Seventh Edition (November 2005)

This edition applies to Version 3 Release 5 of Enterprise PL/I for z/OS, 5655-H31, and to any subsequent releases until otherwise indicated in new editions or technical newsletters. Make sure you are using the correct edition for the level of the product.

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Contents

Figures ................................................. ix

About this book ........................................ xi
Using your documentation .............................. xi
   PL/I information ................................... xii
Language Environment information .................... xii

Part 1. Overview ...................................... 1

Chapter 1. Do I need to recompile? ................. 3
Migration basics ........................................ 4
   Run-time migration - Moving to Language
      Environment ....................................... 4
   Compiler migration .................................. 4
Migration Roadmap ..................................... 5
Service support for OS PL/I and PL/I for MVS &
   VM ..................................................... 5

Chapter 2. Introducing the new compiler
and run-time ......................................... 7
Product relationships - compiler, run-time, debug .... 7
General PL/I compiler information ..................... 7
Language Environment’s run-time support for other
   programs ............................................. 8
Advantages of the new compiler and run-time ......... 8
Major changes with the new compiler and run-time .... 9
General conversion tasks ................................ 10
   Planning your strategy .............................. 10
   Moving to the Language Environment run time ... 11
   Recompiling your source with Enterprise PL/I .... 11
   Adding Enterprise PL/I programs to existing
      applications ....................................... 11

Part 2. Conversion Strategies ..................... 13

Chapter 3. Planning the move to
Language Environment ................................ 15
Prepare to move to the Language Environment
   run-time library .................................... 15
   Installing Language Environment .................. 15
   Assessing storage requirements ................... 15
   Educating your programmers about Language
      Environment ...................................... 16
Take an inventory of your applications ................. 16
   Vendor tools, packages, and products ............. 17
   PL/I applications ................................... 17
   Existing PL/I load modules ....................... 17
Decide how to phase in Language Environment ....... 18
   Multilanguage conversion .......................... 18
   Determining how applications will have access to
      the library ....................................... 18
Set up a regression testing procedure .................. 21
   Take performance measurements .................. 22
Cut over to production use ............................ 22

Chapter 4. Planning to move to the new
compiler .................................................. 23
Prepare to move your source to the new compiler .... 23
   Installing Enterprise PL/I ........................ 23
   Assessing storage requirements .................. 23
   Educating your programmers on new compiler
      features .......................................... 23
Take an inventory of your applications ................. 24
   Taking an inventory of vendor tools, packages,
      and products ................................... 24
   Taking an inventory of PL/I applications ......... 24
   Prioritizing your applications .................... 25
   Setting up move/no move categories ............... 25
Make application program updates ..................... 26

Part 3. Moving existing applications
to Language Environment .......................... 29

Chapter 5. Running existing
applications under Language
Environment ............................................. 31
Invoke existing applications ........................... 31
   For non-CICS applications ....................... 31
   For CICS applications ............................. 32
Link-edit existing applications ....................... 32

Chapter 6. Considerations Before
Migrating .............................................. 35
Differences in Run-Time Options ....................... 35
   Deleted run-time options ........................ 35
   Replaced run-time options ....................... 35
   New run-time options ............................. 36
Differences in Condition Handling .................... 37
   Timing differences ................................ 37
   Unhandled condition differences ................. 38
   IBMIGITA and IBMIBER differences ............. 38
   ABEND U4039 differences ....................... 38
   Severity differences .............................. 38
Differences in PLICALLA and PLICALLB Support ... 38
   PLICALLA Considerations ......................... 38
   PLICALLB Considerations ......................... 39
Differences in Preinitialization Support .......... .... 41
Differences in PLISRTx Support ....................... 41
Differences in Multitasking Support .................. 42
Differences in OS PL/I Shared Library support ...... 42
Differences in DATE/TIME Built-In Functions ....... 42
Differences in User Return Code ..................... 42
Differences in the opening of PRINT files .......... .... 43
Differences in Run-Time Messages ................... 43
Differences in PLIDUMP .............................. 43
Differences in Storage Report ....................... 44
Differences in Interlanguage Communication
Support ............................. 44
Differences in Assembler Support ............................. 45
Assembler programs that find the main parameter list. ............................. 46

Chapter 7. Object and Load Module
Considerations ............................. 47
OS PL/I Version 1 Object Module and Load Module
Compatibility. ............................. 47
OS PL/I Version 1 Release 5.1 ............................. 47
OS PL/I Version 1 Release 5 ............................. 48
OS PL/I Version 1 Release 3.0 - Release 4.0 ............................. 49
OS PL/I Version 1 Prior to Release 3.0 ............................. 49
OS PL/I Version 2 Object Module and Load Module
Compatibility. ............................. 49
Summary of Support for OS PL/I Object and Load Modules ............................. 49

Chapter 8. Link-Edit Considerations ............................. 51
SCEERUN. ............................. 51
Symbol Table Considerations ............................. 51
NCAL Linkage Editor Option ............................. 51
ENTRY cards ............................. 52
Using OS PL/I Math Routines ............................. 52

Chapter 9.Subsystem Considerations ............................. 53
CICS Considerations ............................. 53
Updating CICS System Definition (CSD) File ............................. 53
Error Handling ............................. 53
Restrictions on User-Written Condition Handlers under CICS ............................. 53
Macro-Level Interface ............................. 54
FETCHing a PL/I MAIN Procedure ............................. 54
STACK Run-Time Option. ............................. 54
Run-Time Output ............................. 54
Abend Codes Used by PL/I under CICS ............................. 54
IMS Considerations ............................. 55
Interfaces to IMS ............................. 55
SYSTEM(IMS) Compile-Time Option ............................. 55
PLICALLA Support in IMS ............................. 55
PSB Language Options Supported ............................. 55
Storage Usage Considerations ............................. 56
Coordinated Condition Handling under IMS ............................. 56
Performance Enhancement with Library Retention(LRR) ............................. 57
DB2 Considerations ............................. 57

Part 4. Moving to the new compiler ............................. 59

Chapter 10. Understanding the limitations of the new compiler ............................. 61
LE requirements ............................. 61
Language not supported ............................. 61
Multitasking ............................. 61
CHECK ............................. 61
CHARSET(48) and CHARSET(BCD) ............................. 61
EGCS ............................. 62
Language restricted. ............................. 62

Chapter 11. Understanding the new compiler's options ............................. 71
Understanding the effect of default options on compatibility ............................. 71
BACKREG(5) ............................. 71
BIFPDEC(15) ............................. 72
CMPAT(V2) ............................. 72
EXTRN(FULL) ............................. 73
LIMITS(EXTNAME(7)) ............................. 73
NORENT and WRITABLE ............................. 73
SYSTEM ............................. 74
Choosing non-default options for even more compatibility ............................. 74
COMMON ............................. 74
DFT(NOBIN1ARG) ............................. 75
DEFAULT(LINKAGE(SYSTEM)) ............................. 75
DFT(OVERLAP) ............................. 75
NOREDUCE ............................. 75
NOREXEXP ............................. 75
RULES(LAXCTL) ............................. 76
RULES(NOLAXXOUT NOLAXSEMI) ............................. 76
NOWRITABLE ............................. 76
Choosing options for improved performance ............................. 76
ARCH ............................. 77
BIFPDEC(31) ............................. 77
DEFAULT(NONASGN) ............................. 77
DEFAULT(CONNECTED) ............................. 77
DEFAULT(REORDER) ............................. 78
DEFAULT(NOOVERLAP) ............................. 78
OPTIMIZE(2)/OPTIMIZE(3) ............................. 78
REDUCE ............................. 78
NORENT ............................. 79
RULES(NOLAXCTL) ............................. 80
SCHEDULER ............................. 80
TUNE ............................. 81

Enterprise PL/I for z/OS V3.5 Compiler and Runtime Migration Guide
Index . . . . . . . . . . . . . . . 177
Figures

1. CESE Output Data Queue. . . . . . . 54  
2. CESE output data queue. . . . . . . . 139
About this book

This book provides information to help you to move from a pre-Language Environment run-time library to IBM Language Environment for z/OS or for OS/390 and to upgrade your source programs to IBM Enterprise PL/I for z/OS Version 3 Release 5. It suggests solutions to problems that arise because of differences in support between previous releases of PL/I (OS PL/I, PL/I for MVS & VM, and VisualAge PL/I) and Enterprise PL/I.

**IMPORTANT**
The information in this book discusses migration considerations using Enterprise PL/I V3R5M0 and z/OS V1R3 Language Environment or later. These two products must be installed in order to take advantage of the migration enhancements discussed in this book. The use of Enterprise PL/I will always refer to Version 3 Release 5 unless indicated otherwise. The use of Language Environment will always refer to z/OS V1R3 Language Environment or later unless indicated otherwise.

This book is for system programmers, application programmers, and IBM support personnel who are involved in PL/I product migration. Prerequisite knowledge for using this book is:

- A general understanding of your operating system
- Some knowledge of the PL/I language and options
- Some knowledge of how PL/I uses Language Environment for its run-time environment

Using your documentation

The publications provided with Enterprise PL/I are designed to help you program with PL/I. The publications provided with Language Environment are designed to help you manage your run-time environment for applications generated with Enterprise PL/I. Each publication helps you perform a different task.

The following tables show you how to use the publications you receive with Enterprise PL/I and Language Environment. You’ll want to know information about both your compiler and run-time environment. For the complete titles and order numbers of these and other related publications, see Appendix H, “Bibliography,” on page 175.

xi
About this book

PL/I information

Table 1. How to use Enterprise PL/I publications

<table>
<thead>
<tr>
<th>To...</th>
<th>Use...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate Enterprise PL/I</td>
<td>Fact Sheet</td>
</tr>
<tr>
<td>Understand warranty information</td>
<td>Licensed Programming Specifications</td>
</tr>
<tr>
<td>Plan for and install Enterprise PL/I</td>
<td>Enterprise PL/I Program Directory</td>
</tr>
<tr>
<td>Understand compiler and run-time changes and adapt programs to Enterprise PL/I and Language Environment</td>
<td>Compiler and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Prepare and test your programs and get details on compiler options</td>
<td>Programming Guide</td>
</tr>
<tr>
<td>Get details on PL/I syntax and specifications of language elements</td>
<td>Language Reference</td>
</tr>
<tr>
<td>Diagnose compiler problems and report them to IBM</td>
<td>Diagnosis Guide</td>
</tr>
<tr>
<td>Get details on compile-time messages</td>
<td>Compile-Time Messages and Codes</td>
</tr>
</tbody>
</table>

Language Environment information

Table 2. How to use z/OS Language Environment publications

<table>
<thead>
<tr>
<th>To...</th>
<th>Use...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate Language Environment</td>
<td>Concepts Guide</td>
</tr>
<tr>
<td>Plan for Language Environment</td>
<td>Concepts Guide</td>
</tr>
<tr>
<td>Install Language Environment on z/OS</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Customize Language Environment on z/OS</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Understand Language Environment program models and concepts</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Find syntax for Language Environment run-time options and callable services</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Develop applications that run with Language Environment</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Debug applications that run with Language Environment, get details on run-time messages, diagnose problems with Language Environment</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Develop interlanguage communication (ILC) applications</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
<tr>
<td>Migrate applications to Language Environment</td>
<td>Concepts Guide and Run-Time Migration Guide</td>
</tr>
</tbody>
</table>
Part 1. Overview
Chapter 1. Do I need to recompile?

Ideally, programs should be compiled with IBM Enterprise PL/I for z/OS and run with the supported run-time library (Language Environment). You can reach this ideal state gradually, by starting with a run-time migration followed by a compiler migration.

The remainder of this chapter explains when and why you might want to migrate your applications (run-time or source). It includes the following topics:

- Migration basics
- Migration Roadmap
- Service support for OS PL/I and PL/I for MVS & VM.

### Terminology clarification

In this book, we use the term Enterprise PL/I as a general reference to:
- IBM Enterprise PL/I for z/OS Version 3 Release 5

In this book, we use the term PL/I as a general reference to:
- OS PL/I
- PL/I for MVS & VM
- VisualAge PL/I
- Enterprise PL/I

Also, in this book, we refer to the ‘old’ and ‘new’ PL/I compilers in the course of the discussions. For the purposes of this book, the ‘old’ PL/I compilers refer to
- OS PL/I V3R2 and before
- PL/I for MVS & VM

while the ‘new’ PL/I compilers refer to
- VisualAge PL/I
- Enterprise PL/I

### Important Migration Note:

It is important to understand, from the very beginning, that the ‘old’ and ‘new’ PL/I compilers are completely different from each other. The ‘new’ PL/I compilers are written in PL/I, and do not make use of certain techniques that the ‘old’ PL/I compilers did. They are so different, in fact, that from the perspective of Language Environment they are considered different languages, each with its own signature CSECT.

In the past, migrating from an ‘old’ PL/I compiler to another ‘old’ PL/I compiler was not that difficult. With the introduction of the new Enterprise PL/I compiler the migration process may be much more complicated than before. Migrating to the ‘new’ Enterprise PL/I compiler must be a well researched, planned and executed project if you wish to have a smooth transition.
Migration basics

The migration process involves run-time migration (moving your applications to a new run-time) and compiler migration (compiling your source programs with the new compiler). As part of the migration process, you’ll also need to do inventory assessment and testing. As stated previously, you are not required to migrate your run-time and source concurrently.

For more details on the migration process, see “General conversion tasks” on page 10.

For information on performing an inventory assessment and test plan, see “Take an inventory of your applications” on page 16.

Run-time migration - Moving to Language Environment

Every PL/I program requires run-time library routines to execute.

Do not make more than one PL/I run-time library available to your applications at execution time. For example, there should be one and only one PL/I run-time library, such as SCEERUN for Language Environment, in LNKLIST. If you have more than one you will either get hard-to-find errors or you will have an unused load library in your concatenation. In addition, if you have more than one run-time library in your concatenation, then you have an invalid configuration that is not supported by IBM.

If you have not already moved to Language Environment and are using a pre-Language Environment PL/I compiler, such as OS PL/I V2R3, you will need to read Chapter 3, “Planning the move to Language Environment,” on page 15.

If you have already moved to Language Environment and are migrating to the new IBM Enterprise PL/I for z/OS compiler, you can begin reading about compiler migration in Chapter 4, “Planning to move to the new compiler,” on page 23.

Compiler migration

It is strongly recommended that you recompile all your source with the new Enterprise PL/I compiler (unless you have already recompiled all your source with VisualAge PL/I). Since the Enterprise PL/I compiler is a completely different compiler from the ‘old’ PL/I compilers, recompiling your source would be the best way to avoid the limitations imposed by mixing ‘new’ PL/I with ‘old’ PL/I object and load modules.

Compiler migration can be done all at once or by separate execution units. How to divide up your PL/I source into separate execution units is described in “Partitioning PL/I source programs into units of execution” on page 123.

If you decide to mix old PL/I modules with Enterprise PL/I modules, there are limited circumstances in which this mix will work. These limitations are described in “Object and load module considerations” on page 121.

In a few cases, some changes to your code will be necessary when moving from OS PL/I to Enterprise PL/I. These cases are described in Chapter 13, “Understanding when working code must be changed,” on page 97 and Chapter 14, “Understanding when working code may need to be changed,” on page 105.
If you have already moved to Language Environment and are migrating to the new IBM Enterprise PL/I for z/OS compiler, you can begin reading about migrating to the new compiler in Chapter 4, “Planning to move to the new compiler,” on page 23.

If you are migrating to the PL/I for MVS & VM compiler, you should be using the IBM PL/I for MVS & VM Compiler and Run-Time Migration Guide.

Migration Roadmap

Here is a short summary of migration possibilities.

• If you are migrating from OS PL/I or PL/I for MVS & VM and
  – Are NOT currently migrated to Language Environment then
    - If you intend to migrate to Language Environment and then to Enterprise PL/I for z/OS, you want to begin with Chapter 3, “Planning the move to Language Environment,” on page 15 and then continue with Part 3, “Moving existing applications to Language Environment,” on page 29.
    - If you are migrating from OS PL/I we recommend migration to PL/I for MVS & VM first, in which case you would use the IBM PL/I for MVS & VM Compiler and Run-Time Migration Guide.
  – If you have already migrated to Language Environment then
    - If you intend to migrate to Enterprise PL/I for z/OS, you want to begin with Chapter 2, “Introducing the new compiler and run-time,” on page 7 and then continue with Chapter 4, “Planning to move to the new compiler,” on page 23 and Part 4, “Moving to the new compiler,” on page 59.

• If you are migrating from VisualAge PL/I or an earlier release of Enterprise PL/I, then
  – You will want to review Part 4, “Moving to the new compiler,” on page 59 paying special attention to Chapter 19, “Moving from VisualAge PL/I or Enterprise PL/I V3R1, V3R2, V3R3 or V3R4 to Enterprise PL/I V3R5,” on page 125.
  – Additional information concerning subsystems can be found in Part 5, “Subsystem and other language considerations,” on page 133.

Service support for OS PL/I and PL/I for MVS & VM

Note: The CICS TS (Transaction Server) release that follows CICS TS Version 2 Release 2 will not support OS PL/I modules. You must move from OS PL/I to an LE-enabled PL/I compiler to use CICS after CICS TS V2 R2.

IBM will continue to provide service support for the execution of programs compiled with the OS PL/I compiler when these programs use the Language Environment run-time library versions of the PL/I library routines.

For more information about this support and its restrictions, refer to Chapter 7, “Object and Load Module Considerations,” on page 47.
Chapter 2. Introducing the new compiler and run-time

This chapter provides an overview of the Enterprise PL/I compiler, (IBM Enterprise PL/I for z/OS) and the common run time (Language Environment) and introduces you to the terminology used throughout this book. This chapter includes information on the following:

- Product relationships - compiler, run-time, debug
- General PL/I compiler information
- Language Environment’s run-time support for other programs
- Advantages of the new compiler and run-time
- Major changes with the new compiler and run-time
- General conversion tasks

Product relationships - compiler, run-time, debug

IBM Enterprise PL/I for z/OS is IBM’s strategic PL/I compiler for the zSeries platform. Enterprise PL/I is comprised of features from OS PL/I, PL/I for MVS & VM, and VisualAge PL/I with additional features such as Unicode support, XML parsing capabilities, improved C and Java interoperability, integrated CICS preprocessor, and integrated SQL preprocessor.

Language Environment provides a single language run-time environment for COBOL, PL/I, C, and FORTRAN. In addition to support for existing applications, Language Environment also provides common condition handling, improved interlanguage communication (ILC), reusable libraries, and more efficient application development of interlanguage applications. Application development is simplified by the use of common conventions, common run-time facilities, and a set of shared callable services. Language Environment is required to run Enterprise PL/I programs.

Debug Tool provides significantly improved debugging function over previous PL/I debugging tools, and you can use it to debug Enterprise PL/I programs and other Language Environment-conforming language programs including COBOL and C/C++.

Debug Tool is included with the full-function version of the compiler.

General PL/I compiler information

You must have access to Language Environment when you compile your Enterprise PL/I application. When you compile your application and you use existing JCL, be sure your STEPLIB or JOBLIB statement includes SCEERUN (Language Environment run-time library) or that SCEERUN is in LNKLST. You can use the IBMZC cataloged procedure to compile PL/I applications.

Your compile step should include the following:

```plaintext
//PL1 EXEC PGM=IBMZPLI,REGION=4000K
//STEPLIB DD DSN=&LNGPRFX;.SIBMZCMP,DISP=SHR
//                   DD DSN=&LIBPRFX;.SCEERUN,DISP=SHR
```
Reading about the cataloged procedures provided with Enterprise PL/I can help you understand the use of SCEERUN during compilation. See “Using PL/I Cataloged Procedures” in Enterprise PL/I for z/OS Programming Guide for more details.

When you link-edit your Enterprise PL/I application with Language Environment and you use existing JCL, be sure your SYSLIB statement includes SCEELKED (Language Environment link-time library).

Language Environment’s run-time support for other programs

Enterprise PL/I uses Language Environment as its run-time environment.

Language Environment is the common run-time environment for the following language compilers:

- C/370
- C/C++
- COBOL for MVS & VM
- COBOL for OS/390 & VM
- Fortran
- PL/I for MVS & VM
- Enterprise PL/I

It provides a common set of run-time options and callable services. It also improves interlanguage communication (ILC) between high-level languages (HLL) and assembler by eliminating language-specific initialization and termination on each ILC invocation. Language Environment provides compatibility support for existing applications with a few restrictions.

Advantages of the new compiler and run-time

The new IBM Enterprise PL/I for z/OS compiler has many new features and advantages, including the following:

- FETCH improvements:
  - FETCHed routines may FETCH other routines
  - FETCHed routines can perform same I/O as MAIN
  - FETCHed routines may have their own CONTROLLED
- 31 digit DECIMAL and PICTURE precision
- Increased limits:
  - internal and external names may have up to 100 characters
  - no compiler limit on the number of FILEs and CONTROLLED variables
  - up to 4095 parameters allowed per PROCEDURE
- Support for many new 390 instructions (such as AHI and ALCR)
- Support for writeable reentrant static and DLLs
- Easier compatibility and interoperability with C/C++
- Better integer support:
  - maximum precision of 63 for signed FIXED BIN
  - UNSIGNED attribute supported (with a maximum precision of 64)
  - signed FIXED BIN(7) mapped to one byte (as is UNSIGNED FIXED BIN(8))
- Many powerful new language features, including:
  - PACKAGEs (the ANSI alternative to secondary ENTRYs)
  - DO FOREVER (as a good alternate to DO WHILE( i = 1 ); )
Delimiting strings with " (double quotes)
- Using underscores to make constants more readable (e.g. ’0011_0101’b )
- Compound assignments (e.g. x += 1;)
- RESIGNAL (for more powerful exception handling)

- Many powerful new attributes, including:
  - ABNORMAL (like volatile in C)
  - NONASSIGNABLE (like const in C)
  - BYVALUE
  - LIMITED ENTRY (for C function pointers)
  - ORDINAL (for strongly-typed enums)
  - RESERVED (for C-like static)
  - UNION
  - UNSIGNED
  - VALUE (for named constants)
  - VARYINGZ (for C-style null-terminated strings)

- Over 100 new built-in functions, including:
  - HEX and HEXIMAGE (for debugging)
  - PROCNAME and SOURCELINE (for tracing)
  - PLIMOVE, PLIFILL and COMPARE (like memcpy, memset and memcmp)
  - IAND, IOR, IEOR and NOT (for bitwise integer operations)
  - COPY (the “nice” REPEAT as defined by ANSI)

- Full z/OS UNIX System Services support, including
  - Source, object and listing files in HFS
  - I/O to HFS files

- Improved macro facility:
  - Deck file preserves case of source
  - Macro variables may now be arrays
  - Many more built-in functions supported
  - Support for the ANSWER statement
  - WHILE, UNTIL and LOOP keywords supported in %DO statements
  - SELECT statement supported (in open code and in macros)
  - ITERATE statement supported
  - LEAVE statement supported
  - REPLACE statement supported

- Support for Multithreading
- Support for UTF-16 Unicode
- Support for IEEE floating-point
- SAX-style XML parsing
- XML generation
- Integrated CICS Preprocessor
- Integrated SQL Preprocessor

For more information on these items see the PL/I Language Reference and the Enterprise PL/I for z/OS Programming Guide.

Major changes with the new compiler and run-time

With Enterprise PL/I, you will find that existing PL/I applications are affected by several areas such as removed or changed compiler options, different default compiler options, and restrictions in combining old and new load modules.
The following list of concerns is merely a representative list that reflects what has been important to some customers. It may not indicate what is important to any one individual customer. More details are provided in the rest of this book.

- Enterprise PL/I supports only Language Environment releases currently in support.
- Enterprise PL/I has no support for VM.
- Enterprise PL/I has no support for multitasking (but it does support multithreading).
- Code that is incorrect or invalid (for instance, code that uses uninitialized variables) may not run the same. This may not seem like an important problem, but it has been a significant issue for most of the customers that have migrated.
- You may need to specify some non-default options to get the most compatible behavior from the compiler and to get the best performance from the compiler.
- Programs may need to be tuned for optimal performance. In particular, the use of the runtime option RPTSTG(ON), while useful when tuning, is much more costly now to leave on in a production program.
- Recompiling all your PL/I source is recommended. If this isn’t done, you need to carefully select the compiler options for compiling Enterprise PL/I code that will be mixed with older PL/I objects. You will also need to divide your source into partitions according to how they use FILEs, CONTROLLED variables and conditions. For more information, see “Object and load module considerations” on page 121.

General conversion tasks

Depending on your shop’s needs, you will most likely need to complete one or more of the general conversion tasks, which include:

- Planning your strategy
- Moving to the Language Environment run-time library
- Recompiling your source with Enterprise PL/I
- Adding Enterprise PL/I programs to existing applications

Planning your strategy

Before moving to the Language Environment run-time library or recompiling your source programs with Enterprise PL/I, develop a conversion strategy. A thorough strategy will help ensure a smooth transition to the new compiler and run time.

Your conversion strategy might be to move to Language Environment, and then gradually recompile your existing applications with Enterprise PL/I as needed. This book provides separate strategies for moving to the new run time and for recompiling your PL/I source.

If you are not currently on Language Environment and want information on how to plan your move, see Chapter 3, “Planning the move to Language Environment,” on page 15.

If you have already moved to Language Environment and want information on moving to the new compiler, see Chapter 4, “Planning to move to the new compiler,” on page 23.
Moving to the Language Environment run time

You can run existing load modules under Language Environment and receive the same results as with pre-Language Environment libraries. For important compatibility information, see Chapter 5, “Running existing applications under Language Environment,” on page 31.

For information on moving applications that are running under older PL/I run-times, see Chapter 6, “Considerations Before Migrating,” on page 35.

In almost all cases, you will need to link-edit existing applications with Language Environment or recompile programs with Enterprise PL/I. To determine which programs require link-editing with Language Environment, see Chapter 8, “Link-Edit Considerations,” on page 51.

Recompiling your source with Enterprise PL/I

The new Enterprise PL/I compiler has many powerful, new features of which you may want to take advantage. There are also some differences between this new compiler and the previous PL/I compilers.

To read about the differences between the Enterprise PL/I compiler and the previous PL/I compilers, see Chapter 10, “Understanding the limitations of the new compiler,” on page 61.

To find out more about the new compiler options, see Chapter 11, “Understanding the new compiler’s options,” on page 71.

To determine which programs must be changed and then recompiled with Enterprise PL/I, see Chapter 13, “Understanding when working code must be changed,” on page 97 and Chapter 14, “Understanding when working code may need to be changed,” on page 105.

Adding Enterprise PL/I programs to existing applications

You can create new Enterprise PL/I programs (or recompile existing programs with Enterprise PL/I) and run them with existing applications under Language Environment.

When adding Enterprise PL/I programs to existing applications, you need to be aware of the limitations of mixing old and new PL/I modules. For details, see Chapter 18, “Adding Enterprise PL/I programs to existing PL/I applications,” on page 121.
Part 2. Conversion Strategies
Chapter 3. Planning the move to Language Environment

This chapter describes a general strategy for moving your run-time environment to Language Environment. The following tasks are necessary, and should be performed in roughly the following order:

- Prepare to move to the Language Environment run-time library
- Take an inventory of your applications
- Decide how to phase in Language Environment
- Set up a regression testing procedure
- Cut over to production use

If you have already moved to Language Environment you do not need to read this chapter and can proceed to reading about planning for the new compiler in Chapter 4, “Planning to move to the new compiler,” on page 23.

Important
- Enterprise PL/I programs can only run with the Language Environment element of z/OS Version 1 Release 3 or later.

Prepare to move to the Language Environment run-time library

In preparing to move to Language Environment, you need to perform the following tasks, which can be done concurrently:
- Install Language Environment
- Educate your programmers about Language Environment
- Assess storage requirements.

Installing Language Environment

On z/OS
To install z/OS, including the Language Environment element, refer to either the z/OS Program Directory or consult your ServerPac: Installing Your Order.

On OS/390
To install OS/390, including the Language Environment element, refer to either the OS/390 Program Directory or consult your ServerPac: Installing Your Order.

Important: To ensure that the Language Environment run-time results are compatible with pre-Language Environment results, you may need to change the default run-time options. See “Differences in Run-Time Options” on page 35 for more details.

Assessing storage requirements

Storage requirements for Language Environment are larger than for pre-Language Environment PL/I libraries.
DASD storage requirements

During conversion you will need DASD storage for the Language Environment run-time as well as any pre-Language Environment run-time libraries. When you have finished moving to Language Environment, you will be able to free the storage reserved for the previous PL/I run-time libraries.

To determine the amount of DASD storage required by Language Environment, see:

- On z/OS: z/OS Program Directory
- On OS/390: OS/390 Program Directory

Virtual storage requirements

Virtual storage requirements for running PL/I programs with Language Environment will increase over the OS PL/I run-time. For both CICS and non-CICS applications, the amount of increase depends on many factors, such as:

- The values used for the Language Environment run-time storage options: STACK, LIBSTACK, HEAP, ANYHEAP, BELOWHEAP.
- The value used for the Language Environment run-time option ALL31.
- Which run-time routines are in the LPA (link pack area) or the ELPA (extended link pack area)

Note: You can use the information generated by the Language Environment RPTSTG(ON) run-time option to help tune your storage options during the tuning phase. For details, see the z/OS Language Environment Programming Reference. Be sure to reset this option to RPTSTG(OFF) before putting the PL/I application into production, as it will greatly worsen performance.

Educating your programmers about Language Environment

Before moving to Language Environment, ensure that your application programmers are familiar with the features of Language Environment and the differences between the pre-Language Environment run-time and the Language Environment run time.

Once your programmers are familiar with Language Environment, they can better prepare for the move to Language Environment. For example, they can assist in taking an inventory of applications.

For information on Enterprise PL/I and Language Environment education available through IBM, you can call 1-800-IBM-TEACH. You can also get information directly from Language Environment publications, from user groups (such as SHARE), and from the Web at www.ibm.com/s390/le.

Take an inventory of your applications

While planning your move to the Language Environment run time, you need to take a comprehensive inventory of the applications that you intend to run on Language Environment. Include in this inventory:

- Vendor tools, packages, and products
- PL/I applications

The Edge Portfolio Analyzer can aid in taking an inventory of your existing load modules. See “EDGE Portfolio Analyzer” on page 152 for more information.
Vendor tools, packages, and products

Before you can begin moving your run time to Language Environment, you need to know if your vendor tools, packages, and products are designed to run under Language Environment. Verify that:

- All packages will run under Language Environment, especially if you do not have the source code for them.
- Source code for packages, if you do have the source, is able to be compiled with the Enterprise PL/I compiler.
- Code generators generate source code that is able to be compiled with the Enterprise PL/I compiler.
- Development tools and debuggers that issue their own ESPIE or ESTAE coordinate with Language Environment.

For information on how to obtain a list of vendor products that are enabled for Language Environment, see “Vendor products” on page 152.

PL/I applications

When taking an inventory of your PL/I applications, you need to gather information about the program attributes that affect moving to Language Environment. This information includes how and what to test and what will affect performance under Language Environment. For your inventory, determine:

For moving your applications to Language Environment:
- Which programs have been compiled with OS PL/I and which programs have been compiled with PL/I for MVS & VM
- Which programs have been linked with PL/I shared libraries
- Run-time options used (and how specified)
- Which PL/I programs call or are called by assembler programs
- Which PL/I programs are multitasking.
- Which PL/I programs use interlanguage communication (COBOL, C, or FORTRAN)
- Which PL/I programs are used under CICS, IMS, DB2, or other subsystems
- Frequency and types of abends expected

For regression testing:
- Test cases required and available

For performance measurements:
- Amount of storage used
- Frequency of execution of reusable/common modules
- Program execution time (both CPU and elapsed)

Existing PL/I load modules

Knowing what versions of PL/I load modules you have in your libraries is important in planning your migration to Language Environment. As mentioned above, the Edge Portfolio Analyzer can aid in taking an inventory of your existing load modules.

Another tool that will give you some information about your load modules is the AMBLIST utility. AMBLIST is provided by IBM and is usually found in SYS1.LINKLIST. Using the LISTIDR control statement you can obtain listings of
selected CSECT identification records (IDR). One of the fields in the IDR contains the name of the translator, or compiler in the case of PL/I, that was used to compile the CSECT. Sample output from AMBLIST would look like this:

<table>
<thead>
<tr>
<th>CSECT</th>
<th>TRANSLATOR</th>
<th>VR.MD</th>
<th>YR/DY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MYPL1</td>
<td>5655-H31</td>
<td>32.00</td>
<td>2003/171</td>
</tr>
<tr>
<td>MYPL12</td>
<td>5655-B22</td>
<td>22.01</td>
<td>2001/073</td>
</tr>
<tr>
<td>D1</td>
<td>566896201</td>
<td>02.01</td>
<td>1972/271</td>
</tr>
<tr>
<td>UNRES</td>
<td>566896201</td>
<td>02.01</td>
<td>1992/034</td>
</tr>
</tbody>
</table>

Using the text in the TRANSLATOR column you can determine which PL/I compiler created the module. Refer to Table 3 for the Translator field values for the various PL/I compilers.

Table 3. PL/I compiler IDR values

<table>
<thead>
<tr>
<th>PL/I Compiler Version</th>
<th>Translator Identification Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS PL/I V1.5</td>
<td>5743-PL1</td>
</tr>
<tr>
<td>OS PL/I V2.3</td>
<td>5668-910</td>
</tr>
<tr>
<td>PL/I for MVS &amp; VM</td>
<td>5688-235</td>
</tr>
<tr>
<td>VisualAge PL/I for OS/390 V2R2</td>
<td>5655-B22</td>
</tr>
<tr>
<td>Enterprise PL/I for z/OS Version 4</td>
<td>5655-H31</td>
</tr>
</tbody>
</table>

Decide how to phase in Language Environment

When you are ready to use Language Environment in production mode, you need to:

- Determine how to handle multilanguage conversion
- Determine how applications will have access to the library

Multilanguage conversion

If you have PL/I applications with ILC, move them to the Language Environment run time after you have converted each of the languages involved. For example, move a PL/I-COBOL application to Language Environment after you have moved your PL/I-only and COBOL-only applications to Language Environment.

Note: Do not install two different libraries for a given language in LNKLST/LPALST. For example, if you install Language Environment with the PL/I component in LNKLST/LPALST, do not have the OS PL/I library or the PL/I for MVS & VM library installed in LNKLST/LPALST.

After Language Environment has been installed in LNKLST, all of your PL/I applications will run under Language Environment by default.

Determining how applications will have access to the library

Two general methods are available for moving Language Environment into production: adding Language Environment to the LNKLST/LPALST or using a STEPLIB approach.

LNKLST/LPALST

After you add Language Environment to the LNKLST/LPALST, Language Environment is available to all of your applications. To ensure that all applications are functioning correctly under Language Environment before adding Language
Environment to your LNKLST/LPALST, you can temporarily install Language Environment in LNKLST/LPALST or use STEPLIB.

Do not make more than one PL/I run-time library available to your applications at execution time. For example, there should be one and only one PL/I run-time library, such as SCEERUN for Language Environment, in LNKLST. If you have more than one, you will either get hard-to-find errors or you will have an unused load library in your concatenation. When you add Language Environment to LNKLST/LPALST, remove any other PL/I run-time libraries.

**Temporary installation in LNKLST/LPALST or use STEPLIB:** Suggestions for temporarily installing Language Environment in LNKLST/LPALST include:

- Install Language Environment in LNKLST/LPALST on a test or development machine first.
- Use the SETPROG MVS system command to temporarily modify the LNKLST or LPA, without having to IPL the system. For information on using the SETPROG command, see z/OS MVS System Commands, SA22-7627 or OS/390 MVS System Commands, GC28-1781.
- IPL over a weekend and install Language Environment in LNKLST/LPALST. Verify over the weekend that your applications run under Language Environment.

**Note:** Although many elements of z/OS and OS/390 depend on the Language Environment run-time library, both z/OS and OS/390 do not require Language Environment to be installed in LNKLST. (However, Language Environment must be installed in the same zone as z/OS and OS/390.) If you choose not to place Language Environment in LNKLST, you must STEPLIB Language Environment in the individual z/OS or OS/390 PROCs that required Language Environment. For information on which elements require Language Environment, see:

- z/OS Program Directory for z/OS Version 1 Release 1 or OS/390 Program Directory for OS/390 Version 2 Release 10

**STEPLIB**

You can choose to phase in Language Environment gradually by using the STEPLIB approach. When you STEPLIB to the Language Environment run time, you phase in one region (CICS or IMS), batch (group of applications), or user (TSO) at a time.

