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WebSphere® Development Studio: ILE COBOL Programmer's Guide

Version 5

SC09-2540-04

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WebSphere® Development Studio: ILE COBOL Programmer's Guide

Version 5

SC09-2540-04

Note!
Before using this information and the product it supports, be sure to read the general information under “Notices” on page 647.

Fifth Edition (May 2004)

This edition applies to Version 5, Release 3, Modification Level 0, of IBM WebSphere Development Studio for iSeries (5722-WDS) and to all subsequent releases and modifications until otherwise indicated in new editions. This edition applies only to reduced instruction set computer (RISC) systems.

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About This Guide

This guide describes how to write, compile, bind, run, debug, and maintain Integrated Language Environment (ILE) COBOL compiler programs on the Operating System/400 (OS/400). It provides programming information on how to call other ILE COBOL and non-ILE COBOL programs, share data with other programs, use pointers, and handle exceptions. It also describes how to perform input/output operations on externally attached devices, database files, display files, and ICF files.

Using this book, you will be able to:
- Design and code ILE COBOL programs
- Enter, compile, and bind ILE COBOL programs
- Run and debug ILE COBOL programs
- Study coded ILE COBOL examples.

Note: You should be familiar with Chapters 1 through 6 of this guide before proceeding to the other chapters.

This book refers to other IBM® publications. These publications are listed in the "Bibliography" on page 651 with their full title and base order number. When they are referred to in text, a shortened version of the title is used.

Who Should Use This Guide

This guide is intended for application programmers who have some experience with the COBOL programming language and for the operators who run the programs. It is a guide to programming in the ILE COBOL language for users of the iSeries system.

Before you use this guide you should have a basic understanding of the following:
- Data processing concepts
- The COBOL programming language
- The IBM Operating System/400® (OS/400®) operating system
- Integrated Language Environment (ILE) concepts
- Application Programming Interfaces (APIs)
- Development tools, such as *Application Development ToolSet* (ADTS) for Non-Programmable Terminal (NPT) base.

  Note: Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about the workstation tools appears in that product's online help.
- How to use the controls and indicators on your display and how to use the keys on your keyboard, such as:
  - Cursor movement keys
  - Function keys
  - Field exit keys
  - Insert and Delete keys
  - Error Reset key.

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- How to operate your display station when it is linked to the IBM iSeries system and running iSeries software. This means knowing how to use the OS/400 operating system and its Control Language (CL) to do such things as:
  - Sign on and sign off the display station
  - Interact with displays
  - Use Help
  - Enter CL commands
  - Use Application Development Tools
  - Respond to messages
  - Perform file management.
- The basic concepts of OS/400 CL functions.
- How to use data management support to allow an application to work with files.
- How to use the following *Application Development ToolSet for OS/400* tools:
  - The Screen Design Aid (SDA) used to design and code displays or the DDS design utility that is a part of CODE/400
  - The Source Entry Utility (SEU) used to enter and update source members or the language sensitive editor that is a part of CODE/400

    Note: Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about the workstation tools appears in that product's online help.
- The Structured Query Language (SQL) used to insert SQL statements into ILE COBOL programs.

Prerequisite and Related Information

Use the iSeries Information Center as your starting point for looking up iSeries and AS/400e technical information. You can access the Information Center in two ways:

- From the following Web site:

  `http://www.ibm.com/eserver/iseries/infocenter`
- From CD-ROMs that ship with your Operating System/400 order:

  iSeries Information Center, SK3T-4091-02. This package also includes the PDF versions of iSeries manuals, *iSeries Information Center: Supplemental Manuals*, SK3T-4092-01, which replaces the Softcopy Library CD-ROM.

The iSeries Information Center contains advisors and important topics such as CL commands, system application programming interfaces (APIs), logical partitions, clustering, Java™ , TCP/IP, Web serving, and secured networks. It also includes links to related IBM Redbooks and Internet links to other IBM Web sites such as the Technical Studio and the IBM home page.

The manuals that are most relevant to the ILE COBOL compiler are listed in the "Bibliography" on page 651.

How to Send Your Comments

Your feedback is important in helping to provide the most accurate and high-quality information. IBM welcomes any comments about this book or any other iSeries 400 documentation.

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- The name of the book.
- The publication number of the book.
- The page number or topic to which your comment applies.

What's New This Release?

The following list describes the enhancements made to ILE COBOL in V5R3:

- Large VALUE clause support

  When the *NOSTDTRUNC compiler option is in effect, data items described with usage BINARY, or COMP-4 that do not have a picture symbol P in their PICTURE clause can have a value up to the capacity of the native binary representation.
- CONSTANT data type

  A CONSTANT data type is defined by specifying a level-01 entry containing the CONSTANT clause for a literal. The CONSTANT data item can then be used in place of the literal.
- XML support

  XML PARSE statement provides the interface to a high-speed XML parser that is part of the COBOL run time. The XML PARSE statement parses an XML document into its individual pieces and passes each piece, one at a time, to a user-written processing procedure.

  These XML special registers are used to communicate information between the XML parser and the user-written processing procedure:
  - XML-CODE
  - XML-EVENT
  - XML-NTEXT
  - XML-TEXT
- Alternate Record Key support

  The ALTERNATE RECORD KEY clause lets you define alternate record keys associated with indexed files. These alternate keys allow you to access the file using a different logical ordering of the file records.
- DBCS data item names (DBCS word support)
- 63 digit support
  - The maximum length of packed decimal, zoned decimal, and numeric-edited items has been extended from 31 to 63 digits.

- The ARITHMETIC parameter on the CRTCBLMOD and CRTBNDCBL commands and on the PROCESS statement has a new EXTEND63 option.

- 7 new ANSI Intrinsic functions:
  - INTEGER
  - REM
  - ANNUITY
  - INTEGER-PART
  - MOD
  - FACTORIAL
  - RANDOM
- New CRTBNDCBL / CRTCBLMOD options:
  - *NOCRTARKIDX / *CRTARKIDX Specifies whether or not to create temporary alternate record key indexes if permanent ones can not be found.
  - *STDINZHEX00 Specifies that data items without a value clause are initialized with hexadecimal zero.
  - *EXTEND63 option for the ARITHMETIC parameter increases the precision of intermediate results for fixed-point arithmetic up to 63 digits.
- New PROCESS statement options:
  - PROCESS statement option NOCOMPRESSDBG/COMPRESSDBG indicates whether listing view compression should be performed by the compiler when DBGVIEW option *LIST or *ALL is specified
  - NOCRTARKIDX/CRTARKIDX
  - STDINZHEX00
  - EXTEND63 option for the ARITHMETIC parameter
- Program Status Structure

  The program status structure is a predefined structure that contains error information when the COBOL program receives an error. The PROGRAM STATUS clause is use to specify the error information that is received.

Changes to this Guide Since V5R1

This V5R3 guide, *WebSphere Development Studio: ILE COBOL Programmer's Guide*, SC09-2540-04, differs in many places from the V5R1 guide, *WebSphere Development Studio: ILE COBOL Programmer's Guide*, SC09-2540-03 and *WebSphere Development Studio: ILE COBOL Programmer's Guide*, SC09-2540-02. Most of the changes are related to the enhancements that have been made since V5R1; others reflect minor technical corrections. To assist you in using this manual, technical changes and enhancements made in V5R3 are noted with a vertical bar (|). Changes made in V5R2 are noted with a pound sign (#).

What's New in V5R2?

The following list describes the enhancements made to ILE COBOL in V5R2:

- Recursive program support

  An optional RECURSIVE clause has been added to provide support for recursive programs. These are COBOL programs that can be recursively re-entered.
- Local Storage Section support

  A new data section that defines storage allocated and freed on a per-invocation basis has been added. You can specify the Local-Storage Section in both recursive and non-recursive programs.

• Java interoperability

Two new features have been added to enhance Java interoperability. These include:

– UTF8String intrinsic function

This function provides the ability to convert strings to UTF-8 format.

– PCML support

New parameters have been added to the CRTCBLMOD and CRTBNDCBL commands to give users the ability to tell the compiler to generate PCML source for their COBOL program. When the user specifies PGMINFO(*PCML) and the name of a streamfile on the INFOSTMF parameter, the compiler will generate PCML into the specifed streamfile. The generated PCML makes it easier for Java programs to call this COBOL program, with less Java code.

• Additional intrinsic functions

Several new intrinsic funcitons have been added to this release. These include:

– Max

– Median

– Midrange

– Min

– ORD-Max

– ORD-Min

– Present Value

– Range

– Standard Deviation

– Sum

– Variance

• IFS

ILE Cobol source stored in IFS stream files can be compiled. The SRCSTMF and INCDIR parameters have been added to the CRTCBLMOD and CRTBNDCBL commands to give users the ability to tell the compiler to compile from source stored in IFS stream files.

What's New in V5R1?

The following list describes the enhancements made to ILE COBOL in V5R1:

- UCS-2 (Unicode) support

  National data, a new type of data item, has been added to provide support for the coded character set specified in ISO/IEC 10646-1 as UCS-2. The code set is the basic set defined in the Unicode standard.

  – UCS-2 character set

    This coded character set provides a unique code for each character appearing in the principal scripts in use around the world. Each character is represented by a 16-bit (2-byte) code.

  – National data

    This new type of data item specifies that the item contains data coded using the UCS-2 code set. An elementary data item whose description contains a USAGE NATIONAL clause, or an elementary data item subordinate to a group item whose description contains a USAGE NATIONAL clause, is a national data item.

  – NTLPADCHAR compiler option and PROCESS statement option

This option allows you to specify three values: the SBCS padding character, DBCS padding character, and national padding character. The appropriate padding character is used when a value is moved into a national datatype item and does not fill the national datatype item completely.

  - ALL national literal

    Allows the word ALL wherever a national hexadecimal literal is allowed, so that for example you could move all UCS-2 blanks into a national data item.

  - PROCESS statement option NATIONAL

    When this option is specified, elementary data items defined using the picture symbol N will have an implied USAGE NATIONAL clause. A USAGE DISPLAY-1 clause will be implied for these items if the compiler option is not used.

  - National hexadecimal literals

    Literals containing national data values may be specified using the syntax:

    ```
    NX"hexadecimal-character-sequence..."
    ```

  - Figurative constants

    The figurative constant SPACE/SPACES represents one or more UCS-2 single byte space characters (U+0020) when used with national data items.

- JAVA interoperability support
  - QCBLLESRC.JNI file

    This file provides the same definitions and prototypes that are provided in the JNI.h file, but written in COBOL rather than C.

  - Data mapping between Java and COBOL datatypes
- Mainframe portability support
  - NOCOMPASBIN/COMPASBIN PROCESS statement option indicates whether USAGE COMPUTATIONAL or COMP has the same meaning as USAGE COMP-3 or USAGE COMP-4.
  - NOLSPTRALIGN/LSPTRALIGN PROCESS statement option indicates whether data items with USAGE POINTER or PROCEDURE-POINTER are aligned at multiples of 16 bytes relative to the beginning of the record in the linkage section.
  - NOADJFILLER/ADJFILLER PROCESS statement option indicates whether any implicit fillers inserted by the compiler to align a pointer data item should be inserted before or after a group that has a pointer data item as the first member of the group.
  - Complex OCCURS DEPENDING ON (ODO) support

    The following constitute complex ODO:

    - Entries subordinate to the subject of an OCCURS or an ODO clause can contain ODO clauses (table with variable length elements).
    - A data item described by an ODO can be followed by a non-subordinate data item described with ODO clause (variably located table).
    - Entries containing an ODO clause can be followed by non-subordinate items (variably located fields). These non-subordinate items, however, cannot be the object of an ODO clause.
    - The location of any subordinate or non-subordinate item, following an item containing an ODO clause, is affected by the value of the ODO object.
    - The INDEXED BY phrase can be specified for a table that has a subordinate item that contains an ODO clause.
- The LICOPT parameter has been added to the CRTCBLMOD and CRTBNDCBL commands to allow advanced users to specify Licensed Internal Code options.

- The OPTVALUE PROCESS statement option indicates whether the generation of code to initialize data items containing a VALUE clause in the working-storage section should be optimized.

What's New in V4R4?

The following list describes the enhancements made to ILE COBOL in V4R4:

- Thread Safety Support

  Support for calling ILE COBOL procedures from a threaded application, such as Domino™ or Java. The THREAD parameter has been added to the PROCESS statement, to enable ILE COBOL modules for multithreaded environments. Access to the procedures in the module should be serialized.
- 31-digit support
  - The maximum length of packed decimal, zoned decimal, and numeric-edited items has been extended from 18 to 31 numeric digits.
  - The ARITHMETIC parameter has been added to the CRTCBLMOD and CRTBNDCBL commands, and to the PROCESS statement to allow the arithmetic mode to be set for numeric data. This allows you to specify the computational behavior of numeric data.
- Euro currency support
  - The ability to specify more than one currency sign in a COBOL program to support the dual currency system that will be in effect for three years starting in January 1999 among the participating countries.
  - The ability to represent multi-character currency signs, so that the international currency signs (e.g. USD, FRF, DEM, EUR) as well as single-character currency signs (e.g. ″$″) can be specified for COBOL numeric edited fields.
  - The OPTION parameter values *MONOPIC/*NOMONOPIC have been added to the CRTCBLMOD and CRTBNDCBL commands, and MONOPIC/NOMONOPIC have been added to the PROCESS statement. This allows you to choose between a moncased or a case sensitive currency symbol in a PICTURE character-string.

What's New in V4R2?

The following list describes the enhancements made to ILE COBOL in V4R2:

- User-defined data types

  A user-defined data type is defined by specifying a level-01 entry containing the TYPEDEF clause; all entries that are subordinate to the level-01 entry are considered part of the user-defined data type. A user-defined data type can be used to define new data items of level-01, -77, or -02 through -49, by specifying a TYPE clause for the new data item, that references the user-defined data type.
- Program profiling support

  The PRFDTA parameter has been added to both the CRTCBLMOD and CRTBNDCBL commands, and to the PROCESS statement, to allow a program to be profiled for optimization.
- Null-values support

  Null-values support (by way of the NULL-MAP and NULL-KEY-MAP keywords) has been added to the following statements and clauses to allow the manipulation of null values in database records:
  - ASSIGN clause
  - COPY-DDS statement

  - DELETE statement
  - READ statement
  - REWRITE statement
  - START statement
  - WRITE statement.
- Locale support

  iSeries Locale objects (*LOCALE) specify certain cultural elements such as a date format or time format. This cultural information can be associated with ILE COBOL date, time, and numeric-edited items. The following new characters, clauses, phrases and statements were added to support this:
  - The LOCALE clause of the SPECIAL-NAMES paragraph
    - Associates an iSeries locale object with a COBOL mnemonic-name
  - The LOCALE phrase of a date, time, or numeric-edited item
    - Allows you to specify a locale mnemonic-name, so that the data item is associated with an iSeries locale object
  - Along with specific locales defined in the LOCALE clause of the SPECIAL-NAMES paragraph, a current locale, and a default locale have been defined. The current locale can be changed with the new SET LOCALE statement (Format 8).
    - A locale object is made up of locale categories, each locale category can be changed with the SET LOCALE statement.
  - Locale categories have names such as LC_TIME and LC_MONETARY. These names include the underscore character. This character has been added to the COBOL character set.
    - The SUBSTITUTE phrase of the COPY DDS statement has been enhanced to allow the underscore character to be brought in.

  The following new intrinsic functions allow you to return culturally-specific dates and times as character strings:
  - LOCALE-DATE
  - LOCALE-TIME.
- Additions to Century support

  The following enhancements have been made to the ILE COBOL Century support:
  - A new class of data items, class date-time, has been added. Class date-time includes date, time, and timestamp categories. Date-time data items are declared with the new FORMAT clause of the Data Description Entry.
  - Using COPY-DDS and the following values for the CVTOPT compiler parameter, iSeries DDS data types date, time, and timestamp can be brought into COBOL programs as COBOL date, time, and timestamp items:
    - *DATE
    - *TIME
    - *TIMESTAMP.
  - Using the CVTOPT parameter value *CVTTODATE, packed, zoned, and character iSeries DDS data types with the DATFMT keyword can be brought into COBOL as date items.
  - The following new intrinsic functions allow you to do arithmetic on items of class date-time, convert items to class date-time, test to make sure a date-time item is valid, and extract part of a date-time item:
    - ADD-DURATION
    - CONVERT-DATE-TIME
    - EXTRACT-DATE-TIME

- FIND-DURATION
- SUBTRACT-DURATION
- TEST-DATE-TIME.

What's New in V3R7?

The following list describes the enhancements made to ILE COBOL in V3R7:

- Century support

  The capability for users to work with a 4-digit year has been added in the following statements and functions:

  – ACCEPT statement with the YYYYDDD and YYYYMMDD phrases

  – The following intrinsic functions convert a 2-digit year to a 4-digit year:
    - DATE-TO-YYYYMMDD
    - DAY-TO-YYYYDDD
    - YEAR-TO-YYYY

  – The following intrinsic functions return a 4-digit year:
    - CURRENT-DATE
    - DAY-OF-INTEGER
    - DATE-OF-INTEGER
    - WHEN-COMPILED

- Floating-point support

  The *FLOAT value of the CVTOPT parameter on the CRTCBLMOD and CRTBNDCBL commands allows floating-point data items to be used in ILE COBOL programs. Also, the affected statements (such as ACCEPT, DISPLAY, MOVE, COMPUTE, ADD, SUBTRACT, MULTIPLY, and DIVIDE) support floating-point.

- Data area support

  New formats of the ACCEPT and DISPLAY statements have been added to provide the ability to retrieve and update the contents of iSeries data areas.

- Intrinsic Functions

  The following intrinsic functions have been added:

  ACOS
  ASIN
  ATAN
  CHAR
  COS
  CURRENT-DATE
  DATE-OF-INTEGER
  DAY-OF-INTEGER
  DATE-TO-YYYYMMDD
  DAY-TO-YYYYDDD
  INTEGER-OF-DATE
  INTEGER-OF-DAY
  LENGTH
  LOG
  LOG10
  LOWER-CASE
  MEAN
  NUMVAL
  NUMVAL-C
  ORD
  REVERSE
  SIN
  SQRT
  TAN
  UPPER-CASE
  WHEN-COMPILED
  YEAR-TO-YYYY

- Binding Directory parameter—BNDDIR

  The BNDDIR parameter has been added to the CRTBNDCBL command to allow the specification of the list of binding directories that are used in symbol resolution.

- Activation Group parameter—ACTGRP

The ACTGRP parameter has been added to the CRTBNDCBL command to allow the specification of the activation group that a program is associated with when it is called.

- Library qualified program objects and data areas

  The LIBRARY phrase has been added to the following ILE COBOL statements to allow OS/400 program objects and data areas to be qualified with an OS/400 library name:
  - CALL
  - CANCEL
  - SET
  - ACCEPT
  - DISPLAY
- Performance collection data

  The ENBPFRCOL parameter has been added to the CRTCBLMOD and CRTBNDCBL commands, and to the PROCESS statement to allow performance measurement code to be generated in a module or program. The data collected can be used by the system performance tool to profile an application's performance.
- New ILE debugger support

  The ILE debugger now allows you to:
  - Debug most OPM programs
  - Set watch conditions, which are requests to set breakpoints when the value of a variable (or an expression that determines the address of a storage location) changes.

What's New in V3R6/V3R2?

The following list describes the enhancements made to ILE COBOL in V3R6 and V3R2:

- New EXIT PROGRAM phrase

  The AND CONTINUE RUN UNIT phrase has been added to the EXIT PROGRAM statement to allow exiting of a calling program without stopping the run unit.
- New SET statement pointer format

  A new format of the SET statement has been added that enables you to update pointer references.
- DBCS Data Support

  You can now process Double Byte Character Set (DBCS) data in ILE COBOL. The ILE COBOL compiler supports DBCS, in which each logical character is represented by two bytes. DBCS provides support for ideographic languages, such as the IBM Japanese Graphic Character Set, Kanji.
- Support for CALL...BY VALUE and CALL...RETURNING

  CALL...BY VALUE and CALL...RETURNING gives you the ability to pass arguments BY VALUE instead of BY REFERENCE and receive RETURN values. This allows for greater ease of migration, and improved interlanguage support as ILE C for iSeriesand ILE RPG for iSeries both support CALL... BY VALUE and CALL...RETURNING.
- Support of the BY VALUE and RETURNING phrases of the PROCEDURE DIVISION Header

  The BY VALUE phrase of the PROCEDURE DIVISION header allows COBOL to receive BY VALUE arguments from a calling COBOL program or other ILE

language such as RPG, C, or C++. The RETURNING phrase of the PROCEDURE DIVISION header allows COBOL to return a VALUE to the calling ILE procedure.

What's New in V3R1?

The following list describes the enhancements made to ILE COBOL in V3R1:

- EXTERNAL data items

  You can define data items that are available to every program in the ILE COBOL run unit by using the EXTERNAL clause. No longer do you need to pass all variables that are to be shared across programs as arguments on the CALL statement. This support encourages greater modularity of applications by allowing data to be shared without using arguments and parameters on the CALL statement.

- EXTERNAL files

  You can define files that are available to every program in the run unit. You can seamlessly make I/O requests to the same file from any ILE COBOL program within the run unit that declares the file as EXTERNAL. For external files there is only one file cursor regardless of the number of programs that use the file. You can share files across programs, and thereby develop smaller, more maintainable programs. Using EXTERNAL files provides advantages over using shared open files since only one OPEN and CLOSE operation is needed for all participating programs to use the file. However, an EXTERNAL file cannot be shared among different activation groups nor with programs written in other programming languages.

- Nested Source Programs

  An ILE COBOL source program can contain other ILE COBOL source programs. These contained programs may refer to some of the resources, such as data items and files, of the programs within which they are contained or define their own resources locally, which are only visible in the defining program. As the ILE COBOL programs are themselves resources, their scope is also controlled by the nesting structure and the scope attribute attached to the program. This provides greater flexibility in controlling the set of ILE COBOL programs that can be called by an ILE COBOL program. Nested ILE COBOL programs provides a mechanism to hide resources that would otherwise be visible.

- INITIAL Clause

  You have a mechanism whereby an ILE COBOL program and any programs contained within it are placed in their initial state every time they are called. This is accomplished by specifying INITIAL in the PROGRAM-ID paragraph. This provides additional flexibility in controlling the COBOL run unit.

- REPLACE statement

  The REPLACE statement is useful to replace source program text during the compilation process. It operates on the entire file or until another REPLACE statement is encountered, unlike the COPY directive with the REPLACING phrase. The REPLACE statements are processed after all COPY statements have been processed. This provides greater flexibility in changing the ILE COBOL text to be compiled.

- DISPLAY WITH NO ADVANCING statement

  By using the NO ADVANCING phrase on the DISPLAY statement, you have the capability to leave the cursor following the last character that is displayed. This allows you to string together items to be displayed on a single line from various points in the ILE COBOL program.

- ACCEPT FROM DAY-OF-WEEK statement

ILE COBOL now allows you to accept the day of the week (Monday = 1, Tuesday = 2 ...) and assign it to an identifier. This support complements the existing ACCEPT FROM DAY/DATE/TIME support.

- SELECT OPTIONAL clause for Relative Files

  This allows for the automatic creation of relative files even when the file is opened I-O. This extends the support that is already available for sequential files.

- Support for Nested COPY statements

  Copy members can contain COPY statements thereby extending the power of the COPY statement. If a COPY member contains a COPY directive, neither the containing COPY directive nor the contained COPY directive can specify the REPLACING phrase.

- Enhancements to Extended ACCEPT and DISPLAY statements

  You can work with tables on the Extended ACCEPT statement. This allows you to easily and selectively update the elements of the table.

  Variable length tables are also allowed on the Extended ACCEPT and DISPLAY statements.

  Also, the SIZE clause is supported on the extended ACCEPT statement.

- Procedure-pointer support

  Procedure-pointer is a new data type that can contain the address of an ILE COBOL program or a non-ILE COBOL program. Procedure-pointers are defined by specifying the USAGE IS PROCEDURE-POINTER clause on a data item. This new data type is useful in calling programs and or ILE procedures that are expecting this type of data item as its parameter. Procedure-pointer data items can also be used as the target of a CALL statement to call another program.

- New Special Registers
  - RETURN-CODE special register

    Allows return information to be passed between ILE COBOL programs. Typically, this register is used to pass information about the success or failure of a called program.
  - SORT-RETURN special register

    Returns information about success of a SORT or MERGE statement. It also allows you to terminate processing of a SORT/MERGE from within an error declarative or an input-output procedure.

- New Compiler options
  - *PICGGRAPHIC/*NOPICGGRAPHIC

    *PICGGRAPHIC is a new parameter for the CVTOPT option which allows the user to bring DBCS data into their ILE COBOL program.
  - *IMBEDERR/*NOIMBEDERR option

    *IMBEDERR is a new compiler option which includes compile time errors at the point of occurrence in the compiler listing as well as at the end of the listing.
  - *FLOAT/*NOFLOAT

    *FLOAT is a new parameter for the CVTOPT option which allows you to bring floating-point data items into your ILE COBOL programs with their DDS names and a USAGE of COMP-1 (single-precision) or COMP-2 (double-precision).
  - *NOSTDTRUNC/*STDTRUNC option

*NOSTDTRUNC is a new compiler option which suppresses the truncation of values in BINARY data items. This option is useful in migrating applications from IBM System/390®® (S/390®).

– *CHGPOSSGN/*NOCHGPOSSGN option

This option is useful when sharing data between the OS/400 and IBM S/390®. This option is provided for IBM System/390 compatibility. It changes the bit representation of signed packed and zoned data items when they are used in arithmetic statements or MOVE statements and the values in these data items are positive.

- Quoted system names support

  Support has been added to allow literals where system-names are allowed. You can use whatever names the system supports and is no longer limited to valid COBOL names.

- There is no COBOL limit on the following functions as these are now determined by system constraints.
  – Number of declared files.
  – Number of parameters on the CALL statement and on the Procedure Division USING phrase. A system limit of 400 for ILE procedures and 255 for program objects does apply here.
  – Number of SORT-MERGE input files and the number of SORT-MERGE keys. The maximum number of SORT-MERGE input files is 32 and the maximum length of the SORT-MERGE key is 2000 bytes.

- START with NO LOCK statement.

  By using the NO LOCK phrase on the START statement, the file cursor will be positioned on the first record to be read without placing a lock on the record. This support is provided for indexed and relative files and complements the READ with NO LOCK function that is already available.

  Note: START with NO LOCK is a new statement in both ILE COBOL and OPM COBOL/400.

- Static procedure call support

  You can develop your applications in smaller, better maintainable module objects, and link them together as one program object, without incurring the penalty of dynamic program call overhead. This facility, together with the common runtime environment provided by the system, also improves your ability to write mixed language applications. The ILE programming languages permits the binding of C, RPG, COBOL, and CL into a single program object regardless of the mix of source languages.

  New syntax on the CALL literal statement and a new compiler option have been added to ILE COBOL to differentiate between static procedure calls and dynamic program calls.

- Variable Length Record support (RECORD IS VARYING Clause)

  You can define and easily use different length records on the same file using standard ANSI COBOL syntax. Not only does this provide great savings in storage but it also eases the task of migrating complex applications from other systems.

- Expanded compiler limits

  ILE COBOL now offers expanded compiler limits:
  – size of group and elementary data items
  – size of fixed and variable length tables
  – number of nesting levels for conditional statements
  – number of operands in various Procedure Division statements

Industry Standards

Throughout this document, Standard COBOL refers to the COBOL programming language as defined in the document:

- American National Standard for Information Systems - Programming Language - COBOL, ANSI X3.23-1985, ISO 1989:1985 updated with the content of the following documents, in the order they are listed:
  - ANSI X3.23a-1989, American National Standard for Information Systems - Programming Language - Intrinsic Function Module for COBOL and ISO 1989:1985/Amd.1:1992, Programming Languages - COBOL, Amendment 1: Intrinsic function module
  - ANSI X3.23b-1993, American National Standard for Information Systems - Programming Language - Correction Amendment for COBOL and ISO/IEC 1989 DAM2 Programming Languages - COBOL, Amendment 2: Correction and clarification amendment for COBOL

The ILE COBOL compiler is designed to support Standard COBOL (as defined above) and

- FIPS Publication 21-4, Federal Information Processing Standard 21-4, COBOL

at the intermediate subset level, as understood and interpreted by IBM as of January, 1995.

From this point on, the term Standard COBOL will be used to refer to the ANSI standard just described.

Portions of this manual are copied from Standard COBOL documents, and are reproduced with permission from these publications (copyright 1985 by the American National Standards Institute), copies of which you can purchase from the American National Standard Institute at 1430 Broadway, New York, New York, 10018.

The COBOL language is maintained by the ANSI Technical Committee X3J4.

Refer to Appendix A, “Level of Language Support,” on page 581 for more information on the industry standards supported by the ILE COBOL compiler.

An Acknowledgment

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ILE COBOL Syntax Notation

ILE COBOL basic formats are presented in a uniform system of syntax notation. This notation, designed to assist you in writing COBOL source statements, is explained in the following paragraphs:

- COBOL keywords and optional words appear in uppercase letters; for example:

  ```
  MOVE
  ```

  They must be spelled exactly as shown. If any keyword is missing, the compiler considers it to be an error.
- Variables representing user-supplied names or values appear in all lowercase letters; for example:

  ```
  parmx
  ```
- For easier text reference, some words are followed by a hyphen and a digit or a letter, as in:

  ```
  identifier-1
  ```

  This suffix does not change the syntactical definition of the word.
- Arithmetic and logical operators (+, –, *, /, **, >, <, =, >=, and <=) that appear in syntax formats are required. For a complete listing of reserved ILE COBOL words, see the *WebSphere Development Studio: ILE COBOL Reference*.
- All punctuation and other special characters appearing in the diagram are required by the syntax of the format when they are shown; if you leave them out, errors will occur in the program.
- You must write the required and optional clauses (when used) in the order shown in the diagram unless the associated rules explicitly state otherwise.

Reading Syntax Diagrams

Throughout this book, syntax is described using the structure defined below.

- Read the syntax diagrams from left to right, and from top to bottom, following the path of the line:

  ►►— Indicates the beginning of a statement. Diagrams of syntactical units other than statements, such as clauses, phrases and paragraphs, also start with this symbol.

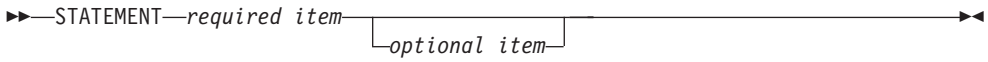
  —► Indicates that the statement syntax is continued on the next line.

►—— Indicates that a statement is continued from the previous line.

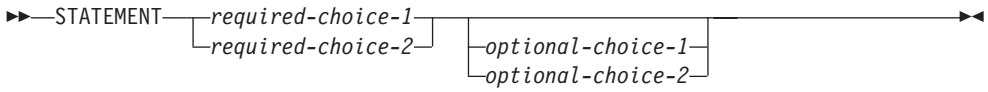
——►◄ Indicates the end of a statement. Diagrams of syntactical units other than statements, such as clauses, phrases and paragraphs, also end with this symbol.

Note: Statements within a diagram of an entire paragraph do not start with ►►—— and end with ——►◄ unless their beginning or ending coincides with that of the paragraph.

- Required items appear on the horizontal line (the main path). Optional items appear below the main path:

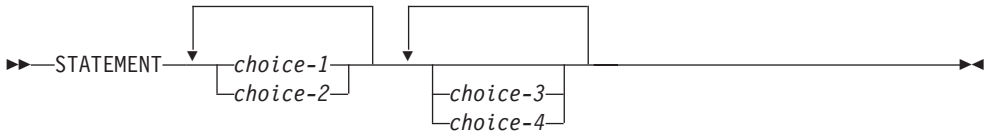


- When you can choose from two or more items, they appear vertically, in a stack. If you must choose one of the items, one item of the stack appears on the main path. If choosing an item is optional, the entire stack appears below the main path:



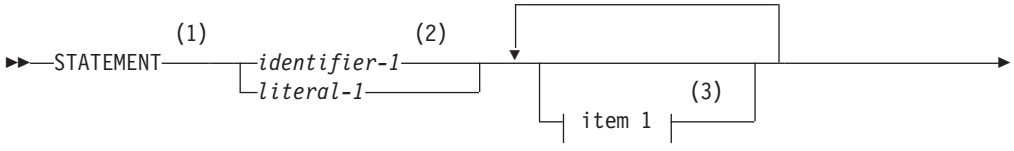
- An arrow returning to the left above an item indicates that the item can be repeated:

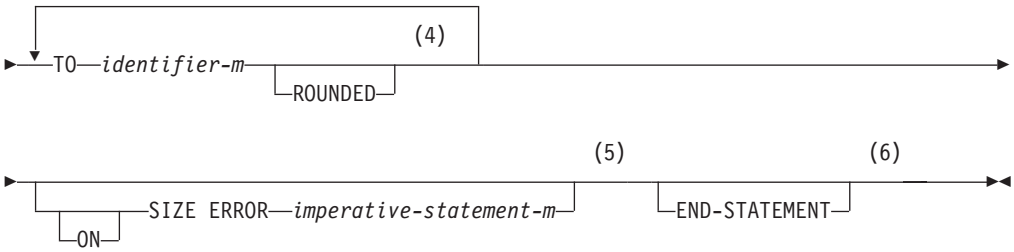
- A repeat arrow above a stack of required or optional choices indicates that you can make more than one choice from the stacked items, or repeat a single choice:



The following example shows how the syntax is used:

Format





item 1:

Notes:

1 The STATEMENT key word must be specified and coded as shown.

2 This operand is required. Either identifier-1 or literal-1 must be coded.

3 The item 1 fragment is optional; it can be coded or not, as required by the application. If item 1 is coded, it can be repeated with each entry separated by one or more COBOL separators. Entry selections allowed for this fragment are described at the bottom of the diagram.

4 The operand identifier-m and associated TO key word are required and can be repeated with one or more COBOL separators separating each entry. Each entry can be assigned the key word ROUNDED.

5 The ON SIZE ERROR phrase with associated imperative-statement-m are optional. If the ON SIZE ERROR phrase is coded, the key word ON is optional.

6 The END-STATEMENT key word can be coded to end the statement. It is not a required delimiter.

Identifying Documentary Syntax

COBOL clauses and statements illustrated within syntax diagrams that are syntax checked, but are treated as documentation by the ILE COBOL compiler, are identified by footnotes.

Interpreting Control Language (CL) Entry Codes

The code that appears in the upper right corner of each CL syntax diagram contains the entry codes that specify the environment in which the command can be entered. The codes indicate whether or not the command can be:

- Used in a batch or interactive job (outside a compiled program; Job:B or I)
- Used in a batch or interactive compiled program (Pgm:B or I)
- Used in a batch or interactive REXX procedure (REXX:B or I)
- Used as a parameter for the CALL CL command, or passed as a character string to the system program QCMDEXC (Exec).

Part 1. Compiling, Running, and Debugging ILE COBOL Programs

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Chapter 1. Introduction

COmmon Business Oriented Language (COBOL) is a programming language that resembles English. As its name suggests, COBOL is especially efficient for processing business problems. It emphasizes describing and handling data items and input/output records; thus, COBOL is well adapted for managing large files of data.

This chapter provides the following:

- an introduction to the Integrated Language Environment (ILE)
- an introduction to ILE COBOL
- an overview of function that has been incorporated in ILE COBOL that is not available in OPM COBOL/400
- an overview of the major steps in creating a runnable program object
- an overview of other application development tools that are available to help you develop ILE COBOL applications more effectively.

Integrated Language Environment

The **Integrated Language Environment (ILE)** is the current stage in the evolution of OS/400 program models. Each stage evolved to meet the changing needs of application programmers. For a full description of the concepts and terminology pertaining to ILE, refer to the *ILE Concepts* book.

The programming environment provided when the iSeries server was first introduced is called the **Original Program Model (OPM)**. COBOL, RPG, CL, BASIC and PL/1 all operated in this model. In Version 1 Release 2, the **Extended Program Model (EPM)** was introduced. EPM was created to support languages like C, Pascal, and FORTRAN. For a full description of the principal characteristics of OPM and EPM, refer to the *ILE Concepts* book.

The most significant difference between the OPM COBOL/400 environment and the ILE COBOL environment is how a runnable program object is created. The ILE COBOL compiler does not produce a runnable program object. It produces one or more **module objects** that can be **bound** together in various combinations to form one or more runnable units known as **program objects**.

