z/OS

XL C/C++ Compiler and Runtime Migration Guide for the Application Programmer

Version 2 Release 2

GC14-7306-03

Note

Before using this information and the product it supports, read the information in “Notices” on page 149.

This edition applies to Version 2 Release 2 of z/OS (5650-ZOS) and to all subsequent releases and modifications until otherwise indicated in new editions.

Contents

About this document

This document discusses the implications of migrating applications from each of the supported compilers and libraries to the IBM® z/OS® V2R2 XL C/C++ release. To find the section of the document that applies to your migration, see “How to use this document.”

This document contains terminology, maintenance, and editorial changes. Technical changes or additions to the text and illustrations are indicated by a vertical line (|) to the left of the change.

You may notice changes in the style and structure of some of the contents in this document; for example, headings that use uppercase for the first letter of initial words only, and procedures that have a different look and format. The changes are ongoing improvements to the consistency and retrievability of information in our documents.

How to use this document

You can use this document to:

- Help determine whether and how you can continue to use existing source code, object code, and load modules
- Become aware of the changes in compiler and runtime behavior that may affect your migration from earlier versions of the compiler

Note: In most situations, existing well-written applications can continue to work without modification.

This document does not:

- Discuss all of the enhancements that have been made to the z/OS XL C/C++ compiler and IBM Language Environment® element provided with z/OS.

  Notes:
  1. All subsequent "Language Environment" references in this document apply to the Language Environment element that is provided with the z/OS operating system unless otherwise specified as applying to an earlier operating system.
  2. For a list of books that provide information about the z/OS XL C/C++ compiler and Language Environment element, refer to “z/OS XL C/C++ and related documents” on page xi.
- Show how to change an existing C program so that it can use C++.

  Note: For a description of some of the differences between C and C++, see *z/OS XL C/C++ Language Reference*.

How this document is organized

This document includes the following topics:

- Part 1 provides information that you will need to understand before you migrate programs or applications, as well as assistance in finding the information that is relevant to your migration. See Chapter 1, “New migration issues for z/OS V2R2 XL C/C++,” on page 3 and Chapter 3, “Program migration checklists,” on page 7.

- Part 2 describes the considerations for migrating from a pre-OS/390 C and C++ application. See Part 2, “Migration of pre-OS/390 C/C++ applications to z/OS V2R2 XL C/C++,” on page 15.
- Part 3 describes the considerations for migrating from an IBM OS/390® C and C++ application. See Part 3, “Migration of OS/390 C/C++ applications to z/OS V2R2 XL C/C++,” on page 55.
- Part 4 describes the considerations for migrating from an earlier z/OS C/C++ application. See Part 4, “Migration of earlier z/OS C/C++ applications to z/OS V2R2 XL C/C++,” on page 77.
- Part 5 describes the migration issues related to *Programming languages - C++ (ISO/IEC 14882:2003(E))*, which documents the C++ Standard. See Part 5, “ISO Standard C++ compliance migration issues,” on page 115.
- Part 6 describes the issues related to migration of C/C++ programs that access IBM CICS® or IBM DB2® information. See Part 6, “Migration issues for C/C++ applications that use other IBM products,” on page 131.

Within Parts 2, 3, and 4, chapters are organized around the following areas:

- Possible changes to source code that are required by the migration.
- Migration issues that affect compilations.
- Migration issues that affect the linking or binding process.
- Migration issues that affect application execution.
- Migration issues that are caused by class library changes.

In this release of the document, you will notice that some topics are covered in different locations. Use the index to see all discussions related to a specific topic, such as POSIX compliance or globalization. The index is structured to support quick and selective retrieval of specific topics.

Typographical conventions

The following table explains the typographical conventions used in this document.

Table 1. Typographical conventions

Typeface	Indicates	Example
bold	Commands, executable names, compiler options and pragma directives that contain lower-case letters.	The xlc utility provides two basic compiler invocation commands, **xlc** and **xlC** (**xlc++**), along with several other compiler invocation commands to support various C/C++ language levels and compilation environments.
italics	Parameters or variables whose actual names or values are to be supplied by the user. Italics are also used to introduce new terms.	Make sure that you update the *size* parameter if you return more than the *size* requested.
`monospace`	Programming keywords and library functions, compiler built-in functions, file and directory names, examples of program code, command strings, or user-defined names.	If one or two cases of a `switch` statement are typically executed much more frequently than other cases, break out those cases by handling them separately before the `switch` statement.

z/OS XL C/C++ and related documents

This topic summarizes the content of the z/OS XL C/C++ documents and shows where to find related information in other documents.

Table 2. z/OS XL C/C++ and related documents

Document Title and Number	Key Sections/Chapters in the Document
z/OS XL C/C++ Programming Guide, SC14-7315	Guidance information for: • XL C/C++ input and output • Debugging z/OS XL C programs that use input/output • Using linkage specifications in C++ • Combining C and assembler • Creating and using DLLs • Using threads in z/OS UNIX System Services applications • Reentrancy • Handling exceptions, error conditions, and signals • Performance optimization • Network communications under z/OS UNIX • Interprocess communications using z/OS UNIX • Structuring a program that uses C++ templates • Using environment variables • Using System Programming C facilities • Library functions for the System Programming C facilities • Using runtime user exits • Using the z/OS XL C multitasking facility • Using other IBM products with z/OS XL C/C++ (IBM CICS Transaction Server for z/OS, CSP, DWS, IBM DB2, IBM GDDM, IBM IMS™, ISPF, IBM QMF™) • Globalization: locales and character sets, code set conversion utilities, mapping variant characters • POSIX character set • Code point mappings • Locales supplied with z/OS XL C/C++ • Charmap files supplied with z/OS XL C/C++ • Examples of charmap and locale definition source files • Converting code from coded character set IBM-1047 • Using built-in functions • Using vector programming support • Using runtime check library • Using high performance libraries • Programming considerations for z/OS UNIX C/C++

Table 2. z/OS XL C/C++ and related documents (continued)

Document Title and Number	Key Sections/Chapters in the Document
z/OS XL C/C++ User's Guide, SC14-7307	Guidance information for: • z/OS XL C/C++ examples • Compiler options • Binder options and control statements • Specifying Language Environment runtime options • Compiling, IPA Linking, binding, and running z/OS XL C/C++ programs • Utilities (Object Library, CXXFILT, DSECT Conversion, Code Set and Locale, ar and make, BPXBATCH, c89, xlc) • Diagnosing problems • Cataloged procedures and IBM REXX EXECs • Customizing default options for the z/OS XL C/C++ compiler
z/OS XL C/C++ Language Reference, SC14-7308	Reference information for: • The C and C++ languages • Lexical elements of z/OS XL C and C++ • Declarations, expressions, and operators • Implicit type conversions • Functions and statements • Preprocessor directives • C++ classes, class members, and friends • C++ overloading, special member functions, and inheritance • C++ templates and exception handling • z/OS XL C and C++ compatibility
z/OS XL C/C++ Messages, GC14-7305	Provides error messages and return codes for the compiler, and its related application interface libraries and utilities. For the XL C/C++ runtime library messages, refer to *z/OS Language Environment Runtime Messages, SA38-0686*. For the c89 and xlc utility messages, refer to *z/OS UNIX System Services Messages and Codes, SA23-2284*.
z/OS XL C/C++ Runtime Library Reference, SC14-7314	Reference information for: • header files • library functions
z/OS C Curses, SA38-0690	Reference information for: • Curses concepts • Key data types • General rules for characters, renditions, and window properties • General rules of operations and operating modes • Use of macros • Restrictions on block-mode terminals • Curses functional interface • Contents of headers • The terminfo database

Table 2. z/OS XL C/C++ and related documents (continued)

Document Title and Number	Key Sections/Chapters in the Document
z/OS XL C/C++ Compiler and Runtime Migration Guide for the Application Programmer, GC14-7306	Guidance and reference information for: • Common migration questions • Application executable program compatibility • Source program compatibility • Input and output operations compatibility • Class library migration considerations • Changes between releases of z/OS • Pre-z/OS C and C++ compilers to current compiler migration • Other migration considerations
z/OS Metal C Programming Guide and Reference, SC14-7313	Guidance and reference information for: • Metal C run time • Metal C programming • AR mode
Standard C++ Library Reference, SC14-7309	The documentation describes how to use the following three main components of the Standard C++ Library to write portable C/C++ code that complies with the ISO standards: • ISO Standard C Library • ISO Standard C++ Library • Standard Template Library (C++) The ISO Standard C++ library consists of 51 required headers. These 51 C++ library headers (along with the additional 18 Standard C headers) constitute a hosted implementation of the C++ library. Of these 51 headers, 13 constitute the Standard Template Library, or STL.
z/OS Common Debug Architecture User's Guide, SC14-7310	This documentation is the user's guide for IBM's `libddpi` library. It includes: • Overview of the architecture • Information on the order and purpose of API calls for model user applications and for accessing DWARF information • Information on using the Common Debug Architecture with C/C++ source This user's guide is part of the Runtime Library Extensions documentation.
z/OS Common Debug Architecture Library Reference, SC14-7311	This documentation is the reference for IBM's `libddpi` library. It includes: • General discussion of Common Debug Architecture • Description of APIs and data types related to stacks, processes, operating systems, machine state, storage, and formatting This reference is part of the Runtime Library Extensions documentation.
DWARF/ELF Extensions Library Reference, SC14-7312	This documentation is the reference for IBM's extensions to the `libdwarf` and `libelf` libraries. It includes information on: • Consumer APIs • Producer APIs This reference is part of the Runtime Library Extensions documentation.
Debug Tool documentation, available on the Debug Tool for z/OS library page on the World Wide Web	The documentation, which is available at http://www.ibm.com/software/awdtools/debugtool/library/, provides guidance and reference information for debugging programs, using Debug Tool in different environments, and language-specific information.

Table 2. z/OS XL C/C++ and related documents (continued)

Document Title and Number	Key Sections/Chapters in the Document
README file	The README file provides additional information for using the z/OS XL C/C++ licensed program, including late changes to z/OS XL C/C++ publications. To access any README files that were published after the ship date, go to http://www.ibm.com/support/docview.wss?uid=swg27007531.
Note: For complete and detailed information on linking and running with Language Environment services and using the Language Environment runtime options, refer to *z/OS Language Environment Programming Guide, SA38-0682*. For complete and detailed information on using interlanguage calls, refer to *z/OS V2R1.0 Language Environment Writing Interlanguage Communication Applications, SA38-0684*.	

The following table lists the z/OS XL C/C++ and related documents. The table groups the documents according to the tasks they describe.

Table 3. Documents by task

Tasks	Documents
Planning, preparing, and migrating to z/OS XL C/C++	• *z/OS XL C/C++ Compiler and Runtime Migration Guide for the Application Programmer, GC14-7306* • *z/OS Language Environment Customization, SA38-0685* • *z/OS V2R1.0 Language Environment Runtime Application Migration Guide, GA32-0912* • *z/OS UNIX System Services Planning, GA32-0884* • *z/OS Planning for Installation, GA32-0890*
Installing	• *z/OS Program Directory* • *z/OS Planning for Installation, GA32-0890* • *z/OS Language Environment Customization, SA38-0685*
Option customization	• *z/OS XL C/C++ User's Guide, SC14-7307*
Coding programs	• *z/OS XL C/C++ Runtime Library Reference, SC14-7314* • *z/OS XL C/C++ Language Reference, SC14-7308* • *z/OS XL C/C++ Programming Guide, SC14-7315* • *z/OS Metal C Programming Guide and Reference, SC14-7313* • *z/OS V2R1.0 Language Environment Concepts Guide, SA38-0687* • *z/OS Language Environment Programming Guide, SA38-0682* • *z/OS Language Environment Programming Reference, SA38-0683*
Coding and binding programs with interlanguage calls	• *z/OS XL C/C++ Programming Guide, SC14-7315* • *z/OS XL C/C++ Language Reference, SC14-7308* • *z/OS Language Environment Programming Guide, SA38-0682* • *z/OS V2R1.0 Language Environment Writing Interlanguage Communication Applications, SA38-0684* • *z/OS MVS Program Management: User's Guide and Reference, SA23-1393* • *z/OS MVS Program Management: Advanced Facilities, SA23-1392*
Compiling, binding, and running programs	• *z/OS XL C/C++ User's Guide, SC14-7307* • *z/OS Language Environment Programming Guide, SA38-0682* • *z/OS Language Environment Debugging Guide, GA32-0908* • *z/OS MVS Program Management: User's Guide and Reference, SA23-1393* • *z/OS MVS Program Management: Advanced Facilities, SA23-1392*

Table 3. Documents by task (continued)

Tasks	Documents
Compiling and binding applications in the z/OS UNIX (z/OS UNIX) environment	• *z/OS XL C/C++ User's Guide, SC14-7307* • *z/OS V2R2.0 UNIX System Services User's Guide, SA23-2279* • *z/OS UNIX System Services Command Reference, SA23-2280* • *z/OS MVS Program Management: User's Guide and Reference, SA23-1393* • *z/OS MVS Program Management: Advanced Facilities, SA23-1392*
Debugging programs	• README file • *z/OS XL C/C++ User's Guide, SC14-7307* • *z/OS XL C/C++ Messages, GC14-7305* • *z/OS XL C/C++ Programming Guide, SC14-7315* • *z/OS Language Environment Programming Guide, SA38-0682* • *z/OS Language Environment Debugging Guide, GA32-0908* • *z/OS Language Environment Runtime Messages, SA38-0686* • *z/OS UNIX System Services Messages and Codes, SA23-2284* • *z/OS V2R2.0 UNIX System Services User's Guide, SA23-2279* • *z/OS UNIX System Services Command Reference, SA23-2280* • *z/OS UNIX System Services Programming Tools, SA23-2282* • Debug Tool documentation, available on the Debug Tool Library page on the World Wide Web (http://www.ibm.com/software/awdtools/debugtool/library/)
Developing debuggers and profilers	• *z/OS Common Debug Architecture User's Guide, SC14-7310* • *z/OS Common Debug Architecture Library Reference, SC14-7311* • *DWARF/ELF Extensions Library Reference, SC14-7312*
Packaging XL C/C++ applications	• *z/OS XL C/C++ Programming Guide, SC14-7315* • *z/OS XL C/C++ User's Guide, SC14-7307*
Using shells and utilities in the z/OS UNIX environment	• *z/OS XL C/C++ User's Guide, SC14-7307* • *z/OS UNIX System Services Command Reference, SA23-2280* • *z/OS UNIX System Services Messages and Codes, SA23-2284*
Using sockets library functions in the z/OS UNIX environment	• *z/OS XL C/C++ Runtime Library Reference, SC14-7314*
Using the ISO Standard C++ Library to write portable C/C++ code that complies with ISO standards	• *Standard C++ Library Reference, SC14-7309*
Performing diagnosis and submitting an Authorized Program Analysis Report (APAR)	• *z/OS XL C/C++ User's Guide, SC14-7307*

Note: For information on using the prelinker, see the appendix on prelinking and linking z/OS XL C/C++ programs in *z/OS XL C/C++ User's Guide*.

Softcopy documents

The z/OS XL C/C++ publications are supplied in PDF format and available for download at http://www.ibm.com/software/awdtools/czos/library/.

To read a PDF file, use the Adobe Reader. If you do not have the Adobe Reader, you can download it (subject to Adobe license terms) from the Adobe website at http://www.adobe.com.

You can also browse the documents on the World Wide Web by visiting the z/OS library at http://www.ibm.com/systems/z/os/zos/bkserv/.

Note: For further information on viewing and printing softcopy documents and using IBM BookManager®, see *z/OS V2R2 Information Roadmap*.

z/OS XL C/C++ on the World Wide Web

Additional information on z/OS XL C/C++ is available on the World Wide Web on the z/OS XL C/C++ home page at http://www.ibm.com/software/awdtools/czos/.

This page contains late-breaking information about the z/OS XL C/C++ product, including the compiler, the C/C++ libraries, and utilities. There are links to other useful information, such as the z/OS XL C/C++ information library and the libraries of other z/OS elements that are available on the web. The z/OS XL C/C++ home page also contains links to other related websites.

Where to find more information

For an overview of the information associated with z/OS, see *z/OS V2R2 Information Roadmap*.

Information updates on the web

For the latest information updates that have been provided in PTF cover letters and documentation APARs for z/OS, see the online document z/OS APAR book (http://publibz.boulder.ibm.com/cgi-bin/bookmgr_OS390/Shelves/ ZDOCAPAR).

This document is updated weekly and lists documentation changes before they are incorporated into z/OS publications.

The z/OS Basic Skills Information Center

The z/OS Basic Skills Information Center is a Web-based information resource intended to help users learn the basic concepts of z/OS, the operating system that runs most of the IBM mainframe computers in use today. The Information Center is designed to introduce a new generation of Information Technology professionals to basic concepts and help them prepare for a career as a z/OS professional, such as a z/OS system programmer.

Specifically, the z/OS Basic Skills Information Center is intended to achieve the following objectives:

- Provide basic education and information about z/OS without charge
- Shorten the time it takes for people to become productive on the mainframe
- Make it easier for new people to learn z/OS.

To access the z/OS Basic Skills Information Center, open your Web browser to the following Web site, which is available to all users (no login required): z/OS Basic Skills in IBM Knowledge Center (http://www.ibm.com/support/knowledgecenter/zosbasics/com.ibm.zos.zbasics/homepage.html)

Technical support

Additional technical support is available from the z/OS XL C/C++ Support page. This page provides a portal with search capabilities to a large selection of technical support FAQs and other support documents. You can find the z/OS XL C/C++ Support page on the Web at:

http://www.ibm.com/software/awdtools/czos/support

If you cannot find what you need, you can e-mail:

compinfo@ca.ibm.com

For the latest information about z/OS XL C/C++, visit the product information site at:

http://www.ibm.com/software/awdtools/czos/

For information about boosting performance, productivity and portability, visit the C/C++ Cafe Community & Forum.

How to send your comments to IBM

We appreciate your input on this documentation. Please provide us with any feedback that you have, including comments on the clarity, accuracy, or completeness of the information.

Use one of the following methods to send your comments:

Important: If your comment regards a technical problem, see instead “If you have a technical problem.”

- Send an email to mhvrcfs@us.ibm.com.
- Send an email from the "Contact us" web page for z/OS (http://www.ibm.com/systems/z/os/zos/webqs.html).

Include the following information:

- Your name and address
- Your email address
- Your phone or fax number
- The publication title and order number:
  z/OS V2R2 XL C/C++ Compiler and Runtime Migration Guide for the Application Programmer
  GC14-7306-03
- The topic and page number or URL of the specific information to which your comment relates
- The text of your comment.

When you send comments to IBM, you grant IBM a nonexclusive right to use or distribute the comments in any way appropriate without incurring any obligation to you.

IBM or any other organizations use the personal information that you supply to contact you only about the issues that you submit.

If you have a technical problem

Do not use the feedback methods that are listed for sending comments. Instead, take one or more of the following actions:

- Visit the IBM Support Portal (support.ibm.com).
- Contact your IBM service representative.
- Call IBM technical support.

Part 1. Introduction

Before you start migrating applications to z/OS V2R2 XL C/C++, familiarize yourself with the following information:

- Chapter 1, “New migration issues for z/OS V2R2 XL C/C++,” on page 3
- Chapter 3, “Program migration checklists,” on page 7

Chapter 1. New migration issues for z/OS V2R2 XL C/C++

IBM z/OS V2R2 XL C/C++ compiler has made performance and usability enhancements for the IBM z/OS operating platform V2R2 release ("z/OS V2R2" hereafter). For detailed information about these changes, see *z/OS XL C/C++ User's Guide, SC14-7307*.

For information about the changes that the IBM Language Environment element has made for z/OS V2R2, see "What's New in Language Environment for z/OS" in *z/OS V2R1.0 Language Environment Concepts Guide*.

This document alerts you to the migration issues that result from the following enhancements:

New compiler options

z/OS V2R2 XL C/C++ compiler introduces support for the following new compiler options:

- CHECKNEW - Specify this option to control whether a null pointer check is performed on the pointer that is returned by an invocation of the throwing versions of `operator new` and `operator new[]`.

For detailed information about these new compiler options, see *z/OS XL C/C++ User's Guide, SC14-7307*.

New compiler suboptions

z/OS V2R2 XL C/C++ compiler introduces support for the following new compiler suboptions:

- DSAUSER(*value*) - Specify *value* to allocate a user field with the size of *value* 32-bit words.
- LANGLVL(NULLPTR) - Specify this suboption to enable the `nullptr` feature.
- TARGET(zOSV2R2) - Specify this suboption to instruct the compiler to generate object code to run under z/OS Version 2 Release 2 and subsequent releases.
- VECTOR(TYPE | AUTOSIMD) - Specify the TYPE suboption to support the `vector` data types and specify the AUTOSIMD suboption to generate code, when possible, using the SIMD instructions enabled under the Vector facility for z/Architecture®.

For detailed information about these suboptions, see *z/OS XL C/C++ User's Guide, SC14-7307*.

Changes to default ARCH and TUNE level

Starting with z/OS V2R2, the default ARCH level is changed from ARCH(7) to ARCH(8), and the default TUNE level is changed from TUNE(7) to TUNE(8). For detailed information, see ARCHITECTURE and TUNE in *z/OS XL C/C++ User's Guide, SC14-7307*.

Canges to fprintf and fscanf strings due to new specifiers for vector types

As of z/OS V2R1 (with APAR PI20843), XL C/C++ runtime supports new specifiers for the fprintf and fscanf families of functions for vector data types. For detailed information, see "Required changes to fprintf and fscanf strings due to new specifiers for vector types" on page 83.

Migration tools
: You can use migration tools to facilitate migration activities. For detailed information, see "Tools that facilitate your migration" on page 11.

Chapter 2. New migration issues for z/OS XL C/C+ V2R1M1

The IBM z/OS XL C/C++ compiler updates for z/OS V2R1 are available as a web download from http://www-03.ibm.com/systems/z/os/zos/downloads/ (see "XL C/C++ V2R1M1 web deliverable for z/OS 2.1"). These updates are referred to as z/OS XL C/C++ V2R1M1 in this document. Performance and usability enhancements are made for the z/OS V2R1 XL C/C++ compiler. For detailed information about these changes, see *z/OS XL C/C++ User's Guide, SC14-7307*.

This document alerts you to the migration issues that result from the following enhancements:

New compiler options

Use the following new compiler options that are introduced with z/OS XL C/C++ V2R1M1 :

- ASM - Specify the ASM compiler option to support embedded assembler source inside the C and C++ programs.
- ASMLIB - Use the ASMLIB compiler option to specify assembler macro libraries to be used.
- FUNCEVENT - Specify the FUNCEVENT compiler option to enable LE CEL4CASR, CELHCASR, and __CEL4CASR CWI (compler-writer interface) notifications for each specified function upon function entry.
- -MG, -MT, and -MQ - Specify the -MG, -MT, and -MQ compiler options to generate dependency files that can be used by the make utility.
- VECTOR - Specify the VECTOR compiler option to enable the vector processing support.

For detailed information about these new compiler options, see *z/OS XL C/C++ User's Guide, SC14-7307*.

New compiler suboptions

Use the following compiler suboptions that are introduced with z/OS XL C/C++ V2R1M1:

- ARCH(11) - Specify this suboption to instruct the compiler to produce code that uses instructions available on the 2964-xxx (IBM z Systems™ z13™ (z13)) models in z/Architecture mode.
- KEYWORD(asm) - Specify this suboption to add `asm` to the list of keywords for C and C++ languages.
- LANGLVL(REDEFMAC) - Specify this suboption to redefine a macro without a prior `#undef` or `undefine()` statement.
- MAKEDEP(GCC) - Specify this suboption to instruct the compiler to produce make dependencies file format with a single make rule for all dependencies.
- MAKEDEP(PPONLY) - Specify this suboption to instructs the compiler to produce only the make dependencies file without generating an object file, with the same make file format as the format produced with the gcc suboption.
- NAMEMANGLING(zOSV2R1M1_ANSI) - Use this suboption to specify the name mangling scheme that is compatible with z/OS XL C++ V2R1M1 link modules.

- TUNE(11) - Specify this suboption to instruct the compiler to generate code that is optimized for the 2964-xxx (IBM z Systems z13 (z13)) models.

For detailed information about these suboptions, see *z/OS XL C/C++ User's Guide, SC14-7307*.

Hardware model and feature built-ins
Use the hardware model and feature built-ins in your source programs to query the model of the underlying hardware and the features unique to the identified model. For detailed information, see Hardware model and feature built-ins in *z/OS XL C/C++ Programming Guide, SC14-7315*.

Support for inline assembly statement

Inline assembly statement in source code is supported in C and C++ programs. The ASM option causes the __asm and __asm__ statements to follow the asm statement rules. The ASMLIB option specifies the assembler macro libraries to be used when assembling the inlined statements in source code. For more information, see ASM | NOASM and ASMLIB | NOASMLIB in *z/OS XL C/C++ User's Guide, SC14-7307*.

When the ASM option is specified, the __IBM_ASM_SUPPORT macro is predefined to 1. The __IBM_INLINE_ASM_SUPPORT macro has been removed.

Support for vector processing
Explore the vector programming support to make use of the Vector Facility for z/Architecture. For detailed information, see Using vector programming support in *z/OS XL C/C++ Programming Guide, SC14-7315*.

Support for MASS and ATLAS libraries
Use the Mathematical Acceleration Subsystem (MASS) and Automatically Tuned Linear Algebra Software (ATLAS) libraries for high-performance mathematical computing. For detailed information, see Using high performance libraries in *z/OS XL C/C++ Programming Guide, SC14-7315*.

Migration tools
You can use migration tools to facilitate migration activities. For detailed information, see "Tools that facilitate your migration" on page 11.

Chapter 3. Program migration checklists

This information includes checklists that you can use at various stages of migrating an application to the z/OS V2R2 XL C/C++ compiler. These phases are:

- "Before you start your migration"
- "When you are compiling code" on page 8
- "When you are binding program objects or load modules" on page 9
- "When you are running an application" on page 10

For product history information to help you determine which topics in this document apply to your migration, see "Applicability of product information" on page 12.

Before you start your migration

Before you migrate programs or applications to z/OS V2R2 XL C/C++ compiler, determine potential problems with your source code by reviewing the following checklist:

1. Determine the group of compiler releases from which you are migrating:
   - An earlier z/OS C/C++ compiler
   - An OS/390 C/C++ compiler
   - A pre-OS/390 C/C++ compiler
2. View the documentation updates and other post-release information provided by the ReadMe files at http://www.ibm.com/support/docview.wss?uid=swg27007531.
3. Review the changes introduced in z/OS V2R2 XL C/C++ compiler. See Chapter 1, "New migration issues for z/OS V2R2 XL C/C++," on page 3.
4. Review the changes that have been implemented since the last C/C++ compiler that was used with the application:
   - If you are migrating from an earlier z/OS C/C++ application, see Part 4, "Migration of earlier z/OS C/C++ applications to z/OS V2R2 XL C/C++," on page 77.
   - If you are migrating from an OS/390 C/C++ application, see Part 3, "Migration of OS/390 C/C++ applications to z/OS V2R2 XL C/C++," on page 55.
   - If you are migrating from a pre-OS/390 C/C++ compiler, see Part 2, "Migration of pre-OS/390 C/C++ applications to z/OS V2R2 XL C/C++," on page 15.
5. Review the types of source code changes that have been identified since the last C/C++ compiler that was used with the application:
   - If you are migrating from an earlier z/OS C/C++ application, see Chapter 14, "Source code compatibility issues with earlier z/OS C/C++ programs," on page 79.
   - If you are migrating from an OS/390 C/C++ application, see Chapter 9, "Source code compatibility issues with OS/390 programs," on page 57.
   - If you are migrating from a pre-OS/390 C/C++ application, see Chapter 4, "Source code compatibility issues with pre-OS/390 C/C++ programs," on page 17.

Note: If your application uses class libraries that have been modified or are no longer supported, the resulting migration issues are discussed as source code compatibility changes.

6. Use the INFO compiler option to identify the following potential problems:
   - Functions not prototyped. See "INFO compiler option" on page 62.

     Notes:
     1. Function prototypes allow the compiler to check for mismatched parameters.
     2. Return parameters might be mis-matched, especially when the code expects a pointer. (For example, `malloc` and family)
   - Assignment of a `long` or a pointer to an integer, or assignment of an integer to a pointer. See "Pointer incompatibilities" on page 19.

     Note: This type of assignment could cause truncation. A reference to the pointer might be invalid. Even assignments with an explicit cast will be flagged. See "CHECKOUT(CAST) compiler option" on page 62.
7. If your code must be compliant with a specific ISO C++ standard, see Part 5, "ISO Standard C++ compliance migration issues," on page 115.
8. If you are using the IBM object model for an XL C++ program or application that was last compiled or executed with the compat object model, see "Alignment incompatibilities between object models" on page 102.

When you are compiling code

Before you use z/OS V2R2 XL C/C++ compiler to compile pre-existing source code, review the following checklist:

1. Review the compile-time migration issues that have been identified in one of the following topics:
   - Chapter 15, "Compile-time migration issues with earlier z/OS C/C++ programs," on page 87.
   - Chapter 10, "Compile-time migration issues with OS/390 programs," on page 59.
   - Chapter 5, "Compile-time issues with pre-OS/390 C/C++ programs," on page 23.
2. If you are using a SYSLIB DD card to compile your XL C/C++ program, see "Changes that affect SYSLIB DD cards" on page 28.
3. If your XL C/C++ program behaves unexpectedly after you re-compile it, consider the following possibilities:
   - At least one of the compiler options that you used does not function as it did before, or it is no longer supported. See the appropriate information in this document:
     - If you are migrating from any application, see "Changes in compiler option functionality" on page 91
     - If you are migrating from an OS/390 C/C++ application, see "Changes in compiler options" on page 60
     - If you are migrating from a pre-OS/390 C/C++ application, see "Changes in compiler options" on page 23
   - The compiler invocation has been modified since you last used it.
   - There might be a newer option or invocation that is more suitable for your source program. See the appropriate information in this document:

  - If you are migrating from any application, see “Changes that affect compiler invocations” on page 96
  - If you are migrating from a pre-OS/390 C/C++ application, see “Changes that affect compiler invocations” on page 27
4. Are you using the NAMEMANGLING compiler option under ILP32 in a batch environment? If so, see “ILP32 compiler option and name mangling” on page 99.
5. If you are using the IPA or IPA(LINK) option to compile the program, see the appropriate information in this document:
   - If you are migrating from any application, see:
     - “Changes that affect JCL procedures” on page 98
     - “IPA(LINK) compiler option and exploitation of 64-bit virtual memory” on page 99
   - If you are migrating from a pre-OS/390 C/C++ application, see
     - “IPA Link step default changes” on page 63
     - “IPA object module binary compatibility” on page 64

When you are binding program objects or load modules

Before you try to bind or relink pre-existing program objects or load modules, review the following checklist:

1. Review the potential bind-time migration issues that have been identified since the last C/C++ compiler that was used with the application:
   - If you are migrating from any z/OS C/C++ application, see Chapter 16, “Bind-time migration issues with earlier z/OS C/C++ programs,” on page 101.
   - If you are migrating from an OS/390 C/C++ application, see Chapter 11, “Bind-time migration issues with OS/390 C/C++ programs,” on page 71.
   - If you are migrating from a pre-OS/390 C/C++ application, see Chapter 6, “Bind-time migration issues with pre-OS/390 C/C++ programs,” on page 29.
2. Consider the following questions:

   Are there any relevant library changes? For information, see Chapter 13, “Migration issues resulting from class library changes between OS/390 C/C++ applications and Standard C++ library,” on page 75.

   Do input/output or other operations have library dependencies that might be affected by product changes since the program was last run? For more information, see Chapter 8, “Input and output operations compatibility,” on page 49.

   Has there been any change in exception handling since the program was last run? For information, see “Hardware and OS exceptions” on page 46 or (for C++ programs) “cv-qualifications when the thrown and caught types are the same” on page 122.

   Are you using System Program C (SPC) facility modules? For information, see “Assembler source code changes in System Programming C (SPC) applications built with EDCXSTRX” on page 20.

   Does the program need to access IBM CICS or IBM DB2 data? For information, see Part 6, “Migration issues for C/C++ applications that use other IBM products,” on page 131.

   Does the C or C++ module include interlanguage calls (ILC)? For information, see “C/370 modules with interlanguage calls (ILC)” on page 32 or more specific topics listed in the index.

If you are migrating from a pre-OS/390 C/C++ application, are you using the TARGET(OSV2R10) compiler option? If so, see "Namespace pollution binder errors" on page 101.