Although using STEPLIB means changing your JCL, a gradual conversion can be easier than moving all of your applications at one time. Also note that when using STEPLIB, programs will run slower than when they access the run-time library through LNKLST/LPALST and more virtual storage will be used.

**Note:** If you have multiple processors linked together with channel-to-channel connections, you must treat the entire system as one processor and should convert subsystem by subsystem. In addition to revising your JCL to STEPLIB to the Language Environment run time during initial setup, you might also need to specify CEEDUMP DD if the default allocation for CEEDUMP does not meet your shop’s needs. (CEEDUMP is the ddname where Language Environment writes its dump output.)

**Problems with STEPLIB and IMS programs**

When you use STEPLIB on IMS/DC online to access the Language Environment run time, any Language Environment library routines that you have preloaded will
not be loaded into read-only storage. If your application has an error and overwrites non-application storage, preloaded run-time routines can become corrupted and eventually cause abends when used. At refresh time, these preloaded routines marked reentrant are not refreshed unless loaded from the LPA or the LNKLST/LPALST. Thus, the abends will recur.

**Note:** This is a 20-year-old problem with MVS (OS/390), IMS, and STEPLIB, and is mentioned here because of the proposed STEPLIB approach for gradually moving to Language Environment.

You can use either of the following methods to prevent this problem:
- Install Language Environment into the LNKLST/LPALST.
- Do not preload any run-time routines. (This will slow performance.)

**How to minimize the impact:**
- Keep your certification of Language Environment as short as possible. (The sooner it is certified, the sooner you can install in LNKLST/LPALST.)
- Watch for different applications abending in the same region, which would indicate that you need to follow the recovery procedure.

**How to recover:** If you do notice several different applications abending in the same region, stop the region and restart with these IMS commands:
1. Determine the region number by issuing: `/DISPLAY ACTIVE`
2. Stop the region by issuing: `/STOP REGION region#`
3. Restart the region by issuing: `/START REGION region-name`

**STEPLIB example**

Here is one example of how to phase in Language Environment using the STEPLIB method: for an organization that has a central development center (all compiling and linking is done in one location) and separate production sites. This is a very conservative approach, but it has been used by many customers who require absolutely no disruption in production applications.

   - Run tests with captured data on your current run time, and save all results.
   - Install Language Environment in a STEPLIB environment. This means that unchanged jobs will run with your current run time, and that some users can use the Language Environment run time by using STEPLIB JCL to access the Language Environment run-time library.
   - Run tests with captured data on the Language Environment run time, using the STEPLIB environment, and compare the results to your current run time. Run parallel tests throughout the certification cycle to ensure that your applications produce the same results when run with Language Environment as they did with your current run time.
   - Finally, compile your test applications using Enterprise PL/I. STEPLIB to the Language Environment run-time library, and rerun the certification tests.

2. Install Language Environment on the central development center’s system and test.
   - Run parallel tests of the nonconverted versions of your existing applications using STEPLIB to access your current run time.
   - Run all new applications in the Language Environment run-time environment before releasing to production runs.

3. Prepare a backout strategy
• Save the procedures for installing your current run time in case you need to back out the Language Environment run time.

4. Install the Language Environment run time at one production site.
• Continue to run parallel tests of the nonconverted versions of your existing applications with your current run time in the STEPLIB environment.
• Run the Language Environment run time for one month at this production site.

5. Install the Language Environment run time at all production sites.
• Optional: continue to run parallel tests of the nonconverted versions of your existing applications with your current run time in the STEPLIB environment.
• Run the Language Environment run time for one month at all production sites.
• After one month, delete the entire contents of your current run time library.

Try to move the largest units of work that you can. Moving entire online regions, applications, or run units at once ensures that interactions between programs within an application or run unit can be tested.

Set up a regression testing procedure

Although most applications will run under Language Environment with the same results as on their existing run-time, results could differ depending on coding styles, resource utilization, performance, abend behavior, or more strict adherence to IBM conventions in Language Environment. For information on situations where existing code may behave differently, see Chapter 14, “Understanding when working code may need to be changed,” on page 105.

Because there are so many possible combinations of coding techniques, the only way to determine if your applications will run under Language Environment and receive the expected results, is to set up a procedure for regression testing. Move your applications to a test environment, and ensure that you receive the expected results when running under Language Environment.

Regression testing will help to identify if there are:
• Source code changes required as indicated in Chapter 14, “Understanding when working code may need to be changed,” on page 105.
• Storage usage differences between your current run time and the Language Environment run time.
• CPU time differences between your current run time and the Language Environment run time.

During testing, run your existing applications in parallel on both your current run time and under the Language Environment run time to verify that the results are the same. Take performance measurements of your existing applications to compare with Language Environment.

After the program runs correctly, test it separately and also test it with other programs in a run unit. By testing it against a variety of data, you can exercise all the program processing features to help ensure that there are no unexpected execution differences.
Analyze program output and, if the results are not correct, use Debug Tool or Language Environment dump output to uncover any errors and correct those errors. Make any further changes that you need and then rerun, and, if necessary, continue to debug.

**Take performance measurements**

After your applications are running under Language Environment in a test environment, take performance measurements—especially on any time-critical or response-critical applications.

After you compare run-time performance between Language Environment and your current run time environment and have identified which applications, if any, need performance improvements, you can investigate the methods available to tune your programs and improve performance. For example, you can modify storage values using the Language Environment run-time options.

---

**Cut over to production use**

When your testing shows the entire application (or group of applications, if running more than one application in an IMS region, or on TSO) receives the expected results, you can move the entire unit over to production use. However, in case of unexpected errors, be prepared for recovery:

- Under z/OS and OS/390, run the old version as a substitute from the latest productivity checkpoint.
- Under DB2, CICS, and IMS, return to the last commit point and then continue processing from that point using the unmigrated PL/I program. (For DB2, use an SQL ROLLBACK WORK statement.)
- For batch applications, use your shop’s backup and restore facilities to recover.

After you move your existing applications to production use under the Language Environment run time, monitor your applications for a short time to ensure that they continue to work properly. Then, you can run with the confidence that you had in your previous run time.
Chapter 4. Planning to move to the new compiler

This chapter describes a general strategy for moving your source programs to Enterprise PL/I. The following tasks are necessary, and should be performed in roughly the following order:

1. Prepare to move your source to the new compiler
2. Take an inventory of your applications.
3. Make application program updates.

Because of the loss of service support for older PL/I compilers, you should eventually move all of your PL/I source programs to the new compiler. Although this is not an immediate requirement, at some future date the older compilers and any supported fixes will not be available. At that point, you will be forced to do a ‘quick’ migration, and this might be a very inconvenient time.

Before you can move your source programs to the new compiler, you must move your applications to Language Environment.

Prepare to move your source to the new compiler

In preparing to move your source to the new Enterprise PL/I compiler, you need to perform the following tasks, which can be done concurrently:

• Install Enterprise PL/I
• Assess storage requirements
• Educate your programmers on new compiler features

Installing Enterprise PL/I

If you haven’t already done so, install the compiler:

• For z/OS or OS/390, see the Program Directory for your product.

Assessing storage requirements

Enterprise PL/I object programs may execute in 31-bit addressing mode and can reside above the 16-MB line, which frees storage below the 16-MB line. You can use the freed storage for programs or data that must reside below the 16-MB line.

During the compiler migration, you will need DASD storage for your current PL/I compilers as well as for the Enterprise PL/I compiler. When you have completed the compiler migration, and if you have moved all of your OS PL/I, PL/I for MVS & VM, or VisualAge PL/I programs to Enterprise PL/I, you will be able to free the storage reserved for your current PL/I compiler.

The load module produced from the same source code when compiled with Enterprise PL/I may be larger than when compiled with OS PL/I or PL/I for MVS & VM.

Educating your programmers on new compiler features

Early in the conversion effort, ensure that your application programmers are familiar with the features of Enterprise PL/I and the relationship and interdependencies between Enterprise PL/I, Language Environment, and Debug Tool and any other application productivity tools your shop uses.
In addition, your programmers will need to be familiar with Language Environment run-time options, condition handling and callable services.

Choosing the right compiler options for your environment is a critical task. The options you choose can vary widely depending on whether you are looking for optimum performance or maximum compatibility with previous versions of PL/I. For more information on choosing compiler options see Chapter 11, “Understanding the new compiler’s options,” on page 71.

For information on Enterprise PL/I and Language Environment education available through IBM, you can call 1-800-IBM-TEACH. You can also get information directly from Language Environment publications or technical conferences such as SHARE, or the IBM Technical Interchange.

After your programmers are familiar with Enterprise PL/I features, they can assist you in taking the inventory of programs as described in “Take an inventory of your applications.”

**Take an inventory of your applications**

In planning to move your PL/I source programs to Enterprise PL/I, you need to take a comprehensive inventory of applications in which you have programs that you intend to compile with Enterprise PL/I. By taking an inventory of your applications, you get a detailed picture of the work that is required. You need to take an inventory of:

- Vendor tools, packages, and products
- PL/I applications

The Edge Portfolio Analyzer can aid in taking an inventory of your existing load modules, see “EDGE Portfolio Analyzer” on page 152 for more information.

**Taking an inventory of vendor tools, packages, and products**

Before you can begin moving your source, you need to know if your vendor tools, packages, and products are designed to work with Enterprise PL/I. Verify that:

- PL/I code generators generate PL/I programs that can be compiled with Enterprise PL/I.
- PL/I packages can be compiled with Enterprise PL/I.

**Taking an inventory of PL/I applications**

For each program in your PL/I applications, include at least the following information in your inventory:

**OS PL/I, PL/I for MVS & VM and VisualAge PL/I:**

- Programmer responsible
- Compiler used
- Compiler options used, especially CMPAT
- Precompiler options used
- PL/I modules
- INCLUDE library members used in PL/I programs
- Called or FETCHed subprograms
- Calling or FETCHing programs
- Frequency of execution
- Test cases required and available
If you are planning to mix ‘old’ PL/I modules with Enterprise PL/I modules, you will also want this information in your inventory:

- Use of CONTROLLED variables
- Use of FILE variables and constants

For information on the partitioning of PL/I source programs into units of execution based on the above information, see “Partitioning PL/I source programs into units of execution” on page 123.

Prioritizing your applications

Using the complete inventory, you can now prioritize the conversion effort.

1. Assign complexity ratings to each item in your completed inventory and determine each program or application’s resulting overall complexity rating.
2. Determine the conversion priority of each program or application.

Determining conversion priority

After you have determined the complexity rating for each program in your inventory, you can make informed decisions about the programs that you want to move to the new Enterprise PL/I compiler, and the order in which you want to move them.

Consider the following when deciding on conversion priorities:

- If your application is at the limits of the storage available below the 16-MB line, it is a prime candidate for conversion to Enterprise PL/I. With z/OS or OS/390 architecture you can obtain virtual storage constraint relief.
- If the program cannot run under Language Environment, you must convert it.

After you determine the priority of each program that you need to move and the effort required to move those programs, you can decide the order in which you want to convert your applications and programs.

Setting up move/no move categories

By using the conversion priorities that you have established, and taking into account program importance and frequency of execution, you can list most of your programs in the order that you want to convert them to Enterprise PL/I.

There might be some programs that you do not want to convert at all, such as:

- Programs for which you have no source code, that will never need recompilation, and that run correctly under Language Environment.
- Programs of low importance to your organization that run correctly under Language Environment and that would take a very high conversion effort.
- Programs that are being phased out of production.

Note, however, that there might be restrictions on running existing modules mixed with programs that have been moved to the new Enterprise PL/I compiler. See Chapter 18, “Adding Enterprise PL/I programs to existing PL/I applications,” on page 121.
Make application program updates

The following application programming tasks are necessary when converting your source. You must decide what size your program updates will be. For example, you can choose to update programs along with your regular maintenance, or you can divide your programs into functional groups and update the source group by group. Some customers have followed the 'big bang' process and have made all their program updates at once. However you decide to proceed, these tasks should be performed in roughly the following order:

Save the existing source as a back-up—a benchmark to compare to and a version to recover to—if the converted modules have problems.

1. Update the job and module documentation.
   It is extremely important that all updates be properly documented. PL/I itself is reasonably self-documenting. However, keep a log of the compiler options you specify and the reasons for specifying them. Also document any special system considerations. This is an iterative process and should be performed throughout the conversion programming task.

2. Update the available source code.
   Update the source code manually or with tools that you have developed. For information on when source code must or may need to be changed, see Chapter 13, “Understanding when working code must be changed,” on page 97 and Chapter 14, “Understanding when working code may need to be changed,” on page 105.

3. Compile, link-edit, and run.
   After the source has been updated, you can process the program as you would a newly written Enterprise PL/I program. (You need the Language Environment run time installed.) If, during the compile process, you see new messages and wish to understand them better, see Chapter 12, “Understanding the new compiler’s messages,” on page 85.

4. Debug.
   Analyze program output and, if the results are not correct, use Debug Tool or Language Environment dump output to uncover any errors.

5. Test the converted programs.
   After moving your source to Enterprise PL/I, set up a procedure for regression testing. Regression testing will help to identify:
   • Code that must be changed.
   • File attribute mismatches.
   • Storage initialization issues.
   • Performance differences.
   • AMODE issues.
   After you have established a regression testing procedure, and after your programs run correctly, test them against a variety of data:
   • Locally—each program separately
   • Globally—programs in a run unit in interaction with each other
   In this way, you can exercise all the program processing features to help ensure that there are no unexpected execution differences.
   The importance of regression testing cannot be stressed enough. You should consider the move from an ‘old’ PL/I compiler to Enterprise PL/I as a move to a different, though similar, language and plan your testing accordingly.

6. Repeat when necessary.
Make any further corrections that you need, and then recompile, relink, rerun, and, if necessary, continue to debug.

7. Cut over to production mode.

When your testing shows that the entire application receives the expected results, you can move the entire unit over to production mode. (This assumes your production system is already using the Language Environment run time. If not, STEPLIB to the Language Environment run time. See “STEPLIB” on page 19.)

In case of unexpected errors, be prepared for recovery:

- Under z/OS or OS/390, run the old version as a substitute from the latest productivity checkpoint.
- Under DB2 and IMS return to the last commit point and then continue processing from that point using the unmigrated PL/I program. (For DB2, use an SQL ROLLBACK WORK statement.)
- For non-CICS applications, use your shop’s backup and restore facilities to recover.

8. Run in production mode.

After cut over, monitor the application for a short time to ensure that you are getting the results expected. After that, your source conversion task is completed.
Part 3. Moving existing applications to Language Environment

<table>
<thead>
<tr>
<th>Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>This part is intended for users who are migrating from OS PL/I and are not currently on Language Environment. If you are currently using PL/I for MVS &amp; VM, VisualAge PL/I, or Enterprise PL/I you may go directly to Part 4, “Moving to the new compiler,” on page 59.</td>
</tr>
</tbody>
</table>
Chapter 5. Running existing applications under Language Environment

Depending on the characteristics of your applications, you might need to make application modifications and perform some of the following Language Environment customization tasks to ensure that your current applications run under Language Environment:

- Invoke existing applications
- Link-edit existing applications

Other factors also apply to ensure compatibility, depending on if you are moving your run-time from OS PL/I or PL/I for MVS & VM. For details, see:

- Chapter 6, “Considerations Before Migrating,” on page 35

Invoke existing applications

To access Language Environment you will need to change the procedures you use for invoking applications. The procedures required for non-CICS applications are different than the procedures for CICS applications.

Note: Make sure your program names do not begin with AFH, CEE, EDC, IBM, IGZ, ILB, or FOR. These prefixes are reserved for Language Environment library routine module names.

For non-CICS applications

The following sections detail the changes required for non-CICS applications. For more information on how to prepare and run your programs with Language Environment, see the z/OS Language Environment Programming Guide.

Specify the correct library

To invoke existing applications when running under Language Environment, you need to replace your current library with the Language Environment SCEERUN library.

Specify alternate DDNAMES (optional)

With Language Environment, you can indicate the destination for Language Environment output by changing the ddname in the MSGFILE run-time option to the ddname you want. Table 4 lists the default ddnames for Language Environment output.

<table>
<thead>
<tr>
<th>Output</th>
<th>Default ddname</th>
</tr>
</thead>
<tbody>
<tr>
<td>Messages</td>
<td>SYSOUT</td>
</tr>
<tr>
<td>Run-time options report (RPTOPTS)</td>
<td>SYSOUT</td>
</tr>
<tr>
<td>Storage reports (RPTSTG)</td>
<td>SYSOUT</td>
</tr>
<tr>
<td>Dumps</td>
<td>CEEDUMP</td>
</tr>
</tbody>
</table>

All of the ddnames in the above table are dynamically allocated.
You do not need to alter your JCL, CLISTs, or Rexx EXECs to define the ddnames for Language Environment messages, reports, or dumps unless the defaults used by Language Environment do not meet the needs of your shop. The Language Environment default destinations are:
- On z/OS and OS/390: SYSOUT=*  

**For CICS applications**

To run Language Environment on CICS, you need to perform several required steps. For details on how to invoke PL/I applications running on CICS under Language Environment, including how to specify the Language Environment run-time library SCEERUN, see:
- For z/OS, z/OS Language Environment Customization
- For OS/390, Language Environment for OS/390 Customization

**Output differences when using Language Environment on CICS**

Under CICS, Language Environment output goes to a transient data queue named CESE. Each record written to the file has a header that includes the terminal ID, the transaction ID, date, and time. The transient data queue (CESE) receives the following types of Language Environment output:
- Messages
- Run-time options report (RPTOPTS)
- Storage reports (RPTSTG)
- Dumps
- PL/I Stream output

**Link-edit existing applications**

After determining which of your existing applications either require or will benefit from link-editing with Language Environment, you need to specify the correct library name. The Language Environment link-edit library is the same for non-CICS applications as for CICS applications.

**Under z/OS and OS/390**

Include the Language Environment SCEELKED in the SYSLIB concatenation.

**Note:** If you link-edit with the NCAL linkage editor option, ensure that all of the required run-time routines from SCEELKED are included in the load module. Otherwise, unpredictable errors will occur (typically a program check).

There are some names in the SCEELKED library that do not follow IBM naming conventions, and that can conflict with your subprogram names. For example, if you have a statically called subroutine named DUMP and if SCEELKED is ahead of your private subroutine library in the concatenation at link-edit time, then your references to DUMP will be resolved in SCEELKED. In this example, the FORTRAN routine AFHUDUMS will be link-edited in, and you could get incorrect results, loss of function, or slower performance as a result. (Another common name is ABORT, which is an entry point in EDC4$05C, a C run-time library routine.)

There are a couple of ways to avoid these problems:
• You can check the names in the SCEELKED data set against the names of your private subroutines. If there are any duplicates, you can rename your private subroutines so that they do not have the same names as the names in the SCEELKED data set.

• Another way is to place your private subroutine libraries before SCEELKED in the SYSLIB concatenation. However, doing this could result in losing function that is available under Language Environment if your application contains Fortran or C/C++ programs. Changing the name of your subroutine to avoid the conflict with the Language Environment subroutine is preferable to placing your private subroutine libraries ahead of SCEELKED.

To determine which applications require link-editing with Language Environment, see Chapter 8, “Link-Edit Considerations,” on page 51.
Chapter 6. Considerations Before Migrating

Language Environment is now part of z/OS and OS/390 and you can start migrating your applications to Language Environment prior to installing a Language Environment-enabled PL/I compiler such as PL/I for MVS & VM, VisualAge PL/I or Enterprise PL/I. This chapter discusses the functional differences between OS PL/I run-time and Language Environment. These differences should be considered before migrating your applications to Language Environment.

Differences in Run-Time Options

Language Environment run-time options replace PL/I run-time options. Most PL/I run-time options have an equivalent Language Environment run-time option that provides the same function. This section describes differences in the use of run-time options.

You should adapt your applications to allow for the following differences:

**Deleted run-time options**

- The OS PL/I COUNT option is ignored.
- The OS PL/I FLOW option is ignored.
- The OS PL/I HEAP option is always in effect. This means that when you allocate storage for BASED and CONTROLLED variables, the storage always comes from HEAP storage. The storage does not come from a PL/I Initial Storage Area (ISA). HEAP(0) is not supported and, if used, is ignored.

**Replaced run-time options**

- The Language Environment NATLANG option replaces the OS PL/I LANGUAGE option.
- The Language Environment RPTSTG option replaces the OS PL/I REPORT option.
- The Language Environment TRAP option replaces both OS PL/I SPIE and STAЕ options. The following table shows how the OS PL/I SPIE and STAЕ options map to Language Environment’s TRAP option:

<table>
<thead>
<tr>
<th>OS PL/I</th>
<th>Language Environment</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPIE</td>
<td>NOSPIDE</td>
<td>TRAP(ON</td>
</tr>
<tr>
<td>STAЕ</td>
<td>NOSTAE</td>
<td>TRAP(ON</td>
</tr>
<tr>
<td>SPIE STAЕ or SPIE NOSTAE or STAЕ NOSPIDE</td>
<td>TRAP(ON)</td>
<td>If both SPIE</td>
</tr>
<tr>
<td>NOSPIDE NOSTAE</td>
<td>TRAP(OFF)</td>
<td></td>
</tr>
</tbody>
</table>

TRAP(ON) must be in effect for applications to run successfully.
Note: Applications performing their own condition management often conflict with Language Environment condition management. See your z/OS Language Environment Programming Guide for more information on Language Environment condition handling.

- The Language Environment STACK option replaces both OS PL/I ISASIZE and ISAINC options. You do not need to change and recompile source code that contains ISASIZE and ISAINC. In addition, object modules and/or load modules containing the PLIXOPT string will run under Language Environment with the ISASIZE and ISAINC honored as before.
  
  STACK(,,ANY) can be used for an OS PL/I application relinked with Language Environment that does not contain any edited stream I/O.
  
  Your application must run in AMODE(31) to use STACK(,,ANY).
  
  Under CICS, ALL31(ON) and STACK(,,ANY) are the defaults; however, because STACK(,,BELOW) is required for OS PL/I applications that have not been relinked with Language Environment, you must change the default to STACK(,,BELOW) during installation or explicitly specify STACK(,,BELOW) for any OS PL/I applications that have not been relinked.

New run-time options

- The Language Environment ABTERMENC option controls which type of return/abend code your application receives at abnormal termination.
  
  ABTERMENC(RETCODE) allows your application to receive a run-time return code, which is equivalent to the way OS PL/I worked.

- The Language Environment ERRCOUNT option limits the number of conditions that are handled at run time. ERRCOUNT(0) specifies that there is no limit, which is equivalent to the way the OS PL/I worked.

- The Language Environment DEPTHCONDLMT option limits the extent to which conditions can be nested. To maintain compatibility, specify DEPTHCONDLMT(0), which means there is an unlimited depth.

- The Language Environment XUFLOW option determines if the UNDERFLOW condition is raised when underflow occurs. XUFLOW(AUTO) preserves PL/I semantics with regard to raising the UNDERFLOW condition.

- The Language Environment ALL31 option controls AMODE switching among library routines. You should set ALL31(ON) if all of your applications are AMODE(31).

When you pass run-time options in the MVS GO step, your run-time options string must end with a slash (/) to distinguish it from a main procedure parameter string. If you omit the slash, the string is passed as the main procedure parameter.

The following run-time options are needed to provide compatibility with OS PL/I:

- ABTERMENC(RETCODE)
- ERRCOUNT(0)
- DEPTHCONDLMT(0)
- TRAP(ON)
- XUFLOW(AUTO | ON)

For more information about run-time options, see the z/OS Language Environment Programming Reference.
For OS PL/I applications, the options specified in the PLIXOPT string is processed as the application-specific options. If you provide the Language Environment CEEUOPT, CEEUOPT is ignored.

If the main load module contains ILC, the PLIXOPT string is ignored. In this case, you must provide CEEUOPT for the application-specific options.

### Differences in Condition Handling

#### Timing differences

PL/I condition handling semantics remain supported under Language Environment; however, the timing of issuing the run-time message for an ERROR condition with respect to the ERROR ON-Unit is different in the following way:

- The run-time message for an ERROR condition is issued only if there is no ERROR ON-Unit established, or if the ERROR ON-Unit does not recover from the condition by using a GOTO out of block. You can use a GOTO out of the ERROR ON-Unit to avoid a message for a PL/I ERROR condition.

For PL/I conditions whose implicit action includes issuing a message and raising the ERROR condition, the timing of issuing the message is unchanged.

Table 6 shows when the run-time message for an ERROR condition is issued under OS PL/I with respect to the ERROR On-Unit.

**Table 6. OS PL/I Version 2 Release 3 ERROR ON-Unit and Message for an ERROR condition**

<table>
<thead>
<tr>
<th>Condition</th>
<th>No ON-Units</th>
<th>ERROR ON-Unit No GOTO</th>
<th>ERROR ON-Unit GOTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERROR condition raised¹</td>
<td>Message</td>
<td>Message prior to ON-unit</td>
<td>Message prior to ON-unit</td>
</tr>
<tr>
<td>ZERODIVIDE condition raised²</td>
<td>Message</td>
<td>Message prior to ON-unit</td>
<td>Message prior to ON-unit</td>
</tr>
</tbody>
</table>

**Notes:**

1. Taking the square root of a negative number, data exception, etc.
2. With no ZERODIVIDE ON-unit; thus, implicit action is taken. Message is printed, ERROR condition is raised.

Table 7 shows when the run-time message for an ERROR condition is issued under Language Environment with respect to the ERROR On-Unit.

**Table 7. Language Environment ERROR ON-Unit and Message for an ERROR Condition**

<table>
<thead>
<tr>
<th>Condition</th>
<th>No ON-units</th>
<th>ERROR ON-unit No GOTO</th>
<th>ERROR ON-unit GOTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERROR condition raised¹</td>
<td>Message</td>
<td>Message after ON-unit</td>
<td>No message</td>
</tr>
<tr>
<td>ZERODIVIDE condition raised²</td>
<td>Message</td>
<td>Message prior to ON-unit</td>
<td>Message prior to ON-unit</td>
</tr>
</tbody>
</table>

**Notes:**

1. Taking the square root of a negative number, data exception, etc.
2. With no ZERODIVIDE ON-unit; thus, implicit action is taken. Message is printed, ERROR condition is raised.
The SNAP traceback message produced by ON ERROR SNAP continues to be issued before the ERROR ON-unit receives control. The SNAP traceback message is not identical to the regular ERROR message.

Unhandled condition differences
If your OS PL/I application used to force an abend for an unhandled condition under OS PL/I run-time using OS PL/I assembler user exit IBMBXITA or abend exit IBMBEER, use the following ways to force an abend under Language Environment:

- Run your application with Language Environment ABTERMENC(ABEND) option. You cannot specify your own abend code via the run-time option.
- Use Language Environment assembler user exit CEEBXITA to force an abend with your own abend code.

IBMBXITA and IBMBEER differences
Language Environment provides limited support for OS PL/I IBMBXITA and IBMBEER. See “Considerations for using assembler user exits” on page 136 for details.

ABEND U4039 differences
An UNHANDLED condition of severity 2 or higher now produces an abend U4039 and optionally a system dump if SYSUDUMP or SYSABEND ddname is present. If ABTERMENC(RETCODE) is in effect, your application continues the termination with an abend code. If you don’t want to see the U4039 abend, Language Environment provides you the facilities to suppress it.

See “Abnormal Termination Exit” in z/OS Language Environment Installation and Customization under OS/390 or z/OS Language Environment Customization for ways to suppress or change the U4039 abend.

Severity differences
Severities of some PL/I conditions are different under Language Environment. See PL/I Language Reference for the severities.

Differences in PLICALLA and PLICALLB Support
The interfaces in the following sections are not recommended for use under Language Environment.

PLICALLA Considerations
Language Environment provides support for OS PL/I applications that use the PLICALLA entry point. You can also relink your program under Language Environment. See “OS PL/I Routine Replacement Tool” on page 149 for details on how to relink an application under Language Environment.

You can use PLICALLA as the primary entry point of a FETCHed/CALLED PL/I main load module; however, the calling routine must pass only user arguments which are passed to a subroutine. If run-time options are passed, they are treated as user arguments.

If you develop a new PL/I application and you want the main procedure to receive user arguments like a subroutine, do one of the following:
- Receive control directly from IMS by
- Using CEESTART or PLISTART as the primary entry point of the load module
- Specifying the SYSTEM(IMS) compile-time option

• Receive control from an assembler program or a procedure using a FETCH or CALL statement by:
  - Using CEESTART or PLISTART as the primary entry point of the load module
  - Specifying the NOEXECOPS option and the SYSTEM(MVS) compile-time option
  - Specifying either the BYADDR option or the BYVALUE option as necessary and/or appropriate for the mechanism the assembler code used to pass the parameters.

Language Environment support of PLICALLA is not available in the following environments:
  - CICS environment
  - Preinitialized environment
  - Nested enclave environment except the PL/I FETCHable main.

PLICALLB Considerations

Language Environment provides support for PL/I applications that use the PLICALLB entry point. The following table shows the PLICALLB parameter mapping between OS PL/I and Language Environment:

Table 8. Differences in PLICALLB Argument List Support

<table>
<thead>
<tr>
<th>OS PL/I</th>
<th>Language Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of the length of ISA storage for a nonmultitasking program or the major task in a multitasking program</td>
<td>Mapped to STACK(init_size)</td>
</tr>
<tr>
<td>Address of ISA storage</td>
<td>Used as the initial STACK segment</td>
</tr>
<tr>
<td>Address of the length of ISA storage for each subtask</td>
<td>Mapped to NONIPTSTACK(init_size)</td>
</tr>
<tr>
<td>Address of the maximum number of concurrent subtasks</td>
<td>Mapped to PLITASKCOUNT(max_thread)</td>
</tr>
<tr>
<td>Address of the options word, in which the following run-time options can be specified:</td>
<td>Supported as follows:</td>
</tr>
<tr>
<td>REPORT</td>
<td>REPORT mapped to RPTSTG</td>
</tr>
<tr>
<td>SPIE</td>
<td>STAE</td>
</tr>
<tr>
<td>COUNT</td>
<td>COUNT ignored</td>
</tr>
<tr>
<td>FLOW</td>
<td>FLOW ignored</td>
</tr>
<tr>
<td>HEAP suboptions</td>
<td>HEAP(,KEEP</td>
</tr>
<tr>
<td>TASKHEAP suboptions</td>
<td>THREADHEAP(,KEEP</td>
</tr>
<tr>
<td>Address of HEAP storage length for a nonmultitasking program or the major task in a multitasking program</td>
<td>Mapped to HEAP(init_size)</td>
</tr>
<tr>
<td>Address of HEAP storage</td>
<td>Used as the initial HEAP segment</td>
</tr>
<tr>
<td>Address of HEAP increment for a nonmultitasking program or the major task in a multitasking program</td>
<td>Mapped to HEAP(increment)</td>
</tr>
<tr>
<td>Address of HEAP for subtasks</td>
<td>Mapped to THREADHEAP(increment)</td>
</tr>
<tr>
<td>Address of ISA increment for a nonmultitasking program or the major task in a multitasking program</td>
<td>Mapped to STACK(increment)</td>
</tr>
<tr>
<td>Address of ISA increment for each subtask (optional for a nontasking application)</td>
<td>Mapped to NONIPTSTACK(increment)</td>
</tr>
</tbody>
</table>
When the above argument list is passed in via the PLICALLB entry point, the argument in the list must either point to an address or be zero. The high-order bit ON in an argument indicates the end of the argument list. R1 must contain the address of the argument list.

With Language Environment, the run-time options passed via the PLICALLB entry point are processed as options specified on invocation of the application and have a higher precedence than CEEUOPT or PLIXOPT options. The assembler user exit cannot be used to alter the run-time options passed through the PLICALLB invocation.

To summarize, the run-time options passed in have the following precedence (from highest to lowest) among Language Environment option specification methods:
1. Options defined at installation time that have the non-overridable attribute
2. Options specified via the PLICALLB entry point
3. Options specified in the PLIXOPT string or in CEEUOPT
4. Option defaults defined at installation time

The user arguments passed to the PL/I main routine have the following precedence (from highest to lowest):
1. Output from CEXIT_PARM or AUE_PARM of the assembler user exit
2. User arguments passed in via the PLICALLB entry

Note: The input to CEXIT_PARM or AUE_PARM of the assembler user exit is the first argument in the PLICALLB parameter list, that is, the address of a vector of user argument addresses.

Language Environment encourages the use of above-16M-line storage. For compatibility with OS PL/I, Language Environment maps the user-supplied ISA and HEAP storage to STACK and HEAP. With this mapping, however, Language Environment still needs to issue some GETMAINs. Since user-supplied ISA/HEAP storage is usually below the 16M line, below-16M-line storage can be quickly consumed under Language Environment. How Language Environment manages storage is described in the z/OS Language Environment Programming Guide.

Language Environment manages storage differently than OS PL/I. It divides storage into more categories than the OS PL/I supported ISA and HEAP. As a result, mapping the user-supplied OS PL/I ISA or HEAP storage to Language Environment STACK or HEAP storage still requires GETMAINs during run time. Further, Language Environment provides diagnostics to ensure the user-supplied length of ISA or HEAP storage is a multiple of 8 bytes and the address is on a double-word boundary.

Language Environment also ensures that the location of the user-supplied ISA or HEAP storage matches the location specification in the STACK or HEAP run-time option. The user-supplied HEAP storage is ignored when all of the following are true:
1. User-supplied heap storage is above the 16M line
2. The ANYWHERE suboption of the HEAP option is in effect
3. The main program is in AMODE(24)

Language Environment allocates below-16M-line storage using the init_sz24 and incr_sz24 suboptions specified in the HEAP option.

Language Environment support of PLICALLB is not available in the following environments:
Differences in Preinitialization Support

Enterprise PL/I does not support the old preinitialization scheme and you may want to consider redesigning your applications. Language Environment preinitialization services should be used with Enterprise PL/I in the redesigned applications. However, if you want to run your preinitialized programs under Language Environment in the interim while waiting for them to be redesigned, this section describes the differences that you may want to consider prior to the migration.

The PL/I preinitialized program interface is supported with the following changes:

• The PL/I preinitialized program interface no longer supports the REINITIALIZE request modifier code. If you attempt to use this function, it is diagnosed with the 4093-136 abend code.
• If the routine specified in the CALL request is not statically linked with the assembler driver and it contains ILC, you must ensure the ILC environment is initialized by including the same ILC in the routine specified in the INIT request.
• The TERM request no longer returns 1000 return code as OS PL/I run time did.
• Some of the return and reason codes for the service vector defined by OS PL/I have changed. You must use the return and reason codes for the service vector defined by Language Environment preinitialization services as described in z/OS Language Environment Programming Reference.

Language Environment preinitialization services support multiple preinitialization environments under the same TCB. Multiple preinitialization environments under the same TCB is not supported by OS PL/I. To understand how the service works, see “Using Preinitialization Services” in z/OS Language Environment Programming Guide.

Differences in PLISRTx Support

OS PL/I applications containing PLISRTx invocations are supported by Language Environment for OS/390 & VM Release 1.4 or later; however, you must relink your applications if you are using Release 1.3 of Language Environment as your run time. It is a good idea to relink your load module with Language Environment, regardless of the release you are using, for the following reasons:

• Relinking allows the library routine to access the Language Environment-provided DFSORT interface for a more integrated language and sort environment.
• Relinking allows the library routine to replace the 24-bit DFSORT parameter list with the extended 31-bit DFSORT parameter list.

You can relink your OS PL/I PLISRTx applications using one of the following methods:

• For object module relinking, use OS PL/I Object Module Relinking Tool - APAR PN69803 described on “OS PL/I Object Module Relinking Tool - APAR PN69803” on page 151.
For library routine replacement, use the **OS PL/I Routine Replacement Tool** described on page 149. Relinking the object module directly with Language Environment.

### Differences in Multitasking Support

Enterprise PL/I does not support multitasking. You must change your applications to use multithreading or else use the PL/I for MVS compiler. Note also that Enterprise PL/I multithreading code must use the POSIX(ON) run-time option.

