes the computers where the source program is compiled and those where the object program is run. It provides a linkage between the logical concept of files and their records, and the physical aspects of the devices on which files are stored.

**environment-name**
A name, specified by IBM, that identifies system logical units, printer and card punch control characters, report codes, program switches or all of these. When an environment-name is associated with a mnemonic-name in the ENVIRONMENT DIVISION, the mnemonic-name can be substituted in any format in which such substitution is valid.

**environment variable**
Any of a number of variables that define some aspect of the computing environment, and are accessible to programs that operate in that environment. Environment variables can affect the behavior of programs that are sensitive to the environment in which they operate.

**execution time**
See run time.

**execution-time environment**
See runtime environment.

* **explicit scope terminator**
A reserved word that terminates the scope of a particular PROCEDURE DIVISION statement.

**exponent**
A number that indicates the power to which another number (the base) is to be raised. Positive exponents denote multiplication; negative exponents denote division; and fractional exponents denote a root of a quantity. In COBOL, an exponential expression is indicated with the symbol ** followed by the exponent.

* **expression**
An arithmetic or conditional expression.
* extend mode
  The state of a file after execution of an OPEN statement, with the EXTEND phrase specified for that file, and before the execution of a CLOSE statement, without the REEL or UNIT phrase for that file.

Extensible Markup Language
  See XML.

extensions
  COBOL syntax and semantics supported by IBM compilers in addition to those described in the 85 COBOL Standard.

external code page
  For XML documents, the value specified by the CODEPAGE compiler option.

* external data
  The data that is described in a program as external data items and external file connectors.

* external data item
  A data item that is described as part of an external record in one or more programs of a run unit and that can be referenced from any program in which it is described.

* external data record
  A logical record that is described in one or more programs of a run unit and whose constituent data items can be referenced from any program in which they are described.

external decimal data item
  See zoned decimal data item and national decimal data item.

* external file connector
  A file connector that is accessible to one or more object programs in the run unit.

external floating-point data item
  See display floating-point data item and national floating-point data item.

external program
  The outermost program. A program that is not nested.

* external switch
  A hardware or software device, defined and named by the implementor, which is used to indicate that one of two alternate states exists.

F

factory data
  Data that is allocated once for a class and shared by all instances of the class. Factory data is declared in the WORKING-STORAGE SECTION of the DATA DIVISION in the FACTORY paragraph of the class definition, and is equivalent to Java private static data.

factory method
  A method that is supported by a class independently of an object instance. Factory methods are declared in the FACTORY paragraph of the class definition, and are equivalent to Java public static methods. They are typically used to customize the creation of objects.

* figurative constant
  A compiler-generated value referenced through the use of certain reserved words.

* file
  A collection of logical records.

* file attribute conflict condition
  An unsuccessful attempt has been made to execute an input-output operation on a file and the file attributes, as specified for that file in the program, do not match the fixed attributes for that file.

* file clause
  A clause that appears as part of any of the following DATA DIVISION entries: file description entry (FD entry) and sort-merge file description entry (SD entry).

* file connector
  A storage area that contains information about a file and is used as the linkage between a file-name and a physical file and between a file-name and its associated record area.
* file control entry
  A SELECT clause and all its subordinate clauses that declare the relevant physical attributes of a file.

FILE-CONTROL paragraph
  A paragraph in the ENVIRONMENT DIVISION in which the data files for a given source unit are declared.

* file description entry
  An entry in the FILE SECTION of the DATA DIVISION that is composed of the level indicator FD, followed by a file-name, and then followed by a set of file clauses as required.

* file-name
  A user-defined word that names a file connector described in a file description entry or a sort-merge file description entry within the FILE SECTION of the DATA DIVISION.

* file organization
  The permanent logical file structure established at the time that a file is created.

file position indicator
  A conceptual entity that contains the value of the current key within the key of reference for an indexed file, or the record number of the current record for a sequential file, or the relative record number of the current record for a relative file, or indicates that no next logical record exists, or that an optional input file is not available, or that the AT END condition already exists, or that no valid next record has been established.

* FILE SECTION
  The section of the DATA DIVISION that contains file description entries and sort-merge file description entries together with their associated record descriptions.

file system
  The collection of files that conform to a specific set of data-record and file-description protocols, and a set of programs that manage these files.

* fixed file attributes
  Information about a file that is established when a file is created and that cannot subsequently be changed during the existence of the file. These attributes include the organization of the file (sequential, relative, or indexed), the prime record key, the alternate record keys, the code set, the minimum and maximum record size, the record type (fixed or variable), the collating sequence of the keys for indexed files, the blocking factor, the padding character, and the record delimiter.

* fixed-length record
  A record associated with a file whose file description or sort-merge description entry requires that all records contain the same number of bytes.

fixed-point item
  A numeric data item defined with a PICTURE clause that specifies the location of an optional sign, the number of digits it contains, and the location of an optional decimal point. The format can be either binary, packed decimal, or external decimal.

floating comment indicators (>>)
  A floating comment indicator indicates a comment line if it is the first character string in the program-text area (Area A plus Area B), or indicates an inline comment if it is after one or more character strings in the program-text area.

floating point
  A format for representing numbers in which a real number is represented by a pair of distinct numerals. In a floating-point representation, the real number is the product of the fixed-point part (the first numeral) and a value obtained by raising the implicit floating-point base to a power denoted by the exponent (the second numeral). For example, a floating-point representation of the number 0.0001234 is 0.1234 -3, where 0.1234 is the mantissa and -3 is the exponent.

floating-point data item
  A numeric data item that contains a fraction and an exponent. Its value is obtained by multiplying the fraction by the base of the numeric data item raised to the power that the exponent specifies.

* format
  A specific arrangement of a set of data.
function
A temporary data item whose value is determined at the time the function is referenced during the execution of a statement.

function-identifier
A syntactically correct combination of character strings and separators that references a function. The data item represented by a function is uniquely identified by a function-name with its arguments, if any. A function-identifier can include a reference-modifier. A function-identifier that references an alphanumeric function can be specified anywhere in the general formats that an identifier can be specified, subject to certain restrictions. A function-identifier that references an integer or numeric function can be referenced anywhere in the general formats that an arithmetic expression can be specified.

function-name
A word that names the mechanism whose invocation, along with required arguments, determines the value of a function.

function-pointer data item
A data item in which a pointer to an entry point can be stored. A data item defined with the USAGE IS FUNCTION-POINTER clause contains the address of a function entry point. Typically used to communicate with C and Java programs.

G
garbage collection
The automatic freeing by the Java runtime system of the memory for objects that are no longer referenced.

* global name
A name that is declared in only one program but that can be referenced from the program and from any program contained within the program. Condition-names, data-names, file-names, record-names, report-names, and some special registers can be global names.

global reference
A reference to an object that is outside the scope of a method.

group item
(1) A data item that is composed of subordinate data items. See alphanumeric group item and national group item. (2) When not qualified explicitly or by context as a national group or an alphanumeric group, the term refers to groups in general.

grouping separator
A character used to separate units of digits in numbers for ease of reading. The default is the character comma.

H
header label
(1) A data-set label that precedes the data records in a unit of recording media. (2) Synonym for beginning-of-file label.

hide
To redefine a factory or static method (inherited from a parent class) in a subclass.

* high-order end
The leftmost character of a string of characters.

hiperspace
In a z/OS environment, a range of up to 2 GB of contiguous virtual storage addresses that a program can use as a buffer.