ILE allows you to bind module objects written in different languages. Therefore, it is possible to create runnable program objects that consist of module objects written separately in COBOL, RPG, C, C++ and CL.

Major Steps in Creating a Runnable ILE COBOL Program Object

Figure 1 on page 4 illustrates the typical steps involved in the development of a runnable program object written in ILE COBOL:

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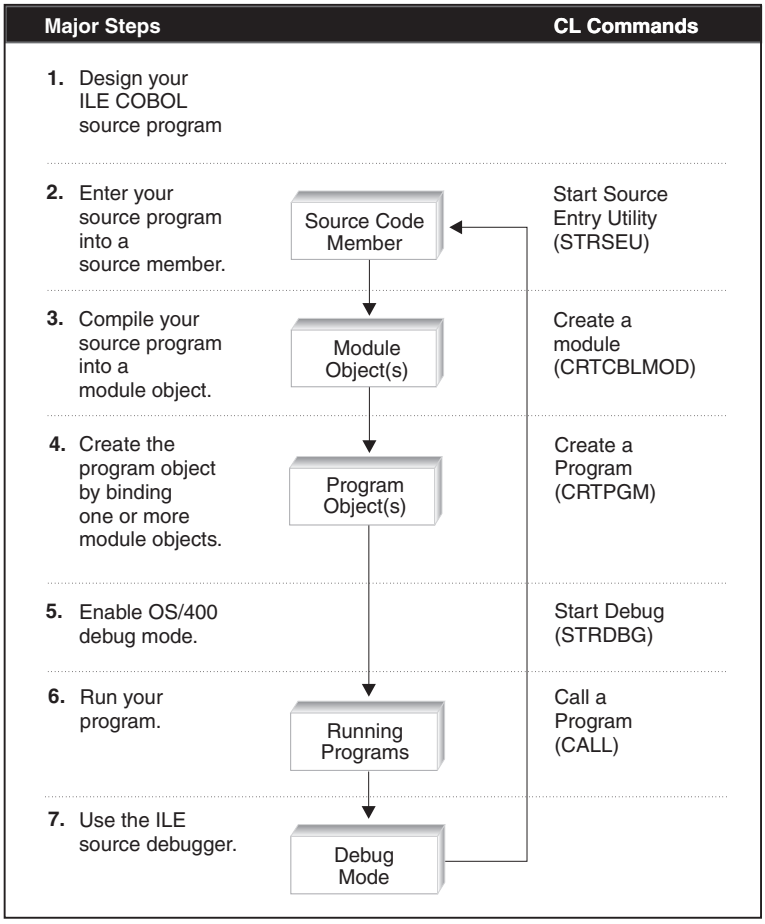

Figure 1. Major Steps in Creating a Runnable ILE COBOL Program Object

Steps 3 and 4 can be accomplished with a single command, CRTBNDCBL. This command creates temporary module objects from the ILE COBOL source program and then creates the program object. Once the program object is created, the module objects are deleted.

Designing Your ILE COBOL Source Program

The first step in creating a runnable ILE COBOL program object is to design your ILE COBOL source program.

An **ILE COBOL source program** consists of four divisions. The skeleton program in Figure 2 on page 5 shows the structure of an ILE COBOL source program. It can be used as a sample for designing ILE COBOL source programs.

ILE COBOL programs can be contained in other ILE COBOL programs. This concept is known as nesting and the contained program is known as a **nested program**. Figure 2 on page 5 shows how a nested ILE COBOL program is included in an outermost ILE COBOL program. Not all the entries provided in the skeleton program are required; most are provided for informational purposes only.

```
 IDENTIFICATION DIVISION. 1
   PROGRAM-ID. outermost-program-name.
   AUTHOR. comment-entry.
   INSTALLATION. comment-entry.
   DATE-WRITTEN. comment-entry.
   DATE-COMPILED. comment-entry.
   SECURITY.
*   The SECURITY paragraph can be used to specify
*   copyright information pertaining to the
*   generated module object.  The first 8 lines
*   of the SECURITY paragraph generate the
*   copyright information that is displayed on
*   the Copyright Information panel when the
*   Display Module (DSPMOD) CL command is issued.
 ENVIRONMENT DIVISION. 2
  CONFIGURATION SECTION. 3
   SOURCE-COMPUTER. IBM-ISERIES.
   OBJECT-COMPUTER. IBM-ISERIES.
   SPECIAL-NAMES.   REQUESTOR IS CONSOLE.
 INPUT-OUTPUT SECTION. 4
   FILE-CONTROL.
     SELECT file-name ASSIGN TO DISK-file-name
       ORGANIZATION IS SEQUENTIAL
       ACCESS MODE IS SEQUENTIAL
       FILE STATUS IS data-name.
 DATA DIVISION. 5
  FILE SECTION.
  FD file-name.
  01 record-name  PIC X(132).
  WORKING-STORAGE SECTION.
  77 data-name PIC XX.
  LINKAGE SECTION.
 PROCEDURE DIVISION. 6
  DECLARATIVES
  END DECLARATIVES.
  main-processing SECTION.
   mainline-paragraph.
    ILE COBOL statements.
      STOP RUN.
 IDENTIFICATION DIVISION. 7
   PROGRAM-ID. nested-program-name.
 ENVIRONMENT DIVISION. 8
  INPUT-OUTPUT SECTION.
   FILE-CONTROL.
     SELECT file-name ASSIGN TO DISK-file-name
       ORGANIZATION IS SEQUENTIAL
       ACCESS MODE IS SEQUENTIAL
       FILE STATUS IS data-name.
 DATA DIVISION.
  FILE SECTION.
  FD file-name.
  01 record-name  PIC X(132).
  WORKING-STORAGE SECTION.
  77 data-name PIC XX.
  LINKAGE SECTION.
 PROCEDURE DIVISION.
  DECLARATIVES
  END DECLARATIVES.
  main-processing SECTION.
   mainline-paragraph.
      ILE COBOL statements.
          EXIT PROGRAM.

 END PROGRAM nested-program-name. 9
 END PROGRAM outermost-program-name.
```

Figure 2. Example of ILE COBOL Program Structure

- The Identification Division 1 is the only division that must be included; all other divisions are optional.
- The Environment Division 2 is made up of two sections: the Configuration Section 3, which describes the overall specifications of the source and object computers, and the Input-Output Section 4, which defines each file, and specifies information needed for transmission of data between an external medium and the ILE COBOL program.
- The Data Division 5 describes the files to be used in the program and the records contained within the files. It also describes any internal Working-Storage or Local-Storage data items that are needed.
- The Procedure Division 6 consists of optional declaratives, and procedures that contain sections and/or paragraphs, sentences, and statements.
- This second Identification Division 7 marks the beginning of a nested ILE COBOL program which is contained within the outermost ILE COBOL program.
- Nested programs cannot have a Configuration Section 8 in the Environment Division. The outermost program must specify any Configuration Section options that may be required.
- Nested programs and the outermost program must be terminated by an END PROGRAM 9 header.

An ILE COBOL program is identified by the PROGRAM-ID in the IDENTIFICATION DIVISION. It contains a set of self-contained statements that perform a particular task.

In ILE, an ILE COBOL source program is considered to be an **ILE procedure**. If an ILE COBOL program contains nested ILE COBOL programs, each nested ILE COBOL program is an ILE procedure. The name of the nested program is only known within its containing program. If the nested program has the COMMON attribute, the name of the nested program is also known to other programs in the same compilation unit. ILE procedures are not to be confused with COBOL procedures, which are found in the Procedure Division of a COBOL program and contain sections, paragraphs, sentences, and statements.

For more information on writing your ILE COBOL program, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Entering Source Statements into a Source Member

Once you have designed your ILE COBOL program, you must enter it into a source member.

Use WebSphere Development Studio Client for iSeries. Your program editing tasks are simplified with the Remote Systems LPEX editor. The editor can access source files on your workstation or your iSeries server. When a compilation results in errors, you can jump directly from the compiler messages to an editor containing the source. The editor opens with the cursor positioned at the offending source statements so that you can correct them.

The Source Entry Utility (SEU) command, Start Source Entry Utility (STRSEU), is used to enter and edit your ILE COBOL source statements. To help you enter accurate ILE COBOL statements into the system the SEU display corresponds to the standard COBOL coding form and as you enter or change a line of code, the COBOL syntax checker checks the line for errors.

A **compilation unit** is an outermost ILE COBOL program and any nested ILE COBOL programs within the outermost program. Multiple compilation units may be entered in a single source member.

For information on entering source statements, refer to Chapter 2, "Entering Source Statements into a Source Member," on page 11.

Compiling a Source Program into Module Objects

Once you have completed entering or editing the source statements in a source member, you now need to create module objects using the Create COBOL Module (CRTCBLMOD) command. This command compiles the source statements in the source member into one or more module objects. Each compilation unit in the source member creates a separate module object.

Module objects are the output of the ILE COBOL compiler. They are represented on the system by the type *MODULE. Module objects cannot be run without first being bound into program objects.

For more information on creating module objects using the CRTCBLMOD command, refer to Chapter 3, "Compiling Source Programs into Module Objects," on page 21.

Creating a Program Object

In order to create a runnable **program object**, module objects must be bound together. One or more module objects can be bound together to create a program object. Module objects need to be bound into program objects since only program objects can be run. Module objects written in various programming languages can be bound together to create a program object. For example, a program object could consist of COBOL or RPG module objects for the report, but a C module object for the calculations. A program object can be created using one of the following commands:

- Create Program (CRTPGM)
- Create Bound COBOL Program (CRTBNDCBL)

For information on these commands, refer to Chapter 4, "Creating a Program Object," on page 75.

Running a Program Object

You run a program object by calling it. You can use one of the following ways to call a program object:

- The CALL CL command on any command line
- A high-level language CALL statement
- An application-oriented menu
- A user-created command
- The Run menu action or Run toolbar icon in the WebSphere Development Studio Client for iSeries workbench

For information on running a program, refer to Chapter 6, "Running an ILE COBOL Program," on page 107.

Debugging a Program

The ILE source debugger is used to detect errors in and eliminate errors from program objects and service programs. You can use the ILE source debugger to:

- View the program source

- Set and remove conditional and unconditional breakpoints
- Step through the program
- Display the value of variables, structures, records, and arrays
- Change the value of variables
- Change the reference scope
- Equate a shorthand name to a variable, expression, or debug command.

For information on the debugger, refer to Chapter 7, "Debugging a Program," on page 113.

Other Application Development Tools

The iSeries server offers a full set of tools that you may find useful for programming.

WebSphere Development Studio

WebSphere Development Studio is an application development package to help you rapidly and cost-effectively increase the number of e-business applications for the iSeries server. This package consolidates all of the key iSeries development tools, both host and workstation, into one iSeries offering.

The host development tools have undergone major improvements. We are shipping new C and C++ compilers, completely refreshed from the latest AIX compilers, to replace the existing versions of these compilers. This will help customers and solution providers port e-business solutions from other platforms. ILE RPG has also made major enhancements. Improved Java interoperability and free-form C-Specs top the list of enhancements. COBOL has added z/OS migration capabilities as well as introducing some COBOL/Java interoperability capabilities.

The following components are included in WebSphere Development Studio for iSeries.

Host components:
- ILE RPG
- ILE COBOL
- ILE C/C++
- Application Development ToolSet (ADTS)

Workstation components:
- IBM WebFacing Tool
- iSeries development tools: Remote System Explorer and iSeries projects
- Java development tools (with iSeries enhancements)
- Web development tools (with iSeries enhancements)
- Struts environment support
- Database development tools
- Web services development tools
- Server development tools
- XML development tools
- CODE
- VisualAge RPG
- Integrated iSeries debugger

WebSphere Development Studio Client for iSeries

WebSphere Development Studio Client for iSeries (Development Studio Client) is an application development package of workstation tools that helps you rapidly and cost-effectively increase the number of e-business applications for the iSeries server.

This package consolidates all of the key iSeries workstation-based development tools into one iSeries offering. It is also an included entitlement for purchasers of WebSphere Development Studio for iSeries.

WebSphere Development Studio Client for iSeries Feature List:

The workbench-based integrated development environment
IBM WebSphere Development Studio Client for iSeries uses WebSphere Studio Workbench (WSWB) version 2.1.

The IBM WebFacing Tool
The IBM WebFacing Tool can convert your DDS display source files into an application that can be run in a browser.

Remote System Explorer and iSeries Development Tools
The Remote System Explorer, included as a part of iSeries development tools, encompasses the framework, user interface, editing, and file, command, and job actions of iSeries capability.

iSeries Java development tools
Java development tools and iSeries Java development tools give you the ability to develop Java applications and write, compile, test, debug, and edit programs written in the Java programming language for Java applications development.

iSeries Web development tools
Web development tools give you the ability to create new e-business applications that use a Web-based front end to communicate with the business logic in an ILE and non-ILE language program residing on an iSeries host.

Struts environment support
Development Studio Client offers support for Struts and the Web Diagram editor.

Database development tools
Database development tools support any local or remote database that has a Java Database Connectivity (JDBC) driver.

Web services development tools
Web services development tools allow developers to create modular applications that can be invoked on the World Wide Web.

Server development tools
Server development tools are used to test applications in a local or remotely installed run-time environment.

XML development tools
XML development tools support any XML-based development.

CODE (CoOperative Development Environment)
CODE is the classic set of Windows tools for iSeries development. It gives you a suite of utilities for creating source and DDS files, and managing your projects.

VisualAge RPG
VisualAge RPG is a visual development environment that allows you to create and maintain client/server applications on the workstation.

Integrated iSeries debugger
The integrated iSeries debugger helps you debug code that is running on the iSeries system or on your Windows system, using a graphical user interface on your workstation.

If you want to learn more about WebSphere Development Studio Client for iSeries, see the most current information available on the World Wide Web at **ibm.com**/software/awdtools/iseries/.

Chapter 2. Entering Source Statements into a Source Member

This chapter provides the information you need to enter your ILE COBOL source statements. It also briefly describes the tools and methodology necessary to complete this step.

To enter ILE COBOL source statements into the system, use one of the following methods:

1. Enter source statements using the Source Entry Utility (SEU). This is the method documented in this chapter.
2. Enter the source statements from a diskette or a tape by using the OS/400 CL commands, CPYFRMTAP and CPYFRMDKT.

   To obtain information on how to enter source statements using the CL commands, refer to the *CL and APIs* section of the *Database and File System* category in the **iSeries 400 Information Center** at this Web site -http://www.ibm.com/eserver/iseries/infocenter.
3. Enter the source statements into a stream file using the Edit File (EDTF) CL command. This command is a general purpose stream file editor that can also be used to enter ILE Cobol source statements. However, this editor does not provide syntax checking capability and special format lines like SEU to aid in source entry. If you want to store your ILE Cobol source statements in a stream file but also want to use the syntax checking features of SEU, perform the following steps:
   - Enter the source statements into a file member using SEU
   - Use the Copy to Stream File (CPYTOSTMF) command to copy the contents of the file member to a stream file

Creating a Library and Source Physical File

Source statements are entered into a member of a physical file. Before you can enter your source, you must first create a library and a source physical file.

A **library** is a system object that serves as a directory to other objects. A library groups related objects and allows you to find objects by name. The object type for a library is *LIB.

A **Source physical file** is a file that stores members. These members contain source statements, such as ILE COBOL source statements.

To create a library called MYLIB, use the Create Library (CRTLIB) command:

```
CRTLIB LIB(MYLIB)
```

To create a source physical file called QCBLLESRC in library MYLIB, use the Create Source Physical File (CRTSRCPF) command:

```
CRTSRCPF FILE(MYLIB/QCBLLESRC)
```

Note: In the above example, the library MYLIB must exist before you can create the source physical file.

For more information on creating library and source physical files, refer to *ADTS/400: Programming Development Manager* manual.

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Once you have the library and source physical file created, you can start an edit session. You can use the Start Source Entry Utility (STRSEU) command to start an edit session and enter your source statements.

Note: You can also enter your source program from diskette or tape with the OS/400 copy function. For information on the OS/400 copy function, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://www.ibm.com/eserver/iseries/infocenter.

Entering Source Statements Using the Source Entry Utility

The Source Entry Utility provides special display formats for COBOL which correspond to the COBOL Coding Form and are designed to help you enter COBOL source statements. Figure 3 shows an example of a display format that SEU provides for COBOL. SEU can display a format line to help you enter or make changes to source code, position by position (see **1**).

```
Columns . . . :    1  71           Edit                        MYLIB/QCBLLESRC
SEU==> _____________________________________________________________      XMPLE1
FMT CB ......-A+++B++++++++++++++++++++++++++++++++++++++++++++++++++++++ 1
       *************** Beginning of data ************************************
0001.00        IDENTIFICATION DIVISION.
0002.00          PROGRAM-ID. XMPLE1.
0003.00
0004.00        ENVIRONMENT DIVISION.
0005.00        CONFIGURATION SECTION.
0006.00          SOURCE-COMPUTER.  IBM-ISERIES.
0007.00        INPUT-OUTPUT SECTION.
0008.00        FILE-CONTROL.
0009.00            SELECT FILE-1 ASSIGN TO DATABASE-MASTER.
       ****************** End of data ***************************************
Prompt type . . .   CB      Sequence number . . .  0008.00
Continuation
_
Area-A      Area-B
FILE       -CONTROL.

F3=Exit   F4=Prompt   F5=Refresh          F11=Previous record
F12=Cancel            F23=Select prompt   F24=More keys
```

Figure 3. An SEU Display Format

For a complete description of how to enter source statements using SEU, refer to *ADTS for AS/400: Source Entry Utility*.

A **compilation unit** is an outermost ILE COBOL program and any nested ILE COBOL programs within the outermost program. Multiple compilation units may be entered in a single source member.

COBOL Source File Format

The standard record length of your source files is 92 characters. These 92 characters are made up of a 6-character sequence number, an 80-character data field, and a 6-character date-last-modified area.

The ILE COBOL compiler supports an additional record length of 102; a field of 10 characters containing supplementary information is placed at the end of the record (positions 93-102). This information is not used by the ILE COBOL compiler, but is

placed on the extreme right of the compiler listing. You are responsible for placing information into this field. If you want to use this additional field, create a source file with a record length of 102.

A source file is supplied where you can store your source records if you do not want to create your own file. This file, named QCBLLESRC, is in library QGPL and has a record length of 92 characters.

Starting SEU

To enter ILE COBOL source program using SEU, enter the Start Source Entry Utility (STRSEU) command, and specify CBLLE for the TYPE parameter. Specify SQLCBLLE for the TYPE parameter if your source program contains imbedded SQL.

If you do not specify a TYPE parameter, SEU uses the same type used when the member was last edited, as the default value. If you do not specify a TYPE parameter and you are creating a new member, SEU assigns a default member type associated with the name of the source physical file. For ILE COBOL, this default member type is CBLLE. For other methods of starting SEU, refer to *ADTS for AS/400: Source Entry Utility*.

Using the COBOL Syntax Checker in SEU

To use the COBOL syntax checker in SEU, specify the TYPE (CBLLE) parameter of the STRSEU command. The COBOL syntax checker checks each line for errors as you enter new lines or change existing lines. Incorrect source statements are identified and error messages displayed, allowing you to correct the errors before compiling the program.

Any time a source line is entered or changed, other lines of source code can be syntax checked as part of that unit of syntax-checking. The length of a single unit of syntax-checking is determined by extending from an entered or changed line as follows:

- A unit of syntax-checking extends towards the beginning of the source member until the beginning of the first source line, or until a period that is the last entry on a line is found.
- A unit of syntax-checking extends towards the end of the source member until the end of the last source line, or until a period that is the last entry on a line is found.

Because the COBOL syntax checker checks only one sentence as it is entered or changed, independent of sentences that precede or follow it, only syntax errors within each source statement can be detected. No inter-relational errors, such as undefined names and incorrect references to names, are detected. These errors are detected by the ILE COBOL compiler when the program is compiled.

Conversely, if a change is made to a sentence that is part of a comment-entry for an optional paragraph of the Identification Division, the syntax checker is not able to recognize that the context permits any combination of characters to be entered. It may generate multiple errors as it attempts to identify the contents of the sentence as a valid COBOL statement. This will be avoided if the comment-entry is written as a single sentence that starts on the same line as the paragraph name, or if the comment-entry is replaced by a series of comment lines.

If there is an error in a unit of syntax-checking, the part of the unit identified as being in error is presented in reverse image. The message at the bottom of the display refers to the first error in the unit.

Syntax checking occurs as you enter the source code. Error messages are generated by lines consisting of incomplete statements. These disappear when the statements are completed, as in the example:

```
Columns . . . :    1  71           Edit                      TESTLIB/QCBLLESRC
SEU==> _____________________________________________________________     ADDATOB
FMT CB ......-A+++B++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
       *************** Beginning of data ************************************
0000.10        IDENTIFICATION DIVISION.
0000.20        PROGRAM-ID. ADDATOB.
0000.30        ENVIRONMENT DIVISION.
0000.40        CONFIGURATION SECTION.
0000.50          SOURCE-COMPUTER. IBM-ISERIES.
0000.60          OBJECT-COMPUTER. IBM-ISERIES.
0000.70        DATA DIVISION.
0000.80        WORKING-STORAGE SECTION.
0000.90        01  A     PIC S9(8) VALUE 5.
0001.00        01  B     PIC S9(8) VALUE 10.
0001.10        PROCEDURE DIVISION.
0001.20        MAINLINE.
0001.30            MOVE A
'''''''
       ****************** End of data ***************************************

F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F10=Cursor   F11=Toggle
F16=Repeat find       F17=Repeat change          F24=More keys
COBOL reserved word or special character 'TO' expected. 'TO' assumed.       +
```

Figure 4. COBOL Syntax Checker error message generated for an incomplete statement

```
Columns . . . :    1  71           Edit                      TESTLIB/QCBLLESRC
SEU==> _____________________________________________________________     ADDATOB
FMT CB ......-A+++B++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
       *************** Beginning of data ************************************
0000.40        IDENTIFICATION DIVISION.
0000.50        PROGRAM-ID. ADDATOB.
0000.60        ENVIRONMENT DIVISION.
0000.70        CONFIGURATION SECTION.
0000.80          SOURCE-COMPUTER. IBM-ISERIES.
0000.90          OBJECT-COMPUTER. IBM-ISERIES.
0000.91        DATA DIVISION.
0000.92        WORKING-STORAGE SECTION.
0000.93        01  A     PIC S9(8) VALUE 5.
0000.94        01  B     PIC S9(8) VALUE 10.
0001.00        PROCEDURE DIVISION.
0001.10        MAINLINE.
0002.00            MOVE A
0003.00            TO B.
'''''''
       ****************** End of data ***************************************
F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F10=Cursor   F11=Toggle
F16=Repeat find       F17=Repeat change          F24=More keys
```

Figure 5. COBOL Syntax Checker error message disappears after statement is completed

An error message is generated after the first line is entered and disappears after the second line is entered, when the statement is completed.

The following regulations apply to syntax checking for ILE COBOL source code:

- Source code on a line with an asterisk (*) or a slash (/) in column 7 is not syntax checked. An asterisk indicates a comment line; a slash indicates a comment line and page eject.

- No compiler options are honored during syntax checking.

  For example, the syntax checker accepts both quotation marks or apostrophes as nonnumeric delimiters provided they are not mixed within one unit of syntax checking. The syntax checker does not check if the delimiter is the one that will be specified in the CRTCBLMOD or CRTBNDCBL commands, or in the PROCESS statement.
- Character replacement specified by the CURRENCY and DECIMAL-POINT clauses of the SPECIAL-NAMES paragraph is not honored during interactive syntax checking.
- When using the REPLACING *Identifier-1* BY *Identifier-2* clause of the COPY statement and when either identifier includes reference modification, the COBOL syntax checker in SEU checks for matching parentheses only.
- The COPY statement and REPLACE statement are checked for syntax structure.
- Imbedded SQL statements are syntax-checked.

Example of Entering Source Statements into a Source Member

This example shows you how to create a library and source physical file, start an edit session, and enter source statements using the Create Library (CRTLIB), Create Source Physical File (CRTSRCPF) and Start SEU (STRSEU) commands.

Note: In order to perform these tasks using these commands you must first have the authority to use the commands.

1. To create a library called MYLIB, type

   ```
   CRTLIB LIB(MYLIB)
   ```

   and press Enter.

   The CRTLIB command creates a library named MYLIB.
2. To create a source physical file called QCBLLESRC, type

   ```
   CRTSRCPF FILE(MYLIB/QCBLLESRC)
   TEXT ('Source physical file for an ILE COBOL for iSeries program')
   ```

   and press Enter.

   The CRTSRCPF command creates a source physical file named QCBLLESRC in library MYLIB.
3. To start an edit session and create a source physical file member XMPLE1, type

   ```
   STRSEU SRCFILE(MYLIB/QCBLLESRC) SRCMBR(XMPLE1)
   TYPE(CBLLE) OPTION(2)
   ```

   and press Enter.

   The STRSEU command creates a new member XMPLE1 in file QCBLLESRC in library MYLIB.

   The SEU Edit display appears as shown in Figure 6.

```
Columns . . . :    1  71           Edit                        MYLIB/QCBLLESRC
SEU==> _____________________________________________________________      XMPLE1
FMT CB ......-A+++B++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
       *************** Beginning of data ************************************
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
'''''''
       ****************** End of data ***************************************
 F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F10=Cursor   F11=Toggle
 F16=Repeat find       F17=Repeat change          F24=More keys
Member XMPLE1 added to file MYLIB/QCBLLESRC.                              +
```

Figure 6. Edit Display for a New Member

4. Type your source in the SEU Edit Display.
5. Press F3 (Exit) to go to the Exit display. Type Y (Yes) to save your XMPLE1 and press Enter.

   The member XMPLE1 is saved.

Using Coded Character Set Identifiers

A Coded Character Set Identifier (CCSID) is a number identifying a specific set of encoding scheme identifiers, character set identifiers, code page identifiers, and additional coding-related information that uniquely identifies the coded graphic character representation used.

All valid ILE COBOL characters except $, @, and # are included in the Syntactic/Invariant Character Set 640. Characters in this set have the same code point in all single-byte EBCDIC code pages, except Code Page 290 (where the code points used for lower-case alphabetic characters in the other code pages are assigned to Katakana characters), and certain code pages which use a different code point for the " (quotes) character.

Note: The @ and # characters support IBM extensions and conventions. The @ character can appear as a conversion specifier in a FORMAT clause literal. The @ and # characters are accepted as valid when checking a literal that defines a program name in a CALL statement.

The ILE COBOL compiler will accept source code written in any single-byte or mixed-byte EBCDIC CCSID, except those based on Code Page 290 (for example, CCSID 290 or CCSID 930). If the source code is stored in a stream file, it may have a non-EBCDIC CCSID. In this case, the compiler will convert the stream file to an EBCDIC CCSID related to the stream file's CCSID before compiling the source code.

CCSIDs can help you to maintain the integrity of character data across systems.

Character Data Representation Architecture (CDRA) definesCCSID values to identify the code points used to represent characters, and to convert these codes as needed to preserve their meanings.

The Extended ACCEPT and DISPLAY statements do not support CCSID conversion.

Assigning a CCSID to a Source Physical File

A CCSID is assigned to each source file at the time it is created on the system. You can explicitly specify the character set you want to use with the CCSID parameter of the CRTSRCPF command when you create the source physical file, or you can accept the default which is *DFTCCSID. For example, to create a source physical file with CCSID 273, type:

```
CRTSRCPF FILE(MYLIB/QCBLLESRC) CCSID(273)
```

If you accept the default, then the CCSID of the job will be assigned to the source physical file. The CCSID assigned depends on the code page being used by the iSeries machine on which the source file is created.

The default CCSID for an iSeries system is CCSID 65535. If the system's CCSID is 65535, then the CCSID assigned to the source physical file is determined by the language identifier of the job.

Including Copy Members with Different CCSIDs in Your Source File

Your ILE COBOL source program can consist of more than one source file. You can
have a primary source file and multiple secondary source files such as copy books and DDS files.

The secondary source files can have CCSIDs that are different from the CCSID of the primary source file. In this case, the contents of the secondary files are converted to the CCSID of the primary source files as they are processed by the ILE COBOL compiler.

CCSID 65535 implies that no conversion of the source file is to take place. If either the primary source file, the secondary source file, or both are assigned CCSID 65535 then no conversion takes place. A syntax error could be reported by the ILE COBOL compiler if the secondary source file contains characters that are not recognized by the character set specified by the CCSID of the primary source file.

When a Format 2 COPY statement is used to incorporate DDS file descriptions into your source program, CCSID conversion does not take place. If the DDS source has a different CCSID than the source member into which it is being copied, then the copied DDS source may contain some characters which are not valid. These characters will be flagged as syntax errors.

If the primary source file and the secondary source files have different CCSIDs and neither is CCSID 65535 then the compile time performance may be impacted. The ILE COBOL compiler must spend time converting the secondary source files from one CCSID to the CCSID of the primary source file. This time may be significant depending on the size of the source files. This is illustrated in the following figure:

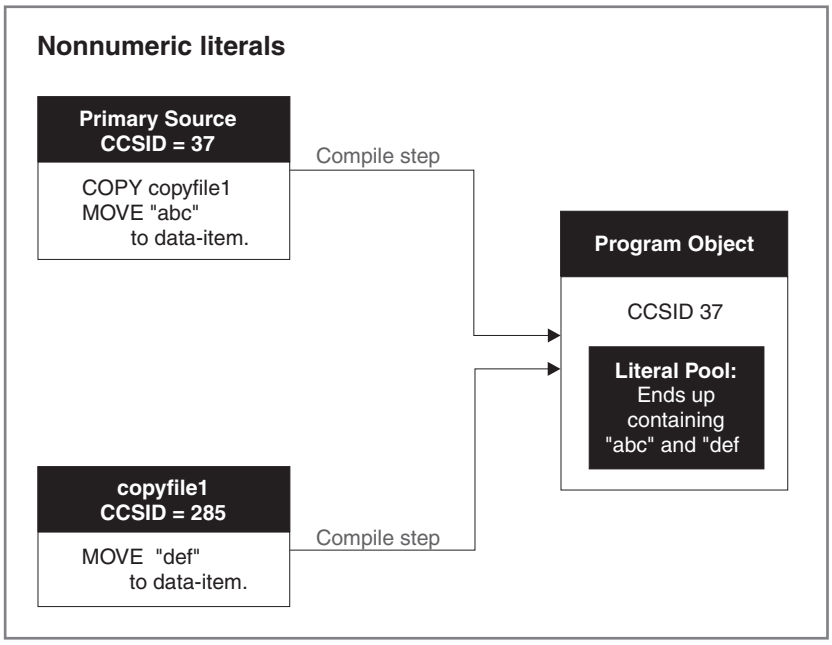

Figure 7. Converting Source Files based on CCSID

Setting the CCSID for the COBOL Syntax Checker in SEU

In order for the COBOL Syntax Checker in SEU to behave in the same manner as the ILE COBOL compiler, you must set the CCSID of the SEU job to be the same as the CCSID of the primary source file that you are editing. In most situations, they will already be the same. However, if they are different, you can change the CCSID of the job by specifying the new CCSID number in the CCSID parameter of the CHGJOB command. For example, to change the CCSID of the current job to 280, type:

```
CHGJOB CCSID(280)
```

For more information on changing the attributes of a job, see the CHGJOB command in the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://www.ibm.com/eserver/iseries/infocenter.

Assigning a CCSID to a Locale

A CCSID is assigned to each locale when it is created on the system. Unlike a file, you have to specify a CCSID when you create the locale. You do this by specifying the CCSID parameter on the CRTLOCALE (Create Locale) command. For example, to create a locale with CCSID 273, type:

```
CRTLOCALE LOCALE('/qsys.lib/testlib.lib/en_us.locale')
SRCFILE('/qsys.lib/qsyslocale.lib/qlocalesrc.file/en_us.mbr')
CCSID(273)
```

Runtime CCSID Considerations

This section describes the runtime CCSID considerations for:

- iSeries files, and their associated COBOL files
- iSeries locales and their associated COBOL data items, which include numeric-edited, date, and time data items.

For Locales and Files

Once you have assigned a CCSID to an iSeries system object (for example, a file or a locale), the ILE COBOL runtime checks the specified CCSID parameter of your CRTCBLMOD (Create ILE COBOL Module) command to decide whether conversion is necessary. The values you can specify for the CCSID parameter are:

***JOBRUN**
: The runtime job's CCSID is used.

***JOB** The compile job's CCSID is used.

***HEX** The CCSID 65535 is used.

coded-character-set-identifier
: The CCSID that you specify is used.

In the case that any of these CCSIDs is equal to 65535, no conversion is done.

When you create a locale object, you can assign a CCSID to it. For example, the locale object created in "Assigning a CCSID to a Locale" on page 18 is created with a CCSID of 273. When you compile a program, you can also assign a CCSID. If the CCSID you specify at compile time is different than the CCSID you specified at the time the locale object was created, then at runtime, a conversion is made to the CCSID specified at compile time.

For Date-Time Data Items and Numeric-Edited Items

For locale objects, locales in ILE COBOL are associated with numeric-edited items and date-time items of category date and time. The following is an example of how to associate a locale with a date-time item and a numeric-edited item:

```
SPECIAL-NAMES.
    LOCALE "EN_US" IN LIBRARY "QSYSLOCALE" IS usa. 1
⋮
DATA DIVISION.
WORKING-STORAGE SECTION.
01 DATE-WITH-LOCALE FORMAT DATE SIZE 10 LOCALE USA. 2
01 DATE-NO-LOCALE FORMAT DATE "@Y-%m-%d"    VALUE "1997-08-09". 3
01 NUMERIC-EDITED-WITH-LOCALE  PIC +$9(6).99 SIZE 15  LOCALE USA.  4
01 NUMERIC-EDITED-NO-LOCALE    PIC +9(6).99   VALUE "+123456.78".
⋮
PROCEDURE DIVISION.
    MOVE DATE-NO-LOCALE TO DATE-WITH-LOCALE.
    MOVE NUMERIC-EDITED-NO-LOCALE TO NUMERIC-EDITED-WITH-LOCALE.
    DISPLAY "date-with-locale = " date-with-locale.
    DISPLAY "numeric-edited-with-locale = "
             numeric-edited-with-locale.
    STOP RUN.
```

The output of the program is:

```
date-with-locale = 08/09/97
numeric-edited-with-locale =    $123,456.78
```

In the above example, line 1 defines the locale mnemonic-name `usa`, and associates that locale mnemonic-name `usa` with `EN_US` in library `QSYSLOCALE`. Although this line defines a locale object, it doesn't have to exist at compile time. However, the locale object does have to exist at runtime. For more information about creating locale objects, refer to "Creating Locales on the iSeries" on page 189 or "Assigning a CCSID to a Locale" on page 18.

Line 2 associates the locale mnemonic-name defined in line 1 with the date data item DATE-WITH-LOCALE. Line 4 associates the locale mnemonic-name defined in line 1 with the numeric-edited data item NUMERIC-EDITED-WITH-LOCALE.

At runtime, when the data in DATE-NO-LOCALE is moved to DATE-WITH-LOCALE, the CCSID of the locale object defined in line 1 (EN_US) is compared to the CCSID specified at compile time. If the CCSIDs are different, then the data defined in DATE-NO-LOCALE (line 3) is converted to the compile-time CCSID, and the formatted data resulting from the MOVE statements is based on the new CCSID.

Most statements in ILE COBOL assume the data is in CCSID 37 (in other words, single-byte EBCDIC). However some statements do support data in one or multiple CCSIDs:

- A MOVE statement with a receiver associated with a locale will convert the sending data to the compile time CCSID.
- A MOVE statement with a sender associated with a locale, or a statement that involves implicit moves, will convert the sender to CCSID 37 when:
  - A numeric-edited item is de-edited
  - A date-time item is de-edited.
- A relational condition that results in date-time comparison, non-numeric comparison, or numeric comparison.

Handling Different CCSIDs with the ILE Source Debugger

Refer to “National Language Support for the ILE Source Debugger” on page 146 for a description of how the ILE source debugger handles different CCIDs.

Chapter 3. Compiling Source Programs into Module Objects

Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about compiling source appears in that product's online help.

The ILE COBOL compiler does not produce a runnable program object. It produces one or more module objects that can be bound together in various combinations to form one or more runnable units known as program objects. For more information on creating runnable program objects, refer to Chapter 4, "Creating a Program Object," on page 75.

This chapter describes:

- how to create a module object
- the CRTCBLMOD command and its parameters
- how to use the PROCESS statement to specify compiler options
- how to understand the output that the ILE COBOL compiler produces.