### Differences in OS PL/I Shared Library support

Enterprise PL/I does not support the old OS PL/I shared library.

### Differences in DATE/TIME Built-In Functions

The DATETIME and TIME built-in functions now return the number of milliseconds in all environments. The syntax and description of these built-in functions are in the **PL/I Language Reference**.

### Differences in User Return Code

Language Environment supports a FIXED BIN(31) four-byte user return code value for PLIRETC, PLIRETV, and OPTIONS(RETCODE). This support removes the restriction of maximum value 999. OS PL/I applications must be relinked with Language Environment in order to take advantage of the four-byte user return-code value.

The following table shows how PL/I user return code is supported:

**Table 9. Return Code Behavior under Language Environment**

<table>
<thead>
<tr>
<th>Function</th>
<th>OS PL/I load module</th>
<th>OS PL/I object module linked with Language Environment</th>
<th>Enterprise PL/I load module</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLIRETC</td>
<td>2-byte value with restriction of 999</td>
<td>4-byte value without restriction of 999</td>
<td>4-byte value without restriction of 999</td>
</tr>
<tr>
<td>PLIRETV</td>
<td>2-byte value</td>
<td>Lower 2 bytes of a 4-byte value</td>
<td>4-byte value</td>
</tr>
<tr>
<td>RETCODE option</td>
<td>Lower 2 bytes of R15</td>
<td>Lower 2 bytes of R15</td>
<td>2-byte value</td>
</tr>
</tbody>
</table>

For PLIRETC, relinked OS PL/I load modules can set a 4-byte user return code value.

Under Language Environment, the PL/I user return code is always reset to zero upon return from the PLISRTx invocation. This is not the case with OS PL/I run time.
Differences in the opening of PRINT files

PRINT files must be declared and/or allocated with the attribute "A" (for example, FBA or VBA) to allow for the control character in column 1. With pre-VisualAge PL/I, there were cases where the "A" attribute was forced onto PRINT files that didn’t have it specified (for example, FB or VB), but this can cause confusion as the file is opened with attributes other than that specified by the user. Starting with VisualAge PL/I, the UNDEFINEDFILE condition will be raised if a PRINT file is not specified with the "A" attribute.

Differences in Run-Time Messages

The format and content of run-time messages are different. If you have applications that analyze run-time messages, you must change the applications to allow for the differences. The differences include:

• The message number in the message prefix is four digits instead of three digits in the form IBMmnnn, where mnnn represents the message number and x represents the severity of the message.
• The message severity in the message prefix can be I, W, E, S, or C.
• The message text of some mixed-case English and Japanese messages has been enhanced. The message text of uppercase English messages remains unchanged.

Details are provided in Language Environment Debugging Guide and Run-Time Messages.

Under Language Environment, run-time messages go to the MSGFILE destination specified in the run-time option MSGFILE. The default for MSGFILE destination is SYSOUT. The user output still goes to SYSPRINT. MSGFILE(SYSPRINT) is supported under Enterprise PL/I only after applying the PTFs for the runtime APAR PQ78307. For more information about the MSGFILE option, refer to z/OS Language Environment Programming Guide.

Differences in PLIDUMP

PLIDUMP now produces a Language Environment-style dump. The way you use PLIDUMP and the dump output is different. The following list the differences in the way you use PLIDUMP and the output produced. Compile unit refers to the primary entry point of the external procedure and Compile unit name refers to the name of the external procedure.

• The ddname of the dump output file can be CEEDUMP, PLIDUMP, or PL1DUMP. If you do not define one of these files, Language Environment creates a default CEEDUMP file to contain the dump output. The LRECL of the dump output file must be at least 133 bytes to prevent dump records from wrapping, not the 121 bytes required by OS PL/I.
• When you use the hexadecimal (H) option of PLIDUMP, you must specify the ddname CEESNAP for MVS, or the file name CEESNAP for VM; otherwise the H option is ignored. This data set contains the SNAP dump output. When you specify the hexadecimal (H) option under MVS, the output from SNAP includes all system control program information (SDATA=ALL). OS PL/I provides only partial information (SDATA=CB, Q, and TRT).
• When you use ILC, the dump output contains information related to other languages (for example, C/C++ or COBOL).
• The identifier character string is limited to 60 bytes rather than the 90 bytes OS PL/I supported.
• The traceback section lists the compile-unit name associated with each entry point name. When the entry point is a secondary entry point, the primary entry point name associated with the actual entry point is not listed. The traceback section also contains offsets relative to the address of the compile unit, as well as offsets relative to the address of the real entry point.

• Run-time messages are in a separate section; they are no longer part of the traceback section.

• When you specify the BLOCK (B) option of PLIDUMP, the condition handler save areas appear in the block section of the dump. If you do not specify the BLOCK option of PLIDUMP, the condition handler save areas do not appear in the dump.

• If the program was compiled with the TEST compile-time option, and a begin-block has a label, the begin-block is identified as Label:BEGIN block.. Otherwise, the begin-block is identified as %BLOCKnn, where nn is the block count for the begin-block.

• Compiler-generated ILC subroutines now appear in the traceback section. They are identified as the compile unit name concatenated with the suffix ILC.

• PL/I library routines that have Language Environment-defined Program Prologue Areas (PPAs) are identified by name in the dump. If the library routines do not have Language Environment PPAs, they are identified as Library(PL/1).

• A HEX dump of STATIC storage is included in the Language Environment formatted dump. If more than one routine from a compilation unit is on the stack when a dump is produced, static will be dumped only once for that compilation unit.

• Assembler routines that conform to the rules for mimicking PL/I routines are identified by their CSECT names in the dump output.

• PLIDUMP now conforms to National Language Support standards.

• PLIDUMP can supply information across multiple Language Environment enclaves. For example, if an application running in one enclave FETCHes a main procedure (an action that creates another enclave), PLIDUMP contains information about both procedures.

Differences in Storage Report

The format, contents, and destination of the run-time storage report have changed. Language Environment provides storage information equivalent to OS PL/1. The details of the storage report is described in z/OS Language Environment Programming Reference.

The PLIXHD declaration is no longer used to provide the heading for the run-time storage report. Instead, use Language Environment’s Callable Service, CEE3RPH, to specify the heading. If you do not use CEE3RPH, the heading includes the main procedure name, date, and time of execution.

Differences in Interlanguage Communication Support

There are some restrictions on support for ILC applications containing OS PL/1 and other pre-Language Environment language programs. The restrictions fall into three groups:

• Fully supported load modules
  Load modules containing OS PL/1 and pre-Language Environment C/370 programs are supported under Language Environment.
• Load modules you must relink

Load modules containing OS PL/I and VS COBOL II Release 3 (or later) programs must be relinked with Language Environment.

OS PL/I Version 2 Release 3 provides a migration aid, APARs PN69803 and PN69804, to allow you to do relinking while you are under OS PL/I Version 2 Release 3 environment. As long as the application is relinked with PN69803 and PN69804 under OS PL/I Version 2 Release 3, the application is supported under Language Environment. See “OS PL/I Object Module Relinking Tool - APAR PN69803” on page 151 for details of the migration aid.

• Unsupported ILC

ILC between OS PL/I and the following languages is not supported:
- Fortran (prior to Language Environment Release 5)
- OS/VS COBOL
- VS COBOL II Version 1 Release 2 or earlier releases

For more information, see Language Environment for OS/390 & VM Writing Interlanguage Communication Applications or z/OS Language Environment Writing Interlanguage Applications.

The behavior of certain applications that use ILC might be different. For example:

• Condition handling might behave differently. The major causes of differences in condition handling are that the INTER option is now ignored, and that PL/I condition handling facilities can deal with conditions occurring in non-PL/I routines whether or not you specify INTER.

• Under OS PL/I, in applications that used ILC, the environment initialization and termination of the involved languages, including PL/I, could occur multiple times. With Language Environment, there is only one run-time environment, and language-specific initialization and termination occurs only once. Changes in behavior that you might see include opening and closing of files, releasing of allocated storage, and invocation of establish ON-units.

Note: If you have designed your own code to manage your run-time environments, you should remove it as part of your migration efforts. This private code is incompatible with Language Environment and will conflict with the run-time environment.

For a complete description of how ILC works in the Language Environment run-time environment, see either Language Environment for OS/390 & VM Writing Interlanguage Communication Applications or z/OS Language Environment Writing Interlanguage Applications.

### Differences in Assembler Support

With Language Environment, assembler programs that call a PL/I routine must follow the calling conventions defined by Language Environment. For example, Register 13 pointing to a save area, save areas properly back-chained, and the first word of the save area being zero. For detailed information, see the z/OS Language Environment Programming Guide.

If your OS PL/I main program is called by an assembler program and you want to convert your assembler program to use Language Environment-conforming assembler, you must either recompile your OS PL/I program without OPTIONS(MAIN) or ensure the entry point receiving control is the real entry point of the PL/I program. In either case, the called PL/I program is treated as a
subroutine. Either of these programs run under the same Language Environment enclave where the assembler program is the main program and the called PL/I program is a subroutine.

Your Language Environment-conforming assembler main program must explicitly include the Language Environment-PL/I for MVS & VM signature CSECT, CEESG010, when calling an OS PL/I subroutine to ensure the Language Environment-PL/I-specific run-time environment is initialized. There are three ways Language Environment-conforming assembler can pass control to an OS PL/I subroutine:

1. Branch to a statically linked PL/I subroutine.
2. Use the Language Environment macro CEELOAD and branch to a separately linked PL/I subroutine.
3. Use assembler instructions such as LOAD and BALR to a separately linked PL/I subroutine.

The condition-handling behavior of the LINK from assembler is now clearly defined. For detailed information, see z/OS Language Environment Programming Guide.

**Assembler programs that find the main parameter list**

Assembler programs called from PL/I that use the save area back chain to find the parameter list passed to the PL/I main program will no longer work when running on Language Environment. This is because the number of save areas between the assembler program and the save area of the program that invoked the PL/I main program has changed.

Assembler programs that need to find the parameter list passed to the PL/I main program can use the CEEEDB_R13_PARENT field in the Language Environment EDB to obtain the save area address of the program that invoked the PL/I main program.
Chapter 7. Object and Load Module Considerations

This chapter describes factors that affect the compatibility of OS PL/I object and load modules in Language Environment. The discussions include both OS PL/I Version 1 and OS PL/I Version 2 object and load modules.

All of the library routines in a load module must be from the same release of the run-time library. For example, Language Environment stubs, OS PL/I Shared Library stubs, and OS PL/I resident library routines cannot exist in the same load module.

To find out what tools are available to help you migrate your libraries to the Language Environment run-time environment, see Appendix A, “Conversion and Migration Aids,” on page 149.

OS PL/I Version 1 Object Module and Load Module Compatibility

Language Environment supports object modules and load modules for OS PL/I Version 1 with some restrictions. You can continue to use most of your Version 1 object and load modules if you observe the rules described in the following sections.

If a load module contains an OS PL/I Version 1 object module but is linked with OS PL/I Version 2 resident library, the load module is considered an OS PL/I Version 2 load module and the rules for OS PL/I Version 2 apply. If the load module contains OS PL/I Version 1 Release 1.0 - 2.3 object modules, however, the object module must be recompiled.

If a load module contains the OS PL/I abend exit, IBMBEER, the abend exit is ignored by Language Environment. See “Considerations for using assembler user exits” on page 136 for more information on this topic.

OS PL/I Version 1 Release 5.1

Object Module
The object module is supported.

Load Module Not Using Shared Library:

- Main load module for MVS non-CICS nonmultitasking
  The OS PL/I bootstrap routine, IBMPIRA, always linked with a user load module, contains features such as the fast initialization and termination that are not compatible with Language Environment. A sample ZAP, IBMZAPM, is provided in Language Environment SCEESAMP to help you deactivate those incompatible features. The sample ZAP is described in “OS PL/I Version 1 Release 5.1 main load module ZAP” on page 150.
  ZAPped load modules continue to work under OS PL/I V1.5.1 and V2, as well as Language Environment; however, performance degradation might occur if the original load module contains the fast initialization and termination feature.
  If you do not ZAP your load module, you must do one of the following:
    - Relink your object module with Language Environment or OS PL/I Version 2
– Use the OS PL/I Library Routine Replacement Tool described in “OS PL/I Routine Replacement Tool” on page 149 to replace the library routines in the load module with Language Environment stubs.

- Main load module for MVS non-CICS multitasking
  The load module is supported.
- Main load module under CICS
  The load module is supported.
- Main load module under VM
  The OS PL/I VM-specific bootstrap routine, DMSIBM, contains features that are not compatible with Language Environment. A sample ZAP, IBMRZAPV, is provided in Language Environment SCEESAMP to help you deactivate the incompatible features. The sample ZAP is described in “OS PL/I Version 1 Release 5.1 main load module ZAP” on page 150.

The ZAPped load module is supported under Language Environment only. It no longer works under OS PL/I Version 1 or Version 2. If you do not ZAP your load module, you must do one of the following:
  – Relink your object module with Language Environment or OS PL/I Version 2
  – Use the OS PL/I Library Routine Replacement Tool to replace the library routines in the load module with Language Environment stubs See “OS PL/I Routine Replacement Tool” on page 149 for a description of this tool.

- FETCHed subroutine load module
  The load module is supported.

Load Module Using the Shared Library
The load module is supported as long as the OS PL/I V1R5.1 Shared Library was created with all PLRSHR options and the Shared Library, including the multitasking Shared Library, is replaced with Language Environment stubs. The Shared Library needs to be replaced only once during Language Environment installation.

If the Shared Library was not created with all PLRSHR options or the Shared Library is not replaced with Language Environment stubs, the object module must be relinked with Language Environment or OS PL/I Version 2, or you can replace the Shared Library stubs in the load module with Language Environment stubs. After the object module is relinked or the load module is replaced, the OS PL/I Shared Library feature is no longer used.

Note that Enterprise PL/I doesn’t support the shared library. If you intend to migrate to Enterprise PL/I, you should stop using the shared library. Under Language Environment, PL/I uses stubs instead of full size resident modules and there is no need to use the shared library.

OS PL/I Version 1 Release 5
OS PL/I Version 1 Release 5 provides support only for MVS applications. VM and CICS are not supported in Release 5.0.

Object Module
The object module is supported.

Load Module
The load module is not supported, whether or not you use the Shared Library. You must relink your object module with Language Environment or OS PL/I Version 2, or you can use the OS PL/I Library Routine Replacement Tool to replace the
library routines in the load module with Language Environment stubs. See “OS PL/I Routine Replacement Tool” on page 149 for a description of this tool.

**OS PL/I Version 1 Release 3.0 - Release 4.0**

**Object Module**
- Under MVS
  The object module is supported except for the CICS macro language.
- Under VM
  The object module is supported.

**Load Module**
The load module is not supported, whether or not you use the Shared Library. You must relink your object module with Language Environment or OS PL/I Version 2, or you can use the OS PL/I Library Routine Replacement Tool to replace the library routines in the load module with Language Environment stubs. See “OS PL/I Routine Replacement Tool” on page 149 for a description of this tool.

**OS PL/I Version 1 Prior to Release 3.0**
Object modules or load modules created prior to Release 3.0 are not supported and you must recompile your application with an LE supported PL/I compiler or OS PL/I Version 2.

**OS PL/I Version 2 Object Module and Load Module Compatibility**
In most cases, object modules and load modules created with OS PL/I Version 2 do not require relinking. Earlier sections of this migration guide discuss OS PL/I features in more detail. Some of these features do require relinking, however, and a few are no longer supported.

Language Environment supports OS PL/I applications that contain the PL/I assembler user exit, IBMxXITA. See “Considerations for using assembler user exits” on page 136 for more information on this topic.

**Summary of Support for OS PL/I Object and Load Modules**
The following table summarizes the PL/I object- and load-module support described in this chapter. Exceptions to support are shown in the footnotes and are described elsewhere in a related section.

<table>
<thead>
<tr>
<th>Support description</th>
<th>V2</th>
<th>V1R5.1</th>
<th>V1R5.0</th>
<th>V1R3.0-V1R4.0</th>
<th>Prior to V1R3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main load module</td>
<td>Yes³</td>
<td>Yes³,³</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fetched subroutine load module</td>
<td>Yes³</td>
<td>Yes³</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Object module</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes²</td>
<td>No</td>
</tr>
</tbody>
</table>

Chapter 7. Object and Load Module Considerations 49
Table 10. Summary of Object and Load Module Support by Language Environment (continued)

<table>
<thead>
<tr>
<th>Support description</th>
<th>V2</th>
<th>V1R5.1</th>
<th>V1R5.0</th>
<th>V1R3.0 - V1R4.0</th>
<th>Prior to V1R3.0</th>
</tr>
</thead>
</table>

Exceptions:

1. MVS non-CICS nonmultitasking load modules and VM load modules are not supported unless specific action is taken. Review [Load Module Not Using Shared Library:](#) on page 47 for what action you need to take to enable support for these modules.

2. CICS macro language is not supported as described in [Object Module](#) under "OS PL/I Version 1 Release 3.0 - Release 4.0" on page 49.

3. Shared Library must be created with all PLRSHR options and must be replaced with Language Environment stubs. Review [“Differences in OS PL/I Shared Library support”](#) on page 42 for actions you need to take to make this happen.
Chapter 8. Link-Edit Considerations

This chapter describes factors you must consider when you link-edit an object module produced by OS PL/I. Topics discussed include symbol tables and math routines.

SCEERUN

When you run your OS PL/I application under Language Environment and you use existing JCL, be sure your STEPLIB or JOBLIB statement includes SCEERUN, unless you TASKLIB or LINKLIB which already includes SCEERUN.

Symbol Table Considerations

If you link-edit an object module produced by different releases of PL/I, and the object module contains symbol tables for external variables, the symbol table that appears in the resultant load module must be the one produced by the most recent release of PL/I.

The compiler produces an object module that contains external symbol table control sections (CSECTs) if your program includes one or more of the following PL/I features for external variables:

- GET DATA statements
- PUT DATA statements
- The TEST(SYM) compile-time option

If your program uses one or more of these features with external module variables, you must ensure that the correct symbol table appears in your load module. Place the object module produced by the most recent release of PL/I ahead of all other object modules in the link-edit job stream. If more than one object module produces a symbol table CSECT with the same name, the linkage editor keeps the symbol table CSECT that it encounters first and discards the other symbol tables.

For example, suppose you link-edit an object module produced by OS PL/I Version 1 Release 5.1 with an object module produced by OS PL/I Version 2 Release 3. Put the object module produced by OS PL/I Version 2 Release 3 ahead of the object module produced by OS PL/I Version 1 Release 5.1 in the link-edit job stream. By doing this, the linkage editor keeps the symbol table produced by OS PL/I Version 2 Release 3 if both object modules produce symbol tables.

NCAL Linkage Editor Option

Under Language Environment, the NCAL linkage editor option continues to be required when you link-edit your subroutine object modules for the future use.

Load modules must not contain Language Environment stubs and OS PL/I resident library routines.
ENTRY cards

The entry point for a MAIN program compiled with the OS PL/I compiler is PLISTART, but the entry point is CEESTART if the MAIN is compiled with the PL/I for MVS compiler or any later compiler.

If an ENTRY card must be used during the building of a batch application, then you should not use CEESTART for a program compiled with the OS PL/I compiler.

Using OS PL/I Math Routines

Language Environment provides a set of math routines, including routines for exponentiation. For most commonly used routines, Language Environment produces more accurate results than OS PL/I. Some of the Language Environment routines also have better performance than OS PL/I. You should use the Language Environment-provided math routines.

Language Environment also provides the OS PL/I math routines to help you to migrate to Language Environment; however, the OS PL/I math routines are provided for compatibility only and will be withdrawn in the future.

If your application must use the OS PL/I math routines under Language Environment, place SIBMMATH in front of SCEELKED when you link-edit your object module.
Chapter 9. Subsystem Considerations

This chapter discusses subsystem-specific considerations that you need to know when you migrate your applications running under CICS, IMS, and DB2.

CICS Considerations

Language Environment provides the same level of OS PL/I object and load module support as for non-CICS. See Chapter 7, "Object and Load Module Considerations," on page 47 for details. If you are running under CICS Version 3 Release 3, you must ensure the CICS APAR PN38032 is installed. Without PN38032, your application trying to use Language Environment will receive the APLE abend.

The CICS Storage Protect facility was introduced under CICS 3.3. This provides more data integrity and security for the application program and especially for the entire CICS region. Because of the new feature, you might discover that some of the successfully running OS PL/I applications start to fail with ASRA(0C4) abend and the CICS message DFHSR0622.

If the above problem is happening in your OS PL/I application program, either of the following two methods might be able to fix your problem:

1. Set the CICS system initialization parameter RENTPGM=NOPROTECT. This sets the protection of the user program in user key. The default for RENTPGM is PROTECT.
2. Relink your OS PL/I application program under Language Environment with APAR PN38032 installed.

If the stream output function is used in your OS PL/I CICS application, especially the PUT DATA; statement, it might trigger the above error. PL/I stream output function is intended for debugging purposes only. For performance reasons, we recommend that you don’t use it in production programs.

Updating CICS System Definition (CSD) File

When you bring up a CICS region with Language Environment, you must ensure the module names listed in Language Environment CEECCSD are defined in the CSD. You can locate CEECCSD in SCEESAMP. If you use CICS Version 4 autoinstall facility, you do not need to define Language Environment modules manually in the CSD.

Error Handling

A diagnostic message is issued only if there is no ERROR ON-unit established in the program, or the ERROR ON-unit does not recover from the condition by using a GOTO out of block.

Restrictions on User-Written Condition Handlers under CICS

The following EXEC CICS commands cannot be used within a user-written condition handler established using CEEHDLR, or within any routine called by the user-written condition handler:

• EXEC CICS ABEND
• EXEC CICS HANDLE AID
• EXEC CICS HANDLE ABEND
• EXEC CICS HANDLE CONDITION
• EXEC CICS IGNORE CONDITION
• EXEC CICS POP HANDLE
• EXEC CICS PUSH HANDLE

All other EXEC CICS commands are allowed within a user-written condition handler. However, they must be coded using the NOHANDLE option, the RESP option, or the RESP2 option. This prevents additional conditions being raised due to a CICS service failure.

**Macro-Level Interface**
The CICS macro-level interface is not supported.

**FETCHing a PL/I MAIN Procedure**
CICS does not support PL/I FETCHing a PL/I MAIN procedure.

**STACK Run-Time Option**
Language Environment supports PL/I for MVS & VM applications that use the run-time option STACK(,,ANY). Language Environment also supports STACK(,,ANY) for OS PL/I applications that have been relinked with Language Environment as long as the applications meet the following conditions:

- Contains no edited stream I/O (for example, EDIT was not used in a PUT statement)
- Specifies AMODE(31)

**Run-Time Output**
Run-time output is now transmitted to a CICS transient data queue CESE. Language Environment ignores the MSGFILE option under CICS. Figure 1 shows format of the output data queue.

In addition, PL/I transient queues CPLI and CPLD are no longer used. As a result,

<table>
<thead>
<tr>
<th>ASA</th>
<th>Terminal id</th>
<th>Transaction id</th>
<th>B</th>
<th>DateTime YYYYMMDDHHMMSS</th>
<th>B</th>
<th>Data</th>
</tr>
</thead>
</table>

*Figure 1. CESE Output Data Queue*

you do not need to specify entries for the CPLI and CPLD in the CICS Destination Control Table (DCT).

**Abend Codes Used by PL/I under CICS**
The APLx abend codes that were issued under OS PL/I Version 2 are no longer issued. Instead, Language Environment-defined abend codes are issued. For more information about Language Environment abend codes, see z/OS Language Environment Run-Time Messages.
IMS Considerations

Language Environment provides the same level of OS PL/I object and load module support for IMS as for non-IMS. See Chapter 7, “Object and Load Module Considerations,” on page 47 for details.

Interfaces to IMS

Language Environment supports the PLITDLI, ASMTDLI, and EXEC DLI interfaces from a PL/I routine.

SYSTEM(IMS) Compile-Time Option

The SYSTEM(IMS) option, available in OS PL/I Version 2, was supported for PL/I IMS applications only. The main procedure of an IMS application must use the POINTER data type for its parameters.

PLICALLA Support in IMS

The OS PL/I PLICALLA entry point is supported under Language Environment; however, it is not a recommended interface for IMS and support can be withdrawn at any time. Instead use the SYSTEM(IMS) compile-time option and the PLISTART or CEESTART entry point.

Language Environment provides the same support for OS PL/I PLICALLA applications; however, if you recompile your main load module with PL/I for MVS & VM and want to continue to use PLICALLA, you must follow additional rules. See “PLICALLA Considerations” on page 38 for details.

PSB Language Options Supported

Language Environment supports PL/I applications with the following PSBGEN LANG options in the supported releases of IMS:

IMS/ESA Version 4

Table 11 shows support for PSB LANG options in IMS/ESA Version 4.

Table 11. PSB LANG Options for IMS/ESA Version 4 Release 1

<table>
<thead>
<tr>
<th>SYSTEM option</th>
<th>Entry point</th>
<th>LANG=</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMS</td>
<td>CEESTART, PLISTART</td>
<td>PLI or other values except PASCAL</td>
</tr>
<tr>
<td>IMS</td>
<td>PLICALLA1</td>
<td>PLI</td>
</tr>
<tr>
<td>Omitted</td>
<td>CEESTART, PLISTART</td>
<td>Illegal</td>
</tr>
<tr>
<td>Omitted</td>
<td>PLICALLA1</td>
<td>PLI</td>
</tr>
</tbody>
</table>

Note: 1Supported only for compatibility.

IMS/ESA Version 3 Release 1

Table 12 shows support for PSB LANG options in IMS/ESA Version 3 Release 1.

Table 12. PSB LANG Options for IMS/ESA Version 3 Release 1

<table>
<thead>
<tr>
<th>SYSTEM option</th>
<th>Entry point</th>
<th>LANG=</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMS</td>
<td>CEESTART, PLISTART</td>
<td>PLI</td>
</tr>
<tr>
<td>IMS</td>
<td>PLICALLA1</td>
<td>PLI</td>
</tr>
<tr>
<td>Omitted</td>
<td>CEESTART, PLISTART</td>
<td>Illegal</td>
</tr>
<tr>
<td>Omitted</td>
<td>PLICALLA1</td>
<td>PLI</td>
</tr>
</tbody>
</table>
Storage Usage Considerations

With IMS/ESA Version 3 Release 1, the parameters passed to the IMS interfaces are no longer restricted to the area below the 16M line. The parameters will most likely be placed above the 16M line if you use the following methods:

- Use the ANYWHERE suboption of the HEAP run-time option. It applies to variables with the CONTROLLED or BASED attribute because their storage is obtained from the heap.
- Use the ANYWHERE suboption of the STACK run-time option. If you relink your OS PL/I application with Language Environment and your application does not use any edited stream I/O, or you recompile your application with PL/I for MVS & VM, you can use STACK(,,ANYWHERE) if your application is AMODE(31). In this case, the variables in automatic storage are placed above the 16M line.
- Place parameters in static storage and make sure the load module attribute used is RMODE(ANY).

Coordinated Condition Handling under IMS

Language Environment and IMS condition handling is coordinated, meaning that if a program interrupt or abend occurs when you application is running in an IMS environment, the Language Environment condition manager is informed whether the problem occurred in your application or in IMS. If the problem occurs in IMS, Language Environment, as well as any invoked HLL-specific condition handler, percolates the condition back to IMS.

With Language Environment run-time option TRAP(ON), Language Environment continues to support coordinated condition handling for the PLITDLI and ASMTDLI interface invoked from a PL/I routine.

With IMS/ESA Version 3 with PTF UN4928 or IMS/ESA Version 4, Language Environment also supports the coordinated condition handling for CEETDLI, CTDLI from a C routine, CBLTDLI from a COBOL program, AIBTDLI from a PL/I program, and ASMTDLI from a non-PL/I program.

Note that if a program interrupt or abend occurs in your application outside of IMS, or if a software condition of severity 2 or greater is raised outside of IMS, the Language Environment condition manager takes normal condition handling actions described in the z/OS Language Environment Programming Guide. In this case, in order to give IMS a chance to do database rollback, you must do one of the following:

- Resolve the error completely so that your application can continue.
- Issue a rollback call to IMS, and then terminate the application.
- Make sure that the application terminates abnormally by using the ABTERMENC(ABEND) run-time option to transform all abnormal terminations into system abends in order to cause IMS rollbacks.
- Make sure that the application terminates abnormally by providing a modified assembler user exit (CEEBXITA) that transforms all abnormal terminations into system abends in order to cause IMS rollbacks.
The assembler user exit you provide should check the return code and reason code or the CEEAUCE_ABTERM bit, and requests an abend by setting the CEEAUCE_ABND flag to ON, if appropriate. See the z/OS Language Environment Programming Guide for details.

**Performance Enhancement with Library Retention (LRR)**

If you use LRR, you can get an improvement in performance. See “Improving CPU Utilization” on page 117 for details.

**DB2 Considerations**

There are no special considerations for using DB2 other than the considerations described in “IMS Considerations” on page 55.
Part 4. Moving to the new compiler
Chapter 10. Understanding the limitations of the new compiler

In addition to not supporting VM, the new compiler has various other limitations that you should understand. This chapter lists and explains these differences.

**LE requirements**

Enterprise PL/I V3R5 is supported only on LE for z/OS 1.4 or later.

In order for the V3R5 compiler to work correctly, you must have PTFs for the following LE APARs applied:

- PQ79048
- PQ74798
- PQ72404
- PQ62055
- PQ61351
- PQ55964

APAR PQ74798 is needed for the compiler to be able to honor all of the listing options - without it, the compiler may abend. The other APARs in the list above contain fixes to conversion routines that may be invoked by the compiler - without them the compiler might generate incorrect code.

**Language not supported**

The compiler will flag any language that is not supported.

**Multitasking**

The multitasking language supported by the old compilers is not supported by the new compiler.

However, the new compiler does support multithreading. But, in order to use the multithreading facilities, your code must run with the POSIX(ON) option.

For more information on the multithreading statements, see the PL/I Language Reference.

**CHECK**

PL/I for MVS & VM dropped support for the CHECK statement, the CHECK prefix, and the CHECK condition, and the new compiler also does not support these constructs.

**CHARSET(48) and CHARSET(BCD)**

Support for these options were dropped by OS PL/I Version 2. However, there is an IBM-supplied tool that will convert your source.
EGCS

OS PL/I Version 1 supported EGCS, which was a precursor to the GRAPHIC support in OS PL/I Version 2, which dropped the support for EGCS. The new compiler also does not support EGCS.

Language restricted

Except where indicated, the compiler will flag the use of any language that is restricted.

RECORD I/O

RECORD I/O is supported, but with the following restrictions:
- REGIONAL(1) files larger than 2.1 Gigabytes are not supported.
- The EVENT clause on READ/WRITE statements is not supported.
- The UNLOCK statement is not supported.
- The following file attributes are not supported:
  - BACKWARDS
  - EXCLUSIVE
  - TRANSIENT
- The following options of the ENVIRONMENT attribute are not supported, but their use is flagged only under LANGLVL(NOEXT):
  - ADDBUFF
  - ASCII
  - BUFFERS
  - BUFND
  - BUFNI
  - BUFOFF
  - INDEXAREA
  - LEAVE
  - NCP
  - NOWRITE
  - REGIONAL(2)
  - REGIONAL(3)
  - REREAD
  - SIS
  - SKIP
  - TOTAL
  - TP
  - TRKOFL

STREAM I/O

STREAM I/O is supported, but the following restrictions apply to PUT/GET DATA statements:
- SYSPRINT cannot be shared between two PL/I MAIN routines that run in separate LE enclaves unless running under CICS or unless you compiled the with the STDSYS compiler option.
- DEFINED is not supported if both of the following are true:
  - the DEFINED variable is BIT or GRAPHIC
  - the DEFINED variable has the POSITION attribute
- DEFINED is not supported if its base variable is an array slice or an array with a different number of dimensions than the defined variable.
Structure expressions

Structure expressions as arguments are not supported unless both of the following conditions are true:
- There is a parameter description.
- The parameter description specifies all constant extents.

However, structure expressions are not supported in any GENERIC reference. Mismatched parameter and argument structures are also not supported in any GENERIC reference.

Array expressions

An array expression is not allowed as an argument to a user function unless it is an array of scalars of known size. Consequently, any array of scalars of arithmetic type may be passed to a user function, but there may be problems with arrays of varying-length strings.

However, array expressions are not supported in any GENERIC reference. Mismatched parameter and argument arrays are also not supported in any GENERIC reference.

The following example shows a numeric array expression supported in a call:

```fortran
  dcl x entry, (y(10),z(10)) fixed bin(31);
  call x(y + z);
```

The following unprototyped call would be flagged since it requires a string expression of unknown size:

```fortran
  dcl a1 entry;
  dcl (b(10),c(10)) char(20) var;
  call a1(b || c);
```

However, the following prototyped call would not be flagged:

```fortran
  dcl a2 entry(char(30) var);
  dcl (b(10),c(10)) char(20) var;
  call a2(b || c);
```

DEFAULT statement

Factored default specifications are not supported.

For example, a statement such as the following is not supported:

```fortran
  default ( range(a:h), range(p:z) ) fixed bin;
```

But you could change the above statement to the following equivalent and supported statement:

```fortran
  default range(a:h) fixed bin, range(p:z) fixed bin;
```

The use of a "(" after the DEFAULT keyword is reserved for the same purpose as under the ANSI standard: after the DEFAULT keyword, the standard allows a parenthesized logical predicate in attributes.
Extents of automatic variables
An extent of an automatic variable cannot be set by a function nested in the procedure where the automatic variable is declared or by an entry variable unless the entry variable is declared before the automatic variable.

Built-in functions
Built-in functions are supported with the following exceptions/restrictions:
• The PLTEST built-in function is not supported.
• Pseudovariables are not supported in:
  – The STRING option of PUT statements
• Pseudovariables permitted in DO loops are restricted to:
  – IMAG
  – REAL
  – SUBSTR
  – UNSPEC
• The POLY built-in function has the following restrictions:
  – The first argument must be REAL FLOAT.
  – The second argument must be scalar.
• The COMPLEX pseudovariable is not supported.

DEFINED BIT aggregates
If a DEFINED variable is a structure or union containing any elements which are UNALIGNED NONVARYING BIT, then all array bounds and string lengths in the DEFINED variable must be specified as constants. The compiler will issue the S-level message IBM1900I when this restriction is violated.

iSUB defining
Support for iSUB defining is limited to arrays of scalars.

LABEL arrays
The Enterprise PL/I compiler does not require that arrays of statement labels be declared. If such an array is declared, it should either be declared without a storage class (and without an active DEFAULT statement that would imply a storage class) or it should be declared as STATIC. The old PL/I compiler would require either the former or that the array be declared as AUTOMATIC. Hence if you want your code to be accepted by both compilers, you must declare such an array, but you should declare it neither as AUTOMATIC nor as STATIC.

DBCS
DBCS can be used only in the following:
• G and M constants
• Identifiers
• Comments

G literals can start and end with a DBCS quote followed by either a DBCS G or an SBCS G.
Macro preprocessor

Suffixes that follow string constants are not replaced by the macro preprocessor—whether or not these are legal PL/I suffixes—unless you insert a delimiter between the ending quotation mark of the string and the first letter of the suffix.

Note that the OS PL/I V2R1 compiler introduced this change, and so this is not a difference between the Enterprise PL/I compiler and either the PL/I for MVS & VM compiler or the OS PL/I V2Rx compilers. This restriction is consequently not flagged.

As an example, consider:

```
%DCL (GX, XX) CHAR;
%GX='FX';
%XX='ZZ';
DATA = 'STRING'GX;
DATA = 'STRING'XX;
DATA = 'STRING' GX;
DATA = 'STRING' XX;
```

Under OS PL/I V1, this produces the source:

```
DATA = 'STRING'FX;
DATA = 'STRING'ZZ;
DATA = 'STRING' FX;
DATA = 'STRING' ZZ;
```

whereas, under Enterprise PL/I it produces:

```
DATA = 'STRING'GX;
DATA = 'STRING'XX;
DATA = 'STRING' FX;
DATA = 'STRING' ZZ;
```

Options restricted

The following compiler options are restricted:

- INCLUDE
  The NOINCLUDE option is not supported, and the old INCLUDE option is essentially always enabled.