I
IBM COBOL extension
COBOL syntax and semantics supported by IBM compilers in addition to those described in the 85 COBOL Standard.
IDENTIFICATION DIVISION
One of the four main component parts of a COBOL program, class definition, or method definition. The IDENTIFICATION DIVISION identifies the program, class, or method. The IDENTIFICATION DIVISION can include the following documentation: author name, installation, or date.

* identifier
A syntactically correct combination of character strings and separators that names a data item. When referencing a data item that is not a function, an identifier consists of a data-name, together with its qualifiers, subscripts, and reference-modifier, as required for uniqueness of reference. When referencing a data item that is a function, a function-identifier is used.

* imperative statement
A statement that either begins with an imperative verb and specifies an unconditional action to be taken or is a conditional statement that is delimited by its explicit scope terminator (delimited scope statement). An imperative statement can consist of a sequence of imperative statements.

* implicit scope terminator
A separator period that terminates the scope of any preceding unterminated statement, or a phrase of a statement that by its occurrence indicates the end of the scope of any statement contained within the preceding phrase.

* index
A computer storage area or register, the content of which represents the identification of a particular element in a table.

* index data item
A data item in which the values associated with an index-name can be stored in a form specified by the implementor.

indexed data-name
An identifier that is composed of a data-name, followed by one or more index-names enclosed in parentheses.

* indexed file
A file with indexed organization.

* indexed organization
The permanent logical file structure in which each record is identified by the value of one or more keys within that record.

indexing
Synonymous with subscripting using index-names.

* index-name
A user-defined word that names an index associated with a specific table.

inheritance
A mechanism for using the implementation of a class as the basis for another class. By definition, the inheriting class conforms to the inherited classes. Enterprise COBOL does not support multiple inheritance; a subclass has exactly one immediate superclass.

inheritance hierarchy
See class hierarchy.

* initial program
A program that is placed into an initial state every time the program is called in a run unit.

* initial state
The state of a program when it is first called in a run unit.

inline
In a program, instructions that are executed sequentially, without branching to routines, subroutines, or other programs.

inline comments
An inline comment is identified by a floating comment indicator (*>) preceded by one or more character-strings in the program-text area, and can be written on any line of a compilation group. All characters that follow the floating comment indicator up to the end of area B are comment text.
* input file
  A file that is opened in the input mode.

* input mode
  The state of a file after execution of an OPEN statement, with the INPUT phrase specified, for that file and before the execution of a CLOSE statement, without the REEL or UNIT phrase for that file.

* input-output file
  A file that is opened in the I-O mode.

* input-output SECTION
  The section of the ENVIRONMENT DIVISION that names the files and the external media required by an object program or method and that provides information required for transmission and handling of data at run time.

* input-output statement
  A statement that causes files to be processed by performing operations on individual records or on the file as a unit. The input-output statements are ACCEPT (with the identifier phrase), CLOSE, DELETE, DISPLAY, OPEN, READ, REWRITE, SET (with the TO ON or TO OFF phrase), START, and WRITE.

* input procedure
  A set of statements, to which control is given during the execution of a format 1 SORT statement, for the purpose of controlling the release of specified records to be sorted.

instance data
  Data that defines the state of an object. The instance data introduced by a class is defined in the WORKING-STORAGE SECTION of the DATA DIVISION in the OBJECT paragraph of the class definition. The state of an object also includes the state of the instance variables introduced by classes that are inherited by the current class. A separate copy of the instance data is created for each object instance.

* integer
  (1) A numeric literal that does not include any digit positions to the right of the decimal point. (2) A numeric data item defined in the DATA DIVISION that does not include any digit positions to the right of the decimal point. (3) A numeric function whose definition provides that all digits to the right of the decimal point are zero in the returned value for any possible evaluation of the function.

integer function
  A function whose category is numeric and whose definition does not include any digit positions to the right of the decimal point.

Interactive System Productivity Facility (ISPF)
  An IBM software product that provides a menu-driven interface for the TSO or VM user. ISPF includes library utilities, a powerful editor, and dialog management.

interlanguage communication (ILC)
  The ability of routines written in different programming languages to communicate. ILC support lets you readily build applications from component routines written in a variety of languages.

intermediate result
  An intermediate field that contains the results of a succession of arithmetic operations.

* internal data
  The data that is described in a program and excludes all external data items and external file connectors. Items described in the LINKAGE SECTION of a program are treated as internal data.

* internal data item
  A data item that is described in one program in a run unit. An internal data item can have a global name.

internal decimal data item
  A data item that is described as USAGE PACKED-DECIMAL or USAGE COMP-3, and that has a PICTURE character string that defines the item as numeric (a valid combination of symbols 9, S, P, or V). Synonymous with packed-decimal data item.

* internal file connector
  A file connector that is accessible to only one object program in the run unit.
**internal floating-point data item**
A data item that is described as USAGE COMP-1 or USAGE COMP-2. COMP-1 defines a single-precision floating-point data item. COMP-2 defines a double-precision floating-point data item. There is no PICTURE clause associated with an internal floating-point data item.

**intrarecord data structure**
The entire collection of groups and elementary data items from a logical record that a contiguous subset of the data description entries defines. These data description entries include all entries whose level-number is greater than the level-number of the first data description entry describing the intra-record data structure.

**intrinsic function**
A predefined function, such as a commonly used arithmetic function, called by a built-in function reference.

**invalid key condition**
A condition, at run time, caused when a specific value of the key associated with an indexed or relative file is determined to be not valid.

**I-O-CONTROL**
The name of an ENVIRONMENT DIVISION paragraph in which object program requirements for rerun points, sharing of same areas by several data files, and multiple file storage on a single input-output device are specified.

**I-O-CONTROL entry**
An entry in the I-O-CONTROL paragraph of the ENVIRONMENT DIVISION; this entry contains clauses that provide information required for the transmission and handling of data on named files during the execution of a program.

**I-O mode**
The state of a file after execution of an OPEN statement, with the I-O phrase specified, for that file and before the execution of a CLOSE statement without the REEL or UNIT phase for that file.

**I-O status**
A conceptual entity that contains the two-character value indicating the resulting status of an input-output operation. This value is made available to the program through the use of the FILE STATUS clause in the file control entry for the file.

**is-a**
A relationship that characterizes classes and subclasses in an inheritance hierarchy. Subclasses that have an is-a relationship to a class inherit from that class.

**ISPF**
See Interactive System Productivity Facility (ISPF).

**iteration structure**
A program processing logic in which a series of statements is repeated while a condition is true or until a condition is true.

**J**

**J2EE**
See Java 2 Platform, Enterprise Edition (J2EE).

**Java 2 Platform, Enterprise Edition (J2EE)**
An environment for developing and deploying enterprise applications, defined by Oracle. The J2EE platform consists of a set of services, application programming interfaces (APIs), and protocols that provide the functionality for developing multitiered, Web-based applications. (Oracle)

**Java batch-processing program (JBP)**
An IMS batch-processing program that has access to online databases and output message queues. JBPs run online, but like programs in a batch environment, they are started with JCL or in a TSO session.

**Java batch-processing region**
An IMS dependent region in which only Java batch-processing programs are scheduled.
Java Database Connectivity (JDBC)
A specification from Oracle that defines an API that enables Java programs to access databases.

Java message-processing program (JMP)
A Java application program that is driven by transactions and has access to online IMS databases and message queues.