Definition of a Module Object

Module objects are the output of all ILE compilers including the ILE COBOL compiler. They are system objects of type *MODULE. For ILE COBOL, the name of any permanently created module objects is determined by the CRTCBLMOD command or the PROGRAM-ID paragraph of the outermost ILE COBOL source program. Each compilation unit in a source member creates a separate module object. The outermost ILE COBOL program in a module object can be called by another ILE COBOL program in a different module object through a bound procedure call. It can also be called using a dynamic program call after the module object has been bound into a program object. Refer to "Calling an ILE COBOL Program" on page 204 for a description of bound procedure calls and dynamic program calls.

A module object cannot be run by itself. It must first be bound into a program object. You can bind one or more module objects together to create a program object (type *PGM) or a service program (type *SRVPGM). This ability to combine module objects allows you to:

- Reuse pieces of code generally resulting in smaller programs.
- Share code between several programs therefore eliminating the chance of introducing errors to other parts of the overall program while updating a shared section.
- Mix languages to select the language that best performs the task that needs to be done.

A module object can consist of one or more ILE procedures.

The Create COBOL Module (CRTCBLMOD) command creates one or more module objects from ILE COBOL source statements. These module objects remain stored in the designated library until explicitly deleted or replaced. The module objects can then later be bound into a runnable program object using the Create Program (CRTPGM) command or into a service program using the Create Service Program (CRTSRVPGM) command. The module objects still exist in the library after the

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program object or service program has been created. For more information on creating a program object from one or more module objects, refer to “Using the Create Program (CRTPGM) Command” on page 77. For more information on creating a service program from one or more module objects, refer to Chapter 5, “Creating a Service Program,” on page 101.

The Create Bound COBOL Program (CRTBNDCBL) command creates a program object(s) from ILE COBOL source statements in a single step. CRTBNDCBL does create module objects; however, these module objects are created only temporarily and are not reusable. Once CRTBNDCBL has completed creating the program object(s), the temporary module objects are deleted.

For more information on creating a program object in one step, refer to “Using the Create Bound COBOL (CRTBNDCBL) Command” on page 79.

When a module object is created, it may contain the following:

- Debug data

  Debug data is the data necessary for debugging a program object using the ILE source debugger. This data is generated based on the option specified in the DBGVIEW parameter of the CRTCBLMOD or CRTBNDCBL command.

- Program entry procedure (PEP)

  A **program entry procedure** is the compiler-generated code that is the entry point for a program object on a dynamic program call. Control is passed to the PEP of a program object when it is called using a dynamic program call. It is similar to the code provided for the entry point in an OPM program. The PEP identifies the ILE procedure within a module object that is to be run first when its program object is called using a dynamic program call. When a module object is created by the ILE COBOL compiler, a PEP is generated. This PEP calls the outermost ILE COBOL program contained in the compilation unit.

  When you bind multiple module objects together to create a program object, you must specify which module object will have the PEP of the program object being created. You do this by identifying the module object in the ENTMOD parameter of the CRTPGM command. The PEP of this module object then becomes the PEP for the program object. The PEPs of all other module objects are logically deleted from the program object.

- User entry procedure (UEP)

  When a module object is created by the ILE COBOL compiler, the outermost ILE COBOL program contained in the compilation unit is the **user entry procedure**. During a dynamic program call, the UEP is the ILE procedure that gets control from the PEP. During a static procedure call between ILE procedures in different module objects, the UEP is given control directly.

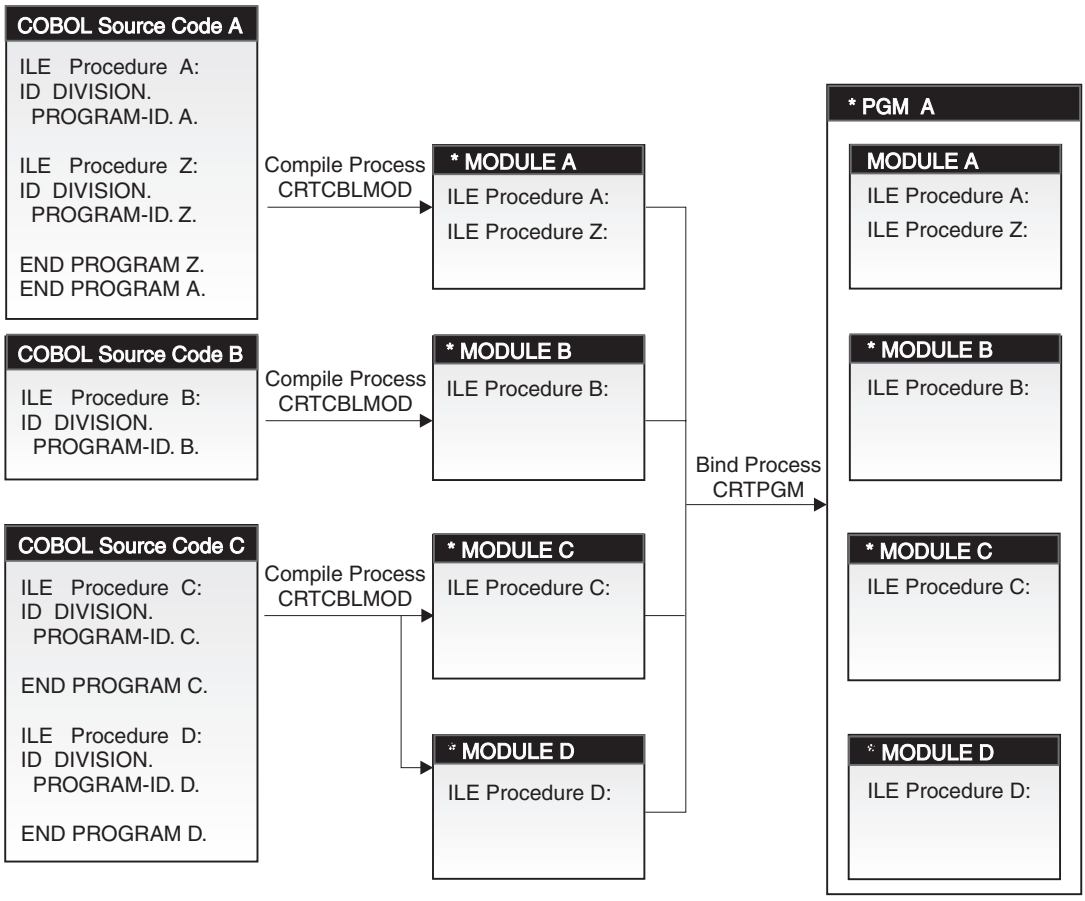


Figure 8. Creating Module Objects Using the CRTCBLMOD Command

In Figure 8, *PGM A is created with *MODULE A designated the module object having the entry point for the program object. The PEP for *MODULE A calls ILE Procedure A. The PEP for *MODULE A also becomes the PEP for *PGM A so the PEP for *PGM A calls ILE Procedure A. The UEP for *PGM A is also ILE Procedure A. *MODULE B, *MODULE C, and *MODULE D also have PEPs but they are ignored by *PGM A. Also, ILE Procedure Z can only be called from ILE Procedure A. ILE Procedure Z is not visible to ILE Procedures B, C, and D as they are in separate module objects and ILE Procedure Z is not the outermost COBOL program in *MODULE A. ILE Procedures A, B, C, and D can call each other. Recursion is not allowed because all of them are non recursive procedures.

Each declarative procedure in an ILE COBOL source program generates a separate ILE procedure.

Each nested COBOL program generates a separate ILE procedure.

A module object can have module exports and module imports associated with it.

A **module export** is the name of a procedure or data item that is available for use by other ILE objects through the binding process. The module export is identified by its name and its associated type, either procedure or data. Module exports can be scoped in two ways: to the program object and to the activation group. Not all names that are exported to the program object are exported to the activation group. The ILE COBOL compiler creates module exports for each of the following COBOL programming language constructs:

- A procedure name corresponding to the outermost ILE COBOL program in a compilation unit.
- A cancel procedure name corresponding to the outermost ILE COBOL program in a compilation unit.
- A weak export of an EXTERNAL file or EXTERNAL data.

A **module import** is the use of or reference to the name of a procedure or data item not defined in a referencing module object. The module import is identified by its name and its associated type, either procedure or data. The ILE COBOL compiler creates module imports for each of the following COBOL programming language constructs:

- A procedure name corresponding to an ILE COBOL program that is called using a static procedure call.
- A cancel procedure name corresponding to an ILE COBOL program that is called using a static procedure call.
- A weak import of an EXTERNAL file or EXTERNAL data.
- A procedure name corresponding to an ILE COBOL program that is set by the SET *procedure-pointer-item* TO ENTRY *procedure-name* statement where the name of *procedure-name* is to be interpreted as an ILE procedure.

The module import is generated when the target procedure is not defined in the referencing module object. A weak import to data item is generated when the data item is referenced in the ILE COBOL program.

Using the Create COBOL Module (CRTCBLMOD) Command

To compile ILE COBOL source statements into one or more module objects, you must use the CRTCBLMOD command. This command starts the ILE COBOL compiler that creates the module object(s) based on your ILE COBOL statements in the source member. You can use the CRTCBLMOD command interactively, or in
batch mode, or from a CL program on the iSeries server.

Note: In order to create a module object with the CRTCBLMOD command you must have authority to use the command.

If the Format 2 COPY statement is used in the program to access externally described files, the operating system provides information about the externally described files to the compiled program.

If the ILE COBOL compiler stops, the message LNC9001

```
Compile failed. module-name not created.
```

You can use a control language program that can monitor for this exception by using the Monitor Message (MONMSG) CL command.

Using Prompt Displays with the CRTCBLMOD Command

The CRTCBLMOD command can be entered using prompt display screens. To enter command parameters in this manner, type CRTCBLMOD and press F4.

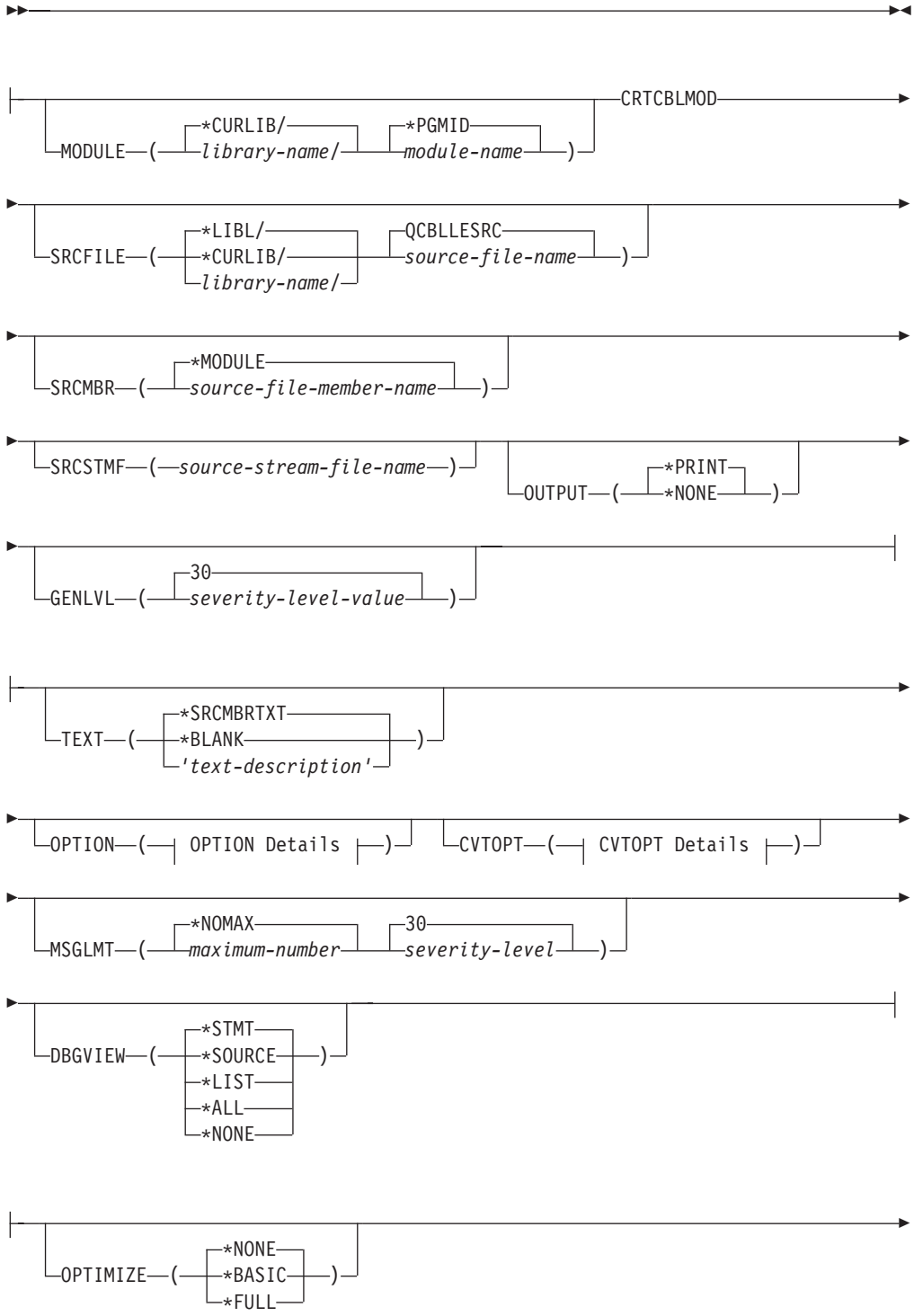
Each parameter on this display shows a default value. Type over any items to set different values or options. If you are unsure about the setting of a parameter value, type a question mark (?) in the first position of the field and press Enter, or F4 (Prompt), to receive more detailed information. The question mark must be

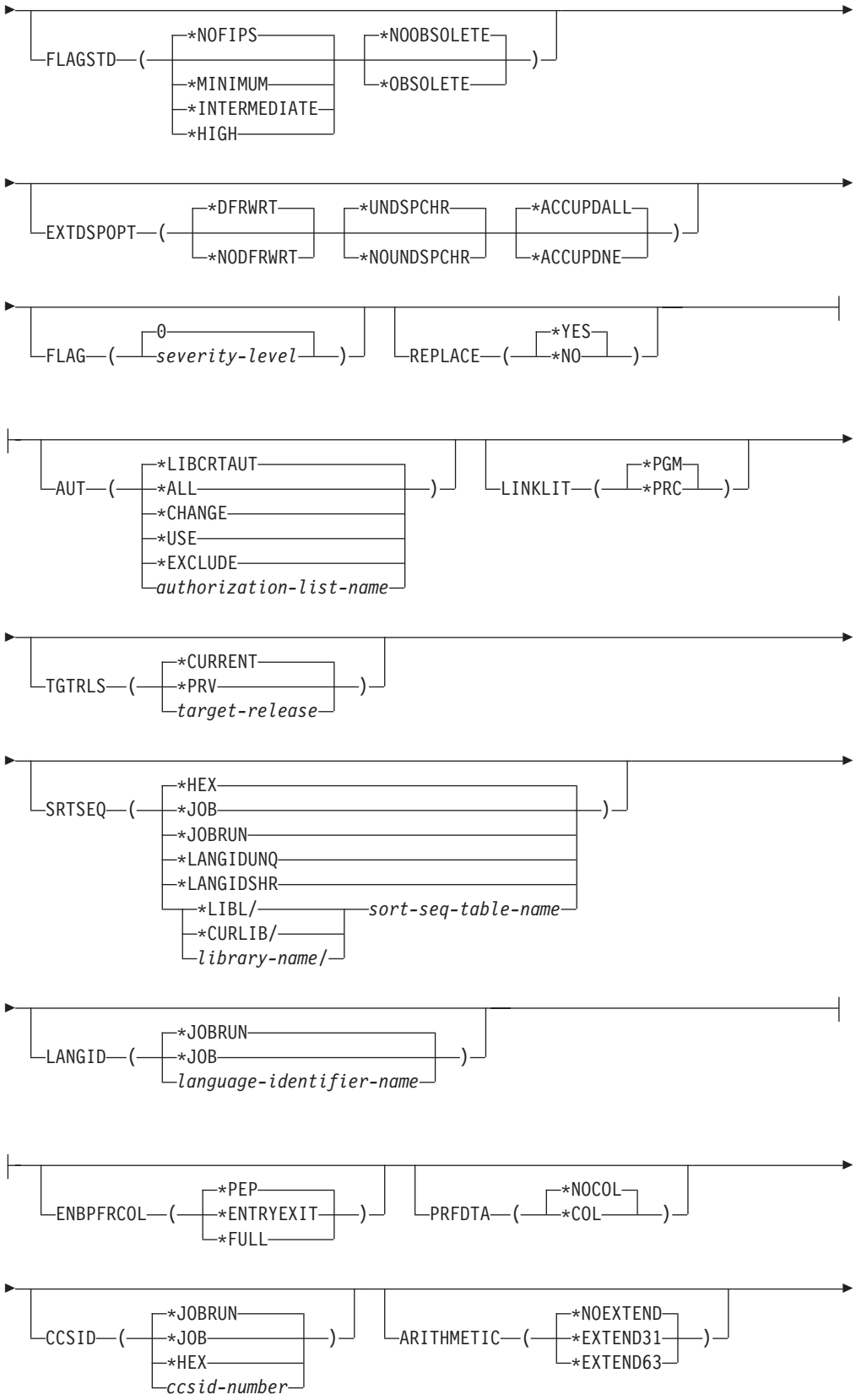
followed by a blank. If you entered some of the parameters before requesting the prompt display screen, the values that you supplied are displayed for the parameter.

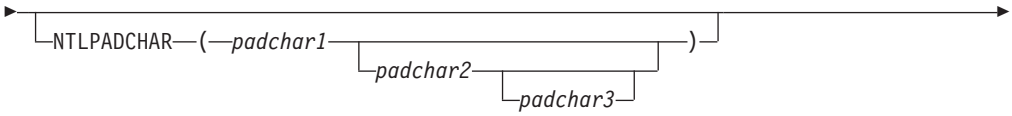
For a description of the parameters for the CRTCBLMOD command refer to "Parameters of the CRTCBLMOD Command" on page 28.

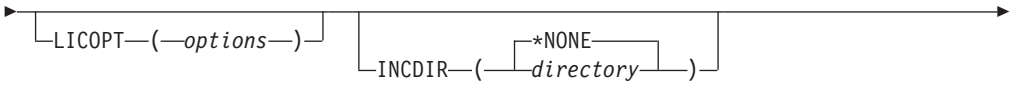
Syntax for the CRTCBLMOD Command

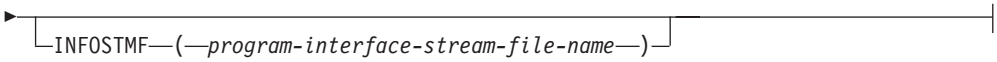
CRTCBLMOD Command—Format



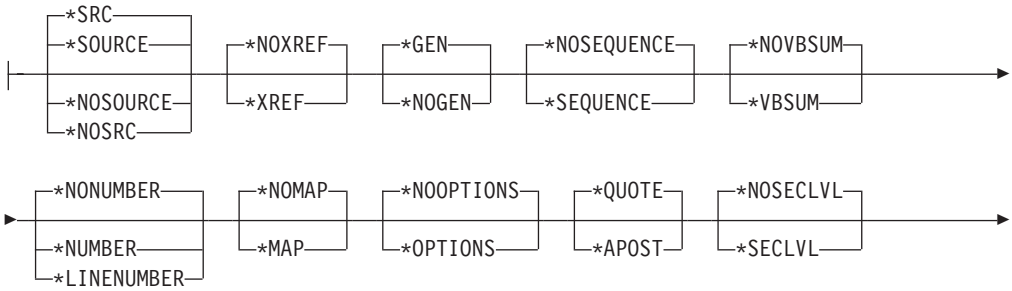

FLAGSTD
*NOFIPS
*MINIMUM
*INTERMEDIATE
*HIGH
*NOOBSOLETE
*OBSOLETE
EXTDSPOPT
*DFRWRT
*NODFRWRT
*UNDSPCHR
*NOUNDSPCHR
*ACCUPDALL
*ACCUPDNE
FLAG
0
severity-level
REPLACE
*YES
*NO
AUT
*LIBCRTAUT
*ALL
*CHANGE
*USE
*EXCLUDE
authorization-list-name
LINKLIT
*PGM
*PRC
TGTRLS
*CURRENT
*PRV
target-release
SRTSEQ
*HEX
*JOB
*JOBRUN
*LANGIDUNQ
*LANGIDSHR
*LIBL/
*CURLIB/
library-name/
sort-seq-table-name
LANGID
*JOBRUN
*JOB
language-identifier-name
ENBPFRCOL
*PEP
*ENTRYEXIT
*FULL
PRFDTA
*NOCOL
*COL
CCSID
*JOBRUN
*JOB
*HEX
ccsid-number
ARITHMETIC
*NOEXTEND
*EXTEND31
*EXTEND63



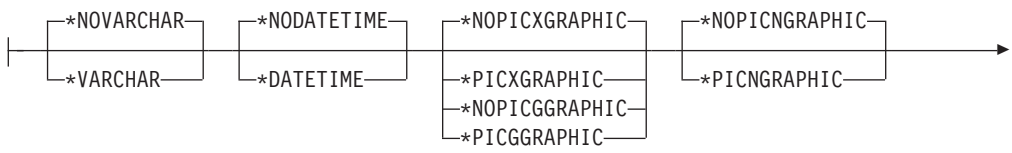


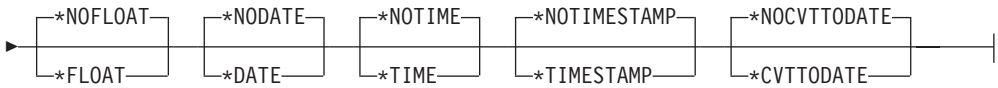


OPTION Details:



CVTOPT Details:





Parameters of the CRTCBLMOD Command

A description of the parameters for the CRTCBLMOD command are defined in this section. The parameters and options are described in the order they appear on the prompt displays.

The default values are displayed first, and are underscored for identification.

All object names specified for the CRTCBLMOD command must follow iSeriesnaming conventions: the names may be basic names, ten characters in length, composed of alphanumeric characters, the first of which must be alphabetic; or the names may be quoted names, eight characters in length, enclosed in double quotes.

You can specify various compiler options by using the OPTION parameter of the CRTCBLMOD command or from within the source program using the PROCESS statement. Any options specified in the PROCESS statement override the corresponding options on the CRTCBLMOD command.

MODULE Parameter:

Specifies the module name and library name for the module object you are creating. The module name and library name must conform to iSeries naming conventions. The possible values are:

***PGMID**

The name for the module is taken from the PROGRAM-ID paragraph in the outermost ILE COBOL source program of the compilation unit.

module-name

Enter a name to identify the compiled ILE COBOL module. If you specify a module name for this parameter, and compile a *sequence of source programs* (multiple compilation units in a single source file member) the first module in the sequence uses this name; any other modules use the name specified in the PROGRAM-ID paragraph in the corresponding outermost ILE COBOL source program of the compilation unit.

The possible library values are:

***CURLIB**

The created module object is stored in the current library. If you have not assigned a library as the current library, QGPL is used.

library-name

Enter the name of the library where the created module object is to be stored.

SRCFILE Parameter:

Specifies the name of the source file and library that contains the ILE COBOL source code to be compiled. This source file should have a record length of 92. The possible values are:

QCBLLESRC

Specifies that the source file, QCBLLESRC, contains the ILE COBOL source code to be compiled.

source-file-name
Enter the name of the source file that contains the ILE COBOL source code to be compiled.

The possible library values are:

***LIBL**
The library list is searched to find the library where the source file is located.

***CURLIB**
The current library is used. If you have not assigned a library as the current library, QGPL is used.

library-name
Enter the name of the library where the source file is located.

SRCMBR Parameter:
Specifies the name of the member that contains the ILE COBOL source code to be compiled. You can specify this parameter only if the source file referred to in the SRCFILE parameter is a database file. The possible values are:

***MODULE**
The source file member with the same name as the module name specified on the MODULE parameter, is used.

If you do not specify a module name for the MODULE parameter, the first member of the database source file is used.

source-file-member-name
Enter the name of the member that contains the ILE COBOL source code.

SRCSTMF Parameter:
Specifies the path name of the stream file containing the ILE COBOL source
code to be compiled. The path name can be either absolutely or relatively
qualified. An absolute path name starts with '/'; a relative path name starts
with a character other than '/'. If absolutely-qualified, the path name is
complete. If relatively-qualified, the path name is completed by appending the
job's current working directory to the path name. The SRCMBR and SRCFILE
parameters cannot be specified with the SRCSTMF parameter.

OUTPUT Parameter:
Specifies if the compiler listing is generated or not. The possible values are:

***PRINT**
A compiler listing is generated. If a member is being compiled, the output
file has the same name as the member. If a stream file is being compiled
and *PGMID is specified in the PGM parameter, the output file has the
name COBOLPGM00. Otherwise, it has the same name as the program.

***NONE**
No compiler listing is generated.

GENLVL Parameter:
Specifies the severity level that determines if a module object is created. The severity level corresponds to the severity level of the messages produced during compilation. This parameter applies individually to each compilation unit in a source file member. Other compilation units in the source file member will still be compiled even if a previous compilation unit fails.

The possible values are:

30 No module object is created if errors occur with a severity level equal to or greater than 30.

severity-level
Specify a one or two-digit number, 0 through 30, which is the severity level you want to use to determine if a module object is to be created. No module object is created if errors occur with a severity level equal to or greater than this severity level.

TEXT Parameter:
Allows you to enter text that briefly describes the module and its function.

***SRCMBRTXT**
The same text that describes the database file member containing the ILE COBOL source code, is used to describe the module object. If the source comes from a device or inline file, specifying *SRCMBRTXT has the same effect as specifying *BLANK.

***BLANK**
No text is specified.

text-description
Enter text briefly describing the module and its function. The text can be a maximum of 50 SBCS characters in length and must be enclosed in single quotation marks. The single quotation marks are not part of the 50-character string.

OPTION Parameter:
Specifies the options to use when the ILE COBOL source code is compiled.

Options specified in the PROCESS statement of an ILE COBOL source program override the corresponding options of the OPTION parameter.

The possible values of the OPTION parameter are:

***SOURCE or *SRC**
The compiler produces a source listing, consisting of the ILE COBOL source program and all compile-time error messages.

***NOSOURCE or *NOSRC**
The compiler does not produce the source part of the listing. If you do not require a source listing, you should use this option because compilation may take less time.

***NOXREF**
The compiler does not produce a cross-reference listing for the ILE COBOL source program.

***XREF**
The compiler produces a cross-reference listing for the source program.

***GEN**
The compiler creates a module object after the ILE COBOL source is compiled.

***NOGEN**
The compiler does not create a module object after the ILE COBOL source program is compiled. You might specify this option if you want only error messages or listings.

***NOSEQUENCE**
The reference numbers are not checked for sequence errors.

***SEQUENCE**
The reference numbers are checked for sequence errors. Sequence errors do not occur if the *LINENUMBER option is specified.

***NOVBSUM**
Verb usage counts are not printed.

***VBSUM**
Verb usage counts are printed.

***NONUMBER**
The source-file sequence numbers are used for reference numbers.

***NUMBER**
The user-supplied sequence numbers (columns 1 through 6) are used for reference numbers.

***LINENUMBER**
The sequence numbers created by the compiler are used for reference numbers. This option combines ILE COBOL program source code and source code introduced by COPY statements into one consecutively numbered sequence. Use this option if you specify FIPS (Federal Information Processing Standards) flagging.

***NOMAP**
The compiler does not list the Data Division map.

***MAP**
The compiler lists the Data Division map.

***NOOPTIONS**
Options in effect are not listed for this compilation.

***OPTIONS**
Options in effect are listed for this compilation.

***QUOTE**
Specifies that the delimiter quotation mark (") is used for nonnumeric literals, hexadecimal literals, and Boolean literals. This option also specifies that the value of the figurative constant QUOTE has the EBCDIC value of a quotation mark.

***APOST**
Specifies that the delimiter apostrophe (') is used for nonnumeric literals, hexadecimal literals, and Boolean literals. This option also specifies that the value of the figurative constant QUOTE has the EBCDIC value of an apostrophe.

***NOSECLVL**
Second level message text is not listed for this compilation.

***SECLVL**
Second level message text is listed for this compilation, along with the first-level error text, in the message section of the compiler listing.

***PRTCORR**
Comment lines are inserted in the compiler listing indicating which elementary items were included as a result of the use of the CORRESPONDING phrase.

***NOPRTCORR**
Comment lines are not inserted in the compiler listing when the CORRESPONDING phrase is used.

***MONOPRC**
The program-name (literal or word) found in the PROGRAM-ID paragraph, the CALL, CANCEL, or SET ENTRY statements, and the END PROGRAM header is converted to all uppercase characters (monocasing) and the rules for program-name formation are enforced.

***NOMONOPRC**
The program-name (literal or word) found in the PROGRAM-ID paragraph, the CALL, CANCEL, or SET ENTRY statements, and the END PROGRAM header is not converted to all uppercase characters (no monocasing) and the rules for program-name formation are not enforced. This option allows special characters not allowed for standard COBOL to be used in the CALL target.

***RANGE**
At run time, subscripts are verified to ensure they are within the correct ranges, but index ranges are not verified. Reference modification and compiler-generated substring operations are also checked.

The contents of date-time items are checked to make sure their format is correct, and that they represent a valid date, time, or timestamp.

***NORANGE**
Ranges are not verified at run time.

Note: The *RANGE option generates code for checking subscript ranges. For example, it ensures that you are not attempting to access the element 21 of a 20-element array.

The *NORANGE option does not generate code to check subscript ranges. As a result, the *NORANGE option produces faster running code.

***NOUNREF**
Unreferenced data items are not included in the compiled module. This reduces the amount of storage used, allowing a larger program to be compiled. You cannot look at or assign to an unreferenced data item during debugging when the *NOUNREF option is chosen. The unreferenced data items still appear in the cross-reference listings produced by specifying OPTION (*XREF).

***UNREF**
Unreferenced data items are included in the compiled module.

***NOSYNC**
The SYNCHRONIZED clause is syntax checked only.

***SYNC**
The SYNCHRONIZED clause is compiled by the compiler. The SYNCHRONIZED clause causes the position of a data item to be aligned such that the right-hand (least-significant) end is on the natural storage boundary. The natural storage boundary is the next nearest 4-byte, 8-byte, or 16-byte boundary in storage depending on the length and type of data being stored. Extra storage is reserved adjacent to the synchronized item to achieve this alignment. Each elementary data item that is described as SYNCHRONIZED is aligned to the natural storage boundary that corresponds to its data storage assignment.

***NOCRTF**
Disk files that are unavailable at the time of an OPEN operation are not created dynamically.

***CRTF**
Disk files that are unavailable at the time of an OPEN operation are created dynamically.

Note: The maximum record length for a file that will be created dynamically is 32 766. Indexed files will not be dynamically created even though the *CRTF option has been specified.

***NODUPKEYCHK**
Does not check for duplicate primary keys for INDEXED files.

***DUPKEYCHK**
Checks for duplicate primary keys for INDEXED files.

***NOINZDLT**
Relative files with sequential access are not initialized with deleted records during the CLOSE operation if the files have been opened for OUTPUT. The record boundary is determined by the number of records written at OPEN OUTPUT time. Subsequent OPEN operations allow access only up to the record boundary.

***INZDLT**
Relative files with sequential access are initialized with deleted records during the CLOSE operation if the files were opened for OUTPUT. Active records in the files are not affected. The record boundary is defined as the file size for subsequent OPEN operations.

***NOBLK**
The compiler allows blocking only of SEQUENTIAL access files with no START statement. The BLOCK CONTAINS clause, if specified, is ignored, except for tape files.

***BLK**
When *BLK is used and a BLOCK CONTAINS clause is specified, the compiler allows blocking for DYNAMIC access files and SEQUENTIAL access files with a START statement. Blocking is not allowed for RELATIVE files opened for output operations. The BLOCK CONTAINS clause controls the number of records to be blocked.

When *BLK is used and no BLOCK CONTAINS clause is specified, the compiler allows blocking only of SEQUENTIAL access files with no START statement. The operating system determines the number of records to be blocked.

***STDINZ**
For those items with no VALUE clause, the compiler initializes data items to default values. The value assigned to each area of storage of the first level-01 or level-77 data item that occupies the area.

***NOSTDINZ**
For those items with no VALUE clause, the compiler does not initialize data items to system defaults.

***STDINZHEX00**
For those items with no VALUE clause, the compiler initializes data items to hexadecimal zero.

***NODDSFILLER**
If no matching fields are found by a COPY DDS statement, no field descriptions are generated.

***DDSFILLER**
If no matching fields are found by a COPY DDS statement, a single character FILLER field description, "07 FILLER PIC X", is always created.

***NOIMBEDERR**
Error messages are not included in the source listing section of the compiler listing. Error messages only appear in the error message section of the compiler listing.

***IMBEDERR**
First level error messages are included in the source listing section of the compiler listing, immediately following the line where the error occurred. Error messages also appear in the error message section of the compiler listing.

***STDTRUNC**
This option applies only to USAGE BINARY data. When *STDTRUNC is selected, USAGE BINARY data is truncated to the number of digits in the PICTURE clause of the BINARY receiving field.

***NOSTDTRUNC**
This option applies only to USAGE BINARY data. When *NOSTDTRUNC is selected, BINARY receiving fields are truncated only at half-word, full-word, or double-word boundaries. BINARY sending fields are also handled as half-words, full-words, or double-words. Thus, the full binary content of the field is significant. Also, the DISPLAY statement will convert the entire content of a BINARY field, with no truncation.

Note: *NOSTDTRUNC has no effect on the VALUE clause.

***NOCHGPOSSGN**
Hexadecimal F is used as the default positive sign for zoned and packed numeric data. Hexadecimal F is the system default for the OS/400 operating system.

***CHGPOSSGN**
Hexadecimal C is used as the default positive sign for zoned and packed numeric data. This applies to all results of the MOVE, ADD, SUBTRACT, MULTIPLY, DIVIDE, COMPUTE, and INITIALIZE statements, as well as the results of the VALUE clause.

***NOEVENTF**
Do not create an Event File for use by CoOperative Development Environment/400 (CODE/400). CODE/400 uses this file to provide error feedback integrated with the CODE/400 editor. An Event File is normally created when you create a module or program from within CODE/400.

***EVENTF**
Create an Event File for use by CODE/400. The Event File is created as a member in file EVFEVENT in the library where the created module or program object is to be stored. If the file EVFEVENT does not exist it is automatically created. The Event File member name is the same as the name of the object being created.

CODE/400 uses this file to provide error feedback integrated with the CODE/400 editor. An Event File is normally created when you create a module or program from within CODE/400.

***MONOPIC**
All alphabetic characters in a PICTURE character-string will be converted to uppercase (monocasing).

***NOMONOPIC**
The currency symbol used in the PICTURE character-string is case sensitive. That is, the lowercase letters corresponding to the uppercase letters for the PICTURE symbols A, B, E, G, N, P, S, V, X, Z, CR, and DB are equivalent to their uppercase representations in a PICTURE character-string. All other lowercase letters are not equivalent to their corresponding uppercase representations.

***NOCRTARKIDX**
Temporary alternate record key (ARK) indexes are not created if permanent ones cannot be found.

***CRTARKIDX**
Temporary alternate record key (ARK) indexes are created if permanent ones cannot be found.

CVTOPT Parameter:
Specifies how the compiler handles date, time, and timestamp field types, DBCS-graphic field type, variable-length field types, and floating-point field types passed from externally-described files to your program through COPY DDS. The possible values are:

***NOVARCHAR**
Variable-length fields are declared as FILLER fields.

***VARCHAR**
Variable-length fields are declared as group items, and are accessible to the ILE COBOL source program.

***NODATETIME**
Date, time, and timestamp data items are declared as FILLER fields.

***DATETIME**
Date, time, and timestamp DDS data items are given COBOL data item names based on their DDS names. The category of the COBOL data item is alphanumeric, unless one of the CVTOPT parameter values *DATE, *TIME, or *TIMESTAMP is specified. In this case, the category of the COBOL data item is date, time, or timestamp, respectively.

***NOPICXGRAPHIC**
DBCS-graphic data items are declared as FILLER fields.

***PICXGRAPHIC**
Fixed-length DBCS-graphic data items are declared as fixed-length alphanumeric fields, and are accessible to the ILE COBOL source program.