When you are running an application

Before you try to run a legacy application under z/OS V2R2, review the following checklist:

1. Review the potential runtime migration issues that have been identified:
   - If the application has been run successfully under an earlier z/OS runtime environment, see Chapter 17, "Runtime migration issues with earlier z/OS C/C++ applications," on page 105.
   - If the application was last run successfully under an OS/390 runtime environment, see Chapter 12, "Runtime migration issues with OS/390 C/C++ applications," on page 73.
   - If the application has not been run in an environment more recent than an OS/390 runtime environment, see Chapter 7, "Runtime migration issues with pre-OS/390 C/C++ applications," on page 39.
2. If you need to retain the runtime behavior of the application, see "Retention of previous runtime behavior" on page 106, "Retention of OS/390 runtime behavior" on page 73, or "Retention of pre-OS/390 runtime behavior" on page 39, as appropriate.
3. If you are migrating from a runtime environment that predates the z/OS V1R5 Language Environment release, verify the following:
   - The concatenation order of your libraries, to ensure that there are no links to non-Language Environment interfaces.
   - Data set names that are referenced by all customized procedures (such as JCL and makefiles) have not been changed.

   See "Runtime library compatibility issues with pre-OS/390 applications" on page 43 and "Changes that affect customized JCL procedures" on page 41.
4. If your application does not run, it may be either a migration problem, or an error in your program that surfaces as a result of enhancements to Language Environment services. Do the following:
   - Relink application load modules or program objects if any of the following are true:

     It is an IBM C/370™ application.

     It contains ILCs between C and Fortran, or between C and COBOL. For information, see "C/370 modules with interlanguage calls (ILC)" on page 32.

     It is an SPC application that uses the library. For information, see "Assembler source code changes in System Programming C (SPC) applications built with EDCXSTRX" on page 20.

     It contains calls to `ctest()`. For information, see "Requirements for relinking C/370 modules that invoke Debug Tool" on page 32.

     The PDS with the low-level qualifier SCEERUN (which belongs to the runtime library), is not concatenated ahead of the PDS with the low-level qualifier SIBMLINK (which belongs to the C-PL/I Common Library). For information, see "Common library initialization compatibility issues with C/370 modules" on page 44.

     A message suggests either resetting an environment variable or relinking application load modules or program objects. For information, see

Chapter 16, “Bind-time migration issues with earlier z/OS C/C++ programs,” on page 101, “Runtime library messages” on page 39 or “Program modules from an earlier release” on page 101.

- Use the STORAGE and HEAP runtime options to find uninitialized storage. For information about initialization schemes and procedures, see “Common library initialization compatibility issues with C/370 modules” on page 44.

  Notes:

  a. In some cases, applications will run with uninitialized storage, because the runtime library may inadvertently clear storage, or because the storage location referenced is set to zero.
  b. IBM recommends STORAGE(FE,DE,BE) and HEAP(16,16,ANY,FREE) to determine if your application is coded correctly. Any uninitialized pointers will fail at first reference instead of accidentally referencing storage locations at random.
  c. The STORAGE or HEAP option will cause your program to run more slowly. Do not use them for production; use them for development only.
- Look for undocumented interfaces.

  It is possible that your application has dependencies on undocumented interfaces. For example, you might have dependencies on library control blocks, specific `errno` values, or specific return values. Alter your code to use only documented interfaces, and then recompile the code and relink the load modules or program objects. For information, see Chapter 8, “Input and output operations compatibility,” on page 49.
- It is possible that your application is being initialized or terminated differently because of changes in the runtime environment. See “Common library initialization compatibility issues with C/370 modules” on page 44 and “Order of destruction for statically initialized objects” on page 120.

5. If your application does not require the features provided by z/OS V2R2, use environment variables to maintain the expected behavior. For information, see “Changes that affect compiler invocations” on page 96.
6. Contact your System Programmer to determine whether or not all service has been applied to your system. Often, the problem you encounter has already been reported to IBM, and a fix is available.
7. If you have verified with your System Programmer that all service has been applied to your system, ask your Service Representative to open a Problem Management Record (PMR) against the applicable IBM product. For information on how to open a PMR, refer to http://techsupport.services.ibm.com/guides/handbook.html.

Tools that facilitate your migration

This section describes tools available for your assistance during the migration activity.

The Edge Portfolio Analyzer

The Edge Portfolio Analyzer can provide assistance in taking an inventory of your existing XL C/C++ load modules. The object must be compiled with z/OS V1R10 XL C/C++ compiler or later for reporting of compiler options.

The Edge Portfolio Analyzer is no longer sold by IBM. For more information about the Edge Portfolio Analyzer, visit their Web site at http://www.edge-information.com.

Note: Any references in this information to non-IBM Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this IBM product and use of those Web sites is at your own risk.

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Applicability of product information

In Table 4, references to the products listed in the first column also apply to the products in the second column.

Table 4. Product references

Referenced compilers	Related products
Pre-OS/390 C/C++ compilers **Note:** If you are migrating a program that has been run successfully only with a pre-OS/390 C/C++ compiler, contact your service representative.	• IBM C/C++ for MVS/ESA V3R1 or V3R2 • IBM AD/Cycle C/370 V1R1 or V1R2 • IBM C/370 V1R1 or V1R2 • IBM C/370 V2R1 compiler and the IBM C/370 V2R1 library • IBM C/370 V2R1 compiler and the IBM C/370 V2R2 library
OS/390 C/C++ compilers **Notes:** 1. IBM OS/390 V1R1 C/C++ is the same as IBM C/C++ for MVS/ESA V3R2. 2. IBM z/OS V1R1 C/C++ is the same as IBM OS/390 V2R10 C/C++. IBM OS/390 V2R10 is also reshipped in z/OS V1R2 through to V1R6. 3. If you are migrating a program that has been run successfully only with the OS/390 V1R1 C/C++ compiler, contact your service representative. 4. IBM OS/390 is no long in service.	• IBM OS/390 V1R1 C/C++ (reship of IBM C/C++ for MVS/ESA V3R2) • IBM OS/390 V1R2 or V1R3 C/C++ • IBM OS/390 V2R4, V2R5, V2R6, V2R7, V2R8, V2R9, or V2R10 C/C++ • IBM z/OS V1R1 C/C++ (reship of IBM OS/390 V2R10 C/C++)

Table 4. Product references (continued)

Referenced compilers	Related products
Earlier releases of the z/OS C/C++ compilers **Note:** Service is available for compilers z/OS XL C/C++ V1R13 through z/OS V2R2 XL C/C++.	• IBM z/OS V1R1 C/C++ (equivalent to the OS/390 V2R10 compiler) • IBM z/OS V1R2 C/C++ • IBM z/OS V1R3 C/C++ • IBM z/OS V1R4 C/C++ • IBM z/OS V1R5 C/C++ • IBM z/OS V1R6 C/C++ • IBM z/OS V1R7 XL C/C++ • IBM z/OS V1R8 XL C/C++ • IBM z/OS V1R9 XL C/C++ • IBM z/OS V1R10 XL C/C++ • IBM z/OS V1R11 XL C/C++ • IBM z/OS V1R12 XL C/C++ • IBM z/OS V1R13 XL C/C++ • IBM z/OS V2R1 XL C/C++ • IBM z/OS XL C/C++ V2R1M1 web deliverable

Version history of IBM C/C++ compilers and libraries

You can use the version history of IBM C/C++ compilers and libraries to help determine whether specific information in this document applies to your migration, as well as whether the information you seek is provided by this document.

The version history pertains to each C/370, VM/ESA, VSE/ESA, MVS/ESA, OS/390, z/OS and z/VM® compiler that has been distributed by IBM. It contains the following information:

- Compiler name and ID
- General release, end-of-marketing, and end-of-service dates
- Runtime library

Note: For the version history of IBM C/C++ compilers and libraries, see http://www-03.ibm.com/systems/z/os/zos/support/zos_eos_dates.html.

Part 2. Migration of pre-OS/390 C/C++ applications to z/OS V2R2 XL C/C++

Prior to IBM OS/390, C/C++ applications were created with one of the following products:

- IBM C/C++ for MVS/ESA V3R1 or V3R2
- IBM AD/Cycle C/370 V1R1 or V1R2
- IBM C/370 V1R1 or V1R2
- IBM C/370 V2R1 compiler and the IBM C/370 V2R1 library
- IBM C/370 V2R1 compiler and the IBM C/370 V2R2 library

Notes:

1. If your application uses IBM CICS information or statements, also see Chapter 20, "Migration issues with earlier C/C++ applications that run CICS statements," on page 133.
2. If your application uses IBM DB2 information or statements, also see Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139.

The following topics provide information relevant to migrating a pre-OS/390 application to z/OS V2R2 XL C/C++:

- Chapter 4, "Source code compatibility issues with pre-OS/390 C/C++ programs," on page 17
- Chapter 5, "Compile-time issues with pre-OS/390 C/C++ programs," on page 23
- Chapter 6, "Bind-time migration issues with pre-OS/390 C/C++ programs," on page 29
- Chapter 7, "Runtime migration issues with pre-OS/390 C/C++ applications," on page 39
- Chapter 8, "Input and output operations compatibility," on page 49

Chapter 4. Source code compatibility issues with pre-OS/390 C/C++ programs

When you migrate applications that predate IBM OS/390 C/C++ compilers to the IBM z/OS V2R2 XL C/C++ product, be aware of the following migration issues:

- "Removal of IBM Open Class Library support"
- "Source code modifications necessitated by changes in runtime library"
- "Resource allocation and memory management issues"
- "Addressing incompatibilities" on page 18
- "Data type incompatibilities" on page 19
- "Changes required by programs with interlanguage calls" on page 20
- "Internationalization incompatibilities" on page 21

Note: Some source code compatibility issues can be addressed by modifying runtime options. See Chapter 12, "Runtime migration issues with OS/390 C/C++ applications," on page 73.

Removal of IBM Open Class Library support

As of z/OS V1R9, IBM Open Class® Library (IOC) dynamic link libraries (DLLs) are no longer shipped with the z/OS XL C/C++ compiler.

Any source dependency on an IOC DLL must be removed.

For information about the libraries that are supported by the current release, see *z/OS XL C/C++ Runtime Library Reference*.

Source code modifications necessitated by changes in runtime library

When you migrate programs to z/OS V2R2 XL C/C++, review "Changes in runtime option specification" on page 41 for changes that will necessitate changes in your source code. Also review your use of the **#pragma runopts** directive in your source code.

The #pragma runopts directive

If occurrences of the ISASIZE/ISAINC, STAE/SPIE, LANGUAGE, or REPORT runtime options are specified by a **#pragma runopts** directive in your source code, you might want to change them to the supported equivalent before recompiling to avoid a warning or informational message during compilation.

For more information on preprocessor directives, refer to *z/OS XL C/C++ Language Reference*.

Resource allocation and memory management issues

Incompatibilities in resource allocation and memory management might cause unexpected results in the output of your program. In your source code, you should be aware of potential problems when you use any of the following operators or structures:

- "The sizeof operator applied to a function return type" on page 18

- “A user-defined global new operator and array new”

The sizeof operator applied to a function return type

Figure 1 illustrates how the behavior of `sizeof`, when applied to a function return type, was changed in the C/C++ for MVS/ESA V3R2 compiler.

```
char foo();
..
s = sizeof foo();
```

Figure 1. Statements that apply the sizeof operator to a function return type

If the example in Figure 1 is compiled with a compiler prior to C/C++ for MVS/ESA V3R2 compiler, `char` is widened to `int` in the return type, so `sizeof` returns `s = 4`.

If the example in Figure 1 is compiled with the C/C++ for MVS/ESA V3R2 compiler, or with any OS/390 C/C++ compiler, the size of the original `char` type is retained. In Figure 1, `sizeof` returns `s = 1`. The size of the original type of other data types such as `short`, and `float` is also retained.

If your code has a dependency on the behavior of the `sizeof` operator, be aware that with the OS/390 V2R4 C/C++ and subsequent compilers, you can use the **`#pragma wsizeof`** directive or the WSIZEOF compiler option to get `sizeof` to return the widened size for function return types.

For more information on **`#pragma wsizeof`**, see *z/OS XL C/C++ Language Reference, SC14-7308*. For more information on the WSIZEOF compiler option, see *z/OS XL C/C++ User's Guide, SC14-7307*.

A user-defined global new operator and array new

If you are migrating from the C/C++ for MVS/ESA V3R2 compiler to z/OS V2R2 XL C/C++, and you have written your own global `new` operator, it is no longer called when you create an array object: In this case, you must add a local overloaded operator.

```
void*   operator new (size_t sz) {
  g_new_count++;
  return MyMalloc(sz);
}

main() {
    X new_array[10]; // the global new operator
                     // shown above is not called
                     // in compilers for OS/390 or later
}
```

Figure 2. Example of user-defined global new operator and array new

Addressing incompatibilities

Addressing incompatibilities might cause unexpected results in the output of your program. In your source code, you should be aware of the following migration issues:

- “C/370 V2 main program and main entry point” on page 19
- “Pointer incompatibilities” on page 19

C/370 V2 main program and main entry point

C/370 V2 programs that are fetched must be recompiled without a main entry point. Any attempt to fetch a main program will fail.

Pointer incompatibilities

According to the *ISO C Standard*, pointers to `void` types and pointers to functions are incompatible types. The C/370, AD/Cycle C/370, IBM C/MVS™, and z/OS XL C compilers perform some type-checking, such as in assignments, argument passing on function calls, and function return codes.

Note: If you are not conforming to ISO rules for the use of pointer types, your runtime results may not be as expected, especially when you are using the OPTIMIZE compiler option.

With the AD/Cycle C/370, and the C/C++ for MVS/ESA compilers, you could not assign NULL to an integer value. The statement shown in Figure 3 was not allowed:

```
int i = NULL;
```

Figure 3. Assignment of NULL to an integer value

With the z/OS XL C compilers, you can assign NULL pointers to void types only if you specify LANGLVL(COMMONC) when you compile your program. For information about constructs supported by LANGLVL(COMMONC) but not by LANGLVL(EXTENDED) or LANGLVL(ANSI), refer to LANGLVL compiler option in *z/OS XL C/C++ User's Guide, SC14-7307*.

Data type incompatibilities

Data type incompatibilities might cause unexpected results in the output of your program. In your source code, you should be aware of potential migration issues:

- "Assignment restrictions for packed structures and unions"
- "DSECT header files and packed structures"

Assignment restrictions for packed structures and unions

With the z/OS XL C compiler, you can no longer do the following:

- Assign packed and non-packed structures to each other.
- Assign packed and non-packed unions to each other.
- Pass a packed union or packed structure as a function parameter if a non-packed version is expected.
- Pass a non-packed union or non-packed structure as a function parameter if a packed version is expected.

If you attempt to do so, the compiler issues an error message.

DSECT header files and packed structures

Header files generated by the DSECT utility use **`#pragma pack`** rather than the _Packed qualifier to pack structures or unions. In rare cases, you might have to modify and recompile your code.

Note: The _Packed qualifier is an IBM extension of the C language that was introduced with the C/370 family of compilers. It can also be applied to C++

classes. If you specify the _Packed qualifier on a structure or union that contains another structure or union as a member, the qualifier is not passed to the contained structure or union.

Changes required by programs with interlanguage calls

If your code calls functions that have mixed-language input or output, you should be aware of the following potential source code issues:

- "Explicit program mask manipulations"
- "Assembler source code changes in System Programming C (SPC) applications built with EDCXSTRX"

Explicit program mask manipulations

Programs created with the C/370 V2 compiler and library that explicitly manipulated the program mask might require source changes.

Changes are required if you have one of the following types of programs:

- A C program containing interlanguage calls (ILC), where the invoked code uses the S/370 decimal instructions that might generate an unmasked decimal overflow condition, requires modification for migration. Use either of the following two methods:
  - Preferred method: If the called routine is assembler, save the existing mask, set the new value, and when finished, restore the saved mask.
  - Change the C code so that the produced SIGFPE signal is ignored in the called code. In the following example, the SIGNAL calls surround the overflow-producing code. The SIGFPE exception handling is disabled before the problem signal is encountered, and then reenabled after it has been processed. See Figure 4.
- A C program containing assembler ILCs that explicitly alter the program mask, and do not explicitly save and restore it, also requires modification for migration.

  If user code explicitly alters the state of the program mask, the value before modification must be saved, and the value restored to its former value after the modification. You must ensure that the decimal overflow program mask bit is enabled during the execution of C code. Failure to preserve the mask may result in unpredictable behavior.

These changes also apply in a System Programming C environment, and to Customer Information Control System (CICS) programs in the handling and management of the PSW mask.

```
signal(SIGFPE, SIG_IGN);   /* ignore exceptions */
  ...
  callit():                 /* in called routine */
  ...
  signal(SIGFPE, SIG_DFL);   /* restore default handling */
```

Figure 4. Statements that ignore SIGFPE exception and restore default exception handling

Assembler source code changes in System Programming C (SPC) applications built with EDCXSTRX

If you have SPC applications that are built with EDCXSTRX and use dynamic C library functions, note that the name of the C library function module was changed from EDCXV in C/370 V2 to CEEEV003 with the Language Environment V1R5 release. Change the name from EDCXV to CEEEV003 in the assembler source of your program that loads the library, and reassemble.

Internationalization incompatibilities

If your code will be used with different locales, you should be aware of the information in “Support of alternate code points.”

Support of alternate code points

The following alternate code points are not supported by z/OS V2R2 XL C/C++:

- X'8B' as alternate code point for X'C0' (the left brace)
- X'9B' as alternate code point for X'D0' (the right brace)

These alternate code points are supported by the C/370 and AD/Cycle C/370 compilers (the NOLOCALE option is required if you are using the AD/Cycle C/370 V1R2 compiler).

For more information about using coded character sets and locale functions, see *z/OS XL C/C++ Programming Guide, SC14-7315*.

Chapter 5. Compile-time issues with pre-OS/390 C/C++ programs

When you use z/OS V2R2 XL C/C++ to compile programs that were last compiled as part of a pre-OS/390 C/C++ application, be aware of the following migration issues:

- "Changes in compiler listings, messages, and return codes"
- "Changes in compiler options"
- "Changes that affect compiler invocations" on page 27
- "Changes that affect SYSLIB DD cards" on page 28

Changes in compiler listings, messages, and return codes

From release to release, message contents can change and, for some messages, return codes can change. Errors can become warnings, and warnings can become errors. You must update any application that is affected by changes in message contents or return codes. Do not build dependencies on message contents, message numbers, or return codes. See *z/OS XL C/C++ Messages* for a list of compiler messages.

Listing formats, especially the pseudo-assembler parts, will continue to change from release to release. Do not build dependencies on the structure or content of listings. For information about C listings or the C++ listings for the current release, refer to *z/OS XL C/C++ User's Guide, SC14-7307*.

Macro redefinitions might result in severe errors

As of z/OS V1R7 XL C, the behavior of macro redefinition has changed. For certain language levels, the XL C compiler will issue a severe error message instead of a warning message when a macro is redefined to a value that is different from the first definition.

For information about the language levels that are affected, see "LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions" on page 25 and "LANGLVL(EXTENDED) compiler option and macro redefinitions" on page 25.

Changes in compiler options

This topic describes changes that would affect your use of compiler options.

Compiler options that are no longer supported

This topic lists compiler options that were supported in pre-OS/390 compilers but not in subsequent compilers.

DECK compiler option

As of z/OS V1R2 C/C++ compiler, the DECK compiler option is no longer supported. If you want to route output to DD:SYSPUNCH, use OBJECT(DD:SYSPUNCH).

LANGLVL(COMPAT) compiler option

In C/C++ for MVS/ESA V3R2, the LANGLVL(COMPAT) option directed the compiler to generate code that is compatible with older levels of C and C++. As of z/OS V1R2 C/C++ compiler, the LANGLVL(COMPAT) compiler option is no longer supported.

OMVS compiler option

As of z/OS V1R2 C/C++ compiler, the OMVS compiler option is no longer supported. The replacement for it is the OE option.

SRCMSG compiler option

As of z/OS V1R2 C/C++ compiler, the SRCMSG compiler option is no longer supported.

SYSLIB, USERLIB, SYSPATH and USERPATH compiler options

In IBM C/C++ for MVS/ESA V3R2 compiler, the SYSLIB, USERLIB, SYSPATH and USERPATH compiler options directed the compiler to specified include files. As of z/OS V1R2 C/C++ compiler, these compiler options are no longer supported. Instead, use the SEARCH and LSEARCH options to find include files.

Compiler options that were introduced in OS/390 C/C++ or later

When you are compiling pre-OS/390 C/C++ source code, you should treat compiler options that were introduced in OS/390 or later as new compiler options.

ENUMSIZE compiler option

As of z/OS V1R7 XL C/C++, selected enumerated (`enum`) type declarations in system header files are protected to avoid potential execution errors. This allows you to specify the ENUMSIZE compiler option with a value other than SMALL without risking incorrect mapping of `enum` data types (for example, if they were used inside of a structure). For more information, see "ENUMSIZE(SMALL) and protected enumeration types in system header files" on page 92.

z/OS V1R2 introduced the ENUMSIZE option as a means for controlling the size of enumeration types. The default setting, ENUMSIZE(SMALL), provides the same behavior that occurred in previous releases of the compiler.

If you want to continue to use the ENUMSIZE option, it is recommended that the same setting be used for the whole application; otherwise, you might find inconsistencies when the same enumeration type is declared in different compilation units. Use the **`#pragma enum`**, if necessary, to control the size of individual enumeration types (especially in common header files).

Changes in compiler option functionality

HALT compiler option

As of C/C++ for MVS/ESA V3R2 compiler, the C++ compiler does not accept 33 as a valid parameter for the HALT compiler option.

HWOPTS compiler option

In AD/Cycle C/370 V1, the HWOPTS compiler option directed the compiler to generate code to take advantage of different hardware. As of z/OS V1R2 C/C++ compiler, the HWOPTS compiler option is no longer supported. The replacement for it is the ARCHITECTURE option.

INFO compiler option

As of z/OS V1R2 C/C++, the INFO option default has been changed from NOINFO to INFO(LAN) for C++.

As of z/OS V1R6 C/C++, the INFO option is supported by the C compiler as well as the C++ compiler.

Note: The CHECKOUT C compiler option will continue to be supported for compatibility with earlier releases only.

INLINE compiler option

For C, the default for the INLINE compiler option was changed to 100 ACUs (Abstract Code Units) in the C/C++ for MVS/ESA compiler. Hence, with C/C++ for MVS/ESA V3R2, OS/390 C/C++, and z/OS XL C/C++ compilers, the default is 100 ACUs. In the past, the default was 250 ACUs.

For C++, the z/OS V1R1 and earlier compilers did not accept the INLINE option but did perform inlining at OPT with a fixed value of 100 for the threshold and 2000 for the limit. As of z/OS V1R2, the C++ compiler accepts the INLINE option, with defaults of 100 and 1000 for the threshold and limit, respectively. As a result of this change, code that used to be inlined may no longer be inlined due to the decrease in the limit from 2000 to 1000 ACUs.

LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions

As of z/OS V1R7 XL C, the treatment of macro redefinitions has changed. For LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2), the XL C compiler will issue a severe message instead of a warning message when a macro is redefined to a value that is different from the first definition.

```
#define COUNT 1
#define COUNT 2   /* error */
```

Figure 5. Macro redefinition

Note: Compare the treatment of macro redefinitions for these LANGLVL sub-options with that for "LANGLVL(EXTENDED) compiler option and macro redefinitions."

LANGLVL(EXTENDED) compiler option and macro redefinitions

As of z/OS V1R7 XL C, you can redefine a macro that has not been first undefined with LANGLVL(EXTENDED).

```
#define COUNT 1
#define COUNT 2

int main () {
   return COUNT;
}
```

Figure 6. Macro redefinition under LANGLVL(EXTENDED)

With z/OS V1R6 C and previous C compilers, this test will return "1". As of z/OS V1R7 XL C, this test will return "2".

Note: Compare the treatment of macro redefinitions for LANGLVL(EXTENDED) with that for "LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions."

LOCALE compiler option

As of z/OS V1R9 XL C/C++, the __LOCALE__ macro is defined to the name of the compile-time locale. If you specified LOCALE(strinf *string literal*), the compiler uses the runtime function setlocale(LC_ALL "*string literal*") to determine the name of the compile-time locale. If you do not use the LOCALE compiler option, the macro is undefined.

Prior to z/OS V1R9 XL C/C++, the __LOCALE__ macro was defined to "" when the LOCALE option was specified without a suboption.

OPTIMIZE optimization level mapping

As compilers are developed, the OPTIMIZE optimization levels are remapped.

In the IBM C/370 compilers, OPTIMIZE was mapped to OPT(1).

In the IBM AD/Cycle C/370 compilers:
- OPT(0) was mapped to NOOPT
- OPT and OPT(1) were mapped to OPT(1)
- OPT(2) was mapped to OPT(2)

In the C/C++ for MVS/ESA V3R2 compiler and the OS/390 V1R1 compiler:
- OPT(0) was mapped to NOOPT
- OPT, OPT(1) and OPT(2) were mapped to OPT

In the OS/390(r) V1R2, V1R3, V2R4, and V2R5 C/C++ compilers:
- OPT(0) mapped to NOOPT
- OPT and OPT(1) mapped to OPT(1)
- OPT(2) mapped to OPT(2)

As of OS/390(r) V2R6 C/C++:
- OPT(0) maps to NOOPT
- OPT, OPT(1) and OPT(2) map to OPT(2)

As of z/OS V1R5 C/C++, OPT(3) provides the compiler's highest and most aggressive level of optimization. OPT(3) is recommended only when the desire for runtime improvement outweighs the concern for minimizing compilation resources.

SEARCH and LSEARCH compiler options

Prior to C/C++ for MVS/ESA V3R2 compilers, if you used the LSEARCH option more than once, the compiler would only search the locations specified for the last LSEARCH option.

As of C/C++ for MVS/ESA V3R2 compilers (including z/OS XL C/C++ compiler), the compiler searches all of the locations specified for all of the SEARCH options, from the point of the last NOSEARCH option. Previously, only the locations specified for the last SEARCH option were searched.

SQL compiler option and SQL EXEC statements

For migration information about using the SQL compiler option, see Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139

TEST compiler option

As of the OS/390 C/C++ compilers, the default for the PATH suboption of the TEST option has changed from NOPATH to PATH. Also, the INLINE option is ignored when the TEST option is in effect at OPT(0), but the INLINE option is no longer ignored if OPT(1), OPT(2), or OPT(3) is in effect.

As of C/C++ MVS V3R2 compiler, the following restriction applies to the TEST compiler option: The maximum number of lines in a single source file cannot exceed 131,072. If you exceed this limit, the results from the Debug Tool and Language Environment dump services are undefined.

As of z/OS V1R6 C/C++, when using the c89/c++ utility, the **`-g`** flag has changed from specifying the TEST option to DEBUG(FORMAT(DWARF)). For more information, see “Debug format specification” on page 97.

Note: Under ILP32 only, you can use the environment variable {_DEBUG_FORMAT} to determine the debug format (DWARF or ISD) to which the **`-g`** flag option is translated. For information about this environment variable and the c89/c++ utility, refer to the c89 utility information in *z/OS XL C/C++ User's Guide, SC14-7307*.

Changes that affect compiler invocations

When you invoke the compiler, you should be aware of potential problems in the following areas:

- “IPA compiler option and very large applications”
- “Customized JCL and the CXX format”
- “CBCI and CBCXI procedures in JCL” on page 28

IPA compiler option and very large applications

As of z/OS V1R12 XL C/C++, when using the IPA compiler option to compile very large applications, you might need to increase the size of the work file associated with SYSUTIP DD in the IPA Link step. If you are linking the application in a USS environment, you can control the size of this work file with the _CCN_IPA_WORK_SPACE environment variable. If particularly large source files are compiled with IPA, the default size of the compile-time work files might also need to be increased. These can be modified via the *prefix*_WORK_SPACE environment variables.

Customized JCL and the CXX format

The CBCC, CBCCL, and CBCCLG procedures, which compile C++ code, include parameter CXX when the following compilers are used:

- C/C++ for MVS/ESA V3R2
- OS/390 C/C++
- z/OS C/C++

If you have written your own JCL to compile a C++ program, you must include this parameter; otherwise, the C compiler is invoked.

When you pass options to the compiler, you must specify parameter CXX. You must use the following format to specify options:

```
runtime options/CXX compiler options
```

CBCI and CBCXI procedures in JCL

As of z/OS V1R5 C/C++ compiler, the CBCI and CBCXI procedures contain the variable CLBPRFX. If you have any JCL that uses these procedures, you must either customize these procedures (for example, at installation time) or modify your JCL to provide a value for CLBPRFX.

Changes that affect SYSLIB DD cards

If your batch job uses a SYSLIB concatenation to search for files, remove those job steps and use the SEARCH compiler option instead.

Change in SCLBH logical record length

As of z/OS V1R2 C/C++ compiler, the logical record length for the SCLBH data sets is increased from 80 bytes to 120 bytes. Because of this change, the SYSLIB DD card (shown in Figure 7) that specifies library search paths no longer works, and must be removed from your JCL. In its place, you must use the SEARCH compiler option.

Example: See the following example.

```
SEARCH(//'CEE.SCEEH.+',//'CBC.SCLBH.+')
```

Using the SEARCH compiler option instead of a SYSLIB concatenation allows the C/C++ compiler to search for files based on both file name and file type.

```
//SYSLIB DD DSN=CEE.SCEEH.H,DISP=SHR
//       DD DSN=CEE.SCEEH.SYS.H,DISP=SHR
//       DD DSN=CBC.SCLBH.H,DISP=SHR
```

Figure 7. Example of SYSLIB DD cards that must be removed as of z/OS V1R2 C/C++ compiler

Chapter 6. Bind-time migration issues with pre-OS/390 C/C++ programs

This information helps you understand compatibility issues related to binding or linking executable C/C++ programs from applications that predate IBM OS/390 C/C++ compiler.

The output of a prelinking, linking, or binding process depends on where the programs are stored:
- When the programs are stored in a PDS, the output is a *load module*.
- When the programs are stored in a PDSE or in UNIX System Services files, the output is a *program object*.

For more information, see "Prelinking and linking z/OS XL C/C++ programs" and "Binding z/OS XL C/C++ programs" in *z/OS XL C/C++ User's Guide*.

Note: The terms in these topics that are associated with linking (bind, binding, link, link-edit) refer to the process of creating an executable program from object modules.

Generally, pre-OS/390 C/C++ load modules or programs execute successfully under z/OS V2R2 without relinking. This information highlights exceptions and shows how to solve specific problems in compatibility.

Note: If you are not sure which libraries were used to link an executable program, see "Library release level in use."

Executable program compatibility problems requiring source changes are discussed in Chapter 4, "Source code compatibility issues with pre-OS/390 C/C++ programs," on page 17.

When you use z/OS V2R2 XL C/C++ to bind programs that were last linked as part of pre-OS/390 C/C++ applications, be aware the following information:
- "Binder invocation changes" on page 31
- "Changes due to customizations of the runtime environment" on page 31
- "Incompatibilities in external references" on page 32
- "Requirements for relinking C/370 modules that invoke Debug Tool" on page 32
- "C/370 modules with interlanguage calls (ILC)" on page 32

Also see "Common library initialization compatibility issues with C/370 modules" on page 44.

Library release level in use

The `__librel()` function is a System/370 extension to SAA C. It returns the release level of the library that your program is using, in a 32-bit integer. With Language Environment services, a field containing a number that represents the library product.

The `__librel()` return value is a 32-bit integer intended to be viewed in hexadecimal format as shown in Table 5. The hexadecimal value is interpreted as 0x*PVRRMMMM*, where:

- The first hex digit *P* represents the product.
- The second hex digit *V* represents the version.
- The third and fourth hex digits *RR* represent the release.
- The fifth through eighth hex digits *MMMM* represent the modification level.

Table 5. Return values for the __librel() function

Product	**librel value**
C/370 V2R2	`0x02020000`
Language Environment V1R5	`0x11050000`
OS/390 V1R1 **Note:** The `_librel` return value for OS/390 V1R1, 5645-001 is the same as it is for Language Environment V1R5 runtime libraries.	`0x11050000`
OS/390 V1R2	`0x21020000`
OS/390 V1R3	`0x21030000`
OS/390 V2R4	`0x22040000`
OS/390 V2R6	`0x22060000`
OS/390 V2R7	`0x22070000`
OS/390 V2R8	`0x22080000`
OS/390 V2R9	`0x22090000`
OS/390 V2R10	`0x220A0000`
z/OS V1R1	`0x220A0000`
z/OS V1R2	`0x41020000`
z/OS V1R3	`0x41030000`
z/OS V1R4	`0x41040000`
z/OS V1R5	`0x41050000`
z/OS V1R6	`0x41060000`
z/OS V1R7	`0x41070000`
z/OS V1R8	`0x41080000`
z/OS V1R9	`0x41090000`
z/OS V1R10	`0x410A0000`
z/OS V1R11	`0x410B0000`
z/OS V1R12	`0x410C0000`
z/OS V1R13	`0x410D0000`
z/OS V2R1	`0x42010000`

In C/370 V2, the high-order 8 bits were used to return the version number. Now these 8 bits are divided into two fields. The first 4 bits contain the product number and the second 4 bits contain the version number.