- LANGLEVEL
  The NOSPROG and SPROG suboptions are not supported - SPROG is always in effect.

- LIST
  The LIST option is supported, but no suboptions of the LIST option are supported - under the new compiler, the psuedo-assembly listing always appears in one column.

- STMT
  The STMT option is supported, but it currently has no effect on the output produced by the LIST, MAP or OFFSET options.

- SYSTEM
  The CMS and CMSTPL options are not supported (since VM is not supported).
Options not supported

The following compiler options are not supported:

- **CONTROL**
- **COUNT**

  The COUNT options is not supported, and it is also not supported by the PL/I for MVS & VM compiler.

- **DECK**

- **ESD**

  The ESD option is not supported, but an External Symbol Dictionary is produced if either the LIST or MAP option is in effect.

- **FLOW**

  The FLOW option is not supported, and it is also not supported by the PL/I for MVS & VM compiler.

- **GOSTMT**

  The GOSTMT option is not supported, but the GONUMBER option is supported (and can be used even if the STMT option is in effect).

- **LMESSAGE**
- **SEQUENCE**
- **SIZE**
- **SMESSAGE**

Restrictions on other interfaces to the compiler

**Batch compilation**

Compilation is not performed in PROCESS-delimited chunks, and this difference has the following consequences:

- Options on later sets of PROCESS statements are ignored
- One TEXT deck or .o is produced
- One listing file with one set of messages is produced
- External variables with the same name must match

The following example demonstrates a batch compilation. In this case, the mismatches in \textit{b} and \textit{x} would be flagged by the new compiler only.

```pli
*a process opt(0);

a: proc;
   dcl b ext entry(1,2 char(2), 2 char(2));
   dcl
     1 x ext,
     2 xla char(2),
     2 xlb char(2);

   call b(x);
end;

*a process opt(2);

b: proc(p);
   dcl p pointer;
   dcl
     1 x ext,
```
You can imitate how batch compilations worked by using a program like the one in Appendix E, “Batch processing sample,” on page 169.

**Invoking the compiler from assembler**

The new compiler cannot be invoked from assembler by calling IEL0AA.

The new DD option can be used to specify a list of alternate ddnames for the compiler to use. This provides the key functionality offered by invoking the old compiler from assembler and should alleviate the need to invoke the compiler from assembler.

Note also that the compiler can be invoked from an Enterprise PL/I program by using the SYSTEM built-in function.

However, if you must invoke the compiler from assembler, you can do so as long as your assembler code satisfies these requirements:

- the assembler code must be LE-enabled
- it must load IBMZPLI using CEEFETCH
- when it calls IBMZPLI, register 1 must point to the address of a varying string containing the options to be passed in the compilation

**Compiling under TSO**

There is no support for compilations under TSO.

This means that the ISPF 4.5 option is useless with Enterprise PL/I. You should probably disable this option or use it for another purpose.

However, you can invoke the compiler under z/OS UNIX using the *pli* command. For more information on using the compiler under z/OS UNIX, see the Enterprise PL/I for z/OS Programming Guide.

**Specifying INCLUDE dataset names**

The DD statement corresponding to a %INCLUDE statement should specify the name of the PDS (or PDSE) containing the file to be included, but it must not specify the name of the member file. For example, to include the file DEBUG from the dataset INCLUDE.PLI using the TEST DD statement, the %INCLUDE statement would be:

```plaintext
%INCLUDE TEST(DEBUG);
```

The corresponding DD statement would be

```plaintext
TEST DD DISP=SHR, DSN=INCLUDE.PLI
```

The following DD statement would not be accepted by the new compiler.

```plaintext
TEST DD DISP=SHR, DSN=INCLUDE.PLI(DEBUG)
```

**Compiler time and space requirements**

The LRECL for the compiler SYSPRINT dataset is 137.
The new compiler can require much more time and use much more storage when generating your code. This is especially true under \texttt{OPT(2)} or \texttt{OPT(3)}, in which case some compiles may need a region greater than 100M and may possibly require several minutes to compile. Using the options \texttt{OPT(2)} or \texttt{OPT(3)} without the option \texttt{DFT(REORDER)} can easily lead to this problem and should be avoided.

When the region size is too small for a compile, the compilation will often end with this message:

\texttt{IBM1936I S Invocation of compiler backend ended abnormally.}

In these situations, you will also find in \texttt{SYSOUT} the following message from the compiler backend:

\texttt{SEVERE ERROR IBM5002: Virtual storage exceeded.}

If you see this combination of messages, you should either split your program into several smaller programs or recompile using a larger region size.

The new compiler always runs with \texttt{ALL31(ON)} and with \texttt{HEAP} and \texttt{STACK} obtained from above the 16MB line.

\textbf{AMODE(24) restrictions}

\texttt{AMODE(31)} and \texttt{RMODE(ANY)} are the default settings for Enterprise PL/I applications. To run an application in \texttt{AMODE(24)}, you must:

1. compile all the PL/I source with the compiler option \texttt{NORENT}
2. link with the SIBMAM24 dataset concatenated in front of the \texttt{SCEELKED} dataset
3. run with the Language Environment run-time option \texttt{ALL31(OFF), HEAP(,,BELOW,,,) and STACK=(,,BELOW,,,)}

If some of your \texttt{AMODE(24)} application is compiled with an older PL/I application or if you have merely linked in \texttt{CEESG011} with your old \texttt{AMODE(24)} application, then the MAIN procedure must be compiled with Enterprise PL/I.

\textbf{Notes:}

1. There is no support for \texttt{AMODE(24)} in ILC applications, including those involving both Enterprise PL/I and older PL/I. The single exception to this restriction is ILC between Enterprise PL/I and supported High-Level Assembler releases.
2. The SIBMAM24 link-edit dataset is available only through ++APAR PQ62003 for \texttt{z/OS} releases prior to \texttt{z/OS} 1.6.

\textbf{EXTERNAL names restricted}

You must not declare as \texttt{EXTERNAL} a variable whose name begins with any of the following:

- @@
- CEE
- IBM
- PLI (except PLIXOPT)

The code generator for the new compiler uses C functions to perform some tasks, particularly under \texttt{OPT(0)}. As a result, unless you are intending to invoke the C function directly, you must not declare as \texttt{EXTERNAL} a variable with any of the following names:
• LONGJMP
• MEMCCPY
• MEMCHR
• MEMCMP
• MEMCPY
• MEMMOVE
• MEMSET
• SETJMP
• STRLEN
• SYSTEM

The PLIXHD variable is no longer used as the heading in storage reports.
Consequently, the identifier PLIXHD is no longer reserved, and you can declare it
and use it as you would declare and use any other variable (as long as you don’t
declare it EXTERNAL).

Listing differences

The new compiler produces a listing that is significantly different from the listing
produced by the old compiler. Some of the differences include:
• the LRECL for the listing is 137
• the first line of the source will not be reflected in the first line of the first page,
  but the first 25 characters from that line will be incorporated into the header line
  of the following pages (except for some parts of the pseudoassembler listing)

Control block differences

The new compiler uses some different internal control blocks in its generated code
than did the old compiler. If you had code that knew the layout and meaning of
such control blocks, that code is highly likely not to work now and will probably
have to be changed. Some examples where these differences would require
code changes:
• assembler code that “knows” the layout of a PL/I label variable and uses that to
try to branch back from assembler into PL/I code
• assembler code that "knows" the layout of a PL/I file variable and associated file
control block and uses that to try to get the DCB for a file

ISAM support differences

The Enterprise PL/I compiler provides no support for ISAM datasets.
Chapter 11. Understanding the new compiler’s options

This section describes some important compiler options, and after a description of some important defaults, it describes choices you can make to improve:

- compatibility
- performance
- quality
- test

If you want to ignore all the discussion below and blindly try to maximize compatibility at all costs, you should:

1. use the following default options:
   - BACKREG(5)
   - BIFPREC(15)
   - CMPAT(V2) or CMPAT(V1)
   - EXTRN(FULL)
   - LIMITS(EXTNAME(7))
   - NORENT

2. specify the following additional, non-default options:
   - COMMON
   - DFT(NOBIN1ARG)
   - DFT(LINKAGE(SYSTEM))
   - DFT(OVERLAP)
   - NOREDUCE
   - NORESEXP
   - RULES(LAXCTL)
   - RULES(NOLAXINOUT NOLAXSEMI)
   - STATIC(FULL)
   - NOWRITABLE(PRV)

The rest of this section will describe these and other options in detail so that you can understand the consequences of your choices.

Understanding the effect of default options on compatibility

This section describes some of the default settings for the compiler options and why you might want to use them.

**BACKREG(5)**

The BACKREG option controls the backchain register, which is the register used to pass the address of a parent routine’s automatic storage when a nested routine is invoked.

For best compatibility with PL/I for MVS & VM, OS PL/I V2R3 and earlier compilers, BACKREG(5) should be used.

All routines that share an ENTRY VARIABLE must be compiled with the same BACKREG option, and it is strongly recommended that all code in application be compiled with the same BACKREG option.
Note that code compiled with VisualAge PL/I effectively used the BACKREG(11) option. Code compiled with Enterprise PL/I V3R1 or V3R2 also used the BACKREG(11) option by default.

**BIFPREC(15)**

The BIFPREC option controls the precision of the FIXED BIN result returned by the following built-in functions:

- COUNT
- INDEX
- LENGTH
- LINENO
- ONCOUNT
- PAGENO
- SEARCH
- SEARCHR
- SIGN
- VERIFY
- VERIFYR

The effect of the BIFPREC compiler option is most visible when the result of one of the above built-in functions is passed to an external function that has been declared without a parameter list. For example, consider the following code fragment:

```plaintext
dcl parm char(40) var;
dcl funky ext entry( pointer, fixed bin(15) );
dcl beans ext entry;
call beans( addr(parm), verify(parm), ' ' );
```

If the function `beans` actually declares its parameters as POINTER and FIXED BIN(15), then if the code above were compiled with the option BIFPREC(31) and if it were run on a big-endian system such as z/OS, the compiler would pass a four-byte integer as the second argument and the second parameter would appear to be zero.

Note that the function `funky` would work on all systems with either option.

The BIFPREC option does not affect the built-in functions DIM, HBOUND and LBOUND. The CMPAT option determines the precision of the FIXED BIN result returned these three functions: under CMPAT(V1), these array-handling functions return a FIXED BIN(15) result, while under CMPAT(V2) and CMPAT(LE), they return a FIXED BIN(31) result.

**CMPAT(V2)**

With V3R2 of Enterprise PL/I, CMPAT(V2) became the default (previously CMPAT(LE) was the default). This default will ease your migration because under CMPAT(V2),

- all descriptors will be the same as those generated by the OS PL/I V2R3 and PL/I for MVS & VM compilers
- functions returning a string will also use a string locator descriptor (as did the old compilers) for the return value

CMPAT(V1) still limits array bounds to halfword values.

CMPAT(V2) and CMPAT(V1) will not prevent the use of any new feature of Enterprise PL/I. However, if you have assembler code that examines or builds
PL/I descriptors (even if only for strings), the CMPAT(V2) (or CMPAT(V1)) option must be used. For example, DB2 contains such assembler code where it invokes PL/I stored procedures and hence your stored procedures written in PL/I must be compiled with CMPAT(V1) or CMPAT(V2).

Unlike CMPAT(V1) and CMPAT(V2), there is no feature that will work only with CMPAT(LE). Do not use it.

If any suboption will be dropped later, it will be the LE suboption.

**EXTRN(FULL)**

By default, the Enterprise compiler will not discard unused EXTERNAL ENTRYs.

This would cause problems if the EXTRN for a discarded entry was used to force the linker to resolve other references. For example, this would cause problems if your program called the secondary entry point B inside a procedure called A, but contained a declare but no references for A itself.

Note, however, this option will cause EXTRNs to be emitted for all declared external ENTRYs. If you include a file with all the declares potentially used by your code, this can populate your text decks with a large number of EXTRNs.

**LIMITS(EXTNAME(7))**

With V3R2 of Enterprise PL/I, LIMITS(EXTNAME(7)) became the default (previously LIMITS(EXTNAME(100)) was the default). This default will ease your migration because this will make the default under the new compiler match what the old compilers always did - they had a limit of 7 characters in an external name and no option that allowed for a higher limit.

Also note that any n > 8 in LIMITS(EXTNAME(n)) requires the prelinker to be used or your modules to be stored in PDSEs.

Additionally, under LIMITS(EXTNAME(7)) (and under all the old compilers), if an 8-character name is declared as EXTERNAL, the compiler will take the first 4 and last 3 characters to make a 7-character name which it will pass to the linker. However, under LIMITS(EXTNAME(8)), the full 8-character name would be passed to the linker, thereby creating an incompatibility with the code generated by the old compilers.

For example, if the name DEZEMBER is declared as EXTERNAL, then under LIMITS(EXTNAME(7)), the linker will see the name DEZEBER, while under LIMITS(EXTNAME(8)), it would see DEZEMBER.

Consequently, for compatibility, do not use LIMITS(EXTNAME(8)) - use the default of LIMITS(EXTNAME(7)).

Finally note that LIMITS(EXTNAME(7)) applies only to PL/I names; assembler and COBOL routines can have 8 characters (exactly as they could with the old compilers).

**NORENT and WRITABLE**

With V3R2 of Enterprise PL/I, NORENT became the default (previously RENT was the default). This default will ease your migration because now, by default, the
new compiler, just like the old compilers, will not generate any extra code to make
your static variables writeable and still REENTRANT (which is what the RENT
option does).

Also note that using the RENT option requires the prelinker to be used or your
modules to be stored in PDSEs.

The new WRITABLE option is also the default since it gives you the best
performance in combination with NORENT.

But if you are using the NORENT option, then you must also use the
NOWRITABLE option if both of the following are true:
1. your code must be REENTRANT
2. your code uses CONTROLLED variables or FILEs

With Enterprise V3R4, the NOWRITABLE option has two suboptions which can
also make your code more (or less) compatible:

FWS The NOWRITABLE(FWS) option will make your code compatible with the
code generated by earlier releases of Enterprise PL/I under the
NOWRITABLE option, but it does not allow CONTROLLED variables to
be shared between code generated by Enterprise PL/I and code generated
by the PL/I for MVS & VM and earlier compilers.

PRV The NOWRITABLE(PRV) option will allow code compiled by Enterprise
PL/I to share CONTROLLED variables with code compiled by the old
PL/I compilers. However, it will also impose the same limits as imposed
by those compilers on using CONTROLLED with FETCH.

SYSTEM
The SYSTEM option generally effects only the way parameters are passed to
MAIN. The default is SYSTEM(MVS), and this option should be used for all
programs except as noted below.

SYSTEM(CICS)
The SYSTEM(CICS) option should be used for all CICS MAIN programs.

SYSTEM(IMS)
The SYSTEM(IMS) option should be used only for those IMS MAIN programs to
which IMS will pass parameters BYVALUE.

SYSTEM(OS)
The SYSTEM(OS) option should be used only for those z/OS UNIX MAIN
programs that want to receive the parameter list built by z/OS UNIX. For more
discussion of this option, see the Enterprise PL/I for z/OS Programming Guide.

Choosing non-default options for even more compatibility
This section describes some of the options that you can choose to increase the
compatibility between the old and new compilers.

COMMON
The COMMON option specifies that the compiler should generate CM linkage
records for uninitialized EXTERNAL STATIC. This option can it make it easier to
migrate your code if you declare an EXTERNAL STATIC variable in more than one
routine but initialize it in only one.
Please note however that this option is valid only if both the NORENT and LIMITS(EXTNAME(7)) options are in effect.

**DFT(NOBIN1ARG)**

The DFT(NOBIN1ARG) compiler option will generally increase the compatibility of your code, but at the expense of limiting the use of some new function.

For more discussion of this option, see “One-byte FIXED BIN” on page 107.

**DEFAULT(LINKAGE(SYSTEM))**

DFT(LINKAGE(SYSTEM)) causes the parameter list to be built in the same way that it was built by the old compilers (including turning on the high-order bit of the address of the last parameter).

This is not the default linkage used by C or JAVA; their default linkage is what you get with the new compiler’s default of DFT( LINKAGE(OPTLINK) ). Under the OPTLINK linkage, the last parameter may not even be an address (for instance, if it is a BYVALUE FIXED BIN(31)), and its high-order bit will not turned on even when it is an address. Furthermore, under the OPTLINK linkage, the return value, if any, may be returned in Register 15.

The SYSTEM linkage is assumed for any OPTIONS(COBOL) or OPTIONS(ASM) routine.

When one PL/I routine calls another, it does not matter what linkage they use as long as they match. However, some non-PL/I routines are not declared as OPTIONS(ASM) but do use the SYSTEM linkage. So, for easiest compatibility and migration, you should probably use the DFT(LINKAGE(SYSTEM)) option.

However if you make the SYSTEM linkage your default, you will need to add OPTIONS( LINKAGE(OPTLINK) ) to the declares of any functions (such as the C library function fread) that use that linkage. For example, you would declare fread as follows:

```
dcl fread ext entry(...) options( linkage(optlink) );
```

**DFT(OVERLAP)**

The DFT(OVERLAP) compiler option will generally increase the compatibility of your code, but at some expense to performance.

For more discussion of this option, see “Source-target overlap” on page 101.

**NOREDUCE**

The NOREDUCE compiler option will slightly increase the compatibility of your code, but at a significant expense to performance.

For more discussion of this option, see “REDUCE” on page 78.

**NORESEXP**

The NORESEXP compiler option will increase the compatibility of your code if your code intentionally forces a ZERODIVIDE condition:
The REEXP compiler option allows the compiler to evaluate all restricted expressions at compiler time. For example, programs with the following code would fail at compile-time with an S-level message:

```pli
if somevariable = goodvalue then;
   else
       put skip list( 1 / 0 );
```

Under the NOREEXP compiler option, the compiler would not flag this statement and the ZERODIVIDE condition would be raised at run-time, as originally intended.

**RULES(LAXCTL)**

The RULES(LAXCTL) compiler option will slightly increase the compatibility of your code, but at a significant expense to performance.

For more discussion of this option, see “RULES(NOLAXCTL)” on page 80.

**RULES(NOLAXINOUT NOLAXSEMI)**

These suboptions of the RULES option have no effect on object compatibility since they do not change the code that is generated. But if you specify them, the new compiler will act more like the old because it will then issue two messages that the old compiler would issue; in particular, the compiler will issue a W-level message under:

**RULES(NOLAXINOUT)**

if it finds a possibly uninitialized scalar passed as an ASSIGNABLE BYADDR parameter

**RULES(NOLAXSEMI)**

if it finds a semicolon inside a comment

**NOWRITABLE**

You should choose the NORENT option for the greatest compatibility with your old modules.

The NORENT WRITABLE options allow the compiler to use a static pointer
- as the base for the stack that tracks a CONTROLLED variable
- as the handle for the storage that represents a FILE

Under the NOWRITABLE option, the compiler will not use a static pointer for either of these purposes, but it has to generate more lines of code to provide the same function.

But you must use the NOWRITABLE option if both of the following are true:
1. your code must be REENTRANT
2. your code uses CONTROLLED variables or FILES

However, the NOWRITABLE(FWS) option can have a potentially very strong negative impact on performance, so do not use it if either of the above items does not apply to you.

**Choosing options for improved performance**

This section describes some of the options that you can choose to improve the performance of the compiler generated code.
If you want to ignore all the discussion below and blindly try to improve performance at all costs, you should:

1. use the following default options:
   - REDUCE
   - NORENT
   - RULES(NOLAXCTL)

2. specify the following additional, non-default options:
   - ARCH(5)
   - BIFPREC(31)
   - DFT(NONASGN)
   - DFT(CONNECTED)
   - DFT(REORDER)
   - DFT(NO_OVERLAP)
   - OPT(3)
   - SCHEDULER
   - TUNE(5)

However, while there are considerations (discussed below) that may make you choose not to use all of the above options, unless you use both DFT(REORDER) and at least OPT(2), you will not get good performance from the generated code.

ARCH

The default since Enterprise PL/I V3R2 is ARCH(2). You should not use a lower value for the ARCH option since Enterprise PL/I requires LE 1.3 (and later) and LE 1.3 requires machines that support ARCH(2).

Note that if you specify an ARCH level that is greater than the lowest level of any machine on which your code runs, then it is likely that your code will abend with a specification exception on those machines.

If you specify a value of 0 or 1, the compiler will reset the value to 2.

BIFPREC(31)

Specifying the BIFPREC(31) will make your code perform better if you use of the built-in functions to which it applies. However, as discussed above, the BIFPREC(15) option will give you better compatibility if you use unprototyped ENTRY declarations.

DEFAULT(NONASGN)

The option DFT(NONASGN) will add the NONASSIGNABLE attribute to all STATIC variables not explicitly declared as ASSIGNABLE. If your STATIC variables are, in fact, not altered, using this option will allow the compiler to put them in read-only storage and that will give you better performance (particularly if you use the RENT option).

DEFAULT(CONNECTED)

Nonconnected arrays are arrays whose elements do not occupy adjacent pieces of storage. Nonconnected arrays are passed by both of these calls:

```pli
  dcl a(3,4) fixed bin;

  dcl 1 x(5), 2 y fixed bin, 2 z fixed bin;
```
call f( a(*,1) );
call f( x.y );

The new and old compilers fully support nonconnected arrays, and in fact, the compilers assume that any array parameter is not connected - that there may be other bytes between successive array elements.

This assumption slows down the compiler and requires more code to be generated which slows down your application.

If you use the new DFT(CONNECTED) compiler option, the compiler will assume that all arrays received are connected and will generate much better code. Hence, if you never pass a discontiguous slice of an array (such as a column), use this option for better performance.

**DEFAULT(REORDER)**

If you do not use DFT(REORDER) and either OPTIMIZE(2) or OPTIMIZE(3), you will not get good performance from the compiler generated code.

Also, do not use OPT(2) or OPT(3) without DFT(REORDER) - the compiler will generate worse code and take much longer to do so.

**DEFAULT(NOOVERLAP)**

While you may want to use the DFT(OVERLAP) option for compatibility, using the DFT(NOOVERLAP) option will give you much better performance.

For more discussion of this option, see “Source-target overlap” on page 101.

**OPTIMIZE(2)/OPTIMIZE(3)**

If you do not use DFT(REORDER) and either OPTIMIZE(2) or OPTIMIZE(3), you will not get good performance from the compiler generated code.

Also, do not use OPT(2) or OPT(3) without DFT(REORDER) - the compiler will generate worse code and take much longer to do so.

Note that OPT(3) will produce slightly better code than OPT(2), but the compiler will take much longer to compiler programs (especially large programs) under OPT(3) than under OPT(2). For this reason, the compiler maps OPT(TIME) to OPT(2).

**REDUCE**

The REDUCE option specifies that the compiler is permitted to reduce an assignment of a null string to a structure into fewer, simpler operations - even if that means padding bytes might be overwritten.

The REDUCE option will cause fewer lines of code to be generated for an assignment of a null string to a structure, and that will usually mean your compilation will be quicker and your code will run much faster. However, padding bytes may be zeroed out.

For instance, in the following structure, there is one byte of padding between field11 and field12:
dcl
1 sample ext,
   5 field10 bin fixed(31),
   5 field11 dec fixed(13),
   5 field12 bin fixed(31),
   5 field13 bin fixed(31),
   5 field14 bit(32),
   5 field15 bin fixed(31),
   5 field16 bit(32),
   5 field17 bin fixed(31);

Now consider the assignment sample = ";

Under the NOREDUCE option, it will cause eight assignments to be generated, but
the padding byte will be unchanged.

However, under REDUCE, the assignment would be reduced to three operations.

With NOREDUCE, you get code that looks like:

```
00004C 5810 3056 00015 | L r1,=A(@CONSTANT_AREA)(,r3,86)
000050 58E0 305A 00015 | L r14,=A(SAMPLE)(,r3,90)
000054 4100 0000 00015 | LA r0,0
00005B D206 E004 1000 00015 | MVC FIELD11(7,r14,4),+CONSTANT_AREA(r1,0)
00005E 5000 E000 00015 | ST r0,<s9:d32:l4>(,r14,0)
000062 5000 E00C 00015 | ST r0,<s9:d32:l4>(,r14,12)
000066 5000 E010 00015 | ST r0,<s9:d32:l4>(,r14,16)
00006A 5000 E014 00015 | ST r0,<s9:d32:l4>(,r14,20)
000072 5000 E018 00015 | ST r0,<s9:d32:l4>(,r14,24)
000076 5000 E01C 00015 | ST r0,<s9:d32:l4>(,r14,28)
00007A 5000 E020 00015 | ST r0,<s9:d32:l4>(,r14,32)
```

But with REDUCE, you get code like:

```
00004C 5810 3042 00015 | L r1,=A(SAMPLE)(,r3,66)
000050 58E0 3046 00000 | L r14,=A(@CONSTANT_AREA)(,r3,70)
000054 D703 1000 1000 00015 | XC _shadow1(4,r1,0),_shadow1(r1,0)
000058 D206 1004 E000 00015 | MVC _shadow1(7,r1,4),+CONSTANT_AREA(r14,0)
000060 D717 100C 100C 00015 | XC _shadow1(24,r1,12),_shadow1(r1,12)
```

Consequently, for best performance use the REDUCE compiler option.

**NORENT**

While the NORENT option is now one of the compiler defaults because its use
increases the compatibility of the object code generated, it may also significantly
improve the performance of your code - as long as you do not also use the
NOWRITABLE option.

The reasons for this performance improvement are that, under the RENT option,
the initialization of every load module takes more time and the code length is
longer both for calls and for references to static variables.

However, please note that if your code must be REENTRANT and if your code
uses CONTROLLED variables or FILES, then you must use either the RENT option
or both the NORENT and NOWRITABLE options.

If you use NOWRITABLE with NORENT and your application consists of many
programs using CONTROLLED variables, then you will get better performance if
you use NOWRITABLE(PRV) than if you use NOWRITABLE(FWS). However, as
discussed earlier in this chapter, using NOWRITABLE(PRV) will also impose all the
old limits on using CONTROLLED variables with FETCH.

Chapter 11. Understanding the new compiler's options 79
RULES(NOLAXCTL)

Using RULES(LAXCTL) can significantly slow the compiler and cause it to generate more copious and more time-consuming code.

For one large customer program, this reduced the compile-time by 40% and run-time by 50%.

To understand this option, consider the following declaration:

DCL
  01 VTAB(*) CTL, /* VALOREN-TABLE */
  02 WA0102 CHAR(26), /* MUTATIONSDATUM DB2-TIMESTAMP */
  02 WA0104I BIN FIXED(31), /* PKEY AKTIONSNR-ID */
  02 WA0104K CHAR(1), /* PKEY VALOREN-KNZ */
  02 WA0104V DEC FIXED(15,0), /* PKEY VALORENNR */
  02 WA0104L BIN FIXED(15), /* PKEY VV_SEG_LFNR */
  02 WA0104A CHAR(4); /* PKEY TERM_ID */

The bounds of VTAB are clearly not known at compile-time. But is the length of WA0104K really 1? The structure would normally be allocated with a statement like one of the following two statements:

ALLOC VTAB( 100 );
ALLOC VTAB( N + M );

After either of these allocations, WA0104K would have length 1.

But the structure could be allocated as follows:

ALLOC
  1 VTAB(17),
  2 WA0102,
  2 WA0104I,
  2 WA0104K CHAR(29);

But then WA0104K has length 29 !

The compiler option RULES(LAXCTL) permits allocations such as the one immediately above despite the fact that the original declared length for the string was a constant. However, using this option will also force the compiler to generate much longer code sequences.

In contrast, the compiler option RULES(NOLAXCTL) assumes that all lengths and bounds that are declared as constant are, in fact, constants. - and any ALLOCATE statement that violated this assumption will be flagged with an S-level message IBM2063.

Consequently, using this option will not leave you with any run-time surprises, and it will give you much better performance, both at compile-time and at run-time.

SCHEDULER

The SCHEDULER option will cause the compiler to make extra attempts to optimize the scheduling (or ordering) of the machine instructions that it generates. While these extra attempts will cause the generated code to be slightly faster, they will also cause, especially for large programs, the compile time to be significantly longer.
TUNE

The default since Enterprise PL/I V3R2 is TUNE(2). You should not use a lower value for the TUNE option since Enterprise PL/I requires LE 1.3 (and later) and LE 1.3 requires machines that support ARCH(2).

Note that unlike the ARCH option, specifying too high a value for the TUNE option will not cause your program to abend: the TUNE option merely directs the compiler to generate code that favors certain machine levels, but it does not cause the compiler to generate code that requires any particular machine levels.

If you specify a value of 0 or 1, the compiler will reset the value to 2.

Choosing options for better quality

This section describes some of the options that you can choose to improve or insure the quality of your code.

RULES(NOLAXDCL)

RULES(LAXDCL) causes the compiler to emit only an I-level message for each undeclared variable. But, under RULES(NOLAXDCL), you get an E-level message.

If your code is to have any reasonable quality, you should always compile with RULES(NOLAXDCL).

However, when we made this the default on Windows, too many users objected, and it is now not the default.

Under RULES(NOLAXDCL), compiling:

```
x: proc( starting_role ) returns( fixed bin(31) );
  dcl starting_role fixed bin(31);
  return( starring_role + 1 );
end;
```

will cause the compiler to issue an E-level message saying that `starring_role` is undeclared. This would alert you to the fact that this name is almost certainly a typo, and this is an example of why you want to use this compiler option.

The option RULES(NOLAXDCL) may also flag “working” code:

```
read_in = fileread( file_in, addr(buffer), stg(buffer) );
  if read_in = 0 then
    leave;
```

If `read_in` is undeclared, the code will work; however, `read_in` will have FLOAT as an attribute and that is probably not what you want.

RULES(NOLAXIF)

The expressions in IF, WHILE, UNTIL and undominated WHEN clauses should have the attributes BIT(1) NONVARYING; however, all the new and old compilers would allow any computational expression in these clauses. For example, you could write:

```
dcl x fixed bin(31);
  if x then ...
```
You may have intended this IF statement to mean the same as the following statement:

\[
\text{if } x \neq 0 \text{ then}
\]

But the old and new compilers will interpret the statement as:

\[
\text{if } \text{abs}(x) \neq 0 \text{ then}
\]

It would be much better to code this statement and similar statements so that the conditional expression was a boolean.

Under the compiler option RULES(NOLAXIF), the compiler will flag with an E-level message any conditional expression that does not have the attributes BIT(1) NONVARYING. Hence you can use this option to enforce this good coding practice.

Under RULES(NOLAXIF), the compiler will also flag an IF clause consisting of just a reference to a BIT(8) variable, say Y. In this case, the generated code will treat the expression as true if any of the 8 bits is on, but it might be better to change this IF clause to \( Y \neq \text{"b} \).

Note that the RULES(NOLAXIF) option will have effect on the code generated for any statement that it flags.

**RULES(NOLAXLINK)**

Specifying the option RULES(LAXLINK) originally caused the compiler just to ignore the LINKAGE and other options specified in the declarations of two ENTRY variables or constants when you assign or compare them.

By customer demand, the RULES(LAXLINK) option now also causes the compiler not to flag various other errors (which were also not flagged by the old compiler):

- declaring a name (such as FETCH) as BUILTIN would get no message under RULES(LAXLINK) unless the name is used in any way
- having no RETURN( ... ) statement in a PROC with the RETURNS option
- having a RETURN; statement in a PROC with the RETURNS option
- assigning or comparing two ENTRY variables or constants with mismatching ENTRY descriptions and/or mismatching RETURNS

For example, if you use the RULES(LAXLINK) option, the following incorrect program would not be flagged:

```
dcl funtion ext entry returns( char(20) );
dcl subrtn  entry variable;

subrtn = function;
call subrtn;
```

You should use the RULES(NOLAXLINK) option to catch these errors and to enforce basic coding standards.

**RULES(NOLAXMARGINS)**

Under the option RULES(NOLAXMARGINS), any line with non-blanks after the right margin will be flagged.
This can help detect problems when code, especially an end-of-comment marker, has been accidentally shifted too far right.

However, since many source files have serial numbers or other data after the right margin, RULES(LAXMARGINS) is the default.

**RULES(LAXSTRZ)**

The new compiler will flag any string assignment where the source has a known length, the target has a known maximum length, and the source length is greater than the maximum target length. Unfortunately, this will cause the compiler to flag even those assignments where the trailing bits or characters are "uninteresting".

The compiler option RULES(LAXSTRZ) can help reduce this "noise": under RULES(LAXSTRZ), no message will be issued in an initial clause or an assignment if:

- a bit variable has a source that is too long but whose excess bits are all 0's
- a character variable has a source that is too long but whose excess characters are all blanks

Consequently, under RULES(LAXSTRZ), only the second of the following statements would be flagged:

```plaintext
dc1 a char(4) init('ok');
dc1 b char(4) init('error');
```

The default option is RULES(NOLAXSTRZ), but using RULES(LAXSTRZ) might give you better quality by letting you focus on the truly problematic assignments.

**RULES(NOMULTICLOSE)**

The new and old compilers all allow you to close more than one DO, SELECT, BEGIN or PROCEDURE group with one END statement, although the new compiler will issue an I-level message.

However, closing multiple groups with one END statement is not a good programming practice, and the compiler option RULES(NOMULTICLOSE) allows you to force the compiler to flag such code with an E-level message. For example, under this option the compiler would object to the following code:

```plaintext
a: do i = 1 to 17;
    b: do j = 1 to 29;
        t = x(i,j);
        /* transpose i and j */
        x(i,j) = x(j,i);
        x(j,i) = t;
    end b; /* end of loop */
end a;
```

Note that since the first comment is unclosed, the `end a;` closes both DO loops.

---

### Choosing options for test

This section describes some of the options that you can choose during development when you want to test your code.

**CHECK(CONFORMANCE)**

Specifying the CONFORMANCE suboption of the CHECK option will cause the compiler to generate extra code in the prologue of some procedures to check that the parameters passed match what those procedures expect.
The Programming Guide describes in more detail when this option applies and what it will do, and it can be a very useful tool in development to test your code.

**GONUMBER**

When you specify the compiler option GONUMBER, the compiler generates a "statement number table". This table allows the error handler, when it needs to produce a message for a condition that has been raised, to identify where the condition occurred not only by its offset within the containing procedure, but also by its location within your source program.

This extra information can be very useful in helping you analyze errors in your program. If you choose not to use this option, you should probably use the OFFSET option so that the compiler will produce a table that you can use to determine the source statement from the entry offset.

**PREFIX**

The PREFIX compiler option allows you to enable PL/I conditions without editing your source. The following three conditions are particularly useful to enable during test:

- SIZE
- STRINGRANGE
- STRINGSIZE
- SUBSCRIPTRANGE

However, all these conditions will cause the compiler to generate more code and will sometimes cause the performance of the generated code to be significantly worse. Enabling the SIZE condition for an entire compilation can be especially expensive, and it is not recommended that you use this option with production programs.

**TEST**

Finally, if you are using Debug Tool, you should use the TEST option so that the compiler will generate symbol tables and other information needed for the debugger. However, this is another option that you should probably not use with production programs.
Chapter 12. Understanding the new compiler’s messages

The new compiler issues many messages that are very similar to those issued by the old compilers. However, it also issues many new messages, some of which can be very important as you migrate to the new compiler. Paying attention to messages such as these can alert you to possible migration problems. This section will attempt to explain some of the more important of these messages.

Many of the messages discussed here are I-level and W-level messages, but that does not mean you should ignore them. In fact, these messages are highlighting probable errors in your “working” code.

IBM1044: one-byte FIXED BIN

This I-level message alerts you to a difference between Enterprise PL/I and the old PL/I compilers. The message produced by the new compiler looks like:

IBM1044I I FIXED BINARY with precision 7 or less is mapped to 1 byte.

This is a feature of Enterprise PL/I: it supports one-byte integers. This is a very useful feature, especially when exchanging data with C or JAVA.

However, this is also a difference between the old and the new compilers: under the old compilers, a variable declared as, for example, FIXED BIN(7) would have been allocated 2 bytes which meant that unless SIZE was enabled, it could have assumed values ranging from -32768 to 32767 rather than the much smaller range of -128 to 127 allowed by a one-byte integer.

Unless you are intentionally exploiting this new feature, you should probably use the EXIT option to increase the severity of this message and then change all code that produces the message.