When the *VARCHAR option is also in use, variable-length DBCS-graphic data items are declared as fixed-length group items, and are accessible to the ILE COBOL source program.

***PICGGRAPHIC**
Fixed-length DBCS-graphic data items are declared as fixed-length G fields, and are accessible to the ILE COBOL source program.

When the *VARCHAR option is also in use, variable-length DBCS-graphic data items are declared as fixed-length group items (made of a numeric field followed by G type field), and are accessible to the ILE COBOL source program.

***NOPICGGRAPHIC**
DBCS-graphic data items are declared as FILLER fields. *NOPICGGRAPHIC will be printed as *NOPICXGRAPHIC in the listing.

***PICNGRAPHIC**
Fixed-length graphic data items associated with CCSID 13488 are declared as fixed-length N fields, and are accessible to the ILE COBOL source program.

When the *VARCHAR option is also in use, variable-length graphic data items with CCSID 13488 are declared as fixed-length group items (made of a numeric field followed by N type field), and are accessible to the ILE COBOL source program.

***NOPICNGRAPHIC**
The processing of graphic fields depends upon the values specified for the PICXGRAPHIC/NOPICXGRAPHIC and PICGGRAPHIC/NOPICGGRAPHIC options.

***NOFLOAT**
Floating-point data items are declared as FILLER fields with a USAGE of binary.

***FLOAT**
Floating-point data items are brought into the program with their DDS names and a USAGE of COMP-1 (single-precision) or COMP-2 (double-precision). The fields are made accessible to the ILE COBOL source program.

***NODATE**
Date data items are declared as category alphanumeric COBOL data items, for example:

```
06 FILLER PIC X(10).
```

The COBOL data item name is determined by the *NODATETIME/*DATETIME CVTOPT parameter.

***DATE**
DDS date data items are declared as category date COBOL data items, for example:

```
06 FILLER FORMAT DATE '@Y-%m-%d'.
```

The COBOL data item name is determined by the *NODATETIME/*DATETIME CVTOPT parameter.

***NOTIME**
DDS time data items are declared as category alphanumeric COBOL data items, for example:

```
06 FILLER PIC X(8).
```

The COBOL data item name is determined by the *NODATETIME/*DATETIME CVTOPT parameter.

***TIME**
DDS time data items are declared as category time COBOL data items, for example:

```
06 FILLER FORMAT TIME '%H:%M:%S'.
```

The COBOL data item name is determined by the *NODATETIME/*DATETIME CVTOPT parameter.

***NOTIMESTAMP**
DDS timestamp data items are declared as category alphanumeric COBOL data items, for example:

```
06 FILLER PIC X(26).
```

The COBOL data item name is determined by the *NODATETIME/*DATETIME CVTOPT parameter.

***TIMESTAMP**
DDS timestamp data items are declared as category timestamp COBOL data items, for example:

```
06 FILLER FORMAT TIMESTAMP.
```

The COBOL data item name is determined by the *NODATETIME/*DATETIME CVTOPT parameter.

***NOCVTTODATE**
DDS data items with the DATFMT keyword (excluding DDS date data items) are declared in ILE COBOL based on their original DDS type.

***CVTTODATE**
DDS data items with the DATFMT keyword (excluding DDS date data items) are declared in ILE COBOL as date data items. For more information about using the *CVTTODATE option, refer to "Specifying Date, Time, and Timestamp Data Types" on page 48.

MSGLMT Parameter:
Specifies the maximum number of messages of a given error severity level that can occur for each compilation unit before compilation stops. As soon as one compilation unit reaches the maximum, compilation stops for the entire source member.

For example, if you specify 3 for the maximum number of messages and 20 for the error severity level then compilation will stop if three or more errors with a severity level of 20 or higher occur. If no messages equal or exceed the given error severity level, compilation continues regardless of the number of errors encountered.

number-of-messages
Specifies the maximum number of messages. The possible values are:

***NOMAX**
Compilation continues until normal completion regardless of the number of errors encountered.

maximum-number
Specifies the maximum number of messages that can occur at or above the specified error severity level before compilation stops. The valid range is 0-9999.

message-limit-severity
Specifies the error severity level used to determine whether or not to stop compilation. The possible values are:

30 Compilation stops if the number of errors with severity level 30 or higher exceeds the maximum number of messages specified.

error-severity-level
Enter a one or two-digit number, 0 through 30, which is the error severity level you want to use to determine whether or not to stop

compilation. Compilation stops if the number of errors with this severity level or higher exceeds the maximum number of messages you specified.

DBGVIEW Parameter:
Specifies options that control which views of the source program or generated listing are available for debugging the compiled module. The possible values are:

***STMT**
The compiled module can be debugged using symbolic names and statement numbers.

***SOURCE**
The primary source member, as well as copied source members which were included through COPY statements, will have source views available for debugging the compiled module. These views are available only if the primary source member and copied source members come from local database source files. Do not change or delete members during the time between compile and debug.

***LIST**
A listing view, which shows the source code after the processing of any COPY and REPLACE statements, will be made available for debugging the compiled module. This option increases the size of the compiled module, without affecting the runtime performance of the compiled module.

The listing view will include the cross-reference listing, Data Division map, and verb usage counts when the corresponding compiler options are requested. For example, a cross-reference listing will be included if OPTION(*XREF) is specified.

Listing views can be generated regardless of where the primary source members or copied source members come from. Listing views are not affected by changes to or deletion of the source members following the compilation.

***ALL**
Equivalent to specifying *STMT, *SOURCE, and *LIST combined.

***NONE**
The compiled module cannot be debugged. This reduces the size of the compiled program, but does not affect its runtime performance. When this option is specified, a formatted dump can not be taken.

OPTIMIZE Parameter:
Specifies the level of optimization of the module. The possible values are:

***NONE**
No optimization is performed on the compiled module. Compilation time is minimized when this option is used. This option allows variables to be displayed and changed during debugging.

***BASIC**
Some optimization (only at the local block level) is performed on the compiled module. This option allows user variables to be displayed but not changed during debugging.

***FULL**
Full optimization (at the global level) is performed on the compiled module. This optimization increases compilation time but also generates the most efficient code. This option allows user variables to be displayed

but not changed during debugging. The displayed values of the variables may not be their current values. Some variables may not be displayable.

Note: Regardless of the optimization level chosen, all information to allow full optimization is generated. The user can change optimization levels of the module object from *NONE to *FULL using the CHGMOD command without having to recompile the source program.

FLAGSTD Parameter:

Specifies the options for FIPS flagging. (Select the *LINENUMBER option to ensure that the reference numbers used in the FIPS messages are unique.) The possible values are:

***NOFIPS**
The ILE COBOL source program is not FIPS flagged.

***MINIMUM**
FIPS flag for minimum subset and higher.

***INTERMEDIATE**
FIPS flag for intermediate subset and higher.

***HIGH**
FIPS flag for high subset.

***NOOBSOLETE**
Obsolete language elements are not flagged.

***OBSOLETE**
Obsolete language elements are flagged.

EXTDSPOPT Parameter:

Specifies the options to use for extended ACCEPT and extended DISPLAY statements for workstation I/O. The possible values are:

***DFRWRT**
Extended DISPLAY statements are held in a buffer until an extended ACCEPT statement is encountered, or until the buffer is filled.

The contents of the buffer are written to the display when the extended ACCEPT statement is encountered or the buffer is full.

***NODFRWRT**
Each extended DISPLAY statement is performed as it is encountered.

***UNDSPCHR**
Displayable and undisplayable characters are handled by extended ACCEPT and extended DISPLAY statements.

***NOUNDSPCHR**
Only displayable characters are handled by extended ACCEPT and extended DISPLAY statements.

Although you must use this option for display stations attached to remote 3174 and 3274 controllers, you can also use it for local workstations. If you do use this option, your data must contain displayable characters only. If the data contains values less than hexadecimal 20, the results are not predictable, ranging from unexpected display formats to severe errors.

***ACCUPDALL**
All types of data are predisplayed in the extended ACCEPT statements regardless of the existence of the UPDATE phrase.

***ACCUPDNE**
Only numeric edited data are predisplayed in the extended ACCEPT statements that do not contain the UPDATE phrase.

FLAG Parameter:
Specifies the minimum severity level of messages that will appear in the compiler listing. The possible values are:

0 All messages will appear in the compiler listing.

severity-level
Enter a one or two-digit number that specifies the minimum severity level of messages that you want to appear in the compiler listing. Messages that have severity levels of this specified value or higher will appear in the compiler listing.

REPLACE Parameter:
Specifies if a new module is created when a module of the same name in the specified or implied library already exists. The possible values are:

***YES**
A new module is created and it replaces any existing module of the same name in the specified or implied library. The existing module of the same name in the specified or implied library is moved to library QRPLOBJ.

***NO**
A new module is not created if a module of the same name already exists in the specified or implied library. The existing module is not replaced, a message is displayed, and compilation stops.

AUT Parameter:
Specifies the authority given to users who do not have specific authority to the module object, who are not on the authorization list, or whose group has no specific authority to the module object. You can change the authority for all users, or for specific users after the module object is created by using the GRTOBJAUT (Grant Object Authority) or RVKOBJAUT (Revoke Object Authority) commands.

The possible values are:

***LIBCRTAUT**
The public authority for the object is taken from the CRTAUT keyword of the target library (the library that is to contain the created module object). This value is determined when the module object is created. If the CRTAUT value for the library changes after the module object is created, the new value does NOT affect any existing objects.

***ALL**
Provides authority for all operations on the module object except those limited to the owner or controlled by authorization list management authority. The user can control the module object's existence, specify security for it, change it, and perform basic functions on it, but cannot transfer its ownership.

***CHANGE**
Provides all data authority and the authority for performing all operations on the module object except those limited to the owner or controlled by object authority and object management authority. The user can change the object and perform basic functions on it.

***USE**
Provides object operational authority and read authority; authority for

basic operations on the module object. The user can perform basic operations on the object but is prevented from changing the object.

***EXCLUDE**
The user cannot access the module object.

authorization-list-name
The name of an authorization list of users and authorities to which the module is added. The module object is secured by this authorization list, and the public authority for the module object is set to *AUTL. The authorization list must exist on the system when the CRTCBLMOD command is issued. Use the Create Authorization List (CRTAUTL) command to create your own authorization list.

LINKLIT Parameter:
Specifies the linkage type for external CALL/CANCEL 'literal' target and the SET ENTRY target. You may override this option for specific external CALL/CANCEL 'literal' target and the SET ENTRY target lists by specifying the following sentence in the SPECIAL-NAMES paragraph:

```
LINKAGE TYPE IS implementer-name FOR target-list.
```

The possible values for LINKLIT are:

***PGM**
Target for CALL/CANCEL or SET ENTRY is a program object.

***PRC**
Target for CALL/CANCEL or SET ENTRY is an ILE procedure.

TGTRLS Parameter:
Specifies the release of the operating system on which you intend to use the object being created. In the examples given for the *CURRENT and *PRV values, and when specifying the *target-release* value, the format VxRxMx is used to specify the release, where Vx is the version, Rx is the release, and Mx is the modification level. For example, V2R3M0 is version 2, release 3, modification level 0.

Valid values for this parameter change every release. The possible values are:

***CURRENT**
The object is to be used on the release of the operating system currently running on the system. For example, if V2R3M5 is running on the system, *CURRENT means that you intend to use the object on a system with V2R3M5 installed. The object can also be used on a system with any subsequent release of the operating system installed.

Note: If V2R3M5 is running on the system, and the object is to be used on a system with V2R3M0 installed, specify TGTRLS(V2R3M0), not TGTRLS(*CURRENT).

***PRV**
The object is to be used on the previous release with modification level 0 of the operating system. For example, if V2R3M5 is running on the system, *PRV means that you intend to use the object on a system with V2R2M0 installed. You can also use the object on a system with any subsequent release of the operating system installed.

target-release
Specify the release in the format VxRxMx. The object can be used on a system with the specified release or with any subsequent release of the operating system installed.

Valid values depend on the current version, release, and modification level, and they change with each new release. If you specify a *target-release* that is earlier than the earliest release level supported by this command, an error message is sent indicating the earliest supported release.

Note: The current version of the command may support options that are not available in previous releases of the command. If the command is used to create objects that are to be used on a previous release, it will be processed by the compiler appropriate to that release, and any unsupported options will not be recognized. The compiler will not necessarily issue any warnings regarding options that it is unable to process.

SRTSEQ Parameter:

Specifies the sort sequence used when NLSSORT is associated with an alphabet-name in the ALPHABET clause. The SRTSEQ parameter is used in conjunction with the LANGID parameter to determine which system-defined or user-defined sort sequence table the module will use. The possible values are:

***HEX**
No sort sequence table will be used, and the hexadecimal values of the characters will be used to determine the sort sequence.

***JOB**
The sort sequence will be resolved and associated with the module at compile time using the sort sequence of the compile job. The sort sequence table of the compile job must exist in the system at compile time. If at run time, the CCSID of the runtime job differs from the CCSID of the compile time job, the sort sequence table loaded at compile time is converted to match the CCSID of the runtime job.

***JOBRUN**
The sort sequence of the module will be resolved and associated with the module at run time. This value allows a module to be compiled once and used with different sort sequences at run time.

***LANGIDUNQ**
Specifies that the sort sequence table being used must contain a unique weight for each character in the code page. The sort sequence table used will be the unique weighted table associated with the language specified in the LANGID parameter.

***LANGIDSHR**
Specifies that the sort sequence table being used can contain the same weight for multiple characters in the code page. The sort sequence table used will be the shared weighted table associated with the language specified in the LANGID parameter.

table-name
Enter the name of the sort sequence table to be used. The table contains weights for all characters in a given code page. A weight is associated with the character that is defined at the code point. When using a sort sequence table name, the library in which the object resides can be specified. The valid values for the library are:

***LIBL**
The library list is searched to find the library where the sort sequence table is located.

***CURLIB**
The current library is used. If you have not assigned a library as the current library, QGPL is used.

library-name
Enter the name of the library where the sort sequence table is found.

LANGID Parameter:
Specifies the language identifier which is used in conjunction with the sort sequence. The LANGID parameter is used only when the SRTSEQ value in effect is *LANGIDUNQ or *LANGIDSHR. The possible values are:

***JOBRUN**
The language identifier of the module will be resolved at run time. This value allows a module to be compiled once and used with different language identifiers at run time.

***JOB**
The language identifier of the module will be resolved at compile time by using the language identifier of the compile job.

language-identifier-name
Enter a valid 3-character language identifier.

ENBPFRCOL Parameter:
Specifies whether performance measurement code should be generated in the module or program. The data collected can be used by the system performance tool to profile an application's performance. Generating the addition of the performance measurement code in a compiled module or program will result in slightly larger objects and may affect performance.

***PEP**
Performance statistics are gathered on the entry and exit of the program entry procedure only. Choose this value when you want to gather overall performance information for an application. This support is equivalent to the support formally provided with the TPST tool. This is the default.

***ENTRYEXIT**
Performance Statistics are gathered on the entry and exit of all the procedures of the program. This includes the program PEP routine.

This choice would be useful if you want to capture information on all routines. Use this option when you know that all the programs called by your application were compiled with either the *PEP, *ENTRYEXIT or *FULL option. Otherwise, if your application calls other programs that are not enabled for performance measurement, the performance tool will charge their use of resources against your application. This would make it difficult for you to determine where resources are actually being used.

***FULL**
Performance statistics are gathered on the entry and exit of all procedures. Also statistics are gathered before and after each call to an external procedure.

Use this option when you think that your application will call other programs that were not compiled with either *PEP, *ENTRYEXIT or *FULL. This option allows the performance tools to distinguish between resources that are used by your application and those used by programs it calls (even if those programs are not enabled for performance measurement). This option is the most expensive, but allows for selectively analyzing various programs in an application.

PRFDTA Parameter:

Specifies the program profiling data attribute for the module. Program profiling is an advanced optimization technique used to reorder procedures and code within the procedures based on statistical data (profiling data). For more information about collecting profiling data, refer to "Collecting Profiling Data" on page 47.

***NOCOL**
This module is not enabled to collect profiling data. This is the default.

***COL**
This module is enabled to collect profiling data.

Note: *COL can be specified only when the optimization level of the module is *FULL.

CCSID Parameter:

Specifies the coded character set identifier (CCSID) that records in files, and data associated with LOCALEs, are converted to at run time.

***JOBRUN**
The CCSID of the program is resolved at run time. When the compiled program is run, the current job's CCSID is used.

***JOB**
The current job's CCSID at compile time is used.

***HEX**
The CCSID 65535 is used, which indicates that data in the fields is treated as bit data, and is not converted.

coded-character-set-identifier
Specifies the CCSID to be used.

ARITHMETIC Parameter:

Specifies the arithmetic mode for numeric data. The possible values are:

***NOEXTEND**
This option specifies the default arithmetic mode for numeric data. The intermediate result of a fixed-point arithmetic expression can be up to 30 digits and numeric literals may only have a maximum length of 18 digits.

***EXTEND31**
Use this option to increase the precision of intermediate results for fixed-point arithmetic. The intermediate result of a fixed-point arithmetic expression can be up to 31 digits and numeric literals may have a maximum length of 31 digits.

***EXTEND63**
Use this option to increase the precision of intermediate results for fixed-point arithmetic. The intermediate result of a fixed-point arithmetic expression can be up to 63 digits and numeric literals may have a maximum length of 63 digits.

NTLPADCHAR Parameter:

This option specifies padding characters for the MOVE statement, when a national data item receives single-byte, double-byte, or national characters. Specify the padding characters in the following order:

1. Single-byte to national

   The sending item is a single-byte item, such as alphabetic or alphanumeric. Specify a national hexadecimal character. The default is `NX"0020"`.

2. Double-byte to national

   The sending item is a double-byte item. Specify a national hexadecimal character. The default is `NX"3000"`.

3. National to national

   The sending item is a national item. Specify a national hexadecimal character. The default is `NX"3000"`.

LICOPT Parameter:
Specifies one or more Licensed Internal Code compile-time options. This parameter allows individual compile-time options to be selected, and is intended for the advanced programmer who understands the potential benefits and drawbacks of each selected type of compiler option.

INCDIR Parameter:
Specifies one or more directories to add to the search path used by the compiler to find copy files. The compiler will search the directories specified here if the copy files specified in the source code cannot be resolved.

***NONE**
No user directories are searched for copy files. By default, the current directory will still be searched.

directory
Specify up to 32 directories in which to search for copy files. In addition to the specified directories, the current directory is also searched for copy files.

PGMINFO Parameter:
Specifies whether program interface information should be generated into a stream file.

***NO**
Program interface information will not be generated.

***PCML**
PCML (Program Call Markup Language) will be generated into a stream file. The generated PCML makes it easier for Java programs to call this COBOL program, with less Java code. The name of a stream file that will contain the generated PCML must be specified on the INFOSTMF option.

INFOSTMF Parameter:
Specifies the path name of the stream file to contain the generated program interface information specifed on the PGMINFO option. The path name can be either absolutely or relatively qualified. An absolute path name starts with '/'; a relative path name starts with a character other than '/'. If absolutely-qualified, the path name is complete. If relatively-qualified, the path name is completed by appending the job's current working directory to the path name. This parameter can only be specified when the PGMINFO parameter has a value other than *NO.

Example of Compiling a Source Program into a Module Object

This example shows you how to create a ILE COBOL module object using the CRTCBLMOD command.

1. To create a module object, type:

```
CRTCBLMOD MODULE(MYLIB/XMPLE1)
SRCFILE(MYLIB/QCBLLESRC)  SRCMBR(MYLIB/XMPLE1)
OUTPUT(*PRINT)
TEXT('My ILE COBOL Program on iSeries')
CVTOPT(*FLOAT)
```

The CRTCBLMOD command creates the module XMPLE1 in MYLIB, the same library which contains the source. The output option OUTPUT(*PRINT) specifies a compiler listing. The conversion option CVTOPT(*FLOAT) specifies that floating-point data types are brought into the program with their DDS names and a USAGE of COMP-1 (single-precision) or COMP-2 (double-precision).

2. Type one of the following CL commands to view the compile listing.

   Note: In order to view a compiler listing you must have authority to use the commands listed below.
   - `DSPJOB` and then select option 4 (*Display spooled files*)
   - `WRKJOB`
   - `WRKOUTQ queue-name`
   - `WRKSPLF`

Specifying a Different Target Release

You can compile a ILE COBOL program on an iSeries server using the current release of the OS/400 operating system.

Note: The ILE COBOL compiler and the OPM COBOL/400 compiler are separate individual product options. The information contained in this section applies only to the current release of the ILE COBOL compiler.

The Target Release (TGTRLS) parameter of the CRTCBLMOD and CRTBNDCBL commands allows you to specify the release level on which you intend to use the module object. The TGTRLS parameter has three possible values: *CURRENT, *PRV, and *target-release*.

- Specify *CURRENT if the module object is to be used on the release of the operating system currently running on your system. For example, if V4R4M0 is running on the system, *CURRENT means you intend to use the program on a system with V4R4M0 installed. This value is the default.
- Specify *PRV if the object is to be used on the previous release, with modification level 0, of the operating system. For example, if V4R4M0 is running on the system, *PRV means that you intend to use the object on a system with V4R3M0 installed. You can also use the object on a system with any subsequent release of the operating system installed.
- *target-release* allows you to specify the release level on which you intend to use the module object. The values you can enter for this parameter depend on the current version, release, and modification level, and they change with each new release.

  Specify the release level of the target environment in the format VxRxMx. The object can be used on a system with the specified release or with any subsequent release of the operating system installed.

  For example, if you specify V4R2M0, the object can be used on a V4R2M0 system.

For more information about the TGTRLS parameter, see “TGTRLS Parameter” on page 41.

You should be aware of the following limitations:

- You can restore an object program to the current release or to a subsequent release. You cannot restore an object program on a previous release that is not allowed by the TGTRLS *target-release*.
- No product library should be in the system portion of your library list.

Specifying National Language Sort Sequence in CRTCBLMOD

At the time that you compile your ILE COBOL source program, you can explicitly specify the collating sequence that the program will use when it is run, or you can specify how the collating sequence is to be determined when the program is run.

To specify the collating sequence, you first define an *alphabet-name* in the SPECIAL-NAMES paragraph using the ALPHABET clause and associate that *alphabet-name* with the NLSSORT implementor name. Then, refer to this *alphabet-name* in the PROGRAM COLLATING SEQUENCE clause in the ENVIRONMENT DIVISION, or in the COLLATING SEQUENCE phrase in the SORT/MERGE statements, to denote that the specified *alphabet-name* will determine the collating sequence to be used.

You specify the actual collating sequence used, through the options of the SRTSEQ and LANGID parameters of the CRTCBLMOD and CRTBNDCBL commands. For example, if you specify SRTSEQ(*JOBRUN) and LANGID(*JOBRUN), the collating sequence of the program will be resolved at run time. This value allows the source program to be compiled once and used with different collating sequences at run time. The PROCESS statement options associated with SRTSEQ and LANGID may also be used to specify the collating sequence (see "Using the PROCESS Statement to Specify Compiler Options" on page 49).

If your source program does not have NLSSORT associated with an *alphabet-name* in its ALPHABET clause, or has an ALPHABET clause specifying NLSSORT but the associated *alphabet-name* is not referred to in any PROGRAM COLLATING SEQUENCE clause or COLLATING SEQUENCE phrase of SORT/MERGE statements, then the sort sequence identified by the SRTSEQ and LANGID parameters is not used.

The *alphabet-name* associated with NLSSORT cannot be used to determine character code set, as in the CODE-SET clause of the File Description (FD) entry. The *alphabet-name* used to determine character code set must be identified in a separate ALPHABET clause.

Refer to the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the ALPHABET clause, PROGRAM COLLATING SEQUENCE clause, and SORT/MERGE statements. Refer to "Parameters of the CRTCBLMOD Command" on page 28 for a description of the SRTSEQ and LANGID parameters.

Collecting Profiling Data

Once profiling code has been added to a module, it must be placed in a program object or service program object in order for profiling data to be collected. The profiling data can be applied to a program object with the CHGPGM CL command and applied to a service program with the CHGSRVPGM CL command. To apply all the profiling data to a program object or service program specify the PRFDTA parameter with the Apply All (*APYALL) value. To only apply the profiling data

that reorders code within procedures specify the value *APYBLKORD. To only apply the profiling data that reorders procedures specify *APYPRCORD.

Profiling data is collected by specifying the Start Program Profiling (STRPGMPRF) CL command. All the program objects and service programs that are active on the system and that include profiling code will generate profiling data.

Once enough profiling data has been collected, the End Program Profiling (ENDPGMPRF) CL command should be entered.

Program profiling data can be removed from the modules within a program object or service program with the *CLR value of the PRFDTA parameter on the CHGPGM and CHGSRVPGM CL commands.

Enabling a module to collect profiling data causes additional code to be generated in the module object. This code is used to collect data on the number of times basic blocks within procedures have been executed, as well as the number of times procedures have been called. To enable collection of profiling data, modules must be compiled at an optimization level of 30 (*FULL), or greater.

Data that is collected for the basic blocks within procedures is used by the ILE optimizing translator to rearrange these blocks for better cache utilization. Block information is applied to procedures within a module; it does not span module boundaries.

The binder uses the procedure call data in order to package procedures that often call each other together for better page utilization. In other words, it is possible to have PROCA in module A packaged next to PROCB in module B (if PROCA makes many calls to PROCB) in the profiled program. Procedure call data is applied at the program level; it does span module boundaries.

Profiling data can only be collected if the current target release is specified. In order for an ILE program or service program to be profiled, the program *must* have a target release of V4R2M0, or later. This also means that a program enabled to collect profiling data or a profiled program cannot be saved or restored to a release earlier than V4R2M0.

For more information about the PRFDTA parameter, refer to page “PRFDTA Parameter” on page 44.

Note: The potential for inaccuracies in the collected data exists if profile data is collected for programs running in a parallel environment, for example, a multi-threaded process.

Specifying Date, Time, and Timestamp Data Types

Items of COBOL class date-time, include date, time, and timestamp items. These items are declared with the FORMAT clause of a data description entry. For example:

```
01  group-item.
    05 date1 FORMAT DATE "%m/%d/@Y".
    05 date2 FORMAT DATE.
```

For items of class date-time the FORMAT clause is used in place of a PICTURE clause. In the example above, after the keyword FORMAT the keyword DATE declares an item of category date. After the keyword date a format literal describes

the format of the date data item. In the case of data item `date1` the `%m` stands for months, `%d` for days, and the `@Y` for year (including a 2-digit century). The `%` and `@` character begin a specifier. The three specifiers shown here are part of a set of specifiers documented in the *WebSphere Development Studio: ILE COBOL Reference* .

The other date data item, `date2`, has no format literal explicitly specified; however, a default date format can be specified in the SPECIAL-NAMES paragraph. An example is shown below:

```
SPECIAL-NAMES.  FORMAT OF DATE IS "@C:%y:%j".
```

If the above SPECIAL-NAMES paragraph had been specified in the same program as the data item, `date2`, its date format would have been `@C:%y:%j`. On the other hand, if a SPECIAL-NAMES paragraph did not exist, the format of the date item would default to ISO. An ISO date has the format `@Y-%m-%d`.

By default when COPY DDS declares items of class date-time it generates a PICTURE clause for an alphanumeric item. In order to change the PICTURE clause into a FORMAT clause, several new CVTOPT parameter values have been defined. These are:

- *DATE
- *TIME
- *TIMESTAMP.

When *DATE has been specified, any DDS date data types are converted to COBOL date items; in other words, a FORMAT clause is generated instead of a PICTURE clause.

In DDS to specify the format of a date field, the DATFMT keyword can be specified. The DATFMT keyword can also be specified on zoned, packed, and character fields. For these types of fields, COPY DDS would normally generate a PICTURE clause for a numeric zoned, numeric packed, and alphanumeric data item, respectively. You can force COPY DDS to generate a FORMAT clause for these items by specifying the *CVTTODATE value of the CVTOPT parameter.

For a list of the DATFMT parameters allowed for zoned, packed, and character DDS fields, and their equivalent ILE COBOL format that is generated from COPY DDS when the CVTOPT(*CVTTODATE) conversion parameter is specified, refer to “Class Date-Time” on page 416 and “Working with Date-Time Data Types” on page 181.

For moves and comparisons involving a mixture of 4-digit and 2-digit dates, ILE COBOL uses a default windowing algorithm with a base century of 1900 and a base year of 40. Because inaccuracies can result, it may be necessary to override the default window. For more information about the ILE COBOL windowing algorithm and how to override it, refer to “Conversion of 2-Digit Years to 4-Digit Years or Centuries” on page 185.

Using the PROCESS Statement to Specify Compiler Options

The PROCESS statement is an optional part of the ILE COBOL source program. You can use the PROCESS statement to specify options you would normally specify at compilation time.

Options specified in the PROCESS statement **override** the corresponding options specified in the CRTCBLMOD or CRTBNDCBL CL command.

The following rules apply:

- The statement must be placed before the first source statement in the ILE COBOL source program, which starts a new compilation unit, immediately preceding the IDENTIFICATION DIVISION header.
- The statement begins with the word PROCESS. Options can appear on more than one line; however, only the first line can contain the word PROCESS.
- The word PROCESS and all options must appear within positions 8 through 72. Position 7 must be left blank. The remaining positions can be used as in ILE COBOL source statements: positions 1 through 6 for sequence numbers, positions 73 through 80 for identification purposes.
- The options must be separated by blanks and/or commas.
- Options can appear in any order. If conflicting options are specified, for example, XREF and NOXREF, the last option encountered takes precedence.
- If the option keyword is correct and the suboption is in error, the default suboption is assumed.

The following tables indicate the allowable PROCESS statement options and the equivalent CRTCBLMOD or CRTBNDCBL command parameters and options. Defaults are underlined. Descriptions of the PROCESS statement options correspond to the parameter and option descriptions under "Parameters of the CRTCBLMOD Command" on page 28.

Note: Not every parameter of the CRTCBLMOD and CRTBNDCBL commands has a corresponding option in the PROCESS statement. In addition, several options are only available on the process statement. For descriptions of the options that are only on the PROCESS statement, see "PROCESS Statement Options" on page 56.

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	OUTPUT Parameter Options
OUTPUT NOOUTPUT	***PRINT** *NONE

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
	GENLVL Parameter Option
GENLVL(nn)	nn

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	OPTION Parameter Options
SOURCE **SRC** NOSOURCE NOSRC	***SOURCE** ***SRC** *NOSOURCE *NOSRC
NOXREF XREF	***NOXREF** *XREF
GEN NOGEN	***GEN** *NOGEN
NOSEQUENCE SEQUENCE	***NOSEQUENCE** *SEQUENCE

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	OPTION Parameter Options
NOVBSUM VBSUM	***NOVBSUM** *VBSUM
NONUMBER NUMBER LINENUMBER	***NONUMBER** *NUMBER *LINENUMBER
NOMAP MAP	***NOMAP** *MAP
NOOPTIONS OPTIONS	***NOOPTIONS** *OPTIONS
QUOTE APOST	***QUOTE** *APOST
NOSECLVL SECLVL	***NOSECLVL** *SECLVL
PRTCORR NOPRTCORR	***PRTCORR** *NOPRTCORR
MONOPRC NOMONOPRC	***MONOPRC** *NOMONOPRC
RANGE NORANGE	***RANGE** *NORANGE
NOUNREF UNREF	***NOUNREF** *UNREF
NOSYNC SYNC	***NOSYNC** *SYNC
NOCRTF CRTF	***NOCRTF** *CRTF
NODUPKEYCHK DUPKEYCHK	***NODUPKEYCHK** *DUPKEYCHK
NOINZDLT INZDLT	***NOINZDLT** *INZDLT
NOBLK BLK	***NOBLK** *BLK
STDINZ NOSTDINZ STDINZHEX00	***STDINZ** *NOSTDINZ *STDINZHEX00
NODDSFILLER DDSFILLER	***NODDSFILLER** *DDSFILLER
Not applicable	***NOIMBEDERR** *IMBEDERR
STDTRUNC NOSTDTRUNC	***STDTRUNC** *NOSTDTRUNC
CHGPOSSGN NOCHGPOSSGN	***CHGPOSSGN** *NOCHGPOSSGN
Not applicable	***NOEVENTF** *EVENTF
MONOPIC NOMONOPIC	***MONOPIC** *NOMONOPIC

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	OPTION Parameter Options
NOCRTARKIDX CRTARKIDX	***NOCRTARKIDX** *CRTARKIDX

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	CVTOPT Parameter Options
NOVARCHAR VARCHAR	***NOVARCHAR** *VARCHAR
NODATETIME DATETIME	***NODATETIME** *DATETIME
NOCVTPICXGRAPHIC CVTPICXGRAPHIC CVTPICGGRAPHIC NOCVTPICGGRAPHIC	***NOPICXGRAPHIC** *PICXGRAPHIC *PICGGRAPHIC *NOPICGGRAPHIC
NOCVTPICNGRAPHIC CVTPICNGRAPHIC	***NOPICNGRAPHIC** *PICNGRAPHIC
NOFLOAT FLOAT	***NOFLOAT** *FLOAT
NODATE DATE	***NODATE** *DATE
NOTIME TIME	***NOTIME** *TIME
NOTIMESTAMP TIMESTAMP	***NOTIMESTAMP** *TIMESTAMP
NOCVTTODATE CVTTODATE	***NOCVTTODATE** *CVTTODATE

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	OPTIMIZE Parameter Options
NOOPTIMIZE BASICOPT FULLOPT	***NONE** *BASIC *FULL

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	FLAGSTD Parameter Options
NOFIPS MINIMUM INTERMEDIATE HIGH	***NOFIPS** *MINIMUM *INTERMEDIATE *HIGH
NOOBSOLETE OBSOLETE	***NOOBSOLETE** *OBSOLETE

PROCESS Statement Options **EXTDSPOPT**(*a b c*)	CRTCBLMOD/CRTBNDCBL
	EXTDSPOPT Parameter Options
DFRWRT NODFRWRT	***DFRWRT** *NODFRWRT

PROCESS Statement Options EXTDSPOPT(*a b c*)	CRTCBLMOD/CRTBNDCBL
	EXTDSPOPT Parameter Options
UNDSPCHR NOUNDSPCHR	***UNDSPCHR** *NOUNDSPCHR
ACCUPDALL ACCUPDNE	***ACCUPDALL** *ACCUPDNE

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
	FLAG Parameter Option
FLAG(nn)	nn

PROCESS Statement Options	CRTCBLMOD/CRTBNDCBL
	LINKLIT Parameter Options
LINKPGM LINKPRC	***PGM** *PRC

PROCESS Statement Options SRTSEQ(*a*)	CRTCBLMOD/CRTBNDCBL
	SRTSEQ Parameter Options
HEX JOB JOBRUN LANGIDUNQ LANGIDSHR "LIBL/sort-seq-table-name" "CURLIB/sort-seq-table-name" "library-name/sort-seq-table-name" "sort-seq-table-name"	***HEX** *JOB *JOBRUN *LANGIDUNQ *LANGIDSHR *LIBL/sort-seq-table-name *CURLIB/sort-seq-table-name library-name/sort-seq-table-name sort-seq-table-name

PROCESS Statement Options LANGID(*a*)	CRTCBLMOD/CRTBNDCBL
	LANGID Parameter Options
JOBRUN JOB "language-identifier-name"	***JOBRUN** *JOB language-identifier-name

PROCESS Statement Options ENBPFRCOL(*a*)	CRTCBLMOD/CRTBNDCBL
	ENBPFRCOL Parameter Options
PEP ENTRYEXIT FULL	***PEP** *ENTRYEXIT *FULL

PROCESS Statement Options PRFDTA(*a*)	CRTCBLMOD/CRTBNDCBL
	PRFDTA Parameter Options
NOCOL COL	***NOCOL** *COL

PROCESS Statement Options CCSID(*a b c*)	CRTCBLMOD/CRTBNDCBL
	CCSID Parameter Options
a = Locale single-byte data CCSID	
JOBRUN JOB HEX *coded-character-set-identifier*	***JOBRUN** *JOB *HEX *coded-character-set-identifier*
b = Non-locale single-byte data CCSID	
JOBRUN JOB HEX *coded-character-set-identifier*	Not applicable
c = Non-locale double-byte data CCSID	
JOBRUN JOB HEX *coded-character-set-identifier*	Not applicable

PROCESS Statement Options DATTIM(*a b*)	CRTCBLMOD/CRTBNDCBL
4-digit base century (default 1900) *2-digit base year* (default 40)	Not applicable

PROCESS Statement Options THREAD(*a*)	CRTCBLMOD/CRTBNDCBL
NOTHREAD SERIALIZE	Not applicable

PROCESS Statement Options ARITHMETIC(*a*)	CRTCBLMOD/CRTBNDCBL
	ARITHMETIC Parameter Options
NOEXTEND EXTEND31 EXTEND63	***NOEXTEND** *EXTEND31 *EXTEND63

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
NOGRAPHIC GRAPHIC	Not applicable

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
NONATIONAL NATIONAL	Not applicable

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
NOLSPTRALIGN LSPTRALIGN	Not applicable

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
NOCOMPASBIN COMPASBIN	Not applicable

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
NOCOMPRESSDBG COMPRESSDBG	Not applicable

PROCESS Statement Option OPTVALUE(*a*)	CRTCBLMOD/CRTBNDCBL
NOOPT OPT	Not applicable

PROCESS Statement Option	CRTCBLMOD/CRTBNDCBL
NOADJFILLER ADJFILLER	Not applicable

PROCESS Statement Option NTLPADCHAR(a b c)	CRTCBLMOD/CRTBNDCBL
	NTLPADCHAR Parameter Options
a = padding character for moving single-byte to national	
NX″0020″ a national hexadecimal literal representing one national character	**NX″0020″** a national character
b = padding character for moving double-byte to national	
NX″3000″ a national hexadecimal literal representing one national character	**NX″3000″** a national character
c = padding character for moving national to national	
NX″3000″ a national hexadecimal literal representing one national character	**NX″3000″** a national character

PROCESS Statement Option LICOPT(a)	CRTCBLMOD/CRTBNDCBL
	LICOPT Parameter Option
licensed-internal-code-option-string	licensed-internal-code-option-string

The EXTDSPOPT, SRTSEQ, LANGID, ENBPFRCOL, PRFDTA, CCSID, DATTIM, ARITHMETIC, and THREAD options on the PROCESS statement should be coded with the associated options in brackets similar to `FLAG(nn)` syntax.