You must modify programs that use the information returned from `__librel()`. For more information on `__librel()`, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

Binder invocation changes

If your application behaves unexpectedly after you relink the pre-OS/390 C/C++ modules and it includes user-developed exit routines, be aware that rules of precedence have changed.

When you bind programs that were previously compiled with an OS/390 compiler and library, you should also be aware that the following migration issues could also apply to your binder invocations:
- “Namespace pollution binder errors” on page 101
- “Program modules from an earlier release” on page 101

Impact of changes to CC EXEC invocation syntax

As of z/OS V1R2 C/C++ compiler, there are changes in the CC EXEC invocation syntax.

At customization time, your system programmer can modify the CC EXEC to accept:
- Only the original syntax (the one supported by compilers before C/C++ for MVS/ESA V3R2).
- Only the updated syntax.
- Both syntaxes.

The CC EXEC should be customized to accept only the updated syntax.

If the CC EXEC is customized to accept both the original and additional invocations, you must choose to use either the original invocations or the updated invocations. You cannot invoke the CC command by using a mixture of both syntaxes. Be aware that the original syntax does not support UNIX System Services files provided with z/OS UNIX System Services files.

Refer to the *z/OS Program Directory* for more information about installation and customization, and to the *z/OS XL C/C++ User's Guide* for more information about compiler options.

Changes due to customizations of the runtime environment

Your installation of z/OS V2R2 XL C/C++ might have been customized in ways that could affect application behavior at bind-time.

User-developed exit routines

If your application behaves unexpectedly after you relink the pre-OS/390 C/C++ modules and if it includes user-developed exit routines, be aware that rules of precedence have changed. If both CEEBXITA and IBMBXITA are present in a relinked C/370 module, CEEBXITA will have precedence over IBMBXITA.

Abnormal termination exit routines and dump formats

With Language Environment services in a batch environment, abnormal termination exit routine CEEBDATX is automatically linked at installation time.

This change affects you if you have supplied, or need to supply, your own exit routine. The sample exit routine had been available in the sample library provided with IBM AD/Cycle LE/370 V1R3. It automatically generates a system dump (with abend code 4039) whenever an abnormal termination occurs.

You can trigger the dump by ensuring that SYSUDUMP is defined in the GO step of the JCL that you are using (for example, by including the statement SYSUDUMP DD SYSOUT=*).

Note: As of C/C++ for MVS/ESA V3R2, the standard JCL procedures shipped with the compiler do not include SYSUDUMP.

If SYSUDUMP is not included in your JCL, or is defined as DUMMY, the dump will be suppressed.

Incompatibilities in external references

As of z/OS V1R3 C/C++ compiler, external names (such as entry points and external references) can be up to 32,767 bytes long.

As of z/OS V1R2 C/C++ compiler, the binder imposes a limit of 1024 characters for the length of external names. Both the OS/390 C++ compiler and z/OS C++ compiler might generate mangled names that are longer than this limit. This problem is more likely to occur when using the Standard Template Library with the z/OS V1R2 C++ compiler.

If linking programs generates mangled names that exceed the limit, do one of the following actions:
- Reduce the length of the C++ class names.
- Use the **`#pragma map`** directive to map the long name to a short one.
- For NOXPLINK applications, use the prelinker.

Requirements for relinking C/370 modules that invoke Debug Tool

If your C/370 application has any C/C++ modules that reference the C/370 library code @@CTEST, you cannot execute them under z/OS V2R2 until you:
1. Replace the `@@CTEST` objects, as described in "Programs that require the C370 Common Library environment" on page 36 and in "Linkage editor control statements for modules that contain calls to COBOL routines" on page 34.
2. Relink all modules that contain calls to `ctest()`.

C/370 modules with interlanguage calls (ILC)

Table 6 outlines when a relink of ILC applications is required, based on languages found in the executable program: If you have multiple languages in the executable program, then the sum of the restrictions applies. For example: if you have C, PL/I and Fortran in the executable program, then it should be relinked because Fortran needs to be relinked. Refer to *z/OS V2R1.0 Language Environment Writing Interlanguage Communication Applications* for more information.

Table 6. Migrations that require relinking

Language	Relink required
Assembler	No

Table 6. Migrations that require relinking (continued)

Language	Relink required
PL/I	No
Fortran	Yes
COBOL	Yes **Note:** If the C/370 ILC application is built (relinked) after the PTF for APAR PN74931 is applied, no relink is required to run under z/OS V2R2. Otherwise a relink is required.

Interlanguage calls between assembler and PL/I language modules

Programs that contain interlanguage calls to and from assembler or PL/I language modules do not need to be relinked.

Function calls between C and Fortran modules

For applications that use Language Environment services, Fortran/C interlanguage calls were not supported prior to the Language Environment V1R5 release and C/C++ for MVS/ESA. Before you can use Fortran/C ILC applications with Language Environment V1R5 or later, you must relink all Fortran/C ILC applications that contain pre-Language Environment C or Fortran library routines.

Before you relink those applications, be aware of the following constraints:

- You can run them with z/OS V2R2 XL C/C++ compiler only after they are relinked.
- You cannot continue to run them with the C/370 library after they are relinked.

Function calls to and from COBOL modules

The Fortran ILC rules apply to programs that contain interlanguage calls between C/370 and COBOL, unless you relink them with the C/370 V2R1 or V2R2 library that has the PTF for APAR PN74931 applied. This PTF replaces the C/370 V2R1 and V2R2 link-edit stubs so that they tolerate Language Environment service calls. After your application is relinked using the modified C/370 V2R1 or V2R2 stubs, you can run the application with any of the following runtime environments:

- C/370 V2R1 runtime library
- C/370 V2R2 runtime library
- Language Environment runtime libraries

If you run applications with interlanguage calls (ILC) to or from COBOL without applying the PTF for APAR PN74931 and then relinking the C/370 programs that contain the ILC, be aware of the following constraints:

- You can run those applications with z/OS V2R2 only after they are relinked.
- You cannot continue to run those applications with the C/370 library after they are relinked.

Compatibility with earlier and later releases

The PTF for APAR PN74931 replaces the link-edit stubs so that they tolerate Language Environment service calls. After your application is relinked using the modified C/370 V2, you can run the application with the C/370 V2R1 runtime library, the C/370 V2R2 runtime library, or the Language Environment runtime libraries.

Before you can relink your C/370-COBOL ILC application with Language Environment services only, you must replace the old library objects @@C2CBL and @@CBL2C, as described in "Programs that require the C370 Common Library environment" on page 36 and "Linkage editor control statements for modules that contain calls to COBOL routines." After you replace those objects, the affected modules will be executable only with Language Environment services.

Impact of changes in packaging of language libraries

As of z/OS V1R6, Language Environment runtime libraries contain more modules than the pre-Language Environment libraries. For example, all of the Language Environment C/C++ language libraries are packaged in both SCEERUN and SCEERUN2, instead of SCEERUN only.

The impact of these packaging changes for pre-OS/390 C/C++ applications is that certain Language Environment modules can invade user-defined name spaces. If a program uses modules that are the same as those used for Language Environment module names (such as `fetch()`), you must ensure that the program link libraries are loaded before the Language Environment libraries.

Linkage editor control statements for modules that contain calls to COBOL routines

This topic lists the linkage editor control statements required to relink modules that contain ILCs between C and COBOL, or between C and Fortran. The object modules are compatible with the Language Environment service modules; however, the ILC linkage between the applications and the library has changed. You must relink these applications using the JCL shown in Figure 8 on page 36 and the control statements that fit your requirements from the following list. The INCLUDE SYSLIB(@@CTDLI) is necessary only if your program will invoke IBM IMS facilities using the z/OS XL C library function `ctdli()` and if the z/OS XL C function was called from a COBOL main program.

Control statements for various combinations of ILCs and compiler options are as follows. The modules referenced by SYSLMOD contain the routines to be relinked.

1. C `main()` statically calling COBOL routine B1 or dynamically calling the COBOL routine through the use of `fetch()`, where B1 was compiled with the RES option. Relink the C module:

   ```
   MODE    AMODE(31),RMODE(ANY)
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(@@C2CBL)      REQUIRED FOR C CALLING COBOL
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   INCLUDE SYSLMOD(SAMP1)
   ENTRY   CEESTART             MAIN ENTRY POINT
   NAME    SAMP1(R)
   ```

2. C `main()` statically calling COBOL routine B2 or dynamically calling the COBOL routine through the use of fetch(), where B2 was compiled with the NORES option. Relink the C module:

   ```
   MODE    AMODE(24),RMODE(24)
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(@@C2CBL)      REQUIRED FOR C CALLING COBOL
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   ```

```
INCLUDE SYSLIB(IGZENRI)      REQUIRED FOR COBOL with NORES
INCLUDE SYSLMOD(SAMP2)
ENTRY   CEESTART             MAIN ENTRY POINT
NAME    SAMP2(R)
```

3. C `main()` fetches a C1 function that statically calls a COBOL routine B1 compiled with the RES option. Relink the C module:

   ```
   MODE    AMODE(31),RMODE(ANY)
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(@@C2CBL)      REQUIRED FOR C CALLING COBOL
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   INCLUDE SYSLMOD(SAMP3)
   ENTRY   C1                   ENTRY POINT TO FETCHED ROUTINE
   NAME    SAMP3(R)
   ```

4. C `main()` fetches a C1 function that statically calls a COBOL routine B1 that is compiled with the NORES option. Relink the C module:

   ```
   MODE    AMODE(24),RMODE(24)
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(@@C2CBL)      REQUIRED FOR C CALLING COBOL
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   INCLUDE SYSLIB(IGZENRI)      REQUIRED FOR COBOL with NORES
   INCLUDE SYSLMOD(SAMP4)
   ENTRY   C1                   ENTRY POINT TO FETCHED ROUTINE
   NAME    SAMP4(R)
   ```

5. A COBOL main CBLMAIN compiled with the RES option statically or dynamically calls a C1 function. Relink the COBOL module:

   ```
   MODE    AMODE(31),RMODE(ANY)
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(IGZEBST)
   INCLUDE SYSLIB(@@CBL2C)      REQUIRED FOR COBOL CALLING C
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   INCLUDE SYSLMOD(SAMP5)
   ENTRY   CBLRTN               COBOL ENTRY POINT
   NAME    SAMP5(R)
   ```

6. A COBOL main CBLMAIN compiled with the NORES option statically or dynamically calls a C1 function. Relink the COBOL module:

   ```
   MODE    AMODE(24),RMODE(24)
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(IGZENRI)
   INCLUDE SYSLIB(@@CBL2C)      REQUIRED FOR COBOL CALLING C
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   INCLUDE SYSLMOD(SAMP6)
   ENTRY   CBLRTN               COBOL ENTRY POINT
   NAME    SAMP6(R)
   ```

7. C `main()` calls a Fortran routine. Relink the C module:

   ```
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(@@CTOF)       REQUIRED FOR C CALLING Fortran
   INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
   INCLUDE SYSLMOD(SAMP7)
   ENTRY   CEESTART             MAIN ENTRY POINT
   NAME    SAMP7(R)
   ```

8. A Fortran `main()` calls a C function. Relink the C module:

   ```
   INCLUDE SYSLIB(EDCSTART)     ALWAYS NEEDED
   INCLUDE SYSLIB(CEEROOTB)     ALWAYS NEEDED
   INCLUDE SYSLIB(@@FTOC)       REQUIRED FOR Fortran CALLING C
   ```

```
INCLUDE SYSLIB(@@CTDLI)      REQUIRED FOR ILC & IMS
INCLUDE SYSLMOD(SAMP8)
ENTRY   CEESTART             MAIN ENTRY POINT
NAME    SAMP8(R)
```

For other related Fortran considerations, refer to *z/OS Language Environment Programming Guide*.

Programs that require the C370 Common Library environment

Some legacy modules will require the C/370 Common Library environment unless they have been converted to use Language Environment services. These incompatible modules might, for example, contain ILCs to COBOL or use the library function `ctest()` to invoke the Debug Tool.

There are several methods of converting C/370 modules to use Language Environment services.

These methods are:

- Link from the original objects, using Language Environment services. The EDCSTART and CEEROOTB modules must be explicitly included.
- Relink the C/370 program, using the Language Environment CSECT replacement. The EDCSTART and CEEROOTB modules must be explicitly included.

  Figure 8 shows an example of a job that uses this method. The job converts the C/370 program by relinking it and explicitly including the Language Environment CEESTART module, so that it replaces the C/370 CEESTART module.

  This is a general-purpose job. The comments show the other include statements that are necessary if certain calls are present in the code. Refer to "Linkage editor control statements for modules that contain calls to COBOL routines" on page 34 for the specific control statements that are necessary for different kinds of ILCs with COBOL.

```
//Jobcard information
//*
//*************************************************************************//
//*RELINK C/370 V2 USER MODULE FOR Language Environment             *//
//*************************************************************************//
//*
//*
//LINK     EXEC PGM=HEWL,PARM='RMODE=ANY,AMODE=31,MAP,LIST'
//SYSPRINT DD SYSOUT=*
//SYSLIB   DD DSN=CEE.SCEELKED,DISP=SHR
//SYSLMOD  DD DSN=TSUSER1.A.LOAD,DISP=SHR
//SYSUT1   DD UNIT=VIO,SPACE=(CYL,(10,10))
//SYSLIN   DD *
  INCLUDE SYSLIB(EDCSTART)   ALWAYS NEEDED
  INCLUDE SYSLIB(CEEROOTB)   ALWAYS NEEDED
  INCLUDE SYSLIB(@@CTEST)    NEEDED ONLY IF CTEST CALLS ARE PRESENT
  INCLUDE SYSLIB(@@C2CBL)    NEEDED ONLY IF CALLS ARE MADE TO COBOL
  INCLUDE SYSLIB(@@CBL2C)    NEEDED ONLY IF CALLS ARE MADE FROM COBOL
  INCLUDE SYSLMOD(HELLO)
  ENTRY   CEESTART
  NAME    HELLO(R)
/*
```

Figure 8. Link job for converting programs

- For modules that have a C `main()` procedure:
  1. Replace the C/370 program by recompiling the source (if available).

2. Recompile the source containing the `main()` procedure with the z/OS V2R2 XL C/C++ compiler.
3. Relink the objects with Language Environment services.

   Note: This ensures that CEESTART uses the Language Environment initialization scheme. This is an alternative to including EDCSTART explicitly when linking from objects.

Chapter 7. Runtime migration issues with pre-OS/390 C/C++ applications

When you use IBM z/OS V2R2 XL C/C++ to run applications that were most recently executed prior to IBM OS/390 C/C++ compilers, be aware of the following migration issues:

- "Retention of pre-OS/390 runtime behavior"
- "Runtime library messages"
- "Changes that affect customized JCL procedures" on page 41
- "Changes in runtime option specification" on page 41
- "Runtime library compatibility issues with pre-OS/390 applications" on page 43
- "Hardware and OS exceptions" on page 46
- "Resource allocation and memory management migration issues" on page 47

Retention of pre-OS/390 runtime behavior

When your program is using Language Environment services, you can use the ENVAR runtime option to specify the values of environment variables at execution time. You can use some environment variables to specify the original runtime behavior for particular items. The following setting specifies the original runtime behavior for the greatest number of items:

```
ENVAR("_EDC_COMPAT=32767")
```

Alternatively, you can add a call to the `setenv()` function, either in the CEEBINT High-Level Language exit routine or in your `main()` program. If you use CEEBINT only, you will need to relink your application. If you add a call to `setenv()` in the `main()` function, you must recompile the program and then relink your application. For more information, refer to `setenv()` in *z/OS XL C/C++ Runtime Library Reference, SC14-7314* and to Using environment variables in *z/OS XL C/C++ Programming Guide*.

Runtime library messages

There are differences between pre-OS/390 and Language Environment runtime messages. Some messages have been added and some have been deleted; the contents of others have been changed. Any application that is affected by the format or contents of these messages must be updated accordingly.

Note: Well-formed code should not depend on message contents or message numbers.

Refer to *z/OS Language Environment Debugging Guide* for details on runtime messages and return codes.

Return codes and messages

Since C/370 V2, library return codes and messages have been changed. Either JCL, CLISTs and EXECs that are affected by them must be changed accordingly or the CEEBXITA exit routine must be customized to emulate the old return codes. C/370

V2 return codes ranged from 0 to 999 but the Language Environment return codes have a different range. Refer to *z/OS XL C/C++ Messages, GC14-7305* for more information.

Examples: See the following examples.

- Return codes greater than 4095 are returned as modulo 4095 return codes.
- The return code for an `abort` is now 2000; it was 1000.
- The return code for an unhandled `SIGFPE`, `SIGILL`, or `SIGSEGV` condition is now 3000; it was 2000.

For detailed information, refer to *z/OS Language Environment Debugging Guide*.

Error conditions that cause runtime messages

In C/370 V2, if an error was detected with the parameters being passed to the main program, the program terminated with a return code of 8 and a message indicating the reason why the program was not run. For example, if there was an error in the redirection parameters, the message would indicate that the program had terminated because of a redirection error.

Under z/OS V2R2 XL C/C++ compiler, the same message will be displayed, but the program will also terminate with a 4093 abend, reason code 52 (x'34'). For more information about reason codes see *z/OS Language Environment Debugging Guide*.

Prefixes of perror() and strerror() messages

All Language Environment `perror()` and `strerror()` messages in C contain a prefix. (In C/370 V2, there were no prefixes to these messages.) The prefix is EDC*xxxxa*, where *xxxx* is a number (always *5xxx*) and the *a* is either `I`, `E`, or `S`. See *z/OS Language Environment Runtime Messages* for a list of these messages.

Language specification for messages

Instead of specifying a messages data set for the SYSMSGS ddname, you must now use the NATLANG runtime option. If you specify a data set for the SYSMSGS ddname, it will be ignored.

Note: For information about the NATLANG runtime option, see *z/OS Language Environment Customization* and the *z/OS Language Environment Programming Reference*.

User-developed exit routines

With Language Environment services in a batch environment, abnormal termination exit routine CEEBDATX is automatically linked at installation time.

This change affects you if you have supplied, or need to supply, your own exit routine. The sample exit routine had been available in the sample library provided with IBM AD/Cycle LE/370 V1R3. It automatically generates a system dump (with abend code 4039) whenever an abnormal termination occurs.

You can trigger the dump by ensuring that SYSUDUMP is defined in the GO step of the JCL that you are using (for example, by including the statement SYSUDUMP DD SYSOUT=*).

Note: As of C/C++ for MVS/ESA V3R2, the standard JCL procedures shipped with the compiler do not include SYSUDUMP.

If SYSUDUMP is not included in your JCL, or is defined as DUMMY, the dump will be suppressed.

Changes that affect customized JCL procedures

This topic describes changes that may affect your JCL procedures, CLISTs and EXECs.

Changes in data set names

The names of IBM-supplied data sets may change from one release to another. see *z/OS Program Directory* for more information on data set names.

Arguments that contain a slash

You must prefix the arguments with a slash if you use Language Environment services and:

- There are no runtime options.
- The input arguments passed to `main()` contain a slash.

JCL, CLISTs, and EXECs that are affected must be changed accordingly.

Differences in standard streams

There is no automatic association of Language Environment ddnames SYSTERM, SYSERR, SYSPRINT with the `stderr` function. In batch processes, you must use command line redirection of the type `1>&2` if you want `stderr` and `stdout` to share a device.

In C/370 V2, you could override the destination of error messages by redirecting `stderr`. The destination of all Language Environment messages is determined by the MSGFILE runtime option. See the topic on the MSGFILE runtime option in the *z/OS Language Environment Programming Guide* for more information.

Dump generation

You can generate a dump by ensuring that SYSUDUMP is defined in the GO step of the JCL that you are using (for example, by including the statement SYSUDUMP DD SYSOUT=*). If SYSUDUMP is not included in your JCL, or is defined as DUMMY, the dump will be suppressed. As of C/C++ for MVS/ESA V3 compiler, the standard JCL procedures shipped with the compiler do not include SYSUDUMP.

Changes in runtime option specification

This topic describes changes that might affect your specification of runtime options. For information about using pragmas in your source code to specify runtime options, see “The #pragma runopts directive” on page 17.

Runtime options lists

When passing only runtime options to a C/370 V2 program, you did not have to end the arguments with a slash (/). When passing runtime options to a Language Environment program, you must end the arguments with a slash.

Obsolete runtime options

The C/370 runtime options are mapped to Language Environment equivalents. However, if you do not use the Language Environment options, during execution you will get a warning message which cannot be suppressed. JCL, CLISTs and EXECs that are affected by these differences must be changed accordingly.

Use the Language Environment equivalent for the C/370 V2 runtime options on the command line and in **`#pragma runopts`**.

ISASIZE/ISAINC	becomes	STACK
LANGUAGE	becomes	NATLANG
REPORT	becomes	RPTSTG
SPIE/STAE	becomes	TRAP
NONIPTSTACK|NONONIPTSTACK	becomes	XPLINK

Return codes for abnormal enclave terminations

As of OS/390 V2R9, the default option for ABTERMENC is ABEND instead of RETCODE. If your program depends on the default behavior of ABTERMENC to be RETCODE, you must change the setting in CEEDOPT (CEECOPT for CICS). For details about changing CEEDOPT and CEECOPT, refer to *z/OS Language Environment Customization, SA38-0685*.

Abnormal terminations and the TRAP runtime option

STAE and SPIE runtime options have been replaced with the TRAP runtime option. IBM recommends that you use the TRAP(ON,SPIE) option, not STAE and SPIE. However, for ease of migration, the STAE and SPIE options are supported *as long as the TRAP option is not explicitly specified*.

TRAP(ON) must be in effect for the ABTERMENC runtime option to have effect. For more information, refer to ABTERMENC and TRAP in *z/OS Language Environment Programming Reference*.

Default heap allocations

The default size and increment for Language Environment HEAP runtime option differ from those of the C/370 V2 HEAP runtime option. The C/370 V2 defaults were 4K size and 4K increment.

The Language Environment defaults are:

- For CICS applications: HEAP(32K,32K,ANYWHERE,KEEP,8K,4K)
- For non-CICS applications: HEAP(4K,4080,ANYWHERE,KEEP,4K,4080)

The amount of heap storage allocated and incremented below the 16M line is determined by the following Language Environment parameters:

- `initsz24`.
- `incrsz24`.

For information about these parameters, see *z/OS Language Environment Programming Reference*.

HEAP parameter specification

In IBM C/370 V2, only the first two of the four parameters for the HEAP option were positional. The keyword parameters could be specified if the first two were omitted. All Language Environment parameters are positional. To specify the KEEP parameter only, you must enter HEAP(,,,KEEP).

Default stack allocations

The Language Environment STACK option defaults for size and increment differ from the defaults in C/370 V2, which were 0K size and 0K increment.

Language Environment STACK option defaults are:

- For non-CICS, non-XPLINK applications: STACK(128K,128K,ANYWHERE,KEEP,512K,128K)
- For non-CICS, XPLINK applications: STACK(512K,128K,ANYWHERE,KEEP,512K,128K)
- For CICS, non-XPLINK applications: STACK(4K,4080,ANYWHERE,KEEP,4K,4080)
- For CICS, XPLINK applications: STACK(4K,4080,ANYWHERE,KEEP,4K,4080)

STACK parameter specification

All Language Environment STACK parameters are positional. In other words, the keyword parameter could be specified if the first two were omitted. To specify only ANYWHERE you must enter: STACK(,,ANYWHERE).

Note: In C/370 V2 , only the first two parameters were positional.

XPLINK downward-growing stack and the THREADSTACK runtime option

In OS/390 V2R10, the THREADSTACK runtime option replaced the NONIPTSTACK and NONONIPTSTACK options. The OS/390 V2R10 options are still accepted, but an information message will be issued, telling you to switch to the THREADSTACK option.

Be aware that the OS/390 V2R10 options do not support specification of the initial and increment sizes of the XPLINK downward-growing stack. For more information about the THREADSTACK runtime option, refer to *z/OS Language Environment Customization, SA38-0685*.

Runtime library compatibility issues with pre-OS/390 applications

Changes in runtime libraries might cause problems when you run pre-OS/390 C/C++ applications. Be aware of the following issues:

- “Changes to the putenv() function and POSIX compliance”
- “UCMAPS and UCS-2 and UTF-8 converters” on page 44
- “Common library initialization compatibility issues with C/370 modules” on page 44
- “Internationalization issues in POSIX and non-POSIX applications” on page 45

Changes to the putenv() function and POSIX compliance

As of z/OS V1R5 C/C++, the function `putenv()` places the string passed to `putenv()` directly into the array of environment variables. This behavior assures compliance with the POSIX standard.

Prior to z/OS V1R5 C/C++, the string used to define the environment variable passed into `putenv()` was not added to the array of environment variables. Instead, the system copied the string into system-allocated storage.

To allow the POSIX-compliant behavior of `putenv()`, do nothing; it's now the default condition.

To restore the previous behavior of `putenv()`, follow these steps:

1. Ensure that the environment variable, _EDC_PUTENV_COPY, is available on your pre-z/OS V1R5 system.
2. Set the environment variable _EDC_PUTENV_COPY to "YES".

For additional information, see:

- *z/OS XL C/C++ Runtime Library Reference*
- _EDC_PUTENV_COPY in *z/OS XL C/C++ Programming Guide*

UCMAPS and UCS-2 and UTF-8 converters

As of OS/390 V2R9, the compiler supported direct use of the UCS-2 and UTF-8 converters; the tables generated by the processing of UCMAPS by the `uconvdef` utility are no longer used. This is a migration issue if you modified UCMAPS to use the UCS-2 and UTF-8 converters. If you still need to use the modifications that you made to UCMAPS, you will now need to set the _ICONV_UCS2 environment variable to "O". For more information about the _ICONV_UCS2 environment variable, refer to *z/OS XL C/C++ Programming Guide, SC14-7315*.

Common library initialization compatibility issues with C/370 modules

Both Language Environment modules and C/370 modules use static code and dynamic code. Static code sections are emitted or bound with the main program object. Dynamic code sections are loaded and executed by the static component.

The sequence of events during initialization for C/370 modules differs from that for Language Environment modules. The key static code for the CEESTART object controls initialization at execution time. The C/370 CEESTART object contents differ from those of the Language Environment CEESTART object Its contents differ between the products. The Language Environment key dynamic code for the CEESTART object is CEEBINIT, which is stored in SCEERUN. The C/370 R2 key dynamic code for the CEESTART object is IBMBLIIA, which is a Common Library part stored in SIBMLINK. The Common Library is used by the C/370 V2 libraries.

Initialization schemes

The tables in this topic describe the initialization schemes for the CEESTART and IBMBLIIA modules:

- Table 7 describes the initialization scheme for C/370 V2 modules.
- Table 8 on page 45 describes the initialization scheme for Language Environment modules.
- Table 9 on page 45 describes the Language Environment initialization scheme for C/370 programs.

The following describes the C/370 V2 initialization scheme:

Table 7. C/370 V2 initialization scheme

Stage	Description
Load	The C/370 V2 CEESTART loads IBMBLIIA.
Initialize	IBMBLIIA initializes the Common Library.
Run	The Common Library runs C/370-specific initialization.

Table 7. C/370 V2 initialization scheme (continued)

Stage	Description
Call	The main program is called.

The following describes the initialization scheme:

Table 8. Language Environment initialization scheme

Stage	Description
Load	CEESTART loads CEEBINIT.
Initialize	CEEBINIT initializes Language Environment services.
Run	The Language Environment runtime library runs the C-specific initialization.
Call	The main program is called.

Table 9. Language Environment initialization scheme for C/370 programs

Stage	Description
Load	C/370 V2 CEESTART loads CEEBLIIA (as IBMBLIIA).
Initialize	CEEBLIIA (IBMBLIIA) initializes Language Environment services.
Run	The Language Environment runtime library runs the C-specific initialization.
Call	The main program is called.

In Table 9, compatibility with C/370 V2 programs depends upon the program's ability to intercept the initialization sequence at the start of the dynamic code and to initialize the Language Environment services at that point. This interception is achieved by the addition of a part named CEEBLIIA, which has been assigned the alias IBMBLIIA. This provides “initialization compatibility”.

Special considerations: CEEBLIIA and IBMBLIIA

The only way to control which environment is initialized for a given C/370 V2 program (when CEEBLIIA is assigned the alias of IBMBLIIA) is to correctly arrange the concatenation of libraries.

The version of IBMBLIIA that is found first determines the services (Language Environment or Common Library) that are initialized.

- If you intend to initialize the Common Library services, ensure that SIBMLINK is concatenated before SCEERUN.
- If you intend to initialize the Language Environment services, ensure that SCEERUN is concatenated before SIBMLINK.

Internationalization issues in POSIX and non-POSIX applications

You should customize your locale information. Otherwise, in rare cases, you may encounter errors. In a POSIX application, you can supply time zone and alternative time (for example, daylight) information with the TZ environment variable. In a non-POSIX application, you can supply this information with the _TZ environment variable. If no _TZ environment variable is defined for a POSIX application or no _TZ environment variable is defined for a non-POSIX application, any customized information provided by the LC_TOD locale category is used. By setting the TZ environment variable for a POSIX application, or the _TZ environment variable for a non-POSIX application, or by providing customized time zone or daylight information in an LC_TOD locale category, you allow the time functions to preserve both time and date, correctly adjusting for alternative time on a given date.

Refer to *z/OS XL C/C++ Programming Guide* for more information about both environment variables and customizing a locale.

Hardware and OS exceptions

The following points identify migration and coexistence considerations for user applications:

- CICS programs that use Language Environment services are enabled for decimal overflow exceptions.
- The C packed-decimal support routines are not supported in an environment that exploits asynchronous events.

Decimal overflow exceptions

Language Environment services support the packed decimal overflow exception using IBM System zArchitecture systems.

The value of the program mask in the program status word (PSW) is 4 (decimal overflow enabled). See "Unexpected SIGFPE exceptions" and "Explicit program mask manipulations" on page 20.

SIGTERM, SIGINT, SIGUSR1, and SIGUSR2 exceptions

`SIGTERM`, `SIGINT`, `SIGUSR1`, and `SIGUSR2` exceptions are handled differently for C/370 V2 and Language Environment programs.

The differences or incompatibilities are:

- The defaults for the SIGINT, SIGTERM, SIGUSR1, and SIGUSR2 signals changed in AD/Cycle LE/370 V1R3 from what they were in C/370 V1 and V2 and AD/Cycle LE/370 V1R1 and V2R2. These changes were carried into the Language Environment runtime environment. In the C/370 library and AD/Cycle LE/370 V1R1 and V1R2, the defaults for SIGINT, SIGUSR1, and SIGUSR2 were to ignore the signals. As of AD/Cycle LE/370 V1R3, the defaults are to terminate the program and issue a return code of 3000. For SIGTERM, the default has always been to terminate the program. The return code is "3000"; before, it was "0".
- Language Environment programs that terminate abnormally will not drive the `atexit` list.

Unexpected SIGFPE exceptions

Decimal overflow conditions were masked in the C/370 library prior to V2R2. Diagnosis of overflow conditions were enabled when the packed decimal data type was introduced prior to C/370 V2R2.

As of z/OS V1R7 XL C/C++ compiler, load modules that had generated decimal overflow conditions might raise unexpected SIGFPE exceptions. You cannot migrate such modules to the current without altering the source.

Note: These unexpected exceptions are most likely to occur in mixed language modules, particularly those using C and assembler code where the assembler code explicitly manipulates the program mask. See "Explicit program mask manipulations" on page 20.

Resource allocation and memory management migration issues

Incompatibilities in memory management might cause unexpected results in the output of your program. In your source code, you should be aware of potential problems when you use any operators or structures that re-allocate resources during application execution.

The realloc() function

If Language Environment services are initialized when the `realloc()` function is used, a new storage area is obtained and the data is copied. Under C/370 V2, the `realloc()` function will reuse an area unless the function needs a larger area.

If your program uses Language Environment services, ensure that the source code does not depend on the C/370 V2 behavior of the `realloc()` function.

Chapter 8. Input and output operations compatibility

Language Environment V1R5 input and output support differs from that provided by pre-OS/390 libraries. If your programs last performed input and output operations with a pre-OS/390 C/C++ compiler, you should read the changes listed herein.

Note: In this information, references to "previous releases" or "previous behavior" apply either to pre-OS/390 compilers or to a runtime environment that precedes the Language Environment V1R5 release.

You will generally be able to migrate "well-behaved" programs: programs that do not rely on undocumented behavior, restrictions, or invalid behaviors of previous releases. For example, if library documentation specified only that a return code was a negative value, and your code relies on that value being "-3", your code is not well-behaved and is relying on undocumented behavior.

Another example of a program that is not well-behaved is one that specifies `recfm=F` for a terminal file and depends on the runtime environment to ignore this parameter, as it did previously.

You might need to change even well-behaved code under circumstances described in the following topics.

Migration issues when opening pre-OS/390 files

When you call the `fopen()` or `freopen()` library function, you can specify each parameter only once. If you specify any keyword parameter in the *mode* string more than once, the function call fails. Previously, you could specify more than one instance of a parameter.

The library no longer supports uppercase open modes on calls to `fopen()` or `freopen()`. You must specify, for example, `rb` instead of RB, to conform to the ANSI/ISO standard.

You cannot open a non-HFS file more than once for a write operation. Previous releases allowed you, in some cases, to open a file for write more than once. For example, you could open a file by its data set name and then again by its ddname. This is no longer possible for non-HFS files, and is not supported.

Previously, `fopen()` allowed spaces and commas as delimiters for mode string parameters. Only commas are allowed now.

If you are using PDSs or PDSEs, you cannot specify any spaces before the member name.

Migration issues when writing to pre-OS/390 files

Write operations to files opened in binary mode are no longer deferred. Previously, the library did not write a block that held *nn* bytes out to the system until the user wrote *nn*+1 bytes to the block. Language Environment services follow the rules for full buffering, described in *z/OS XL C/C++ Programming Guide*, and write data as soon as the block is full. The *nn* bytes are still written to the file, the only difference is in the timing of when it is done.

For non-terminal files, the backspace character (`'\b'`) is now placed into files as is. Previously, it backed up the file position to the beginning of the line.

For all text I/O, truncation for `fwrite()` is now handled the same way that it is handled for `puts()` and `fputs()`. If you write more data than a record can hold, and your output data contains any of the terminating control characters, `'\n' or '\r'` (or `'\f'`, if you are using ASA), the library still truncates extra data; however, recognizing that the text line is complete, the library writes subsequent data to the next record boundary. Previously, `fwrite()` stopped immediately after the library began truncating data, so that you had to add a control character before writing any more data.

You can now partially update a record in a file opened with `type=record`. Previous services returned an error if you tried to make a partial update to a record. Now, a record is updated up to the number of characters you specify, and the remaining characters are untouched. The next update is to the next record.

Language Environment services block files more efficiently than some previous services did. Applications that depend on the creation of short blocks may fail.

The behavior of ASA files when you close them has changed. In previous releases, this is what happened:

Written to file	**Read from file after fclose(), fopen()**
`abc\n\n\n`	`abc\n\n\n\n`
`abc\n\n`	`abc\n\n\n`
`abc\n`	`abc\n`

Starting with this release, you read from the file what you wrote to it. For example:

Written to file	**Read from file after fclose(), fopen()**
`abc\n\n\n`	`abc\n\n\n`
`abc\n\n`	`abc\n\n`
`abc\n`	`abc\n`

With previous services, writing a single new-line character to a new file created an empty file under MVS™. Language Environment services treat a single new-line character written to a new file as a special case, because it is the last new-line character of the file. A single blank is written to the file. When this file is read, there are two new-line characters instead of one. There are also two new-line characters if two new-line characters were written to the file.

The behavior of appending to ASA files has also changed. The following table shows what you get from an ASA file when you:

1. Open an ASA file for write.
2. Write `abc`.
3. Close the file.
4. Append `xyz` to the ASA file.
5. Open the same ASA file for read.

Table 10. Appending to ASA files

`abc` Written to file, `fclose()` then append `xyz`	What you read from file after `fclose()`, `fopen()`	
	Previous release	New release
`abc ==> xyz`	`\nabc\nxyz\n`	same as previous release
`abc ==> \nxyz`	`\nabc\nxyz\n`	`\nabc\n\nxyz\n`
`abc ==> \rxyz`	`\nabc\rxyz\n`	`\nabc\n\rxyz\n`
`abc\n ==> xyz`	`\nabc\nxyz\n`	same as previous release
`abc\n ==> \nxyz`	`\nabc\nxyz\n`	`\nabc\n\nxyz\n`
`abc\n ==> \rxyz`	`\nabc\rxyz\n`	`\nabc\n\rxyz\n`
`abc\n\n ==> xyz`	`\nabc\n\n\nxyz\n`	`\nabc\n\nxyz\n`
`abc\n\n ==> \nxyz`	`\nabc\n\n\nxyz\n`	same as previous release
`abc\n\n ==> \rxyz`	`\nabc\n\n\rxyz\n`	same as previous release

Changes in DBCS string behavior

I/O now checks the value of MB_CUR_MAX to determine whether to interpret DBCS characters within a file.

When MB_CUR_MAX is 4, you can no longer place control characters in the middle of output DBCS strings for interpretation. Control characters within DBCS strings are treated as DBCS data. This is true for terminals as well. Previous products split the DBCS string at the `'\n'` (new-line) control character position by adding an SI (Shift In) control character at the new-line position, displaying the line on the terminal, and then adding an SO (Shift Out) control character before the data following the new-line character. If MB_CUR_MAX is 1, the library interprets control characters within any string, but does not interpret DBCS strings. SO and SI characters are treated as ordinary characters.

When you are writing DBCS data to text files, if there are multiple SO (Shift Out) control-character write operations with no intervening SI (Shift In) control character, the library discards the SO characters, and marks that a truncation error has occurred. Previous products allowed multiple SO control-character write operations with no intervening SI control character without issuing an error condition.

When you are writing DBCS data to text files and specify an odd number of DBCS bytes before an SI control character, the last DBCS character is padded with a X'FE' byte. If a SIGIOERR handler exists, it is triggered. Previous products allowed incorrectly placed SI control-character write operations to complete without any indication of an error.

Now, when an SO has been issued to indicate the beginning of a DBCS string within a text file, the DBCS must terminate within the record. The record will have both an SO and an SI.

Changes in stdout and stderr file positioning

The Language Environment inheritance model for standard streams supports repositioning. Previously, if you opened `stdout` or `stderr` in update mode, and then called another C program by using the ANSI-style `system()` function, the program that you called inherited the standard streams, but moved the file position for `stdout` or `stderr` to the end of the file. Now, the library does not move the file position to the end of the file. For text files, the position is moved only to the nearest record boundary not before the current position. This is consistent with the way `stdin` behaves for text files.

The values for **`L_tmpnam`** and FILENAME_MAX have been changed:

Constant	Old values	New values
`L_tmpnam`	47	1024
`FILENAME_MAX`	57	1024

The names produced by the `tmpnam()` library function are now different. Any code that depends on the internal structure of these names may fail.

The behavior of `fgetpos()`, `fseek()` and `fflush()` following a call to `ungetc()` has changed. Previously, these functions have all ignored characters pushed back by `ungetc()` and have considered the file to be at the position where the first `ungetc()` character was pushed back. Also, `ftell()` acknowledged characters pushed back by `ungetc()` by backing up one position if there was a character pushed back. Now:
- `fgetpos()` behaves just as `ftell()`does.
- When a seek from the current position (SEEK_CUR) is performed, `fseek()` accounts for any `ungetc()` character before moving, using the user-supplied offset.
- `fflush()` moves the position back one character for every character that was pushed back.

If you have applications that depend on the previous behavior of `fgetpos()`, `fseek()`, or `fflush()`, you may use the _EDC_COMPAT environment variable so that source code need not change to compensate for the change in behavior.

For OS I/O to and from files opened in text mode, the `ftell()` encoding system now supports higher blocking factors for smaller block sizes. In general, you should not rely on `ftell()` values generated by code you developed using previous releases of the library. You can try `ftell()` values taken in previous releases for files opened in text or binary format if you set the environment variable _EDC_COMPAT before you call `fopen()` or `freopen()`. Do not rely on `ftell()` values saved across program boundaries.

For record I/O, `ftell()` now returns the relative record number instead of an encoded offset from the beginning of the file. You can supply the relative record number without acquiring it from `ftell()`. You cannot use old `ftell()` values for record I/O, regardless of the setting of _EDC_COMPAT.

After you have called `ftell()`, calls to `setbuf()` or `setvbuf()` might fail. Applications should never call I/O functions between calls to `fopen()` or `freopen()` and calls to the functions that control buffering.

Note: _EDC_COMPAT is described in *z/OS XL C/C++ Programming Guide*.

Behavior changes when closing and reopening ASA files

The behavior of ASA files when you close and reopen them is now consistent: For more information about using ASA files, refer to *z/OS XL C/C++ Programming Guide*.

Table 11. Closing and reopening ASA files

	Physical record after close					
Written to file	**Previous behavior**			**New behavior**		
`abc`	Char	`abc`	(1)	same as previous release		

	Hex	`4888`
		`0123`
			(1)			

`abc\n`	Char	`abc`	(1)	same as previous release		

	Hex	`4888`
		`0123`
			(1)			

`abc\n\n`	Char	`abc`
		`0`
			(1)
			(2)
				Char	`abc`	(1)
						(2)

	Hex	`4888`
		`0123`
		`F`
		`0`
			(1)
			(2)
				Hex	`4888`
					`0123`
					`4`
					`0`
						(1)
						(2)

`abc\n\n\n`	Char	`abc` `-`	(1) (2)	Char	`abc`	(1) (2)

	Hex	`4888`
		`0123`
		`6`
		`0`
			(1)
			(2)
				Hex	`4888`
					`0123`
					`4`
					`0`
						(1)
						(2)

`abc\r`	Char	`abc` `+`	(1) (2)	same as previous release		

	Hex	`4888`
		`0123`
		`4`
		`E`
			(1)
			(2)			

`abc\f`	Char	`abc`
		`1`
			(1)
			(2)
				same as previous release		

	Hex	`4888`
		`0123`
		`F`
		`1`
			(1)
			(2)			

Changes in values returned by the fldata() function

There are minor changes to the values returned by the `fldata()` library function. It may now return more specific information in some fields. For more information, refer to "fldata() behavior", in *z/OS XL C/C++ Programming Guide*.

VSAM I/O changes

- The library no longer appends an index key when you read from an RRDS file opened in text or binary mode.
- RRDS files opened in text or binary mode no longer support setting the access direction to BWD.

Change in allocation of VSAM control blocks and I/O buffers

As of z/OS V1R10, the XL C/C++ compiler instructs VSAM, by default, to allocate control blocks and I/O buffers above the 16-MB line.

If you determine that this change could be causing a problem, you can use the VSAM JCL parameter AMP to override the default.

Terminal I/O changes

The library will now use the actual `recfm` and `lrecl` specified in the `fopen()` or `freopen()` call that opens a terminal file. Incomplete new records in fixed binary and record files are padded with blank characters until they are full, and the `__recfmF` flag is set in the `fldata()` structure. Previously, MVS terminals unconditionally set `recfm=U`. Terminal I/O did not support opening files in fixed format.

The use of an LRECL value in the `fopen()` or `freopen()` call that opens a file sets the record length to the value specified. Previous releases unconditionally set the record length to the default values.

For input text terminals, an input record now has an implicit logical record boundary at LRECL if the size of the record exceeds LRECL. The character data in excess of LRECL is discarded, and a `'\n'` (new-line) character is added at the end of the record boundary. You can now explicitly set the record length of a file as a parameter on the `fopen()` call. The old behavior was to allow input text records to span multiple LRECL blocks.

Binary and record input terminals now flag an end-of-file condition with an empty input record. You can clear the EOF condition by using the `rewind()` or `clearerr()` library function. Previous products did not allow these terminal types to signal an end-of-file condition. The use of a RECFM value in the `fopen()` or `freopen()` call that opens a file sets the record format to the value specified. Previous releases unconditionally set the record format to the default values.

When an input terminal requires input from the system, all output terminals with unwritten data are flushed in a way that groups the data from the different open terminals together, each separated from the other with a single blank character. The old behavior is equivalent to the new behavior, except that two blank characters separate the data from each output terminal.

Part 3. Migration of OS/390 C/C++ applications to z/OS V2R2 XL C/C++

OS/390 C/C++ applications were created with one of the following products:

- IBM OS/390 V1R1 C/C++ (reship of IBM C/C++ for MVS/ESA V3R2)
- IBM OS/390 V1R2 or V1R3 C/C++
- IBM OS/390 V2R4, V2R5, V2R6, V2R7, V2R8, V2R9, or V2R10 C/C++
- IBM z/OS V1R1 C/C++ (reship of IBM OS/390 V2R10 C/C++)

Notes:

1. The z/OS V1R1 compiler and library are equivalent to the OS/390 V2R10 compiler and library.
2. The OS/390 V2R5 compiler is equivalent to the OS/390 V2R4 compiler.
3. The OS/390 V1R1 compiler and library are equivalent to the final MVS/ESA compiler and library, and are described in Part 2, "Migration of pre-OS/390 C/C++ applications to z/OS V2R2 XL C/C++," on page 15.

Generally, you can bind OS/390 programs successfully with z/OS V2R2 programs without changing source code, and without recompiling or relinking programs.

The following topics provide information relevant to migrating a OS/390 application to z/OS V2R2 XL C/C++:

- Chapter 9, "Source code compatibility issues with OS/390 programs," on page 57
- Chapter 10, "Compile-time migration issues with OS/390 programs," on page 59
- Chapter 11, "Bind-time migration issues with OS/390 C/C++ programs," on page 71
- Chapter 12, "Runtime migration issues with OS/390 C/C++ applications," on page 73
- Chapter 13, "Migration issues resulting from class library changes between OS/390 C/C++ applications and Standard C++ library," on page 75

Notes:

1. If your application uses IBM CICS information or statements, also see Chapter 20, "Migration issues with earlier C/C++ applications that run CICS statements," on page 133.
2. If your application uses IBM DB2 information or statements, also see Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139.

Chapter 9. Source code compatibility issues with OS/390 programs

In general, you can use source programs with the z/OS V2R2 XL C/C++ compiler without modification, if they were created with an OS/390 compiler and library.

For details on support of *Programming languages - C++ (ISO/IEC 14882:2003(E))*, see Part 5, “ISO Standard C++ compliance migration issues,” on page 115.

Note: Some source code compatibility issues can be addressed by modifying runtime options. See Chapter 12, “Runtime migration issues with OS/390 C/C++ applications,” on page 73.

Overflow processing and code modifications

When a data type conversion causes an overflow (that is, the floating type value is larger than INT_MAX), the behavior is undefined according to the C Standard. The actual result depends on the ARCHITECTURE level (the ARCH option), which determines the machine instruction used to do the conversion. For example, there are input values that would result in a large negative value for ARCH(2) and below, while the same input would result in a large positive value for ARCH(3) and above.

If overflow processing is important to the program, the code should provide explicit checks.

Table 12. Modifying code to check overflow processing

Example of code that does not check overflow processing	Example of code that is modified to check overflow processing

`double x;`
`int i;`
`/* ... */`
 	
`i = x; /* overflow if x is too large */`
`/* value of i undefined */`
	`double x;`
	`int i;`
	`if (x < (double) INT_MAX)`
	`    i = x;`
	`else {`
	`    /* overflow */`
	`}`

.

References to class libraries that are no longer shipped

As of z/OS V1R9, IBM Open Class Library (IOC) dynamic link libraries (DLLs) are no longer shipped with the z/OS XL C/C++ compiler.

Any source dependency on an IOC DLL must be removed.

For information about the libraries that are supported by the current release, see *z/OS XL C/C++ Runtime Library Reference*.

Chapter 10. Compile-time migration issues with OS/390 programs

When you compile programs that were previously compiled with an OS/390 compiler and library, be aware of the following migration issues:

- “Changes in compiler listings and messages”
- “Changes in compiler options” on page 60
- “Changes in IBM data set names” on page 67
- “Introduction of 1998 Standard C++ support” on page 68
- “Changes that affect performance and optimization” on page 68
- “Removal of Model Tool support” on page 69

Changes in compiler listings and messages

From release to release, message contents can change and, for some messages, return codes can change. Errors can become warnings, and warnings can become errors. You must update any application that is affected by changes in message contents or return codes. Do not build dependencies on message contents, message numbers, or return codes. See *z/OS XL C/C++ Messages* for a list of compiler messages.

Listing formats, especially the pseudo-assembler parts, will continue to change from release to release. Do not build dependencies on the structure or content of listings. For information about C listings or the C++ listings for the current release, refer to *z/OS XL C/C++ User's Guide, SC14-7307*.

Debug format specification

As of z/OS V1R6 C/C++, the environment variable _DEBUG_FORMAT can be used with the c89 utility to specify translation of the **-g** flag option for 31-bit compilations:

- If _DEBUG_FORMAT equals DWARF (the default), **-g** is translated to DEBUG(FORMAT(DWARF)).
- If _DEBUG_FORMAT equals ISD, then **-g** is translated to TEST (the old translation).

For the impact on the runtime environment, see “Debug format and translation of the c89 -g flag option” on page 74.

For more information about using the c89 utility, see the c89 utility information in *z/OS XL C/C++ User's Guide*.

Language specification for compiler messages

With the C/C++ for MVS/ESA V3R2, OS/390, and z/OS XL C/C++ compilers, the method of specifying the language for compiler messages has changed. At compile time, instead of specifying message data sets on the SYSMSGS and SYSXMSGS ddnames, you must now use the NATLANG runtime option. If you specify data sets for these ddnames, they are ignored.

Note: For information about the NATLANG runtime option, see *z/OS Language Environment Customization* and the *z/OS Language Environment Programming Reference*.

Optimization level mapping and listing content

As of OS/390 V2R6 C/C++ compiler, OPT, OPT(1), and OPT(2) map to OPT(2). The compiler listing no longer contains the part of the pseudo-assembler listing that was associated with OPT(1). Listing formats, especially the pseudo-assembler parts, will continue to change from release to release. Do not build dependencies on the structure or content of listings. For information about C listings or C++ listings for the current release, refer to *z/OS XL C/C++ User's Guide*.

Macro redefinitions and error messages

As of z/OS V1R7 XL C, the behavior of macro redefinition has changed. For certain language levels, the XL C compiler will issue a severe error message instead of a warning message when a macro is redefined to a value that is different from the first definition.

For information about the language levels that are affected, see "LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions" on page 64 and "LANGLVL(EXTENDED) compiler option and macro redefinitions" on page 64.

Changes in compiler options

As the compiler is developed, some options are no longer supported and others undergo functional changes, such as adjustments in the default values.

Compiler options that are no longer supported

As of z/OS V1R2 C/C++ compiler, the following compiler options are no longer supported:

- DECK

  The replacement for DECK functionality that routes output to DD:SYSPUNCH is to use OBJECT(DD:SYSPUNCH).
- GENPCH
- HWOPTS

  The replacement for HWOPTS is ARCHITECTURE.
- LANGLVL(COMPAT)
- OMVS

  The replacement for OMVS is OE.
- SRCMSG
- SYSLIB

  The replacement for SYSLIB is SEARCH.
- SYSPATH

  The replacement for SYSPATH is SEARCH.
- USEPCH
- USERLIB

  The replacement for USERLIB is LSEARCH.
- USERPATH

  The replacement for USERPATH is LSEARCH.

As of OS/390 V2R10 C/C++ compiler, the following SOM-related compiler options are no longer supported:

- SOM | NOSOM
- SOMEinit | NOSOMEinit
- SOMGs | NOSOMGs
- SOMRo | NOSOMRo
- SOMVolattr | NOSOMVolattr
- XSominc | NOXSominc

ARCHITECTURE compiler option

As of z/OS V2R2 XL C/C++ compiler, the default value of the ARCHITECTURE compiler option is 8.

As of z/OS V2R1 XL C/C++ compiler, the default value of the ARCHITECTURE compiler option is 7.

As of z/OS V1R6 C/C++ compiler, the default value of the ARCHITECTURE compiler option is 5.

In OS/390 V2R10 to z/OS V1R5 releases, the default value of the ARCHITECTURE compiler option is 2. In OS/390 V2R9 C/C++ and previous releases, the default value of the ARCHITECTURE compiler option is 0.

ARCHITECTURE level and overflow processing

When a data conversion causes an overflow (for example, the floating type value is larger than INT_MAX), the behavior is undefined according to the C Standard.

The actual result depends on the ARCHITECTURE level (the ARCH option), which determines the machine instruction used to do the conversion. For example, there are input values that would result in a large negative value for ARCH(2) and below, while the same input would result in a large positive value for ARCH(3) and above.

For more information, see “Overflow processing and code modifications” on page 57.

ARCHITECTURE level and Metal C file-scope header SYSSTATE ARCHLVL statement

The SYSSTATE ARCHLVL statement in the Metal C file-scope header identifies the minimum hardware requirement.

Starting from z/OS V2R1 XL C++ compiler, if and only if ARCH(7) or up and OSREL(ZOSV2R1) or higher are in effect, SYSSTATE ARCHLVL=3; otherwise, SYSSTATE ARCHLVL=2.

ARGPARSE compiler option with Metal

Starting from z/OS V1R13 XL C++ compiler, the ARGPARSE option is supported with the METAL option. For more information, see **ARGPARSE | NOARGPARSE** that is documented in *z/OS XL C/C++ User's Guide*.

ASCII compiler option

As of z/OS V1R10 XL C++ compiler, the Unicode characters that use `\U` or `\u` notation are always sensitive to the ASCII compiler option. When the ASCII option is in effect, those characters are encoded in ASCII, even when they are found in **`#pragma comment`** directives. Prior to z/OS V1R10 XL C++ compiler, all **`#pragma comment`** text strings were encoded in EBCDIC.

CHECKOUT(CAST) compiler option

This suboption instructs the C compiler to check the source code for pointer casting that might affect optimization (that is, for those castings that violate the ANSI-aliasing rule). For detailed information, refer to information about the ANSIALIAS option in *z/OS XL C/C++ User's Guide*.

Prior to z/OS V1R2 C/C++ compiler, the compiler issued a warning message whenever this condition was detected. As of z/OS V1R2 C/C++ compiler, this message is informational. If you want to be alerted by the compiler that this message has been issued, you can use the HALTONMSG compiler option. The HALTONMSG option causes the compiler to stop after source code analysis, skip the code generation, and issue a return code of 12.

DIGRAPH compiler option

As of z/OS V1R2 C/C++ compiler, the DIGRAPH option default for C and C++ has been changed from NODIGRAPH to DIGRAPH.

ENUMSIZE compiler option

As of z/OS V1R7 XL C/C++, selected enumerated (`enum`) type declarations in system header files are protected to avoid potential execution errors. This allows you to specify the ENUMSIZE compiler option with a value other than SMALL without risking incorrect mapping of `enum` data types (for example, if they were used inside of a structure). For more information, see "ENUMSIZE(SMALL) and protected enumeration types in system header files" on page 92.

z/OS V1R2 introduced the ENUMSIZE option as a means for controlling the size of enumeration types. The default setting, ENUMSIZE(SMALL), provides the same behavior that occurred in previous releases of the compiler.

If you want to continue to use the ENUMSIZE option, it is recommended that the same setting be used for the whole application; otherwise, you might find inconsistencies when the same enumeration type is declared in different compilation units. Use the **`#pragma enum`**, if necessary, to control the size of individual enumeration types (especially in common header files).

INFO compiler option

As of z/OS V1R2 C/C++, the INFO option default has been changed from NOINFO to INFO(LAN) for C++.

As of z/OS V1R6 C/C++, the INFO option is supported by the C compiler as well as the C++ compiler.

Note: The CHECKOUT C compiler option will continue to be supported for compatibility with earlier releases only.

INLINE compiler option

For C++, the z/OS V1R1 and earlier compilers did not allow you to change the inlining threshold. These compilers performed inlining at OPT with a fixed value of 100 for the threshold and 2000 for the limit.

As of z/OS V1R2 C/C++ compiler, the C++ compiler accepts the INLINE option, with defaults of 100 and 1000 for the threshold and limit, respectively. As a result of this change, code that used to be inlined may no longer be inlined due to the decrease in the limit from 2000 to 1000 ACUs (Abstract Code Units).

As of z/OS V1R11 XL C/C++ compiler, the INLINE option might behave differently from those in the prior releases because of the implementation of a new inliner. You might find different performances of the INLINE option in the following ways:

- The functions that get inlined might be different.
- The inline report might look different.

If your application runs slower because functions that get inlined are different, adjust your inlining settings at high optimization levels, for example, the inlining threshold and the #pragma inline/noinline directives.

As of z/OS V2R1 XL C/C++ compiler, a virtual function might not be inlined even when the function is specified with the always_inline attribute. No informational message is issued when a virtual function is not inlined.

IPA(LINK) compiler option

For detailed information about using IPA Link step, refer to IPA(LINK) in *z/OS XL C/C++ User's Guide*.

IPA Link step default changes

As of OS/390 V1R3 C/C++ compiler, the following IPA Link step defaults changed:

- The default optimization level is OPT(1)
- The default is INLINE, unless NOOPT, OPT(0) or NOINLINE is specified.

As of OS/390 V2R6 C/C++ compiler:

- The default optimization level for the IPA Link step is OPT(2).
- The default inlining threshold is 1000 ACUs (Abstract Code Units). With OS/390 C/C++ V1R2 compiler, the threshold was 100 ACUs.
- The default expansion threshold is 8000 ACUs. With OS/390 C/C++ V1R2 C/C++ compiler, the threshold was 1000 ACUs.

The IPA(LINK) option and exploitation of 64-bit virtual memory

As of z/OS V1R12 XL C/C++, the compiler component that executes IPA at both compile and link time is a 64-bit application, which will cause an XL C/C++ compiler ABEND if there is insufficient storage. The default MEMLIMIT system parameter size in the SMFPRMxparmlib member should be at least 3000 MB for the link, and 512 MB for the compile. The default MEMLIMIT value takes effect whenever the job does not specify one of the following:

- MEMLIMIT in the JCL JOB or EXEC statement
- REGION=0 in the JCL

Notes:

- The compiler component that executes IPA(LINK) has been a 64-bit application since z/OS V1R8 XL C/C++ compiler.
- The MEMLIMIT value specified in an IEFUSI exit routine overrides all other MEMLIMIT settings.

The UNIX System Services **ulimit** command that is provided with z/OS can be used to set the MEMLIMIT default. For information, see *z/OS UNIX System Services Command Reference*. For additional information about the MEMLIMIT system parameter, see *z/OS MVS Programming: Extended Addressability Guide*.

As of z/OS V1R8 XL C/C++ compiler, the EDCI, EDCXI, EDCQI, CBCI, CBCXI, and CBCQI cataloged procedures, which are used for IPA Link, contain the variable IMEMLIM, which can be used to override the default MEMLIMIT value.

IPA object module binary compatibility

Release-to-release binary compatibility is maintained by the z/OS XL C/C++ IPA compilation and IPA link phases, as follows:

- An object file produced by an IPA compilation which contains IPA object or combined IPA and conventional object information can be used as input to the IPA link phase of the same or later version/release of the compiler.
- An object file produced by an IPA compilation which contains IPA object or combined IPA and conventional object information cannot be used as input by the IPA link phase of an earlier Version/Release of the compiler. If this is attempted, an error message will be issued by the IPA Link.
- If the IPA object is reproduced by a later IPA compilation, additional optimizations may be performed and the resulting application program might perform better.

Exception: The IPA object files produced by the OS/390 V1R2 C IPA compilation must by recompiled from the program source using an OS/390 V1R3 or later C/C++ compiler before you attempt to process them with the z/OS V2R2 XL C/C++ IPA Link.

LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions

As of z/OS V1R7 XL C, the treatment of macro redefinitions has changed. For LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2), the XL C compiler will issue a severe message instead of a warning message when a macro is redefined to a value that is different from the first definition.

```
#define COUNT 1
#define COUNT 2   /* error */
```

Figure 9. Macro redefinition

Note: Compare the treatment of macro redefinitions for these LANGLVL sub-options with that for "LANGLVL(EXTENDED) compiler option and macro redefinitions."

LANGLVL(EXTENDED) compiler option and macro redefinitions

As of z/OS V1R7 XL C, you can redefine a macro that has not been first undefined with LANGLVL(EXTENDED).