IBM1053: scaled FIXED BIN evaluation

When compiling some of your code, you may see the following message:

IBM1053I I Scaled FIXED operation evaluated as FIXED DECIMAL.

For an example of the code that will produce this message, and for an explanation of what to do, see “Arithmetic built-ins with scale factors and FIXED BIN” on page 109.

IBM1065: imprecise float constants

This I-level message alerts you to a potential source of problems with Enterprise PL/I:

IBM1065I I Float constant ... would be more precise if specified as a long float.

Floating point constants can represent binary fractions (such .1E0b and .001E0b) very well, but in general, they cannot represent decimal fractions (such .1E0 and 3.1415E0) precisely. This message alerts you to the fact that if such fractions were specified as long-floating point (for instance by specifying more than 6 decimal digits), then the fraction would be more precisely represented.
IBM1091: FIXED BIN precision warning

This W-level message alerts you to what is at best poor programming and at worst a source of problems. The message produced by the new compiler looks like:

```
IBM1091 W FIXED BIN precision less than storage allows.
```

The Enterprise PL/I compiler will produce this message whenever a SIGNED FIXED BIN variable is declared with a precision other than 7, 15, 31 or 63 or whenever an UNSIGNED FIXED BIN variable is declared with a precision other than 8, 16, 32 or 64. The compiler will also issue this message if a built-in function such as BIN, ADD, DIVIDE, etc has a FIXED BIN result but specifies one of the above precisions.

For example, if you declare a variable as FIXED BIN(5), the compiler will flag the declare, and you should probably change the declare to the intended FIXED BIN(15).

IBM1099: mixed FIXED

When compiling some of your code, you may see messages such as:

```
IBM1099I W FIXED DEC(7,2) operand will be converted to FIXED BIN(25,7). Significant digits may be lost.
```

The attributes in your messages may vary, but a sample piece of code that would produce exactly this message is:

```
DCL 1 REC_OUT,
   03 AVAIL FIXED BIN(31),
   03 TOTAL_SPARE FIXED DECIMAL(7,2),
   03 WORK_TOTAL FIXED DECIMAL(7,2);

AVAIL = 17;
WORK_TOTAL = 12.2;

TOTAL_SPARE = AVAIL + WORK_TOTAL;
```

The new and old compilers implement the final assignment in exactly the same way and both would leave TOTAL_SPARE with the value of 29.19 (not 29.20 as you might expect). However, only the new compiler issues a message to tell you that you might want to examine this statement more closely.

To understand what this message is telling you and why the result of the statement above is correct when it seems to be wrong, you need to recall these PL/I rules for arithmetic operations other than exponentiation:

1. if either operand is FLOAT, any FIXED is converted to FLOAT
2. if either operand is BINARY, any DECIMAL is converted to BINARY
3. DECIMAL(p,q) is converted to BINARY( 1+log(10)*p, log(10)*q )

So, adding the FIXED BIN(31,0) variable AVAIL to the FIXED DEC(7,2) variable WORK_TOTAL will force, by the above rules, the DEC(7,2) operand to be converted to BIN(25,7).

But 12.20 cannot be exactly represented as a BIN(25,7), and is actually converted via

```
( bin(12.20,31,0) * 2**7 ) / 10**2
```
This yields a value that is approximately 12.195.

Then adding 17 and converting back results in 29.19.

The compiler behavior in all of the above is correct, but perhaps not what you want. If it is, in fact, not what you want, you could force the operation to be evaluated in DECIMAL by either applying the DECIMAL built-in function to the BINARY operand or by specifying the new compiler option RULES(ANS).

Under RULES(ANS), scaled FIXED BIN is not permitted and the conversion rules are more what a naive user might expect:

- if both operands are FIXED, then
- if either has a non-zero scale, any BIN becomes DEC

So when adding BIN(31,0) to DEC(7,2), the BIN(31,0) is converted to DEC(10,0) and nothing is lost.

The same considerations as detailed above also apply to the following customer code fragment:

```plaintext
dcl a dec fixed(15,3) init(2500000);
dcl zero bin fixed(31) init(0);
if (a ≠ zero) then
  put skip edit('dec fixed ≠ Zero')(a);
else
  put skip edit('dec fixed = Zero')(a);
```

The DEC(15,3) operand gets converted to BIN(31,10).

But BIN(31,10) can hold up to $2^{**21}$ or 2_097_152.

Consequently, this conversion cannot be made successfully, and the SIZE condition would be raised if it were enabled. When the SIZE condition is not enabled, this code is in error and the CVB instruction that is generated to perform the conversion raises the ZERODIVIDE condition.

Again, the new compiler issues an appropriate message:

```plaintext
IBM1099I W FIXED DEC(15,3) operand will be converted to FIXED BIN(31,10). Significant digits may be lost.
```

Finally, using RULES(ANS) compiler option or applying the DEC built-in function to the BINARY operand would again fix this code.

---

**IBM1181: miscoded DO loops**

Some programs that have always compiled cleanly may now produce this message:

```plaintext
IBM1181I W A WHILE or UNTIL option at the end of a series DO specifications applies only to the last specification.
```

This message is produced for statements such as the following:

```plaintext
DO I = 1, 2 WHILE( X = 'Z' );
```

This message says that this DO-loop will be executed once with I equal to 1 (whether or not X = ‘Z’ is true) and then, if X = ‘Z’ is true, with I equal to 2. This DO statement is not the same as this statement (although this is probably what the author intended):
DO I = 1 WHILE( X = 'Z' ), 2 WHILE( X = 'Z' )

If this was what you intended, it would probably be best to code the statement as:
DO I = 1 TO 2 WHILE( X = 'Z');

And, if you did want to test if X = 'Z' only before the second iteration of the DO-group, then it would be best to code the statement as:
DO I = 1 TO 2 UNTIL( X ^= 'Z');

---

**IBM1208: incompletely initialized arrays**

When compiling some of your code, you may also see the following new message:

IBM1208I W INITIAL list for the array WPPXS_TAB
contains only one item.

For instance, this message would be produced if the variable in the following declaration is used in your program:

DCL WPPXS_TAB(15) CHAR(3500) INIT((15)'');

The INIT((15)'') attribute does not specify 15 instances of a string consisting of one blank. The 15 is a string repetition factor, and so this INIT clause specifies only one string (of 15 blanks).

To initialize the whole array to blanks, you should code:

DCL WPPXS_TAB(15) CHAR(3500) INIT( (*)('' ));

The new compiler will also produce this message for many other similar declares, such as:

DCL LISTE(4,60:73) CHAR(50) INIT('');
DCL SPRACH_TAB(4) CHAR(15) INIT('');

Finally, if this array is part of a structure, the compiler will flag any subsequent occurrences of this problem in that structure with the message IBM2603. Hence, you can use the EXIT option to reduce the number of times this problem is flagged to once per structure.

---

**IBM1215: incomplete declares**

When compiling some of your old code, you may additionally see a message such as the following:

IBM1215I W The variable I is declared without any data attributes.

The new compiler would issue this message, for example, for this declaration:

DCL I, J FIXED BIN;

While the older compilers would produce no message for this declare, the new compiler issues the message above because this declare is not equivalent to DCL (I,J) FIXED BIN; it’s actually equivalent to DCL I; DCL J FIXED BIN.

---

**IBM1216: incorrect structure declares**

Similarly, consider the following declare:
DCL
1 S,
  2 A CHAR(10),
  2 B,
  2 C CHAR(3),
  2 D CHAR(3);

The older compilers would produce no message for this declare. However, the new compiler will produce the message:

IBM1216I W The structure member B is declared without any data attributes. A level number may be incorrect.

This message is pointing at some probable errors in the declare, namely that C and D should be declared at level 3 rather than level 2. But given the declare above, since they are at the same structure level as B, B is not their parent and gets the default attributes of FLOAT! This is almost certainly not what you intended, and this new message is directing your attention to this likely problem.

The compiler also issued this message for the following customer code:

DCL PARDIASE CHAR (20);
DCL 1 INDIASE1 BASED (PTPDIASE),
  2 CICODIA CHAR (1),
  2 CIFECDI DEC FIXED (9),
  2 CIADI CHAR (9),
  2 CIABRO CHAR (3),
  2 CIRESDI;
DCL PTPDIASE POINTER;
PTPDIASE = ADDR (PARDIASE);
....
INDIASE1 = "";

The message flags the fact that the variable CIRESDI is declared without any data attributes. Hence it gets the default attributes of FLOAT DEC(6), and that means that the structure INDIASE1 then occupies 22 bytes. But since the structure is based on a pointer that has been assigned the address of a CHAR(20) field, the assignment INDIASE1 = ""; will blank out 2 bytes of storage used by some other variable. In the customer’s code this led to an abend in a library routine. Note that if CIRESDI had been declared as CHAR(2) or even as CHAR(0) (and CHAR(0) is legitimate PL/I), then there would have been no problem.

So, even though this message, like many of the other messages discussed in this chapter, is not an E-level message, it would be very good to change your code so that your compilation is free of this message.

**IBM1220: pointless comparisons**

When compiling some of your code, you may also see the following new message:

IBM1220I W Result of comparison is always constant

For example, the following code would cause the new compiler to produce this message:

DCL ZWSTRING CHAR(B0);
DCL ZWSTRING2 CHAR(B);
ZWSTRING = 'E R R O R';
....
IF ZWSTRING2 = 'E R R O R', THEN
This message is produced because ‘E R R O R’ is CHAR(9) with its last character a non-blank, and hence it could never equal a CHAR(8) field.

Any code that produces this message is problematic and should be closely examined. In fact, ignoring this message when it points at a DO-loop statement means that your code could go into an infinite loop. For example, the compiler would produce this message for all three of these executable statements, and in the last case, the loop would run endlessly unless exited with a LEAVE statement:

```
DCL ZZ9 PIC 'ZZ9';
DCL N FIXED BIN(15);

IF ZZ9 < 0 THEN ...
IF ZZ9 <= 999 THEN ...
DO N = 1 TO 32768; ...; END;
```

Note that if you have a loop that you want to run “endlessly” until exited by a LEAVE (or GOTO) statement, it would be best to code that loop statement using DO FOREVER.

**IBM1927: SIZE condition**

When compiling some of your “working” code, you may also see a message such as the following:

```
IBM1927I $ SIZE condition raised by attempt to convert
32777 to SIGNED FIXED BIN(15)
```

Some sample code that would produce this message is:

```
DCL I BIN FIXED(15);

DCL
  1 $,
  2 A CHAR(10),
  2 B CHAR(32767);

I = STG(S);
```

Note that in the assignment above:
- the source STG(S) is equal to 32777
- the target I has the attributes FIXED BIN(15)

The old compilers would have issued no message.

The new compiler is telling you that 32777 is too large to be converted to FIXED BIN(15) (since a FIXED BIN(15) variable can hold no value larger than 32767).

This message points to a problem you should not ignore, and since it is an S-level message, you will be forced to change your code.

**IBM1948: restricted expression evaluation**

When compiling some of your code, you may see the following message:

```
IBM1948I $ ZERODIVIDE condition with ONCODE=320 raised while evaluating restricted expression.
```

For an example of the code that will produce this message, and for an explanation of what to do, see "NOREEXP" on page 75.
IBM2063: invalid ALLOCATE

When compiling some of your code, you may see the following message:

IBM2063I S Specification of extent for variable-name in
      ALLOCATE statement is invalid since it was declared
      with a constant extent.

For an example of the code that would produce this message, and for an
explanation of what to do, see "RULES(NOLAXCTL)" on page 80.

IBM2402: storage overlay

This message alerts you to a potentially important coding error:

IBM2402I E <variable x> is declared as BASED on the ADDR of <variable y>,
      but <variable x> requires more storage than <variable y>.

The importance of this message depends on how the variables are used in your
program. For instance, if X is a 100-byte structure and Y is declared as CHAR(200)
BASED(ADDR(X)), then the compiler will issue this message. If your program also
contains the statement Y = '', then you have a severe problem (because that
assignment will wipe out 100 bytes of storage that the compiler is likely to be
using for other purposes). You must correct this kind of problem.

However, your program might use Y only in the statements such as:

• SUBSTR(Y,1,STG(X)) = '';
• SUBSTR(Y,1,STG(X)) = LOW(STG(X));

In this case, your code does not need to be changed.

However, in this case, you could change the declare of Y to eliminate these
messages: if you declare Y after X, you could then declare Y as CHAR(STG(X))
BASED(ADDR(X)). This would eliminate this occurrence of the message without
your having to make any changes to your code. But, if you wanted, you could also
then simplify the above assignment statements to:

• Y = '';
• Y = LOW(STG(X));

IBM2409: RETURN; in a function

This message alerts you what is probably a coding error:

IBM2409I E RETURN statement without an expression is invalid inside a
      subprocedure that specified the RETURNS attribute.

The compiler issues this message when it finds a RETURN; statement inside a
function (i.e. inside a PROCEDURE that has the RETURNS options). If this
statement were executed, then the caller of the function would, if it used the result
of the function, use an uninitialized value, and that could have unpredictable and
arbitrarily bad consequences.

Code that produces this message should be corrected.

IBM2410: No RETURN in a function

This message alerts you to another coding error:

IBM2410I E Function F contains no valid RETURN statement.
The compiler issues this message when it finds no RETURN statement inside a function (i.e. inside a PROCEDURE that has the RETURNS options). If this function were called, then the caller of the function would, if it used the result of the function, use an uninitialized value, and that could have unpredictable and arbitrarily bad consequences.

Code that produces this message should be corrected.

**IBM2412: missing RETURNS option**

This message alerts you to a related coding error:

```
IBM2412I E  Procedure has no RETURNS attribute, but contains a RETURN statement.  
        A RETURNS attribute will be assumed.
```

This is the inverse problem to the problem that message IBM2409 flags: here there is a RETURN statement with an expression, but it is inside a PROCEDURE that is a subroutine rather than a function (i.e. inside a PROCEDURE that does not have the RETURNS options). The compiler will assume a RETURNS attribute for the PROCEDURE, but these assumed attributes may not be what you intended. More importantly, if the invoker of this routine invoked it via a CALL statement, then if this RETURN statement were executed, it would assign the return value to storage allocated for other purposes, and that could have unpredictable and arbitrarily bad consequences.

Code that produces this message should be corrected.

**IBM2610: precision interpretation**

This message alerts you to a possible misunderstanding of PL/I rules and, consequently, a possible source of problems:

```
IBM2610I W  One argument to BUILTIN X is FIXED DEC while the other is FIXED BIN 
        or FLOAT.  Compiler will not interpret precision as FIXED DEC.
```

This message applies to the MULTIPLY, DIVIDE, ADD and SUBTRACT built-in functions. You are most likely to see it if:

1. the built-in function has either 3 arguments or 4 arguments the last of which is zero
2. one argument is FIXED DEC(p1,0)
3. one argument is FIXED BIN(p2,0)

If, for instance, X is FIXED BIN(31), the compiler would flag the expression MULTIPLY( X, 1000, 15 ) with this message (even if this expression is assigned to a FIXED DEC(15) variable) because the result of this built-in has the attributes FIXED BIN(15). If you had intended that this built-in function produce a FIXED DEC(15) result (because, for example, you knew the result of the multiplication might be greater than 2G), this code would not perform the way you had intended and might result in the loss of significant data.

Note that if you want to force the result of this MULTIPLY to be FIXED DEC, you could apply the DECIMAL built-in to the FIXED BIN argument (as in MULTIPLY( DEC(X), 1000, 15 )). You also use the PRECTYPE compiler option to change how the compiler interprets the precision, but that would, of course, potentially change the interpretation of other statements.
**IBM2611, IBM2612: duplicate whens**

When compiling some of your "working" code, you may also see a message such as one of the following:

- **IBM2611 W** The binary value ... appears in more than one WHEN clause.
- **IBM2612 W** The character string ... appears in more than one WHEN clause.

This message is easier to understand than some of the others discussed in this section and would be produced by code such as the following:

```pli
SELECT( OPT );
  WHEN( 'F', 'F' )
    BUFROM = ETOS(OPTARG);
  WHEN( 'T', 'T' )
    BUETO = ETOS(OPTARG);
  WHEN( 'N', 'N' )
    MAXRECI = ETOL(OPTARG);
  WHEN( 'K', 'K' )
    KFLG = ^KFLG;
  WHEN( 'M', 'M' )
    MAXERR = ETOL(OPTARG);
OTHERWISE;
  /* ungueltige Option */
END;
```

The message is indicating that the second WHEN clause above is probably meant to be coded as `WHEN( 'T', 'T' )`.

The old compilers would have issued no message, and perhaps the code as written is not incorrect; however, it would probably be worthwhile to examine closely any code producing this message.

**IBM2617: passing labels out of PL/I**

This message alerts you to a bad coding practice that may require you to edit some of your source code.

In general, the use of GOTO statements is a very poor programming practice, but if you pass a LABEL constant or variable to an ENTRY declared with OPTIONS(ASM), OPTIONS(COBOL) or OPTIONS(FORTRAN), you must not attempt to do a GOTO from that non-PL/I code back into your PL/I code by using the passed label. If you have code that is doing this, you must change it.

**IBM2801: introduction of scaled FIXED BIN**

This message alerts you to a possible misunderstanding of PL/I rules and, consequently, a possible source of problems:

- **IBM2801I** FIXED DEC(p1,q1) operand will be converted to FIXED BIN(p2,q2).
  This introduces a non-zero scale factor into an integer operation and will produce a result with the attributes FIXED BIN(r,s).

This message applies to arithmetic operations where one operand is scaled FIXED DEC and one is unscaled FIXED BIN. By PL/I rules, under the RULES(IBM) compiler option, if one operand in an arithmetic operation is DECIMAL and one is BINARY, then the result is BINARY. This applies even if the DECIMAL operand is FIXED DEC with a non-zero scale factor and the BINARY operand is FIXED BIN with a scale factor of zero.
For example, if X is FIXED DEC(5,1) and Y is FIXED BIN(15), then in evaluating the expression X+Y, X will be converted to FIXED BIN(18,4), and the result will have the attributes FIXED BIN(20,4). The compiler will also issue the W-level message IBM1099I because a FIXED DEC(5,1) value whose fractional is not .0 or .5 can not be exactly represented in FIXED BIN.

If you want to eliminate this message and avoid the problems it hints at, you may apply the DECIMAL built-in function to the FIXED BIN operand. For example, X+DEC(Y) would produce a result with the attributes FIXED DEC(8,1).

**IBM2804: suboptimal compares**

This I-level message alerts you to a poor programming practice and possible error:

IBM2804I I Boolean is compared with something other than '1'b or '0'b.

A boolean is a result of a comparison of two expressions or the result of anding, oring or negating booleans. As such, a boolean can have only the values '1'b or '0'b. If your code compares a boolean with something other than one of these values, it may reflect a problem (for instance, maybe the expression (a > b) = c was meant to be (a + b) = c ).

Note that the compiler will produce this message even if you compare a boolean to a value declared as BIT(1) STATIC INIT('1'b). In this situation there is no programming error, but the compiler cannot generate as good as code as it would generate if the value were declared as BIT(1) VALUE('1'b).

**IBM2810: conversion of scaled FIXED BIN**

When compiling some of your code, you may see the following message:

IBM2810I I Conversion of FIXED BIN(31,16) to FIXED DEC(15,12) may produce a more accurate result than under the old compiler.

For an example of the code that will produce this message, and for an explanation of what to do, see “Conversions from scaled FIXED BINARY” on page 108.

**PLIXOPT messages**

The PLIXOPT variable is a varying-length character string that contains run-time options which you can specify at compile time. The messages that the compiler produces to diagnose errors in these options are different than the messages produced by the old compilers. In most cases, the PL/I messages now list an associated Language Environment message that you should read for more information.

A module containing a PLIXOPT declare will also now contain a compiler-generated CEEUOPT CSECT that contains the LE encoding of the run-time options specified in the PLIXOPT string. For small modules, this CSECT can cause a substantial increase in the object size of the modules.

**Using the compiler user exit**

When looking at some of the above messages, you may wish that they had a higher severity. The new compiler option EXIT makes it very easy for you to raise the severity of any informational, warning or error message.
For more information on how to use this option, see the Enterprise PL/I for z/OS Programming Guide.
Chapter 13. Understanding when working code must be changed

This chapter documents situations where the new compiler generates different code than the old compilers. The problems discussed in this chapter have been important to customers who have already migrated to Enterprise PL/I, and you should read this chapter closely to see if they might affect you.

Some of the problematic code discussed in the sections that follow is flagged by the compiler, and you should examine (and change as appropriate) the code associated with the messages issued. In particular, you should examine any compilations producing the following messages:
- IBM1063
- IBM1089

Note also that using the options DECIMAL(NOFOFLONASGN) DFT(OVERLAP) and STATIC(FULL) may eliminate some of these problems.

Retaining unused declarations

**Retaining unused INTERNAL STATIC**

If an INTERNAL static variable is unused, the compiler will not allocate any storage for it.

For example, if the following declaration is the only reference to the variable `build_data`, then no storage would be allocated for this variable and its initial value would not be in the generated text.

```
dcl build_data char(30) var static
    init('Compiled in build 17');
```

If the ABNORMAL attribute is specified on a level-1 static variable, the compiler will allocate storage for the variable. For example, to keep the variable above, you could change the declaration above to:

```
dcl build_data char(30) var static abnormal
    init('Compiled in build 17');
```

Do not apply the ABNORMAL attribute indiscriminately to all variables or all static variables - this will both slow down your compilation and worsen the performance of the generated code.

If you specify the compiler option STATIC(FULL), the compiler will apply the abnormal attribute to all static. This is a coarse solution and is not recommended.

Incorrect code that will now raise exceptions

**FIXEDOVERFLOW when SIZE is disabled**

Under both the old and new compilers, if you try to assign a source to a numeric target and the source is too big, the SIZE condition will be raised if it is enabled.
However, if the SIZE condition is NOT enabled, your program is in error and what happens is unpredictable. You should correct such a program.

Under the old compiler, sometimes no condition would be raised. For example, consider the following program:

```pli
dcl A fixed dec(3);
dcl B pic'9';
A = 123;
B = A;
```

The value in the source A is too large to fit into B, and if SIZE is enabled, it would be raised. However, when SIZE is disabled, the old compiler raises no condition. That does not mean your program is correct - in fact, it is incorrect and should be changed. For instance, if you wished to set B to just the ones digit of A, you could change the above code to:

```pli
dcl A fixed dec(3);
dcl B pic'9';
A = 123;
B = mod(A,10);
```

Moreover, under the old compiler, sometimes a condition would be raised for very similar code. For example, consider the following program:

```pli
dcl X fixed dec(5);
dcl Y fixed dec(4);
dcl Z fixed dec(5);
X = 99999;
Y = X + 1;
Z = X + 1;
```

The value of the expression X + 1 is too large to fit into either Y or Z, and if SIZE is enabled, it would be raised for both statements. However, when SIZE is disabled, the old compiler raises no condition for the assignment to Y and raises FIXEDOVERFLOW for the assignment to Z. Again your program is incorrect and should be changed.

The new compiler handles these statements consistently, but the results depend on the target attributes and the compiler options in effect: when the SIZE condition is disabled,

- if the target has the PICTURE attribute, the generated code will not raise the FIXEDOVERFLOW condition
  
  More precisely, the generated code will not raise the FIXEDOVERFLOW condition when SIZE is disabled when assigning a source expression with any of the following data types to a non-floating point PICTURE target:
  
  - FIXED BIN
  - FIXED DEC
  - non-floating point PICTURE
- if the target has the FIXED DEC attribute, then
  
  - if the default compiler option DECIMAL(NOFOFLONASGN) is in effect, then the generated code will raise the FIXEDOVERFLOW condition
  
  - if the compiler option DECIMAL(NOFOFLONASGN) is in effect, then the generated code will not raise the FIXEDOVERFLOW condition
Note that the above discussion applies to assignments only: if an operation such as addition or multiplication produces a result requiring more than 15 digits (or more than 31 if the LIMITS(FIXEDDEC(15,31)) option is in effect), then an exception will be raised. The exception raised will usually be FIXEDOVERFLOW, but depending on the machine instructions generated, other exceptions, such as a specification exception, may be raised.

Invalid allocations

Under the old compilers, the following piece of code "worked":

```pli
dcl vdptr pointer;
dcl vcom char(2000) based(vdptr);

dcl
  1 vdcommarea based(addr(vcom)),
  2 vda char(1000),
  2 vdb char(1000),
  2 vdz char(1);

alloc vcom;
vdcommarea = '';```

This code is not valid PL/I code because you must not use a 2001 byte area to overlay a 2000 byte allocated piece of storage. By luck, this "worked" under the OS PL/I V2R3 run-time, but under the Language Environment run-time, this code fails miserably.

UNDEFINEDFILE with PRINT files

The UNDEFINEDFILE condition will now be raised if you attempt to open a PRINT file that has the record format VB or FB. PRINT files must have the record format FBA or VBA - the "A" will not be forced onto existing files.

Incorrect code that will now loop endlessly

Even precision PICTURE loop control variables

Consider the following program to initialize an array:

```pli
winter: proc;
dcl n pic'99';
dcl a(0:99) fixed bin ext;
do n = 0 to 99;
a(n) = n;
end;
end;
```

This code is not valid PL/I since if the SIZE condition were enabled, it would be raised after n became equal to 99 (since the next value, 100, it would assume is too large for a PIC'99' variable).

For best performance, using a PICTURE variable for a loop control variable is usually not a good idea. However, for the code above it is a very bad idea since the new compiler will generate code that will make this loop run endlessly.

By the definition of the DO statement, this loop is equivalent to the following code which will loop infinitely under both the old and new compiler.
\( n = 0; \)
\( \text{if } n > 99 \text{ then go to loop_exit; } \)
\( \text{loop_body;} \)
\( \quad a(n) = n; \)
\( n = n + 1; \)
\( \text{if } n <= 99 \text{ then go to loop_body; } \)
\( \text{loop_exit;} \)

However, for the original code using the DO-loop, the old compiler cheats and generates code that is, strictly speaking, incorrect.

The new compiler will try to alert you to this situation by issuing the following messages:

```
IBM1089I W Control variable in DO loop cannot exceed TO value, and loop may be infinite.
IBM1220I W Result of comparison is always constant.
IBM1220I W Result of comparison is always constant.
```

You should closely examine (and probably change) any code that causes the compiler to issue message IBM1089. You could also use the EXIT option to raise the severity of this message.

To correct your code, you could change the attributes for the DO-loop control variable from PICTURE to FIXED BIN(31).

Finally, note that this problem will occur in any loop where the DO-loop control variable is PICTURE\('n\)'9 when \( n \) is an even number and the loop limit is equal to \( 10^n-1 \).

This problem could also occur in forms which would not be flagged by the compiler. For example, consider the following program to initialize an array:

```
sommer: proc;
   dcl n pic'999';
   dcl a(0:999) fixed bin ext;
   do n = 0 to 998 by 2;
      a(n) = n;
   end;
end;
```

In this case, since the TO value of 998 is less than the maximum value that \( n \) could assume, the compiler will not issue message IBM1089. However, after \( n \) assumes the value 998, the next time through the loop \( n \) will be assigned the value 0 and the loop will repeat.

This problem could also occur when the BY value was negative:

```
eiki: proc;
   dcl n pic'999';
   dcl a(0:999) fixed bin ext;
   do n = 79 to 1 by -2;
      a(n) = n;
   end;
end;
```

However, after \( n \) assumes the value 1, the next time through the loop \( n \) will be decremented by 2 and assigned the value 1 and the loop will repeat.
Assignments that will produce different results

Source-target overlap

Consider the assignment \( P \rightarrow Z = Q \rightarrow Z; \) where \( Z \) is CHAR(6) BASED.

Under OPT(0), the old compiler would assign the source first to a 6-byte temporary and then assign the temporary to the target.

However under OPT(2), the old compiler would perform the assignment with one MVC.

These different implementations lead to different results if the source and target overlap.

The new compiler controls this behavior via the OVERLAP suboption of the DEFAULT compiler option:
- under DFT(NO_OVERLAP), the compiler will assume the source and target never overlap.
- under DFT(OVERLAP), the compiler will generate more conservative code whenever necessary.

For example, for the assignment \( \text{SUBSTR}(A,4,6) = \text{SUBSTR}(A,3,6); \), if \( A = \text{‘abcdefghijklm’} \), then
- the old compiler sets \( A = \text{‘abcdefghijkm’} \)
- the new compiler under DFT(OVERLAP), sets \( A = \text{‘abcdefghijklm’} \)
- the new compiler under DFT(NO_OVERLAP), sets \( A = \text{‘abcdefhijklm’} \)

Consequently, for the most compatibility with the least work, you might want to specify the compiler option DFT(OVERLAP).

But specifying this option will also force the compiler to generate slower code in situations where you know the source and target do not overlap and it will also cause the compiler to forego some other optimizations. You would be much better off if you changed your code to avoid source and target overlap and then use DFT(NO_OVERLAP).

For instance, the assignment:
\[
\text{SUBSTR}(A,4,6) = \text{SUBSTR}(A,3,6);
\]

could be replaced by the assignments:
\[
\text{temp_Char6} = \text{SUBSTR}(A,3,6);
\text{SUBSTR}(A,4,6) = \text{temp_Char6};
\]

Float-to-float assignments

The new compiler converts a FLOAT DECIMAL literal, such as 3.1415926E0 or 1E-02, to its internal floating-point representation solely by examining the literal’s attributes and not by examining the context in which it used.

For example, 3.1415926E0 has the attributes FLOAT DEC(8), and hence the new compiler will convert it to long floating point. But, 1E-02 has the attributes FLOAT DEC(1), and hence the new compiler will convert it to short floating point.
If the literal is used in an assignment or an initial clause, the compiler will then convert, if necessary, its floating-point value to the attributes of the target of the assignment or initialization.

However, the old compilers would examine the context in which such a literal is used and convert the literal directly to the attributes of its target. The behavior of the old compilers does not strictly follow the rules for PL/I expression evaluation and can lead to different results than those produced by the new compiler.

Consider this code fragment:

dcl z float dec(06) init(0);
dcl s float dec(06);
dcl q float dec(17);

s = le-2;
q = s;
put skip data( q );
q = le-2;
put skip data( q );
q = le-2 + z;
put skip data( q );

In all three assignments to q above, the attributes of the source are those of a short floating-point number, and the value of the source should be the same. However, the results of the three PUT statements under the old compilers are:

Q= 9.99997913873432861E-03;
Q= 9.9999999999999999E-03;
Q= 9.9999999999999999E-03;

The results of the three PUT statements under the new compiler are:

Q= 9.99999979138743260E-03;
Q= 9.9999999999999999E-03;
Q= 9.9999999999999999E-03;

This kind of difference occurs only for float literals that cannot be exactly represented (such as fractions like 1E-2 that cannot be equated to a binary fraction).

To alert you to situations such as the above, the compiler will issue message IBM1065I when it detects short-floating point literals that cannot be exactly represented.

To get the same results as under the old compilers, you would have to change your source in one of the following ways:

1. specify the constant via the FLOAT built-in function applied to a FIXED DECIMAL literal and with the desired precision
   for example, you would specify 1E-2 as FLOAT(.01,7) to make it a long floating-point value and as FLOAT(.01,17) to make it an extended floating-point value
2. add enough zeroes to the literal to give it the desired precision
   for example, you would specify 1E-2 as 1.000000E-2 to make it a long floating-point value and as 1.0000000000000000E-2 to make it an extended floating-point value
3. use the new D or Q format to indicate the desired precision
   for example, you would specify 1E-2 as 1D-2 to make it a long floating-point value and as 1Q-2 to make it an extended floating-point value
Note that the first two changes in the above list would be accepted by the old and new compilers (and would produce the same results under each), but the third change would work only under the new compiler.

### Other statements that will produce different results

#### STREAM I/O with unprintable characters

If a character with the value '00'x, '0C'x through '0F'x or '15'x is part of the output of a PUT FILE statement, then a period ('4B'x) will be output instead. After APAR PQ79494, this difference will apply only if the FILE is a PRINT file or if the file output is directed to SYSOUT.

#### Uninitialized EXTERNAL STATIC

Under the old compiler, a variable declared as EXTERNAL STATIC but with no INITIAL value(s) specified for it was not allocated any storage (and a linkage editor ESD of type CM was issued). The storage for it must have been defined in some other program object that will be linked with it. In fact, the storage that was actually allocated may be bigger than what its declare specified (or implied). For example, consider the following code declares:

```pli
dcl testpcl ext static, pcl char(16) based(addr(testpcl));
```

The variable testpcl has the (implied) attributes of FLOAT DEC(6) and hence would seem to be allocated only 4 bytes of storage. If all the programs linked with this one also declare testpcl with the same PL/I declare, then exactly 4 bytes will be allocated to it. However, if it is linked with, say, an assembler that defined testpcl as a 16-byte CSECT, then the linker would allocate 16 bytes to it.

The new compiler will currently allocate 4 bytes to such a variable (and issue a linkage editor ESD of type SD and length 4). An attempt to use it as the base for, say, a 16-byte area will lead to errors.

If you want to declare a variable but have its storage allocation be determined by its declaration in another module, you should declare it with the RESERVED option. For example, the declare above should be:

```pli
dcl testpcl ext static reserved, pcl char(16) based(addr(testpcl));
```

If, however, you compile with the option COMMON, then the Enterprise compiler will also issue a linkage editor ESD of type CM, and the code would work as it did with the old compiler.

#### Incompletely declared FILEs

Under the old compiler, if you declared an EXTERNAL FILE in one routine with some attributes, such as RECORD, but in another routine linked with the first routine, you did not declare the file or declared it with no attributes (other than FILE), then the second routine would use the attributes declared in the first routine even if the second routine opened the file first.

Enterprise PL/I would handle this differently: the second routine would not "see" the attributes from the first routine and would instead apply the default attributes, such as STREAM, to the file. This can lead to problems.

You should correct this code by declaring the FILE identically in all routines; in fact, all EXTERNAL variables should be declared identically in all routines.
**Dummy arguments**

According to the Language Reference Manual, a dummy argument will be created if an argument differs from its parameter description in its alignment. However, the old compiler followed this rule for CHARACTER NONVARYING, but not for CHARACTER VARYING. The new compiler applies the rule consistently.

So, for example, given the following code