You can specify more than one option within the brackets for the EXTDSPOPT option. For example, to specify DFRWRT and UNDSPCHR, type

```
EXTDSPOPT(DFRWRT UNDSPCHR)
```

It is also valid to specify `EXTDSPOPT` or `EXTDSPOPT( )`.

When EXTDSPOPT alone is specified in the PROCESS statement, then all the default values for the additional options are in effect.

If you specify `EXTDSPOPT( )`, it has no effect on your program.

The DATTIM and CCSID process statement options also allow more than one value within their brackets. For these two options, the order of the values within their brackets is significant. For example, the DATTIM option has two values. The

first is the base Century, and the second is the base year. This means that you must specify a base century in order to specify a base year.

PROCESS Statement Options

The following options are only available on the PROCESS statement and do not have equivalent CRTCBLMOD or CRTBNDCBL command parameters.

NOGRAPHIC Option:

When NOGRAPHIC is specified or implied, the ILE COBOL compiler will treat nonnumeric literals containing hex 0E and hex 0F as if they only contain SBCS characters. Hex 0E and hex 0F are not treated as shift-in and shift-out characters, they are considered to be part of the SBCS character string. See Appendix D, "Supporting International Languages with Double-Byte Character Sets," on page 593 for information about DBCS support.

GRAPHIC Option:

The GRAPHIC option of the PROCESS statement is available for processing DBCS characters in mixed literals. **Mixed literals** are literals that combine SBCS characters and DBCS characters. When the GRAPHIC option is specified, mixed literals will be handled with the assumption the hex 0E and hex 0F are shift-in and shift-out characters respectively, and they enclose the DBCS characters in the mixed literal. Shift-in and shift-out characters occupy 1 byte each.

DATTIM Option:

Specifies the date window that ILE COBOL uses for its windowing algorithm. (See "Overriding the Default Date Window Using the DATTIM Process Statement Option" on page 186.)

4-digit base century

This must be the first argument. Defines the base century that ILE COBOL uses for its windowing algorithm. If the DATTIM process statement option is not specified, 1900 is used.

2-digit base year

This must be the second argument. Defines the base year that ILE COBOL uses for its windowing algorithm. If the DATTIM process statement option is not specified, 40 is used.

THREAD Option:

Specifies whether or not the created module object will be enabled to run in a multithreaded environment. Refer to Chapter 14, "Preparing ILE COBOL Programs for Multithreading," on page 337 for a discussion of ILE COBOL support for multithreading. The possible values are:

NOTHREAD

The created module object will *not* be enabled to run in a multithreaded environment. This is the default.

SERIALIZE

The created module object will be enabled to run in a job with multiple threads. Access to procedures within the module(s) is serialized. That is, each thread safe module will have a recursive mutex that is locked when a procedure is entered and unlocked when the procedure is exited. Within a run unit, only one thread is allowed to be active at any one time for the same module.

NONATIONAL Option:

When NONATIONAL is specified or implied, USAGE DISPLAY-1 is implied

for any item that has a picture character string consisting of only the picture symbol N and no explicit USAGE clause.

NATIONAL Option:
When NATIONAL is specified, USAGE NATIONAL is implied for any item that has a picture character string consisting of only the picture symbol N and no explicit USAGE clause.

NOLSPTRALIGN Option:
When NOLSPTRALIGN is specified or implied, data items with USAGE POINTER or PROCEDURE-POINTER are placed contiguously without any filler space in the linkage section.

LSPTRALIGN Option:
When LSPTRALIGN is specified, data items with USAGE POINTER or PROCEDURE-POINTER are aligned at multiples of 16 bytes relative to the beginning of the record in the linkage section.

NOCOMPASBIN Option:
When NOCOMPASBIN is specified or implied, USAGE COMPUTATIONAL or COMP has the same meaning as USAGE COMP-3.

COMPASBIN Option:
When COMPASBIN is specified, USAGE COMPUTATIONAL or COMP has the same meaning as USAGE COMP-4.

OPTVALUE Option:
The possible values are:

NOOPT
The generation of code to initialize data items containing a VALUE clause in the working-storage section is not optimized. This is the default.

OPT
The generation of code to initialize data items containing a VALUE clause in the working-storage section is optimized.

NOADJFILLER Option:
If a pointer data item is the first member of a group, any implicit fillers inserted by the compiler to align this pointer data item are inserted immediately after the group. This is the default.

ADJFILLER Option:
If a pointer data item is the first member of a group, any implicit fillers inserted by the compiler to align this pointer data item are inserted immediately before the group.

COMPRESSDBG Option:
When COMPRESSDBG option is specified and the DBGVIEW compiler option is *LIST or *ALL, the ILE COBOL compiler will compress the listing view generated with the compiled module or program. If the DBGVIEW compiler option is not *LIST or *ALL, this option has no effect. By using this option, some but not all large COBOL programs will be able to compile with the *LIST debug view option.

NOCOMPRESSDBG Option:
No listing view compression is performed on the compiled module or program. This is the default.

Compiling Multiple Source Programs

The PROCESS statement can be placed at the beginning of each compilation unit in the sequence of ILE COBOL source programs in the input source member. When compiling multiple ILE COBOL source programs, the merged results of all options specified on the CRTCBLMOD or CRTBNDCBL command, plus all default options, plus the options specified on the last PROCESS statement preceding the ILE COBOL source program will be in effect for the compilation of that ILE COBOL source program. All compiler output is directed to the destinations specified by the CRTCBLMOD or CRTBNDCBL command.

All module objects or program objects are stored in the library specified on the MODULE parameter or PGM parameter. If *module-name* or *program-name* is specified for the MODULE parameter or PGM parameter, the first module object or program object corresponding to the first ILE COBOL source program in the sequence of ILE COBOL source programs use that name, and all module objects or program objects corresponding to the other ILE COBOL source programs in the same input source member use the name specified in the PROGRAM-ID paragraph in the ILE COBOL source program.

Using COPY within the PROCESS Statement

A COPY statement can be used in the source program wherever a character-string or separator can be used. Each COPY statement must be preceded by a space and followed by a period and a space. For more information on the COPY statement, refer to the "COPY Statement" section of the *WebSphere Development Studio: ILE COBOL Reference*.

The Format 1 COPY statement can be used within the PROCESS statement to retrieve compiler options previously stored in a source library, and include them in the PROCESS statement. COPY can be used to include options that override those specified as defaults by the compiler. Any PROCESS statement options can be retrieved with the COPY statement.

Compiler options can both precede and follow the COPY statement within the PROCESS statement. The last encountered occurrence of an option overrides all preceding occurrences of that option.

The following example shows the use of the COPY statement within the PROCESS statement. Notice also that, in this example, NOMAP overrides the corresponding option in the library member:

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL    CBLGUIDE/COPYPROC   ISERIES1   03/09/15 11:39:37     Page    2
                                 Source
STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
          000100 PROCESS XREF
          000200 COPY PROCDFLT.
         +000100         MAP, SOURCE, APOST                                          PROCDFLT
         +000200                                                                     PROCDFLT
          000300         NOMAP, FLAG(20)
     1    000400 IDENTIFICATION DIVISION.
     2    000500 PROGRAM-ID. COPYPROC.
     3    000600 ENVIRONMENT DIVISION.
     4    000700 CONFIGURATION SECTION.
     5    000800   SOURCE-COMPUTER. IBM-ISERIES
     6    000900   OBJECT-COMPUTER. IBM-ISERIES
     7    001000 PROCEDURE DIVISION.
          001100 MAINLINE.
     8    001200     DISPLAY "HELLO WORLD".
     9    001300     STOP RUN.
          001400
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 9. Using COPY within the PROCESS Statement

Understanding Compiler Output

The compiler can be directed to produce a selection of printed reports. By default, this output will be directed to the system printer file QSYSPRT.

The output can include:

- A summary of command options
- An **options listing**, which is a listing of options in effect for the compilation. Use OPTION(*OPTIONS).
- A **source listing**, which is a listing of the statements contained in the source program. Use OPTION(*SOURCE).
- A **verb usage listing**, which is a listing of the COBOL verbs and the number of times each verb is used. Use OPTION(*VBSUM).
- A **Data Division map**, which is a glossary of compiler-generated information about the data. Use OPTION(*MAP).
- **FIPS messages**, which is a list of messages for a FIPS COBOL subset, for any of the optional modules, for all of the obsolete language elements, or for a combination of a FIPS COBOL subset, optional modules and all obsolete elements. Refer to the information on the “FLAGSTD Parameter” on page “FLAGSTD Parameter” on page 39 for the specific options available for FIPS flagging.
- A **cross-reference listing**. Use OPTION(*XREF).
- An **imbedded error listing**. Use OPTION(*IMBEDERR).
- **Compiler messages** (including diagnostic statistics).
- **Compilation statistics**.
- **Module objects**. Use the CRTCBLMOD command.
- **Program objects**. Use the CRTBNDCBL command.

The presence or absence of some of these types of compiler output is determined by options specified in the PROCESS statement or through the CRTCBLMOD or CRTBNDCBL command. The level of diagnostic messages printed depends upon the FLAG option. The DBGVIEW option dictates what kind of debug data is contained in the generated module object or program object.

Specifying the Format of Your Listing

A slash (/) in the indicator area (column 7) of a line results in page ejection of the source program listing. You can also enter comment text after the slash (/) on this line. The slash (/) comment line prints on the first line of the next page.

If you specify the EJECT statement in your program, the next source statement prints at the top of the next page in the compiler listing. This statement may be written anywhere in Area A or Area B and must be the only statement on the line.

The SKIP1/2/3 statement causes blank lines to be inserted in the compiler listing. A SKIP1/2/3 statement can be written anywhere in Area A or B. It must be the only statement on the line.

- SKIP1 inserts a single blank line (double spacing).
- SKIP2 inserts two blank lines (triple spacing).
- SKIP3 inserts three blank lines (quadruple spacing).

Each of the above SKIP statements causes a single insertion of one, two, or three lines.

A TITLE statement places a title on each indicated page.

You can selectively list or suppress your ILE COBOL source statements by using the *CONTROL, *CBL, or COPY statements:

- *CONTROL NOSOURCE and *CBL NOSOURCE suppress the listing of source statements.
- *CONTROL SOURCE and *CBL SOURCE continue the listing of source statements.
- A COPY statement bearing the SUPPRESS phrase suppresses the listing of copied statements. For its duration, this statement overrides any *CONTROL or *CBL statement. If the copied member contains *CONTROL or *CBL statements, the last one runs once the COPY member has been processed.

Refer to the *WebSphere Development Studio: ILE COBOL Reference* for additional information about the EJECT, SKIP1/2/3, *CONTROL, *CBL, COPY, and TITLE statements.

Time-Separation Characters

The TIMSEP parameter of job-related commands (such as CHGJOB) now specifies the time-separation character used in the time stamps that appear on compiler listings. In the absence of a TIMSEP value, the system value QTIMSEP is used by default.

Browsing Your Compiler Listing Using SEU

The Source Entry Utility (SEU) allows you to browse through a compiler listing in an output queue. You can review the results of a previous compilation while making the required changes to your source code.

While browsing the compiler listing, you can scan for errors and correct those source statements that have errors. To scan for errors, type `F *ERR` on the SEU command line.

For complete information on browsing through a compiler listing, see *ADTS for AS/400: Source Entry Utility*.

A Sample Program and Listing

The following sample listings illustrate the compiler options and source listing produced for the program example. References to the figures are made throughout the following text. These references are indexed by the reverse printing of letters on a black background, for example (**Z**). The reverse letters in the text correspond to the letters found in the figures.

Command Summary

This summary, produced as a result of compilation, lists all options specified in the CRTCBLMOD or CRTBNDCBL command. Refer to "Using the Create COBOL Module (CRTCBLMOD) Command" on page 24 for more information about user-defined options.

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL        CBLGUIDE/EXTLFL     ISERIES1   03/09/15 13:11:39      Page    1
Command  . . . . . . . . . . . . . . . :   CRTCBLMOD
Actual Values:
  Module . . . . . . . . . . . . . . . :   EXTLFL
    Library  . . . . . . . . . . . . . :     CBLGUIDE
  Source file  . . . . . . . . . . . . :   QCBLLESRC
    Library  . . . . . . . . . . . . . :     CBLGUIDE
    CCSID  . . . . . . . . . . . . . . :   37
  Source member  . . . . . . . . . . . :   EXTLFL         02/03/05 10:50:50
  Text 'description' . . . . . . . . . :   *BLANK
Command Options:
  Module . . . . . . . . . . . . . . . :   EXTLFL
    Library  . . . . . . . . . . . . . :     CBLGUIDE
  Source file  . . . . . . . . . . . . :   QCBLLESRC
    Library  . . . . . . . . . . . . . :     CBLGUIDE
  Source member  . . . . . . . . . . . :   EXTLFL
  Output . . . . . . . . . . . . . . . :   *PRINT
  Generation severity level  . . . . . :   30
  Text 'description' . . . . . . . . . :   *SRCMBRTXT
  Compiler options . . . . . . . . . . :   *NONE
  Conversion options . . . . . . . . . :   *NONE
  Message limit:
    Number of messages . . . . . . . . :   *NOMAX
    Message limit severity . . . . . . :   30
  Debug view . . . . . . . . . . . . . :   *STMT
  Optimize level . . . . . . . . . . . :   *NONE
  FIPS flagging  . . . . . . . . . . . :   *NOFIPS *NOOBSOLETE
  Extended display options . . . . . . :   *NONE
  Flagging severity  . . . . . . . . . :   0
  Replace module . . . . . . . . . . . :   *NO
  Authority  . . . . . . . . . . . . . :   *LIBCRTAUT
  Link literal . . . . . . . . . . . . :   *PGM
  Target release . . . . . . . . . . . :   *CURRENT
  Sort sequence  . . . . . . . . . . . :   *HEX
    Library  . . . . . . . . . . . . . :
  Language identifier  . . . . . . . . :   *JOBRUN
  Enable performance collection:
    Collection level . . . . . . . . . :   *PEP
  Profiling data . . . . . . . . . . . :   *NOCOL
  Coded character set ID . . . . . . . :   *JOBRUN
  Arithmetic mode. . . . . . . . . . . :   *NOEXTEND
  Padding character:
    Single byte to national  . . . . . :   NX"0020"
    Double byte to national  . . . . . :   NX"3000"
    National to national . . . . . . . :   NX"3000"
Include directory  . . . . . . . . . . :   *NONE
Generate program information . . . . . :   *NO
Compiler . . . . . . . . . . . . . . . :   IBM ILE COBOL
```

Figure 10. CRTCBLMOD Command Summary Listing

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL         CBLGUIDE/SAMPLE      ISERIES1   03/09/15 11:18:21        Page      1
Command  . . . . . . . . . . . . . . . :   CRTBNDCBL
Actual Values:
  Program  . . . . . . . . . . . . . . :   SAMPLE
    Library  . . . . . . . . . . . . . :     CBLGUIDE
  Source file  . . . . . . . . . . . . :   QCBLLESRC
    Library  . . . . . . . . . . . . . :     CBLGUIDE
    CCSID  . . . . . . . . . . . . . . :   37
  Source member  . . . . . . . . . . . :   SAMPLE         02/03/05 14:13:55
  Text 'description' . . . . . . . . . :   *BLANK
Command Options:
  Program  . . . . . . . . . . . . . . :   SAMPLE
    Library  . . . . . . . . . . . . . :     CBLGUIDE
  Source file  . . . . . . . . . . . . :   QCBLLESRC
    Library  . . . . . . . . . . . . . :     CBLGUIDE
  Source member  . . . . . . . . . . . :   SAMPLE
  Output . . . . . . . . . . . . . . . :   *PRINT
  Generation severity level  . . . . . :   30
  Text 'description' . . . . . . . . . :   *SRCMBRTXT
  Compiler options . . . . . . . . . . :   *IMBEDERR
  Conversion options . . . . . . . . . :   *NONE
  Message limit:
    Number of messages . . . . . . . . :   *NOMAX
    Message limit severity . . . . . . :   30
  Debug view . . . . . . . . . . . . . :   *STMT
  Optimize level . . . . . . . . . . . :   *NONE
  FIPS flagging  . . . . . . . . . . . :   *NOFIPS *NOOBSOLETE
  Extended display options . . . . . . :   *NONE
  Flagging severity  . . . . . . . . . :   0
  Replace program  . . . . . . . . . . :   *YES
  Simple program . . . . . . . . . . . :   *YES
  Authority  . . . . . . . . . . . . . :   *LIBCRTAUT
  Link literal . . . . . . . . . . . . :   *PGM
  Target release . . . . . . . . . . . :   *CURRENT
  User profile . . . . . . . . . . . . :   *USER
  Sort sequence  . . . . . . . . . . . :   *HEX
    Library  . . . . . . . . . . . . . :
  Language identifier  . . . . . . . . :   *JOBRUN
  Enable performance collection:
    Collection level . . . . . . . . . :   *PEP
  Binding directory  . . . . . . . . . :   *NONE
    Library  . . . . . . . . . . . . . :
  Activation group . . . . . . . . . . :   QILE
  Profiling data . . . . . . . . . . . :   *NOCOL
  Coded character set ID . . . . . . . :   *JOBRUN
  Arithmetic mode. . . . . . . . . . . :   *NOEXTEND
  Padding character:
    Single byte to national  . . . . . :   NX"0020"
    Double byte to national  . . . . . :   NX"3000"
    National to national . . . . . . . :   NX"3000"
Include directory  . . . . . . . . . . :   *NONE
Generate program information . . . . . :   *NO
  Compiler . . . . . . . . . . . . . . :   IBM ILE COBOL
```

Figure 11. CRTBNDCBL Command Summary Listing

Identifying the Compiler Options in Effect

The PROCESS statement, if specified, is printed first. Figure 12 on page 63 is a list of all options in effect for the compilation of the program example: the options specified in the CRTCBLMOD command, as modified by the PROCESS statement. Compiler options are listed at the beginning of all compiler output when the OPTIONS parameter is specified.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL           CBLGUIDE/SAMPLE       ISERIES1   03/09/15 11:18:21      Page    2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
          000100 PROCESS OPTIONS, SOURCE, VBSUM, MAP,
          000200         FLAG(00), MINIMUM, OBSOLETE, XREF
                    COBOL Compiler Options in Effect
                         SOURCE
                         XREF
                         GEN
                         NOSEQUENCE
                         VBSUM
                         NONUMBER
                         MAP
                         OPTIONS
                         QUOTE
                         NOSECLVL
                         PRTCORR
                         MONOPRC
                         RANGE
                         NOUNREF
                         NOSYNC
                         NOCRTF
                         NODUPKEYCHK
                         NOINZDLT
                         NOBLK
                         STDINZ
                         NODDSFILLER
                         IMBEDERR
                         STDTRUNC
                         NOCHGPOSSGN
                         NOEVENTF
                         MONOPIC
                         NONATIONAL
                         NOLSPTRALIGN
                         NOCOMPASBIN
                         OUTPUT
                         GENLVL(30)
                         NOOPTIMIZE
                         MINIMUM
                         OBSOLETE
                         DFRWRT
                         UNDSPCHR
                         ACCUPDALL
                         FLAG(0)
                         LINKPGM
                         SRTSEQ(*HEX      )
                         LANGID(*JOBRUN   )
                         ENBPFRCOL(PEP)
                         PRFDTA(NOCOL)
                         CCSID(JOBRUN CCSID CCSID)
                         DATTIM(1900 40)
                         THREAD(NOTHREAD)
                         ARITHMETIC(NOEXTEND)
                         NTLPADCHAR(NX"0020" NX"3000" NX"3000")
                         OPTVALUE(NOOPT)
                         NOGRAPHIC
                    COBOL Conversion Options in Effect
                         NOVARCHAR
                         NODATETIME
                         NOCVTPICXGRAPHIC
                         NOFLOAT
                         NODATE
                         NOTIME
                         NOTIMESTAMP
                         NOCVTTODATE
                         NOCVTPICNGRAPHIC
```

Figure 12. List of Options in Effect

Source Listing

Figure 13 illustrates a source listing. The statements in the source program are listed exactly as submitted except for program source text that is identified in the REPLACE statement. The replacement text will appear in the source listing. After the page in which the PROGRAM-ID paragraph is listed, all compiler output pages have the program-id name listed in the heading before the system name.

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL           CBLGUIDE/SAMPLE      ISERIES1   03/09/15 11:18:21      Page    4
STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   A  B      C                                                                          D     E         F
     1     000300 IDENTIFICATION DIVISION.
     2     000500 PROGRAM-ID.     SAMPLE.
     3     000600   AUTHOR.       PROGRAMMER NAME.
     4     000700   INSTALLATION. COBOL DEVELOPMENT CENTRE.
     5     000800   DATE-WRITTEN. 02/24/94.
     6     000900   DATE-COMPILED. 02/02/05 11:18:21
     7     001100 ENVIRONMENT DIVISION.
     8     001300 CONFIGURATION SECTION.
     9     001400 SOURCE-COMPUTER. IBM-ISERIES
    10     001500 OBJECT-COMPUTER. IBM-ISERIES
    11     001700 INPUT-OUTPUT SECTION.
    12     001800 FILE-CONTROL.
    13     001900     SELECT FILE-1 ASSIGN TO DISK-SAMPLE.
    15     002100 DATA DIVISION.
    16     002300 FILE SECTION.
    17     002400 FD  FILE-1
           002500     LABEL RECORDS ARE STANDARD
*===>                 a
*=a> LNC0848   0  The LABEL clause is syntax checked and ignored.  G
           002600     RECORD CONTAINS 20 CHARACTERS
           002700     DATA RECORD IS RECORD-1.
*===>                 a
*=a> LNC0848   0  The DATA RECORDS clause is syntax checked and ignored.
    18     002800 01  RECORD-1.
    19     002900   02 FIELD-A      PIC X(20).
    20     003100 WORKING-STORAGE SECTION.
    21     003200 01  SUBSCRIPT-TYPE   TYPEDEF   PIC S9(2) COMP-3.
    22     003300 01  FILLER.
    23     003400   05 KOUNT        TYPE SUBSCRIPT-TYPE.
    24     003500   05 LETTERS      PIC X(26) VALUE "ABCDEFGHIJKLMNOPQRSTUVWXYZ".
    25     003600   05 ALPHA REDEFINES LETTERS
           003700                   PIC X(1) OCCURS 26 TIMES.
    26     003800   05 NUMBR        TYPE SUBSCRIPT-TYPE.
    27     003900   05 DEPENDENTS   PIC X(26) VALUE "01234012340123401234012340".
    28     004000   05 DEPEND REDEFINES DEPENDENTS
           004100                   PIC X(1)  OCCURS 26 TIMES.
           004200 COPY WRKRCD.
    29    +000100 01  WORK-RECORD.                                                  WRKRCD
    30    +000200   05 NAME-FIELD   PIC X(1).                                      WRKRCD
    31    +000300   05 FILLER       PIC X(1)  VALUE SPACE.                         WRKRCD
    32    +000400   05 RECORD-NO    PIC S9(3).                                     WRKRCD
    33    +000500   05 FILLER       PIC X(1)  VALUE SPACE.                         WRKRCD
    34    +000600   05 LOCATION     PIC A(3)  VALUE "NYC".                         WRKRCD
    35    +000700   05 FILLER       PIC X(1)  VALUE SPACE.                         WRKRCD
```

Figure 13. An Example of an ILE COBOL Source Listing (Part 1 of 2)

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL          CBLGUIDE/SAMPLE       ISERIES1   03/09/15 11:18:21        Page      5
  STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    36    +000800   05 NO-OF-DEPENDENTS                                                    WRKRCD
          +000900                   PIC X(2).                                            WRKRCD
    37    +001000   05 FILLER       PIC X(7)  VALUE SPACES.                              WRKRCD
    38     004300 77  WORKPTR USAGE POINTER.
           004500*******************************************************
           004600* THE FOLLOWING PARAGRAPH OPENS THE OUTPUT FILE TO  *
           004700* BE CREATED AND INITIALIZES COUNTERS               *
           004800*******************************************************
    39     004900 PROCEDURE DIVISION.
           005100 STEP-1.
    40     005200     OPEN OUTPUT FILE-1.
    41     005300     MOVE ZERO TO KOUNT, NUMBR.
           005500*******************************************************
           005600* THE FOLLOWING 3 PARAGRAPHS CREATE INTERNALLY THE  *
           005700* RECORDS TO BE CONTAINED IN THE FILE, WRITES THEM  *
           005800* ON THE DISK, AND DISPLAYS THEM                    *
           005900*******************************************************
           006000 STEP-2.
    42     006100     ADD 1 TO KOUNT, NUMBR.
    43     006200     MOVE ALPHA  (KOUNT) TO NAME-FIELD.
    44     006300     MOVE DEPEND (KOUNT) TO NO-OF-DEPENDENTS.
    45     006400     MOVE NUMBR          TO RECORD-NO.
           006600 STEP-3.
    46     006700     DISPLAY WORK-RECORD.
    47     006800     WRITE RECORD-1 FROM WORK-RECORD.
           007000 STEP-4.
    48     007100     PERFORM STEP-2 THRU STEP-3 UNTIL KOUNT IS EQUAL TO 26.
           007300*******************************************************
           007400* THE FOLLOWING PARAGRAPH CLOSES FILE OPENED FOR    *
           007500* OUTPUT AND RE-OPENS IT FOR INPUT                  *
           007600*******************************************************
           007700 STEP-5.
    49     007800     CLOSE FILE-1.
    50     007900     OPEN INPUT FILE-1.
           008100*******************************************************
           008200* THE FOLLOWING PARAGRAPHS READ BACK THE FILE AND   *
           008300* SINGLE OUT EMPLOYEES WITH NO DEPENDENTS           *
           008400*******************************************************
           008500 STEP-6.
    51     008600     READ FILE-1 RECORD INTO WORK-RECORD
    52     008700       AT END GO TO STEP-8.
           008900 STEP-7.
    53     009000     IF NO-OF-DEPENDENTS IS EQUAL TO "0"
    54     009100       MOVE "Z" TO NO-OF-DEPENDENTS.
    55     009200     GO TO STEP-6.
           009400 STEP-8.
    56     009500     CLOSE FILE-1.
    57     009600     STOP RUN.
*==>                        a
*=a> LNC0650   0  Blocking/Deblocking for file 'FILE-1' will be performed by compiler-generated code.
                       * * * * *   E N D   O F   S O U R C E   * * * * *
```

Figure 13. An Example of an ILE COBOL Source Listing (Part 2 of 2)

Figure 13 on page 64 displays the following fields:

A *Compiler-generated statement number:* The numbers appear to the left of the source program listing. These numbers are referenced in all compiler output listings except for FIPS listings. A statement can span several lines, and a line can contain more than one statement. When a sequence of ILE COBOL source programs exist in the input source member, the statement number is reset to 1 at each new compilation unit. The statement number is not reset in a single compilation unit that may contain one or more nested COBOL programs.

B *Program nesting level:* The number that appears in this field indicates the degree of nesting of the program.

C *Reference number:* The numbers appear to the left of the source statements. The numbers that appear in this field and the column heading (shown as SEQNBR in this listing) are determined by an option specified in the CRTCBLMOD or CRTBNDCBL command or in the PROCESS statement, as shown in the following table:

Option	Heading	Origin
NONUMBER	SEQNBR	Source-file sequence numbers
NUMBER	NUMBER	User-supplied sequence numbers
LINENUMBER	LINNBR	Compiler-generated sequence numbers

D *Sequence error indicator column:* An S in this column indicates that the line is out of sequence. Sequence checking is performed on the reference number field only if the SEQUENCE option is specified.

E *Copyname:* The copyname, as specified in the ILE COBOL COPY statement, is listed here for all records included in the source program by that COPY statement. If the DDS-ALL-FORMATS phrase is used, the name `<--ALL-FMTS` appears under COPYNAME.

F *Change/date field:* The date the line was last modified is listed here.

G *Imbedded error:* The first level error message is imbedding in the listing after the line on which the error occurred. The clause, statement, or phrase causing the error is identified.

Verb Usage by Count Listing

Figure 14 shows the alphabetic list that is produced of all verbs used in the source program. A count of how many times each verb was used is also included. This listing is produced when the VBSUM option is specified.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/SAMPLE         ISERIES1   03/09/15 11:18:21       Page     7
                     V e r b   U s a g e   B y   C o u n t
VERB                   COUNT
ADD                        1
CLOSE                      2
DISPLAY                    1
GOTO                       2
IF                         1
MOVE                       5
OPEN                       2
PERFORM                    1
READ                       1
STOP                       1
WRITE                      1
```

Figure 14. Verb Usage by Count Listing

Data Division Map

The Data Division map is listed when the MAP option is specified. It contains information about names in the ILE COBOL source program. The minimum number of bytes required for the File Section and Working-Storage Section is given at the end of the Data Division map.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL              CBLGUIDE/SAMPLE         ISERIES1   03/09/15 11:18:21        Page      8
                          D a t a   D i v i s i o n   M a p
 STMT LVL  SOURCE NAME                  SECTION    DISP   LENGTH  TYPE     ATTRIBUTES
  H   I      J                            K        L       M      N       O
   17  FD  FILE-1                          FS                              DEVICE DISK, ORGANIZATION SEQUENTIAL,
                                                                           ACCESS SEQUENTIAL, RECORD CONTAINS 20
                                                                           CHARACTERS
   18  01  RECORD-1                        FS  00000000       20  GROUP
   19  02  FIELD-A                         FS  00000000       20  AN
   21  01  SUBSCRIPT-TYPE                  WS  00000000        2  PACKED   TYPEDEF
   22  01  FILLER                          WS  00000000       56  GROUP
   23  05  KOUNT                           WS  00000000        2  PACKED   TYPE SUBSCRIPT-TYPE
   24  05  LETTERS                         WS  00000002       26  AN       VALUE
   25  05  ALPHA                           WS  00000002        1  AN       REDEFINES LETTERS, DIMENSION(26)
   26  05  NUMBR                           WS  00000028        2  PACKED   TYPE SUBSCRIPT-TYPE
   27  05  DEPENDENTS                      WS  00000030       26  AN       VALUE
   28  05  DEPEND                          WS  00000030        1  AN       REDEFINES DEPENDENTS, DIMENSION(26)
   29  01  WORK-RECORD                     WS  00000000       19  GROUP
   30  05  NAME-FIELD                      WS  00000000        1  AN
   31  05  FILLER                          WS  00000001        1  AN       VALUE
   32  05  RECORD-NO                       WS  00000002        3  ZONED
   33  05  FILLER                          WS  00000005        1  AN       VALUE
   34  05  LOCATION                        WS  00000006        3  A        VALUE
   35  05  FILLER                          WS  00000009        1  AN       VALUE
   36  05  NO-OF-DEPENDENTS                WS  00000010        2  AN
   37  05  FILLER                          WS  00000012        7  AN       VALUE
   38  77  WORKPTR                         WS  00000000       16  POINTR
FILE SECTION uses at least 20 bytes of storage
WORKING-STORAGE SECTION uses at least 91 bytes of storage
                  * * * * *   E N D   O F   D A T A   D I V I S I O N   M A P   * * * * *
```

Figure 15. Data Division Map

The Data Division map displays the following fields:

H *Statement number:* The compiler-generated statement number where the data item was defined is listed for each data item in the Data Division map.

I *Level of data item:* The level number of the data item, as specified in the source program, is listed here. Index-names are identified by an *IX* in the level-number and blank fields in the SECTION, DISP, LENGTH, and TYPE fields.

J *Source name:* The data name, as specified in the source program, is listed here.

K *Section:* The section where the item was defined is shown here through the use of the following codes:

```
#                 FS  File Section
#                 WS  Working-Storage Section
#                 LO  Local-Storage Section
#                 LS  Linkage Section
#                 SM  Sort/Merge Section
#                 SR  Special Register.
```

L *Displacement:* The offset, in bytes, of the item from the level-01 group item is given here.

M *Length:* The decimal length, in bytes, of the item is listed here.

N *Type:* The data class type for the item is shown here through the use of the following codes:

Code	Data Class Type
GROUP	Group item
A	Alphabetic
AN	Alphanumeric

Code	Data Class Type
ANE	Alphanumeric edited
DT	Date
TM	Time
TMS	Timestamp
INDEX	Index data item (USAGE INDEX)
BOOLN	Boolean
ZONED	Zoned decimal (external decimal)
PACKED	Packed decimal (internal decimal) (USAGE COMP, COMP-3 or PACKED-DECIMAL)
BINARY	Binary (USAGE COMP-4 or BINARY)
FLOAT	Internal floating-point (USAGE COMP-1 or COMP-2)
EFLOAT	External floating-point (USAGE DISPLAY)
NE	Numeric edited
POINTR	Pointer data item (USAGE POINTER)
PRCPTR	Procedure-pointer data item (USAGE PROCEDURE-POINTER)
G	DBCS
GE	DBCS-edited

0 *Attributes:* The attributes of the item are listed here as follows:

- For files, the following information can be given:
  - DEVICE type
  - ORGANIZATION information
  - ACCESS mode
  - BLOCK CONTAINS information
  - RECORD CONTAINS information
  - LABEL information
  - RERUN is indicated
  - SAME AREA is indicated
  - CODE-SET is indicated
  - SAME RECORD AREA is indicated
  - LINAGE is indicated
  - NULL CAPABLE is indicated.
- For data items, the attributes indicate if the following information was specified for the item:
  - REDEFINES information
  - VALUE
  - JUSTIFIED
  - SYNCHRONIZED
  - BLANK WHEN ZERO
  - SIGN IS LEADING
  - SIGN IS LEADING SEPARATE CHARACTER
  - SIGN IS SEPARATE CHARACTER
  - INDICATORS
  - SIZE
  - TYPEDEF
  - TYPE clause information
  - LOCALE information.

- For table items, the dimensions for the item are listed here in the form DIMENSION (nn). For each dimension, a maximum OCCURS value is given. When a dimension is a variable, it is listed as such, giving the lowest and highest OCCURS values.

FIPS Messages

The FIPS messages, Figure 16, are listed when the FLAGSTD parameter is specified. See "FLAGSTD Parameter" on page 39 for more information about specifying the option for FIPS flagging. Only messages for the requested FIPS subset, optional modules and/or obsolete elements are listed.

Note: The sequence number and column number are given for each time the message is issued.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/SAMPLE         ISERIES1   03/09/15 11:18:21        Page      9
                      C O B O L   F I P S   M e s s a g e s
 FIPS-ID    DESCRIPTION AND SEQUENCE NUMBERS FLAGGED Q
   P
LNC8100     Following items are obsolete language elements.
LNC8102     AUTHOR paragraph.
                000600    10
LNC8103     DATE-COMPILED paragraph.
                000900    10
LNC8104     INSTALLATION paragraph.
                000700    10
LNC8105     DATE-WRITTEN paragraph.
                000800    10
LNC8117     LABEL RECORDS clause.
                002500    12
LNC8177     DATA RECORDS clause.
                002700    12
LNC8200     Following nonconforming standard items valid only at FIPS intermediate level or higher. R
LNC8201     COPY statement.
                004200     8
LNC8500     Following nonconforming nonstandard items are IBM-defined or are IBM extensions.
LNC8504     Assignment-name in ASSIGN clause.
                001900    36
LNC8518     USAGE IS COMPUTATIONAL-3.
                003200    49
LNC8520     USAGE IS POINTER or PROCEDURE-POINTER.
                004300    26
LNC8561     Default library assumed for COPY statement.
                004200     8
LNC8572     SKIP1/2/3 statement.
                000400    13
                001000    13
                001200    13
                001600    13
                002000    13
                002200    13
                003000    13
                004400    13
                005000    13
                005400    13
                006500    13
                006900    13
                007200    13
                008000    13
                008800    13
                009300    13
LNC8616     TYPEDEF clause.
                003200    29
LNC8617     TYPE clause.
                003400    26
                003800    26
  30 FIPS violations flagged. S
               * * * * *  E N D  O F  C O B O L  F I P S  M E S S A G E S  * * * * *
```

Figure 16. FIPS Messages

The FIPS messages consist of the following fields:

P *FIPS-ID*: This field lists the FIPS message number.