Java message-processing region
An IMS dependent region in which only Java message-processing programs are scheduled.

Java Native Interface (JNI)
A programming interface that lets Java code that runs inside a Java virtual machine (JVM) interoperate with applications and libraries written in other programming languages.

Java virtual machine (JVM)
A software implementation of a central processing unit that runs compiled Java programs.

JavaBeans
A portable, platform-independent, reusable component model. (Oracle)

JBP
See Java batch-processing program (JBP).

JDBC
See Java Database Connectivity (JDBC).

JMP
See Java message-processing program (JMP).

job control language (JCL)
A control language used to identify a job to an operating system and to describe the job’s requirements.

JVM
See Java virtual machine (JVM).

K
When referring to storage capacity, two to the tenth power; 1024 in decimal notation.

* key
A data item that identifies the location of a record, or a set of data items that serve to identify the ordering of data.

* key of reference
The key, either prime or alternate, currently being used to access records within an indexed file.

* keyword
A context-sensitive word or a reserved word whose presence is required when the format in which the word appears is used in a source unit.

kilobyte (KB)
One kilobyte equals 1024 bytes.

L
* language-name
A system-name that specifies a particular programming language.

Language Environment-conforming
A characteristic of compiler products (such as Enterprise COBOL, COBOL for OS/390 & VM, COBOL for MVS & VM, C/C++ for MVS & VM, PL/I for MVS & VM) that produce object code conforming to the Language Environment conventions.

last-used state
A state that a program is in if its internal values remain the same as when the program was exited (the values are not reset to their initial values).

* letter
A character belonging to one of the following two sets:
2. Lowercase letters: a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z

* **level indicator**
  Two alphabetic characters that identify a specific type of file or a position in a hierarchy. The level indicators in the DATA DIVISION are: CD, FD, and SD.

* **level-number**
  A user-defined word (expressed as a two-digit number) that indicates the hierarchical position of a data item or the special properties of a data description entry. Level-numbers in the range from 1 through 49 indicate the position of a data item in the hierarchical structure of a logical record. Level-numbers in the range 1 through 9 can be written either as a single digit or as a zero followed by a significant digit. Level-numbers 66, 77, and 88 identify special properties of a data description entry.

* **library-name**
  A user-defined word that names a COBOL library that the compiler is to use for compiling a given source program.

* **library text**
  A sequence of text words, comment lines, inline comments, the separator space, or the separator pseudo-text delimiter in a COBOL library.

**Lilian date**
The number of days since the beginning of the Gregorian calendar. Day one is Friday, October 15, 1582. The Lilian date format is named in honor of Luigi Lilio, the creator of the Gregorian calendar.

* **linage-counter**
  A special register whose value points to the current position within the page body.

**link**
(1) The combination of the link connection (the transmission medium) and two link stations, one at each end of the link connection. A link can be shared among multiple links in a multipoint or token-ring configuration. (2) To interconnect items of data or portions of one or more computer programs; for example, linking object programs by a linkage-editor to produce an executable file.

**LINKAGE SECTION**
The section in the DATA DIVISION of the called program or invoked method that describes data items available from the calling program or invoking method. Both the calling program or invoking method and the called program or invoked method can refer to these data items.

**linker**
A term that refers to either the z/OS binder (linkage-editor).

**literal**
A character string whose value is specified either by the ordered set of characters comprising the string or by the use of a figurative constant.

**little-endian**
The default format that Intel processors use to store binary data and UTF-16 characters. In this format, the most significant byte of a binary data item is at the highest address and the most significant byte of a UTF-16 character is at the highest address. Compare with **big-endian**.

**local reference**
A reference to an object that is within the scope of your method.

**locale**
A set of attributes for a program execution environment that indicates culturally sensitive considerations, such as character code page, collating sequence, date and time format, monetary value representation, numeric value representation, or language.

* **LOCAL-STORAGE SECTION**
The section of the DATA DIVISION that defines storage that is allocated and freed on a per-invocation basis, depending on the value assigned in the VALUE clauses.

* **logical operator**
  One of the reserved words AND, OR, or NOT. In the formation of a condition, either AND, or OR, or both can be used as logical connectives. NOT can be used for logical negation.
logical record
The most inclusive data item. The level-number for a record is 01. A record can be either an elementary item or a group of items. Synonymous with record.

low-order end
The rightmost character of a string of characters.

main program
In a hierarchy of programs and subroutines, the first program that receives control when the programs are run within a process.

makefile
A text file that contains a list of the files for your application. The make utility uses this file to update the target files with the latest changes.

mass storage
A storage medium in which data can be organized and maintained in both a sequential manner and a nonsequential manner.

mass storage device
A device that has a large storage capacity, such as a magnetic disk.

mass storage file
A collection of records that is stored in a mass storage medium.

megabyte (MB)
One megabyte equals 1,048,576 bytes.

merge file
A collection of records to be merged by a MERGE statement. The merge file is created and can be used only by the merge function.

message-processing program (MPP)
An IMS application program that is driven by transactions and has access to online IMS databases and message queues.

message queue
The data set on which messages are queued before being processed by an application program or sent to a terminal.

method
Procedural code that defines an operation supported by an object and that is executed by an INVOLVE statement on that object.

method definition
The COBOL source code that defines a method.

method identification entry
An entry in the METHOD-ID paragraph of the IDENTIFICATION DIVISION; this entry contains a clause that specifies the method-name.

method invocation
A communication from one object to another that requests the receiving object to execute a method.

method-name
The name of an object-oriented operation. When used to invoke the method, the name can be an alphanumeric or national literal or a category alphanumeric or category national data item. When used in the METHOD-ID paragraph to define the method, the name must be an alphanumeric or national literal.

mnemonic-name
A user-defined word that is associated in the ENVIRONMENT DIVISION with a specified implementor-name.

module definition file
A file that describes the code segments within a program object.
MPP
See message-processing program (MPP).

multitasking
A mode of operation that provides for the concurrent, or interleaved, execution of two or more tasks.

multithreading
Concurrent operation of more than one path of execution within a computer. Synonymous with multiprocessing.

N
name
A word (composed of not more than 30 characters) that defines a COBOL operand.

namespace
See XML namespace.

national character
(1) A UTF-16 character in a USAGE NATIONAL data item or national literal. (2) Any character represented in UTF-16.

national character position
See character position.

national data item
A data item of category national, national-edited, or numeric-edited of USAGE NATIONAL.

national decimal data item
An external decimal data item that is described implicitly or explicitly as USAGE NATIONAL and that contains a valid combination of PICTURE symbols 9, S, P, and V.

national-edited data item
A data item that is described by a PICTURE character string that contains at least one instance of the symbol N and at least one of the simple insertion symbols B, 0, or /. A national-edited data item has USAGE NATIONAL.

national floating-point data item
An external floating-point data item that is described implicitly or explicitly as USAGE NATIONAL and that has a PICTURE character string that describes a floating-point data item.

national group item
A group item that is explicitly or implicitly described with a GROUP-USAGE NATIONAL clause. A national group item is processed as though it were defined as an elementary data item of category national for operations such as INSPECT, STRING, and UNSTRING. This processing ensures correct padding and truncation of national characters, as contrasted with defining USAGE NATIONAL data items within an alphanumeric group item. For operations that require processing of the elementary items within a group, such as MOVE CORRESPONDING, ADD CORRESPONDING, and INITIALIZE, a national group is processed using group semantics.