```
#define COUNT 1
#define COUNT 2

int main () {
   return COUNT;
}
```

Figure 10. Macro redefinition under LANGLVL(EXTENDED)

With z/OS V1R6 C and previous C compilers, this test will return "1". As of z/OS V1R7 XL C, this test will return "2".

Note: Compare the treatment of macro redefinitions for LANGLVL(EXTENDED) with that for “LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions” on page 64LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2).

LANGLVL(LONGLONG) compiler option

The `long long` data type is supported as a native data type when the LANGLVL(LONGLONG) option is turned on. This option is turned on by default by the compiler option LANGLVL(EXTENDED). The _LONG_LONG macro is predefined for all language levels other than ANSI.

As of z/OS V1R6 C/C++ compiler, when LANGLVL(LONGLONG) is turned on, the _LONG_LONG macro is defined by the compiler.

Attention: If you have defined your own _LONG_LONG macro in previous compiler releases, you must remove this user-defined macro before you compile your program.

LOCALE compiler option

As of z/OS V1R9 XL C/C++, the __LOCALE__ macro is defined to the name of the compile-time locale. If you specified LOCALE(strinf *string literal*), the compiler uses the runtime function setlocale(LC_ALL "*string literal*") to determine the name of the compile-time locale. If you do not use the LOCALE compiler option, the macro is undefined.

Prior to z/OS V1R9 XL C/C++, the __LOCALE__ macro was defined to "" when the LOCALE option was specified without a suboption.

M compiler option

Before z/OS V1R11, the stand-alone makedepend utility was used to analyze source files and determine source dependencies. As of z/OS V1R11, the M (-qmakedep) compiler option is introduced, and this compiler option is recommended to be used to obtain similar information. Specifying the M compiler option is equivalent to specifying the -qmakedep with no suboption.

The M compiler option is used to generate a `make` description file as a side-effect of the compilation process. The description file contains a rule or rules suitable for `make` that describes the dependencies of the main compilation source file.

On z/OS systems, the M compiler option resolves a number of complexities that is not properly managed by the compiler-independent makedepend utility, thereby improving the accuracy of the dependency information.

The MF option is used in conjunction with the M option and specifies the name of the file where the dependency information is generated, or the location of the file, or both. The MF option has no effect unless `make` dependency information is generated.

The MG option is used in conjunction with the M option and instructs the compiler to include missing header files into the `make` dependencies file.

The MT option is used in conjunction with the M option and sets the target to the `<target_name>` instead of the default target name. This is useful in cases where the target is not in the same directory as the source or when the same dependency rule applies to more than one target.

The MQ option is the same as the MT option except that the MQ option escapes any characters that have special meaning in `make`.

For detailed information, refer to MAKEDEP compiler option in *z/OS XL C/C++ User's Guide*.

OPTIMIZE compiler option

In the OS/390 V1R2, V1R3, V2R4, and V2R5 C/C++ compilers:

- OPT(0) mapped to NOOPT
- OPT and OPT(1) mapped to OPT(1)
- OPT(2) mapped to OPT(2)

As of OS/390 V2R6 C/C++:

- OPT(0) maps to NOOPT
- OPT, OPT(1) and OPT(2) map to OPT(2)

As of z/OS V1R5 C/C++, OPT(3) provides the compiler's highest and most aggressive level of optimization. OPT(3) is recommended only when the desire for runtime improvement outweighs the concern for minimizing compilation resources.

NORENT compiler option

In previous releases of the compiler, **`#pragma variable (name, RENT)`** had no effect if the compiler option was NORENT. As of OS/390 V2R9 compiler, a variable can be reentrant even if the compiler option is NORENT. For more information, see "Reentrant variables when the compiler option is NORENT" on page 71.

ROSTRING compiler option

As of z/OS V1R2 C/C++ compiler, the ROSTRING option default for C is changed from NOROSTRING to ROSTRING. The default for C++ has always been ROSTRING.

ROSTRING informs the compiler that string literals are read-only, thus allowing more freedom for the compiler to handle string literals. If you are not sure whether your program modifies string literals or not, specify the NOROSTRING compiler option.

ROCONST compiler option

As of z/OS V1R2 C/C++ compiler, the ROCONST option default for C++ is changed from NOROCONST to ROCONST. The default for C remains NOROCONST.

As of OS/390 V2R10 C/C++ compiler, **`#pragma variable (name, NORENT)`** is accepted if the ROCONST option is turned on, and the variable is const-qualified and not initialized with an address. In previous releases, **`#pragma variable (name, NORENT)`** was ignored for static variables.

STATICINLINE compiler option

As of z/OS V1R2 C/C++ compiler, the compiler supports the STATICINLINE compiler option. The default is NOSTATICINLINE. Specify STATICINLINE for compatibility with C++ compilers provided by previous versions of the compiler. For detailed information, refer to STATICINLINE compiler option in *z/OS XL C/C++ User's Guide*.

SQL compiler option and SQL EXEC statements

See Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139.

TARGET compiler option

As of z/OS V2R2 XL C/C++, the earliest release that can be targeted is z/OS V1R13. For more information about the TARGET compiler option, refer to *z/OS XL C/C++ User's Guide*.

See also "Program modules from an earlier release" on page 101.

TEST compiler option

As of z/OS V1R6 C/C++, when using the c89/c++ utility, the **`-g`** flag has changed from specifying the TEST option to DEBUG(FORMAT(DWARF)). For more information, see "Debug format specification" on page 97.

Note: Under ILP32 only, you can use the environment variable {_DEBUG_FORMAT} to determine the debug format (DWARF or ISD) to which the **`-g`** flag option is translated. For information about this environment variable and the c89/c++ utility, refer to the c89 utility information in *z/OS XL C/C++ User's Guide, SC14-7307*.

TUNE compiler option

As of z/OS V2R2 XL C/C++ compiler, the default value of the TUNE compiler option is 8.

As of z/OS V2R1 XL C/C++ compiler, the default value of the TUNE compiler option is 7.

As of z/OS V1R6 C/C++ compiler, the default value of the TUNE compiler option is 5.

Changes in IBM data set names

The names of IBM-supplied data sets may change from one release to another. See *z/OS Program Directory* for more information on data set names.

Introduction of 1998 Standard C++ support

As of z/OS V1R2, the C++ compiler supports *Programming languages - C++ (ISO/IEC 14882:1998(E))*. See Part 5, “ISO Standard C++ compliance migration issues,” on page 115 for details.

Changes that affect performance and optimization

When you recompile OS/390 C/C++ programs with z/OS V2R2 XL C/C++ compiler, be aware of changes that you can make to improve performance.

Addition of the #pragma reachable and #pragma leaves directives

The **#pragma reachable** and **#pragma leaves** directives help the optimizer in moving code around the function call site when exploring opportunities for optimization. Since the addition of these pragmas in OS/390 V2R9, the optimizer is more aggressive.

For more information on using #pragma reachable and #pragma leaves directives, refer to *z/OS XL C/C++ Language Reference, SC14-7308*.

Changes that affect customized JCL procedures

The following topics apply if the JCL procedures that you are using either have been customized or should be customized.

Potential increase in memory requirements

Memory requirements for compilation may increase for successive releases as new logic is added. If you cannot recompile an application that you successfully compiled with a previous release of the compiler, try increasing the region size. For the current default region size, refer to the *z/OS XL C/C++ User's Guide*.

As of z/OS V1R12 XL C/C++, when using the IPA compiler option to compile very large applications, you might need to increase the size of the work file associated with SYSUTIP DD in the IPA Link step. If you are linking the application in a USS environment, you can control the size of this work file with the _CCN_IPA_WORK_SPACE environment variable. If particularly large source files are compiled with IPA, the default size of the compile-time work files might also need to be increased. These can be modified via the *prefix*_WORK_SPACE environment variables.

JCL CBCI and CBCXI procedures and the variable CLBPRFX

As of z/OS V1R5 C++ compiler, the CBCI and CBCXI procedures contain the variable CLBPRFX. If you have any JCL that uses these procedures, either they must customized (for example, at installation time) or you must modify your JCL to provide a value for CLBPRFX.

Syntax to invoke the CC command

With the C/C++ for MVS/ESA V3R2, OS/390, and z/OS XL C/C++ compilers, you can use a new syntax to invoke the CC command.

At customization time, your system programmer can customize the CC EXEC to accept only the old syntax (the one supported by compilers before C/C++ for MVS/ESA V3R2) compiler, only the new syntax, or both syntaxes.

The CC EXEC should be customized to accept only the new syntax.

If you customize the CC EXEC to accept both the old and new syntaxes, you must invoke it using either the old or the new syntax, not a mixture of both. Be aware that the old syntax does not support UNIX System Services files provided with z/OS.

Refer to the *z/OS Program Directory* for more information about installation and customization, and to the *z/OS XL C/C++ User's Guide* for more information about compiler options.

Removal of Model Tool support

As of OS/390 V2R10 C/C++ compiler, Model Tool is no longer available.

Chapter 11. Bind-time migration issues with OS/390 C/C++ programs

This information helps application programmers understand and resolve the compatibility issues that might occur when they relink programs from an OS/390 C/C++ compiler to z/OS V2R2 XL C/C++.

Executable program compatibility problems that require source changes are discussed in Chapter 9, “Source code compatibility issues with OS/390 programs,” on page 57.

Notes:
1. An executable program is the output of the prelink/link or bind process. For more information, see "Prelinking and linking of z/OS XL C/C++ programs" in *z/OS XL C/C++ User's Guide*.
2. The terms in this topic having to do with linking (bind, binding, link, link-edit) refer to the process of creating an executable program from object modules.
3. The output of a prelinking, linking, or binding process depends on where the programs are stored:
   - When the programs are stored in a PDS, the output is a *load module*.
   - When the programs are stored in a PDSE or in UNIX System Services files, the output is a *program object*.

When you bind programs that were previously compiled with an OS/390 compiler and library, be aware of the following potential migration issues:
- “Reentrant variables when the compiler option is NORENT”

Reentrant variables when the compiler option is NORENT

If your program includes multithreaded operations, be aware of changes in the behavior of pragma variables.

In previous releases of the compiler, **`#pragma variable (name, RENT)`** had no effect if the compiler option was NORENT. As of OS/390 V2R9, a variable can be reentrant even if the compiler option is NORENT.

This change may cause some programs that compiled and linked successfully in previous releases to fail during link-edit in the current release. This applies if *all* of the following are true:
- The program is written in C and compiled with the NORENT option
- At least one variable is reentrant
- The program is compiled and linked with the output directed to a PDS and the prelinker was NOT used.

  Note: JCL procedures that may have been used to do this in previous releases are: EDCCL, EDCCLG, EDCL, and EDCLG (not all of these procedures are available, starting with the z/OS V1R7 XL C/C++ compiler).

Chapter 12. Runtime migration issues with OS/390 C/C++ applications

This information helps application programmers understand and resolve the compatibility issues that might occur when they relink programs from an OS/390 C/C++ compiler to z/OS V2R2 XL C/C++.

When you run applications that were previously compiled with an OS/390 compiler and library, be aware of the following potential migration issues:
- "Retention of OS/390 runtime behavior"
- "Debug format and translation of the c89 -g flag option" on page 74
- "Language Environment customization issues" on page 74

Retention of OS/390 runtime behavior

When your program is using Language Environment services, you can use the ENVAR runtime option to specify the values of environment variables at execution time. You can use some environment variables to specify the original runtime behavior for particular items. The following setting specifies the original runtime behavior for the greatest number of items:

```
ENVAR("_EDC_COMPAT=32767")
```

Alternatively, you can add a call to the `setenv()` function, either in the CEEBINT High-Level Language exit routine or in your `main()` program. If you use CEEBINT only, you will need to relink your application. If you add a call to `setenv()` in the `main()` function, you must recompile the program and then relink your application. For more information, refer to `setenv()` in *z/OS XL C/C++ Runtime Library Reference, SC14-7314* and to Using environment variables in *z/OS XL C/C++ Programming Guide*.

Changes to the putenv() function and POSIX compliance

As of z/OS V1R5 C/C++, the function `putenv()` places the string passed to `putenv()` directly into the array of environment variables. This behavior assures compliance with the POSIX standard.

Prior to z/OS V1R5 C/C++, the string used to define the environment variable passed into `putenv()` was not added to the array of environment variables. Instead, the system copied the string into system-allocated storage.

To allow the POSIX-compliant behavior of `putenv()`, do nothing; it's now the default condition.

To restore the previous behavior of `putenv()`, follow these steps:
1. Ensure that the environment variable, _EDC_PUTENV_COPY, is available on your pre-z/OS V1R5 system.
2. Set the environment variable _EDC_PUTENV_COPY to "YES".

For additional information, see:
- *z/OS XL C/C++ Runtime Library Reference*
- _EDC_PUTENV_COPY in *z/OS XL C/C++ Programming Guide*

Debug format and translation of the c89 -g flag option

As of z/OS V1R6 C/C++, the environment variable _DEBUG_FORMAT can be used with the c89 utility to specify translation of the **-g** flag option for 31-bit compilations:

- If _DEBUG_FORMAT equals DWARF (the default), **-g** is translated to DEBUG(FORMAT(DWARF)).
- If _DEBUG_FORMAT equals ISD, then **-g** is translated to TEST (the old translation).

For the impact on specification of compiler options, see "Debug format specification" on page 97.

For more information about the c89 utility, see the c89 utility information in *z/OS XL C/C++ User's Guide*.

Language Environment customization issues

For detailed information about customizing Language Environment runtime options, libraries, or processes, refer to *z/OS Language Environment Customization*.

Change in allocation of VSAM control blocks

As of z/OS V1R10, the XL C/C++ compiler instructs VSAM, by default, to allocate control blocks and I/O buffers above the 16-MB line.

If you determine that this change could be causing a problem, you can use the VSAM JCL parameter AMP to override the default.

Chapter 13. Migration issues resulting from class library changes between OS/390 C/C++ applications and Standard C++ library

Class library changes that have taken place since OS/390 C/C++ applications were developed have resulted in the following migration issues:

- "Function calls to different libraries"
- "Removal of IBM Open Class Library support"
- "Removal of Database Access Class Library utility"
- "Migration of programs with calls to UNIX System Laboratories I/O Stream Library functions"

Function calls to different libraries

See "Function calls to different libraries" on page 79.

Removal of IBM Open Class Library support

See "References to class libraries that are no longer shipped" on page 79.

Removal of SOM support

As of OS/390 V2R10 C++ compiler, the IBM System Object Model (SOM) is no longer supported in the C++ compiler.

Removal of Database Access Class Library utility

As of OS/390 V2R4 C++ compiler, the Database Access Class Library utility is no longer available.

Migration of programs with calls to UNIX System Laboratories I/O Stream Library functions

See "Migration from UNIX System Laboratories I/O Stream Library to Standard C++ I/O Stream Library" on page 80.

Part 4. Migration of earlier z/OS C/C++ applications to z/OS V2R2 XL C/C++

Earlier z/OS C/C++ applications were created with one of the following compilers:

- IBM z/OS V1R1 C/C++ (equivalent to the OS/390 V2R10 compiler)
- IBM z/OS V1R2 C/C++
- IBM z/OS V1R3 C/C++
- IBM z/OS V1R4 C/C++
- IBM z/OS V1R5 C/C++
- IBM z/OS V1R6 C/C++
- IBM z/OS V1R7 XL C/C++
- IBM z/OS V1R8 XL C/C++
- IBM z/OS V1R9 XL C/C++
- IBM z/OS V1R10 XL C/C++
- IBM z/OS V1R11 XL C/C++
- IBM z/OS V1R12 XL C/C++
- IBM z/OS V1R13 XL C/C++
- IBM z/OS V2R1 XL C/C++
- IBM z/OS XL C/C++ V2R1M1 web deliverable

Note: The z/OS V1R3 and V1R4 compilers are equivalent to the z/OS V1R2 compiler.

Significant class library changes occurred with releases z/OS V1R5 C/C++ through z/OS V1R9 XL C/C++. These changes could necessitate changes in your source code.

Notes:

1. If your application uses IBM CICS information or statements, also see Chapter 20, "Migration issues with earlier C/C++ applications that run CICS statements," on page 133.
2. If your application uses IBM DB2 information or statements, also see Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139.

The following topics provide information relevant to migrating an earlier z/OS C/C++ application to z/OS V2R2 XL C/C++:

- Chapter 14, "Source code compatibility issues with earlier z/OS C/C++ programs," on page 79
- Chapter 15, "Compile-time migration issues with earlier z/OS C/C++ programs," on page 87
- Chapter 16, "Bind-time migration issues with earlier z/OS C/C++ programs," on page 101
- Chapter 17, "Runtime migration issues with earlier z/OS C/C++ applications," on page 105

Chapter 14. Source code compatibility issues with earlier z/OS C/C++ programs

Significant class library changes have occurred between z/OS V1R5 C/C++ compiler and z/OS V2R2 XL C/C++ compiler. These changes could necessitate changes in your source code. Otherwise, you can likely use source programs that were created with one of the earlier z/OS C/C++ compilers without modification.

Exceptions are highlighted in the following topics:
- "Function calls to different libraries"
- "References to class libraries that are no longer shipped"
- "Migration from UNIX System Laboratories I/O Stream Library to Standard C++ I/O Stream Library" on page 80
- "Standard C++ compliance compatibility issues" on page 80
- "Use of XL C/C++ library functions" on page 80
- "Use of pragmas" on page 84
- "Virtual function declaration and use" on page 84

Note: Some source code compatibility issues can be addressed by modifying runtime options. See Chapter 12, "Runtime migration issues with OS/390 C/C++ applications," on page 73.

Function calls to different libraries

While it is possible to use functions from more than one library, (Standard C++ I/O Stream Library, UNIX System Laboratories I/O Stream Library, and C I/O), it is not recommended because it requires that your code perform extra tasks. For example, the UNIX System Laboratories I/O Stream Library uses a separate buffer so you would need to flush the buffer after each call to `cout` by either setting `ios::unitbuf` or calling `sync_with_stdio()`.

You should avoid switching between the I/O Stream Library formatted extraction functions and C `stdio.h` library functions whenever possible, and you should also avoid switching between versions of the I/O Stream Libraries. For more information, see *z/OS XL C/C++ Programming Guide, SC14-7315*.

References to class libraries that are no longer shipped

As of z/OS V1R9, IBM Open Class Library (IOC) dynamic link libraries (DLLs) are no longer shipped with the z/OS XL C/C++ compiler.

Any source dependency on an IOC DLL must be removed.

For information about the libraries that are supported by the current release, see *z/OS XL C/C++ Runtime Library Reference*.

Migration from UNIX System Laboratories I/O Stream Library to Standard C++ I/O Stream Library

The values for some enumerations differ slightly between the UNIX System Laboratories and Standard C++ I/O Stream Library. This may cause problems when migrating programs to the Standard C++ I/O Stream Library.

The following IOS format flags have been added to the Standard C++ I/O Stream Library:

- `boolalpha`
- `adjustfield`
- `basefield`
- `floatfield`

The following IOS format flags have been removed:

- flags for format control: `stdio`
- flags for open-mode control: `nocreate`, `noreplace`, `bin`
- flags for the io-state control: `hardfail`

There might be other small differences.

Standard C++ compliance compatibility issues

As of z/OS V1R7, the XL C++ compiler supports *Programming languages - C++ (ISO/IEC 14882:2003(E))*, which documents the currently supported Standard C++. For more information, see Part 5, "ISO Standard C++ compliance migration issues," on page 115.

Use of XL C/C++ library functions

The use of XL C/C++ library functions can be affected by performance enhancements such as:

- "Timing of processor release by the pthread_yield() function"
- "New information returned by the getnameinfo() function" on page 81

as well as by changes to external standards, such as:

- "Feature test macros and system header files" on page 81
- "Potential need to include _Ieee754.h" on page 81
- "New definitions exposed by use of the _OPEN_SYS_SOCK_IPV6 macro" on page 82
- "Required changes to fprintf and fscanf strings %D, %DD, and %H" on page 82
- "Changes to the putenv() function and POSIX compliance" on page 82
- "Required changes to fprintf and fscanf strings due to new specifiers for vector types" on page 83

Timing of processor release by the pthread_yield() function

As of z/OS V1R8 XL C/C++ compiler, the _EDC_PTHREAD_YIELD environment variable can be used to either release the processor immediately, or release the processor after a delay. This change affects both the `pthread_yield()` and `sched_yield()` functions.

In prior releases, control was passed back to the calling thread without releasing the processor whenever multiple intra-thread calls to `pthread_yield()` occurred within .01 seconds of one another.

If you want to continue to use the previous internal timing algorithm, use the following command:

```
_EDC_PTHREAD_YIELD=-1
```

For information about _EDC_PTHREAD_YIELD and setting environment variables, see Using environment variables in *z/OS XL C/C++ Programming Guide, SC14-7315*.

For information about the `pthread_yield()` and `sched_yield()` functions, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

New information returned by the getnameinfo() function

As of z/OS V1R9 XL C/C++ compiler, invocations of the `getnameinfo()` function might need to be modified to handle interface information appended to the host name. Prior to z/OS V1R9, the `getnameinfo()` function ignored the zone index value in the `input sockaddr_in6` structure.

Ensure that you verify the capability to handle scope information of `getnameinfo()` invocations that have the following characteristics:

- The `sa` argument represents an IPv6 link-local address.
- The `sin6_scope_id` member of `sa` is non-zero.

The scope information is returned in the format *hostname%interface*. The host name is the node name associated with the IP address in the buffer pointed to by the host argument. By default, the scope information is the interface name associated with the zone index value.

For information about options for addressing this change, see Communications Server migration actions in *z/OS Migration, GA32-0889*.

For information about the `getnameinfo()` function, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

Feature test macros and system header files

You must define the feature test macros that you need before including any system headers.

Feature test macros control which symbols are made visible in a source file (typically a header file). For detailed information about header files and supported feature test macros, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

Potential need to include _Ieee754.h

As of z/OS XL C/C++ V1R9 compiler, the `<math.h>` file (included in the `<tgmath.h>` header file) no longer includes the `<_Ieee754.h>` file, which declares IEEE 754 interfaces.

This change avoids potential namespace pollution. If your code needs any symbols that are defined in `<_Ieee754.h>`, you must explicitly include that header file.

For additional information about runtime library support of decimal floating-point data types and functions, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

New definitions exposed by use of the _OPEN_SYS_SOCK_IPV6 macro

As of z/OS V1R7 XL C++ compiler, recompiling an earlier C/C++ program that uses the `_OPEN_SYS_SOCK_IPV6` feature test macro will expose new definitions in the system header files as well as new functions in `netinet/in.h`. These new functions are:

inet6_opt_append()	inet6_opt_find()	inet6_opt_finish()	inet6_opt_get_val()
inet6_opt_init()	inet6_opt_next()	inet6_opt_set_val()	inet6_rth_add()
inet6_rth_getaddr()	inet6_rth_init()	inet6_rth_reverse()	inet6_rth_segments()
inet6_rth_space()			

Required changes to fprintf and fscanf strings %D, %DD, and %H

As of z/OS V1R8, XL C/C++ supports decimal floating point size modifiers ("D", "DD", and "H") for the `fprintf` and `fscanf` families of functions. If a percent sign (%) is followed by one of these character strings, which had no meaning under previous releases of z/OS XL C/C++, the compiler could interpret the data as a size modifier. Treatment of this condition is undefined and the behavior could be unexpected.

For a description of the potential results, see "Unexpected output from fprintf() or fscanf()" on page 106.

If you are using z/OS V1R9 XL C/C++ compiler and you want the `fprintf()` and `fscanf()` families of functions to produce the same results as your previous compiler, change your source code input as shown in Table 13.

Table 13. Example: Code change for fprintf/fscanf character strings "%D", "%DD", and "%H"

Existing statement	Modification required under z/OS V2R2 XL C/C++
`printf("This results in a 10%Deduction.\n");`	`printf("This results in a 10%%Deduction.\n");`

Changes to the putenv() function and POSIX compliance

As of z/OS V1R5 C/C++, the function `putenv()` places the string passed to `putenv()` directly into the array of environment variables. This behavior assures compliance with the POSIX standard.

Prior to z/OS V1R5 C/C++, the string used to define the environment variable passed into `putenv()` was not added to the array of environment variables. Instead, the system copied the string into system-allocated storage.

To allow the POSIX-compliant behavior of `putenv()`, do nothing; it's now the default condition.

To restore the previous behavior of `putenv()`, follow these steps:

1. Ensure that the environment variable, _EDC_PUTENV_COPY, is available on your pre-z/OS V1R5 system.
2. Set the environment variable _EDC_PUTENV_COPY to "YES".

For additional information, see:

- *z/OS XL C/C++ Runtime Library Reference*

- _EDC_PUTENV_COPY in *z/OS XL C/C++ Programming Guide*

Required changes to fprintf and fscanf strings due to new specifiers for vector types

As of z/OS V2R1 (with APAR PI20843), XL C/C++ runtime supports new specifiers for the fprintf and fscanf families of functions for vector data types. The newly introduced specifiers include separator flags "," (comma), ";" (semicolon), ":" (colon), and "_" (underscore) and optional prefixes "v", "vh", "hv", "vl", "lv", "vll", "llv", "vL", and "Lv". If a percent sign (%) is followed by one of these character strings, which had no meaning under previous releases, the runtime could interpret the data as a vector type specifier. Treatment of this condition is undefined and the behavior could be unexpected.

For a description of the potential results, see "Unexpected output from fprintf() or fscanf()" on page 106. If you want the same results for these strings as the previous releases, change the code to avoid using the percent sign (%) followed by aforementioned character strings in format string parameter of fprintf and fscanf function families.

C99 support of long long data type

As of z/OS V1R7 XL C/C++ compiler, when you recompile an application that uses `long long` support, you might experience problems if the application does one of the following actions:

- Uses a compiler designed to support C99
- Does not ask for extended features

If an application currently uses the LANGLVL(LONGLONG) compiler option to get at the `long long` data type, and also uses certain non-standard `long long` macros, recompiling with z/OS V2R2 XL C/C++ may cause compiler error messages to be issued because these non-standard definitions are hidden unless both LANGLVL(LONGLONG) and LANGLVL(EXTENDED) are in effect.

If an application currently uses LANGLVL(EXTENDED), the non-standard definitions will continue to be exposed since extended features are requested. For those applications that want to use a compiler designed to support C99, but do not want extended features, change the source code to use the C99 standard `long long` macros, as shown in Table 14.

Table 14. C99 standard macros to replace non-standard long long macros that cause z/OS V2R2 errors

Non-standard `long long` macros	**C99 standard `long long` macros**
LONGLONG_MIN	LLONG_MIN
LONGLONG_MAX	LLONG_MAX
ULONGLONG_MAX	ULLONG_MAX

The definitions in Table 14 are commonly used with the following functions:

- `llabs()`
- the following `long long` numeric conversion functions
  - `strtoll()`
  - `strtoull()`
  - `wcstoll()`

– `wcstoull()`

Use of pragmas

Functionality of pragmas can change from release to release, or under different circumstances. Be aware of the following migration issues:

- "Application of #pragma unroll() as of z/OS V1R7 XL C/C++"
- "Unexpected C++ output with #pragma pack(2)"

Application of #pragma unroll() as of z/OS V1R7 XL C/C++

As of z/OS V1R7 XL C/C++ compiler, the **`#pragma unroll()`** directive works only with `for` loops.

If your code applies the **`#pragma unroll()`** directive to a `while` or a `do` loop, the compiler ignores the pragma directive and generates a warning message.

For detailed information about unrolling loops, refer to any or all of the following related documents:

- *z/OS XL C/C++ Language Reference, SC14-7308*
- *z/OS XL C/C++ Programming Guide, SC14-7315*
- *z/OS XL C/C++ User's Guide, SC14-7307*

Unexpected C++ output with #pragma pack(2)

An aggregate, which contains `char` data type members only, has natural alignment of one byte. XL C retains the natural one-byte alignment but when **`#pragma pack(2)`** is applied to an aggregate, its alignment increases to two bytes.

If XL C and XL C++ program objects need to be compatible, do not use **`#pragma pack(2)`** in your XL C or XL C++ code.

Note: You can use the `sizeof` operator to test the output whenever **`#pragma pack(2)`** is used.
For more information about **`#pragma pack(2)`**, refer to the discussion of the **`#pragma pack`** directive **`twobyte`** option in *z/OS XL C/C++ Language Reference*.

Virtual function declaration and use

Figure 11 on page 85 shows a program that, as of z/OS V1R6 C/C++ compiler, would generate an exception under the IBM object model because the call to a member function `version()` on the object `_b` occurs before the declaration of `_b`.

```
#include

class A {
    public:
      A(int i) : v(i) {}
      virtual int version() {return 0;}  1 ;
      private: int v;
};

class B:virtual public A {
   public:
   B(int i) : A(i) {}
};

extern B _b;                              2
static int ver = _b.version();            3
B _b(1);                                  4

int main() {
   printf("version: %d\n", ver);
   return 0;
}
```

Notes:

1. The `virtual` keyword tells the compiler that the function is virtual and it can be overloaded by any derived class of A.
2. A reference to externally defined `_b` of type B.
3. The value of static global variable `ver` is initialized with the value returned by member function `version()` called by object `_b`. An exception will be raised because the object `_b` is not fully constructed at the time of the call to the member function `version()`.
4. The declaration of the polymorphic object `_b` occurs after its use on the previous line. This line should precede the definition of `ver` to ensure that the virtual function `version()` is found at run time.

Figure 11. Example that highlights sequence of statements to declare and call a virtual function

Chapter 15. Compile-time migration issues with earlier z/OS C/C++ programs

When you compile earlier z/OS C/C++ programs with z/OS V2R2 XL C/C++, be aware of the following information:

- "Changes in compiler listings, messages, and return codes"
- "Changes in compiler option functionality" on page 91
- "Changes that affect compiler invocations" on page 96
- "Changes that affect JCL procedures" on page 98
- "JCL that runs pre-z/OS V1R5 C/C++ programs" on page 100
- "Compiler options that manage Standard C++ compliance" on page 100
- "Impact of recompiling applications that include <net/if.h> with the _XOPEN_SOURCE_EXTENDED feature test macro" on page 100
- "Impact of recompiling applications that include the pselect() interface" on page 100
- "Impact of recompiling with the _OPEN_SYS_SOCK_IPV6 macro" on page 100
- "Impact of recompiling code that relies on math.h to include IEEE 754 interfaces" on page 100

Changes in compiler listings, messages, and return codes

From release to release, message contents can change and, for some messages, return codes can change. Errors can become warnings, and warnings can become errors. You must update any application that is affected by changes in message contents or return codes. Do not build dependencies on message contents, message numbers, or return codes. See *z/OS XL C/C++ Messages* for a list of compiler messages.

Listing formats, especially the pseudo-assembler parts, will continue to change from release to release. Do not build dependencies on the structure or content of listings. For information about C listings or the C++ listings for the current release, refer to *z/OS XL C/C++ User's Guide, SC14-7307*.

You might need to be aware of changes with respect to the following issues:

- "Appearance of compiler substitution variables" on page 88
- "Function offsets in source listing" on page 88
- "Diagnostic refinement in identification of linkage issues (C++ only)" on page 88
- "References to UNIX System Services file names" on page 89
- "Non-compliant array index raises an exception" on page 89
- "Unexpected name lookup error messages with template use" on page 90
- "Width of mnemonic in assembly listings" on page 90
- "Macro redefinitions and error messages" on page 90

For information about the language levels that are affected, see "LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions" on page 93 and "LANGLVL(EXTENDED) compiler option and macro redefinitions" on page 94.

Appearance of compiler substitution variables

As of z/OS V1R10, the compiler substitution variable appears, where applicable, in the message section of a compilation listing. This is to avoid the confusion that can be caused by a string of blank spaces in the listing.

Corrections in escape sequence encoding

As of z/OS V1R11, the encoding of octal escape characters in string literals and wide string literals is corrected. See the corrected processing in the following table (where the bytecode is shown using base 16).

Table 15. Corrections in escape sequence encoding

Example	Old bytecode (INCORRECT)	New bytecode (CORRECT)	Description
"\776"	01fe00	fe00	Octal escape overflow in narrow string literals.
L"\776"	0001fe00 00	01fe0000	Octal escape above \377 (no overflow) in wide string literal.

Function offsets in source listing

As of z/OS V1R10, the XL C/C++ compiler adds the starting offset of each function to the listing when the OFFSET option is specified.

Diagnostic refinement in identification of linkage issues (C++ only)

Prior to z/OS V1R9 XL C/C++ PTF UK31348, the XL C++ compiler diagnosed any case in which two functions with the same linkage signature were mapped together. For examples, see Figure 12 and Figure 13 on page 89.

As of z/OS V1R9 XL C/C++ PTF UK31348, the XL C++ compiler diagnoses two functions that are mapped together only when both are defined in the same compilation unit, without considering differences in linkage signature. See Figure 14 on page 89.

```
// t.C
extern "C" int foo(int);
extern "C" int bar(double);
#pragma map (foo, "bar")
int f() { return foo(2) + bar(3.0);}
```

Figure 12. Example of diagnosis of two externally defined functions with different types mapped together, prior to z/OS V1R9 XL C/C++ PTF UK31348

The diagnostic message will identify the mapping of `foo` with `"bar"` as invalid because their declarations differ in type.

```
// t.C
int foo(double);
extern "C" int bar(double);
#pragma map (foo, "bar")
int f() { return foo(2) + bar(3.0);}
```

Figure 13. Example of diagnosis of two externally defined functions with different linkage signatures mapped together, prior to z/OS V1R9 XL C/C++ PTF UK31348

The diagnostic message will identify the mapping of `foo` with `"bar"` as invalid because, although they are defined with the same type, one is defined with a default linkage.

```
// t.C
extern "C" int foo(int) { return 0; }
extern "C" int bar(int) { return 2.0; }
#pragma map (foo, "bar")
int f() { return foo(2) + bar(3.0);}
```

Figure 14. Example of diagnosis of two functions with the same linkage signatures mapped together as of z/OS V1R9 XL C/C++ with PTF UK31348 applied

The diagnostic message will identify the mapping of `foo` with `"bar"` as invalid because both are defined, which violates the one-definition rule.

References to UNIX System Services file names

As of z/OS V1R9, when compiling C source files that reside in the UNIX System Services file system, any messages emitted during the compilation will use relative path information, rather than absolute path information, to reference the file name. This makes all file-name references in the compiler error messages and listings consistent in that they all use relative path information.

Non-compliant array index raises an exception

As of z/OS V1R9 XL C++, an error message is generated whenever an array index is defined as anything other than an integral non-volatile constant expression. This change alerts you that your code does not comply with the currently supported C++ Standard (section 5.19). For an example, see Figure 15.

Notes:

1. To avoid this problem, redefine the array index to an integral non-volatile constant expression.
2. Prior to z/OS V1R9 XL C++, the compiler allowed local validation of this rule.

```
void f() {}
int main()
{
int i[(int)f];
return 0;
}
```

Figure 15. Example of volatile array index

The compiler will generate a message stating that the expression must be an integral non-volatile constant expression.

Unexpected name lookup error messages with template use

As of z/OS V1R9 XL C++ compiler, new name lookup exceptions could result from compiling a template which uses symbolic names that do not depend on that template's parameters. For an example, see Figure 16 and Figure 17.

Symbolic names that are not dependent on a template parameter must be:

- Declared before they are used.
- Defined before they are used in a context that requires a complete definition.

Earlier releases allowed names to be used in a template definition before they were declared as long as they were declared before the template was instantiated.

Note: This change will not affect well-formed code, which always defines names in the source code before using them.
For information about using templates in C++ programs, see *z/OS XL C/C++ Programming Guide, SC14-7315*. For information about compiling, binding, and running C++ templates, see *z/OS XL C/C++ User's Guide*.

```
template <class T> void fnc(T &x, T y)
{
   int t1=FAIL;
   int t2=ZERO;
   int t3=ONE;
}

enum ENUMTYPE {ZERO = 3, ONE, FAIL} e1, e2, e3, e4;

struct tst{};

template void fnc(tst &x, tst y);
```

Figure 16. Example of C++ template code that will cause name lookup exceptions.

If the compiler encounters this code before it encounters the declarations of the symbolic names FAIL, ZERO, and ONE, it will generate the messages listed in Figure 17.