Q *Description and reference numbers flagged:* This field lists a description of the

condition flagged, followed by a list of the reference numbers from the source program where this condition is found.

The type of reference numbers used, and their names in the heading (shown as SEQUENCE NUMBERS in this listing) are determined by an option specified in the CRTCBLMOD or CRTBNDCBL command or in the PROCESS statement, as shown in the following table:

Option	Heading
NONUMBER	DESCRIPTION AND SEQUENCE NUMBERS FLAGGED
NUMBER	DESCRIPTION AND USER-SUPPLIED NUMBERS FLAGGED
LINENUMBER	DESCRIPTION AND LINE NUMBERS FLAGGED

R *Items grouped by level:* These headings subdivide the FIPS messages by level and category.

S *FIPS violations flagged:* The total number of FIPS violations flagged is included at the end of the FIPS listing.

Cross-Reference Listing

Figure 17 shows the cross-reference listing, which is produced when the XREF option is specified. It provides a list of all data references, procedure-name references, and program-name references, by statement number, within the source program.

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/SAMPLE         ISERIES1   03/09/15 11:18:21        Page     10
                            C r o s s   R e f e r e n c e
Data References:
Data-type is indicated by the letter following a data-name definition.
These letters and their meanings are:
    E = EXTERNAL
    G = GLOBAL
    X = EXTERNAL and GLOBAL
DATA NAMES                      DEFINED  REFERENCES (* = CHANGED)
  T                               U       V
ALPHA                             25     43
DEPEND                            28     44
DEPENDENTS                        27     28
FIELD-A                           19
FILE-1                            17     40     49     50     51     56
KOUNT                             23     41*    42*    43     44     48
LETTERS                           24     25
LOCATION                          34
NAME-FIELD                        30     43*
NO-OF-DEPENDENTS                  36     44*    53     54*
NUMBR                             26     41*    42*    45
RECORD-NO                         32     45*
RECORD-1                          18     47*
WORK-RECORD                       29     46     47     51*
WORKPTR                           38
TYPE NAMES                      DEFINED  REFERENCES (* = CHANGED)
SUBSCRIPT-TYPE                    21     23     26
Procedure References:
Context usage is indicated by the letter following a procedure-name reference.
These letters and their meanings are:
    A = ALTER (procedure-name)
    D = GO TO (procedure-name) DEPENDING ON
    E = End of range of (PERFORM) through (procedure-name)
    G = GO TO (procedure-name)
    P = PERFORM (procedure-name)
    T = (ALTER) TO PROCEED TO (procedure-name)
PROCEDURE NAMES                 DEFINED  REFERENCES
STEP-1                            39
STEP-2                            41     48P
STEP-3                            45     48E
STEP-4                            47
STEP-5                            48
STEP-6                            50     55G
STEP-7                            52
STEP-8                            55     52G
Program References:
Program-type of the external program is indicated by the word in a program-name definition.
These words and their meanings are:
    EPGM = a program object that is to be dynamically linked
    BPRC = a COBOL program or a C function or an RPG program that is to be bound
    SYS  = a system program
PROGRAM NAMES                   DEFINED  REFERENCES
SAMPLE                             2
                  * * * * *  E N D  O F  C R O S S  R E F E R E N C E  * * * * *
```

Figure 17. Cross-Reference Listing

The cross-reference listing displays the following fields:

T *Names field:* The data name, type name, procedure name, or program name referenced is listed here. The names are listed alphabetically. Program names may be qualified by a library name.

U *Defined field:* The statement number where the name was defined within the source program is listed here.

V *References field:* All statement numbers are listed in the same sequence as the name is referenced in the source program. An * following a statement number indicates that the item was modified in that statement.

Messages

Figure 18 shows the messages that are generated during program compilation.

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPLE         ISERIES1   03/09/15 11:18:21        Page     12
                                   M e s s a g e s
   STMT
  W                    Y                       X
*    17  MSGID: LNC0848  SEVERITY:  0  SEQNBR:  002500
         Message . . . . :   The LABEL clause is syntax checked and ignored.  Z
*    17  MSGID: LNC0848  SEVERITY:  0  SEQNBR:  002700
         Message . . . . :   The DATA RECORDS clause is syntax checked and
           ignored.
*    57  MSGID: LNC0650  SEVERITY:  0  SEQNBR:  009600
         Message . . . . :   Blocking/Deblocking for file 'FILE-1' will be
           performed by compiler-generated code.
                                         Message Summary
Message totals:  AA
   Information (00-04) . . . . . . . . :      3
   Warning     (05-19) . . . . . . . . :      0
   Error       (20-29) . . . . . . . . :      0
   Severe      (30-39) . . . . . . . . :      0
   Terminal    (40-99) . . . . . . . . :      0
   -------------------------------------------
   Total                                      3
                       * * * * *   E N D   O F   M E S S A G E S   * * * * *
Statistics:  BB
   Source records read . . . . . . . . :     96
   Copy records read . . . . . . . . . :     10
   Copy members processed  . . . . . . :      1
   Sequence errors . . . . . . . . . . :      0
   Highest severity message issued . . :      0
  LNC0901  0  Program SAMPLE created in library CBLGUIDE on 00/08/17 at 11:18:23.
                      * * * * *   E N D   O F   C O M P I L A T I O N   * * * * *
```

Figure 18. Diagnostic Messages

The fields displayed are:

W *Statement number:* This field lists the compiler-generated statement number associated with the statement in the source program for which the message was issued. [1]

X *Reference number:* The reference number is issued here. [1] The numbers that appear in this field and the column heading (shown here as SEQNBR) are determined by an option specified in the CRTCBLMOD or CRTBNDCBL command or in the PROCESS statement, as shown in the following table:

	Heading	Origin
NONUMBER	SEQNBR	Source-file sequence numbers
NUMBER	NUMBER	User-supplied sequence numbers
LINENUMBER	LINNBR	Compiler-generated sequence numbers

When a message is issued for a record from a copy file, the number is preceded by a +.

Y *MSGID* and *Severity Level:* These fields contain the message number and its associated severity level. Severity levels are defined as follows:

00 Informational
10 Warning
20 Error
30 Severe Error
40 Unrecoverable (usually a user error)
50 Unrecoverable (usually a compiler error)

Z *Message:* The message identifies the condition and indicates the action taken by the compiler.

1. The statement number and the reference number do not appear on certain messages that reference missing items. For example, if the PROGRAM-ID paragraph is missing, message LNC0031 appears on the listing with no statement or reference number listed.

AA *Message statistics:* This field lists the total number of messages and the number of messages by severity level.

The totals listed are the number of messages generated for each severity by the compiler and are not always the number listed. For example, if FLAG(10) is specified, no messages of severity less than 10 are listed. The counts, however, do indicate the number that would have been printed if they had not been suppressed.

BB *Compiler statistics:* This field lists the total number of source records read, copy records read, copy members processed, sequence errors encountered, and the highest severity message issued.

Chapter 4. Creating a Program Object

This section provides you with the information on:

- How to create a program object by binding one or more module objects together
- How to create a program object from ILE COBOL source statements
- The CRTBNDCBL command and its parameters
- How to read a binder listing
- How to create program objects using one or more module objects, service programs, and ILE binding directories.

Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about creating a program object appears in that product's online help.

Definition of a Program Object

A **program object** is a runnable system object of type *PGM. For ILE COBOL, the name of the program object is determined by the CRTBNDCBL command, CRTPGM command, or the PROGRAM-ID paragraph of the outermost COBOL source program. The process that creates a program object from one or more module objects and referenced service programs is known as **binding**. One or more module objects are created by the CRTCBLMOD command, or are temporarily created by the CRTBNDCBL command before it creates one or more bound program objects. Binding is a process that takes module objects produced by the CRTCBLMOD or CRTBNDCBL command and combines them to create a runnable bound program object or service program.

When a program object is created, only ILE procedures in those module objects containing debug data can be debugged by the ILE source debugger. The debug data does not affect the performance of the running program object. Debug data does increase the size of the generated program object.

A program object is run by using a dynamic program call. The entry point to the program object is the PEP.

The Binding Process

The binding process improves runtime performance as program objects are able to use static procedure calls to routines already bound as part of a program object. Dynamic program calls are not needed to access the routines. Individual module objects created by different ILE HLL compilers can be bound together in the same program object allowing for a routine to be coded in the most appropriate language and then bound to a program object that requires it.

Previously compiled module objects can be bound in various sequences to create new runnable program objects. The previously compiled module objects can be re-used to create new runnable program objects without having to recompile the original source program. This allows a module object to be re-used as needed.

Instead of re-creating programs each time a module object changes, service programs may be used. Common routines can be created as service programs. If the routine changes but its interface does not, or if only upward compatible

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changes are made to the interface, then the change can be incorporated by re-creating the service program. The program objects and service programs that use these common routines do not have to be re-created.

There are two paths that allow you to create a program object using the binding process. The diagram below shows the two available paths:

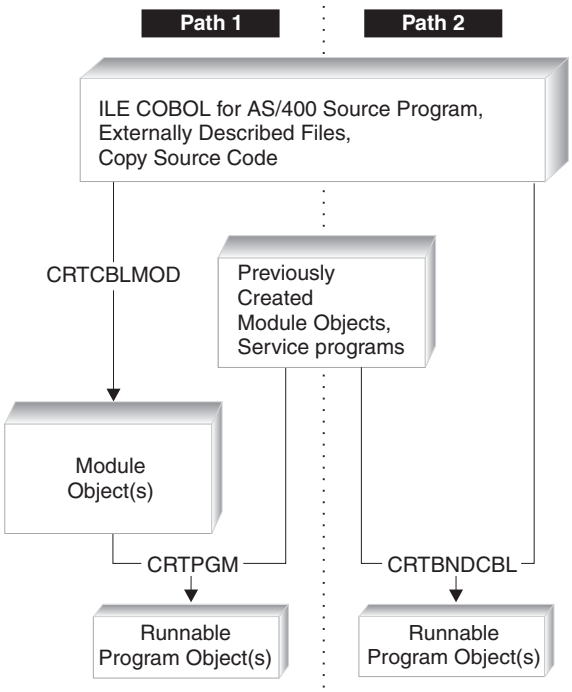


Figure 19. Two paths for creating a Program Object

These two paths both use the binding process. The Create Program (CRTPGM) command creates a program object from module objects created from ILE COBOL source programs using the Create COBOL Module (CRTCBLMOD) command, and zero or more service programs.

Note: Module objects created using the Create RPG Module (CRTRPGMOD), Create C Module (CRTCMOD), and Create CL Module (CRTCLMOD) commands can also be bound using Create Program (CRTPGM).

The Create Bound COBOL (CRTBNDCBL) command creates one or more temporary module objects from one or more ILE COBOL compilation units, and then creates one or more program objects. Once the program object is created, CRTBNDCBL deletes the module object(s) it created. This command performs the combined tasks of the Create COBOL Module (CRTCBLMOD) and Create Program (CRTPGM) commands in a single step. Previously created module objects and service programs can be bound using a binding directory. However, the input source member bound using this step must be the PEP module.

Note: Every program object only recognizes one PEP (and one UEP). If you bind several module objects together to create a program object using CRTPGM and each of these module objects has a PEP, you must specify in the ENTMOD parameter, which module object's PEP is to be used as the PEP for the program object. Also, the order in which module objects and service programs are specified in the CRTPGM command affects the way symbols

are resolved during the binding process. Therefore, it is important that you understand how binding is performed. For more information on the binding process, refer to the *ILE Concepts* book.

A **binding directory** contains the names of modules and service programs that you may need when creating an ILE program or service program. Modules or service programs listed in a binding directory are used when they provide an export that can satisfy any currently unresolved import requests. A binding directory is a system object that is identified to the system by the symbol *BNDDIR.

Binding directories are optional. The reasons for using binding directories are convenience and program size.

- They offer a convenient method of packaging the modules or service programs that you may need when creating your own ILE program or service program. For example, one binding directory may contain all the modules and service programs that provide math functions. If you want to use some of those functions, you specify only the one binding directory, not each module or service program you use.
- Binding directories can reduce program size because you do not specify modules or service programs that do not get used.

Very few restrictions are placed on the entries in a binding directory. The name of a module or service program can be added to a binding directory even if that object does not yet exist.

For a list of CL commands used with binding directories, see the *ILE Concepts* manual. Characteristics of a *BNDDIR object are:

- Convenient method of grouping the names of service programs and modules that may be needed to create an ILE program or service program.
- Because binding directory entries are just names, the objects list does not have to exist yet on the system.
- The only valid library names are *LIBL or a specific library.
- The objects in the list are optional. The named objects are used only if any unresolved imports exist, and if the named object provides an export to satisfy the unresolved import request.

Using the Create Program (CRTPGM) Command

The Create Program (CRTPGM) command creates a program object from one or more previously created module objects and, if required, one or more service programs. You can bind module objects created by any of the ILE Create Module commands, CRTCBLMOD, CRTCMOD, CRTRPGMOD or CRTCLMOD.

Note: In order to use the CRTPGM command, you must have authority to use the command and the modules required must first have been created using the CRTCBLMOD, CRTCMOD, CRTRPGMOD, or CRTCLMOD commands.

Before you create a program object using the CRTPGM command, do the following:

1. Establish a program name.
2. Identify the module object(s), and if required, service program(s) you want to bind into a program object.

3. Identify any binding directories you intend to use. Implicit references to binding directories, for ILE COBOL runtime service programs and ILE bindable APIs, are made from module objects created by CRTCBLMOD and CRTBNDCBL.
4. Identify which module object's PEP will be used as the PEP for the program object being created. Specify this module object in the ENTMOD parameter of CRTPGM.

   If you Specify ENTMOD(*FIRST) instead of explicitly identifying a module object in the ENTMOD parameter, then the order in which the binding occurs is important in deciding which module object has the PEP for the program object being created. The module objects that you list in the MODULE parameter, or those located through a binding directory, may contain one or more PEPs when only one can be used. The order in which binding occurs is also important for other reasons such as the resolution of symbols. For further information on binding, refer to the *ILE Concepts* book.
5. Establish whether the command will allow duplicate procedures and or variable names.

   You may be binding module objects into a program object that each define the same variable names and procedure names in multiple different ways.
6. Identify the activation group in which the program is run. Refer to "Activation and Activation Groups" on page 201 for description of activation groups.

To create a program object using the CRTPGM command, perform the following steps:

1. Enter the CRTPGM command.
2. Enter the appropriate values for the command parameters.

Table 1 lists the CRTPGM command parameters and their default values. For a full description of the CRTPGM command and its parameters, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Table 1. Parameters for CRTPGM Command and their Default Values

Parameter Group	**Parameter(Default Value)**
Identification	PGM(*library name/program name*) MODULE(*PGM)
Program access	ENTMOD(*FIRST)
Binding	BNDSRVPGM(*NONE) BNDDIR(*NONE)
Run time	ACTGRP(*NEW)
Miscellaneous	OPTION(*GEN *NODUPPROC *NODUPVAR *WARN *RSLVREF) DETAIL(*NONE) ALWUPD(*YES) ALWRINZ(*NO) REPLACE(*YES) AUT(*LIBCRTAUT) TEXT(*ENTMODTXT) TGTRLS(*CURRENT) USRPRF(*USER) ALWLIBUPD(*NO)

Once you have entered the CRTPGM command, the program object is created as follows:

1. Listed module objects are copied into what will become the program object.
2. The module objects containing the PEP is identified and the first import in this module is located.
3. The module objects are checked in the order in which they are listed and the first import is matched with a module export.
4. The first module object is returned to and the next import is located.
5. All imports in the first module object are resolved.
6. The next module object is continued to and all imports are resolved.
7. All imports in each subsequent module object are resolved until all of the imports have been resolved.
8. If OPTION(*RSLVREF) is specified and any imports cannot be resolved with an export, the binding process terminates without creating a program object. If OPTION(*UNRSLVREF) is specified then all imports do not need to be resolved to exports for the program object to be created. If the program object uses one of these unresolved imports at run time, a MCH4439 exception message is issued.
9. Once all the imports have been resolved, the binding process completes and the program object is created.

Example of Binding Multiple Modules to Create a Program Object

This example shows you how to use the CRTPGM command to bind the module objects A, B, and C into the program object named ABC. The module object, which has the PEP and UEP for the program object, is the module object named on the ENTMOD parameter.

All external references should be resolved for the CRTPGM command to bind multiple modules into a program object. References to the ILE COBOL runtime functions are resolved as they are automatically bound into any program object containing ILE COBOL module objects.

1. To bind several module objects to create a program object, type:

   ```
   CRTPGM PGM(ABC) MODULE(A B C) ENTMOD(*FIRST) DETAIL(*FULL)
   ```

   and press Enter.

Using the Create Bound COBOL (CRTBNDCBL) Command

The Create Bound COBOL (CRTBNDCBL) command creates one or more program objects from a single ILE COBOL source file member in a single step. This command starts the ILE COBOL compiler and creates temporary module objects which it then binds into one or more program objects of type *PGM.

Unlike the CRTPGM command, when you use the CRTBNDCBL command, you do not need a separate preceding step of creating one or more module objects using the CRTCBLMOD command. The CRTBNDCBL command performs the combined tasks of the Create COBOL Module (CRTCBLMOD) and Create Program (CRTPGM) commands by creating temporary module objects from the source file member, and then creating one or more program objects. Once the program object(s) is created, CRTBNDCBL deletes the module objects it created.

Note: If you want to retain the module objects, use CRTCBLMOD instead of CRTBNDCBL. If you use CRTCBLMOD, you will have to use CRTPGM to

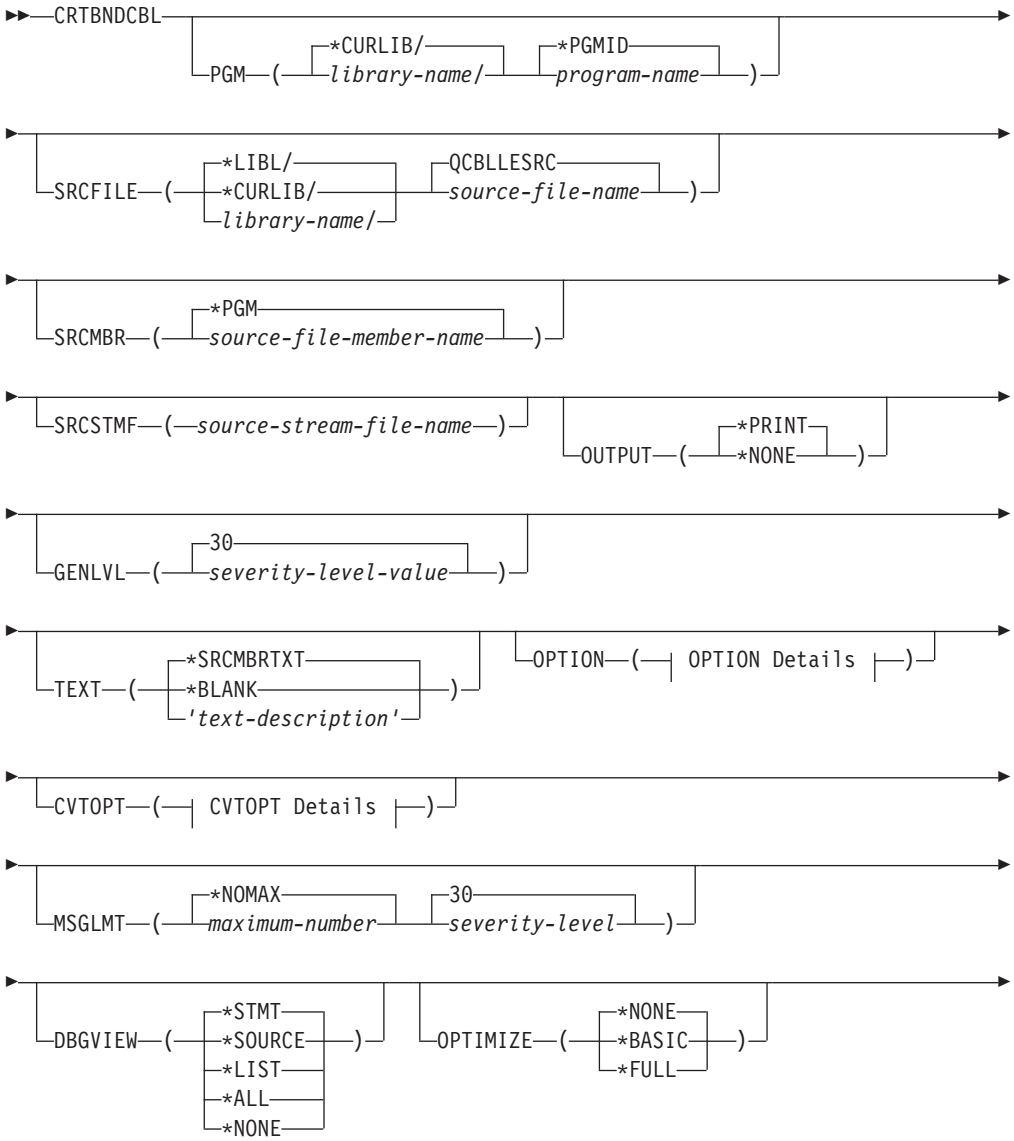
bind the module objects into one or more program objects. Also, if you want to use options of CRTPGM other than those implied by CRTBNDCBL, use CRTCBLMOD and CRTPGM.

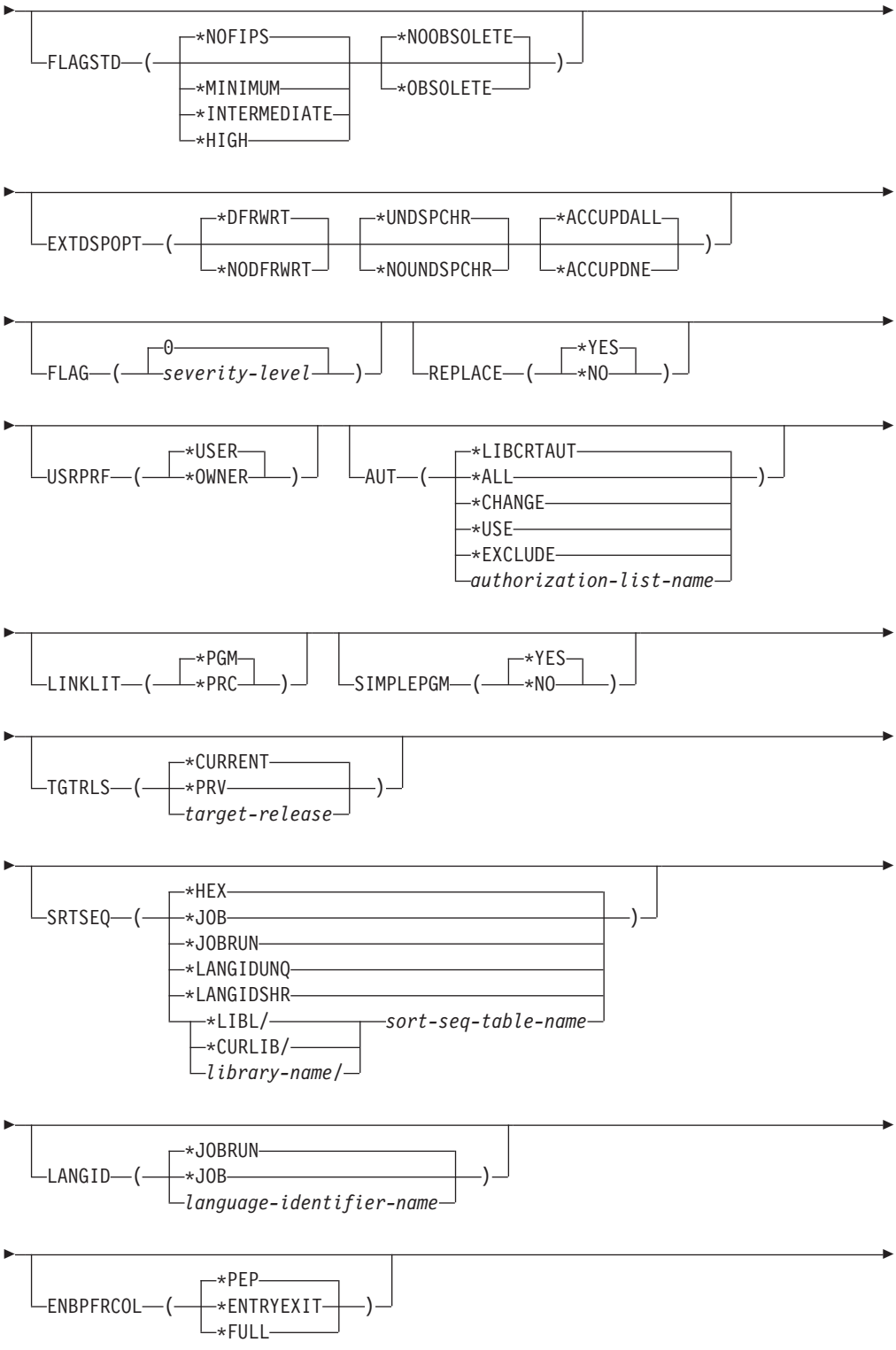
Using Prompt Displays with the CRTBNDCBL Command

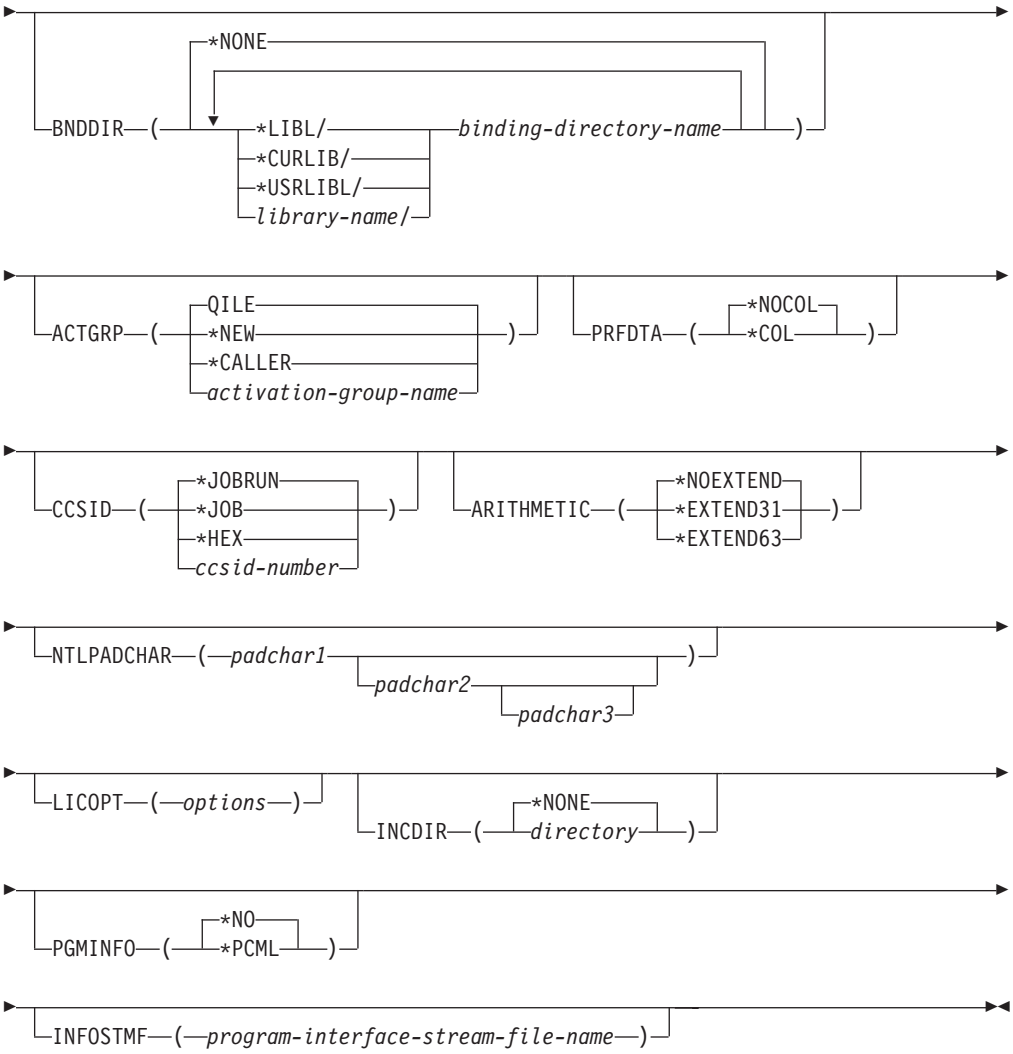
If you require prompting, type CRTBNDCBL and press F4 (Prompt). The CRTBNDCBL display which lists parameters and supplies default values appears. If you have already supplied parameters before you request prompting, the display appears with parameters values filled in. If you require help, type CRTBNDCBL and press F1 (Help).

Syntax for the CRTBNDCBL Command

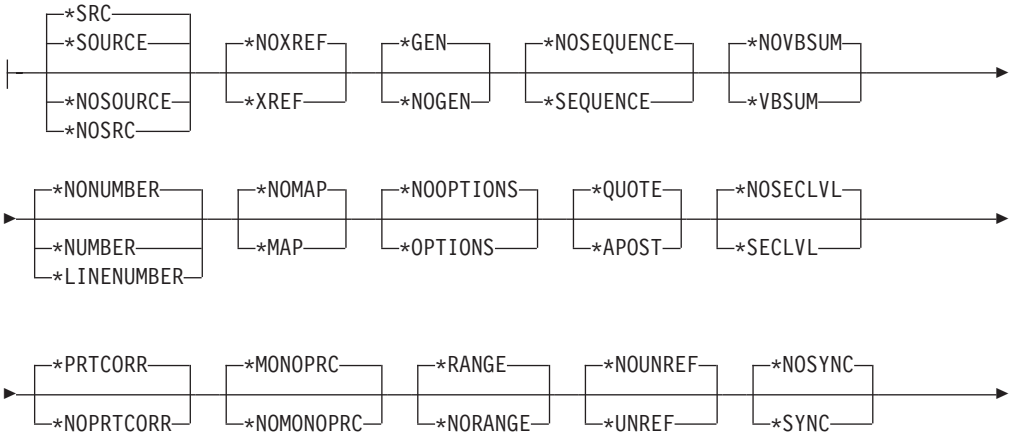
CRTBNDCBL Command - Format

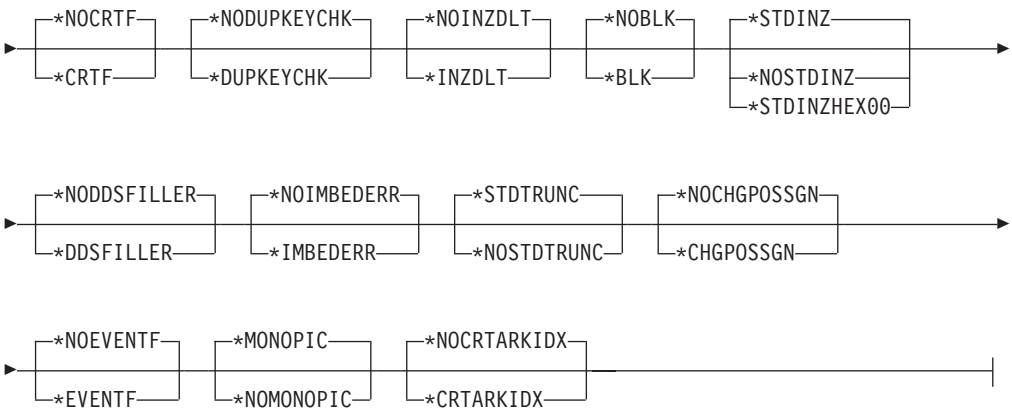



FLAGSTD
*NOFIPS
*MINIMUM
*INTERMEDIATE
*HIGH
*NOOBSOLETE
*OBSOLETE
EXTDSPOPT
*DFRWRT
*NODFRWRT
*UNDSPCHR
*NOUNDSPCHR
*ACCUPDALL
*ACCUPDNE
FLAG
0
severity-level
REPLACE
*YES
*NO
USRPRF
*USER
*OWNER
AUT
*LIBCRTAUT
*ALL
*CHANGE
*USE
*EXCLUDE
authorization-list-name
LINKLIT
*PGM
*PRC
SIMPLEPGM
*YES
*NO
TGTRLS
*CURRENT
*PRV
target-release
SRTSEQ
*HEX
*JOB
*JOBRUN
*LANGIDUNQ
*LANGIDSHR
*LIBL/
*CURLIB/
library-name/
sort-seq-table-name
LANGID
*JOBRUN
*JOB
language-identifier-name
ENBPFRCOL
*PEP
*ENTRYEXIT
*FULL

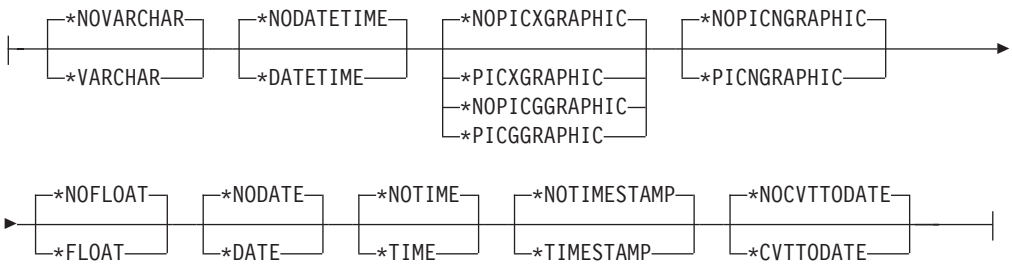


OPTION Details:





CVTOPT Details:



Parameters of the CRTBNDCBL Command

Nearly all of the parameters of CRTBNDCBL are identical to those shown for CRTCBLMOD previously. Only the differences between the two commands will be described here.

CRTBNDCBL differs from CRTCBLMOD in the following ways:

- The introduction of the PGM parameter instead of the MODULE parameter
- The SRCMBR parameter uses *PGM option (instead of *MODULE option)
- A different use of the REPLACE parameter
- The introduction of the USRPRF parameter
- The introduction of the SIMPLEPGM parameter
- A restriction on the objects affected by the PRFDTA parameter
- The introduction of the BNDDIR parameter
- The introduction of the ACTGRP parameter.

PGM Parameter:

Specifies the program name and library name for the program object you are creating. The program name and library name must conform to iSeries naming conventions. The possible values are:

***PGMID**

The name for the compiled program object is taken from the PROGRAM-ID paragraph in the ILE COBOL source program. When SIMPLEPGM(*NO) is specified, the name of the compiled program object

is taken from the PROGRAM-ID paragraph of the first ILE COBOL source program in the *sequence of source programs* (multiple compilation units in a single source file member).

program-name
Enter a name to identify the compiled ILE COBOL program. If you specify a program name for this parameter, and compile a sequence of source programs and if SIMPLEPGM(*YES) is specified, the first program object in the sequence uses this name; any other program objects use the name specified in the PROGRAM-ID paragraph in the corresponding ILE COBOL source program.