* native character set
The implementor-defined character set associated with the computer specified in the OBJECT-COMPUTER paragraph.

* native collating sequence
The implementor-defined collating sequence associated with the computer specified in the OBJECT-COMPUTER paragraph.

native method
A Java method with an implementation that is written in another programming language, such as COBOL.

* negated combined condition
The NOT logical operator immediately followed by a parenthesized combined condition. See also condition and combined condition.

* negated simple condition
The NOT logical operator immediately followed by a simple condition. See also condition and simple condition.
nested program
A program that is directly contained within another program.

* next executable sentence
The next sentence to which control will be transferred after execution of the current statement is complete.

* next executable statement
The next statement to which control will be transferred after execution of the current statement is complete.

* next record
The record that logically follows the current record of a file.

* noncontiguous items
Elementary data items in the WORKING-STORAGE SECTION and LINKAGE SECTION that bear no hierarchic relationship to other data items.

null
A figurative constant that is used to assign, to pointer data items, the value of an address that is not valid. NULLS can be used wherever NULL can be used.

* numeric character
A character that belongs to the following set of digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

numeric data item
(1) A data item whose description restricts its content to a value represented by characters chosen from the digits 0 through 9. If signed, the item can also contain a +, -, or other representation of an operational sign. (2) A data item of category numeric, internal floating-point, or external floating-point. A numeric data item can have USAGE DISPLAY, NATIONAL, PACKED-DECIMAL, BINARY, COMP, COMP-1, COMP-2, COMP-3, COMP-4, or COMP-5.

numeric-edited data item
A data item that contains numeric data in a form suitable for use in printed output. The data item can consist of external decimal digits from 0 through 9, the decimal separator, commas, the currency sign, sign control characters, and other editing characters. A numeric-edited item can be represented in either USAGE DISPLAY or USAGE NATIONAL.

* numeric function
A function whose class and category are numeric but that for some possible evaluation does not satisfy the requirements of integer functions.

* numeric literal
A literal composed of one or more numeric characters that can contain a decimal point or an algebraic sign, or both. The decimal point must not be the rightmost character. The algebraic sign, if present, must be the leftmost character.

0
object
An entity that has state (its data values) and operations (its methods). An object is a way to encapsulate state and behavior. Each object in the class is said to be an instance of the class.

object code
Output from a compiler or assembler that is itself executable machine code or is suitable for processing to produce executable machine code.

* OBJECT-COMPUTER
The name of an ENVIRONMENT DIVISION paragraph in which the computer environment, where the object program is run, is described.

* object computer entry
An entry in the OBJECT-COMPUTER paragraph of the ENVIRONMENT DIVISION; this entry contains clauses that describe the computer environment in which the object program is to be executed.

object deck
A portion of an object program suitable as input to a linkage-editor. Synonymous with object module and text deck.
**object instance**
See object.

**object module**
Synonym for object deck or text deck.

**object of entry**
A set of operands and reserved words, within a DATA DIVISION entry of a COBOL program, that immediately follows the subject of the entry.

**object-oriented programming**
A programming approach based on the concepts of encapsulation and inheritance. Unlike procedural programming techniques, object-oriented programming concentrates on the data objects that comprise the problem and how they are manipulated, not on how something is accomplished.

**object program**
A set or group of executable machine-language instructions and other material designed to interact with data to provide problem solutions. In this context, an object program is generally the machine language result of the operation of a COBOL compiler on a source program or class definition. Where there is no danger of ambiguity, the word program can be used in place of object program.

**object reference**
A value that identifies an instance of a class. If the class is not specified, the object reference is universal and can apply to instances of any class.

**object time**
The time at which an object program is executed. Synonymous with run time.

**obsolete element**
A COBOL language element in the 85 COBOL Standard that was deleted from the 2002 COBOL Standard.

**ODO object**
In the example below, X is the object of the OCCURS DEPENDING ON clause (ODO object).

```
WORKING-STORAGE SECTION
  01  TABLE-1.
    05  X          PICS 9.
    05  Y OCCURS 3 TIMES
                DEPENDING ON X  PIC X.
```

The value of the ODO object determines how many of the ODO subject appear in the table.

**ODO subject**
In the example above, Y is the subject of the OCCURS DEPENDING ON clause (ODO subject). The number of Y ODO subjects that appear in the table depends on the value of X.

**open mode**
The state of a file after execution of an OPEN statement for that file and before the execution of a CLOSE statement without the REEL or UNIT phrase for that file. The particular open mode is specified in the OPEN statement as either INPUT, OUTPUT, I-O, or EXTEND.

**operand**
(1) The general definition of operand is "the component that is operated upon." (2) For the purposes of this document, any lowercase word (or words) that appears in a statement or entry format can be considered to be an operand and, as such, is an implied reference to the data indicated by the operand.

**operation**
A service that can be requested of an object.

**operational sign**
An algebraic sign that is associated with a numeric data item or a numeric literal, to indicate whether its value is positive or negative.

**optional file**
A file that is declared as being not necessarily available each time the object program is run.
optional word
A reserved word that is included in a specific format only to improve the readability of the language. Its presence is optional to the user when the format in which the word appears is used in a source unit.

output file
A file that is opened in either output mode or extend mode.

output mode
The state of a file after execution of an OPEN statement, with the OUTPUT or EXTEND phrase specified, for that file and before the execution of a CLOSE statement without the REEL or UNIT phrase for that file.

output procedure
A set of statements to which control is given during execution of a format 1 SORT statement after the sort function is completed, or during execution of a MERGE statement after the merge function reaches a point at which it can select the next record in merged order when requested.

overflow condition
A condition that occurs when a portion of the result of an operation exceeds the capacity of the intended unit of storage.

overload
To define a method with the same name as another method that is available in the same class, but with a different signature. See also signature.

override
To redefine an instance method (inherited from a parent class) in a subclass.

package
A group of related Java classes, which can be imported individually or as a whole.

packed-decimal data item
See internal decimal data item.

padding character
An alphanumeric or national character that is used to fill the unused character positions in a physical record.

page
A vertical division of output data that represents a physical separation of the data. The separation is based on internal logical requirements or external characteristics of the output medium or both.

* page body
That part of the logical page in which lines can be written or spaced or both.

paragraph
In the PROCEDURE DIVISION, a paragraph-name followed by a separator period and by zero, one, or more sentences. In the IDENTIFICATION DIVISION and ENVIRONMENT DIVISION, a paragraph header followed by zero, one, or more entries.

paragraph header
A reserved word, followed by the separator period, that indicates the beginning of a paragraph in the IDENTIFICATION DIVISION and ENVIRONMENT DIVISION. The permissible paragraph headers in the IDENTIFICATION DIVISION are:

```
PROGRAM-ID. (Program IDENTIFICATION DIVISION)
CLASS-ID. (Class IDENTIFICATION DIVISION)
METHOD-ID. (Method IDENTIFICATION DIVISION)
AUTHOR.
INSTALLATION.
DATE-WRITTEN.
DATE-COMPILED.
SECURITY.
```
The permissible paragraph headers in the ENVIRONMENT DIVISION are:

- SOURCE-COMPUTER.
- OBJECT-COMPUTER.
- SPECIAL-NAMES.
- REPOSITORY. (Program or Class CONFIGURATION SECTION)
- FILE-CONTROL.
- I-O-CONTROL.