```
"./ex1.cpp", line 3.11: CCN5274 (S) The name lookup for "FAIL" did not find a declaration.
"./ex1.cpp", line 8.31: CCN6303 (I) "ENUMTYPE FAIL" is not visible.
"./ex1.cpp", line 1.25: CCN5700 (I) The previous message was produced while
                                    processing "fnctst(tst &, tst)".
"./ex1.cpp", line 4.11: CCN5274 (S) The name lookup for "ZERO" did not find a declaration.
"./ex1.cpp", line 8.16: CCN6303 (I) "ENUMTYPE ZERO" is not visible.
"./ex1.cpp", line 5.11: CCN5274 (S) The name lookup for "ONE" did not find a declaration.
"./ex1.cpp", line 8.26: CCN6303 (I) "ENUMTYPE ONE" is not visible.
```

Figure 17. Messages that result from attempts to compile the code in Figure 16.

Width of mnemonic in assembly listings

As of z/OS V1R9 XL C/C++ compiler, customized JCL procedures or other tools that scan assembly listings might need to be updated because the width of the instruction mnemonic has been increased.

Macro redefinitions and error messages

As of z/OS V1R7 XL C, the behavior of macro redefinition has changed. For certain language levels, the XL C compiler will issue a severe error message instead of a warning message when a macro is redefined to a value that is different from the first definition.

Changes in compiler option functionality

The following topics describe changes in compiler option functionality that might require modifications to either your use of compiler options or your source code. For detailed information about these compiler options, see *z/OS XL C/C++ User's Guide, SC14-7307*.

Option behavior change when processing multiple suboptions

As of z/OS V2R1, when multiple suboptions are specified with the following options, the compiler no longer issues a diagnostic message, and the last suboption is used:

- AGGRCOPY
- ASSERT
- CHECKOUT
- DLL
- PORT
- PPONLY

CHECKOUT compiler option

Starting from z/OS V1R13, the CHECKOUT option is deprecated. Use the INFO option instead of CHECKOUT.

CMDOPTS compiler option and conflict resolution

As of z/OS V1R7 XL C/C++ compiler:

- Default options specified in the configuration file have the same weight as if they were specified on the command line. The XL C/C++ compiler cannot distinguish between an option specified in the configuration file and an option specified on the command line.
- Any conflict between options and pragmas is resolved in favor of the option.
- The XL C/C++ compiler no longer requires that default options be specified in the configuration file.

As of z/OS V1R7 XL C/C++, if you customize your xlc configuration file using the sample default configuration file, you might experience a change in behavior because the defaults for supported xlc commands are no longer specified in the options attribute in the configuration file. Instead, the xlc utility emits the defaults as suboptions of the CMDOPTS compiler option. This may cause a change in behavior because the XL C/C++ compiler resolves conflicts between options and pragmas differently, depending on whether options are specified as suboptions of the CMDOPTS option or explicitly on the command line and in the options attributes.

DFP compiler option and earlier floating-point applications

As of z/OS V1R10, there is a risk that earlier C/C++ applications compiled with the DFP option could inadvertently reset the decimal floating-point rounding mode to the default value. You should consider this risk if you are adding decimal floating-point functionality to an application that includes floating-point operations which use the data type `fenv_t` or the function `fesetenv()` with the static initializer FE_DFL_ENV. This is because the FE_DFL_ENV and `__fe_def_env` static initializers set the decimal floating-point rounding mode to the FE_DEC_TONEAREST value.

Be aware of the following constraints

- Because the decimal floating-point rounding mode field is stored in the FPC register separately from the binary floating-point rounding mode, there will be no effect on the binary floating-point rounding mode. However, you should take care with exception handling routines because binary floating-point applications can use FPC exception flags.
- DFP names will not be exposed when the application is compiled without the DFP compiler option. (There may also be a new __STDC_WANT_DEC_FP__ C99 feature test macro to further protect against namespace invasion).
- If you are compiling a System Programming C (SPC) application, you should not use the DFP option; the statically bound version of the SPC function `sprintf()` does not support decimal floating-point number formats. Standard functions that are already supported in the SPC library (such as `printf()` and `scanf()`) will be able to operate on decimal floating-point numbers.

DSAUSER compiler option

Starting from z/OS V1R13 XL C++ compiler, the DSAUSER option is supported. When the METAL option is in effect, the DSAUSER option requests a user field of the size of a pointer to be reserved on the stack. The default is NODSAUSER. For more information, see **DSAUSER | NODSAUSER (C only)** that is documented in *z/OS XL C/C++ User's Guide*.

ENUMSIZE(SMALL) and protected enumeration types in system header files

As of z/OS V1R7 XL C/C++ compiler, selected enumerated (`enum`) type declarations in system header files are protected to avoid potential execution errors. This allows you to specify the ENUMSIZE compiler option with a value other than SMALL without risking incorrect mapping of `enum` data types (for example, if they were used inside of a structure).

With earlier versions of the compiler, if you specified ENUMSIZE() with a value other than SMALL, data that was declared with certain `enum` types could be incorrectly mapped. In some instances, the header files in the library referenced the types (such as `__device_t` in the typedef `fldata_t`), which resulted in a potential inconsistency between the mapping seen during application execution and that declared in the library (which is built with the default ENUMSIZE(SMALL)).

Even when you specify ENUMSIZE with a value other than SMALL, the enumerations listed in Table 16 will always be ENUMSIZE(SMALL).

Table 16. Header files with declarations of protected enumeration types

Header file	Enumerations
stdio.h	__device_t
search.h	ACTION VISIT
sys/uio.h	uio_rw
sys/wait.h	idtype_t
_Ccsid.h	__csType
__ledebug.h	asfAmodeType asfCallbackResult
yvals.h	_Mux

FLAG compiler option

As of z/OS V1R13, FLAG(I) is the default in z/OS UNIX System Services as it is in batch compilation.

FLOAT(AFP) suboptions for applications that access CICS data

See “CICS TS V4.1 with "Extended MVS Linkage Convention"” on page 136.

GENASM compiler option

Starting from z/OS V1R13, the GENASM option is not supported in UNIX System Services. Instead, you can use the -S flag and the -o option.

GONUMBER compiler option and LP64 support

As of z/OS V1R8 XL C/C++ compiler, the GONUMBER compiler option generates line number tables for both 31-bit and 64-bit applications.

IPA compiler option

Prior to z/OS V2R1, the default optimization level for the IPA option was NOOPTIMIZE when the compiler was invoked from JCL.

Starting with z/OS V2R1, the default optimization level for the IPA option is OPTIMIZE(2) when the compiler is invoked from JCL. This change was made to match the default optimization level when the compiler is invoked from USS, as well as the default on the other platforms.

LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions

As of z/OS V1R7 XL C, the treatment of macro redefinitions has changed. For LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2), the XL C compiler will issue a severe message instead of a warning message when a macro is redefined to a value that is different from the first definition.

```
#define COUNT 1
#define COUNT 2   /* error */
```

Figure 18. Macro redefinition

Note: Compare the treatment of macro redefinitions for these LANGLVL sub-options with that in “LANGLVL(EXTENDED) compiler option and macro redefinitions” on page 94.

LANGLVL(EXTC1X) compiler option

This option controls that compilation is based on the C11 standard, invoking all the currently supported C11 features and other implementation-specific language extensions. For detailed information, see **EXTC1X** that is documented in *z/OS XL C/C++ User's Guide*.

Note: C11 is a new version of the C programming language standard. IBM continues to develop and implement the features of the new standard. The implementation of the language level is based on IBM's interpretation of the standard. Until IBM's implementation of all the features of the C11 standard is complete, including the support of a new C standard library, the implementation may change from release to release. IBM makes no attempt to maintain compatibility, in source, binary, or listings and other compiler interfaces, with earlier releases of IBM's implementation of the new features of the C11 standard and therefore they should not be relied on as a stable programming interface.

LANGLVL(EXTENDED) compiler option and macro redefinitions

As of z/OS V1R7 XL C, you can redefine a macro that has not been first undefined with LANGLVL(EXTENDED).

```
#define COUNT 1
#define COUNT 2

int main () {
   return COUNT;
}
```

Figure 19. Macro redefinition under LANGLVL(EXTENDED)

With z/OS V1R6 C and previous C compilers, this test will return "1". As of z/OS V1R7 XL C, this test will return "2".

Note: Compare the treatment of macro redefinitions for LANGLVL(EXTENDED) with that for “LANGLVL(ANSI), LANGLVL(SAA), or LANGLVL(SAAL2) compiler option and macro redefinitions” on page 93.

LANGLVL(EXTENDED0X) compiler option

This option controls that compilation is based on the C++11 standard, invoking all the currently supported C++11 features and other implementation-specific language extensions. The option is implemented in XL C/C++ compiler as of z/OS V1R11. For detailed information, see **LANGLVL(EXTENDED0X) compiler option** that is documented in *z/OS XL C/C++ User's Guide*.

Note: C++11 is a new version of the C++ programming language standard. IBM continues to develop and implement the features of the new standard. The implementation of the language level is based on IBM's interpretation of the standard. Until IBM's implementation of all the features of the C++11 standard is complete, including the support of a new C++ standard library, the implementation may change from release to release. IBM makes no attempt to maintain compatibility, in source, binary, or listings and other compiler interfaces, with earlier releases of IBM's implementation of the new features of the C++11 standard and therefore they should not be relied on as a stable programming interface.

LOCALE compiler option

As of z/OS V1R9 XL C/C++, the __LOCALE__ macro is defined to the name of the compile-time locale. If you specified LOCALE(strinf *string literal*), the compiler uses the runtime function setlocale(LC_ALL "*string literal*") to determine the name of the compile-time locale. If you do not use the LOCALE compiler option, the macro is undefined.

Prior to z/OS V1R9 XL C/C++, the __LOCALE__ macro was defined to "" when the LOCALE option was specified without a suboption.

M compiler option

Before z/OS V1R11, the stand-alone makedepend utility was used to analyze source files and determine source dependencies. As of z/OS V1R11, the M (-qmakedep) compiler option is introduced to provide similar information.

The M compiler option is used to generate a `make` description file as a side-effect of the compilation process. The description file contains a rule or rules suitable for `make` that describes the dependencies of the main compilation source file.

The MF option is used in conjunction with the M option and specifies the name of the file where the dependency information is generated, or the location of the file, or both. The MF option has no effect unless `make` dependency information is generated.

The MG option is used in conjunction with the M option and instructs the compiler to include missing header files into the `make` dependencies file.

The MT option is used in conjunction with the M option and sets the target to the `<target_name>` instead of the default target name. This is useful in cases where the target is not in the same directory as the source or when the same dependency rule applies to more than one target.

The MQ option is the same as the MT option except that the MQ option escapes any characters that have special meaning in `make`.

For detailed information, refer to MAKEDEP compiler option in *z/OS XL C/C++ User's Guide*.

RESTRICT option

z/OS V1R12 XL C compiler introduces a new option RESTRICT to indicate to the compiler that all pointer parameters in some or all functions are disjoint. The default is NORESTRICT. For detailed information, see RESTRICT | NORESTRICT (C only) in *z/OS XL C/C++ User's Guide*.

SEVERITY option

z/OS V1R12 XL C compiler introduces a new option SEVERITY to support message severity modification. With this option specified, you can set the severity level for a certain message that you specified. The compiler will use the new severity when the specified message is generated by the compiler. The default is NOSEVERITY. For detailed information, see SEVERITY | NOSEVERITY (C only) in *z/OS XL C/C++ User's Guide*.

SQL compiler option and SQL EXEC statements

See Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139.

TARGET compiler option

As of z/OS V2R2 XL C/C++, the earliest release that can be targeted is z/OS V1R13. For more information about the TARGET compiler option, refer to *z/OS XL C/C++ User's Guide*.

See also "Program modules from an earlier release" on page 101.

TEMPLATEDEPTH compiler option

Starting from z/OS V1R13 XL C++ compiler, the TEMPLATEDEPTH option is supported. With this option, you can specify the maximum number of recursively instantiated template specializations that are processed by the compiler. The default is TEMPLATEDEPTH(300). For more information, see **TEMPLATEDEPTH (C++ only)** that is documented in *z/OS XL C/C++ User's Guide*.

Changes that affect compiler invocations

As of z/OS V1R6 C/C++ compiler, compiler invocation is supported by two different utilities:
- c89
- xlc

z/OS V1R6 C/C++ introduced the following utilities:
- **`xlc`** command, to compile a C program
- **`xlC`** and **`xlc++`** commands, to compile a C++ program

z/OS V1R6 C/C++ introduced the following command suffixes:
- _x suffix, which compiles the program with XPLINK
- _64 suffix, which compiles the program under LP64

The utility you want to use depends on:
- Whether you need to port code between z/OS and AIX®.
- How you want to set up your build environment.

For example, you can use the command **`c89_x`** to compile an ANSI-compliant program with XPLINK.

Note: As of z/OS V1R7 XL C/C++, you no longer need to use command names with suffixes _x/_64 to compile/bind an XPLINK or 64-bit application. You can use suffixless command names with **`-qxplink`**/**`-q64`** or **`-Wc,xplink`**/**`-Wc,lp64`** and **`-Wl,xplink`**/**`-Wl,lp64`** instead. For detailed information, refer to the c89 utility information in *z/OS XL C/C++ User's Guide*.

Table 17. Differences between the c89 and xlc compiler invocation utilities

	c89 utility	xlc utility
Command support	The c89 utility does not support • The -S flag option introduced in z/OS V1R9. • AIX options syntax.	The following commands accept AIX C/C++ as well as z/OS C/C++ options syntax: • **`cc`** • **`c89`** • **`cxx`** • **`c++`** The xlc utility does not support the TEMPINC compiler option.
Environment setup	Determined by environment variables	Determined by configuration file

Changes that affect use of the c89 command

Debug format specification

As of z/OS V1R6 C/C++, the environment variable _DEBUG_FORMAT can be used with the c89 utility to specify translation of the **-g** flag option for 31-bit compilations:

- If _DEBUG_FORMAT equals DWARF (the default), **-g** is translated to DEBUG(FORMAT(DWARF)).
- If _DEBUG_FORMAT equals ISD, then **-g** is translated to TEST (the old translation).

For the impact on the runtime environment, see “Debug format and c89 -g flag option translation” on page 103.

For more information about using the `c89` utility, see the c89 utility information in *z/OS XL C/C++ User's Guide*.

Changes that affect use of the xlc utility

When you use the xlc utility to compile or link an existing application, be aware of the following potential migration issues:

- Changes in processing of return code (see “Exposure of build problems and xlc utility”)
- Changes in processing of source file comments (see “When C++ style comments are the default”)

Exposure of build problems and xlc utility

As of z/OS V1R10 XL C/C++ compiler, the xlc utility handles the *_ACCEPTABLE_RC environment variable as the c89 utility handles it. This permits users to specify acceptable return codes in order to expose the same build problems that are exposed with the c89 utility.

You will notice a change in behavior if:

- You use the xlc utility to compile source programs or link-edit object files in an environment in which the *_ACCEPTABLE_RC environment variable is exported:
- The *_ACCEPTABLE_RC environment variable has a value other than "4".

Otherwise, the xlc utility behaves the same as it did for earlier releases (assuming you do not use the `acceptable_rc` configuration file attribute).

For detailed information about the *_ACCEPTABLE_RC environment variable, see *z/OS UNIX System Services Command Reference*. For more information about specifying acceptable return codes, see *z/OS XL C/C++ User's Guide*.

When C++ style comments are the default

As of z/OS V1R7 XL C/C++, the **`xlc`** command causes the compiler to generate C++ style comments by default. This change will not normally affect your program. But in the special cases where it does (as shown in the example below), you must either override **`–qcpluscmt`** or change your source code.

In Figure 20 on page 98, the intention is to increment the input by one.

```
printf("%d\n",i//*something*/
+1);
```

Figure 20. C++ style comment

Prior to z/OS V1R7 XL C/C++ compiler, the compiler saw the equivalent of: `printf("%d\n", i / +1);` and if the input is 4, the output is also 4.

As of z/OS V1R7 XL C/C++ compiler, the compiler sees the equivalent of: `printf("%d\n", i +1);` and if the input is 4, the output is 5, as intended.

Changes that affect JCL procedures

Memory requirements for compilation may increase for successive releases as new logic is added. If you cannot recompile an application that you successfully compiled with a previous release of the compiler, try increasing the region size. For the current default region size, refer to the *z/OS XL C/C++ User's Guide*.

User-defined conversion tables and iconv() functions

As of z/OS V1R9, the `iconv()` family of functions utilizes character conversion services provided by Unicode Services (UCS). Prior to z/OS V1R9 releases, the `iconv()` function used either a single byte or a double byte substitution character; single-byte and double-byte substitution characters were never mixed. As of z/OS V1R9, the `iconv()` function will use a single byte substitution character when converting single byte characters and a multibyte substitution character when converting multibyte characters in a mixed character set conversion. The environment variables, _ICONV_MODE and _ICONV_TECHNIQUE control function behavior.

These changes will affect your compilation only if both of the following conditions are true:

- Your JCL does specifies user-defined conversion tables.
- Your JCL uses conversion techniques other than LMREC (the default value for _ICONV_TECHNIQUE).

Otherwise, set the _ICONV_MODE environment variable to C in order to access the new UCS character conversion services.

Note: When Unicode Services are being used, the _ICONV_UCS2 and _ICONV_PREFIX environment variables have no meaning.

The `iconv()` function returns the number of nonidentical conversions performed during a conversion. As of z/OS V1R9, the `iconv()` function interprets nonidentical conversion more strictly. This means that the nonidentical conversion count for the same input buffer contents might be higher than it was for compilations under previous releases.

If your program includes CICS statements, also see "Customized CEECCSD.COPY and CEECCSDX.COPY files and iconv() changes" on page 136.

Note: As of z/OS V1R11, IBM will no longer ship uconvTable binary tables in either the `installation-prefix.SCEEUTBL` data set or the z/OS UNIX file system directory `/usr/lib/nls/locale/uconvTable`.

ILP32 compiler option and name mangling

As of z/OS V1R9, the default name mangling suboption under ILP32 is zOSV1R2, whether the ILP32 option is specified during the compiler invocation or used by default. Any JCL procedure that is run under the ILP32 compiler option (either explicitly or by default), and does not specify the suboption that controls the name mangling conventions, will instruct the compiler to mangle names differently that it did in earlier supported releases.

This change applies to batch processing only. For programs that are compiled under UNIX System Services, there is no change in behavior.

Note: In earlier supported releases, when ILP32 was either explicitly specified in the JCL or used by default, the default name mangling suboption was ANSI instead of zOSV1R2.

IPA(LINK) compiler option and very large applications

As of z/OS V1R12 XL C/C++, when using the IPA compiler option to compile very large applications, you might need to increase the size of the work file associated with SYSUTIP DD in the IPA Link step. If you are linking the application in a USS environment, you can control the size of this work file with the _CCN_IPA_WORK_SPACE environment variable. If particularly large source files are compiled with IPA, the default size of the compile-time work files might also need to be increased. These can be modified via the *prefix*_WORK_SPACE environment variables.

IPA(LINK) compiler option and exploitation of 64-bit virtual memory

As of z/OS V1R12 XL C/C++, the compiler component that executes IPA at both compile and link time is a 64-bit application, which will cause an XL C/C++ compiler ABEND if there is insufficient storage. The default MEMLIMIT system parameter size in the SMFPRMxparmlib member should be at least 3000 MB for the link, and 512 MB for the compile. The default MEMLIMIT value takes effect whenever the job does not specify one of the following:

- MEMLIMIT in the JCL JOB or EXEC statement
- REGION=0 in the JCL

Note:

- The compiler component that executes IPA(LINK) has been a 64-bit application since z/OS V1R8 XL C/C++ compiler.
- The MEMLIMIT value specified in an IEFUSI exit routine overrides all other MEMLIMIT settings.

The UNIX System Services **ulimit** command that is provided with z/OS can be used to set the MEMLIMIT default. For information, see *z/OS UNIX System Services Command Reference*. For additional information about the MEMLIMIT system parameter, see *z/OS MVS Programming: Extended Addressability Guidez/OS MVS Programming: Extended Addressability Guide*.

As of z/OS V1R8 XL C++ compiler, the EDCI, EDCXI, EDCQI, CBCI, CBCXI, and CBCQI cataloged procedures, which are used for IPA Link, contain the variable IMEMLIM, which can be used to override the default MEMLIMIT value.

JCL that runs pre-z/OS V1R5 C/C++ programs

As of z/OS V1R5, C++ compiler the CBCI and CBCXI procedures contain the variable CLBPRFX. If you have any JCL that uses these procedures, you must either customize these procedures (for example, at installation time) or modify your JCL to provide a value for CLBPRFX.

Compiler options that manage Standard C++ compliance

To make an application conform to the currently supported Standard C++, you might need to change existing source code. You can use the compiler options and suboptions to manage those phases. For details, refer to Language element control options in *z/OS XL C/C++ User's Guide, SC14-7307*.

Impact of recompiling applications that include <net/if.h> with the _XOPEN_SOURCE_EXTENDED feature test macro

As of z/OS V1R9, BSD-like socket definitions will not be automatically exposed when XPG 4.2 namespace is requested. To avoid violation of the standard UNIX namespace, the definitions are protected with the _OPEN_SYS_IF_EXT feature test macro.

Note: BSD sockets are used to manipulate network interfaces that are defined in `<net/if.h>`. For additional information about header files, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

Impact of recompiling applications that include the pselect() interface

As of z/OS V1R11, recompilation of an existing XL C/C++ application that includes the <sys/select.h> header might fail if the application calls the pselect() interface and the undefined _POSIX_C_SOURCE 200112L feature test macro (or equivalent). If you need to recompile applications that call pselect(), you must define the _POSIX_C_SOURCE feature test macro (or equivalent) prior to including the system headers. Prior to z/OS V1R11, the pselect() declaration in <sys/select.h> was not protected by a feature test macro.

Impact of recompiling with the _OPEN_SYS_SOCK_IPV6 macro

As of z/OS V1R7, recompiling an earlier C/C++ program that uses the `_OPEN_SYS_SOCK_IPV6` feature test macro will expose new definitions in Language Environment header files. See "New definitions exposed by use of the _OPEN_SYS_SOCK_IPV6 macro" on page 82.

Impact of recompiling code that relies on math.h to include IEEE 754 interfaces

As of z/OS V1R9 XL C/C++ compiler, recompilation of earlier C/C++ applications will fail if the code relies upon `math.h` to include `_Ieee754.h`. See "Potential need to include _Ieee754.h" on page 81.

Chapter 16. Bind-time migration issues with earlier z/OS C/C++ programs

If you are relinking load modules or program objects from a previous release of z/OS C/C++ compiler, be aware of the following potential migration issues:

- "Unexpected "missing symbol" error (C++ only)"
- "Program modules from an earlier release"
- "Alignment incompatibilities between object models" on page 102
- "Alignment incompatibilities between XL C and XL C++ output with #pragma pack(2)" on page 102
- "Debug format and c89 -g flag option translation" on page 103
- "argc argv parsing support for Metal C programs" on page 103

Unexpected "missing symbol" error (C++ only)

If the binder is generating "missing symbol" error messages that did not appear with earlier compilers, it might be due to the change in the treatment of the `using` directive that was introduced in the z/OS V1R10 XL C++ compiler. See "Unqualified name lookups and the using directive" on page 119.

Program modules from an earlier release

When you use z/OS V2R2 XL C/C++ compiler to bind earlier program modules, be aware of the following migration issues:

- "Namespace pollution binder errors"
- "c89 COMPAT binder option default and programs from an earlier release" on page 102

Namespace pollution binder errors

As of z/OS V1R8 XL C/C++ compiler, when you target OS/390 V2R10 or an earlier release while binding or linking your application, you might encounter the namespace pollution error shown in Figure 21.

Note: z/OS V1R1 C/C++ compiler is the same as OS/390 V2R10 C/C++ compiler. OS/390 V2R10 is also reshipped in z/OS V1R2 through to V1R6.

```
IEW2456E 9207 SYMBOL terminate__3stdFv UNRESOLVED. MEMBER COULD NOT BE INCLUDED
         FROM THE DESIGNATED CALL LIBRARY.
FSUM3065 The LINKEDIT step ended with return code 8.
```

Figure 21. IEW2456E namespace pollution error

If you encounter the error shown in Figure 21, use the code shown in Figure 22 on page 102 inside a header file that is included by the affected source.

```
#ifdef __cplusplus
#if ((__COMPILER_VER__ >= 0x41080000) && (__TARGET_LIB__ == 0x220A0000))
namespace std { void terminate(); }
#pragma map(std::terminate, "terminate__Fv")
#endif
#endif
```

Note: To prevent targeting an inappropriate release, guard the **#pragma map** statement with the __TARGET_LIB__ macro.

Figure 22. Header file code that handles IEW2456E error condition

c89 COMPAT binder option default and programs from an earlier release

As of z/OS V1R8 XL C/C++, the c89 utility no longer emits the default for the COMPAT binder option. This change prevents inadvertant attempts to use features that are not supported by the targeted release. It means that you have the option to obtain the binder defaults for the COMPAT option but you are not forced to override the c89 default when you bind applications intended to run on earlier releases. If you want to maintain the previous c89 utility behavior, you must do one of the following:

- Set the _PVERSION environment variable to a release earlier than z/OS V1R8 XL C/C++.
- Specify the COMPAT option on the command line. For example: **-Wl,compat=curr**.

If you want to override the binder default for the COMPAT option using the C/C++ cataloged procedures, specify the desired COMPAT option in the BPARM proc variable.

Note: When the TARGET compiler option is used, binder features that are not supported by the targeted release should not be used. In previous releases of the z/OS C/C++ compiler, the default COMPAT option had to be overridden.

Alignment incompatibilities between object models

As of z/OS V1R6, C/C++ compilers support the IBM object model as well as the compat object model. The IBM object model has a more complex layout than the compat object model. The more complex layout supports 64-bit processing as well as 31-bit processing.

The IBM object model is the default for for 64-bit processing, which is specified by the LP64 compiler option. The compat object model is the default for 31-bit processing, which is specified by the ILP32 compiler option. Because each object model uses a different memory layout, C++ constructs that work under the compat object model might not work under the IBM object model.

For more information, refer to The z/OS 64-bit environment in *z/OS XL C/C++ Programming Guide*.

Alignment incompatibilities between XL C and XL C++ output with #pragma pack(2)

An aggregate, which contains `char` data type members only, has a natural alignment of one byte. Typically, XL C retains the natural one-byte alignment.

However, when `#pragma pack(2)` is applied to an aggregate, its alignment increases to two bytes. If you are binding both XL C and XL C++ program modules, and both C and C++ program modules use `#pragma pack(2)`, there might be alignment incompatibilities.

See "Unexpected C++ output with #pragma pack(2)" on page 84.

Debug format and c89 -g flag option translation

As of z/OS V1R6 C/C++, the environment variable _DEBUG_FORMAT can be used with the c89 utility to specify translation of the **-g** flag option for 31-bit compilations:

- If _DEBUG_FORMAT equals DWARF (the default), **-g** is translated to DEBUG(FORMAT(DWARF)).
- If _DEBUG_FORMAT equals ISD, then **-g** is translated to TEST (the old translation).

For the impact on specification of compiler options, see "Debug format specification" on page 97.

For detailed information about using the c89 utility, see the c89 in *z/OS XL C/C++ User's Guide*.

argc argv parsing support for Metal C programs

As of z/OS V1R13, the `argc argv` parsing capability is added to Metal C programs. If your Metal C programs work with standard `argc` and `argv` arguments, the newly enabled parsing code generated by the compiler might cause problems.

If you use `argc` and `argv` in your `main()` function, you need to add CBC.SCCNOBJ dataset to the binder SYSLIB for the resolution of CCNZINIT and CCNZTERM routines (CCNZQINI and CCNZQTRM for LP64). The CCNZINIT and CCNZTERM routines need NAB established for their stack space. If you supply your own prolog and epilog for `main()`, you need to allocate 1K of extra space (2K for LP64) in addition to the DSA size suggested by the compiler in the global SET symbol &CCN_DSASZ.

For more information, see ARGPARSE | NOARGPARSE in *z/OS XL C/C++ User's Guide, SC14-7307*.

Chapter 17. Runtime migration issues with earlier z/OS C/C++ applications

Runtime migration issues with earlier z/OS C/C++ programs result from changes in the Language Environment services, or in changes in functionality of runtime options.

Be aware of the following potential migration issues:
- "Earlier AMODE 64 applications"
- "Retention of previous runtime behavior" on page 106
- "Failure of authentication process" on page 106
- "Internationalization issues" on page 108
- "Changes in math library functions" on page 109
- "Changes in floating-point support" on page 111
- "Changes in allocation of VSAM control blocks" on page 112
- "Changes to st_mode attribute of AF_UNIX socket files" on page 112
- "Changes to strfmon() output" on page 113
- "Changes to structure t_opthdr in xti.h" on page 113
- "Removal of conversion table source code" on page 113

Earlier AMODE 64 applications

When you run earlier applications under AMODE 64, be aware of the following potential issues:
- "HEAPPOOLS runtime option no longer ignored in all AMODE 64 applications"

HEAPPOOLS runtime option no longer ignored in all AMODE 64 applications

As of z/OS V1R10, Language Environment services will not ignore the HEAPPOOLS runtime option when AMODE 64 applications specify it by using the _CEE_RUNOPTS environment variable.

In earlier Language Environment releases, when the HEAPPOOLS runtime option was specified via the _CEE_RUNOPTS environment variable, it was handled as follows:
- When an AMODE 64 application spawned an AMODE 31 process, the AMODE 64 application would ignore the HEAPPOOLS runtime option, but the AMODE 31 process would accept and propagate it.
- When an AMODE 31 application spawned an AMODE 64 process, the AMODE 31 application would accept the HEAPPOOLS runtime option, but the AMODE 64 process would ignore it.

Customized runtime libraries

Language Environment improvements might necessitate changing the way you build your libraries.

For a list of Language Environment references, refer to “Bibliography” on page 153.

Failure of authentication process

If a pre-z/OS V1R10 XL C/C++ application fails to authenticate any password strings, it might be because the maximum length of Pass_MAX has increased from 8 bytes to 255 bytes.

You should confirm that there is no change in password authentication behaviour by existing applications that use the `getpass()` function.

Retention of previous runtime behavior

When your program is using Language Environment services, you can use the ENVAR runtime option to specify the values of environment variables at execution time. You can use some environment variables to specify the original runtime behavior for particular items. The following setting specifies the original runtime behavior for the greatest number of items:

```
ENVAR("_EDC_COMPAT=32767")
```

Alternatively, you can add a call to the `setenv()` function, either in the CEEBINT High-Level Language exit routine or in your `main()` program. If you use CEEBINT only, you will need to relink your application. If you add a call to `setenv()` in the `main()` function, you must recompile the program and then relink your application. For more information, refer to `setenv()` in *z/OS XL C/C++ Runtime Library Reference, SC14-7314* and to Using environment variables in *z/OS XL C/C++ Programming Guide*.

Unexpected output from fprintf() or fscanf()

As of z/OS V1R8, XL C/C++ supports decimal floating point size modifiers ("D", "DD", and "H") for the `fprintf` and `fscanf` families of functions. If a percent sign (%) is followed by one of these character strings, which had no meaning under previous releases of z/OS XL C/C++, the compiler could interpret the data as a size modifier. Treatment of this condition is undefined and the behavior could be unexpected.

For example, Table 18 shows the output, under different conditions, for the following statement:

```
printf("This results in a 10% Deduction.\n");
```

Table 18. Potential results of printf(“This results in a 10% Deduction.\n”);

Compiler release	Hardware	Result
z/OS V1R9 XL C/C++	Without the DFP facility.	`EDC6259S This function is not supported running on hardware that does not have the Decimal Floating Point Facility installed.`
z/OS V1R9 XL C/C++	With the DFP facility.	The following is written to `stdout`: `This results in a 10 2.000000e-390duction.`
Earlier z/OS C/C++	Any hardware.	The following is written to `stdout`: `This results in a 10Deduction.`

See “Required changes to fprintf and fscanf strings %D, %DD, and %H” on page 82.

As of z/OS V2R1 (with APAR PI20843), XL C/C++ runtime supports new specifiers for the fprintf and fscanf families of functions for vector data types. The newly introduced specifiers include separator flags "," (comma), ";" (semicolon), ":" (colon), and "_" (underscore) and optional prefixes "v", "vh", "hv", "vl", "lv", "vll", "llv", "vL", and "Lv". If a percent sign (%) is followed by one of these character strings, which had no meaning under previous releases, the runtime could interpret the data as a vector type specifier. Treatment of this condition is undefined and the behavior could be unexpected.

For example, Table 19 shows the output, under different conditions, for the following statement:

```
printf("About 10%visitors are covered%:Need more efforts.\n");
```

Table 19. Potential results of printf("About 10%visitors are covered%:Need more efforts.\n");

Compiler release	**Hardware**	**Result**
z/OS V2R1 XL C/C++ (with APAR PI20843)	Any hardware.	The following is written to `stdout`: `About 100 0 0 0 16 0 0 0 34 29 114 72 0 0 0 0sitors are coveredNeed more efforts.`
z/OS V2R1 XL C/C++ (without APAR PI20843)	Any hardware.	The following is written to `stdout`: `About 10visitors are covered:Need more efforts.`
Earlier z/OS C/C++	Any hardware.	The following is written to `stdout`: `About 10visitors are covered:Need more efforts.`

See "Required changes to fprintf and fscanf strings due to new specifiers for vector types" on page 83.

IEEE754 math functions

As of z/OS V1R9, certain IEEE754 `fdlibm` math functions are replaced by code written by IBM Research. Some of those were enhanced to improve performance and accuracy. The earlier versions are still available. See "Changes in math library functions" on page 109.

Internal timing algorithm specification

As of z/OS V1R8 XL C/C++ compiler, the internal timing algorithm uses the _EDC_PTHREAD_YIELD environment variable setting to control the time at which the processor is released.

If you want to continue to use the previous internal timing algorithm, use the following command:

```
_EDC_PTHREAD_YIELD=-1
```

For information about _EDC_PTHREAD_YIELD and setting environment variables, see Using environment variables in *z/OS XL C/C++ Programming Guide, SC14-7315*.

For information about the `pthread_yield()` and `sched_yield()` functions, see *z/OS XL C/C++ Runtime Library Reference, SC14-7314*.

Daylight saving time definition

If you are using a locale that has been customized wth LC_TOD, you need to be aware that as of z/OS V1R9, the Language Environment default daylight saving time (that for the U.S. Eastern time zone) is changed.

To retain the earlier daylight saving time, use either of the following methods:

- If the TZ environment variable is defined, reset it to override the default time zone, which is the U.S. Eastern time zone. TZ is typically set (with the value that is defined in either the `/etc/environment` or `/etc/profile files`) when the system is started.
- Replace the values in the `time_t` structure with those saved from your earlier `time.h` header file.

  Note: The `time.h` header file contains declarations of all timezone-related subroutines and externals, as well as the `tm` structure.

Changes to the putenv() function and POSIX compliance

As of z/OS V1R5 C/C++, the function `putenv()` places the string passed to `putenv()` directly into the array of environment variables. This behavior assures compliance with the POSIX standard.

Prior to z/OS V1R5 C/C++, the string used to define the environment variable passed into `putenv()` was not added to the array of environment variables. Instead, the system copied the string into system-allocated storage.

To allow the POSIX-compliant behavior of `putenv()`, do nothing; it's now the default condition.

To restore the previous behavior of `putenv()`, follow these steps:
1. Ensure that the environment variable, _EDC_PUTENV_COPY, is available on your pre-z/OS V1R5 system.
2. Set the environment variable _EDC_PUTENV_COPY to "YES".

For additional information, see:
- *z/OS XL C/C++ Runtime Library Reference*
- _EDC_PUTENV_COPY in *z/OS XL C/C++ Programming Guide*

Internationalization issues

If you are running an application that was last compiled under z/OS V1R2, z/OS V1R3, or z/OS V1R4, or z/OS V1R5, be aware of the following internationalization issues:
- "Default daylight saving time change"
- "EEC default currency update" on page 109
- "Movement of LOCALDEF utilities to new data sets" on page 109

Default daylight saving time change

As of z/OS V1R9, the Language Environment default daylight saving time is changed. Functions that depend on the change to or from daylight saving time will be executed in accordance with the new default. For example, a function such as `localtime()` will use the new default daylight saving time to return the local time.

If you are using a locale that has been customized with the LC_TOD IBM extension, you can retain the previous daylight saving time. See "Daylight saving time definition" on page 107.

Note: The LC_TOD IBM extension specifies the rules used to define the beginning, end, and duration of daylight savings time, and the difference between local time and Greenwich Mean Time.

EEC default currency update

Prior to z/OS V1R6, the default currency for EEC was set to local currency in the LC_MONETARY category of the locale. If you wanted to set Euro as currency, the @euro locales would need to be set using `setlocale()`.

As of z/OS V1R6, the LC_MONETARY information in the base locale is now preset to use the Euro, which means that the Euro is the default currency. If you want your applications to continue using the old (local) currency, you will need to issue `setlocale()` with the new @preeuro locale as the parameter.

Behavior of the current @euro locales has not changed.

For z/OS V1R7 to z/OS V1R9, Venezuela is changing its currency from bolivar to bolivar fuerte. The national currency symbol changes from Bs to BSF, and the international currency symbol changes from VEB to VEF. If you want to keep using the old currency symbols, the Bs or VEB (bolivar), you must use setlocale() with a locale name of "Es_VEO" for the language-territory part, instead of "Es_VE".

As of z/OS V1R9, Malta is adopting the euro currency. If you want to keep using the old currency symbol, you must use the @preeuro locales.

Movement of LOCALDEF utilities to new data sets

As of z/OS V1R6, the following LOCALDEF utilities have been moved to new data sets.

Utility	**From C/C++ data set**	**To Language Environment data set**
LOCALDEF	CBC.SCCNUTL	CEE.SCEECLST
EDCLDEF	CBC.SCCNPRC	CEE.SCEEPROC
EDCXLDEF	CEE.SCCNPRC	CEE.SCEEPROC
CCNELDEF	CBC.SCCNCMP	CEE.SCEERUN2
CCNLMSGS	CBC.SCCNCMP	CEE.SCEERUN2

If you use the MVS batch or TSO localedef (LOCALDEF) utility interfaces, you might need to do the following:

- Add or replace the Language Environment procedures library (CEE.SCEEPROC) where you currently have the C/C++ procedures library (CBC.SCCNPRC).
- Add or replace the Language Environment clist/exec library (CEE.SCEECLST) where you currently have the C/C++ clist/exec library (CBC.SCCNUTL). In addition, you may need to customize the Language Environment customization member (CEE.SCEECLST(CEE.CEL4CUST)) in addition to customizing the C/C++ customization member (CBC.SCCNUTL(CBC.CCNCCUST)).
- Add the Language Environment library CEE.SCEERUN2 (in addition to CEE.SCEERUN) where you currently have the C/C++ library CBC.SCCNCMP.

Changes in math library functions

As of z/OS V1R9, certain IEEE754 `fdlibm` math functions are replaced by code written by IBM Research.

The earlier versions of functions that are more closely aligned with the C99 standard are no longer available. Neither the _IEEEV1_COMPATIBILITY feature test macro nor the _EDC_IEEEV1_COMPATIBILITY environment variable can be used to affect these functions.

The earlier versions of functions with performance and accuracy enhancements are still available. See Table 20 on page 111.

To use earlier versions of the IEEE754 `fdlibm` math functions, use either of the following methods:

- When using the FLOAT(IEEE) compiler option, use the _IEEEV1_COMPATIBILITY feature test macro.
- When variable mode is in effect, use environment variable _EDC_IEEEV1_COMPATIBILITY_ENV=ON.

  Note: Variable mode is in effect under either of the following conditions:
  – The _FP_MODE_VARIABLE feature test macro is used.
  – The `math.h` header file is not included.

To modify your source code to use the new performance and accuracy enhancements, use the information in Table 20 on page 111.

Table 20. IEEE754 fdlibm math functions replaced in z/OS V1R9 XL C/C++

Math functions that are enhanced for performance and accuracy	Math functions that are replaced but still available
acos()	acosl()
acosh()	asinl()
asin()	atanl()
asinh()	atan2l()
atan()	coshl()
atanh()	cosl()
atan2()	frexpl()
cbrt()	ldexpl()
cos()	log10l()
cosh()	modfl()
erf()	powl()
erfc()	sinhl()
exp()	tanl()
expm1()	tanhl()
gamma()	
hypot()	
lgamma()	
log()	
log1p()	
log10()	
pow()	
rint()	
sin()	
sinh()	
tan()	
tanh()	

Changes in floating-point support

Changes in hexadecimal floating-point support could produce unexpected results.

Hexadecimal floating-point notation

Changes in support of hexadecimal floating point notation in the numeric conversion functions introduced in *Programming languages - C (ISO/IEC 9899:1999)* can alter the behavior of well-formed applications that comply with the *Programming languages - C (ISO/IEC 9899:1990)* standard and earlier versions of the base documents. One such example would be:

```
int what_kind_of_number (char *s){
    char *endp; *EXP = "p+0"
    double d;
    long l;

    d = strtod(s,&endp);
    if (s != endp && *endp == `\0')
        printf("It is a float with value %g\n", d);          1
    else{
        l = strtol(s,&endp,0);
        if (s != endp && (strcmp(endp,EXP)== 0))
            printf("It is an integer with value %ld\n", l);    2
        else
            return 1;
    }
    return 0;
}
```

Notes:

1. If the function is called with: `what_kind_of_number ("0xAp+0")` and the runtime library is C99-compliant, the output is: `It is a float with value 10`.
2. If the function is called with: `what_kind_of_number ("0xAp+0")` and the runtime library is not C99-compliant, the output is: `It is an integer with value 10` and an exception is raised.

Figure 23. Example of how C99 changes in hexadecimal floating-point notation affect well-formed code

Floating-point special values

The numeric conversion functions accept the following special values at all times:

- ±inf or ±INF
- ±nanq or ±nanq(n-char-sequence), and ±NANQ or ±NANQ(n-char-sequence)
- ±nans or ±nans(n-char-sequence), and ±NANS or ±NANS(n-char-sequence)
- ±nan or ±nan(n-char-sequence), and ±NAN or ±NAN(n-char-sequence)

Note: Neither the z/OS XL C/C++ compiler nor the Language Environment C/C++ runtime library includes `_Imaginary` or formal support of the IEC 60559 floating point as described in Annex F and Annex G of the C99 standard.

Changes in allocation of VSAM control blocks

As of z/OS V1R10, the XL C/C++ compiler instructs VSAM, by default, to allocate control blocks and I/O buffers above the 16-MB line.

If you determine that this change could be causing a problem, you can use the VSAM JCL parameter AMP to override the default.

Changes to st_mode attribute of AF_UNIX socket files

As of z/OS V2R1, the retrieved file type of AF_UNIX socket files that are returned in st_mode is `S_IFSOCK`, rather than `S_IFCHR`. Functions `stat()`, `lstat()`, `stat_o()`, `lstat_o()`, and `__readdir2()` are affected.

You must examine programs that use the affected functions and check the type of AF_UNIX socket files to ensure compatibility with the updated function behavior.

Changes to strfmon() output

As of z/OS V2R1, the alignment of formatted output from `strfmon()` is changed. When `#n` and `(` are specified in the input of `strfmon()`, the formatted output of positive and negative values are aligned in the same columns, as required by the UNIX Standard. This causes the output of a positive value to be wider than in previous releases.

For example, the input format of `strfmon()` is `%(#5n`, which specifies that 5 digits are expected to be formatted to the left of the radix character and that negative amounts are enclosed with parentheses. Given a positive value `1234.56` and a negative value `-1234.56`, the output of `strfmon()` is as follows:

```
[  123456 ]
[( 123456)]
```

Changes to structure t_opthdr in xti.h

As of z/OS V2R1, the member type of structure `t_opthdr` is changed from `unsigned int` to `unsigned long`, when not compiling with AMODE 64.

Programs that are compiled before this change can still run correctly without being re-compiled. Warning messages about conversion between `unsigned int` and `unsigned long` might be reported at compile time if a program does not comply with the new version of structure `t_opthdr`.

Changes to getting group or user database entry

As of z/OS V2R1, the case of not found database entry is not treated as an error case. As required by the UNIX standard, when the group or user database entry that is associated with the specified name or ID is not found, the calling function will not set errno. The impacted functions are `getgrnam()`, `getpwnam()`, and `getgrgid()`.

To ensure compatibility with the updated behavior, examine your programs that get database entry by calling changed functions.

Removal of conversion table source code

As of z/OS V1R12, the C/C++ runtime library will no longer ship any ucmap source code or genxlt source code for character conversions now being performed by Unicode Services.

Users with customized conversion tables should now generate custom Unicode Services conversion tables.

Users of the iconv() family of functions testing to a "known conversion result" who experience testcase failures need to update their expected results to the new conversion results.

Users wanting to create custom conversion tables involving any of the CCSIDs related to the conversion table source no longer being shipped should now generate custom Unicode Services conversion tables instead of custom Language Environment conversion tables.

The <INSTALLATION PREFIX>.SCEEUMAP data set will no longer be shipped.

The /usr/lib/nls/locale/ucmap HFS directory will no longer be shipped.

Note: The _ICONV_TECHNIQUE environment variable must be set to the same technique search order value used for the customized Unicode Services table in order for the iconv() family of functions to use the customized Unicode Services table. For example, if you want the iconv() family of functions to use a user-defined Unicode Services table with a technique search order of 2, the _ICONV_TECHNIQUE environment variable should be set to 2LMREC.

For information about how to generate and use custom Unicode Services conversion tables, see *Support for Unicode: Using Unicode Services*, SA22-7649.

Part 5. ISO Standard C++ compliance migration issues

Programming languages - C++ (ISO/IEC 14882:2003(E)) documents the currently supported Standard C++.

As of z/OS V1R2 C++, the z/OS C++ compiler was compliant with *Programming languages - C++ (ISO/IEC 14882:1998(E))*.

As of z/OS V1R7 XL C/C++:

- z/OS C++ was compliant with *Programming languages - C++ (ISO/IEC 14882:2003(E))*.
- OS/390 V2R10 compiler was no longer shipped with the z/OS product. This means that programs compiled with the z/OS C++ compiler must be compliant with *Programming languages - C++ (ISO/IEC 14882:2003(E))* or *Programming languages - C++ (ISO/IEC 14882:1998(E))*.

Note: You can determine the ISO Standard level that is supported by the compiler by checking the standard macro `__cplusplus` and its value, which remains unchanged from z/OS V1R6 C++. This macro has the value 199711. If you are compiling a C ++ translation unit, the name `__cplusplus` is defined to the value 199711L .

The following topics discuss the implications of migrating applications that were created with C++ compilers that are not compliant with *Programming languages - C++ (ISO/IEC 14882:2003(E))*

- Chapter 18, “Language level and your Standard C++ compliance objectives,” on page 117
- Chapter 19, “Changes that affect Standard C++ compliance of language features,” on page 119

Chapter 18. Language level and your Standard C++ compliance objectives

Code that compiles without errors in pre-z/OS C++ V1R2 compilers might produce warnings or error messages in the z/OS V2R2 XL C++ compiler. This could be due either to changes in the language or to differences in the compiler behavior. Language elements that may affect your code are shown in Chapter 19, “Changes that affect Standard C++ compliance of language features,” on page 119.

Table 21 shows the Standard C++ migration objectives and the recommended approach for each.

Note: Full conformance can be achieved gradually by migrating to selected individual language features in phases.

Table 21. Standard C++ migration objectives and approaches

Is code compliant with 1998 ISO Standard C++?	**Compliance objective**	**Action**
Yes (ported or new).	Migrate to the 2003 Standard C++.	No action required.
	Remain compliant with 1998 Standard C++.	Use one of the following compiler options and suboptions: • LANGLVL(ANSI) • LANGLVL(STRICT98) **Notes:** 1. LANGLVL(ANSI) and LANGLVL(STRICT98) are synonymous. 2. You can use compiler options to control individual language features. See the "Compatability options for z/OS XL C/C++ compiler" table in the LANGLVL description, *z/OS XL C/C++ User's Guide, SC14-7307*.
No	Use Standard C++ language features, even if code must be modified.	Use the following compiler options and suboptions to aid the migration process: • LANGLVL(COMPAT92) if your code compiles with a previous compiler and you want to move to z/OS V2R2 XL C/C++ with minimal changes. **Note:** This group is the closest you can get to the behavior of the previous compilers. • For information about compiler suboptions that you can use to control individual language features, refer to "Compatability options for z/OS(R) XL C/C++ compiler" in the LANGLVL compiler option description in *z/OS XL C/C++ User's Guide, SC14-7307*.
	Avoid modifying code and ignore Standard C++ language features.	Use LANGLVL(COMPAT92) to tolerate language incompatibilities.

Chapter 19. Changes that affect Standard C++ compliance of language features

For information about setting the language level to meet your Standard C++ compliance objectives, see Chapter 18, “Language level and your Standard C++ compliance objectives,” on page 117.

Refer to the *z/OS XL C/C++ Language Reference, SC14-7308* for details.

Unqualified name lookups and the using directive

As of z/OS V1R10 XL C++ compiler, the location of the `using` directive determines how function calls are resolved.

Figure 24 provides an example of code that will be compiled differently by z/OS V1R10 XL C++ compiler than it was by earlier XL C++ compilers.

```
 }namespace bb {
  double sp1(double) { return 1.0; }
}

int main()
{
  double sp1(double);
  sp1(0);
  return 0;
}
 using namespace bb;
```

Figure 24. Example of code with a using directive

Prior to z/OS V1R10 XL C++ compiler, the compiler would resolve the call to the function `sp1` in the namespace `bb` even though the statement `using namespace bb;` is not located before the function is called inside the main routine.

In the example in Figure 24, the declaration of `sp1` in the main function is a declaration in the global namespace. As of z/OS V1R10 XL C++ compiler, the compiler will resolve that function call to the declaration in the global namespace. Because the definition of `sp1` is missing in the global namespace, the binder will generate an error message.

To avoid the error at bind time, you can modify the example in Figure 24 in any of the following ways:

- Explicitly resolve the function call to `sp1` in the namespace `bb` by using the namespace qualifier in the function call
- Implicitly resolve the function call to `sp1` in the namespace `bb` by moving the using directive above the main routine.
- Make the function definition available in the global namespace.

For detailed information, refer to The using declaration and namespaces in *z/OS XL C/C++ Language Reference, SC14-7308*.

For examples of the `using` directive in a sample program, see CCNUBRC and CLB3ATMP.CPP. These are documented in *z/OS XL C/C++ User's Guide*.

Order of destruction for statically initialized objects

As of z/OS V1R5 C++ compiler, you can use the LANGLVL(NOANSISINIT) option to maintain the order of destruction for statically initialized objects whenever you compile programs that had previously been compiled with z/OS V1R1 and earlier C++ compilers.

As of z/OS V1R2 C++ compiler, DLLs built by the compiler run object destructors differently from those created with the earlier C++ compilers.

Note: The compiler became fully compliant with the C++ 2003 standard as of z/OS V1R2 C++ compiler.

Table 22. Destruction of statically initialized objects and compliance with Standard C++

z/OS V1R1 and earlier C++ compilers	z/OS V1R2 and later compilers
Destructor calls are run as the last thing on the `atexit` list, as part of the termination code.	For objects created with the Standard C++ way of initializing (LANGLVL(ANSISINIT)): • Destructor calls for objects created by z/OS V1R2 and later compilers are added to the `atexit` list. This list will then be run before the `atexit` entry for the termination code. • Any DLL built with z/OS V1R2 and later compilers will have the destructors for the global objects run in the wrong order relative to other DLLs or main program that were built with z/OS V1R1 and earlier C++ compilers.

Implicit integer type declarations

The use of an implicit `int` in a declaration, as shown in Figure 25, does not comply with Standard C++. If you need to comply with the Standard C++, specify the type of every function and variable. Otherwise, use the LANGLVL(IMPLICITINT) option to compile code containing declarations of implicit integer types.

```
const i;   // previously meant const int i
main() { } // previously returned int
```

Figure 25. Declaration of implicit integer type.

As of z/OS V1R2 C++, the following code is no longer valid:

```
inline f() {
    return 0;
}
```

Scope of for-loop initializer declarations

In Standard C++, a variable in a `for` loop initializer declaration is declared within, and scoped to, the loop body.

If you are migrating a program that was last compiled by a pre-z/OS V1R2 C++ compiler, you should be aware that such variables were declared outside of the for-loop, and were scoped to the lexical block containing the `for-loop`. See Figure 26.

As of z/OS V1R2 C++ compiler, you can retain the original scope of a `for-loop` initializer declaration by specifying the LANGLVL(NOANSIFOR) compiler option.

```
int i=0;

void f() {
        for(int i=0; i<10; i++)   {
           if(...) break;
        }
       if(i==10) { ... }      //  1
       ...
   }
```

Note: Prior to z/OS V1R2, the variable `i` was declared outside the for-loop.

Figure 26. A for-loop initializer declaration that does not comply with Standard C++

Visibility of friend declarations

As of the z/OS V1R2 C++ compiler, a `friend` class is not visible unless it is introduced into scope by another declaration, as shown in Figure 27. To allow `friend` declarations without elaborated class names, use the LANGLVL(OLDFRIEND) option.

```
class C {
    friend class D;
};
D* p;  // error, D not in scope
```

Figure 27. friend declaration that is not visible

A `friend` class declaration must always be elaborated, as shown in Figure 28.

```
friend class C; // need class keyword
```

Figure 28. friend declaration that is made visible.

Migration of friend declarations in class member lists

A `friend` declaration in a class member list grants, to the nominated `friend` function or class, access to the private and protected members of the enclosing class. In pre-z/OS V1R2 C++ compilers, `friend` declarations introduce the name of a nominated `friend` function to the scope that encloses the class containing the `friend` declaration. As of z/OS V1R2 C++ compiler, `friend` declarations do not introduce the name of a nominated `friend` function to the scope that encloses the class containing the `friend` declaration.

The code in Figure 29 on page 122 will not compile successfully because the z/OS V2R2 XL C/C++ compiler will not know the function name `lib_func1` at the point at which it is called in the function `f`.

```
// g.C
// ---
class A {
    friend int lib_func1(int); // This function is from a library.
};
1
int f(){
    return lib_func1(1);
}
```

Note: The code in Figure 29 will compile successfully if the following declaration is added to the file in the global namespace scope at some point prior to the definition of the function named f:

```
int lib_func1(int);
```

Figure 29. Example of code that does not introduce a friend function

cv-qualifications when the thrown and caught types are the same

As of z/OS V1R2 C++ compiler:

- A temporary copy is thrown rather than the actual object itself.
- The cv-qualification in the catch clause is not considered when one of the following are true:
  - The type caught is the same (possibly cv-qualified) type as that thrown.
  - The type caught is a reference to the same (possibly cv-qualified) type.

  Note: *cv* is short form for *const/volatile*.
- New casts also throw exceptions.

This is not the case in z/OS V1R1 and earlier C++ compilers. As of z/OS V1R5 C++ compiler, there is no available option to enable pre- z/OS V1R2 behavior.

Compiler options that are introduced in C++11 standard

The following topics describe compiler options that are introduced in the C++11 standard as of z/OS V2R1 XL C++ compiler. To make an application conform to the currently supported C++11 standard, you might need to change your existing source code.

- "LANGLVL(AUTOTYPEDEDUCTION) compiler option (C++11)" on page 123
- "LANGLVL(C1XNORETURN) compiler option (C++11)" on page 123
- "LANGLVL(C99LONGLONG) compiler option (C++11)" on page 123
- "LANGLVL(C99PREPROCESSOR) compiler option (C++11)" on page 123
- "LANGLVL(CONSTEXPR) compiler option (C++11)" on page 124
- "LANGLVL(DECLTYPE) compiler option (C++11)" on page 124
- "LANGLVL(DEFAULTANDDELETE) compiler option (C++11)" on page 124
- "LANGLVL(DELEGATINGCTORS) compiler option (C++11)" on page 124
- "LANGLVL(EXPLICITCONVERSIONOPERATORS) compiler option (C++11)" on page 124
- "LANGLVL(EXTENDED0X) compiler option" on page 94
- "LANGLVL(EXTENDEDFRIEND) compiler option (C++11)" on page 124
- "LANGLVL(EXTENDEDINTEGERSAFE) compiler option (C++11)" on page 125

- "LANGLVL(EXTERNTEMPLATE) compiler option (C++11)" on page 125
- "LANGLVL(INLINENAMESPACE) compiler option (C++11)" on page 125
- "LANGLVL(REFERENCECOLLAPSING) compiler option (C++11)" on page 125
- "LANGLVL(RIGHTANGLEBRACKET) compiler option (C++11)" on page 125
- "LANGLVL(RVALUEREFERENCES) compiler option (C++11)" on page 126
- "LANGLVL(SCOPEDENUM) compiler option (C++11)" on page 126
- "LANGLVL(STATIC_ASSERT) compiler option (C++11)" on page 126
- "LANGLVL(VARIADICTEMPLATES) compiler option (C++11)" on page 126
- "WARN0X compiler option (C++11)" on page 126

Note: C++11 is a new version of the C++ programming language standard. IBM continues to develop and implement the features of the new standard. The implementation of the language level is based on IBM's interpretation of the standard. Until IBM's implementation of all the features of the C++11 standard is complete, including the support of a new C++ standard library, the implementation may change from release to release. IBM makes no attempt to maintain compatibility, in source, binary, or listings and other compiler interfaces, with earlier releases of IBM's implementation of the new features of the C++11 standard and therefore they should not be relied on as a stable programming interface.

LANGLVL(AUTOTYPEDEDUCTION) compiler option (C++11)

This option controls whether the auto type deduction feature is enabled. When LANG(AUTOTYPEDEDUCTION) is in effect, you do not need to specify a type when declaring a variable. Instead, the compiler deduces the type of an auto variable from the type of its initializer expression. The default is LANG(NOAUTOTYPEDEDUCTION). For detailed information, see **AUTOTYPEDEDUCTION | NOAUTOTYPEDEDUCTION** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(C1XNORETURN) compiler option (C++11)

This option controls whether the _Noreturn function specifier is supported. The default is LANGLVL(NOC1XNORETURN). For detailed information, see **C1XNORETURN | NOC1XNORETURN** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(C99LONGLONG) compiler option (C++11)

This option controls whether the feature of C99 long long with IBM extensions adopted in C++11 is enabled. When LANG(C99LONGLONG) is in effect, the C++ compiler provides the C99 long long with IBM extensions feature. Source compatibility between the C and the C++ language is improved. The default is LANG(NOC99LONGLONG). For detailed information, see **C99LONGLONG | NOC99LONGLONG** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(C99PREPROCESSOR) compiler option (C++11)

This option controls whether the C99 preprocessor features adopted in C++11 are enabled. When LANG(C99PREPROCESSOR) is in effect, C99 and C++11 compilers provide a common preprocessor interface, which can ease the porting of C source files to the C++ compiler and avoid preprocessor compatibility issues. The default is LANG(NOC99PREPROCESSOR). For detailed information, see **C99PREPROCESSOR | NOC99PREPROCESSOR** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(CONSTEXPR) compiler option (C++11)

This option controls whether the generalized constant expressions feature is enabled. When you specify the LANGLVL(CONSTEXPR) option, the compiler extends the expressions permitted within constant expressions. A constant expression is one that can be evaluated at compile time. The default option is LANGLVL(NOCONSTEXPR). For detailed information, see **CONSTEXPR | NOCONSTEXPR** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(DECLTYPE) compiler option (C++11)

This option controls whether the declaration type feature is enabled. When LANG(DECLTYPE) is in effect, you can get a type that is based on the resultant type of a possibly type-dependent expression. The default is LANG(NODECLTYPE). For detailed information, see **DECLTYPE | NODECLTYPE** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(DEFAULTANDDELETE) compiler option (C++11)

This option controls whether the defaulted and deleted functions feature is enabled. With this feature, you can define explicitly defaulted functions whose implementations are generated by the compiler to achieve higher efficiency. You can also define deleted functions whose usages are disabled by the compiler to avoid calling unwanted functions. The default is LANGLVL(NODEFAULTANDDELETE). For detailed information, see **DEFAULTANDDELETE | NODEFAULTANDDELETE** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(DELEGATINGCTORS) compiler option (C++11)

This option controls whether the delegating constructors feature is enabled. When LANG(DELEGATINGCTORS) is specified, you can concentrate common initializations and post initializations in one constructor, which improves the readability and maintainability of the program. The default is LANG(NODELEGATINGCTORS). For detailed information, see **DELEGATINGCTORS | NODELEGATINGCTORS** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(EXPLICITCONVERSIONOPERATORS) compiler option (C++11)

This option controls whether the explicit conversion operators feature is enabled. When you specify the LANGLVL(EXPLICITCONVERSIONOPERATORS) option, you can apply the explicit function specifier to the definition of a user-defined conversion function, and thus to inhibit unintended implicit conversions through the user-defined conversion function. The default is LANG(NOEXPLICITCONVERSIONOPERATORS). For detailed information, see **EXPLICITCONVERSIONOPERATORS | NOEXPLICITCONVERSIONOPERATORS** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(EXTENDEDFRIEND) compiler option (C++11)

Extended friend declarations which relax syntax rules governing friend declarations are supported by the new standard C++11. This feature is enabled by the new LANGLVL(EXTENDEDFRIEND) compiler option, which can also be enabled by the group option LANGLVL(EXTENDED0X). Otherwise, the feature is disabled by LANGLVL(NOEXTENDEDFRIEND). The default is LANGLVL(NOEXTENDEDFRIEND).

As of z/OS V1R11, when either LANGLVL(EXTENDEDFRIEND) or LANGLVL(EXTENDED0X) compiler option is turned on, the __IBMCPP_EXTENDED_FRIEND macro is defined with the value '1' by the compiler, and is undefined otherwise. For detailed information, see **EXTENDEDFRIEND | NOEXTENDED0XFRIEND** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(EXTENDEDINTEGERSAFE) compiler option (C++11)

With this option, if a decimal integer literal that does not have a suffix containing u or U cannot be represented by the long long int type, you can decide whether to use the unsigned long long int to represent the literal or not. The default is LANG(NOEXTENDEDINTEGERSAFE). For detailed information, see **EXTENDEDINTEGERSAFE | NOEXTENDEDINTEGERSAFE** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(EXTERNTEMPLATE) compiler option (C++11)

Explicit instantiation declarations provide you with the ability to suppress implicit instantiations of a template specialization or its members when the LANGLVL(EXTERNTEMPLATE) option is turned on. It can also be enabled by the group options LANGLVL(EXTENDED) or LANGLVL(EXTENDED0X). This feature is disabled when LANGLVL(NOEXTERNTEMPLATE) is set. The default is LANGLVL(EXTERNTEMPLATE).

As of z/OS V1R11, when LANGLVL(EXTERNTEMPLATE) is set, the macro __IBMCPP_EXTERN_TEMPLATE is defined as the preprocessing number 1, and is undefined otherwise. In both cases, the macro is protected and a compiler warning will be emitted if it is undefined or redefined. For detailed information, see **EXTERNTEMPLATE | NOEXTERNTEMPLATE** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(INLINENAMESPACE) compiler option (C++11)

This option controls whether the inline namespace definitions are enabled. A namespace definition preceded by an initial inline keyword is defined as an inline namespace. When LANG(INLINENAMESPACE) is in effect, members of the inline namespace can be defined and specialized as if they were also members of the enclosing namespace. The default is LANG(NOINLINENAMESPACE). For detailed information, see **INLINENAMESPACE | NOINLINENAMESPACE** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(REFERENCECOLLAPSING) compiler option (C++11)

This option controls whether the reference collapsing feature is enabled. The default option is LANGLVL(NOREFERENCECOLLAPSING). For detailed information, see **REFERENCECOLLAPSING | NOREFERENCECOLLAPSING** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(RIGHTANGLEBRACKET) compiler option (C++11)

This option controls whether the right angle bracket feature is enabled. The default option is LANGLVL(NORIGHTANGLEBRACKET). For detailed information, see **RIGHTANGLEBRACKET | NORIGHTANGLEBRACKET** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(RVALUEREFERENCES) compiler option (C++11)

This option controls whether the rvalue references feature is enabled. The default option is LANGLVL(NORVALUEREFERENCES). For detailed information, see **RVALUEREFERENCES | NORVALUEREFERENCES** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(SCOPEDENUM) compiler option (C++11)

This option controls whether the scoped enumeration feature is enabled. The default option is LANGLVL(NOSCOPEDENUM). For detailed information, see **SCOPEDENUM | NOSCOPEDENUM** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(STATIC_ASSERT) compiler option (C++11)

This option controls whether the static assertions feature is enabled. When LANGLVL(STATIC_ASSERT) is set, a severe error message for compile-time assertions is issued on failure. The default is LANG(NOSTATIC_ASSERT). For detailed information, see **STATIC_ASSERT | NOSTATIC_ASSERT** that is documented in *z/OS XL C/C++ User's Guide*.

LANGLVL(VARIADICTEMPLATES) compiler option (C++11)

This option controls whether the variadic templates feature is enabled. When LANGLVL(VARIADICTEMPLATES) is set, you can define class and function templates that have any number (including zero) of parameters. The default is LANG(NOVARIADICTEMPLATES). For detailed information, see **VARIADICTEMPLATES | NOVARIADICTEMPLATES** that is documented in *z/OS XL C/C++ User's Guide*.

WARN0X compiler option (C++11)

The compiler option WARN0X controls whether to inform users with messages about differences in their programs caused by the migration from C++98 standard to C++11 standard. The default is NOWARN0X. For detailed information, see **WARN0X | NOWARN0X** that is documented in *z/OS XL C/C++ User's Guide*.

Errors due to changes in compiler behavior

This topic describes coding that compiles without errors in z/OS V1R1 and earlier C/C++ compilers but produces errors or warnings as of z/OS V1R7 XL C/C++ compiler. For more details on compiler messages, refer to *z/OS XL C/C++ Messages, GC14-7305*.

C++ class access errors

If your code has not been updated since z/OS V1R2, compiling it could raise exceptions because of changes in Standard C++ compliance. See "CCN5413 exception" and "CCN5193 exception" on page 127.

CCN5413 exception

An access specifier determines the accessibility of members that follow it, either until the next access specifier or until the end of the class definition. Violation of this rule will result in the following error message:

```
CCN5413:"A::B" is already declared with a different access
```

If you later define a class member within its class definition, its access specification must be the same as its declaration. The code in Figure 30 on page 127 violates this rule.