```pli
dcl x entry( unaligned char(8) );
dcl y entry( unaligned char(8) varying );
dcl a aligned char(8);
dcl b aligned char(8) varying;
call x( a );
call y( b );
```

Dummy arguments should be created for both CALL statements, but only the Enterprise compiler will create a dummy argument for the second CALL.

Note that you can use the DEFAULT(DUMMY(UNALIGNED)) compiler option to make the compiler ignore alignment mismatches when deciding when to create dummy arguments. If this option were in effect, the compiler would not create a dummy argument for either of the CALLs in the above example.

**Pointer arithmetic**

In expressions involving pointer arithmetic, it is presumed that the pointers are addresses. Consequently, when adding a value to a pointer, the result pointer may not have the high order bit on even though the source pointer did have the high order bit on.

**Code that will not perform as well**

**FIXED DEC as a loop control**

A DO-loop that has a FIXED DECIMAL or PICTURE control variable will perform much worse than a loop that has a FIXED BINARY control variable.

You can get significantly better code if you change the declarations for your loop control variables from FIXED DEC to FIXED BIN(31).

**FIXED BIN(15) as a loop control**

A DO-loop that has a FIXED BIN(15) control variable will perform worse than a loop that has a FIXED BIN(31) control variable.

Under OPT(2) or OPT(3), the compiler will issue I-level message IBM1063 to flag code that uses FIXED BIN(15) control variables. You can get better code if you change the declarations for your loop control variables from FIXED BIN(15) to FIXED BIN(31).

**I/O using TOTAL**

Since the TOTAL option of the ENVIRONMENT attribute is not supported, I/O to files using it will generally not perform as well.
Chapter 14. Understanding when working code may need to be changed

This chapter documents more situations where the new compiler generates different code than the old compilers. But unlike the previous chapter, these differences are somewhat obscure; they are included in this document for completeness and because they could potentially affect you.

Code that will now raise ERROR

**ZERODIVIDE and OVERFLOW promoted to ERROR**

Under the old compiler if ZERODIVIDE or OVERFLOW were raised and there was an ON-unit for the condition, then if the END statement for the ON-unit was reached, your program would continue with the next machine instruction after the one that raised the condition.

If the condition was raised by a hardware exception, this meant that your program continued on with some unknown value as the result of the operation, and this often led to more errors.

Under the new compiler, if either ZERODIVIDE or OVERFLOW is left unhandled by an ON-unit, then the condition will be promoted to ERROR.

**Invalid RETURNS**

Consider the following somewhat senseless, but illustrative, code fragment:
```
call y;

x: proc returns( pointer );
y: entry;
  return( sysnull() );
end;
```

This program fragment is in error because when the procedure is entered at Y no value should be returned, but the code attempts to return a value nonetheless.

Under the old compiler, no condition would be intentionally raised when the invalid return was attempted, and the program might fail in any number of ways (and it might even complete “successfully”).

Under the new compiler, the ERROR condition would be intentionally raised by the generated code with ONCODE=9004.

**GOTO holes**

Consider the following code fragment:
```
dcl x(4) label;
goto x(n);
x(4):;
  put skip list( n );
x(3):;
  put skip list( n );
```

105

x(2):;
put skip list( n );
x(1):;
put skip list( n );

Note that if \( n < 1 \) or if \( n > 4 \), and if the SUBSCRIPTRANGE condition is not enabled, then your program was in error.

Under the old compiler, a protection exception usually resulted.

Under the new compiler, the ERROR condition will be raised with ONCODE=9003 with the following message:

IBM0751S ONCODE=9003 A GOTO was attempted to an element of a label constant array, but the subscripts for the element were not those of any label in that array.

---

**Code that will now not raise exceptions**

**FIXEDOVERFLOW for FIXED BIN**

Under the old compiler, the FIXEDOVERFLOW (or FOFL) condition would be raised if any FIXED BIN operation produced a result that required more than 31 binary digits. For example, if you multiplied a FIXED BIN variable equal to 100_000 by itself, then the FOFL condition would be raised.

Under the new compiler, the FOFL condition will not be raised for any FIXED BIN computation (but it will still be raised for FIXED DEC computations when needed). This makes the PL/I language match the C and JAVA languages, and it also enables the compiler to generate inline code to perform adds and subtracts on 8-byte integers.

In fact, during run-time initialization, the bit in the PSW that enables integer FOFL will not be set if all your code has been compiled by the C or by the new PL/I compilers. It will be set on if there is any old PL/I code in the main module, and that can have some negative performance consequences for some of your new code.

**CONVERSION when assigning blanks to numeric variables**

Under the old compiler, the CONVERSION (or CONV) condition would be raised if a character string consisting of one or more blanks (and nothing else) was assigned to a numeric variable. However if a varying character string of length zero was assigned to a numeric variable, CONVERSION would not have been raised (even though a zero-length character string compares equal to character string consisting only of blanks).

Under the new compiler, the CONVERSION condition will not be raised by the assignment to a numeric variable of any character string that would compare equal to a blank string.

**ERROR when mapping excessively large aggregates**

If your code declares an aggregate with adjustable extents, its size will be determined at runtime. If its size would be greater than 2G and the compiler generates a call to a library routine to map the variable, then the ERROR condition will be raised.
However, for a simple aggregate with adjustable extents, the compiler will generate inline code to determine the variable’s size - unless the SIZE condition is enabled. If such a variable had a size greater than 2G and SIZE was not enabled, then no condition would be raised and your program would be invalid. Of course, if your aggregates are reasonable in size, you will get far better performance if SIZE is not enabled.

Storage mapped differently

One-byte FIXED BIN

If you have any variables declared as FIXED BIN with a precision of 7 or less, they occupy one byte of storage under Enterprise PL/I instead of two as under PL/I for MVS & VM and earlier. If the variable is part of a structure, this usually changes how the structure is mapped, and that could affect how your program runs. For example, if the structure were read in from a file, fewer bytes would be read in under Enterprise PL/I than under PL/I for MVS & VM or earlier PL/I release.

To avoid this difference, you could change the precision of the variable to a value between 8 and 15 (inclusive).

To help you locate where you might have problems because of this difference, the compiler will flag any FIXED BIN with precision <= 7 with message IBM1044.

The (NO)BIN1ARG suboption of the DEFAULT compiler option controls how the compiler handles one-byte REAL FIXED BIN arguments passed to an unprototyped function:

- Under BIN1ARG, the compiler will pass a FIXED BIN argument as is to an unprototyped function.
- But under NOBIN1ARG, the compiler will assign any one-byte REAL FIXED BIN argument passed to an unprototyped function to a two-byte FIXED BIN temporary and pass that temporary instead.

Consider the following example:

dcl f1 ext entry;
dcl f2 ext entry( fixed bin(15) );
call f1( 1b );
call f2( 1b );

If you specified DEFAULT(BIN1ARG), the compiler would pass the address of a one-byte FIXED BIN(1) argument to the routine f1 and the address of a two-byte FIXED BIN(15) argument to the routine f2. However, if you specified DEFAULT(NOBIN1ARG), the compiler would pass the address of a two-byte FIXED BIN(15) argument to both routines.

Note that if the routine f1 was a COBOL routine, passing a one-byte integer argument to it would cause problems since COBOL has no support for one-byte integers. In this case, using DEFAULT(NOBIN1ARG) might be helpful; but it would be better to specify the argument attributes in the entry declare.

So, while BIN1ARG is the default suboption, you may find it useful to specify the NOBIN1ARG suboption for increased compatibility.
Declarations handled differently

**AREA with INITIAL**
The new compiler ignores the INITIAL attribute for AREAs, and you should convert any INITIAL clauses for AREAs into assignment statements.

For example, in the following code fragment, the elements of the array are not initialized to a1, a2, a3, and a4:

```plaintext
dcl (a1,a2,a3,a4) area;
dcl a(4) area init( a1, a2, a3, a4 );
```

However, you can rewrite the code as follows so that the array is initialized as desired:

```plaintext
dcl (a1,a2,a3,a4) area;
dcl a(4) area;

a(1) = a1;
a(2) = a2;
a(3) = a3;
a(4) = a4;
```

The compiler will flag any declare of AREA with INITIAL with message IBM1196.

Conversions handled differently

**Conversions from float to character**
In some conversions from FLOAT (BIN or DEC) to CHARACTER, there may be a difference of one in the last digit between the result produced under the old and new compiler.

This difference does not reflect a difference in the underlying floating-point value or in the calculations that led up to it. It is generally safe to ignore this difference.

**Conversions from scaled FIXED BINARY**
It is generally best to avoid scaled FIXED BINARY since its use generally causes the compiler to produce less efficient code. Additionally, in some conversions of scaled FIXED BINARY to FIXED DECIMAL, the new compiler may produce a different (but more accurate) result than the old compiler.

For example, consider the following code

```plaintext
dcl i fixed bin(15) init(290);
dcl s fixed bin(31,16);
dcl d fixed dec(15,12);

d = i / 365;
put skip data( d );
s = i / 365;
d = s;
put skip data( d );
```

The results of the two PUT statements under the old compilers are:

```
D= 0.794509887700;
D= 0.794509887700;
```

The results of the two PUT statements under the new compiler are:
\[ D = 0.794509887695; \]
\[ D = 0.794509887695; \]

Note that while the second assignment above clearly involves a conversion of scaled FIXED BIN to FIXED DEC, the first assignment also involves such a conversion since the attributes of the expression \( i / 365 \) are, by the PL/I rules for expression evaluation, FIXED BIN(31,16).

To understand what is happening here, it will help to look at the contents of the variable \( s \) after it is assigned the result of the divide. \( s \) will then hold the hex value 0000CB65. If viewed as a FIXED BIN(31,0) number, this would be the value 52069, but since it has scale factor 16, it represents the value 52069/2**16. That value is mathematically equivalent to 52069*5**16/10**16. So, to convert it from base 2 to base 10, the compiler multiplies the value by 5**16 (or 152587890625). That would produce a FIXED DEC value with scale factor 16; hence to produce the target result with scale factor 12, the last 4 digits are dropped.

As can be verified on a calculator, 52069 times 5**16 is 7945098876953125, and dropping the last digits yields the result produced by the new compiler.

The reason the old compiler produced a different result is that its generated code multiplied \( s \) not by 152587890625, but 152587890626. This leads to a less accurate result.

You can avoid this problem entirely by insuring that all divisions that could yield a fractional result are performed in decimal. Using the DECIMAL built-in function is one easy way to do this. For example, if, in the first assignment above, the expression \( i / 365 \) were changed to \( \text{dec(i) / 365} \), the result of the assignment would be 0.794520547945.

To alert you to situations such as the above, the compiler will issue message IBM28101 when it detects conversions of scaled FIXED BIN to FIXED DEC.

---

**Built-in functions handled differently**

**Arithmetic built-ins with scale factors and FIXED BIN**

Under the RULES(IBM) compile-time option, which is the default, variables can be declared as FIXED BIN with a nonzero scale factor. Infix, prefix, and comparison operations are performed on scaled FIXED BIN using the same semantics as the old compilers.

However, the ADD, DIVIDE, or MULTIPLY built-in functions will not produce FIXED BIN results with nonzero scale factors.

The new compiler evaluates these built-in function as FIXED DEC rather than as FIXED BIN as the old compilers did if either of the following is true:

- their arguments are FIXED BIN with nonzero scale factors
- their arguments are FIXED BIN with zero scale factors but a nonzero value is specified as their fourth argument

For example, the new compiler would evaluate the DIVIDE built-in function in the assignment statement below as a FIXED DEC expression:
dcl (i,j) fixed bin(15);
dcl x fixed bin(15,2);
...

x = divide(i,j,15,2);

Note that in most cases where this message appears, no change is necessary; this is usually what the programmer thought was happening. For example, in the above code, it would be the rare program that actually wanted the result of that divide to have the attributes FIXED BIN(15,2) rather than FIXED DEC(15,2).

The compiler will flag this difference with message IBM1053.

---

**MACRO preprocessor differences**

**MACRO preprocessor and strings**

Under the old compiler, the MACRO preprocessor would uppercase all text except for text enclosed in strings and comments. But the old compiler recognized only text delimited by ‘...’ as strings: text delimited by "..." was not recognized as a string and was uppercased.

The new compiler will, under the default preprocessor option of CASE(UPPER) also uppercase all text except for text enclosed in strings and comments. However, the new compiler recognizes both text delimited by ‘...’ and text delimited by "..." as strings and will not uppercase either.

This difference could cause a problem if you were running the MACRO preprocessor before the SQL preprocessor and if you also had code in your SQL statements such as:

WHERE "system" = 'Wilmer'

Under the old compiler, this would have become:

WHERE "SYSTEM" = 'Wilmer'

But under the old compiler, this becomes:

WHERE "system" = 'Wilmer'

The latter would probably not produce the results you want from DB2. If this is the case, you must change your source so that the text delimited by "..." is in uppercase (before any preprocessing).
Chapter 15. Linking your new objects

This chapter describes factors you must consider when you link-edit an object module produced by the new Enterprise PL/I compiler.

For more information on linking your code, refer to the Enterprise PL/I for z/OS Programming Guide.

Prelinker and PDSE considerations

As long as you use the Enterprise PL/I default compiler options of NORENT and LIMITS(EXTNAME(7)), you do not need to use either the prelinker or PDSEs.

AMODE(24) considerations

For AMODE(24) support you must link your application program with SIBMAM24 concatenated in front of SCEELKED.

The SIBMAM24 link-edit dataset is available only through ++APAR PQ62003 for z/OS releases prior to z/OS 1.6.

For more information on building AMODE(24) applications, refer to “AMODE(24) restrictions” on page 68.

Using PLICALLA or PLICALLB Entry

If you use PLICALLA or PLICALLB as a main entry point in an Enterprise PL/I program, you must concatenate SIBMCAL2 in front of SCEELKED.

CHANGE cards

Enterprise PL/I does not support the use of CHANGE cards during link-edit if either the RENT option is specified or the LIMITS(EXTNAME(n)) option is specified with a value of n greater than 8.
Chapter 16. Using Language Environment with the new compiler

Many of the same considerations that were discussed in Chapter 6, “Considerations Before Migrating,” on page 35 apply to the new compiler as well. Please refer to that chapter for run-time considerations when using the new compiler.

Chapter 13, “Understanding when working code must be changed,” on page 97 also contains useful information about differences between Enterprise PL/I run-time results and previous versions of PL/I.

Using the right run-time options

Under Language Environment, some of the options available under the OS PL/I run-time are no longer available, and some have been renamed, redefined, or merged with other options. In addition, some important new options are now available.

The dropped options are:
- COUNT
- FLOW

The renamed and merged options are:
- HEAP redefines HEAP
- NATLANG replaces LANGUAGE
- RPTSTG replaces REPORT
- STACK merges ISASIZE and ISAINC
- TRAP merges SPIE and STAE

Some of the important new options are:
- ABTERMENC
- ALL31
- DEPTHCONDLMT
- ERRCOUNT
- MSGFILE
- STORAGE
- XUFLOW

For more and complete information about run-time options, see the z/OS Language Environment Programming Reference, but note the following key points:
- For compatibility with OS PL/I, use the following options:
  - ABTERMENC(RETCODE)
  - DEPTHCONDLMT(0)
  - ERRCOUNT(0)
  - TRAP(ON)
  - XUFLOW(ON)
- You must specify the following options in your AMODE(24) applications:
  - ALL31(OFF)
  - HEAP(,,BELOW)
  - STACK(,,BELOW)
- Never use RPTSTG(ON) in any performance-critical application.
• Never use STORAGE(,,00) in any performance-critical application.
• You must specify POSIX(ON) in any multi-threaded application.

Calling PL/I from assembler main programs

There are three ways Language Environment-conforming assembler routines can pass control to a Enterprise PL/I subroutine:

1. Branch to a statically-linked Enterprise PL/I subroutine.
2. Use the Language Environment macro CEEFETCH to branch to a separately-linked Enterprise PL/I subroutine.
3. Use assembler instructions such as LOAD and BALR to branch to a separately-linked Enterprise PL/I subroutine.

In this case, you must explicitly link in the Language Environment-Enterprise PL/I signature CSECT, CEESG011, to ensure the Language Environment-PL/I-specific run-time environment is initialized.

For information on other assembler issues, see “Differences in Assembler Support” on page 45.

Understanding when your results may vary

Return codes

The PLIRETC built-in subroutine will now accept a FIXED BIN(31) argument and does not require the value to be <= 999.

Correspondingly, the PLIRETV built-in function will now return a FIXED BIN(31) value.

Under the Language Environment run-time, the user return code is always reset to zero upon return from a PLISRTx invocation.

The Language Environment run-time adds 3000 to the user return code for severity 3 conditions, and Language Environment classifies all PL/I conditions as severity 3 except:

• ATTENTION (when raised by a SIGNAL statement)
• CONDITION
• ENDPAGE
• FINISH
• NAME
• PENDING
• STRINGRANGE
• STRINGSIZE
• UNDERFLOW

When the run-time issues messages

Under Language Environment, there is a small difference in the timing of when some run-time messages are issued for conditions with ON-units:

• without Language Environment, if a condition such as ZERODIVIDE or ERROR occurred, the run-time would issue a message before invoking the ON-unit for the condition
• with Language Environment, if a condition such as ZERODIVIDE or ERROR occurs, the run-time will issue a message only if the END statement in the ON-unit is executed.

This change gives you the chance to handle a condition (and issue your own message if you wish) and to continue your application via a GOTO without the run-time also issuing its own message.

There is no change to the run-time behavior when there is no ON-unit.

Also, the SNAP traceback message produced by ON ERROR SNAP continues to be issued before the ERROR ON-unit receives control.

**What the run-time messages say**

PL/I for MVS & VM and Enterprise PL/I share the same set of run-time messages, and this can lead to messages that should be read with understanding and flexibility. For example, when the run-time issues a message for UNDEFINEDFILE in an Enterprise PL/I program, the message will mention both MVS and VM constructs even though Enterprise PL/I does not currently support VM. The meaning should be clear nonetheless.

Also, if you compile with the compiler GONUMBER option, the run-time messages will refer to a "statement" where your exception has occurred. This "statement" is, for Enterprise PL/I, the line number in the source program of the statement that raised the exception.

Finally, the format and content of run-time messages are different under the Language Environment run-time than under the OS PL/I run-time. You can find complete descriptions of the run-time messages in *z/OS Language Environment Run-Time Messages*.

**Where the run-time messages go**

Under Language Environment, run-time messages go to the destination specified in the run-time option MSGFILE. The default MSGFILE destination is SYSOUT, not SYSPRINT, as it was under the old run-time. MSGFILE(SYSPRINT) is supported under Enterprise PL/I only after applying the PTFs for the runtime APAR PQ78307.

**Math built-ins**

The new compiler invokes the Language Environment-provided routines to evaluate the mathematical built-in functions (such as SIN or COS). These routines are more precise than the routines provided with the OS PL/I V2R3 library and can sometimes produce results with a different last digit.

As an example of this difference, consider the following program which produces the kind of table seen at the back of trigonometric textbooks:

```plaintext
trigtab: proc options(main);

dcl degrees fixed dec(5,1);
dcl minutes fixed dec(3,1);

do degrees = 0 to 359;
  put skip edit( degrees ) ( f(5) );
do minutes = 0 to .9 by .1;
  put edit( sind(degrees+minutes) ) ( f(9,4) );
```

Chapter 16. Using Language Environment with the new compiler  115
The output of this program looks like:

\[
\begin{array}{cccccccc}
0 & 0.0000 & 0.0017 & 0.0035 & 0.0052 & 0.0070 & \ldots \\
1 & 0.0175 & 0.0192 & 0.0209 & 0.0227 & 0.0244 & \ldots \\
\end{array}
\]

The table produced depends on which math library is used, and even then there are only 5 different values. For instance, with the old compilers using the pre-LE math library, the result for 140.1 is 0.6414, while with the old compilers using the LE math library, the result is 0.6415. Since the new compiler uses only the LE math library, the result with it is also 0.6415.

**Dumps**

Calling PLIDUMP still produces a dump, but the format, contents, and destination of dumps are now controlled by Language Environment. For more information on the many resultant, but mostly small, differences, see “Differences in PLIDUMP” on page 43.

**Storage reports**

The format, contents, and destination of the run-time storage report have changed. For more and complete information about the run-time storage report, see the description of the RPTSTG option in the z/OS Language Environment Programming Reference.

Note that Language Environment does not use the PLIXHD declaration to provide the heading for the run-time storage report. You can, however, specify the heading via Language Environment’s callable service CEE3RPH.

**Prerequisite Language Environment PTFs**

The following PTFs are required to compile and run PL/I applications using Enterprise PL/I.

- For z/OS, Version 1 Release 4: PTF UQ70042 (APAR PQ66155) and PTF UQ88264 (APAR PQ88268).
- For z/OS, Version 1 Release 5: PTF UQ80236 (APAR PQ78173) and PTF UQ88263 (APAR PQ88065).
- For z/OS, Version 1 Release 6: PTFs UQ92073 and UQ92088 (APARs PQ92870 and PQ93118).
- For z/OS, Version 1 Release 7: PTF UK06652 (APAR PK10630).
Chapter 17. Tuning for better CPU and storage utilization

After you migrate to Language Environment, you should retune your applications to maximize the performance. When you retune an application, it is not always possible to maximize CPU and storage at the same time. Often you will find that, in order to obtain better CPU, you need to use more storage, or vice versa. This section provides general tips to help you to retune your applications under Language Environment.

For information on choosing compiler options for improved performance see “Choosing options for improved performance” on page 76.

For more information on tools you can use to improve performance for your applications, see z/OS Language Environment Programming Guide, z/OS Language Environment Installation and Customization under OS/390 or z/OS Language Environment Customization, and Enterprise PL/I for z/OS Programming Guide.

Improving CPU Utilization

The following discussion shows ways to help you obtain better CPU utilization:

• Reduce the number of GETMAINs and FREEMAINs issued by Language Environment. Use the Language Environment RPTSTG(ON) option to produce the storage report. Specify the reported storage amount in the corresponding Language Environment storage run-time options.

• Reduce the number of LOADs and DELETEs issued by Language Environment. Put the commonly used Language Environment library routines in (E)LPA. The following lists the recommended candidates for PL/I:
  – CEEBINIT (LPA)
  – CEEPLPKA (ELPA)
  – CEEEV010 (ELPA) if you still have OS PL/I applications
  – CEEEV011 (ELPA) for Enterprise PL/I applications
  – CEEBLIIA (LPA) for OS PL/I applications not relinked
  – IBMRLIB1 (LPA)

See z/OS Language Environment Installation and Customization under OS/390 or z/OS Language Environment Customization for a complete list of library routines that can be put in (E)LPA.

• Avoid AMODE switching between library routines. Use AMODE(31) for your application, if possible, so you can specify Language Environment ALL31(ON) option. If ALL31(ON) is in effect, there will be no AMODE switching among library routines.

• Avoid overuse of PL/I conditions. All PL/I condition handling is expensive and should only be used where appropriate. Overuse of PL/I condition handling will degrade the performance of your application.

• Use DF/SMS-provided system-determined BLKSIZE. On MVS, use BLKSIZE(0) for an output file that can be blocked. DF/SMS determines the optimal block size for you which can improve the file performance.

• Use Language Environment Library Routine Retention facility (LRR).
You can get a better CPU performance if you use LRR. When LRR is used, Language Environment keeps certain Language Environment resources in storage when an application ends. Subsequent invocations of programs that use LRR is much faster because the Language Environment resources left in storage are reused.

For example, you can use LRR for your IMS/DC environment to improve performance.

Note that because LRR leaves LE resources in the storage for a long period of time, you must assess your storage availability to accommodate the situation.

### Improving Storage Utilization

The following discussion helps you to obtain better storage utilization:

- **Relink with Language Environment if you have not recompiled your OS PL/I programs.**
  
  The relinked OS PL/I load module has a smaller size because it contains the Language Environment stubs only.

- **Make your application AMODE(31) and RMODE(ANY).**
  
  Most likely the application will be loaded above the 16M line. You can specify the Language Environment ALL31(ON) option which allows Language Environment to allocate some of its control blocks above the 16M line.

- **Use Language Environment option HEAP(,,ANY) option, if possible.**
  
  For PL/I, Language Environment will allocate the heap storage above the 16M line if the following is true:
  
  - The requestor is in AMODE(31)
  - HEAP(,,ANY) is in effect
  - The main program is in AMODE(31)

- **Use Language Environment STACK(,,ANY) option, if possible.**
  
  Your application must be in AMODE(31). For PL/I, Language Environment will allocate the stack storage above the 16M line if your application is relinked with Language Environment and contains no edited stream I/O.

- **Analyze the IBM-supplied default values in Language Environment storage options and change them, if possible and as necessary, to make them optimal for your applications.**
  
  Note that specifying a smaller value is not always better: if you use a smaller value, Language Environment will allocate less storage initially, but this could result in more GETMAINs and FREEMAINs being issued over the life of the application - and GETMAINs are very expensive.

- **Put commonly used Language Environment library modules in the (E)LPA.**
  
  The library routines in (E)LPA do not occupy storage in your application region, so your application has more storage to use. See the recommended library routines for (E)LPA in ["Improving CPU Utilization" on page 117](#).

### Improving Performance under Subsystems

The following discussion helps you to obtain better performance under specific subsystems:

- **Under CICS**
  
  Use the PL/I FETCH/CALL statement instead of EXEC CICS LINK. The PL/I FETCH/CALL statement has a much shorter path length than the path length of EXEC CICS LINK.

- **Under IMS**
Use Language Environment Library Routine Retention (LRR) facility to reduce the number of LOADs/DELETEs and GETMAINs/FREEMAINs issued by Language Environment for each transaction.

Preload commonly used Language Environment library modules and frequently used top-level applications.
Chapter 18. Adding Enterprise PL/I programs to existing PL/I applications

When you add an Enterprise PL/I program to an existing application, you are either recompiling an existing program with Enterprise PL/I or including a newly written Enterprise PL/I program. When you add Enterprise PL/I programs to your existing applications, you have the ability to upgrade your existing programs incrementally, as your shop’s needs dictate.

---

**Important**

After you add an Enterprise PL/I program to an existing application, that application must run under Language Environment.

---

This chapter includes information on the following topics:

- Object and load module considerations
- Condition handling in mixed applications

Please also note these important points:

- You cannot mix new and old object code if the old code does any multitasking.
- If you mix old and new code, you cannot do any FETCH from FETCH.

**Object and load module considerations**

While recompiling all your PL/I source is strongly recommended, if this isn’t done, the following options must be used when compiling Enterprise PL/I code that will be mixed with older PL/I objects:

- CMPAT(V2) (or CMPAT(V1) if that’s what you are currently using with old PL/I)
- LIMITS( EXTNAME(7) )
- NORENT
- BACKREG(5)
- BIFPREC(15)

In addition, as discussed in Chapter 11, “Understanding the new compiler’s options,” on page 71, you may also want to use some or all of these options:

- COMMON
- DEFAULT( LINKAGE( SYSTEM ) )
- DEFAULT( OVERLAP )
- EXTRN( FULL )
- NOWRITABLE(PRV)

Note that unless you use the NOWRITABLE(PRV) option, CONTROLLED variables cannot be shared between old and new code.

Even if all the options listed above are used, there are some restrictions on mixing old and new object code:
• FILE variables and constants cannot be shared between old and new code with
one exception: SYSPRINT, when written to SYSOUT, can be shared by old and
new code if the old code was linked under LE. However, a file written out by
old code can be read by new code - and vice-versa.
• Whenever old code is used, all fetch/release restrictions from the older product
apply. In particular, if a new MAIN does successfully FETCH and CALL an old
module, then the old module cannot perform a subsequent FETCH of another
module.
• If any old code is present in an application, DLL code cannot be invoked.
• For old code compiled with OS PL/I V2R3 or earlier:
  − An old MAIN not linked with LE cannot FETCH a new module.
  − A new MAIN cannot CALL or FETCH an old module unless either the old or
new module is linked with SCEELKED and with INCLUDE
SYSLIB(CEESG010).

Previously, Enterprise PL/I had the restriction that if your old code did any I/O,
then MAIN must have been compiled with an old compiler. This restriction is no
longer valid if you have recent library maintenance applied.

### Sharing SYSPRINT

When SYSPRINT is shared between Enterprise PL/I and PL/I for MVS & VM,
only the default DISPLAY(WTO) option is supported. The compiler options
STDSYS and DISPLAY(STD) must not be used when sharing SYSPRINT between
old and new code.

In such a shared SYSPRINT environment, the first SYSPRINT that is opened will
determine the LINESIZE to be used. The second SYSPRINT must be opened with a
LINESIZE equal to or smaller than the LINESIZE of the first. However, it is
strongly recommended to use the same LINESIZE for both SYSPRINTs, either by
opening them both implicitly or both explicitly with the same LINESIZE.

SYSPRINT can be shared with older PL/I only when a STREAM file (i.e. -
SYSOUT=*), and not a permanent dataset, is used.

SYSPRINT cannot be shared with older PL/I under TSO.

### Condition handling considerations

For the purposes of condition handling you must consider old PL/I programs and
Enterprise PL/I programs as separate languages. Both old PL/I and Enterprise PL/I
have their own signature CSECTs (CEESG010 for OS PL/I and PL/I for MVS &
VM and CEESG011 for VisualAge PL/I and Enterprise PL/I), and separate
run-time libraries in Language Environment.

This implies that when software conditions are raised in a PL/I source program on
one side (either old or new PL/I) and is expected to be handled by a PL/I source
program on the other side (new PL/I if it was raised in old PL/I, or old PL/I if it
was raised in new PL/I), the program that is supposed to handle the exception
will not even know about it because it uses a completely separate run-time library
than the program that raised the condition.
Hardware conditions (such as ZERODIVIDE) have a better chance of being handled correctly across the old PL/I/new PL/I boundary because Language Environment gets involved and bridges the gap between the two separate PL/I run-time libraries.

**Partitioning PL/I source programs into units of execution**

You will need to partition your PL/I source programs into units of execution to accommodate the restrictions on mixing and condition handling between old and new PL/I modules as described above.

Careful attention must be paid when partitioning your PL/I source programs into units of execution. Your goal is to contain any restrictions on mixing old and new PL/I modules within the boundaries of the units of execution that you define. For example, if Program A defines a CONTROLLED EXTERNAL variable and Program B references this variable and Program B also creates a file variable that it shares with Program C, then all three Programs A, B, and C must be compiled with Enterprise PL/I in order to work correctly.

Finally, note that when mixing old and new code, you must pay attention to the differences between how the new and old compilers handle various language constructs, as described in Chapter 13, “Understanding when working code must be changed,” on page 97.
Chapter 19. Moving from VisualAge PL/I or Enterprise PL/I V3R1, V3R2, V3R3 or V3R4 to Enterprise PL/I V3R5

This book concentrates on the migration effort in moving from OS PL/I or PL/I for MVS & VM to Enterprise PL/I V3R3. If you have already moved to VisualAge PL/I, Enterprise PL/I V3R1, V3R2, V3R3 or V3R4, migration to Enterprise PL/I V3R5 will be relatively easy.

Migrating from VisualAge PL/I

There have been some important changes since VisualAge PL/I:
• The LRECL for the compiler SYSPRINT dataset is now 137.
• The defaults have been changed for the following compiler options to:
  – ARCH(2)
  – BACKREG(5)
  – BIFPREC(15)
  – CMPAT(V2)
  – CSECT
  – EXTRN(FULL)
  – FLOAT(AFP)
  – LIMITS(EXTNAME(7))
  – NORENT
  – TUNE(3)

There have also been some smaller changes to the set of compiler options:
• The OFFSET option now has the same meaning it had in the compilers before VisualAge PL/I: specifying it will now cause the compiler to produce a statement offset table.
• The FLAG option now has the same meaning it had in the compilers before VisualAge PL/I. The new MAXMSG option now controls the behavior that the FLAG option controlled under VisualAge PL/I.
• The new USAGE option now controls some of the behavior that the RULES(IBM/ANS) option controlled under VisualAge PL/I.

Migrating from Enterprise PL/I V3R1

There have been some important changes since Enterprise PL/I V3R1:
• The LRECL for the compiler SYSPRINT dataset is now 137.
• The defaults have been changed for the following compiler options to:
  – ARCH(2)
  – BACKREG(5)
  – BIFPREC(15)
  – CMPAT(V2)
  – CSECT
  – FLOAT(AFP)
  – EXTRN(FULL)
  – LIMITS(EXTNAME(7))
  – NORENT
  – TUNE(3)

There have also been some smaller changes to the set of compiler options:
• The OFFSET option now has the same meaning it had in the compilers before VisualAge PL/I: specifying it will now cause the compiler to produce a statement offset table.

• The FLAG option now has the same meaning it had in the compilers before VisualAge PL/I. The new MAXMSG option now controls the behavior that the FLAG option controlled under Enterprise PL/I V3R1.

• The new USAGE option now controls some of the behavior that the RULES(IBM/ANS) option controlled under Enterprise PL/I V3R1.

Migrating from Enterprise PL/I V3R2

There have been some important changes since Enterprise PL/I V3R2:
• The defaults have been changed for the following compiler options to:
  – BACKREG(5)
  – BIFPREC(15)
  – EXTRN(FULL)
• Unless you explicitly used these options when compiling with V3R2, you should now compile with the following options:
  – BACKREG(11)
  – BIFPREC(31)
  – EXTRN(SHORT)

Migrating from Enterprise PL/I V3R3

While Enterprise PL/I V3R5 contains some new options and some old options with new suboptions, the defaults for these new options and suboptions will make the compiler produce executable code that is compatible with the code produced by the Enterprise PL/I V3R3 compiler - with one exception:

• an undocumented feature of the DISPLAY(STD) compiler option was that it also effectively turned on the STDSYS option.

• the DISPLAY(STD) compiler option no longer has any effect on the STDSYS option.

So, if you use the default options, you can freely mix code compiled with V3R3 and V3R5. Hence, if you are moving from V3R3 to V3R5, you do not have to recompile all your code. Even if you are moving from V3R2 to V3R5, you do not need to recompile all your code as long as you heed the warnings in the previous section about the BACKREG, BIFPREC and EXTRN options.

There are some differences in the listing, however:
• the listing will always include any options specified at compile-time as well as those specified at install-time (and in z/OS UNIX, those specified via the options environment variable)
• the assembler listing will, with V3R4, appear to be shifted one column in comparison to a listing produced by the earlier Enterprise compilers.
• the column in the assembler listing that holds that line number will now display 6 instead of 5 digits
• there will be a line after the code for each procedure (or begin block) that will give the offset of the start of the procedure from the start of the module - this will make it much easier to convert between block offsets and module offsets
• the output of the STORAGE option has been reformatted to be a little nicer
Also, even if you use the defaults for the new options and suboptions, the V3R4 compiler may issue messages where the earlier Enterprise compilers did not issue any messages. For example, the V3R4 compiler will flag the misuse of RETURN statements while the previous Enterprise compilers would flag this misus only if the RULES(NOLAXLINK) option were in effect.

Of course, if you turn on some of the new RULES suboption, for example by specifying RULES(NOLAXSEMI) or RULES(NOLAXINOUT), the V3R4 compiler will also issue messages where the earlier Enterprise compilers did not issue any messages.

**Migrating from Enterprise PL/I V3R4**

While Enterprise PL/I V3R5 contains some new options and some old options with new suboptions, the defaults for these new options and suboptions will make the compiler produce executable code that is compatible with the code produced by the Enterprise PL/I V3R4 (or V3R3) compiler - with one exception:

- an undocumented feature of the DISPLAY(STD) compiler option was that it also effectively turned on the STDSYS option.
- the DISPLAY(STD) compiler option no longer has any effect on the STDSYS option.

So, if you use the default options, you can freely mix code compiled with V3R3, V3R4 and V3R5. Hence, if you are moving from V3R4 (or V3R3) to V3R5, you do not have to recompile all your code.

Even if you are moving from V3R2 to V3R5, you do not need to recompile all your code as long as you heed the warnings in the previous section about the BACKREG, BIFPREC and EXTRN options.

V3R5 also made these changes to the compiler options:
- the ARCH option now accepts 6 as an architecture level
- the BLOCKEDIO option is no longer supported
- the DD option now accepts alternate DD-names for SYSADATA, SYXMLSD and SYSDEBUG
- the INCLUDE option is no longer supported
- the LINEDIR option is now supported
- the TEST option now accepts SEPARATE as a suboption
- the TUNE option now accepts 6 as an architecture level

**Compiler messages introduced by V3R4**

The following are new messages introduced with V3R4. Many of these messages will be produced only when certain compiler options are in effect. For an exact and a fuller explanation, see the Messages and Codes manual.

- IBM2165: flags use of NOWRITABLE(PRv) with LIMITS(EXTNAME(n)) if n is bigger than 7
- IBM2166: flags use of NOWRITABLE(PRv) with RENT
- IBM2167: flags use of NOWRITABLE(PRv) with CMPAT(LE)
- IBM2170: flags too many instances of INTERNAL CONTROLLED
- IBM2171: flags any FETCHABLE ENTRY declared at the PACKAGE level if the NOWRITABLE option is in effect
• IBM2172: flags any FILE CONSTANT declared at the PACKAGE level if the NOWRITABLE option is in effect
• IBM2173: flags any CONTROLLED VARIABLE declared at the PACKAGE level if the NOWRITABLE option is in effect
• IBM2174: flags REPLACEBY2 built-in function references where the result would be longer than CHAR(32767)
• IBM2175: flags REPLACEBY2 built-in function references where the second and third arguments are not restricted expressions
• IBM2176: flags HEX and HEXIMAGE built-in function references where the result would require more than 32767 characters
• IBM2402: flags the declaration of one variable as based on the address of a second variable when the second variable is not large enough to contain the first variable
• IBM2403: flags the use of *PROCESS statements
• IBM2404: flags the declaration of one variable as based on the address of a second variable when the structure containing the second variable is not large enough to contain the first variable
• IBM2405: flags declares and built-in functions that specify an even FIXED DEC precision
• IBM2406: flags arithmetic precision specified in a DEFAULT statement but outside of a VALUE clause
• IBM2407: flags string length specified in a DEFAULT statement but outside of a VALUE clause
• IBM2408: flags AREA size specified in a DEFAULT statement but outside of a VALUE clause
• IBM2409: flags RETURN; statements in functions
• IBM2410: flags the lack of any RETURN statements inside a function
• IBM2411: flags STRING of GRAPHIC aggregates that contain VARYING strings or NONCONNTECT array slices
• IBM2412: flags RETURN statements that specify an expression if the containing PROCEDURE statement does not specify the RETURNS option
• IBM2413: flags use of CONNECTED apart from on parameters and in descriptor lists
• IBM2604: flags FIXED DEC assignments that could raise SIZE
• IBM2605: flags invalid carriage control characters
• IBM2607: flags PIC to FIXED DEC assignments that could raise SIZE
• IBM2608: flags PIC to PIC assignments that could raise SIZE
• IBM2609: flags semicolons in comments
• IBM2610: flags MULTIPLY, DIVIDE, ADD and SUBTRACT built-in function references where one operand is FIXED DEC and the other is FIXED BIN or FLOAT
• IBM2611: flags duplicate binary or bit WHEN values and identifies the duplicate value
• IBM2612: flags duplicate character WHEN values and identifies the duplicate value
• IBM2613: flags possibly uninitialized scalars used as ASGN BYADDR arguments
• IBM2614: flags expressions where the results of two compares are compared
• IBM2801: flags any arithmetic operation where one operand is FIXED BIN with zero scale factor and the other is FIXED DEC with non-zero scale factor, thus producing a FIXED BIN result with non-zero scale factor
• IBM2802: flags aggregate mapping done by library call
• IBM2803: flags statements where GET/PUT STRING EDIT has been optimized
• IBM2804: flags suboptimal compares
• IBM3270: flags EXEC CICS statements when the CICS option is not in effect
• IBM3271: flags EXEC CSPM statements when the CSPM option is not in effect
• IBM3272: flags EXEC DLI statements when the DLI option is not in effect

Compiler messages introduced by V3R5

The following are new messages introduced with V3R5. Many of these messages will be produced only when certain compiler options are in effect. For an exact and a fuller explanation, see the Messages and Codes manual.
• IBM2177: flags using a PDS member as the SYSADATA dataset
• IBM2178: flags %INCLUDE statements when the LINEDIR option is in effect
• IBM2179: flags %LINE directives that are too large for the margins
• IBM2416: flags using the LINEDIR option with the TEST(SEPARATE) option
• IBM2417: flags ALLOCATE and FREE of non-PARAMETER CONTROLLED in FETCHABLE using PRV
• IBM2418: flags unreferenced variables
• IBM2615: flags one-time DO loops
• IBM2616: flags use of SIZE against CHAR(*) NONVARYING parameter in an OPTIONS(NODESCRIPTOR) procedure
• IBM2617: flags passing a label as a parameter to a non-PL/I routine
• IBM2618: flags invalid suboptions of compiler suboptions
• IBM2805: flags conversions done by library call when the target can be named
• IBM2806: flags passing a label as a parameter
• IBM2809: flags implicit FIXED DEC to 8-byte integer conversions
• IBM2810: flags difference in conversion of scaled FIXED BIN to FIXED DEC

Object compatibility

If you want to maintain object compatibility with code generated by VisualAge PL/I or Enterprise PL/I V3R1, V3R2, V3R3 or V3R4, it is imperative that you use, with Enterprise PL/I V3R5, the same value from each of the following set of options that you used with the earlier compiler:
• BACKREG(5) or BACKREG(11)
• BIFPREC(15) or BIFPREC(31)
• CMPAT(V2) or CMPAT(V1) or CMPAT(LE)
• CSECT or NOCSECT
• LIMITS(EXTNAME(n))
• NORENT or RENT
• WRITABLE or NOWRITABLE
The PTF for APAR PQ66252 changed VisualAge PL/I 2.2.1 (and corresponding PTFs changed Enterprise PL/I 3.1 and 3.2) so that the results of conversions of FLOAT to FIXED DEC and PICTURE would match those produced by the old compilers.

This can cause a small difference in some conversions. For example given:

```pli
  dc1 f  float dec(16);
  dc1 d2  dec(15,2);

  f = 1.4417e+04;
  f = f / 100;
  d2 = f;
```

all the compilers will now assign the value 144.17 to d2, while before this PTF, the new compilers would have assigned the value 144.16 to d2.

Apart from this change, there is complete object compatibility between code compiled by the Enterprise PL/I V3R2 compiler and code compiled by either the VisualAge PL/I or the Enterprise PL/I V3R1 compiler as long as you adhere to these limitations:

- you must not mix code compiled with different CMPAT options
- you may mix RENT and NORENT code subject to the same restrictions as before:
  - code compiled with RENT cannot be mixed with code compiled with NORENT if they share any EXTERNAL STATIC variables
  - code compiled with RENT cannot call an ENTRY VARIABLE set in code compiled with NORENT
  - code compiled with RENT cannot call an ENTRY CONSTANT that was FETCHed in code compiled with NORENT
  - code compiled with RENT can FETCH a module containing code compiled with NORENT if one of the following is true
    - all the code in the FETCHed module was compiled with NORENT
    - the code containing the entry point to the module was compiled with RENT
  - code compiled with NORENT code cannot FETCH a module containing any code compiled with RENT
  - code compiled with NORENT WRITABLE cannot be mixed with code compiled with NORENT NOWRITABLE if they share any external CONTROLLED variables or any external FILEs

It remains our recommendation that all code be compiled with the same settings for the RENT/NORENT and WRITABLE/NOWRITABLE options.

**Run-time changes**

Finally, the only change to the run-time (apart from bug fixes and performance enhancements) that affects the behavior of your code is that the SIZE condition is no longer promoted to the ERROR condition if unhandled.

However, some of the compiler changes made in V3R5 require corresponding library. So, if you are using V3R5 compiled code, you must have the PTFs for these APARs installed:

- PQ97843 - for support of TEST(NOHOOK)
- PQ98938 - for support of less code for REFER
• PK03093 - for support of DebugTool starting after MAIN
• PK04110 - for support of PLITABS
• PK11161 - for support of alternate packed decimal signs in FIXED DEC(31) operations
• PK12504 - for support of the DB2 date-time patterns
• PK12833 - for support of TEST(SEPARATE)
Part 5. Subsystem and other language considerations
Chapter 20. Assembler considerations for PL/I applications

This chapter contains information for applications that contain mixed PL/I programs and assembler programs. It includes information on:

- Considerations for assembler programs mimicking PL/I main procedures
- Calling PL/I from assembler and Language Environment conforming assembler
- Condition handling and assembler programs
- Considerations for using assembler user exits

The new compiler uses some different internal control blocks in its generated code than did the old compiler. If you had assembler code that knew the layout and meaning of such control blocks, that code is highly likely not to work now and will probably have to be changed. Some examples where where these differences would require code changes:

- assembler code that "knows" the layout of a PL/I label variable and uses that to try to branch back from assembler into PL/I code
- assembler code that "knows" the layout of a PL/I file variable and associated file control block and uses that to try to get the DCB for a file

Considerations for assembler programs mimicking PL/I main procedures

If you have an assembler program mimicking a PL/I MAIN procedure you must convert that assembler program to an Language Environment-conforming assembler program that is MAIN.

An assembler program that is not LE-conforming cannot call a non-MAIN PL/I procedure (unless it was called from a PL/I MAIN procedure).

For more information on this topic, refer to z/OS Language Environment Programming Guide.

Calling PL/I from assembler and Language Environment conforming assembler

With Language Environment, assembler programs that call a PL/I routine must follow the calling conventions defined by Language Environment. For example, Register 13 pointing to a save area, save areas properly back-chained, and the first word of the save area being zero. For detailed information, see the z/OS Language Environment Programming Guide.

If your PL/I main program is called by an assembler program and you want to convert your assembler program to use Language Environment-conforming assembler, you must either:

- Recompile your PL/I program with a newer PL/I compiler without OPTIONS(MAIN), or
- Ensure the entry point receiving control is the real entry point of the PL/I program.
In either case, the called PL/I program is treated as a subroutine. Either of these programs run under the same Language Environment enclave where the assembler program is the main program and the called PL/I program is a subroutine.

There are three ways Language Environment-conforming assembler can pass control to an Enterprise PL/I subroutine:

1. Branch to a statically linked PL/I subroutine.
2. Use the Language Environment macro CEEFETCH to branch to a separately linked Enterprise PL/I subroutine.
3. Use assembler instructions such as LOAD and BALR to a separately linked Enterprise PL/I subroutine.

If you recompile PL/I subroutines that use method 1 or 2 with Enterprise PL/I you don’t need to include CEESG011 with your assembler program. If your assembler program uses instructions as described in method 3, you must always include CEESG011 with your assembler program, even if you recompile your PL/I subroutine with Enterprise PL/I.

**Condition handling and assembler programs**

The condition-handling behavior of the LINK from assembler is now clearly defined. For detailed information, see z/OS Language Environment Programming Guide.

**Considerations for using assembler user exits**

The only Assembler user exit supported by Enterprise PL/I is the Language Environment user exit CEEBXITA. IBMBXITA and IBMFXITA are not supported. For a detailed parameter description for CEEBXITA, see OS/390 Language Environment Programming Guide.

**Specific considerations**

- The PL1DUMP, PLIDUMP or CEEDUMP file for the dump output is treated as a process resource and must not be cleared during enclave termination.
- The OS PL/I abend exit IBMBEER is ignored under Language Environment. See “Differences in Condition Handling” on page 37 for information on how to force an abend under Language Environment.

For more information on assembler language user exits, see OS/390 Language Environment Programming Guide.
Chapter 21. CICS considerations for PL/I applications

This chapter explains the source language considerations for programs that run under CICS. It describes the actions that you need to take for applications that use either CICS source or Enterprise PL/I source and involve the following functions:

- General CICS considerations
- Compiler options for programs that run under CICS
- Linking CICS applications and run-time considerations
- Migrating to the integrated CICS preprocessor

General CICS considerations

The CICS Storage Protect facility was introduced under CICS 3.3. This provides more data integrity and security for the application program and especially for the entire CICS region. Because of the new feature, you might discover that some of your successfully running PL/I applications start to fail with ASRA(0C4) abend and the CICS message DFHSR0622.

If the above problem occurs in your PL/I applications, set the CICS system initialization parameter RENTPGM=NOPROTECT. This sets the protection of the user program in user key. The default for RENTPGM is PROTECT.

If PUT statements are used in your Enterprise PL/I CICS application, especially the PUT DATA statement, it might trigger the above error.

Remember also that in CICS programs these PUT statements are intended for debugging purposes only. They have a negative impact on performance, and we recommend that you don’t use them in production programs.

If you mix old and new object code under CICS, you must adhere to all the rules and restrictions described in “Object and load module considerations” on page 121.

Updating CICS System Definition (CSD) file

When you bring up a CICS region with Language Environment, you must ensure the module names listed in Language Environment CEECCSD are defined in the CSD. You can locate CEECCSD in SCEESAMP. If you use CICS Version 4 autoinstall facility, you do not need to define Language Environment modules manually in the CSD.

In order to run a Enterprise PL/I CICS application, you need to define the Enterprise PL/I member event handler CEEEV011 in the CICS CSD definition table:

```
DEFINE PROGRAM(CEEEV011) GROUP(CEE) LANGUAGE(ASSEMBLER)
```

In order to debug a PL/I transaction using Debug Tool, you need to define the Debug Tool APIs in the CICS CSD definition table:

```
DEFINE PROGRAM(IBMPDACPI) GROUP(CEE) LANGUAGE(ASSEMBLER)
```
**Macro-level interface**

The CICS macro-level interface is not supported.

---

**Compiler options for programs that run under CICS**

The SYSTEM(CICS) or SYSTEM(MVS) option must be used when you compile your CICS programs that are PL/I MAINs.

If a CICS program is to be reentrant (and most should be) and if it uses CONTROLLED variables or FILEs, then it must also be compiled with the NOWRITABLE option.

---

**Linking CICS applications and run-time considerations**

You are generally no longer required to take special action when you link an Enterprise PL/I object module under CICS with the exception that for a routine that is to be FETCHed, you must code the linkage editor ENTRY statement so that it nominates the actual entry point.

PDSEs are supported by CICS Transaction Server 1.3 or later. Please refer to the CICS Transaction Server for OS/390 Release Guide, GC34-5701, where there are several references to PDSEs, and a list of prerequisite APAR fixes.

---

**Error-handling**

LE prohibits the use of the following EXEC CICS commands in any PL/I ON-unit or in any code called from a PL/I ON-unit.

- EXEC CICS ABEND
- EXEC CICS HANDLE AID
- EXEC CICS HANDLE ABEND
- EXEC CICS HANDLE CONDITION
- EXEC CICS IGNORE CONDITION
- EXEC CICS POP HANDLE
- EXEC CICS PUSH HANDLE

All other EXEC CICS commands are allowed within an ON-unit. However, they must be coded using the NOHANDLE option, the RESP option or the RESP2 option.

---

**FETCHing a PL/I MAIN procedure**

CICS does not support PL/I FETCHing a PL/I MAIN procedure.

---

**Run-time output**

Run-time output is now transmitted to the CICS transient data queue CESE. Language Environment ignores the MSGFILE option under CICS. Figure 2 on page 139 shows format of the output data queue.
In addition, the PL/I transient queues CPLI and CPLD are no longer used. As a result, you do not need to specify entries for the CPLI and CPLD in the CICS Destination Control Table (DCT).

**Abend codes used by PL/I under CICS**

The APLx abend codes that were issued under OS PL/I Version 2 are no longer issued. Instead, Language Environment-defined abend codes are issued. For more information about Language Environment abend codes, see *z/OS Language Environment Run-Time Messages*.

**Migrating to the integrated CICS preprocessor**

When you are developing programs for execution under CICS, all the EXEC CICS commands must be translated in one of two ways:

- by the command language translator provided by CICS in a job step prior to the PL/I compilation
- by the PL/I CICS preprocessor as part of the PL/I compilation (this requires CICS TS 2.2 or later)

To use the CICS preprocessor, you must also specify the PP(CICS) compile-time option.

If your CICS program is a MAIN procedure, you must also compile it with the SYSTEM(CICS) option. NOEXECOPS is implied with this option, and all parameters passed to the MAIN procedure must be POINTERS.

If your CICS program includes any files or uses any macros that contain EXEC CICS statements, you must also run the MACRO preprocessor before your code is translated (in either of the ways described above). If you are using the CICS preprocessor, you can specify this with one PP option as illustrated in the following example:

```
pp (macro(...) cics(...) )
```

Finally, in order to use the CICS preprocessor, you must have the CICS SDFHLOAD dataset as part of the STEPLIB DD for the PL/I compiler.

For more information about the integrated PL/I CICS preprocessor, refer to the *Enterprise PL/I for z/OS Programming Guide*.  

---

**Figure 2. CESE output data queue**

<table>
<thead>
<tr>
<th>ASA</th>
<th>Terminal id</th>
<th>Transaction id</th>
<th>B</th>
<th>Date/Time YYYYMMDDHHMMSS</th>
<th>B</th>
<th>Data</th>
</tr>
</thead>
</table>

Chapter 21. CICS considerations for PL/I applications  139
Chapter 22. IMS considerations for PL/I applications

This chapter explains the considerations for running Enterprise PL/I programs that use IMS under Language Environment. The following topics are discussed:

- Interfaces to IMS
- SYSTEM(IMS) compile-time option
- PLICALLA support in IMS
- PSB language options supported
- Storage usage considerations
- Coordinated condition handling under IMS
- Performance enhancement with Library Retention (LRR)

Interfaces to IMS

Language Environment supports the PLITDLI, ASMTDLI, and EXEC DLI interfaces from a PL/I routine. It also supports CEETDLI interface from a Enterprise PL/I routine running under IMS/ESA® Version 4.

Under Language Environment, CEETDLI is the recommended interface. CEETDLI supports calls that use an Application Interface Block (AIB) or a Program Communication Block (PCB). For more information about AIB and a complete description of the CEETDLI interface, see IMS/ESA Version 4 Application Programming Guide.

SYSTEM(IMS) compile-time option

The SYSTEM(IMS) option should be used when compiling all PL/I MAIN programs invoked from IMS.

When you recompile your main procedure with Enterprise PL/I, the object module assumes that the parameters are passed as BYVALUE. Language Environment converts the parameters to the BYVALUE style for you, if necessary, so the parameters are always passed correctly.

If the BYADDR attribute is specified or implied for the parameters to an IMS MAIN routine, when you compile your main procedure with Enterprise PL/I, you will receive an error message and the compiler will apply the BYVALUE attribute instead.

Refer to the Enterprise PL/I for z/OS Programming Guide for more information on the SYSTEM(IMS) compile-time option.

PLICALLA support in IMS

The PL/I PLICALLA entry point is supported under Language Environment.

See “PLICALLA Considerations” on page 38 for details.
PSB language options supported

Language Environment supports PL/I applications with the following PSBGEN LANG options in the supported releases of IMS:

**IMS/ESA Version 4**

Table 13. PSB LANG options for IMS/ESA Version 4, Release 1

<table>
<thead>
<tr>
<th>SYSTEM option</th>
<th>Entry point</th>
<th>LANG=</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMS</td>
<td>CEESTART</td>
<td>PLI or other values except PASCAL</td>
</tr>
<tr>
<td>IMS</td>
<td>PLICALLA</td>
<td>PLI</td>
</tr>
<tr>
<td>MVS</td>
<td>PLICALLA</td>
<td>PLI</td>
</tr>
<tr>
<td>MVS</td>
<td>CEESTART</td>
<td>PLI</td>
</tr>
<tr>
<td>Other</td>
<td>- -</td>
<td>Illegal</td>
</tr>
</tbody>
</table>

**IMS/ESA Version 3 Release 1**

Table 14. PSB LANG options for IMS/ESA Version 3, Release 1

<table>
<thead>
<tr>
<th>SYSTEM option</th>
<th>Entry point</th>
<th>LANG=</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMS</td>
<td>CEESTART</td>
<td>PLI</td>
</tr>
<tr>
<td>IMS</td>
<td>PLICALLA</td>
<td>PLI</td>
</tr>
<tr>
<td>MVS</td>
<td>PLICALLA</td>
<td>PLI</td>
</tr>
<tr>
<td>MVS</td>
<td>CEESTART</td>
<td>PLI</td>
</tr>
<tr>
<td>Other</td>
<td>- -</td>
<td>Illegal</td>
</tr>
</tbody>
</table>

Storage usage considerations

With IMS/ESA Version 3 Release 1 or later, the parameters passed to the IMS interfaces are no longer restricted to the area below the 16M line. The parameters will be above the 16M line if you observe the following rules:

- If the parameters passed to IMS are in CONTROLLED or BASED storage, specify the ANYWHERE suboption of the HEAP run-time option.
- If the parameters passed to IMS are in AUTOMATIC storage, specify the ANYWHERE suboption of the STACK run-time option.
- If the parameters passed to IMS are in STATIC storage, link the load module with the AMODE(31) attribute.

Coordinated condition handling under IMS

Language Environment and IMS condition handling are coordinated, which means that if a program interrupt or abend occurs when your application is running in an IMS environment, the Language Environment condition manager is informed whether the problem occurred in your application or in IMS. If the problem occurs in IMS, Language Environment, as well as any invoked HLL-specific condition handler, percolates the condition back to IMS.
With Language Environment run-time option TRAP(ON), Language Environment continues to support coordinated condition handling for the PLITDLI and ASMTDLI interface invoked from a PL/I routine.

With IMS/ESA Version 3 with PTF UN4928 or IMS/ESA Version 4, Language Environment also supports the coordinated condition handling for CEETDLI, CTDLI from a C routine, CBLTDLI from a COBOL program, AIBTDLI from a PL/I program, and ASMTDLI from a non-PL/I program.

Note that if a program interrupt or abend occurs in your application outside of IMS, or if a software condition of severity 2 or greater is raised outside of IMS, the Language Environment condition manager takes normal condition handling actions described in the z/OS Language Environment Programming Guide. In this case, in order to give IMS a chance to do database rollback, you must do one of the following:

- Resolve the error completely so that your application can continue.
- Issue a rollback call to IMS, and then terminate the application.
- Make sure that the application terminates abnormally by using the ABTERMENC(ABEND) run-time option to transform all abnormal terminations into system abends in order to cause IMS rollbacks.
- Make sure that the application terminates abnormally by providing a modified assembler user exit (CEEBXITA) that transforms all abnormal terminations into system abends in order to cause IMS rollbacks.

The assembler user exit you provide should check the return code and reason code or the CEEAUE_ABTERM bit, and requests an abend by setting the CEEAUE_ABND flag to ON, if appropriate. See the z/OS Language Environment Programming Guide for details.

**Performance enhancement with Library Retention (LRR)**

If you use LRR, you can get an improvement in performance. See “Improving CPU Utilization” on page 117 for details.
Chapter 23. DB2 Considerations for PL/I applications

This chapter explains the source language considerations for programs that run with DB2. The following topics are discussed:

• General DB2 considerations
• Migrating to the integrated SQL preprocessor

General DB2 considerations

If you write a user-defined function in PL/I, DB2 passes some string-locator descriptors to the PL/I procedure.

In order for such a program to run correctly under Enterprise PL/I, you must compile the program with the CMPAT(V2) or CMPAT(V1) option.

Migrating to the integrated SQL preprocessor

The integrated PL/I SQL preprocessor approach eliminates the need for a separate precompilation step with the DB2 precompiler in PL/I programs containing SQL statements.

Note: You must have DB2 for OS/390 Version 7 Release 1 or later to use the SQL preprocessor.

Note: The PL/I SQL Preprocessor currently does not support DBCS.

Programming and compilation considerations

When you use the PL/I SQL Preprocessor the PL/I compiler handles your source program containing embedded SQL statements at compile time, without your having to use a separate precompile step. Although the use of a separate precompile step continues to be supported, use of the PL/I SQL Preprocessor is recommended. Interactive debugging with Debug Tool is enhanced when you use the PL/I SQL Preprocessor because you see only the SQL statements while debugging (and not the generated PL/I source).

In addition, using the PL/I SQL Preprocessor lifts some of the DB2 precompiler’s restrictions on SQL programs. When you process SQL statements with the PL/I SQL Preprocessor, you can now

• use fully-qualified names for structured host variables
• include SQL statements at any level of a nested PL/I program, instead of in only the top-level source file
• use nested SQL INCLUDE statements

The PL/I compiler listing includes the error diagnostics (such as syntax errors in the SQL statements) that the PL/I SQL Preprocessor generates.

To use the PL/I SQL Preprocessor, you need to do the following things:

• Specify the following option when you compile your program

  `PP(SQL('options'))`
This compiler option indicates that you want the compiler to invoke the PL/I SQL preprocessor. Specify a list of SQL processing options in the parenthesis after the SQL keyword. The options can be separated by a comma or by a space but must be enclosed in single or double quotes.

For example, `PP(SQ\(\text{L('DATE(USA),\ TIME(USA)')}\)` tells the preprocessor to use the USA format for both DATE and TIME data types.

In addition, for LOB support you must specify the option

```
LIMITS( FIXEDBIN(31,63)  FIXEDDEC(31) )
```

- Include DD statements for the following data sets in the JCL for your compile step:
  - DB2 load library (`prefix:DSNLOAD`)
    The PL/I SQL preprocessor calls DB2 modules to do the SQL statement processing. You therefore need to include the name of the DB2 load library data set in the STEPLIB concatenation for the compile step.
  - Library for SQL INCLUDE statements
    If your program contains SQL INCLUDE `member-name` statements that specify secondary input to the source program, you need to include the name of the data set that contains `member-name` in the SYSLIB concatenation for the compile step.
  - DBRM library
    The compilation of the PL/I program generates a DB2 database request module (DBRM) and the DBRMLIB DD statement is required to designate the data set to which the DBRM is written.
  - For example, you might have the following lines in your JCL:
    ```
    //STEPLIB DD DSN=DSN710.DSNLOAD,DISP=SHR
    //SYSLIB DD DSN=PAYROLL.MONTHLY.INCLUDE,DISP=SHR
    //DBRMLIB DD DSN=PAYROLL.MONTHLY.DBRMLIB.DATA(MASTER),DISP=SHR
    ```

**FOR BIT DATA assignment notes**

The old DB2 Precompiler services did not know about or handle CCSID values for host variables. Because of this lack of knowledge, you could update FOR BIT DATA columns with CHARACTER data.

The new DB2 V7.1 or later DB2 Precompiler services does know about CCSID values and will assign them to host variables using the default CCSID value. This will cause problems if you have code that updates FOR BIT DATA columns with CHARACTER data. The integrated PL/I SQL preprocessor has created a new option, `CCSID0 / NOCCSID0` to handle these cases. The `CCSID0` option, the default, will cause a CCSID of 0 to be assigned to host variables allowing the assignment of CHARACTER variables to FOR BIT DATA database columns.

For more information about the integrated PL/I SQL preprocessor, refer to the *Enterprise PL/I for z/OS Programming Guide*. 


Part 6. Appendixes
Appendix A. Conversion and Migration Aids

This section describes the conversion and migration tools available for your assistance during the actual conversion and migration activities. These tools are:

- OS PL/I Routine Replacement Tool
- OS PL/I V1R5.1 main load module ZAP
- OS PL/I Shared library replacement tool
- OS PL/I object module relinking tool - APARs PN69803
- EDGE Portfolio Analyzer
- Vendor products

OS PL/I Routine Replacement Tool

Language Environment does not support OS PL/I Version 1 Release 3.0 - 5.0 load modules. For these load modules, you can do one of the following:

- Relink the object modules directly with Language Environment.
- Replace the library routines in the load module with the Language Environment stubs.

Language Environment provides two samples, located in SCEESAMP, that replace the library routines in your OS PL/I Version 1 Release 3.0 - 5.1 and Version 2 load modules with corresponding Language Environment stubs. These samples contain a list of linkage editor REPLACE control statements that replace each library routine in your load module with the corresponding stub in Language Environment and are described as follows:

- IBMWRLK is for MVS non-CICS and VM.

  **For MVS non-CICS**, use it to replace OS PL/I V1R3.0 - V1R5.1 and V2 load modules, both multitasking and nonmultitasking. It contains a CHANGE statement to rename the OS PL/I HLL user exit IBMBINT to CEEBINT.

- IBMWRLKC is for CICS.

  Use it to replace OS PL/I V1R3.0 - V1R5.1 and V2 load modules. It contains a CHANGE statement to rename the OS PL/I HLL user exit IBMBINT to CEEBINT and PLIMAIN to CEEMAIN. It also contains INCLUDE statements to ensure the load module works under CICS.

  The CICS macro language is not supported.

The MVS JCL example below shows the replacement of run-time library routines from a user load module while retaining the user object module. In the example, MYPDS.LOAD is the data-set name of a load module library that contains the load module with the name MYLMOD.