* paragraph-name
  A user-defined word that identifies and begins a paragraph in the PROCEDURE DIVISION.

parameter
  (1) Data passed between a calling program and a called program. (2) A data element in the USING phrase of a method invocation. Arguments provide additional information that the invoked method can use to perform the requested operation.

Persistent Reusable JVM
  A JVM that can be serially reused for transaction processing by resetting the JVM between transactions. The reset phase restores the JVM to a known initialization state.

* phrase
  An ordered set of one or more consecutive COBOL character strings that form a portion of a COBOL procedural statement or of a COBOL clause.

* physical record
  See block.

pointer data item
  A data item in which address values can be stored. Data items are explicitly defined as pointers with the USAGE IS POINTER clause. ADDRESS OF special registers are implicitly defined as pointer data items. Pointer data items can be compared for equality or moved to other pointer data items.

port
  (1) To modify a computer program to enable it to run on a different platform. (2) In the Internet suite of protocols, a specific logical connector between the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP) and a higher-level protocol or application. A port is identified by a port number.

portability
  The ability to transfer an application program from one application platform to another with relatively few changes to the source program.

preinitialization
  The initialization of the COBOL runtime environment in preparation for multiple calls from programs, especially non-COBOL programs. The environment is not terminated until an explicit termination.

* prime record key
  A key whose contents uniquely identify a record within an indexed file.

* priority-number
  A user-defined word that classifies sections in the PROCEDURE DIVISION for purposes of segmentation. Segment numbers can contain only the characters 0 through 9. A segment number can be expressed as either one or two digits.

private
  As applied to factory data or instance data, accessible only by methods of the class that defines the data.

* procedure
  A paragraph or group of logically successive paragraphs, or a section or group of logically successive sections, within the PROCEDURE DIVISION.

* procedure branching statement
  A statement that causes the explicit transfer of control to a statement other than the next executable statement in the sequence in which the statements are written in the source code. The procedure branching statements are: ALTER, CALL, EXIT, EXIT PROGRAM, GO TO, MERGE (with the OUTPUT
PROCEDURE DIVISION
The COBOL division that contains instructions for solving a problem.

procedure integration
One of the functions of the COBOL optimizer is to simplify calls to performed procedures or contained programs.

PERFORM procedure integration is the process whereby a PERFORM statement is replaced by its performed procedures. Contained program procedure integration is the process where a call to a contained program is replaced by the program code.

* procedure-name
A user-defined word that is used to name a paragraph or section in the PROCEDURE DIVISION. It consists of a paragraph-name (which can be qualified) or a section-name.

procedure-pointer data item
A data item in which a pointer to an entry point can be stored. A data item defined with the USAGE IS PROCEDURE-POINTER clause contains the address of a procedure entry point. Typically used to communicate with COBOL and Language Environment programs.

process
The course of events that occurs during the execution of all or part of a program. Multiple processes can run concurrently, and programs that run within a process can share resources.

program
(1) A sequence of instructions suitable for processing by a computer. Processing may include the use of a compiler to prepare the program for execution, as well as a runtime environment to execute it. (2) A logical assembly of one or more interrelated modules. Multiple copies of the same program can be run in different processes.

* program identification entry
In the PROGRAM-ID paragraph of the IDENTIFICATION DIVISION, an entry that contains clauses that specify the program-name and assign selected program attributes to the program.

program-name
In the IDENTIFICATION DIVISION and the end program marker, a user-defined word or alphanumeric literal that identifies a COBOL source program.

project
The complete set of data and actions that are required to build a target, such as a dynamic link library (DLL) or other executable (EXE).

* pseudo-text
A sequence of text words, comment lines, inline comments, or the separator space in a source program or COBOL library bounded by, but not including, pseudo-text delimiters.

* pseudo-text delimiter
Two contiguous equal sign characters (==) used to delimit pseudo-text.

* punctuation character
A character that belongs to the following set:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>,</td>
<td>Comma</td>
</tr>
<tr>
<td>;</td>
<td>Semicolon</td>
</tr>
<tr>
<td>:</td>
<td>Colon</td>
</tr>
<tr>
<td>.</td>
<td>Period (full stop)</td>
</tr>
<tr>
<td>&quot;</td>
<td>Quotation mark</td>
</tr>
<tr>
<td>(</td>
<td>Left parenthesis</td>
</tr>
</tbody>
</table>
QSAM (Queued Sequential Access Method)
An extended version of the basic sequential access method (BSAM). When this method is used, a queue is formed of input data blocks that are awaiting processing or of output data blocks that have been processed and are awaiting transfer to auxiliary storage or to an output device.

* qualified data-name
An identifier that is composed of a data-name followed by one or more sets of either of the connectives OF and IN followed by a data-name qualifier.

* qualifier
(1) A data-name or a name associated with a level indicator that is used in a reference either together with another data-name (which is the name of an item that is subordinate to the qualifier) or together with a condition-name. (2) A section-name that is used in a reference together with a paragraph-name specified in that section. (3) A library-name that is used in a reference together with a text-name associated with that library.

R
* random access
An access mode in which the program-specified value of a key data item identifies the logical record that is obtained from, deleted from, or placed into a relative or indexed file.

* record
See logical record.

* record area
A storage area allocated for the purpose of processing the record described in a record description entry in the FILE SECTION of the DATA DIVISION. In the FILE SECTION, the current number of character positions in the record area is determined by the explicit or implicit RECORD clause.

* record description
See record description entry.

* record description entry
The total set of data description entries associated with a particular record. Synonymous with record description.

record key
A key whose contents identify a record within an indexed file.

* record-name
A user-defined word that names a record described in a record description entry in the DATA DIVISION of a COBOL program.

* record number
The ordinal number of a record in the file whose organization is sequential.

recording mode
The format of the logical records in a file. Recording mode can be F (fixed length), V (variable length), S (spanned), or U (undefined).

recursion
A program calling itself or being directly or indirectly called by one of its called programs.

recursively capable
A program is recursively capable (can be called recursively) if the RECURSIVE attribute is on the PROGRAM-ID statement.
reel
A discrete portion of a storage medium, the dimensions of which are determined by each implementor that contains part of a file, all of a file, or any number of files. Synonymous with unit and volume.

reentrant
The attribute of a program or routine that lets more than one user share a single copy of a program object.

* reference format
A format that provides a standard method for describing COBOL source programs.

reference modification
A method of defining a new category alphanumeric, category DBCS, or category national data item by specifying the leftmost character and length relative to the leftmost character position of a USAGE DISPLAY, DISPLAY-1, or NATIONAL data item.

* reference-modifier
A syntactically correct combination of character strings and separators that defines a unique data item. It includes a delimiting left parenthesis separator, the leftmost character position, a colon separator, optionally a length, and a delimiting right parenthesis separator.

* relation
See relational operator or relation condition.

* relation character
A character that belongs to the following set:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;</td>
<td>Greater than</td>
</tr>
<tr>
<td>&lt;</td>
<td>Less than</td>
</tr>
<tr>
<td>=</td>
<td>Equal to</td>
</tr>
</tbody>
</table>

* relation condition
The proposition (for which a truth value can be determined) that the value of an arithmetic expression, data item, alphanumeric literal, or index-name has a specific relationship to the value of another arithmetic expression, data item, alphanumeric literal, or index name. See also relational operator.