```
class A {
  public:
    class B;
      private:
    class B {};      1
};
```

Note: The compiler will not allow the definition of class `B` because this class has already been declared as private. To correct the program, remove the `private` keyword.

Figure 30. Code that results in CCN5413 exceptions

CCN5193 exception

When you specify a friend within a class, you must use the class name instead of the type-definition name. Without modification, the code in Figure 31 would result in the following error message:

```
CCN5193: A typedef name cannot be used in this context
```

```
    class A { };
    typedef A B;
    class C {
        friend class B;    1
    };
```

Note: Do not use the type-definition name; instead, use the name of the class:

```
friend class A;
```

Figure 31. Example: Correcting a type-definition name used out of context

Exceptions caused by ambiguous overloads

Programming languages - C (ISO/IEC 9899:2003) introduced error messages for standard floating point and long double overloads of standard math functions.

As of z/OS V1R2 C++ compiler, compiling the code in Figure 32 will produce the following error message:

```
CCN5219: The call to "pow" has no best match
```

To handle the exception, you could specify the LANGLVL(OLDMATH) option, which removes the float and long double overloads. If you don't want to remove the overloads, you can modify the code by casting the `pow` arguments.

```
    #include <math.h>
    int main()
    {
        float a = 137;
        float b;
        b = pow(a, 2.0);      1
        return 0;
    }
```

Note: The call to `pow` has no best match. To fix the problem, cast `2.0` to be of type `float`:

```
    b = pow(a, (float)2.0);
```

Figure 32. Code modification to handle CCN5219 exception

Exceptions caused by user-defined conversions

User-defined conversions must be unambiguous, or they are not called.

```
//e.C
struct C {};
struct A {
    A();
    A(const C &);
    A(const A &);
};
struct B {
    operator A() const { A a ; return a;};
    operator C() const { C c ; return c;};
};
void f(A x) {};
int main(){
    B b;
    f((A)b);  // The call matches two constructors for A instead of calling operator A()
    return 0;
}
```

Figure 33. Ambiguous user-defined conversions

Error messages: Error messages are listed below.

```
CCN5216: An expression of type B cannot be converted to A.
CCN5219: The call to "A::A" has no best match.
CCN6228: Argument number 1 is an lvalue of type "B".
CCN6202: No candidate is better than "A::A(const A&)".
CCN6231: The conversion from argument number 1 to "const A &" uses the
user-defined conversion "B::operator A() const" followed by an
lvalue-to-rvalue transformation.
CCN6202: No candidate is better than "A::A(const C &)".
CCN6231: The conversion from argument number 1 to "const C &" uses the
user-defined conversion "B::operator C() const ".
```

Potential solutions: Possible solutions are listed below.

- Changing `f((A)b)` to the explicit call `f(b.operator A())`
- Removing the constructor `A(const C &)`
- Adding a constructor `A(B)`
- Removing either operator `A()` or operator `C()`

Note: The solution you choose depends on your access to classes A and B.

Issues caused by the use of incomplete types in exception-specifications

A type that is denoted in an exception-specification should not denote an incomplete type. Otherwise, the compiler will diagnose with a severe error where there is an incomplete class type, and an error message is produced. For example:

```
struct MyExcept;
void f1() throw (MyExcept);
```

The compiler is required to produce a diagnostic.

The requirement for a complete class means that templates might be instantiated. For example:

```
template <unsigned N>
struct A {
  __static_assert(N != 0, "Error");
};

void f2() throw (A<0>);
```

The template specialization `A<0>` is instantiated from the definition of the primary template, resulting in a static assertion error.

Syntax errors with array new

Prior to z/OS V1R2, C/C++ compilers treated the following two statements as semantically equivalent:

```
    new (int *) [1];  //*Syntactially incorrect statement
    new int* [1];
```

The first statement is syntactically incorrect even in older versions of the C++ Standard. However, previous versions of C++ accepted it.

As of z/OS V1R2, the C/C++ compiler will produce a compilation error message that specifies the syntactically incorrect statement.

Part 6. Migration issues for C/C++ applications that use other IBM products

The following topics provide information about migration issues resulting from enhancements to the interoperability between XL C/C++ and the other products:

- Chapter 20, "Migration issues with earlier C/C++ applications that run CICS statements," on page 133
- Chapter 21, "Migration issues with earlier C/C++ applications that use DB2," on page 139

Chapter 20. Migration issues with earlier C/C++ applications that run CICS statements

This topic provides information about:

- "Migration of CICS statements from pre-OS/390 C/C++ applications"
- "Migration of CICS statements from earlier XL C/C++ applications" on page 135

Migration of CICS statements from pre-OS/390 C/C++ applications

When you are migrating applications or programs with CICS statements from pre-OS/390 C/C++ applications, be aware of changes and constraints in the following areas:

- "CICS statement translation options"
- "HEAP option used with the interface to CICS"
- "User-developed exit routines"
- "Multiple libraries under CICS"

CICS statement translation options

As of z/OS V1R7 XL C/C++ compiler, there is an new option for translating CICS statements into C or C++ code: the z/OS XL C/C++ compiler integrated CICS translator. The standalone CICS translator remains a translation option. For information about when to use the new option, refer to Translating and compiling for reentrancy in *z/OS XL C/C++ Programming Guide, SC14-7315*.

HEAP option used with the interface to CICS

In C/370 V2, the location of heap storage under CICS was primarily determined by the residence mode (RMODE) of the program.

With Language Environment services, heap storage is determined only by the HEAP(,,ANYWHERE|BELOW) options. RMODE does not affect where the heap is allocated. If the location of heap storage is important, you might want to change the source code accordingly.

User-developed exit routines

With Language Environment services in a CICS environment, abnormal termination exit routine CEECDATX is automatically linked at installation time.

This change affects you if you have supplied, or need to supply, your own exit routine. The sample exit routine had been available in the sample library provided with AD/Cycle LE/370 V1R3. It automatically generates a system dump (with abend code 4039) whenever an abnormal termination occurs.

You can modify CEECDATX to suppress the dumps. CEECDATX is available in a z/OS V2R2 XL C/C++ runtime library.

Multiple libraries under CICS

You cannot run two different sets of runtime services within one CICS region.

Both the C/370 V2 CICS interface (EDCCICS) and the Language Environment CICS interface could be present in a CICS system through CEDA/PPT definitions and inclusion of modules in the APF STEPLIB. If both interfaces are present, the Language Environment interface will be initialized by CICS when the region is initialized.

You should be aware of changes and constraints in the following areas:
- "CICS abend codes and messages"
- "CICS reason codes"
- "Standard stream support under CICS"
- "Changes in stderr output under CICS" on page 135
- "Transient data queue names under CICS" on page 135

CICS abend codes and messages

As of z/OS V1R7 XL C/C++ compiler, when you use the CICS option to compile programs with embedded CICS statements, the compiler will issue messages whenever it detects a syntax error before a CICS statement is fully parsed. After a CICS statement is fully parsed, CICS will issue any required messages as described in *CICS Messages and Codes*. The compiler will prepend these CICS messages with product and line numbers and then merge them with the other compiler messages in a single message area.

Abend codes (for example, ACC2) that were used by C/370 V2 under CICS are not issued; the equivalent Language Environment abend code (for example, 4*nnn*) is issued instead.

Default option for ABTERMENC changed to ABEND

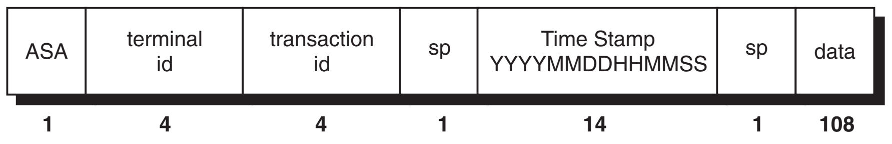
As of OS/390 V2R9, the default option for ABTERMENC is ABEND instead of RETCODE. If you are expecting the default behavior of ABTERMENC to be RETCODE, you must change the setting in CEECOPT. For details on changing CEECOPT, refer to *z/OS Language Environment Customization, SA38-0685*.

CICS reason codes

Reason codes that appeared in the CICS message console log have been changed. The current codes are documented in *z/OS Language Environment Debugging Guide*.

Standard stream support under CICS

With Language Environment services, CICS records sent to the transient data queues associated with `stdout` and `stderr` with default settings take the format of the message shown in Figure 34 on page 135.



where:

ASA is the carriage-control character

terminal id
is a 4-character terminal identifier

transaction id
is a 4-character transaction identifier

sp is a space

Time Stamp
is the date and time displayed in the format YYYYMMDDHHMMSS

data is the data sent to the standard streams `stdout` and `stderr`.

Figure 34. 1 ASA 4 terminal ID 4 transaction ID 1 sp 14 time stamp 1 sp 108 data

With Language Environment services, CICS records are sent in this format, whether they are directed to the transient data queues associated with `stdout` and `stderr`. You should be aware of this change if you are migrating to z/OS V2R2 XL C/C++ compiler, because, previously, this message format had been used for messages directed to the data queue associated with `stdout` only.

Changes in stderr output under CICS

Output from `stderr` is sent to the CICS transient data queue, CESE, which is also used for Language Environment runtime error messages, dumps, and storage reports. If you previously used this file exclusively for C/370 `stderr` output, you should note that the output might be different than you expect.

Transient data queue names under CICS

Table 23C/370 transient data queue names are mapped to Language Environment transient data queue names:

Table 23. Transient data queue names under CICS

C/370 name	Language Environment name
CCSI	CESI
CCSO	CESO
CCSE	CESE

Migration of CICS statements from earlier XL C/C++ applications

When you are migrating applications or programs with CICS statements from earlier C/C++ applications, be aware of the following possibilities:

- “CICS TS V4.1 with "Extended MVS Linkage Convention"” on page 136
- “Customized CEECCSD.COPY and CEECCSDX.COPY files and iconv() changes” on page 136

CICS TS V4.1 with "Extended MVS Linkage Convention"

The FLOAT(AFP) compiler option instructs the compiler to generate code that uses the full complement of 16 floating-point registers (FPRs). The four original floating-point registers are numbered FPR0, FPR2, FPR4, and FPR6; the additional floating-point (AFP) registers are numbered FPR 1, FPR 3, FPR 5, FPR 7 and FPRs 8 through 15. By convention, FPRs 1, 3, 5, and 7 are always volatile. This means that any called routine could change their values without saving and restoring the original values. However, FPRs 8 through 15 are considered non-volatile by the caller.

In z/OS V1R9 XL C/C++ compiler (and later compilers), FLOAT(AFP) supports the VOLATILE | NOVOLATILE suboption. The default is NOVOLATILE; the compiler assumes that any called subroutines will preserve the values in registers FPRs 8 through 15. It is safe to use NOVOLATILE in most environments, including batch. However, CICS environments prior to CICS TS V4.1 use FPRs 7 through 15 to perform their own task switching. Therefore, you need to specify the FLOAT(AFP(VOLATILE)) option to instruct the compiler to treat FPRs 8 through 15 as volatile.

As of CICS TS V4.1, CICS TS fully supports MVS Linkage conventions. Therefore, if you are compiling floating point code to be run on CICS TS V4.1, you no longer need to use the FLOAT(AFP(VOLATILE)) option.

Customized CEECCSD.COPY and CEECCSDX.COPY files and iconv() changes

As of z/OS V1R9, load modules for `iconv()` converters have been renamed in the two CICS sample files CEECCSD.COPY and CEECCSDX.COPY. If your CEECCSD.COPY and CEECCSDX.COPY files have been customized, you need to rename the affected load module entries. Otherwise, the `iconv_open()` and `iconv_close()` functions cannot distinguish between a customer-created converter and a converter shipped with the Language Environment element.

Language Environment converters are:

- Direct converters (including GENXLT, C and Direct Unicode Converters).
- Indirect Binary converter tables (shipped in <hlq>.SCEEUTBL).
- Indirect Binary converter tables (shipped in the HFS).

Renaming direct converters

The Direct converters are shipped as load modules in <hlq>.SCEERUN for 31-bit base code, and in <hlq>.SCEERUN2 for XPLINK and 64-bit base code.

Direct converters for 31-bit base code: Prior to z/OS V1R9, direct converters for 31-bit base code are shipped as load modules in <hlq>.SCEERUN with a four character prefix of either CEUU or EDCU, with an alias defined for the unshipped prefix. For example, if a given converter's load module has a name of CEUUxxxx, it will also have an alias of EDCUxxxx.

Change the prefix for all 31-bit base direct converters to CEUL. An alias prefix will not be required. In other words:

- A direct converter that was named EDCUxxxx in <hlq>.SCEERUN with an alias of CEUUxxxx will be named CEULxxxx in <hlq>.SCEERUN without an alias.
- A direct converter that was named CEUUxxxx in <hlq>.SCEERUN with an alias of EDCUxxxx will be named CEULxxxx in <hlq>.SCEERUN without an alias.

Direct converters for XPLINK processing: Direct converters for XPLINK processing are shipped as load modules in <hlq>.SCEERUN2 with a four character prefix of CEHU. Change the load module prefix for all direct converters for XPLINK to CEHL. In other words, a direct converter that was named CEHUxxxx in <hlq>.SCEERUN2 will be named CEHLxxxx in <hlq>.SCEERUN2.

Direct converters for 64-bit base code: Direct converters for 64-bit base code are shipped as load modules in <hlq>.SCEERUN2 with a four character prefix of CEQU. Change the load module prefix for all 64-bit direct converters to CEQL. In other words, a direct converter that was named CEQUxxxx in <hlq>.SCEERUN2 will be named CEQLxxxx in <hlq>.SCEERUN2.

Renaming indirect binary converter tables

Prior to z/OS V1R9, the indirect binary converter tables (ucmap binaries) were shipped in <hlq>.SCEEUTBL with a prefix of EDCU or CEUU, with aliases CEHU for XPLINK and CEQU for 64-bit programs. Change the prefix name for the ucmap binary converter tables in <hlq>.SCEEUTBL to CEUL, with alias name prefixes of CEHL for XPLINK and CEQL for 64-bit base code. In other words, an indirect binary converter table that was named EDCUxxxx in <hlq>.SCEEUTBL will be named CEULxxxx, with alias names of CEHLxxxx and CEQLxxxx.

Renaming HFS indirect binary converter tables

As of z/OS V1R9, the indirect binary converter tables (ucmap binaries) shipped in the HFS directory `/usr/lib/nls/locale/uconvTable` are named with a suffix of `.libcnvtbl`. Add the suffix `libcnvtbl` to the names of all ucmap binary converter tables in the HFS directory `/usr/lib/nls/locale/uconvTable`. In other words, an indirect binary converter table currently named `IBM-xxxxx` will be renamed to `IBM-xxxxx.libcnvtbl`.

Chapter 21. Migration issues with earlier C/C++ applications that use DB2

When you are migrating C/C++ applications that use IBM DB2 services, be aware of the removal of the Database Access Class Library utility.

In addition, beware of the following information:
- "Namespace violations and SQL coprocessor-based compilations"
- "Potential need to specify DBRMLIB with the SQL option" on page 141

Related information: See the following related information.
- For more information about the IBM XL C/C++ DB2 coprocessor, refer to "Using the XL C/C++ DB2 coprocessor" in *z/OS XL C/C++ Programming Guide*.
- For detailed information about using these macros with the SQL option, refer to SQL | NOSQL in *z/OS XL C/C++ User's Guide*.
- For DB2-supplied documentation, see http://publib.boulder.ibm.com/infocenter/db2luw/v8/.

Namespace violations and SQL coprocessor-based compilations

As of z/OS V1R10 XL C/C++ compiler, when you use the SQL option for SQL coprocessor-based compilations, you can modify your source code to handle an error condition that would result from using an identifer that has the same name as one of the new predefined but unprotected macros added in this release. The names of unprotected macros are in the preprocessing namespace.

Note: Typically, C/C++ compilers treat predefined, unprotected macros as if the source code had been preprocessed with a `#define` directive (such as `#define SQL_VARBINARY_INIT(s) {sizeof(s)-1, s}`).

The XL C/C++ compiler recognizes the following macros as predefined but unprotected:
- SQL_VARBINARY_INIT
- SQL_BLOB_INIT
- SQL_CLOB_INIT
- SQL_DBCLOB_INIT

For example, if you use the z/OS V2R2 XL C/C++ compiler to compile the source code shown in Figure 35 with the SQL option, a message will inform you that the macro is already defined.

Note: If you use a pre-z/OS V1R10 compiler, you will get undetermined results.

```
--- test.c ---
#define SQL_VARBINARY_INIT 1
--- end test.c ---
```

Figure 35. Sample source code

To avoid the error condition you can:

- Perform a macro definition check and handle the error condition, as shown in Figure 36.
- Explicitly undefine the macro, as shown in Figure 38.

Example: Performing a macro definition check

If you run a macro definition check on the SQL_ . . . _INIT identifier, you can specify a preprocessing path that is based on the return code generated by the check.

For example:

- Compiling the code in Figure 36 with the SQL option, and then running it, would generate a return code of "55" if the compiler is z/OS V1R10 XL C/C++ or later, and "66" if a previous version of the compiler is used.
- Compiling the code in Figure 37 with the SQL option, and then running it, would generate a return code of "55".

```
--- test.c ---
#ifdef SQL_VARBINARY_INIT
  int a = 55;
  #else
    int a = 66;
#endif

int main(void) {
  return a;
}
--- end test.c ---
```

Figure 36. Portable macro definition check

```
EXEC SQL INCLUDE SQLCA;

int main(void) {
 EXEC SQL BEGIN DECLARE SECTION;
  #ifdef SQL_VARBINARY_INIT
   SQL TYPE IS VARBINARY(100) myvar = SQL_VARBINARY_INIT("abc");
  #else
   SQL TYPE IS VARBINARY(100) myvar = {sizeof("abc")-1, "abc"};
  #endif
 EXEC SQL END DECLARE SECTION;
 return 55;
}
```

Figure 37. Macro definition check and compiler invocation

Example: Explicitly undefining and redefining a macro

The code in Figure 38 will always be compiled successfully with or without the SQL option because it is completely valid for users to undefine and redefine the various SQL_*_INIT macros.

```
--- test.c ---
#undef SQL_VARBINARY_INIT
#define SQL_VARBINARY_INIT 1
--- end test.c ---
```

Figure 38. Explicitly undefining a macro

Potential need to specify DBRMLIB with the SQL option

As of z/OS V1R9 XL C/C++ compiler, it is not necessary to specify the DBRMLIB option with the SQL option. For information about using these options, see *z/OS XL C/C++ User's Guide*.

When your source code has embedded SQL statements, you need to use DBRMLIB with SQL only when the specified APARs have been applied to z/OS V1R8 XL C with APAR PK38679.

For more information about using SQL statements, refer to *DB2 Application Programming and SQL Guide*. Useful topics include:

- "Processing SQL statements by using the DB2 coprocessor"
- "Preparing an external SQL procedure by using JCL" (lists the external SQL procedure samples shipped with DB2).

Note: The PHASEID compiler option shows the latest PTF that has been applied to the compiler. For detailed information, refer to PHASEID compiler option in *z/OS XL C/C++ User's Guide, SC14-7307*.

Part 7. Appendixes

Appendix. Accessibility

Accessible publications for this product are offered through IBM Knowledge Center (http://www.ibm.com/support/knowledgecenter/SSLTBW/welcome).

If you experience difficulty with the accessibility of any z/OS information, send a detailed message to the "Contact us" web page for z/OS (http://www.ibm.com/systems/z/os/zos/webqs.html) or use the following mailing address.

IBM Corporation
Attention: MHVRCFS Reader Comments
Department H6MA, Building 707
2455 South Road
Poughkeepsie, NY 12601-5400
United States

Accessibility features

Accessibility features help users who have physical disabilities such as restricted mobility or limited vision use software products successfully. The accessibility features in z/OS can help users do the following tasks:

- Run assistive technology such as screen readers and screen magnifier software.
- Operate specific or equivalent features by using the keyboard.
- Customize display attributes such as color, contrast, and font size.

Consult assistive technologies

Assistive technology products such as screen readers function with the user interfaces found in z/OS. Consult the product information for the specific assistive technology product that is used to access z/OS interfaces.

Keyboard navigation of the user interface

You can access z/OS user interfaces with TSO/E or ISPF. The following information describes how to use TSO/E and ISPF, including the use of keyboard shortcuts and function keys (PF keys). Each guide includes the default settings for the PF keys.

- *z/OS TSO/E Primer*
- *z/OS TSO/E User's Guide*
- *z/OS V2R2 ISPF User's Guide Vol I*

Dotted decimal syntax diagrams

Syntax diagrams are provided in dotted decimal format for users who access IBM Knowledge Center with a screen reader. In dotted decimal format, each syntax element is written on a separate line. If two or more syntax elements are always present together (or always absent together), they can appear on the same line because they are considered a single compound syntax element.

Each line starts with a dotted decimal number; for example, `3` or `3.1` or `3.1.1`. To hear these numbers correctly, make sure that the screen reader is set to read out punctuation. All the syntax elements that have the same dotted decimal number (for example, all the syntax elements that have the number `3.1`) are mutually exclusive alternatives. If you hear the lines `3.1 USERID` and `3.1 SYSTEMID`, your syntax can include either `USERID` or `SYSTEMID`, but not both.

The dotted decimal numbering level denotes the level of nesting. For example, if a syntax element with dotted decimal number 3 is followed by a series of syntax elements with dotted decimal number 3.1, all the syntax elements numbered 3.1 are subordinate to the syntax element numbered 3.

Certain words and symbols are used next to the dotted decimal numbers to add information about the syntax elements. Occasionally, these words and symbols might occur at the beginning of the element itself. For ease of identification, if the word or symbol is a part of the syntax element, it is preceded by the backslash (\) character. The `*` symbol is placed next to a dotted decimal number to indicate that the syntax element repeats. For example, syntax element `*FILE` with dotted decimal number 3 is given the format `3 \* FILE`. Format `3* FILE` indicates that syntax element `FILE` repeats. Format `3* \* FILE` indicates that syntax element `* FILE` repeats.

Characters such as commas, which are used to separate a string of syntax elements, are shown in the syntax just before the items they separate. These characters can appear on the same line as each item, or on a separate line with the same dotted decimal number as the relevant items. The line can also show another symbol to provide information about the syntax elements. For example, the lines `5.1*, 5.1 LASTRUN, and 5.1 DELETE` mean that if you use more than one of the `LASTRUN` and `DELETE` syntax elements, the elements must be separated by a comma. If no separator is given, assume that you use a blank to separate each syntax element.

If a syntax element is preceded by the `%` symbol, it indicates a reference that is defined elsewhere. The string that follows the `%` symbol is the name of a syntax fragment rather than a literal. For example, the line `2.1 %OP1` means that you must refer to separate syntax fragment OP1.

The following symbols are used next to the dotted decimal numbers.

`? indicates an optional syntax element`
The question mark (?) symbol indicates an optional syntax element. A dotted decimal number followed by the question mark symbol (?) indicates that all the syntax elements with a corresponding dotted decimal number, and any subordinate syntax elements, are optional. If there is only one syntax element with a dotted decimal number, the ? symbol is displayed on the same line as the syntax element, (for example `5? NOTIFY`). If there is more than one syntax element with a dotted decimal number, the ? symbol is displayed on a line by itself, followed by the syntax elements that are optional. For example, if you hear the lines `5 ?, 5 NOTIFY`, and `5 UPDATE`, you know that the syntax elements `NOTIFY` and `UPDATE` are optional. That is, you can choose one or none of them. The ? symbol is equivalent to a bypass line in a railroad diagram.

`! indicates a default syntax element`
The exclamation mark (!) symbol indicates a default syntax element. A dotted decimal number followed by the ! symbol and a syntax element indicate that the syntax element is the default option for all syntax elements that share the same dotted decimal number. Only one of the syntax elements that share the dotted decimal number can specify the ! symbol. For example, if you hear the lines `2? FILE, 2.1! (KEEP), and 2.1 (DELETE)`, you know that `(KEEP)` is the

default option for the FILE keyword. In the example, if you include the FILE keyword, but do not specify an option, the default option KEEP is applied. A default option also applies to the next higher dotted decimal number. In this example, if the FILE keyword is omitted, the default FILE(KEEP) is used. However, if you hear the lines 2? FILE, 2.1, 2.1.1! (KEEP), and 2.1.1 (DELETE), the default option KEEP applies only to the next higher dotted decimal number, 2.1 (which does not have an associated keyword), and does not apply to 2? FILE. Nothing is used if the keyword FILE is omitted.

*** indicates an optional syntax element that is repeatable**
The asterisk or glyph (*) symbol indicates a syntax element that can be repeated zero or more times. A dotted decimal number followed by the * symbol indicates that this syntax element can be used zero or more times; that is, it is optional and can be repeated. For example, if you hear the line 5.1* data area, you know that you can include one data area, more than one data area, or no data area. If you hear the lines 3* , 3 HOST, 3 STATE, you know that you can include HOST, STATE, both together, or nothing.

Notes:

1. If a dotted decimal number has an asterisk (*) next to it and there is only one item with that dotted decimal number, you can repeat that same item more than once.
2. If a dotted decimal number has an asterisk next to it and several items have that dotted decimal number, you can use more than one item from the list, but you cannot use the items more than once each. In the previous example, you can write HOST STATE, but you cannot write HOST HOST.
3. The * symbol is equivalent to a loopback line in a railroad syntax diagram.

+ indicates a syntax element that must be included
The plus (+) symbol indicates a syntax element that must be included at least once. A dotted decimal number followed by the + symbol indicates that the syntax element must be included one or more times. That is, it must be included at least once and can be repeated. For example, if you hear the line 6.1+ data area, you must include at least one data area. If you hear the lines 2+, 2 HOST, and 2 STATE, you know that you must include HOST, STATE, or both. Similar to the * symbol, the + symbol can repeat a particular item if it is the only item with that dotted decimal number. The + symbol, like the * symbol, is equivalent to a loopback line in a railroad syntax diagram.

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Policy for unsupported hardware

Various z/OS elements, such as DFSMS, HCD, JES2, JES3, and MVS, contain code that supports specific hardware servers or devices. In some cases, this device-related element support remains in the product even after the hardware devices pass their announced End of Service date. z/OS may continue to service element code; however, it will not provide service related to unsupported hardware devices. Software problems related to these devices will not be accepted for service, and current service activity will cease if a problem is determined to be associated with out-of-support devices. In such cases, fixes will not be issued.

Minimum supported hardware

The minimum supported hardware for z/OS releases identified in z/OS announcements can subsequently change when service for particular servers or devices is withdrawn. Likewise, the levels of other software products supported on a particular release of z/OS are subject to the service support lifecycle of those products. Therefore, z/OS and its product publications (for example, panels, samples, messages, and product documentation) can include references to hardware and software that is no longer supported.

- For information about software support lifecycle, see: IBM Lifecycle Support for z/OS (http://www.ibm.com/software/support/systemsz/lifecycle/)
- For information about currently-supported IBM hardware, contact your IBM representative.

Programming interface information

This publication documents *intended* Programming Interfaces that allow the customer to write z/OS XL C/C++ programs.

Standards

The following standards are supported in combination with the Language Environment element:

- The C language is consistent with *Programming languages - C (ISO/IEC 9899:1999)* and a subset of *Programming languages - C (ISO/IEC 9899:2011)*. For more information on ISO, visit their website at http://www.iso.org.
- The C++ language is consistent with *Programming languages - C++ (ISO/IEC 14882:1998)*, *Programming languages - C++ (ISO/IEC 14882:2003(E))*, and a subset of *Programming languages - C++ (ISO/IEC 14882:2011)*.

The following standards are supported in combination with the Language Environment and z/OS UNIX System Services elements:

- A subset of *IEEE Std. 1003.1-2001 (Single UNIX Specification, Version 3)*. For more information on IEEE, visit their website at http://www.iso.org.
- *IEEE Std 1003.1—1990, IEEE Standard Information Technology—Portable Operating System Interface (POSIX)—Part 1: System Application Program Interface (API) [C language]*, copyright 1990 by the Institute of Electrical and Electronic Engineers, Inc.
- The core features of *IEEE P1003.1a Draft 6 July 1991, Draft Revision to Information Technology—Portable Operating System Interface (POSIX), Part 1: System Application Program Interface (API) [C Language]*, copyright 1992 by the Institute of Electrical and Electronic Engineers, Inc.
- *IEEE Std 1003.2—1992, IEEE Standard Information Technology—Portable Operating System Interface (POSIX)—Part 2: Shells and Utilities*, copyright 1990 by the Institute of Electrical and Electronic Engineers, Inc.
- The core features of *IEEE Std P1003.4a/D6—1992, IEEE Draft Standard Information Technology—Portable Operating System Interface (POSIX)—Part 1: System Application Program Interface (API)—Amendment 2: Threads Extension [C language]*, copyright 1990 by the Institute of Electrical and Electronic Engineers, Inc.

- The core features of *IEEE 754-1985 (R1990) IEEE Standard for Binary Floating-Point Arithmetic (ANSI)*, copyright 1985 by the Institute of Electrical and Electronic Engineers, Inc.
- *X/Open CAE Specification, System Interfaces and Headers, Issue 4 Version 2*, copyright 1994 by The Open Group
- *X/Open CAE Specification, Networking Services, Issue 4*, copyright 1994 by The Open Group
- *X/Open Specification Programming Languages, Issue 3, Common Usage C*, copyright 1988, 1989, and 1992 by The Open Group
- United States Government's *Federal Information Processing Standard (FIPS) publication for the programming language C, FIPS-160*, issued by National Institute of Standards and Technology, 1991

Trademarks

Bibliography

This bibliography lists the publications for IBM products that are related to z/OS XL C/C++. It includes publications covering the application programming task. The bibliography is not a comprehensive list of the publications for these products, however, it should be adequate for most z/OS XL C/C++ users. Refer to *z/OS V2R2 Information Roadmap, SA23-2299*, for a complete list of publications belonging to the z/OS product.

z/OS

- *z/OS Introduction and Release Guide, GA32-0887*
- *z/OS Planning for Installation, GA32-0890*
- *z/OS Summary of Message and Interface Changes, SA23-2300*
- *z/OS V2R2 Information Roadmap, SA23-2299*
- *z/OS Licensed Program Specifications, GA32-0888*
- *z/OS Migration, GA32-0889*
- *z/OS Program Directory, GI11-9848*

z/OS XL C/C++

- *z/OS XL C/C++ Programming Guide, SC14-7315*
- *z/OS XL C/C++ User's Guide, SC14-7307*
- *z/OS XL C/C++ Language Reference, SC14-7308*
- *z/OS XL C/C++ Messages, GC14-7305*
- *z/OS XL C/C++ Runtime Library Reference, SC14-7314*
- *z/OS C Curses, SA38-0690*
- *z/OS XL C/C++ Compiler and Runtime Migration Guide for the Application Programmer, GC14-7306*
- *Standard C++ Library Reference, SC14-7309*

z/OS Metal C Runtime Library

- *z/OS Metal C Programming Guide and Reference, SC14-7313*

z/OS Runtime Library Extensions

- *z/OS Common Debug Architecture User's Guide, SC14-7310*
- *z/OS Common Debug Architecture Library Reference, SC14-7311*
- *DWARF/ELF Extensions Library Reference, SC14-7312*

Debug Tool

- Debug Tool documentation, which is available at http://www.ibm.com/software/awdtools/debugtool/library/.

z/OS Language Environment

- *z/OS V2R1.0 Language Environment Concepts Guide, SA38-0687*
- *z/OS Language Environment Customization, SA38-0685*
- *z/OS Language Environment Debugging Guide, GA32-0908*
- *z/OS Language Environment Programming Guide, SA38-0682*
- *z/OS Language Environment Programming Reference, SA38-0683*

- *z/OS V2R1.0 Language Environment Runtime Application Migration Guide, GA32-0912*
- *z/OS V2R1.0 Language Environment Writing Interlanguage Communication Applications, SA38-0684*
- *z/OS Language Environment Runtime Messages, SA38-0686*

Assembler

- *HLASM Language Reference, SC26-4940*
- *HLASM Programmer's Guide, SC26-4941*

COBOL

- COBOL documentation, which is available at: http://www.ibm.com/software/awdtools/cobol/zos/library/.

PL/I

- PL/I documentation, which is available at http://www.ibm.com/software/awdtools/pli/plizos/library/.

VS FORTRAN

- VS FORTRAN documentation, which is available at http://www.ibm.com/software/awdtools/fortran/vsfortran/library.html.

CICS Transaction Server for z/OS

- CICS Transaction Server for z/OS documentation, which is available at: http://www.ibm.com/software/htp/cics/

DB2

- DB2 for z/OS documentation, which is available at http://www.ibm.com/software/data/db2/zos/library.html.

IMS/ESA®

- IMS documentation, which is available at http://www.ibm.com/software/data/ims/library.html.

MVS

- *z/OS MVS Program Management: User's Guide and Reference, SA23-1393*
- *z/OS MVS Program Management: Advanced Facilities, SA23-1392*

QMF

- QMF documentation, which is available at http://www.ibm.com/software/data/qmf/library.html.

DFSMS

- *z/OS DFSMS Introduction, SC23-6851*
- *z/OS DFSMS Managing Catalogs, SC23-6853*
- *z/OS DFSMS Using Data Sets, SC23-6855*
- *z/OS DFSMS Macro Instructions for Data Sets, SC23-6852*
- *z/OS DFSMS Access Method Services Commands, SC23-6846*

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