The possible library values are:

***CURLIB**
The created program object is stored in the current library. If you have not assigned a library as the current library, QGPL is used.

library-name
Enter the name of the library where the created program object is to be stored.

REPLACE Parameter:
Specifies if a new program object is created when a program object of the same name in the specified or implied library already exists. The intermediate module objects created during the processing of the CRTBNDCBL command are not subject to the REPLACE specifications, and have an implied REPLACE(*NO) against the QTEMP library. The intermediate module objects are deleted once the CRTBNDCBL command has completed processing. The possible values of the REPLACE parameter are:

***YES**
A new program object is created and it replaces any existing program object of the same name in the specified or implied library. The existing program object of the same name in the specified or implied library is moved to library QRPLOBJ.

***NO**
A new program object is not created if a program object of the same name already exists in the specified library. The existing program object is not replaced, a message is displayed, and compilation stops.

USRPRF Parameter:
Specifies the user profile that will run the created program object. The profile of the program owner or the program user is used to run the program object and control which objects can be used by the program object (including the authority the program object has for each object). This parameter is not updated if the program object already exists. To change the value of USRPRF, delete the program object and recompile using the correct value (or, if the constituent *MODULE objects exist, you may choose to invoke the CRTPGM command).

The possible values are:

***USER**
The user profile of the program user is to be used when the program object is run.

***OWNER**
The user profiles of both the owner and user of the program object are to be used when the program object is run. The collective sets of object

authorities in both owner and user profiles are to be used to find and access objects during the running of the program object. Any objects that are created when the program is run are owned by the user of the program.

SIMPLEPGM Parameter:

Specifies if a program object is created for each of the compilation units in the sequence of source programs. This option is meaningful only if the input source member to this command contains a sequence of source programs which generate multiple module objects. If this option is specified but the input source member does not have a sequence of source programs, then the option is ignored. The possible values are:

***YES**

A program object is created for each of the compilation units in the sequence of source programs. If REPLACE(*NO) is specified and a program object of the same name already exists for a compilation unit in the sequence of source programs, that program object is not replaced and compilation continues at the next compilation unit.

***NO**

A single program object is created from all the compilation units in the sequence, with the first compilation unit representing the Program Entry. With SIMPLEPGM(*NO) specified, if one source program in a sequence of source programs fails to generate a module object then all subsequent source programs in the sequence will also fail to generate module objects.

PRFDTA Parameter:

This parameter works the same as described on page "PRFDTA Parameter" on page 44, with the following note.

Note: If you use the BNDDIR parameter to bind additional modules and service programs, these additional objects are not affected when *COL or *NOCOL is specified for the program. The program profiling data attribute for a module is set when the module is created.

BNDDIR Parameter:

Specifies the list of binding directories that are used in symbol resolution. Can specify up to 50 binding directories.

***NONE**

No binding directory is specified.

binding-directory-name

Specify the name of the binding directory used in symbol resolution. The directory name can be qualified with one of the following library values:

***LIBL**

The system searches the library list to find the library where the binding directory is stored. This is the default.

***CURLIB**

The current library for the job is searched. If no library is specified as the current library for the job, library QGPL is used.

***USRLIBL**

Only the libraries in the user portion of the job's library list are searched.

library-name

Specify the name of the library to be searched.

ACTGRP Parameter:
Specifies the activation group this program is associated with when it is called.

QILE
When this program is called, it is activated into the named activation group QILE. This is the default.

***NEW**
When this program is called, it is activated into a new activation group.

***CALLER**
When this program is called, it is activated into the caller's activation group.

activation-group-name
Specify the name of the activation group to be used when this program is called.

Invoking CRTPGM Implicitly from CRTBNDCBL

There are implied default values to be used in the CRTPGM step implicitly invoked from the CRTBNDCBL command. They are described in the description that follows.

The parameters used in CRTPGM when it is invoked from CRTBNDCBL are as follows:

PGM
When SIMPLEPGM(*YES) is specified or implied, CRTPGM is invoked for each compilation unit in the sequence of source programs. The program name specified in the PROGRAM-ID paragraph in the corresponding outermost ILE COBOL source program of each compilation unit is used with the PGM parameter for CRTPGM each time it is invoked. An individually bound program object is created for each compilation unit.

When SIMPLEPGM(*NO) is specified, CRTPGM is invoked only one time against all of the compilation units in the sequence of source programs at once. Only the program name specified in the PROGRAM-ID paragraph in the corresponding outermost ILE COBOL source program for the first compilation unit in the sequence of the source programs is used with the PGM parameter for CRTPGM when it is invoked. All of the compilation units are bound together to create one program object.

MODULE
When SIMPLEPGM(*YES) is specified or implied, the name of the module created in QTEMP for each compilation unit is used with the MODULE parameter for CRTPGM each time it is invoked.

When SIMPLEPGM(*NO) is specified, all the names of the modules created in QTEMP for the compilation units are listed in the MODULE parameter for the CRTPGM command when it is invoked.

BNDDIR
Specifies the list of binding directories that are used in symbol resolution.

When *NONE (the default) is specified, no binding directory is used.

When *binding-directory-name* is specified, the name of the binding directory you specify is used in symbol resolution. The directory name can be qualified with one of the following library values:

***LIBL** The system searches the library list to find the library where the binding directory is stored. This is the default.

***CURLIB**
The current library for the job is searched. If no library is specified as the current library for the job, library QGPL is used.

***USRLIBL**
Only the libraries in the user portion of the job's library list are searched.

library-name
Specify the name of the library to be searched.

ACTGRP
Activation group specified is used

REPLACE
The REPLACE option specified in the CRTBNDCBL command is used

USRPRF
The USRPRF option specified in the CRTBNDCBL command is used

AUT
The AUT option specified in the CRTBNDCBL command is used

TEXT
The TEXT option specified in the CRTBNDCBL command is used

TGTRLS
The TGTRLS option specified in the CRTBNDCBL command is used

The default values are used for all of the remaining parameters of CRTPGM when it is invoked from the CRTBNDCBL command. For a description of these default values Refer to the CRTPGM command in the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Example of Binding One Module Object to Create a Program Object

This example shows you how to create a program object from a module using the CRTBNDCBL command.

1. To create a program object, type:

```
CRTBNDCBL PGM(MYLIB/XMPLE1)
SRCFILE(MYLIB/QCBLLESRC)  SRCMBR(XMPLE1)
OUTPUT(*PRINT)
TEXT('ILE COBOL Program')
CVTOPT(*FLOAT)
```

   and press Enter.

   The CRTBNDCBL command creates the program XMPLE1 in MYLIB. The OUTPUT(*PRINT) option specifies that you want a compilation listing.

2. Type one of the following CL commands to view the listing.

   Note: In order to view a compiler listing you must have authority to use the commands listed below.
   - `DSPJOB` and the select option 4 (*Display spooled files*)
   - `WRKJOB`
   - `WRKOUTQ queue-name`

- WRKSPLF

Specifying National Language Sort Sequence in CRTBNDCBL

At the time that you compile your COBOL source program, you can explicitly specify the collating sequence that the program will use when it is run, or you can specify how the collating sequence is to be determined when the program is run.

You specify the collating sequence through CRTBNDCBL in the same manner as you would through CRTCBLMOD. For a full description of how to specify an NLS collating sequence, refer to "Specifying National Language Sort Sequence in CRTCBLMOD" on page 47.

Reading a Binder Listing

The binding process can produce a listing that describes the resources used, symbols and objects encountered, and problems that were resolved or not resolved in the binding process. The listing is produced as a spool file for the job you use to enter the CRTPGM command. The command default, *NONE, is to not produce this information but you can select to generate this as printed output at three levels of detail as a value in the DETAIL parameter:

- *BASIC
- *EXTENDED
- *FULL

The binder listing includes the following sections depending on the value specified for DETAIL:

Table 2. Sections of the Binder Listing based on DETAIL Parameter

Section Name	*NONE	*BASIC	*EXTENDED	*FULL
Command Option Summary		X	X	X
Brief Summary Table		X	X	X
Extended Summary Table		X	X	
Binder Information Listing			X	X
Cross-Reference Listing				X
Binding Statistics				X

The information in this listing can help you diagnose problems if the binding was not successful or to give feedback on what the binder encountered in the process.

A Sample Binder Listing

The following sample listings illustrate the binder listing produced using the CRTPGM command. References to the figures are made throughout the following text. These references are indexed by the reverse printing of letters on a black background, for example (**Z**). The reverse letters in the text correspond to the letter found in the figures.

Command Option Summary

The Command Option Summary is produced whenever a binder listing is requested. It shows what options were used when the ILE program was created. You may want to store this information description of the command for some

future reference when you need to create the program again. Figure 20 shows you the command option summary listing.

```
                                                Create Program                                                    Page     1
5722WDS V5R3M0  030905                                                    CBLGUIDE/EXTLFL    ISERIES1  03/09/15  13:14:03
 Program  . . . . . . . . . . . . . . . . . . . . . . :   EXTLFL
   Library  . . . . . . . . . . . . . . . . . . . . . :     CBLGUIDE
 Program entry procedure module . . . . . . . . . . . :   *FIRST
   Library  . . . . . . . . . . . . . . . . . . . . . :
 Activation group . . . . . . . . . . . . . . . . . . :   *NEW
 Creation options . . . . . . . . . . . . . . . . . . :   *GEN        *NODUPPROC  *NODUPVAR   *WARN       *RSLVREF
 Listing detail . . . . . . . . . . . . . . . . . . . :   *FULL
 Allow update . . . . . . . . . . . . . . . . . . . . :   *YES
 Allow bound *SRVPGM library name update  . . . . . . :   *NO
 User profile . . . . . . . . . . . . . . . . . . . . :   *USER
 Replace existing program . . . . . . . . . . . . . . :   *YES
 Authority  . . . . . . . . . . . . . . . . . . . . . :   *LIBCRTAUT
 Target release . . . . . . . . . . . . . . . . . . . :   *CURRENT
 Allow reinitialization . . . . . . . . . . . . . . . :   *NO
 Storage model  . . . . . . . . . . . . . . . . . . . :   *SNGLVL
 Interprocedural analysis . . . . . . . . . . . . . . :   *NO
 IPA control file . . . . . . . . . . . . . . . . . . :   *NONE
 IPA replace IL data  . . . . . . . . . . . . . . . . :   *NO
 Text . . . . . . . . . . . . . . . . . . . . . . . . :   *ENTMODTXT
 Module      Library             Module      Library             Module      Library             Module      Library
 EXTLFL      CBLGUIDE
 Service                         Service                         Service                         Service
 Program     Library             Program     Library             Program     Library             Program     Library
 *NONE
 Binding                         Binding                         Binding                         Binding
 Directory   Library             Directory   Library             Directory   Library             Directory   Library
 *NONE
```

Figure 20. CRTPGM Command Option Summary Listing

Extended Summary Table

The Extended Summary Table is provided if *EXTENDED or *FULL is supplied. It contains statistical information that provides a general view of the imports and exports that the binder resolved. Figure 21 shows the layout of the Extended Summary Table.

```
                                                Create Program                                                    Page     3
5722WDS V5R3M0  030905                                                    CBLGUIDE/EXTLFL    ISERIES1  03/09/15  13:14:03
                                                    Extended Summary Table
   Valid definitions  . . . . . . . . . . :          341  A
     Strong . . . . . . . . . . . . . . . :          340
     Weak . . . . . . . . . . . . . . . . :            1
   Resolved references  . . . . . . . . . :           16  B
     To strong definitions  . . . . . . . :           15
     To weak definitions  . . . . . . . . :            1
                          * * * * *  E N D  O F  E X T E N D E D  S U M M A R Y  T A B L E  * * * * *
```

Figure 21. CRTPGM Listing - Extended Summary Table

The Extended Summary Table provides statistical information on the following items:

A *Valid definitions:* This field provides the number of named variables or procedures available for exporting. The definitions are further categorized as **strong definitions** or **weak definitions**. For strong definitions, storage is allocated for the variable or procedure. For weak definitions, storage is referenced for the variable or procedure.

In ILE COBOL, the outermost COBOL source program and its associated CANCEL procedure will have strong definitions. EXTERNAL data and EXTERNAL files will have weak definitions. CALL, CANCEL, and SET ENTRY to an external static procedure will have module imports that are strong definitions. References to EXTERNAL data and EXTERNAL files will have module imports that are weak definitions.

B *Resolved references:* This field provides the number of imports that are matched with inter-module exports.

The usage counts shown in Figure 21 on page 89 are in decimal form.

Brief Summary Table

This Brief Summary Table, available when *BASIC, *EXTENDED, or *FULL is specified, provides information that reflects what was found to be in error during the binding process. Figure 22 shows the layout of the Brief Summary Table.

```
                                                Create Program                                                    Page     4
5722WDS V5R3M0  030905                                                        CBLGUIDE/EXTLFL    ISERIES1  03/09/15  13:14:03
                                                     Brief Summary Table
 Program entry procedures . . . . . . . . . . . :   1   C
   Symbol    Type      Library     Object      Bound       Identifier
     F        G          H          I            J            K
             *MODULE   CBLGUIDE    EXTLFL      *YES        _Qln_pep
 Multiple strong definitions  . . . . . . . . . :   0   D
 Unresolved references  . . . . . . . . . . . . :   0   E
                              * * * * *   E N D   O F   B R I E F   S U M M A R Y   T A B L E   * * * * *
```

Figure 22. CRTPGM Listing - Brief Summary Table

The table consists of three lists with the number of entries in each of the following categories:

C *Program entry procedures:* The number of procedures that get control from a calling program.

D *Multiple strong definitions:* The number of module export procedures with the same name. This should be 0.

E *Unresolved references:* The number of imported procedures or variables for which no export was located. This should be 0.

F *Symbol #:* The Symbol number is from the Binder Information Listing shown in "Binding Information Listing" on page 91. If *BASIC is specified for the DETAIL parameter, this area is blank.

G *Type:* The type of the object containing the identifier is shown in the Type field.

H *Library:* The name of the library containing the object is shown in the Library field.

I *Object:* The name of the object which has the program entry procedure, unresolved reference, or strong definition is shown in the Object field.

J *Bound:* If this field shows a value of *YES for a module object, the module object is bound by copy. If this field shows a value of *YES for a program, the program is bound by reference. If this field shows a value of *NO for a module object or program, that object is not included in the bind.

K *Identifier:* The name of the procedure or variable from module source is shown in the Identifier field.

In this example, the total number of program entry procedures, unresolved references, or multiple strong definitions are 1, 0, 0 respectively. The usage counts shown in Figure 22 are in decimal form.

Binding Information Listing

This listing, which provides much more detailed information about the binding process, is available if *EXTENDED or *FULL is specified. Figure 23 shows the layout of the Binder Information Listing.

```
                                                  Create Program                                                    Page     5
5722WDS V5R3M0  030905                                                                  CBLGUIDE/EXTLFL    ISERIES1  03/09/15  13:14:03
                                                    Binder Information Listing
 Module . . . . . . . . . . . :   EXTLFL      L
   Library  . . . . . . . . . :     CBLGUIDE
   Bound  . . . . . . . . . . :     *YES
   Change date/time . . . . . :     00/08/15  13:11:40
   Teraspace storage enabled  :     *YES
   Storage model  . . . . . . :     *SNGLVL
       Number    Symbol      Ref       Identifier                                  Type      Scope       Export       Key
         M         N         O            P                                          Q         R           S          T
       00000001  Def                   EF1_ffd                                     Data      Module      Weak              190
 ****                                  Best weak definition
       00000002  Def                   EF1MAIN                                     Proc      Module      Strong
       00000003  Def                   EF1MAIN_reset                               Proc      Module      Strong
       00000004  Ref         000000A7  _Qln_rut                                    Data
       00000005  Ref         00000001  EF1_ffd                                     Data
       00000006  Ref         000000C6  _Qln_cancel_handler                         Proc
       00000007  Ref         000000D6  _Qln_cancel_handler_pep                     Proc
       00000008  Ref         000000A8  _Qln_init_mod                               Proc
       00000009  Ref         000000A9  _Qln_init_mod_bdry                          Proc
       0000000A  Ref         000000AA  _Qln_init_oprg                              Proc
       0000000B  Ref         000000B9  _Qln_recurse_msg                            Proc
       0000000C  Ref         00000022  _Qln_disp_norm                              Proc
       0000000D  Ref         000000BE  _Qln_stop_prg                               Proc
       0000000E  Ref         000000BB  _Qln_cancel_msg                             Proc
       0000000F  Ref         000000BD  _Qln_fc_hdlr                                Proc
       00000010  Ref         0000012A  Q LE leDefaultEh                            Proc
       00000011  Ref         00000131  Q LE leBdyCh                                Proc
       00000012  Ref         00000161  Q LE leActivationInit                       Proc
       00000013  Ref         00000132  Q LE leBdyEpilog                            Proc
 Service program  . . . . . . :   QLNRACPT
   Library  . . . . . . . . . :     QSYS
   Bound  . . . . . . . . . . :     *YES
   Change date/time . . . . . :     00/08/14  18:54:04
   Teraspace storage enabled
     modules  . . . . . . . . :     *ALL
   Storage model  . . . . . . :     *SNGLVL
       Number    Symbol      Ref       Identifier                                  Type      Scope       Export       Key
       00000014  Def                   _Qln_DateISODescriptor                      Data                  Strong
       00000015  Def                   _Qln_TimeISODescriptor                      Data                  Strong
       00000016  Def                   _Qln_acpt_norm                              Proc                  Strong
       00000017  Def                   _Qln_acpt_console                           Proc                  Strong
       00000018  Def                   _Qln_acpt_session                           Proc                  Strong
       00000019  Def                   _Qln_acpt_time                              Proc                  Strong

⋮
       0000015B  Def                   CEESECI                                     Proc                  Strong
       0000015C  Def                   CEEDYWK                                     Proc                  Strong
       0000015D  Def                   CEELOCT                                     Proc                  Strong
       0000015E  Def                   CEEUTC                                      Proc                  Strong
       0000015F  Def                   CEEGMT                                      Proc                  Strong
       00000160  Def                   CEEUTCO                                     Proc                  Strong
       00000161  Def                   Q LE leActivationInit                       Proc                  Strong
       00000162  Def                   Q LE leActivationInitRouter                 Proc                  Strong
       00000163  Def                   QleActBndPgm                                Proc                  Strong
       00000164  Def                   QleGetExp                                   Proc                  Strong
       00000165  Def                   Q LE leCheck                                Proc                  Strong
                        * * * * *   E N D   O F   B I N D E R   I N F O R M A T I O N   L I S T I N G   * *
```

Figure 23. CRTPGM Listing - Binder Information Listing

L *Module and Library:* This field identifies the library and name of the module object or service program that was processed.

M *Number:* A unique identifier assigned to each data item or ILE procedure in this program. This number is used for cross referencing.

N *Symbol:* This field identifies the symbol as an export or an import. If this field shows a value of Def then the symbol is an export. If this field shows a value of Ref then the symbol is an import.

O *Ref:* This field is blank if Symbol is Def or contains a symbol number if the value in the Symbol column is Ref. If the Symbol column is Ref, this field contains the unique number identifying the export (Def) that satisfies the import request.

P *Identifier:* This is the name of the symbol that is exported or imported.

Q *Type:* If the symbol name is an ILEprocedure, this field contains Proc. If the symbol name is a data item, this field contains Data.

R *Scope:* This field identifies the level at which the exported symbol name can be accessed.

S *Export:* This field identifies whether the data items be exported has a weak definition or a strong definition.

T *Key:* This field contains the length of weak exported items. The values shown in this field are in hexadecimal form.

The columns of the listing contain the following information:

Cross Reference Listing

The cross reference listing, provided only if *FULL is specified, is useful to the programmer who has a large binder listing and wants a handy index for it. The cross reference listing alphabetically lists all the unique identifiers in the binder listing with a corresponding list of all the definitions and resolved references of that identifier. Figure 24 on page 93 shows the layout of the Cross Reference Listing.

```
                                                Create Program                                                    Page    15
5722WDS V5R3M0  030905                                                          CBLGUIDE/EXTLFL    ISERIES1  03/09/15  13:14:03
                                                   Cross-Reference Listing
                                                                  --------Refs--------
        Identifier                                  Defs        Ref         Ref         Type        Library       Object
           U                                         V                  W                X           Y             Z
        __CEEDOD                                    0000014F                            *SRVPGM     QSYS          QLEAWI
        __CEEGSI                                    00000150                            *SRVPGM     QSYS          QLEAWI
        __CEEHDLR                                   0000013C                            *SRVPGM     QSYS          QLEAWI
        __CEEHDLU                                   0000013D                            *SRVPGM     QSYS          QLEAWI
        __CEERTX                                    00000135                            *SRVPGM     QSYS          QLEAWI
        __CEETSTA                                   0000014E                            *SRVPGM     QSYS          QLEAWI
        __CEEUTX                                    00000136                            *SRVPGM     QSYS          QLEAWI
        _C_session_cleanup                          00000144                            *SRVPGM     QSYS          QLEAWI
        _C_session_open                             00000145                            *SRVPGM     QSYS          QLEAWI
        _Qln_acos                                   000000D7                            *SRVPGM     QSYS          QLNRMATH
        _Qln_acpt_attribute                         0000001D                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_console                           00000017                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_da                                0000002B                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_date                              0000001A                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_date_yyyy                         0000002C                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_day                               0000001B                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_day_of_week                       0000001C                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_day_yyyy                          0000002D                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_io_feed                           00000021                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_lda                               0000001F                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_norm                              00000016                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_open_feed                         00000020                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_pip                               0000001E                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_session                           00000018                            *SRVPGM     QSYS          QLNRACPT
        _Qln_acpt_time                              00000019                            *SRVPGM     QSYS          QLNRACPT

⋮

        Q LE leBdyCh                                00000131    00000011                *SRVPGM     QSYS          QLEAWI
        Q LE leBdyEpilog                            00000132    00000013                *SRVPGM     QSYS          QLEAWI
        Q LE leCheck                                00000165                            *SRVPGM     QSYS          QLEAWI
        Q LE leDefaultEh                            0000012A    00000010                *SRVPGM     QSYS          QLEAWI
        Q LE AG_prod_rc                             00000129                            *SRVPGM     QSYS          QLEAWI
        Q LE AG_user_rc                             00000128                            *SRVPGM     QSYS          QLEAWI
        Q LE HdlrRouterEh                           00000138                            *SRVPGM     QSYS          QLEAWI
        Q LE RtxRouterCh                            00000137                            *SRVPGM     QSYS          QLEAWI
        QleActBndPgm                                00000163                            *SRVPGM     QSYS          QLEAWI
        QleGetExp                                   00000164                            *SRVPGM     QSYS          QLEAWI
        QlnDumpCobol                                000000C0                            *SRVPGM     QSYS          QLNRMAIN
        QlnRtvCobolErrorHandler                     000000C1                            *SRVPGM     QSYS          QLNRMAIN
        QlnSetCobolErrorHandler                     000000C2                            *SRVPGM     QSYS          QLNRMAIN
                        * * * * *   E N D   O F   C R O S S - R E F E R E N C E   L I S T I N G   * * * * *
```

Figure 24. CRTPGM Listing - Cross Reference Listing

The fields contain the following information:

U *Identifier:* The name of the export that was processed during symbol resolution.

V *Defs:* The unique identification number associated with each export.

W *Refs:* Lists the unique identification numbers of the imports (Ref) that were resolved to this import (Def).

X *Type:* Identifies whether the export can from a module object (*MODULE) or a service program (*SRVPGM).

Y *Library:* The name of the library in which the symbol described on this line has been defined.

Z *Object:* The name of the module object or service program in which the symbol described on this line has been defined.

Binding Statistics

The Binding Statistics section is produced only when the *FULL value is used on the DETAIL parameter. It shows how much system CPU time was used to bind specific parts of the program. These values may only have meaning to you when compared to similar output from other ILE programs or other times when a particular program has been created. The value for the binding language

compilation CPU time is always zero for an ILE program. Figure 25 shows the layout of the Binding Statistics.

```
                                                Create Program                                                    Page    22
5722WDS V5R3M0  030905                                                        CBLGUIDE/EXTLFL    ISERIES1  03/09/15  13:14:03
                                                      Binding Statistics
 Symbol collection CPU time . . . . . . . . . . . . . . . . . . :                .001
 Symbol resolution CPU time . . . . . . . . . . . . . . . . . . :                .000
 Binding directory resolution CPU time  . . . . . . . . . . . . :                .009
 Binder language compilation CPU time . . . . . . . . . . . . . :                .000
 Listing creation CPU time  . . . . . . . . . . . . . . . . . . :                .082
 Program/service program creation CPU time  . . . . . . . . . . :                .020
 Total CPU time . . . . . . . . . . . . . . . . . . . . . . . . :                .322
 Total elapsed time . . . . . . . . . . . . . . . . . . . . . . :               1.145
                              * * * * *  E N D  O F  B I N D I N G  S T A T I S T I C S  * * * * *
*CPC5D07 - Program EXTLFL created in library CBLGUIDE.
                          * * * * *  E N D  O F  C R E A T E  P R O G R A M  L I S T I N G  * * * * *
```

Figure 25. CRTPGM Listing - Binding Statistics

Modifying a Module Object and Binding the Program Object Again

Once a program object is created, it may need to be changed to address problems or to meet changing requirements. A program object is built from module objects, so you may not need to change the entire program object. You can isolate just the module object that needs to be changed, change it, and then bind the program object again. How you change the module object depends on what needs to be changed.

You can change a module object in five ways:
- Change the ILE COBOL source program of the module object
- Change the optimization level of the module object
- Change the observability of the module object
- Change the amount of performance collection enablement
- Change the profiling data enablement.

Note: You need authority to the source code and the necessary commands to make any of these changes to the module object.

If you want to change the optimization level or observability of a module object, you may not be required to create it again. This often happens when you want to debug a program object or when you are ready to put a program object into production. Such changes can be performed more quickly and use less system resources than creating the module object again.

In these situations you may have many module objects to create at the same time. You can use the Work with Modules (WRKMOD) command to get a list of module objects selected by library, name, generic symbol, or *ALL. You can also limit the list to just module objects created by the ILE COBOL compiler.

Once you have made a change to a module object, you must use the CRTPGM command or UPDPGM command to bind the program object again.

Changing the ILE COBOL Source Program

When you need to make a change to the ILE COBOL source program, do the following:
1. Change the ILE COBOL source program where required using SEU. Refer to “Entering Source Statements Using the Source Entry Utility” on page 12 for further details on change the source code.

2. Compile the ILE COBOL source program using the CRTCBLMOD command to create a new module object(s). Refer to "Using the Create COBOL Module (CRTCBLMOD) Command" on page 24 for a description of compiling the ILE COBOL source program.
3. Bind the module objects using the CRTPGM command or UPDPGM command to create a new program object. Refer to "Using the Create Program (CRTPGM) Command" on page 77 for information about creating a program object.

Changing the Optimization Levels

You can change the levels at which the generated code is optimized to run on the system. When the compiler optimizes the code, it looks for processing shortcuts that reduce the amount of system resources necessary to produce the same output. It then translates the shortcuts into machine code.

For example:

```
a = (x + y) + (x + y) + 10
```

In solving for `a`, the compiler recognizes the equivalence between the two expressions `(x + y)` and uses the already computed value to supply the value of the second expression.

Greater optimization increases the efficiency with which the program object runs on the system. However, with greater optimization, you will encounter increased compile time and also you may not be able to view variables that have been optimized. You can change the optimization level of a module object to display variables accurately as you debug a program object and then change the optimization level when the program object is ready for production.

ILE compilers support a range of optimization levels. There are currently four optimization levels, three of which are available to ILE COBOL users, these are:

***NONE or 10**
: No additional optimization is performed on the generated code. This optimization level allows variables to be displayed and changed when the program object is being debugged. This value provides the lowest level of runtime performance.

***BASIC or 20**
: Some optimization (only at the local block level) is performed on the generated code. When the program object is being debugged, variables can be displayed but not changed. This level of optimization slightly improves runtime performance.

***FULL or 30**
: Full optimization (at the global level) is performed on the generated code. Variables cannot be changed but can be displayed while the program object is being debugged. However, the displayed value of a variable during debugging may not be its current value.

The effect of optimization on runtime performance varies depending on the type of application. For example, for an application that is compute intensive, optimization may improve runtime performance significantly whereas for an application that is I/O intensive, optimization may improve runtime performance only minimally.

To change the optimization level of a module object in a program object, use the Work with Modules (WRKMOD) command. Type WRKMOD on the command line and the Work with Modules display is shown. Select option 5 (Display) from the

Work with Modules display to view the attribute values that need to be changed. The Display Module Information display is shown in Figure 26.

```
                          Display Module Information
                                                                  Display 1 of 1
 Module . . . . . :   COPYPROC
   Library  . . . . . :     TESTLIB
 Detail . . . . . :   *BASIC
 Module attribute . . . . . :   CBLLE
 Module information:
   Module creation date/time . . . . . :   98/08/25  12:57:17
   Source file . . . . . :   QCBLLESRC
     Library . . . . . :     TESTLIB
   Source member . . . . . :   COPYPROC
   Source file change date/time  . . . . . :   98/08/19  12:04:57
   Owner . . . . . :   TESTLIB
   Coded character set identifier  . . . . . :   37
   Text description  . . . . . :   PG - COPY within PR
OCESS Statement Example
   Creation data . . . . . :   *YES
   Intermediate language data  . . . . . :   *NO
                                                                        More...
 Press Enter to continue.
F3=Exit   F12=Cancel
```

Figure 26. First screen of Display Module Information display

First, check that the *Creation data* value is *YES. This means that the module object can be translated again once the *Optimization level* value is changed. If the value is *NO, you must create the module object again and include the machine instruction template to change the optimization level.

Next, press the Roll Down key to see more information about the module object.

```
                          Display Module Information
                                                                  Display 1 of 1
 Module . . . . . :   COPYPROC
   Library  . . . . . :     TESTLIB
 Detail . . . . . :   *BASIC
 Module attribute . . . . . :   CBLLE
   Sort sequence table . . . . . :   *HEX
   Language identifier . . . . . :   *JOBRUN
   Optimization level  . . . . . :   *NONE
   Maximum optimization level  . . . . . :   *FULL
   Debug data  . . . . . :   *YES
   Compressed  . . . . . :   *NO
   Program entry procedure name  . . . . . :   _Qln_pep
   Number of parameters  . . . . . :   0
   Module state  . . . . . :   *USER
   Module domain . . . . . :   *SYSTEM
   Number of exported defined symbols  . . . . . :   2
   Number of imported (unresolved) symbols . . . . . :   14
                                                                        More...
 Press Enter to continue.
 F3=Exit   F12=Cancel
```

Figure 27. Second screen of Display Module Information display

Check the *Optimization level* value. It may already be at the level you desire.

If the module has the machine instruction template and you want to change the optimization level, press F12 (Cancel). The Work with Modules display is shown. Select option 2 (Change) for the module object whose optimization level you want to change. the CHGMOD command prompt is shown as in Figure 29 on page 97. Type over the value specified for the *Optimize module* prompt.

Next, press the Roll Down key to see the final set of information about the module object.

```
                        Display Module Information
                                                                  Display 1 of 7
Module . . . . . . . . . . . . :   COPYPROC
  Library  . . . . . . . . . . :     TESTLIB
Detail . . . . . . . . . . . . :   *BASIC
Module attribute . . . . . . . :   CBLLE
  Profiling data  . . . . . . . . . . . . . . . . . . . :   *NOCOL
  Enable performance collection . . . . . . . . . . . . :   *PEP

  Teraspace storage enabled . . . . . . . . . . . . . . :   *YES

Module compatibility:
  Module created on . . . . . . . . . . . . . . . . . . :   V4R4M0
  Module created for  . . . . . . . . . . . . . . . . . :   V4R4M0
  Earliest release module can be restored to  . . . . . :   V4R4M0
  Conversion required . . . . . . . . . . . . . . . . . :   *NO




                                                                        Bottom
Press Enter to continue.

F3=Exit   F12=Cancel
```

Figure 28. Third screen of Display Module Information display

The *Enable performance collection* prompt shows that the module has been created with performance measurement code for the entry into and exit from program entry point only. The module compatibility prompts show the release and version of the operating system that the module is compatible with.

```
                           Change Module (CHGMOD)
Type choices, press Enter.
Module . . . . . . . . . . . .   COPYPROC      Name, generic*, *ALL
  Library  . . . . . . . . . .     TESTLIB_    Name, *USRLIBL, *LIBL
Optimize module  . . . . . . .   *NONE_        *SAME, *FULL, *BASIC...
Remove observable info . . . .   *DBGDTA       *SAME, *NONE, *ALL...
              + for more values
Enable performance collection:
  Collection level . . . . . .   *PEP          *SAME, *NONE, *PEP, *FULL...
  Procedures . . . . . . . . .                 *ALLPRC, *NONLEAF
Profiling data . . . . . . . .   *COL          *SAME, *NOCOL, *COL
Force module recreation  . . .   *NO           *NO, *YES
Text 'description' . . . . . .   'PG - COPY within Process Statement Example
      '_____________________________


                                                                        Bottom
F3=Exit   F4=Prompt   F5=Refresh   F12=Cancel   F13=How to use this display
F24=More keys
```

Figure 29. Prompt of the CHGMOD Command

Changing the module object to a lower level of optimization allows you to display and possibly change the value of variables while debugging.

Repeat the process for any additional module objects whose optimization you may want to change. Whether you are changing one module object or several in the same program object, the program creation time is the same because all imports are resolved when the system encounters them.

When you are finished changing the optimization level for the module objects in a program object, create the program object again using the CRTPGM command, or update the existing program object with the new module objects using the UPDPGM command.

Removing Module Observability

Module observability refers to three kinds of data that can be stored with a module object. This data allows the module object to be debugged, to be changed without being created again, or to be optimized with an intermediate language optimizer. Once a module object is created, you can only remove this data. Once the data is removed, you must create the module object again to replace it. The three types of data are:

Intermediate Language Data
Represented by the *ILDTA value. This data is necessary to allow a module object to be optimized with an intermediate language optimizer. At the current time, only ILE C compiler supports the creation of this type of data.

Create Data
Represented by the *CRTDTA value. This data is necessary to translate the code to machine instructions. The machine instruction (MI) template is included with the module object when the module object is created using the CRTCBLMOD command. The MI template continues to be there until it is explicitly removed. The module object must have this data for you to change its optimization level.

Debug Data
Represented by the *DBGDTA value. This data is necessary to allow a module object to be debugged. Debug data is included with the module object when the module object is created using the CRTCBLMOD command. The type and amount of debug data is determined by the DBGVIEW parameter.

Removing all observability reduces the module object to its minimum size (with compression). Once all observability is removed, you cannot change the module object in any way unless you create the module object again.

To remove a type of data from the module object, remove all types, or remove none, use the Work with Modules (WRKMOD) command. Type WRKMOD on the command line and the Work with Modules display is shown. Select option 5 (Display) to view the attribute values that need to be changed. The Display Module Information display is shown in Figure 26 on page 96.

First, check the value of the *Creation Data* parameter. If it is *YES, the Create Data exists and can be removed. If the value is *NO, there is no Create Data to remove. The module object cannot be translated again unless you create it again and include the machine instruction template.

Next, press the Roll Down key to see more information about the module object. Check the value of the *Debug data* parameter. If it is *YES, the Debug Data exists and the module object can be debugged. If it is *NO, the Debug Data does not exist and the module object cannot be debugged unless you create it again and include the Debug Data. Select option 2 (Change) for the module object whose observability you want to change. The CHGMOD command prompt is shown. Type over the value specified for the *Remove observable info* prompt.

You can ensure that the module object is created again using the *Force module recreation* parameter. When the optimization level is changed, the module object is always created again if the Create Data has not been removed. If you want the program object to be translated again removing the debug data and not changing the optimization level, you must change the *Force module recreation* parameter value to *YES.

Repeat the process for any additional module objects you may want to change. Whether you are changing one module object or several in the same program object, the program creation time is the same because all imports are resolved when the system encounters them.

When you are finished changing the optimization level for the module objects in a program object, create the program object again using the CRTPGM command, or update the existing program object with the new module objects using the UPDPGM command.

Enabling Performance Collection

The following are the options that may be specified when performance measurements are invoked for a compilation unit.