* relational operator
A reserved word, a relation character, a group of consecutive reserved words, or a group of consecutive reserved words and relation characters used in the construction of a relation condition. The permissible operators and their meanings are:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS GREATER THAN</td>
<td>Greater than</td>
</tr>
<tr>
<td>IS &gt;</td>
<td>Greater than</td>
</tr>
<tr>
<td>IS NOT GREATER THAN</td>
<td>Not greater than</td>
</tr>
<tr>
<td>IS NOT &gt;</td>
<td>Not greater than</td>
</tr>
<tr>
<td>IS LESS THAN</td>
<td>Less than</td>
</tr>
<tr>
<td>IS &lt;</td>
<td>Less than</td>
</tr>
<tr>
<td>IS NOT LESS THAN</td>
<td>Not less than</td>
</tr>
<tr>
<td>IS NOT &lt;</td>
<td>Not less than</td>
</tr>
<tr>
<td>IS EQUAL TO</td>
<td>Equal to</td>
</tr>
<tr>
<td>IS =</td>
<td>Equal to</td>
</tr>
</tbody>
</table>
### Character

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS NOT EQUAL TO</td>
<td>Not equal to</td>
</tr>
<tr>
<td>IS NOT =</td>
<td>Not equal to</td>
</tr>
<tr>
<td>IS GREATER THAN OR EQUAL TO</td>
<td>Greater than or equal to</td>
</tr>
<tr>
<td>IS &gt;=</td>
<td>Greater than or equal to</td>
</tr>
<tr>
<td>IS LESS THAN OR EQUAL TO</td>
<td>Less than or equal to</td>
</tr>
<tr>
<td>IS &lt;=</td>
<td>Less than or equal to</td>
</tr>
</tbody>
</table>

**relative file**

A file with relative organization.

**relative key**

A key whose contents identify a logical record in a relative file.

**relative organization**

The permanent logical file structure in which each record is uniquely identified by an integer value greater than zero, which specifies the logical ordinal position of the record in the file.

**relative record number**

The ordinal number of a record in a file whose organization is relative. This number is treated as a numeric literal that is an integer.

**reserved word**

A COBOL word that is specified in the list of words that can be used in a COBOL source program, but that must not appear in the program as a user-defined word or system-name.

**resource**

A facility or service, controlled by the operating system, that an executing program can use.

**resultant identifier**

A user-defined data item that is to contain the result of an arithmetic operation.

**reusable environment**

A reusable environment is created when you establish an assembler program as the main program by using either the old COBOL interfaces for preinitialization (RTEREUS runtime option), or the Language Environment interface, CEEPIPI.

**routine**

A set of statements in a COBOL program that causes the computer to perform an operation or series of related operations. In Language Environment, refers to either a procedure, function, or subroutine.

**routine-name**

A user-defined word that identifies a procedure written in a language other than COBOL.

**run time**

The time at which an object program is executed. Synonymous with *object time*.

**runtime environment**

The environment in which a COBOL program executes.

**run unit**

A stand-alone object program, or several object programs, that interact by means of COBOL CALL or INVOKE statements and function at run time as an entity.

**S**

**SBCS**

See *single-byte character set (SBCS)*.

**scope terminator**

A COBOL reserved word that marks the end of certain PROCEDURE DIVISION statements. It can be either explicit (END-ADD, for example) or implicit (separator period).
* section
A set of zero, one, or more paragraphs or entities, called a section body, the first of which is preceded by a section header. Each section consists of the section header and the related section body.

* section header
A combination of words followed by a separator period that indicates the beginning of a section in any of these divisions: ENVIRONMENT, DATA, or PROCEDURE. In the ENVIRONMENT DIVISION and DATA DIVISION, a section header is composed of reserved words followed by a separator period. The permissible section headers in the ENVIRONMENT DIVISION are:

```plaintext
CONFIGURATION SECTION.
INPUT-OUTPUT SECTION.
```

The permissible section headers in the DATA DIVISION are:

```plaintext
FILE SECTION.
WORKING-STORAGE SECTION.
LOCAL-STORAGE SECTION.
LINKAGE SECTION.
```

In the PROCEDURE DIVISION, a section header is composed of a section-name, followed by the reserved word SECTION, followed by a separator period.

* section-name
A user-defined word that names a section in the PROCEDURE DIVISION.

selection structure
A program processing logic in which one or another series of statements is executed, depending on whether a condition is true or false.

* sentence
A sequence of one or more statements, the last of which is terminated by a separator period.

* separately compiled program
A program that, together with its contained programs, is compiled separately from all other programs.

* separator
A character or two or more contiguous characters used to delimit character strings.

* separator comma
A comma (,) followed by a space used to delimit character strings.

* separator period
A period (.) followed by a space used to delimit character strings.

* separator semicolon
A semicolon (;) followed by a space used to delimit character strings.

sequence structure
A program processing logic in which a series of statements is executed in sequential order.

* sequential access
An access mode in which logical records are obtained from or placed into a file in a consecutive predecessor-to-successor logical record sequence determined by the order of records in the file.

* sequential file
A file with sequential organization.

* sequential organization
The permanent logical file structure in which a record is identified by a predecessor-successor relationship established when the record is placed into the file.

serial search
A search in which the members of a set are consecutively examined, beginning with the first member and ending with the last.
**Session bean**
In EJB, an enterprise bean that is created by a client and that usually exists only for the duration of a single client/server session. (Oracle)

**77-level-description-entry**
A data description entry that describes a noncontiguous data item that has level-number 77.

**Sign condition**
The proposition (for which a truth value can be determined) that the algebraic value of a data item or an arithmetic expression is either less than, greater than, or equal to zero.

**Signature**
(1) The name of an operation and its parameters. (2) The name of a method and the number and types of its formal parameters.

**Simple condition**
Any single condition chosen from this set:
- Relation condition
- Class condition
- Condition-name condition
- Switch-status condition
- Sign condition

See also condition and negated simple condition.

**Single-byte character set (SBCS)**
A set of characters in which each character is represented by a single byte. See also ASCII and EBCDIC (Extended Binary-Coded Decimal Interchange Code).

**Slack bytes**
Bytes inserted between data items or records to ensure correct alignment of some numeric items. Slack bytes contain no meaningful data. In some cases, they are inserted by the compiler; in others, it is the responsibility of the programmer to insert them. The SYNCHRONIZED clause instructs the compiler to insert slack bytes when they are needed for proper alignment. Slack bytes between records are inserted by the programmer.

**Sort file**
A collection of records to be sorted by a format 1 SORT statement. The sort file is created and can be used by the sort function only.

**Sort-merge file description entry**
An entry in the FILE SECTION of the DATA DIVISION that is composed of the level indicator SD, followed by a file-name, and then followed by a set of file clauses as required.

**Source-computer**
The name of an ENVIRONMENT DIVISION paragraph in which the computer environment, where the source program is compiled, is described.

**Source computer entry**
An entry in the SOURCE-COMPUTER paragraph of the ENVIRONMENT DIVISION; this entry contains clauses that describe the computer environment in which the source program is to be compiled.

**Source item**
An identifier designated by a SOURCE clause that provides the value of a printable item.

**Source program**
Although a source program can be represented by other forms and symbols, in this document the term always refers to a syntactically correct set of COBOL statements. A COBOL source program commences with the IDENTIFICATION DIVISION or a COPY statement and terminates with the end program marker, if specified, or with the absence of additional source program lines.