```
//RELINK EXEC PGM=IEWL,PARM='LIST,MAP,XREF,SIZE(3072K,4K)',REGION=5M
//SYSPRINT DD SYSOUT=A
//SYSLIB DD DSN=CEE.V1R4M0.SCEELKED,DISP=SHR
//SAMPLIB DD DSN=CEE.V1R4M0.SCEESAMP,DISP=SHR
//SYSLIN DD UNIT=SYSDA,SPACE=(1024,(200,200))
//SYSLMOD DD DSN=MYPDS.LOAD,DISP=OLD
//SLSLN DD *
INCLUDE SAMPLIB(IBMWRLK)
INCLUDE SYSLMOD(MYLMOD)
NAME MYLMOD(R)
```
If you replace a load module under CICS, the CICS SDFHLOAD data set must be specified in the SYSLIB.

**OS PL/I Version 1 Release 5.1 main load module ZAP**

Language Environment supports OS PL/I Version 1 Release 5.1 main load module with the following restriction:

- If the main load module is for MVS non-Shared Library, non-CICS and nonmultitasking, or VM, it must first be ZAPped with one of the Language Environment-provided samples located in Language Environment SCEESAMP. Detailed instructions for using the ZAP are provided in IBMRZAPM and IBMZAPV. The following describes each sample:
  - IBMRZAPM for MVS non-Shared Library, non-CICS, nonmultitasking
    The ZAPped main load module, including one that contains the OS PL/I fast initialization and termination feature, continues to run under OS PL/I Version 1 Release 5.1 and Version 2. When the ZAPped main load module contains the OS PL/I fast initialization and termination feature, it always dynamically loads the OS PL/I run-time initialization routine IBMBPIIA once. IBMBPIIA is not deleted until the task terminates. This one-time loading of IBMBPIIA might affect the performance of your application. If you put IBMBPIIA in LPA, the performance effect can be minimized.
    The ZAPped main load module is supported by Language Environment unless the load module contains the OS PL/I fast initialization and termination feature. Language Environment always dynamically loads the initialization and termination routines. If you put the Language Environment library routines and CEEBLIIA in LPA(E) as recommended in z/OS Language Environment Installation and Customization under OS/390 and z/OS Language Environment Customization, the performance effect can be minimized.
  - IBMZAPV for VM
    The ZAPped main load module is **not** supported under OS PL/I Version 1 Release 5.1 or Version 2. It is supported only under Language Environment.

If you do not ZAP your main load module, read "OS PL/I Routine Replacement Tool" on page 149 to understand what else you can do. You can also recompile your application with Enterprise PL/I or OS PL/I Version 2. See Chapter 7, "Object and Load Module Considerations," on page 47 to understand how Language Environment supports OS PL/I object and load modules.

The sample ZAP is available in the IBM Support Center for customers who do not have Language Environment but want to prepare to migrate to Language Environment.

**OS PL/I Shared library replacement tool**

In order to support OS PL/I Version 1 Release 5.1 and Version 2 load modules that use the Shared Library, the library module in that Shared Library must be replaced with Language Environment stubs.

Language Environment provides the following two sample JCL, located in SCEESAMP, to replace the Shared Library:

- IBMRLSLA for OS PL/I Version 1 Release 5.1 MVS CICS or multitasking and OS PL/I Version 2 Shared Library
• IBMRLSLB for OS PL/I Version 1 Release 5.1 MVS non-CICS nonmultitasking
  Shared Library

You must understand how Language Environment supports OS PL/I Shared
Library before you use the JCL.

OS PL/I Object Module Relinking Tool - APAR PN69803

OS PL/I Version 2 Release 3 provides APAR PN69803 help you migrate your
PL/I-COBOL ILC applications and PLISRTx applications.

ILC Applications

Language Environment does not support the OS PL/I-COBOL ILC applications.
You must relink any OS PL/I object module in a PL/I-COBOL ILC application. See
“Differences in Interlanguage Communication Support” on page 44 for ILC
support under Language Environment. If you relink your OS PL/I object module
in the PL/I-COBOL ILC application with PN69803, however, the resultant load
module is supported by Language Environment. PN69803 provides you the
flexibility to prepare the PL/I-COBOL ILC relinking while you are using OS PL/I
Version 2 Release 3. When you complete the relinking, you can switch to Language
Environment whenever you are ready.

Before you relink your PL/I-COBOL ILC applications with PN69803, you must first
apply the following PL/I-COBOL ILC APARs to PL/I and COBOL:
  OS PL/I V2R3 common library: PN36844
  VS COBOL II V1R3.0 library: PN13459
  VS COBOL II V1R3.1 library: PN04721
  VS COBOL II V1R3.2 library: PN09732

Note: VS COBOL II V1R4.0 has the above COBOL APARs in its base code.

If you have not applied the above APARs, PN69803 will not work. The above
APARs are not required if your applications do not contain PL/I-COBOL ILC.

Even though your PL/I-COBOL ILC applications are relinked with PN69803, you
might still be required to link them with Language Environment if they contain a
function described in this book or in COBOL for OS/390 & VM Migration Guide that
requires relinking. For example, you will still have to relink your application if it
contains any COBOL NORES or the load module contains an OS PL/I object
module that is not supported by Language Environment. In the latter case, you
must recompile your OS PL/I object module with Enterprise PL/I or OS PL/I
Version 2.

PLISRTx Applications

While OS PL/I applications that use PLISRTx are supported by Language
Environment for OS/390 & VM Release 1.4 and later, we recommend that you
relink your applications that use PLISRTx. See “Differences in PLISRTx Support”
on page 41 for the reasons. The recommended relinking can be done either with
Language Environment or with PN69803 on OS PL/I Version 2 Release 3. Either
method gives your load module the benefits of exploiting the Language
Environment DFSORT interface support.
EDGE Portfolio Analyzer

The Edge Portfolio Analyzer helps you to take an inventory of your existing OS PL/I and PL/I for MVS & VM load modules. The Edge Portfolio Analyzer can:

- Determine which version and release of the OS PL/I compiler or the PL/I for MVS & VM compiler created the load module
- Determine which compiler options were specified when the load module was compiled
- Determine which load modules call for the current system date
- Determine which CSECTs need to be replaced

Note: The Edge Portfolio Analyzer is no longer sold by IBM, but you can still purchase the product from Edge directly. For more information you can visit their Web site at: www.edge-information.com

Vendor products

A number of non-IBM conversion tools are available to help you upgrade your source programs to Enterprise PL/I programs and move to Language Environment. IBM has compiled a list of vendor products enabled to work with Language Environment and Enterprise PL/I in the Language Environment Enabled Vendor Tools and Application Packages document. You can get this information: on the Web at http://www.ibm.com/s390/el then go to the Library link.
Appendix B. Compiler elements comparison

Enterprise PL/I has renamed its parts so that, if you want to, you can install it in the same SMP/E zone as OS PL/I or PL/I for MVS & VM. To help you identify the elements of each product, the following table lists the name differences:

*Table 15. PL/I element names*

<table>
<thead>
<tr>
<th>OS PL/I</th>
<th>PL/I for MVS &amp; VM</th>
<th>Enterprise PL/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEL0AA</td>
<td>IEL1AA</td>
<td>IBMZPLI</td>
</tr>
<tr>
<td>IKJEN00n</td>
<td>IEL1IKJn</td>
<td></td>
</tr>
<tr>
<td>IEL0nn</td>
<td>IEL1nn</td>
<td>IBMZnn</td>
</tr>
<tr>
<td>PLInnnnn</td>
<td>IEL1Mnnn</td>
<td>IBMZMnnn</td>
</tr>
<tr>
<td>PLIXnnn</td>
<td>IEL1nnn</td>
<td>IBMZnnn</td>
</tr>
<tr>
<td>PLIHELP</td>
<td>IEL1PLIH</td>
<td>--</td>
</tr>
</tbody>
</table>
Appendix C. Compiler option comparison

This appendix briefly describes which compiler options are available in the OS PL/I PL/I for MVS & VM, VisualAge PL/I and Enterprise PL/I compilers.

Important
For complete descriptions of the Enterprise PL/I options, see the Enterprise PL/I for z/OS Programming Guide.

Table 16. Compiler option comparison

<table>
<thead>
<tr>
<th>Option</th>
<th>Available in</th>
<th>Abbreviated option description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGGREGATE</td>
<td>X</td>
<td>Creates an aggregate length table that gives the lengths of arrays and major structures.</td>
</tr>
<tr>
<td>NOAGGREGATE</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ARCH</td>
<td>X</td>
<td>Specifies the architecture for which the executable program's instructions are to be generated.</td>
</tr>
<tr>
<td>ATTRIBUTES</td>
<td>X</td>
<td>Specifies that the compiler includes a table of source-program identifiers and their attributes in the compiler listing.</td>
</tr>
<tr>
<td>NOATTRIBUTES</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>BACKREG</td>
<td>X</td>
<td>Controls the backchain register</td>
</tr>
<tr>
<td>BIFPREC</td>
<td>X</td>
<td>Controls the precision of the FIXED BIN result returned by various built-in functions.</td>
</tr>
<tr>
<td>BLANK</td>
<td>X</td>
<td>Specifies up to ten alternate symbols for the blank character.</td>
</tr>
<tr>
<td>BLKOFF NOBLKOFF</td>
<td>X</td>
<td>Controls whether the offsets shown in the pseudo-assembler listing are from the start of the current module or from the start of the current procedure.</td>
</tr>
<tr>
<td>BLOCKEDIO</td>
<td>X</td>
<td>Controls whether WRITE statements are performed record by record or block by block.</td>
</tr>
<tr>
<td>NOBLOCKEDIO</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CHECK</td>
<td>X</td>
<td>Alters the behavior of the ALLOCATE and FREE statements.</td>
</tr>
<tr>
<td>CMPAT</td>
<td>X</td>
<td>Controls object compatibility between releases of PL/I.</td>
</tr>
<tr>
<td>CODEPAGE</td>
<td>X</td>
<td>Specifies the code page used for conversions between CHARACTER and WIDECHAR and used by the PLISAX built-in subroutines.</td>
</tr>
<tr>
<td>COMMON</td>
<td>X</td>
<td>Directs the compiler to generate CM linkage records for EXTERNAL STATIC variables.</td>
</tr>
<tr>
<td>COMPACT</td>
<td>X</td>
<td>Influences the size and speed of code that the compiler generates.</td>
</tr>
<tr>
<td>COMPIL.COMPILE</td>
<td>X</td>
<td>Controls whether the compiler stops or continues when it produces a message of the specified severity.</td>
</tr>
<tr>
<td>Option</td>
<td>Available in</td>
<td>Abbreviated option description</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>COPYRIGHT NOCOPYRIGHT</td>
<td></td>
<td>Places a string in the object module, if generated.</td>
</tr>
<tr>
<td>CSECT NOCSECT</td>
<td>X X</td>
<td>Controls the generation of named CSECTs.</td>
</tr>
<tr>
<td>CSECTCUT</td>
<td>X</td>
<td>Controls how the compiler, when processing the CSECT option, handles long names.</td>
</tr>
<tr>
<td>CONTROL</td>
<td>X X</td>
<td>Specifies that any compile-time options deleted for your installation are available for this compilation.</td>
</tr>
<tr>
<td>CURRENCY</td>
<td>X X</td>
<td>Allows you to specify an alternate character for the dollar sign.</td>
</tr>
<tr>
<td>DBCS NODBCS</td>
<td>X</td>
<td>Ensures that the listing, if generated, is sensitive to the possible presence of DBCS even though the GRAPHIC options has not been specified.</td>
</tr>
<tr>
<td>DD</td>
<td>X X</td>
<td>Allows you to specify alternate DD names for the compiler listing, the primary source file, the default include dataset and the MDECK dataset.</td>
</tr>
<tr>
<td>DECIMAL</td>
<td>X</td>
<td>Specifies how the compiler should handle certain FIXED DECIMAL operations and assignments.</td>
</tr>
<tr>
<td>DECK NODECK</td>
<td>X X</td>
<td>Specifies that the compiler produces an object module in the form of 80-character records and store it in the SYSPUNCH dataset.</td>
</tr>
<tr>
<td>DEFAULT</td>
<td>X X</td>
<td>Specifies defaults for attributes.</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>X X</td>
<td>Determines where output of the DISPLAY statement is directed.</td>
</tr>
<tr>
<td>DLLINIT NODLLINIT</td>
<td>X X</td>
<td>Applies OPTIONS(FETCHABLE) to all external procedures that are not MAIN.</td>
</tr>
<tr>
<td>ESD NOESD</td>
<td>X X</td>
<td>Specifies that the external symbol dictionary (ESD) is listed in the compiler listing.</td>
</tr>
<tr>
<td>EXIT NOEXIT</td>
<td>X X</td>
<td>Enables the compiler user exit to be invoked.</td>
</tr>
<tr>
<td>EXTRN</td>
<td>X X</td>
<td>Controls when EXTRNs are emitted for external entry constants.</td>
</tr>
<tr>
<td>FLAG</td>
<td>X X X</td>
<td>Specifies the minimum severity of error that requires a message listed in the compiler listing.</td>
</tr>
<tr>
<td>FLOAT</td>
<td>X X</td>
<td>Controls the use of additional floating-point registers.</td>
</tr>
<tr>
<td>FLOATINMATH</td>
<td>X</td>
<td>Specifies the precision that the compiler should use when invoking the mathematical built-in functions.</td>
</tr>
<tr>
<td>Option</td>
<td>Available in</td>
<td>Abbreviated option description</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>OS PL/I</td>
<td>PL/I for MVS &amp; VM</td>
</tr>
<tr>
<td>GONUMBER</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOGONUMBER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOSTMT</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOGOSTMT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRAPHIC</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOGRAPHIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMPRECISE</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOIMPRECISE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INCAFTER</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>INCDIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INCLUDE</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>INCPDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INITAUTO</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>INITBASED</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>INITCTL</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>INITSTATIC</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>INSOURCE</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOINSOURCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERRUPT</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOINTERRUPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LANGLEVEL</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LIMITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>Available in</td>
<td>Abbreviated option description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>OS PL/I</td>
<td>PL/I for MVS &amp; VM</td>
</tr>
<tr>
<td>LINECOUNT</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LIST</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOLIST</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LMESSAGE</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SMESSAGE</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MACRO</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NOMACRO</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MAP</td>
<td>X</td>
<td>X</td>
</tr>
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<td>NOMAP</td>
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</tr>
<tr>
<td>MARGINI</td>
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<td>X</td>
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<tr>
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<td>X</td>
</tr>
<tr>
<td>MARGINS</td>
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</tr>
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<td>MAXMEM</td>
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<td>X</td>
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<tr>
<td>NAMES</td>
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<td></td>
</tr>
<tr>
<td>NAME</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NONAME</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NATLANG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>Available in</td>
<td>Abbreviated option description</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>NEST</td>
<td>OS PL/I: X</td>
<td>Specifies that the listing resulting from the SOURCE option indicates the block level and the do-group level for each statement.</td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>NOT</td>
<td></td>
<td>Specifies up to seven alternate symbols that can be used as the logical NOT operator.</td>
</tr>
<tr>
<td>NUMBER</td>
<td>OS PL/I: X</td>
<td>Specifies that statements in the source program are to be identified by the line and file number of the file from which they derived.</td>
</tr>
<tr>
<td>NONUMBER</td>
<td>PL/I for MVS &amp; VM: X, VisualAge PL/I: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>OBJECT</td>
<td>OS PL/I: X</td>
<td>Specifies that the compiler creates an object module.</td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>OFFSET</td>
<td>OS PL/I: X</td>
<td>Specifies that the compiler is to print a table of line numbers for each procedure and BEGIN block with their offset addresses relative to the primary entry point of the procedure.</td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>OPTIMIZE</td>
<td>OS PL/I: X</td>
<td>Specifies the type of optimization required.</td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>OPTIONS</td>
<td>OS PL/I: X</td>
<td>Specifies that the compiler includes a list showing the compile-time options to be used during this compilation in the compiler listing.</td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td>Specifies up to seven alternate symbols as the logical OR operator.</td>
</tr>
<tr>
<td>PREFIX</td>
<td></td>
<td>Enables or disables the specified PL/I conditions in the compilation unit being compiled without you having to changed the source program.</td>
</tr>
<tr>
<td>PROCEED</td>
<td>OS PL/I: X</td>
<td>Stops the compiler after processing by a preprocessor is completed depending on the severity of messages issued by previous preprocessors.</td>
</tr>
<tr>
<td>NOPROCEED</td>
<td>PL/I for MVS &amp; VM: X, VisualAge PL/I: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enterprise PL/I: X</td>
<td></td>
</tr>
<tr>
<td>PROCESS</td>
<td></td>
<td>Determines if *PROCESS statements are allowed and, if they are allowed, if they are written to the MDECK file.</td>
</tr>
<tr>
<td>Option</td>
<td>Available in</td>
<td>Abbreviated option description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>REDUCE</td>
<td>X</td>
<td>Specifies that the compiler is permitted to reduce an assignment of a null string to a structure into a simple copy operation - even if that means padding bytes might be overwritten.</td>
</tr>
<tr>
<td>NOREDUCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RENT</td>
<td>X</td>
<td>Specifies that the compiler is to take code that is not naturally reentrant and make it reentrant. compiler listing.</td>
</tr>
<tr>
<td>NORENT</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>REDUCE</td>
<td>X</td>
<td>Specifies that the compiler is permitted to reduce an assignment of a null string to a structure into a simple copy operation - even if that means padding bytes might be overwritten.</td>
</tr>
<tr>
<td>NOREDUCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESPECT</td>
<td>X</td>
<td>Causes the compiler to honor any specification of the DATE attribute and to apply the DATE attribute to the result of the DATE built-in function.</td>
</tr>
<tr>
<td>NORESPECT</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>RULES</td>
<td>X</td>
<td>Allows certain language capabilities and lets you choose semantics when alternatives are available.</td>
</tr>
<tr>
<td>SCHEDULER</td>
<td>X</td>
<td>Determines if the compiler tries to optimize instruction scheduling when optimizing a program.</td>
</tr>
<tr>
<td>SEMANTIC</td>
<td>X</td>
<td>Specifies that the execution of the compiler’s semantic checking stage depends on the severity of messages issued prior to this stage of processing.</td>
</tr>
<tr>
<td>NOSEMANTIC</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>SEQUENCE</td>
<td>X</td>
<td>Defines the section of the input record from which the compiler takes the sequence numbers.</td>
</tr>
<tr>
<td>NOSEQUENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERVICE</td>
<td>X</td>
<td>Places a string in the object module, if generated.</td>
</tr>
<tr>
<td>NOSERVICE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIZE</td>
<td>X</td>
<td>Limits the amount of main storage the compiler uses.</td>
</tr>
<tr>
<td>SOURCE</td>
<td>X</td>
<td>Specifies that the compiler includes a listing of the source program in the compiler listing.</td>
</tr>
<tr>
<td>NOSOURCE</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>SPILL</td>
<td>X</td>
<td>Specifies the size of the spill area to be used for the compilation.</td>
</tr>
<tr>
<td>STATIC</td>
<td>X</td>
<td>Controls whether INTERNAL STATIC variables are retained in the object module even if unreferenced.</td>
</tr>
<tr>
<td>STDSYS</td>
<td>X</td>
<td>Specifies that the compiler should cause the SYSPRINT file to be equated to the C stdout file.</td>
</tr>
<tr>
<td>NOSTDSYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STMT</td>
<td>X</td>
<td>Specifies that statements in the source program are to be counted and that this “statement number” is used to identify statements in the compiler listing.</td>
</tr>
<tr>
<td>NOSTMT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>OS PL/I</td>
<td>PL/I for MVS &amp; VM</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------</td>
<td>-------------------</td>
</tr>
<tr>
<td>STORAGE NOSTORAGE</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>STRINGOFGRAPHIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYNTAX NOSYNTAX</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SYSPARM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSTEM</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TERMINAL NOTERMINAL</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TEST NOTEST</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TUNE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WIDECHAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WINDOW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRITABLE NOWRITABLE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XINFO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XREF NOXREF</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Appendix D. Compiler limit comparison

The following table lists the compiler implementation limits for OS PL/I, PL/I for MVS & VM, VisualAge PL/I, and Enterprise PL/I.

Table 17. Language element limits

<table>
<thead>
<tr>
<th>Language Element</th>
<th>Description</th>
<th>OS PL/I</th>
<th>PL/I for MVS&amp;VM</th>
<th>VisualAge PL/I</th>
<th>Enterprise PL/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrays</td>
<td>Maximum number of dimensions for an array</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Minimum lower bound</td>
<td>-2147483648</td>
<td>-2147483648</td>
<td>-2147483648</td>
<td>-2147483648</td>
</tr>
<tr>
<td></td>
<td>Maximum upper bound</td>
<td>+2147483647</td>
<td>+2147483647</td>
<td>+2147483647</td>
<td>+2147483647</td>
</tr>
<tr>
<td>Structures</td>
<td>Maximum number of levels in a structure</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maximum level-number in a structure</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>Maximum precision for FIXED DEC</td>
<td>15</td>
<td>15</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Precision</td>
<td>Maximum precision for FIXED BINARY</td>
<td>31</td>
<td>31</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Maximum precision for FLOAT DEC</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Maximum precision for FLOAT BINARY</td>
<td>109</td>
<td>109</td>
<td>109</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Maximum scale factor for FIXED data</td>
<td>127</td>
<td>127</td>
<td>127</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>Minimum scale factor for FIXED data</td>
<td>-128</td>
<td>-128</td>
<td>-128</td>
<td>-128</td>
</tr>
</tbody>
</table>
Table 17. Language element limits (continued)

<table>
<thead>
<tr>
<th>Language Element</th>
<th>Description</th>
<th>OS PL/I</th>
<th>PL/I for MVS&amp;VM</th>
<th>VisualAge PL/I</th>
<th>Enterprise PL/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>String and AREA Variables or Constants</td>
<td>Maximum length of CHARACTER</td>
<td>32767</td>
<td>32767</td>
<td>32767</td>
<td>32767</td>
</tr>
<tr>
<td></td>
<td>Maximum length of BIT</td>
<td>32767</td>
<td>32767</td>
<td>32767</td>
<td>32767</td>
</tr>
<tr>
<td></td>
<td>Maximum length of GRAPHIC</td>
<td>16383</td>
<td>16383</td>
<td>16383</td>
<td>16383</td>
</tr>
<tr>
<td></td>
<td>Maximum length of WIDECHAR</td>
<td>n/a</td>
<td>n/a</td>
<td>16383</td>
<td>16383</td>
</tr>
<tr>
<td></td>
<td>Maximum size of AREA</td>
<td>2147483647</td>
<td>2147483647</td>
<td>2147483647</td>
<td>2147483647</td>
</tr>
<tr>
<td>Built-In Functions</td>
<td>Maximum number of arguments to the IAND, IOR, MAX, and MIN functions</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
</tbody>
</table>
Table 17. Language element limits (continued)

<table>
<thead>
<tr>
<th>Language Element</th>
<th>Description</th>
<th>OS PL/I</th>
<th>PL/I for MVS&amp;VM</th>
<th>VisualAge PL/I</th>
<th>Enterprise PL/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Size</td>
<td>Maximum length of an identifier</td>
<td>31</td>
<td>31</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Maximum number of procedures in a program</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>Maximum number of DEFAULT statements in a block</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Maximum nesting of %INCLUDE statements</td>
<td>8</td>
<td>8</td>
<td>2046</td>
<td>2046</td>
</tr>
<tr>
<td></td>
<td>Maximum number of lines in any source file</td>
<td>65,535</td>
<td>65,535</td>
<td>1048575</td>
<td>1048575</td>
</tr>
<tr>
<td></td>
<td>Maximum number of statements</td>
<td>32,767</td>
<td>32,767</td>
<td>16777215</td>
<td>16777215</td>
</tr>
<tr>
<td></td>
<td>Maximum number of LIKE-attributes in a block</td>
<td>63</td>
<td>63</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Maximum number of output expressions in a data-list</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Maximum number of repetitive DO-specifications in a data-list</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Language Element</td>
<td>Description</td>
<td>OS PL/I</td>
<td>PL/I for MVS&amp;VM</td>
<td>VisualAge PL/I</td>
<td>Enterprise PL/I</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------</td>
<td>-----------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Program Size</td>
<td>Maximum size of a data aggregate containing no unaligned bits</td>
<td>2147483648</td>
<td>2147483648</td>
<td>2147483647</td>
<td>2147483647</td>
</tr>
<tr>
<td></td>
<td>Maximum size of a data aggregate containing some unaligned bits</td>
<td>268435455</td>
<td>268435455</td>
<td>268435455</td>
<td>268435455</td>
</tr>
<tr>
<td></td>
<td>Maximum number of arguments in a CALL or function reference</td>
<td>64</td>
<td>64</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>Maximum number of parameters for a procedure</td>
<td>64</td>
<td>63</td>
<td>4095</td>
<td>4095</td>
</tr>
<tr>
<td></td>
<td>Maximum nesting of factored attributes</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maximum nesting of BEGIN and PROCEDURE statements</td>
<td>42</td>
<td>42</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Maximum nesting of DO-groups</td>
<td>38</td>
<td>38</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Maximum nesting of IF statements</td>
<td>80</td>
<td>80</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Maximum nesting of SELECT-statements</td>
<td>50</td>
<td>50</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Maximum length of %NOTE message</td>
<td>256</td>
<td>256</td>
<td>32767</td>
<td>32767</td>
</tr>
</tbody>
</table>
Table 17. Language element limits (continued)

<table>
<thead>
<tr>
<th>Language Element</th>
<th>Description</th>
<th>OS PL/I</th>
<th>PL/I for MVS&amp;VM</th>
<th>VisualAge PL/I</th>
<th>Enterprise PL/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous</td>
<td>Maximum number of picture characters in a character picture</td>
<td>511</td>
<td>511</td>
<td>511</td>
<td>511</td>
</tr>
<tr>
<td></td>
<td>Maximum number of bytes in a numeric picture</td>
<td>256</td>
<td>256</td>
<td>253</td>
<td>253</td>
</tr>
<tr>
<td></td>
<td>Maximum number of numeric picture characters in a numeric picture</td>
<td>15</td>
<td>15</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Maximum length for a KEYTO character string</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Maximum length for a KEYTO graphic or widechar string</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Maximum KEY length</td>
<td>8</td>
<td>8</td>
<td>32763</td>
<td>32763</td>
</tr>
<tr>
<td></td>
<td>Maximum line size for LINESIZE</td>
<td>32,000</td>
<td>32,000</td>
<td>32,000</td>
<td>32,759 for F-format or U-format, and 32,751 for V-format</td>
</tr>
<tr>
<td></td>
<td>Minimum line size for LINESIZE</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Maximum page size for PAGESIZE</td>
<td>32,000</td>
<td>32,000</td>
<td>32,767</td>
<td>32,767</td>
</tr>
<tr>
<td>Language Element</td>
<td>Description</td>
<td>OS PL/I</td>
<td>PL/I for MVS&amp;VM</td>
<td>VisualAge PL/I</td>
<td>Enterprise PL/I</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
<td>-----------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Minimum page size for PAGESIZE</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Maximum size of DISPLAY character string</td>
<td>126</td>
<td>126</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>Maximum DISPLAY reply message</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
</tbody>
</table>
Appendix E. Batch processing sample

The following code samples show how to implement a 'batch compiler' with Enterprise PL/I.

```
batch: proc options(main);
    dcl eof bit(1);
    dcl rc fixed bin(15);
    dcl system builtin;
    dcl source char(80);
    dcl sysutz file output record sequential
        env(fb, recsize(80));
    dcl compin file input record sequential;
    dcl plixopt ext static char(40) var
        init('errcount(0), heap(2m,1m, any,free)');

    open file(compin);
    rc = 0;
    eof = '0'b;
    data_read = '0'b;
    on endfile(compin) eof = '1'b;

    data_read = '0'b;
    open file(sysutz);
    read file(compin) into(source);
    do while( eof = '0'b );
        if substr(source,1,8) = '*PROCESS' then
            if data_read then
                do;
                    close file(sysutz);
                    rc = max( rc, system('ibmzpli @dd:options') );
                    data_read = '0'b;
                    open file(sysutz);
                    end;
            else;
                else
                    data_read = '1'b;
                    write file(sysutz) from(source);
                    read file(compin) into(source);
                    end;
                end;
            end;
        close file(sysutz);

        rc = max( rc, system('ibmzpli @dd:options') );
        call pliretc(rc);
    end;
```

This program when compiled and linked could be used as a "batch compiler" if the following JCL were used when the program is run.

```
//SYSPRINT DD SYSOUT**
//OPTIONS DD *
dd(*, sysutz) name
limits(extrname(7)) norent cmpat(v2)
//COMPIN DD *
*PROCESS X(F);
x: proc;
    dcl a ext char(80);
```
end;
*PROCESS NORENT;
y: proc;
dcl b ext char(40);
end;
//SYSLIN DD DSN=...,DISP=(MOD)
//SYSUT1 DD DSN=&SYSUT1,UNIT=SYSDA,
 // SPACE=(1024,(200,50),CONTIG,ROUND),DCB=BLKSIZE=1024
//SYSUTZ DD DSN=&SOURCE,DISP=(NEW),UNIT=SYSSQ,
 // SPACE=(CYL,(3,1))

The first line in the OPTIONS DD specifies the DD(*,SYSUTZ) and NAME and is necessary to make the program work as a batch compiler. The second line is used merely as an example.
Appendix F. Debugging tool comparison

Debug Tool is a program analyzer that runs within Language Environment and supports a number of high level languages, including Enterprise PL/I.

For Enterprise PL/I, Debug Tool is orderable as a feature of the compiler.

Differences between debugging tools

IBM Debug Tool is the interactive debugger that supports PL/I and Language Environment. Debug Tool functions are equivalent to PLITEST functions. Some names of PLITEST commands, however, have changed in Debug Tool and are no longer accepted. These are listed in Table 18.

You must have Language Environment for OS/390 & VM Release 4 or later installed on your system before you can use Debug Tool with your OS PL/I applications.

Table 18. PLITEST Commands and Their Debug Tool Equivalents

<table>
<thead>
<tr>
<th>PLITEST Command</th>
<th>Equivalent Debug Tool Command</th>
</tr>
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<tbody>
<tr>
<td>CLEAR ON</td>
<td>CLEAR AT OCCURENCE</td>
</tr>
<tr>
<td>LIST %FPRS</td>
<td>LIST SHORT FLOATING</td>
</tr>
<tr>
<td>LIST %LPRS</td>
<td>LIST LONG FLOATING</td>
</tr>
<tr>
<td>LIST %GPRS</td>
<td>LIST REGISTERS</td>
</tr>
<tr>
<td>LIST SNAP</td>
<td>LIST CALLS</td>
</tr>
<tr>
<td>MOVECURS</td>
<td>CURSER</td>
</tr>
<tr>
<td>ON</td>
<td>AT OCCURENCE</td>
</tr>
<tr>
<td>QUERY AT</td>
<td>LIST AT</td>
</tr>
<tr>
<td>QUERY ATTRIBUTES</td>
<td>DESCRIBE ATTRIBUTES</td>
</tr>
<tr>
<td>QUERY BEARINGS</td>
<td>QUERY LOCATION</td>
</tr>
<tr>
<td>QUERY ENVIRONMENT</td>
<td>DESCRIBE ENVIRONMENT</td>
</tr>
<tr>
<td>QUERY MONITOR</td>
<td>LIST MONITOR</td>
</tr>
<tr>
<td>QUERY NAMES ‘pattern’</td>
<td>LIST NAMES ‘pattern’</td>
</tr>
<tr>
<td>QUERY NAMES PROCEDURE</td>
<td>LIST PROCEDURE</td>
</tr>
<tr>
<td>QUERY PROGRAM</td>
<td>DESCRIBE PROGRAM</td>
</tr>
<tr>
<td>QUERY STATEMENT NUMBERS</td>
<td>LIST STATEMENT NUMBERS</td>
</tr>
<tr>
<td>SEARCH</td>
<td>FIND</td>
</tr>
<tr>
<td>SET GRAPHIC</td>
<td>SET DBCS</td>
</tr>
<tr>
<td>SET LANGUAGE</td>
<td>SET NATIONAL LANGUAGE</td>
</tr>
<tr>
<td>SET LAST n</td>
<td>SET HISTORY n</td>
</tr>
<tr>
<td>SET FILE</td>
<td>SET LOG</td>
</tr>
<tr>
<td>SIGNAL (ON cond) PROGRAM</td>
<td>TRIGGER (ON cond)</td>
</tr>
<tr>
<td>SIGNAL (ON cond) TEST</td>
<td>TRIGGER AT OCCURENCE (ON cond)</td>
</tr>
<tr>
<td>SIGNAL (AT cond) TEST</td>
<td>TRIGGER AT (AT cond)</td>
</tr>
</tbody>
</table>
Table 18. PLTEST Commands and Their Debug Tool Equivalents (continued)

<table>
<thead>
<tr>
<th>PLTEST Command</th>
<th>Equivalent Debug Tool Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTRACE</td>
<td>STEP</td>
</tr>
<tr>
<td>WINDOWS</td>
<td>LAYOUT</td>
</tr>
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compiler options (continued)
unsupported 66
USAGE 125, 126
WRITABLE 73, 130
compiler options restricted
INCLUDE 65
LANGlvl 65
LIST 65
STMT 65
SYSTEM 65
compiler options unsupported
CONTROL 66
COUNT 66
DECK 66
ESD 66
FLOW 66
GOSTMT 66
LMESSAGE 66
SEQUENCE 66
SIZE 66
SMMESSAGE 66
compiler restrictions
array expressions 63
built-in functions 64
DBCS 64
DEFAULT statement 63
extents of automatic variables 64
iSUB defining 64
LABEL arrays 64
MACRO preprocessor 65
multitasking facility 42
pseudovariables 64
RECORD I/O 62
STREAM I/O 62
structure expressions 63
VM 9
compiler support dropped
CHARSET(48) 61
CHECK 61
EGCS 62
multitasking 61
VM 9
condition handling
differences 37
IBMBXITA and IBMBEER differences 38
IMS considerations 56, 142
severity differences 38
timing differences 37
U4039 differences 38
unhandled condition differences 38
conditions
ERROR 37
FIXEDOVERFLOW 97, 106
OVERFLOW 105
UNDERFLOW 36
ZERO DIVIDE 105
considerations
before migrating 35
assembler 135
ccondition handling 37
LIST 37
DATE/TIME built-in functions 42
debugging tools 171
ILC differences 44
performance returning 117
PLIDUMP 43
preinitialized program 41
considerations (continued)
before migrating (continued)
runtime message 43
runtime options 35
storage report 44
storage use retuning 117
user return code 42
using sort program 41
installation
Enterprise PL/I 23
OS/390 requirements 7
product configuration 153
product configuration,
SCEELKED 7
product configuration,
SCEEDRUN 7
link-edit
CHANGE card 111
math routines 52
NCAL linkage editor option 51
PLICALLA and PLICALLB 111
symbol table 51
subsystem
CICS 53, 137
DB2 57, 145
IMS 55, 141
Considerations
Before Migrating
Run-time messages 114, 115
CONTROL compiler option 66
COUNT compiler option 66
COUNT run-time option 35, 113
CPU utilization, improving 117
CSD file, updating 53, 137
CSECT compiler option 125
CSECTs
IDR information 17, 152
symbol table 51
D
data sets
load module considerations 47
new, OS/390 7
DATE/TIME built-in functions 42
DB2 considerations 57, 145
DBCS restrictions 64
SQL Preprocessor 145
Debug Tool 171
comparing with PLITEST 171
product relationships 7
debugging tools, differences in 171
DECK compiler option 66
DEFAULT compiler option
LINKAGE 73, 121
NOBINIARG 75
NONASGN 77
NONCONNECTED 77
NOOVERLAP 78
OVERLAP 75, 101, 121
REORDER 78
DEFAULT statement restrictions 63
DEPTCHCONDLMT run-time option 36, 113
DFSORT, using 41
dump differences 116
E
education
Enterprise PL/I 23
Language Environment 16
element names 152
elements 152
Enterprise PL/I for z/OS library xii
Enterprise PL/I library xii
ENVIRONMENT options not supported 62
ERRCOUNT run-time option 36, 113
ERROR condition 37
error handling, CICS considerations 53
ESD compiler option 66
EXCLUSIVE file attribute 62
EXEC DLI interface 55, 141
EXEC SQL statements 145
EXTERNAL
initialized STATIC 103
EXTRN compiler option 73, 121
F
FETCH
compiler advantages 8
file attributes not supported
BACKWARDS 62
EXTERNAL 62
TRANSIENT 62
FIXED BIN
and FIXEDOVERFLOW 106
with precision <= 7 107
FIXEDOVERFLOW
and SIZE 97
restricted to FIXED DEC 106
FLAG compiler option 125, 126
FLOAT
assignments to FLOAT 101
FLOAT compiler option 125
FLOW compiler option 66
FLOW run-time option 35, 113
G
GONUMBER compiler option 84
GOSTMT compiler option 66
H
HEAP run-time option 35, 113, 118
I
IBMEX user exit
differences 38
installation considerations 136
IBMBXITA user exit 136
differences 38
IBMEXITA user exit 136
IBMRLSx, replacing Shared Library 150
IBMWRILKx, replacing library routine 149
IEEE floating point
support of 8
ILC (interlanguage communication)
differences in 44
enabled languages 44
migration considerations 18
PL/I compiler option 36
implementation limits 163
IMS considerations
assembler language options
support 55, 142
condition handling 56, 142
discussion of 55, 141
interfaces 55, 141
interfaces to 55, 141
PLICALLA support 55, 141
PSB language options 55, 142
STEPLIB use and LE 19
storage usage 56, 142
SYSTEM compiler option 55, 141
INCLUDE compiler option 65
INDEXAREA ENVIRONMENT
option 62
installation
Language Environment 15
interlanguage communication (ILC)
differences in 44
enabled languages 44
introduction
PL/I run-time environment 8
ISAINC run-time option 113
ISASIZE run-time option 35, 113
iSUB defining restrictions 64

L

LABEL array restrictions 64
LANGLVL compiler option 65
Language Environment
educating programmers 16
Enterprise PL/I prerequisite level 15
invoking existing CICS applications 32
invoking existing non-CICS applications 31
planning move to 15
running existing applications 31
Language Environment library xii
LANGUAGE run-time option 35, 113
LEAVE ENVIRONMENT option 62
library routine replacement tool
using IBMWRKLx 149
LIMITS compiler option
EXTNAME 73, 121, 125
link-edit considerations 111
link-edit
AMODE(24) considerations 111
and CHANGE 111
and PLICALLA 111
and PLICALLB 111
effects of LIMITS on 111
effects of RENT/NORENT on 111
existing applications with LE 32
math routines, using 52
NCAL option 51
symbol table 51
symbol tables
CSECT 51
discussion of 51
link-edit (continued)
using NCAL option 51
linking applications under CICS 138
LIST compiler option 65
LMESSAGE compiler option 66
LINKLST
SCEERUN 4, 7
use in migration 18
load module
considerations for
data sets 47
OS PL/I Version 2 49
general considerations 47
identifying PL/I version 17, 152
IDR information 17, 152
Language Environment support
OS PL/I version 1 prior to release
3.0 49
OS PL/I version 1.3.0 - 1.4.0 49
OS PL/I version 1.5.0 48
OS PL/I version 1.5.1 47
OS PL/I version 2 49
loops
endless 99
LPALST
use in migration 18
LRECL
compiler SYSPRINT 67

M

macro-level interface, CICS
considerations 54, 138
main load module relinking aid
using sample ZAP 150
main load module, user
sample ZAP relinking aid 150
math built-ins
differences 115
math routines, using OS PL/I 52
MAXMSG compiler option 125, 126
messages
2603 88
EXIT option 94
IBM1044 85
IBM1053 85
IBM1065 85
IBM1091 86
IBM1099 86
IBM1181 87
IBM1208 88
IBM1215 88
IBM1216 88
IBM1220 89
IBM1927 90
IBM1948 90
IBM2063 80, 91
IBM2402 91
IBM2409 91
IBM2410 91
IBM2412 92
IBM2610 92
IBM2611 93
IBM2617 93
IBM2801 93
IBM2804 94
IBM2810 94
migrating
to new compiler 23
migration
aid for replacing Shared Library 150
compiler, basics 4
cut to production 22
general tasks 10
ILC considerations 18
library routine replacement tool 149
LINKLST use 18
object module relinking tool 151
phasing in LE 18
PL/I application conversion 26
PL/I application priority 25
regression testing 21
relinking aid, using 151
relinking PL/SRTx modules 151
run-time, basics 4
sample ZAP for relinking main load module 150
STEPLIB example 20
STEPLIB use 19
taking application inventory 16, 24
tools and aids 149
MSCFILE run-time option 43, 113, 115
multitasking facility
support of 9
multithreading
support of 8

N

NATLANG run-time option 35, 113
NCAL linkage editor option 51
NCP ENVIRONMENT option 62
NOREDUCE compiler option 75, 78
NORENT compiler option 73, 79, 121,
125, 130
link-edit considerations 111
notices 173
NOWRITABLE compiler option 73, 76,
130
NOWRITE ENVIRONMENT option 62

O

object and load module
considerations 47, 51
object module
general considerations 47
ILC migration aid 151
Language Environment support
OS PL/I version 1 prior to release
3.0 49
OS PL/I version 1.3.0 - 1.4.0 49
OS PL/I version 1.5.0 48
OS PL/I version 1.5.1 47
OS PL/I version 2 49
OFFSET compiler option 125
OPTIMIZE compiler option 78
OS PL/I
service 5
Version 2 load modules 49
OVERFLOW condition 105
REGIONAL ENVIRONMENT option  62
relinking OS PL/I-COBOL ILC
  using the relinking tool  151
relinking user main load module
  sample ZAP relinking aid  150
RENT compiler option  73, 130
link-edit considerations  111
  replacing library routines
  using IBMWRKLK  149
replacing OS PL/I Shared Library
  sample replacement aid  150
REPORT run-time option  35, 113
REREAD ENVIRONMENT option  62
reverting applications
  CPU utilization  117
  storage utilization, improving  118
  under IMS, improving  118
return codes  114
RPTSTG run-time option  35, 113
using for tuning storage  16, 117
RULES compiler option  125, 126
  ANS  87
  LAXCTL  76
  LAXSTRZ  83
  NOLAXCTL  80
  NOLAXDCL  81
  NOLAXIF  81
  NOLAXLINK  82
  NOLAXMARGINS  82
  NOMULTICLOSE  83
run-time environment
  for PL/I  8
  run-time message differences  43
  Run-time messages  114, 115
  run-time options
  ABTERENC  36, 113
  ALL31  36, 113, 117
  COUNT  35, 113
  DEPTHCONDLMT  36, 113
  differences  35
  ERRCOUNT  36, 113
  FLOW  35, 113
  HEAP  35, 113, 118
  ISASIZE  35
  LANGUAGE  35
  MSGFILE  43, 113, 115
  NATLANG  35, 113
  REPORT  35
  RPTSTG  9, 35, 113, 117
  SPIE  35
  STACK  35, 113, 118
  STAE  35
  STORAGE  113
  TRAP  35, 113
  XFLOW  36, 113
  run-time output, CICS
  considerations  54, 138
SEQUENCE compiler option  66
  service
  CICS support  5
  OS PL/I  5
  Shared Library replacement aid
  using IBMRLSLK  150
  Shared Library support  42
  Shared Library, OS PL/I
  sample replacement aid  150
  SIS ENVIRONMENT option  62
SIZE
  and FIXEDOVERFLOW  97
SIZE compiler option  66
SKIP ENVIRONMENT option  62
SMESSAGE compiler option  66
SPIE run-time option  35, 113
SQL preprocessor
  EXEC SQL statements  145
  new, integrated  8
SQL Preprocessor
  restrictions lifted  145
  using  145
  STACK run-time option  35, 54, 113, 118
  STAE run-time option  35, 113
  STATIC
  retaining unused INTERNAL  97
  uninitialized EXTERNAL  103
  writable reentrant  8
STEPLIB
  migration example  20
  use in migration  19
STMT compiler option  65
storage
  DASD requirements  15
  Enterprise PL/I requirements  23
  usage
  IMS considerations  56, 142
  returning for  117
  virtual requirements  16
  storage report differences  44, 116
  STORAGE run-time option  113
  storage utilization, improving  118
STREAM I/O
  restrictions  62
  unprintable characters  103
  structure expression restrictions  63
  subsystem considerations
    CICS  53, 137
    DB2  57, 145
    IMS  55, 141
  subsystem performance, improving  118
  symbol tables
    considerations for  51
    CSECT  51
SYSPRINT
  LRECL value  67, 125
  sharing between old and new
  PL/I  122
  support for MSGFILE(SYSPRINT)  43, 115
SYSTEM compiler option  65, 74
  CICS considerations  138
  IMS considerations  55, 141
T
TEST compiler option 84
TOTAL environment option 104
TOTAL ENVIRONMENT option 62
TP ENVIRONMENT option 62
TRANSIENT file attribute 62
TRAP run-time option 35, 113
TRKOFL ENVIRONMENT option 62
TSO 67
TUNE compiler option 125

U
U4039 ABEND 38
UNDERFLOW condition 36
UNICODE
   support of 8
UNLOCK statement 62
USAGE compiler option 125, 126
user exits
   assembler
      specific considerations 136
   CEEBINT 136
   CEEBXITA 136
   IBMBEER 136
   IBMBXITA 136
   IBMFXITA 136
   installation considerations 136
   user exits 136
user information xi
user main load module
   sample ZAP relinking aid 150
user return code differences 42

V
VisualAge PL/1
   moving to Enterprise PL/1 125
VM
   support of 9

W
WRITABLE compiler option 73, 130

X
XUFLOW run-time option 36, 113

Z
ZAP, main load module relinking
   aid 150
   ZERODIVIDE condition 105
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Version 3 Release 5

Publication No. GC27-1458-04

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<th>Accurate</th>
<th>Complete</th>
<th>Easy to find</th>
<th>Easy to understand</th>
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