**Source unit**
A unit of COBOL source code that can be separately compiled: a program or a class definition. Also known as a compilation unit.
special character
A character that belongs to the following set:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Plus sign</td>
</tr>
<tr>
<td>-</td>
<td>Minus sign (hyphen)</td>
</tr>
<tr>
<td>*</td>
<td>Asterisk</td>
</tr>
<tr>
<td>/</td>
<td>Slant (forward slash)</td>
</tr>
<tr>
<td>=</td>
<td>Equal sign</td>
</tr>
<tr>
<td>$</td>
<td>Currency sign</td>
</tr>
<tr>
<td>,</td>
<td>Comma</td>
</tr>
<tr>
<td>;</td>
<td>Semicolon</td>
</tr>
<tr>
<td>.</td>
<td>Period (decimal point, full stop)</td>
</tr>
<tr>
<td>“</td>
<td>Quotation mark</td>
</tr>
<tr>
<td>'</td>
<td>Apostrophe</td>
</tr>
<tr>
<td>(</td>
<td>Left parenthesis</td>
</tr>
<tr>
<td>)</td>
<td>Right parenthesis</td>
</tr>
<tr>
<td>&gt;</td>
<td>Greater than</td>
</tr>
<tr>
<td>&lt;</td>
<td>Less than</td>
</tr>
<tr>
<td>:</td>
<td>Colon</td>
</tr>
<tr>
<td>_</td>
<td>Underscore</td>
</tr>
</tbody>
</table>

SPECIAL-NAMES
The name of an ENVIRONMENT DIVISION paragraph in which environment-names are related to user-specified mnemonic-names.

* special names entry
An entry in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION; this entry provides means for specifying the currency sign; choosing the decimal point; specifying symbolic characters; relating implementor-names to user-specified mnemonic-names; relating alphabet-names to character sets or collating sequences; and relating class-names to sets of characters.

* special registers
Certain compiler-generated storage areas whose primary use is to store information produced in conjunction with the use of a specific COBOL feature.

* statement
A syntactically valid combination of words, literals, and separators, beginning with a verb, written in a COBOL source program.

structured programming
A technique for organizing and coding a computer program in which the program comprises a hierarchy of segments, each segment having a single entry point and a single exit point. Control is passed downward through the structure without unconditional branches to higher levels of the hierarchy.

* subclass
A class that inherits from another class. When two classes in an inheritance relationship are considered together, the subclass is the inheritor or inheriting class; the superclass is the inheritee or inherited class.
An operand or reserved word that appears immediately following the level indicator or the level-number in a DATA DIVISION entry.

* subprogram

See called program.

* subscript

An occurrence number that is represented by either an integer, a data-name optionally followed by an integer with the operator + or -, or an index-name optionally followed by an integer with the operator + or -, that identifies a particular element in a table. A subscript can be the word ALL when the subscripted identifier is used as a function argument for a function allowing a variable number of arguments.

* subscripted data-name

An identifier that is composed of a data-name followed by one or more subscripts enclosed in parentheses.

substitution character

A character that is used in a conversion from a source code page to a target code page to represent a character that is not defined in the target code page.

* superclass

A class that is inherited by another class. See also subclass.

surrogate pair

In the UTF-16 format of Unicode, a pair of encoding units that together represents a single Unicode graphic character. The first unit of the pair is called a high surrogate and the second a low surrogate. The code value of a high surrogate is in the range X'D800' through X'DBFF'. The code value of a low surrogate is in the range X'DC00' through X'DFFF'. Surrogate pairs provide for more characters than the 65,536 characters that fit in the Unicode 16-bit coded character set.

switch-status condition

The proposition (for which a truth value can be determined) that an UPSI switch, capable of being set to an on or off status, has been set to a specific status.

* symbolic-character

A user-defined word that specifies a user-defined figurative constant.

syntax


* system-name

A user-defined word that identifies library text.

text deck

Synonym for object deck or object module.

* text-name

A user-defined word that identifies library text.

* text word

A character or a sequence of contiguous characters between margin A and margin R in a COBOL library, source program, or pseudo-text that is any of the following characters:
• A separator, except for space; a pseudo-text delimiter; and the opening and closing delimiters for alphanumeric literals. The right parenthesis and left parenthesis characters, regardless of context within the library, source program, or pseudo-text, are always considered text words.

• A literal including, in the case of alphanumeric literals, the opening quotation mark and the closing quotation mark that bound the literal.

• Any other sequence of contiguous COBOL characters except comment lines and the word COPY bounded by separators that are neither a separator nor a literal.

thread
A stream of computer instructions (initiated by an application within a process) that is in control of a process.

token
In the COBOL editor, a unit of meaning in a program. A token can contain data, a language keyword, an identifier, or other part of the language syntax.

top-down design
The design of a computer program using a hierarchic structure in which related functions are performed at each level of the structure.

top-down development
See structured programming.

trailer-label
(1) A data-set label that follows the data records on a unit of recording medium. (2) Synonym for end-of-file label.

troubleshoot
To detect, locate, and eliminate problems in using computer software.

* truth value
The representation of the result of the evaluation of a condition in terms of one of two values: true or false.

typed object reference
A data-name that can refer only to an object of a specified class or any of its subclasses.

U

* unary operator
A plus (+) or a minus (-) sign that precedes a variable or a left parenthesis in an arithmetic expression and that has the effect of multiplying the expression by +1 or -1, respectively.

Unicode
A universal character encoding standard that supports the interchange, processing, and display of text that is written in any of the languages of the modern world. There are multiple encoding schemes to represent Unicode, including UTF-8, UTF-16, and UTF-32. Enterprise COBOL supports Unicode using UTF-16 in big-endian format as the representation for the national data type.

Uniform Resource Identifier (URI)
A sequence of characters that uniquely names a resource; in Enterprise COBOL, the identifier of a namespace. URI syntax is defined by the document Uniform Resource Identifier (URI): Generic Syntax.

unit
A module of direct access, the dimensions of which are determined by IBM.

universal object reference
A data-name that can refer to an object of any class.

unrestricted storage
Storage below the 2 GB bar. It can be above or below the 16 MB line. If it is above the 16 MB line, it is addressable only in 31-bit mode.

* unsuccessful execution
The attempted execution of a statement that does not result in the execution of all the operations specified by that statement. The unsuccessful execution of a statement does not affect any data referenced by that statement, but can affect status indicators.
**UPSI switch**
A program switch that performs the functions of a hardware switch. Eight are provided: UPSI-0 through UPSI-7.

**URI**
See *Uniform Resource Identifier (URI)*.

*user-defined word*
A COBOL word that must be supplied by the user to satisfy the format of a clause or statement.

**V**

*variable*
A data item whose value can be changed by execution of the object program. A variable used in an arithmetic expression must be a numeric elementary item.

**variable-length item**
A group item that contains a table described with the DEPENDING phrase of the OCCURS clause.

*variable-length record*
A record associated with a file whose file description or sort-merge description entry permits records to contain a varying number of character positions.

*variable-occurrence data item*
A variable-occurrence data item is a table element that is repeated a variable number of times. Such an item must contain an OCCURS DEPENDING ON clause in its data description entry or be subordinate to such an item.

*variably located group*
A group item following, and not subordinate to, a variable-length table in the same record. The group item can be an alphanumeric group or a national group.

*variably located item*
A data item following, and not subordinate to, a variable-length table in the same record.

*verb*
A word that expresses an action to be taken by a COBOL compiler or object program.

**volume**
A module of external storage. For tape devices it is a reel; for direct-access devices it is a unit.

**volume switch procedures**
System-specific procedures that are executed automatically when the end of a unit or reel has been reached before end-of-file has been reached.

**VSAM file system**
A file system that supports COBOL sequential, relative, and indexed organizations.

**W**

**web service**
A modular application that performs specific tasks and is accessible through open protocols like HTTP and SOAP.

**white space**
Characters that introduce space into a document. They are:

- Space
- Horizontal tabulation
- Carriage return
- Line feed
- Next line
  as named in the Unicode Standard.

*word*
A character string of not more than 30 characters that forms a user-defined word, a system-name, a reserved word, or a function-name.
*WORKING-STORAGE SECTION*

The section of the DATA DIVISION that describes WORKING-STORAGE data items, composed either of noncontiguous items or WORKING-STORAGE records or of both.

**workstation**

A generic term for computers, including personal computers, 3270 terminals, intelligent workstations, and UNIX terminals. Often a workstation is connected to a mainframe or to a network.

**wrapper**

An object that provides an interface between object-oriented code and procedure-oriented code. Using wrappers lets programs be reused and accessed by other systems.

**X**

The symbol in a PICTURE clause that can hold any character in the character set of the computer.

**XML**

Extensible Markup Language. A standard metalanguage for defining markup languages that was derived from and is a subset of SGML. XML omits the more complex and less-used parts of SGML and makes it much easier to write applications to handle document types, author and manage structured information, and transmit and share structured information across diverse computing systems. The use of XML does not require the robust applications and processing that is necessary for SGML. XML is developed under the auspices of the World Wide Web Consortium (W3C).

**XML data**

Data that is organized into a hierarchical structure with XML elements. The data definitions are defined in XML element type declarations.

**XML declaration**

XML text that specifies characteristics of the XML document such as the version of XML being used and the encoding of the document.

**XML document**

A data object that is well formed as defined by the W3C XML specification.

**XML namespace**

A mechanism, defined by the W3C XML Namespace specifications, that limits the scope of a collection of element names and attribute names. A uniquely chosen XML namespace ensures the unique identity of an element name or attribute name across multiple XML documents or multiple contexts within an XML document.

**XML schema**

A mechanism, defined by the W3C, for describing and constraining the structure and content of XML documents. An XML schema, which is itself expressed in XML, effectively defines a class of XML documents of a given type, for example, purchase orders.

**z/OS UNIX file system**

A collection of files and directories that are organized in a hierarchical structure and can be accessed by using z/OS UNIX.

**zoned decimal data item**

An external decimal data item that is described implicitly or explicitly as USAGE DISPLAY and that contains a valid combination of PICTURE symbols 9, S, P, and V. The content of a zoned decimal data item is represented in characters 0 through 9, optionally with a sign. If the PICTURE string specifies a sign and the SIGN IS SEPARATE clause is specified, the sign is represented as characters + or -. If SIGN IS SEPARATE is not specified, the sign is one hexadecimal digit that overlays the first 4 bits of the sign position (leading or trailing).

#

**85 COBOL Standard**

The COBOL language defined by the following standards:
• ANSI INCITS 23-1985, Programming languages - COBOL, as amended by ANSI INCITS 23a-1989, Programming Languages - COBOL - Intrinsic Function Module for COBOL and ANSI INCITS 23b-1993, Programming Languages - Correction Amendment for COBOL


2002 COBOL Standard
The COBOL language defined by the following standards:

• INCITS/ISO/IEC 1989-2002, Information Technology - Programming Languages - COBOL
List of resources

Enterprise COBOL for z/OS

COBOL for z/OS publications

You can find the following publications in the Enterprise COBOL for z/OS library:

- Customization Guide, SC27-8712
- Language Reference, SC27-8713
- Programming Guide, SC27-8714
- Migration Guide, GC27-8715
- Program Directory, G113-4526
- Licensed Program Specifications, G113-4532

Softcopy publications


- z/OS Software Products Collection
- z/OS and Software Products DVD Collection

Support


If you have a problem using Enterprise COBOL for z/OS, see the following site that provides up-to-date support information: https://www.ibm.com/support/home/product/B984385H82239E03/Enterprise_COBOL_for_z/OS.

Related publications

z/OS library publications

You can find the following publications in the z/OS Internet Library.

Run-Time Library Extensions

- Common Debug Architecture Library Reference
- Common Debug Architecture User's Guide
- DWARF/ELF Extensions Library Reference

z/Architecture

- Principles of Operation

z/OS DFSMS

- Access Method Services for Catalogs
- Checkpoint/Restart
- Macro Instructions for Data Sets
• Using Data Sets
• Utilities

**z/OS DFSORT**
• Application Programming Guide
• Installation and Customization

**z/OS ISPF**
• Dialog Developer's Guide and Reference
• User's Guide Vol I
• User's Guide Vol II

**z/OS Language Environment**
• Concepts Guide
• Customization
• Debugging Guide
• Language Environment Vendor Interfaces
• Programming Guide
• Programming Reference
• Run-Time Messages
• Run-Time Application Migration Guide
• Writing Interlanguage Communication Applications

**z/OS MVS**
• JCL Reference
• JCL User's Guide
• Programming: Callable Services for High-Level Languages
• Program Management: User's Guide and Reference
• System Commands
• z/OS Unicode Services User's Guide and Reference
• z/OS XML System Services User's Guide and Reference

**z/OS TSO/E**
• Command Reference
• Primer
• User's Guide

**z/OS UNIX System Services**
• Command Reference
• Programming: Assembler Callable Services Reference
• User's Guide

**z/OS XL C/C++**
• Programming Guide
• Run-Time Library Reference

**CICS Transaction Server for z/OS**
You can find the following publications in the CICS library:
• Developing CICS Applications
You can find the following publications in the DB2 Library:

- Application Programming and SQL Guide
- Command Reference
- SQL Reference

IBM Debug for z/OS (formerly IBM Debug for z Systems and IBM Debug Tool for z/OS)

You can find information about IBM Debug for z/OS in the IBM Debug for z/OS Library.

IBM Debug for z/OS supersedes IBM Debug for z Systems® and IBM Debug Tool for z/OS. Not all references to IBM Debug for z Systems and IBM Debug Tool for z/OS have been changed in the COBOL documentation library. It is recommended that you upgrade your debugger to the latest level in order to have the full range of debugging features available. In some cases, you must upgrade your debugger to a certain version depending on what level of Enterprise COBOL you are using to create the COBOL application:

- IBM Debug Tool V13.1 supports Enterprise COBOL V5.1 and earlier versions
- IBM Debug for z Systems V14.0 supports Enterprise COBOL V6.1 and earlier versions

To find out which IBM debug product best suits your needs, see https://www.ibm.com/support/knowledgcenter/SSQ2R2_14.2.0/com.ibm.debug.cg.doc/common/dcompo.html?sc=SSQ2R2_latest.

WebSphere Application Server for z/OS

- Applications, SA22-7959

Softcopy publications for z/OS

The following collection kit contains z/OS and related product publications:

- z/OS CD Collection Kit, SK3T-4269

Java

- IBM SDK for Java - Tools Documentation, publib.boulder.ibm.com/infocenter/javasdk/tools/index.jsp
- The Java EE 5 Tutorial, download.oracle.com/javaee/5/tutorial/doc/
- The Java Native Interface, download.oracle.com/javase/1.5.0/docs/guide/jni/
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