Collection Levels

The collection levels are:

***PEP** Performance statistics are gathered on the entry and exit of the program entry procedure only. Choose this value when you want to gather overall performance information for an application. This support is equivalent to the support formally provided with the TPST tool. This is the default.

***ENTRYEXIT**
Performance statistics are gathered on the entry and exit of all the procedures of the program. This includes the program PEP routine.

This choice would be useful if you want to capture information on all routines. Use this option when you know that all the programs called by your application were compiled with either the *PEP, *ENTRYEXIT or *FULL option. Otherwise, if your application calls other programs that are not enabled for performance measurement, the performance tool will charge their use of resources against your application. This would make it difficult for you to determine where resources are actually being used.

***FULL** Performance statistics are gathered on the entry and exit of all procedures. Also statistics are gathered before and after each call to an external procedure.

Use this option when you think that your application will call other programs that were not compiled with either *PEP, *ENTRYEXIT or *FULL. This option allows the performance tools to distinguish between resources that are used by your application and those used by programs it calls (even if those programs are not enabled for performance measurement). This option is the most expensive but allows for selectively analyzing various programs in an application.

Procedures

The procedure level values are:

***ALLPRC**
The performance data is collected for all procedures.

***NONLEAF**
Performance data is collected for procedures that are non-leaf procedures and for the PEP.

Note: *NOLEAF has no effect on ILE COBOL programs.

Chapter 5. Creating a Service Program

A service program is a special kind of system object that provides a set of services to ILE program objects that are bound to it.

This chapter describes:
- How service programs can be used
- How to write binder language commands for a service program
- How to create a service program using the CRTSRVPGM command
- How to call and share data with a service program.

Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about creating a service program appears in that product's online help.

Definition of a Service Program

A **service program** is a collection of runnable procedures and available data items that are used by other ILE program objects and service programs. Service programs are system objects of type *SRVPGM and have a name specified when the service program is created.

You use the Create Service Program (CRTSRVPGM) command to create a service program. A service program resembles a program object in that both consist of one or more module objects bound together to make a runnable object. However, a service program differs in that it has no PEP. Since it has no PEP, it cannot be called nor canceled. In place of a PEP, the service program can export procedures. Only the exported procedures from the service program can be called through a static procedure call made from outside of the service program. Exports of service programs are defined using the binder language.

Refer to the *ILE Concepts* book for further information on service programs.

Using Service Programs

Service programs are typically used for common routines that are frequently called within an application and across applications. For example, the ILE COBOL compiler uses service programs to provide runtime services such as math functions and input/output routines. Service programs enable reuse of source programs, simplify maintenance, and reduce storage requirements. In many respects, a service program is similar to a subroutine library or procedure library.

You can update a service program without having to re-create the other program objects or service programs that use the updated service program provided that the interface is unchanged or changed only in an upward compatible manner. You control whether the changes are compatible with the existing support provided by the service program. To make compatible changes to a service program, new procedure names or data names should be added to the end of the export list and the same signature as before must be retained.

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Writing the Binder Language Commands for an ILE COBOL Service Program

The **binder language** allows you to define the list of procedure names and data items that can be exported from a service program. For a full description of the binder language and the binder language commands, refer to the *ILE Concepts* book.

A **signature** is generated from the names of procedures and date items and from the order in which they are specified in the binder language. A signature is a value that identifies the interface supported by the service program. You can also explicitly specify the signature with the SIGNATURE parameter in the binder language.

For service programs created from ILE COBOL source programs, the following language elements are module exports that can be included in the export list of the binder language:

- The name in the PROGRAM-ID paragraph in the outermost ILE COBOL program of a compilation unit.
- The ILE COBOL compiler generated name derived from the name in the PROGRAM-ID paragraph in the outermost ILE COBOL program of a compilation unit provided that program does not have the INITIAL attribute. The name is derived by adding the suffix `_reset` to the name in the PROGRAM-ID paragraph. This name needs to be included in the export list only if the ILE COBOL program in the service program needs to be canceled.

Using the Create Service Program (CRTSRVPGM) Command

You create a service program using the Create Service Program (CRTSRVPGM) command. Any ILE module object can be bound into a service program. The module objects must exist before you can create a service program with it. You can create module objects from ILE COBOL source programs using the CRTCBLMOD command. Refer to "Using the Create COBOL Module (CRTCBLMOD) Command" on page 24 for a description of how to create a module object using the CRTCBLMOD command.

Table 3 lists the CRTSRVPGM parameters and their defaults. For a full description of the CRTSRVPGM command and its parameters, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm..

Table 3. Parameters for CRTSRVPGM Command and Their Default Values

Parameter Group	Parameter(Default Value)
Identification	SRVPGM(*CURLIB/*service-program-name*) MODULE(*SRVPGM)
Program access	EXPORT(*SRCFILE) SRCFILE(*LIBL/QSRVSRC) SRCMBR(*SRVPGM)
Binding	BNDSRVPGM(*NONE) BNDDIR(*NONE)
Run time	ACTGRP(*CALLER)

Table 3. Parameters for CRTSRVPGM Command and Their Default Values (continued)

Parameter Group	Parameter(Default Value)
Miscellaneous	OPTION(*GEN *NODUPPROC *NODUPVAR *WARN *RSLVREF) DETAIL(*NONE) REPLACE(*YES) AUT(*LIBCRTAUT) ALWUPD(*YES) ALWRINZ(*NO) TEXT(*BLANK) ALWLIBUPD(*NO) USRPRF(*USER) TGTRLS(*CURRENT)

Example of Creating a Service Program

This example shows you how to use the binder language to create a service program to perform financial calculations.

Assume that the following ILE COBOL source programs comprise the module objects that make up the service program.

- RATE

  Computes the interest rate, given a loan amount, term, and payment amount.
- AMOUNT

  Computes the loan amount, given an interest rate, term, and payment amount.
- PAYMENT

  Computes the payment amount, given an interest rate, term, and loan amount.
- TERM

  Computes the term of payment, given an interest rate, loan amount, and payment amount.

1. The binder language for the service program that makes the RATE, AMOUNT, PAYMENT, and TERM ILE COBOL programs available looks like the following:

   ```
   FILE: MYLIB/QSRVSRC  MEMBER: FINANCIAL
   STRPGMEXP  PGMLVL(*CURRENT)
     EXPORT SYMBOL('TERM')
     EXPORT SYMBOL('RATE')
     EXPORT SYMBOL('AMOUNT')
     EXPORT SYMBOL('PAYMENT')
   ENDPGMEXP
   ```

   You can use SEU to enter the binder language source statement. The syntax checker in SEU will prompt and validate the binder language input when you specify a source type of BND. To start an edit session to enter the binder language source, type:

   ```
   STRSEU SRCFILE(MYLIB/QSRVSRC) SRCMBR(FINANCIAL)
   TYPE(BND) OPTION(2)
   ```

   and press Enter.
2. Compile the four ILE COBOL source programs into module objects using the CRTCBLMOD command. Assume that the module objects also have the names RATE, AMOUNT, PAYMENT, and TERM.

   To create the service program you can run the required binder statements with this command:

```
CRTSRVPGM  SRVPGM(MYLIB/FINANCIAL)
           MODULE(MYLIB/TERM MYLIB/RATE MYLIB/AMOUNT MYLIB/PAYMENT)
           EXPORT(*SRCFILE)
           SRCFILE(MYLIB/QSRVSRC)
           SRCMBR(*SRVPGM)
```

Notes:

a. Source file QSRVSRC in library MYLIB is the file that contains the binder language source.

b. A binding directory is not required here because all module objects needed to create the service program have been specified with the MODULE parameter.

Further examples of using the binder language and creating service programs can be found in the *ILE Concepts* book.

Using the Retrieve Binder Source (RTVBNDSRC) Command as Input

The Retrieve Binder Source (RTVBNDSRC) command can be used to retrieve the exports from a module or a set of modules, and place them (along with the binder language statements needed for the exports) in a specified file member. After the binder language has been retrieved into a source file member, you can edit the binder language to make changes as needed. This file member can later be used as input to the SRCMBR parameter of the Create Service Program (CRTSRVPGM) command.

By default, the CRTSRVPGM command has a binder language file specified on the EXPORT and SRCFILE parameters to identify the exports from the service program. The RTVBNDSRC command can be useful in helping you automatically create this binder language.

For more information about the Retrieve Binder Source (RTVBNDSRC) command, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Calling Exported ILE Procedures in Service Programs

Exported ILE procedures in service programs can only be called from an ILE program object or another service program using a static procedure call.

You can call an exported ILE procedure in a service program from an ILE COBOL program by using the CALL *literal* statement (were *literal* is the name of an ILE procedure in the service program). See “Performing Static Procedure Calls using CALL literal” on page 211 for detailed information on how to write the CALL statement in your ILE COBOL program to call an exported ILE procedure in a service program.

Sharing Data with Service Programs

External data can be shared among the module objects in a service program, across service programs, across program objects, and between service programs and program objects.

In the ILE COBOL program, the data items to be shared among different module objects must be described with the EXTERNAL clause in the Working Storage

Section. See “Sharing EXTERNAL Data” on page 226 or refer the section on the EXTERNAL clause in the *WebSphere Development Studio: ILE COBOL Reference* for a further description of how external data is used in an ILE COBOL program.

Data and files declared as EXTERNAL in an ILE COBOL program in a service program cannot be in the export list on the binder language for the service program. Data and files declared as EXTERNAL in an ILE COBOL program that is outside of the service program can share this data with an ILE COBOL program that is inside the service program by the activation time resolution to the EXTERNAL data and EXTERNAL files. This same mechanism also allows you to share EXTERNAL data and EXTERNAL files between two completely separate program objects activated in the same activation group.

Canceling an ILE COBOL Program in a Service Program

For you to cancel an ILE COBOL program that is part of a service program from outside that service program, you must specify the CANCEL procedure name of the ILE COBOL program in the export list of the binder language.

Chapter 6. Running an ILE COBOL Program

This chapter provides the information you need to run your ILE COBOL program.

The most common ways to run an ILE COBOL program are:
- Using a Control Language (CL) CALL command
- Using a High Level Language CALL statement (for example, ILE COBOL's CALL statement)
- Using a menu-driven application program
- Issuing a user-created command.
- Selecting the Run menu action or Run toolbar icon on the WebSphere Development Studio Client for iSeries workbench. Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about running an ILE COBOL program and appears in that product's online help.

Running a COBOL Program Using the CL CALL Command

You can use the CL CALL command to run an ILE COBOL program. You can use a CL CALL command interactively, as part of a batch job, or include it in a CL program. An example of a CL CALL command is as follows:

```
CALL program-name
```

The program object specified by program-name must exist in a library and this library must be contained in the library list *LIBL. You can also explicitly specify the library in the CL CALL command as follows:

```
CALL library-name/program-name
```

For further information about using the CL CALL command, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

When you are running a batch job that calls an ILE COBOL program that uses the Format 1 ACCEPT statement, the input data is taken from the job stream. This data must be placed immediately following the CL CALL for the ILE COBOL program. You must ensure that your program requests (through multiple ACCEPT statements) the same amount of data as is available. See the "ACCEPT Statement" section of the *WebSphere Development Studio: ILE COBOL Reference* for more information.

If more data is requested than is available, the CL command following the data is treated as input data. If more data is available than is requested, each extra line of data is treated as a CL command. In each instance, undesirable results can occur.

Passing Parameters to an ILE COBOL Program Through the CL CALL Command

You use the PARM option of the CL CALL command to pass parameter to the ILE COBOL program when you run it.

```
CALL PGM(program-name) PARM(parameter-1 parameter-2 parameter-3)
```

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Each of the parameter values can only be specified in only one of the following ways:
- a character string constant
- a numeric constant
- a logical constant
- a double-precision floating point constant
- a program variable.

Refer to the section on passing parameters between programs in the *CL Programming* book for a full description of how parameters are handled.

Running an ILE COBOL Program Using a HLL CALL Statement

You can run an ILE COBOL program by calling it from another HLL program.

You can use the ILE COBOL CALL statement in a ILE COBOL program to call another ILE COBOL program. If the ILE COBOL call is a dynamic program call, the program object can be library qualified by using the IN LIBRARY phrase. For example, to call program object PGMNAME in library LIBNAME, you would specify:

```
CALL "PGMNAME" IN LIBRARY "LIBNAME" USING variable1.
```

Without the IN LIBRARY phrase, a program object is found by searching the library list *LIBL. See the "CALL Statement" section of the *WebSphere Development Studio: ILE COBOL Reference* for more information.

To run an ILE COBOL program from ILE C, use an ILE C function call. The name of the function corresponds to the name of the ILE COBOL program. By default, this function call is a static procedure call. To perform a dynamic program call, use the `#pragma linkage (PGMNAME, OS)` directive. `PGMNAME` represents the name of the ILE COBOL program that you want to run from the ILE C program. Once you have used the `#pragma linkage (PGMNAME, OS)` directive to tell the ILE C compiler that `PGMNAME` is an external program, you can run your ILE COBOL program through an ILE C function call. For more information, refer to the chapter on writing programs that call other programs in the *WebSphere Development Studio: ILE C/C++ Programmer's Guide*.

To run an ILE COBOL program from an ILE RPG program, use the CALL operation code to make a dynamic program call or the CALLB operation code to make a static procedure call. You identify the program to be called by specifying its name as the Factor 2 entry. For more information, refer to the chapter on calling programs and procedures in the *WebSphere Development Studio: ILE RPG Programmer's Guide*.

To run an ILE COBOL program from C++, use a C++ function call. The name of the function corresponds to the name of the ILE COBOL program. To prevent C++ from internally changing the name of the function, that is to prevent the VisualAge® C++ function name from mangling, you must prototype the function call using the `extern` keyword. To call an ILE COBOL procedure that returns nothing, and takes one 2 byte binary number, the C++ prototype would be:

```
extern "COBOL" void PGMNAME(short int);
```

To call the same COBOL program object, you would specify a linkage of "OS". The prototype becomes:

```
extern "OS" void PGMNAME(short int);
```

A linkage of ″COBOL″ on a C++ function call not only prevents function name mangling but causes any arguments passed to the ILE COBOL procedure to be passed BY REFERENCE. If the ILE COBOL procedure is expecting a BY VALUE parameter then a linkage of ″C″ should be specified.

Running an ILE COBOL Program From a Menu-Driven Application

Another way to run an ILE COBOL program is from a menu-driven application. The workstation user selects an option from a menu, calling the appropriate program. The following figure illustrates an example of an application menu.

```
                          PAYROLL DEPARTMENT MENU

  1.  Inquire into employee master
  2.  Change employee master
  3.  Add new employee
  4.  Return


Option:
```

Figure 30. Example of an Application Menu

The menu shown in this figure is normally displayed by a CL program in which each option calls a separate COBOL program.

The DDS for the display file of the above PAYROLL DEPARTMENT MENU looks like the following:

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* MENU PAYROLLD PAYROLL DEPARTMENT MENU
     A
     A          R MENU                      TEXT('PAYROLL DEPARTMENT MENU')
     A                                   1 29'PAYROLL DEPARTMENT MENU'
     A                                   5  4'1.  Inquire into employee master'
     A                                   6  4'2.  Change employee master'
     A                                   7  4'3.  Add new employee'
     A                                   8  4'4.  Return'
     A                                  12  2'Option:'
     A            RESP                  12 10VALUES(1 2 3 4)
     A                                       DSPATR(MDT)
```

Figure 31. Data Description Specification of an Application Menu

Figure 31 shows an example of the CL program for the application menu illustrated in Figure 30.

```
            PGM /* PAYROLL Payroll Department Menu */
            DCLF FILE (PAYROLLD)
     START: SNDRCVF RCDFMT(MENU)
            IF (&RESP=1); THEN(CALL CBLINQ)
            /* Inquiry */
            ELSE +
              IF (&RESP=2); THEN(CALL CBLCHG)
              /* Change */
              ELSE +
                IF (&RESP=3); THEN(CALL CBLADD)
                /* Add */
                ELSE +
                  IF (&RESP=4); THEN(RETURN)
                  /* Return */
            GOTO START
            ENDPGM
```

Figure 32. Example of a CL program which calls ILE COBOL Programs

If the user enters 1, 2, or 3 from the application menu, the CL program in Figure 32 calls the ILE COBOL programs CBLINQ, CBLCHG, or CBLADD respectively. If the user enters 4 from the application menu, the CL program returns to the program that called it.

Running an ILE COBOL Program Using a User Created Command

You can also create a command yourself to run an ILE COBOL program by using a command definition. A **command definition** is an object that contains the definition of a command (including the command name, parameter descriptions, and validity-checking information), and identifies the program that performs the function requested by the command. The system-recognized object type is *CMD.

For example, you can create a command, PAY, that calls a program, PAYROLL. PAYROLL is the name of an ILE COBOL program that is called and run. You can enter the command interactively, or in a batch job. See the *CL Programming* book for further information about using the command definition.

Ending an ILE COBOL Program

When an ILE COBOL program ends normally, the system returns control to the caller. The caller could be a workstation user, a CL program (such as the menu-handling program), or another HLL program.

If an ILE COBOL program ends abnormally during run time, the escape message CEE9901

```
Application error. message-id unmonitored by program-name
at statement statement-number, instruction instuction-number.
```

is issued to the caller of the run unit. A CL program can monitor for this exception by using the Monitor Message (MONMSG) command. For more information about control language commands, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

If a program ends for any reason other than by:

- Use of the STOP RUN statement
- Use of the GOBACK statement in the main program

- Use of the EXIT-PROGRAM AND CONTINUE RUN UNIT statement in the main program
- Falling through to the end of the program,

the RTNCDE job attribute is set to 2.

See the RTVJOBA and DSPJOB commands in the *CL Programming* book for more information about return codes.

Replying to Run Time Inquiry Messages

When you run an ILE COBOL program, run-time inquiry messages may be generated. The messages require a response before the program continues running.

You can add the inquiry messages to a system reply list to provide automatic replies to the messages. The replies for these messages may be specified individually or generally. This method of replying to inquiry messages is especially suitable for batch programs, which would otherwise require an operator to issue replies.

You can add the following ILE COBOL inquiry messages to the system reply list:
- LNR7200
- LNR7201
- LNR7203
- LNR7204
- LNR7205
- LNR7206
- LNR7207
- LNR7208
- LNR7209
- LNR7210
- LNR7211
- LNR7212
- LNR7213
- LNR7214
- LNR7604.

The reply list is only used when an inquiry message is sent by a job that has the Inquiry Message Reply (INQMSGRPY) attribute specified as `INQMSGRPY(*SYSRPYL)`.

The INQMSGRPY parameter occurs on the following CL commands:
- Change Job (CHGJOB)
- Change Job Description (CHGJOBD)
- Create Job Description (CRTJOBD)
- Submit Job (SBMJOB).

You can select one of four reply modes by specifying one of the following values for the INQMSGRPY parameter:

SAME No change is made in the way that replies are sent to inquiry messages

RQD All inquiry messages require a reply by the receiver of the inquiry messages

DFT A default reply is issued

SYSRPYL The system reply list is checked for a matching reply list entry. If a match occurs, the reply value in that entry is used. If no entry exists for that inquiry message, a reply is required.

You can use the Add Reply List Entry (ADDRPYLE) command to add entries to the system reply list, or the Work with Reply List Entry (WRKRPYLE) command to change or remove entries in the system reply list. You can also reply to run time inquiry messages with a user-defined error-handler.

For details of the ADDRPYLE and WRKRPYLE commands, and for more information about error-handling APIs, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Chapter 7. Debugging a Program

Debugging allows you to detect, diagnose, and eliminate errors in a program.

Use WebSphere Development Studio Client for iSeries. This is the recommended method and documentation about debugging ILE COBOL programs and appears in that product's online help.

With the integrated iSeries debugger you can debug your program running on the iSeries server from a graphical user interface on your workstation. You can also set breakpoints directly in your source before running the debugger. The integrated iSeries debugger client user interface also enables you to control program execution. For example, you can run your program, set line, watch, and service entry point breakpoints, step through program instructions, examine variables, and examine the call stack. You can also debug multiple applications, even if they are written in different languages, from a single debugger window. Each session you debug is listed separately in the Debug view.

You can also debug your OPM and ILE COBOL programs using the ILE source debugger. This chapter describes how to use the ILE source debugger to:

- Prepare your ILE COBOL program for debugging
- Start a debug session
- Add and remove programs from a debug session
- View the program source from a debug session
- Set and remove conditional and unconditional breakpoints
- Set and remove watch conditions
- Step through a program
- Display the value of variables, records, group items, and arrays
- Change the value of variables
- Change the reference scope
- Equate a shorthand name to a variable, expression, or debug command.

While debugging and testing your programs, ensure that your library list is changed to direct the programs to a test library containing test data so that any existing real data is not affected.

You can prevent database files in production libraries from being modified unintentionally by using one of the following CL commands:

- Use the Start Debug (STRDBG) command and specify the UPDPROD(*NO) parameter
- Use the Change Debug (CHGDBG) command, and specify the *NO value of the UPDPROD parameter
- Use the SET debug command in the Display Module Source display. The syntax for preventing file modification would be:

  ```
  SET UPDPROD NO
  ```

  which can be abbreviated as

  ```
  SET U N
  ```

See the chapter on debugging in the *ILE Concepts* book for more information on the ILE source debugger (including authority required to debug a program object or a service program and the affects of optimization levels).

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The ILE Source Debugger

The ILE source debugger is used to detect errors in and eliminate errors from program objects and service programs. Using debug commands with any ILE program that contains debug data you can:

- Debug any ILE COBOL or mixed ILE language application
- Monitor the flow of a program by using the debug commands while the program is running.
- View the program source or change the debug view
- Set and remove conditional and unconditional breakpoints
- Set and remove watch conditions
- Step through a specified number of statements
- Display or change the value of variables, records, group items, and arrays.

Note: The ILE COBOL COLLATING SEQUENCE is not supported by the ILE source debugger. If you use the ILE COBOL COLLATING SEQUENCE clause in your ILE COBOL program to specify your own collating sequence, this collating sequence will not be used by the ILE source debugger.

When a program stops because of a breakpoint or a step command, the pertinent module object's view is shown on the display at the point where the program stopped. At this point you can enter more debug commands.

Before you can use the source debugger, you must specify the DBGVIEW parameter with a value other than *NONE when you create a module object or program object using the CRTCBLMOD or CRTBNDCBL command. After you have started the debugger, you can set breakpoints or other ILE source debugger options, and then run the program.

Debug Commands

Many debug commands are available for use with the ILE source debugger. The debug commands and their parameters are entered on the Debug command line displayed on the bottom of the Display Module Source and Evaluate Expression displays. These commands can be entered in upper, lower or mixed case. Refer to *ILE Concepts* book for a further discussion of the debug commands.

Note: The debug commands entered on the debug command line are not CL commands.

Table 4 summarizes these debug commands. The online help for the ILE source debugger describes the debug commands and explains their allowed abbreviations.

Table 4. ILE Source Debugger Commands

Debug Command	Description
ATTR	Permits you to display the attributes of a variable. The attributes are the size and type of the variable as recorded in the debug symbol table. Refer to Table 5 on page 116 for a list of attributes and their ILE COBOL equivalences. These attributes are not the same as the attributes defined by ILE COBOL.
BREAK	Permits you to enter either an unconditional or conditional job breakpoint at a position in the program being tested. Use BREAK *position* WHEN *expression* to enter a conditional job breakpoint.

Table 4. ILE Source Debugger Commands (continued)

Debug Command	Description
CLEAR	Permits you to remove conditional and unconditional breakpoints, or to remove one or all active watch conditions.
DISPLAY	Allows you to display the names and definitions assigned by using the EQUATE command. It also allows you to display a different source module than the one currently shown on the Display Module Source display. The module object must exist in the current program object.
EQUATE	Allows you to assign an expression, variable, or debug command to a name for shorthand use.
EVAL	Allows you to display or change the value of a variable or to display the value of expressions, records, group items, or arrays.
QUAL	Allows you to define the scope of variables that appear in subsequent EVAL or WATCH commands.
SET	Allows you to change debug options, such as the ability to update production files, specify if find operations are to be case-sensitive, or to enable OPM source debug support.
STEP	Allows you to run one or more statements of the program being debugged.
TBREAK	Permits you to enter either an unconditional or a conditional breakpoint in the current thread at a position in the program being tested.
THREAD	Allows you to display the Work with Debugged Threads display or change the current thread.
WATCH	Allows you to request a breakpoint when the contents of a specified storage location is changed from its current value.
FIND	Searches ahead in the module currently displayed for a specified line number or string or text.
UP	Moves the displayed window of source towards the beginning of the view by the amount entered.
DOWN	Moves the displayed window of source towards the end of the view by the amount entered.
LEFT	Moves the displayed window of source to the left by the number of characters entered.
RIGHT	Moves the displayed window of source to the right by the number of characters entered.
TOP	Positions the view to show the first line.
BOTTOM	Positions the view to show the last line.
NEXT	Positions the view to the next breakpoint in the source currently displayed.
PREVIOUS	Positions the view to the previous breakpoint in the source currently displayed.
HELP	Shows the online help information for the available source debugger commands.

Attributes of Variables

The ILE source debugger does not describe the attributes of variables in the same manner as ILE COBOL. Table 5 on page 116 shows the equivalence between the attributes of variables as described by the ILE source debugger and ILE COBOL data categories.

Table 5. Equivalence Between ILE Source Debugger Variable Attributes and ILE COBOL Data Categories

ILE source debugger attributes of variables	ILE COBOL data categories
FIXED LENGTH STRING	Alphabetic Alphanumeric Alphanumeric-edited Numeric-edited External floating-point Date Time Timestamp
GRAPHIC	DBCS DBCS-edited
CHAR	Boolean
BINARY	Binary
ZONED(2,0)	Zoned Decimal
PACKED(2,0)	Packed Decimal Packed Date Packed Time
PTR	Pointer Procedure-pointer
REAL	Internal floating-point

Preparing a Program Object for a Debug Session

Before you can use the ILE source debugger, you must use either the CRTCBLMOD or CRTBNDCBL command specifying the DBGVIEW parameter.

You can create one of three views for each ILE COBOL module object that you want to debug. They are:
- Listing view
- Source view
- Statement view.

Note: An OPM program must be compiled with OPTION(*SRCDBG) or OPTION(*LSTDBG) in order to debug it using the ILE source debugger. For more information, see "Starting the ILE Source Debugger" on page 118.

Using a Listing View

A listing view is similar to the source listing portion of the compile listing or spool file produced by the ILE COBOL compiler.

In order to debug an ILE COBOL module object using a listing view, use the *LIST or *ALL value on the DBGVIEW parameter for either the CRTCBLMOD or CRTBNDCBL commands when you create the module object or program object.

One way to create a listing view, is as follows:

```
CRTCBLMOD MODULE(MYLIB/xxxxxxxx)
SRCFILE(MYLIB/QCBLLESRC) SRCMBR(xxxxxxxx)
TEXT('CBL Program') DBGVIEW(*LIST)
```

When you generate the listing view by specifying DBGVIEW(*LIST) on the CRTCBLMOD or CRTBNDCBL commands, the size of the created module object is increased because of the listing view. The listing view provides all expansions (for example, COPY and REPLACE statements) made by the ILE COBOL compiler when it creates the module object or program object. The listing view exist independent of the source member. The source member can be changed or deleted without affecting the listing view.

If the source member contains multiple compilation units, the listing view will contain the source listings of all of the compilation units, even if only one of them will be debugged. However, any debug commands issued from the Display Module Source display will be applied only to the compilation unit that can be debugged.

Using a Source View

A source view contains references to the source statements of the source member.

To use the source view with the ILE source debugger, the ILE COBOL compiler creates references to the source member while the module object (*MODULE) is being created.

Note: The module object is created using references to locations of the source statements in the root source member instead of copying the source statements into the view. Therefore, you should not modify, rename, or move root source members between the creation of the module and the debugging of the module created from these members.

In order to debug an ILE COBOL module object using a source view, use the *SOURCE or *ALL value on the DBGVIEW parameter for either the CRTCBLMOD or CRTBNDCBL commands.

One way to create a source view, is as follows:

```
CRTCBLMOD MODULE(MYLIB/xxxxxxxx)
SRCFILE(MYLIB/QCBLLESRC) SRCMBR(xxxxxxxx)
TEXT('CBL Program') DBGVIEW(*SOURCE)
```

When you generate the source view by specifying DBGVIEW(*SOURCE) on the CRTCBLMOD or CRTBNDCBL commands, the size of the created module object is increased because of the source view but the size is smaller than that generated with the listing view. The size of the generated module object will be the same as for the statement view. The source view does not provide any expansions made by the ILE COBOL compiler when it creates the module object or program object. The source view depends on the unchanged existence of the source member. Any changes made to the source member will affect the source view.

If the source member contains multiple compilation units, the source view will contain the source code of all of the compilation units, even if only one of them can be debugged. However, any debug commands issued from the Display Module Source display will be applied only to the compilation unit being debugged.

Using a Statement View

A statement view does not contain source statements. It contains line numbers and statement numbers. To debug an ILE COBOL module object using a statement view, you need a hard copy of the compiler listing.

Note: No source code is shown in the Display Module Source display when a statement view is used to debug an ILE COBOL module object.

To debug an ILE COBOL module object using a statement view, use the *STMT, *SOURCE, *LIST or *ALL value on the DBGVIEW parameter for either the CRTCBLMOD or CRTBNDCBL commands when you create the module.

One way to create a statement view, is as follows:

```
CRTCBLMOD MODULE(MYLIB/xxxxxxxx)
SRCFILE(MYLIB/QCBLLESRC) SRCMBR(xxxxxxxx)
TEXT('CBL Program') DBGVIEW(*STMT)
```

When you generate the statement view by specifying DBGVIEW(*STMT) on the CRTCBLMOD or CRTBNDCBL commands, the size of the created module object is increased minimally because of the statement view. The size of the created module object is smaller than that generated with the listing view or the source view. The statement view minimizes the size of the created module object while still allowing some form of debugging. The statement view only provides the symbol table and a mapping between statement numbers and debug line numbers.

Starting the ILE Source Debugger

Once you have created a debug view, you can begin debugging your application.

To start the ILE source debugger, use the Start Debug (STRDBG) command. Once the debugger is started, it remains active until you enter the End Debug (ENDDBG) command. You can change the attributes of the debug mode later in the job by using the Change Debug (CHGDBG) command.

Table 6 lists the parameters and their default values for the STRDBG command and the CHGDBG command. The ENDDBG command does not have any parameters associated with it. For a full description of the STRDBG, CHGDBG, and ENDDBG commands and their parameters, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Table 6. Parameters for STRDBG and CHGDBG Commands and their Default Values

Parameter Group	STRDBG Command Parameter(Default Value)	CHGDBG Command Parameter(Default Value)
Identification	PGM(*NONE) DFTPGM(*PGM)	DFTPGM(*SAME)
Trace	MAXTRC(200) TRCFULL(*STOPTRC)	MAXTRC(*SAME) TRCFULL(*SAME)
Miscellaneous	UPDPROD(*NO) OPMSRC(*NO) SRVPGM(*NONE) CLASS(*NONE) DSPMODSRC(*PGMDEP) SRCDBGPGM(*SYSDFT) UNMONPGM(*NONE)	UPDPROD(*SAME) OPMSRC(*SAME)

Note: Trace applies only to OPM programs and is not applicable to ILE programs and service programs.

You can initially add as many as 20 program objects to a debug session by using the Program (PGM) parameter on the STRDBG command. (Depending on how the

OPM programs were compiled and also on the debug environment settings, you may be able to debug them by using the ILE source debugger.) They can be any combination of ILE or OPM programs.

Only program objects can be specified on the PGM parameter of the STRDBG command. Up to 20 service programs can initially be added to the debug session by using the Service Program (SRVPGM) parameter of the STRDBG command. Additional service programs can be added to the debug session after it has been started. In addition, you can initially add as many as 20 service program objects to a debug session by using the Service Programs (SRVPGM) parameter on the STRDBG command. The rules for debugging a service program are the same as those for debugging a program:

- The program or service program must have debug data
- You must have *CHANGE authority to a program or service program object to include it in a debug session.

The first program specified on the STRDBG command is shown if it has debug data, and, if OPM, the OPMSRC parameter is *YES. If ILE, the entry module is shown, if it has debug data; otherwise, the first module bound to the ILE program with debug data is shown.

To debug an OPM program using the ILE source debugger, the following conditions must be met:

1. The OPM program was compiled with OPTION(*LSTDBG) or OPTION(*SRCDBG). (Three OPM languages are supported: RPG, COBOL, and CL. RPG and COBOL programs can be compiled with *LSTDBG or *SRCDBG, but CL programs must be compiled with *SRCDBG.)
2. The ILE debug environment is set to accept OPM programs. You can do this by specifying OPMSRC(*YES) on the STRDBG command. (The system default is OPMSRC(*NO).)

If these two conditions are not met, then you must debug the OPM program with the OPM system debugger.

If an OPM program compiled without *LSTDBG or *SRCDBG is specified, and a service program is specified, the service program is shown if it has debug data. If there is no debug data, then the DSPMODSRC screen will be empty. If an ILE program and a service program are specified, then the ILE program will be shown.

STRDBG Example

For example, to start a debug session for the sample debug program MYPGM1 and a called OPM program MYPGM2, type:

```
STRDBG PGM(TESTLIB/MYPGM1 MYLIB/MYPGM2) OPMSRC(*YES)
```

Note: You must have *CHANGE authority to a program object to add it to a debug session.

After entering the STRDBG command, the Display Module Source display appears. When a mixture of ILE programs and ILE debugger-enabled OPM programs are specified on the STRDBG command, the first program with debug data is shown. If the first program is an ILE program, the first module object bound to the program object with debug data is shown as in Figure 33 on page 120.

```
                        Display Module Source
 Program:   MYPGM1         Library:   TESTLIB        Module:   MYPGM1
      1         IDENTIFICATION DIVISION.
      2         PROGRAM-ID.  MYPGM1.
      3        *
      4        * This is the main program that controls
      5        * the external file processing.
      6        *
      7
      8         ENVIRONMENT DIVISION.
      9         INPUT-OUTPUT SECTION.
     10         FILE-CONTROL.
     11              SELECT EF1
     12                 ASSIGN TO DISK-EFILE1
     13                 FILE STATUS IS EFS1
     14                 ORGANIZATION IS SEQUENTIAL.
     15
                                                                 More...
 Debug . . .   ____________________________________________________________
_____________________________________________________________________________
 F3=End program   F6=Add/Clear breakpoint   F10=Step   F11=Display variable
 F12=Resume       F17=Watch variable   F18=Work with watch   F24=More keys
```

Figure 33. Starting a Debug Session

Setting Debug Options

After you start a debug session, you can set or change the following debug options using the SET debug command on the debug command line:

- Whether database files can be updated while debugging your program. (This option corresponds to the UPDPROD parameter of the STRDBG command.)
- Whether text searches using FIND are case-sensitive.
- Whether OPM programs are to be debugged using the ILE source debugger. (This option corresponds to the OPMSRC parameter.)

Changing the debug options using the SET debug command affects the value for the corresponding parameter, if any, specified on the STRDBG command. You can also use the Change Debug (CHGDBG) command to set debug options. However, the OPMSRC option cannot be changed by the CHGDBG command. OPMSRC can only be changed by the SET debug command.

Suppose you are in a debug session working with an ILE program, and you decide you should also debug an OPM program that has debug data available. To enable the ILE source debugger to accept OPM programs, follow these steps:

1. After entering STRDBG, if the current display is *not* the Display Module Source display, type:

   `DSPMODSRC`

2. Type:

   `SET`

   The Set Debug Options display appears.

3. On this display, type `Y` (Yes) in the *OPM source debug support* field, and press the Enter key to return to the Display Module Source display.

You can now add the OPM program, either by using the Work with Module display, or by processing a call statement for that program.

Running a Program Object in a Debug Session

Once the debug session has been started, you can run a program object in the debug session by pressing:
- F3 (End Program),
- F12 (Resume), or
- F21 (Command Line)

from the Display Module Source display. Then, call the program object from the command line using the CALL CL command.

When an exception occurs in a program object during a debug session, the exception is handled by the error and exception handling routines specified for the program object. If the exception is not handled by any exception handler prior to the exception being turned into a function check, then the debugger is invoked and the Display Module Source display is shown. The module object within which the exception occurred is displayed at the statement which caused the exception. Refer to Chapter 15, "ILE COBOL Error and Exception Handling," on page 345 for more information on error and exception handling.

You can stop program execution by setting breakpoints or by pressing F3 (End Program) from the Display Module Source display. Refer to "Setting and Removing Breakpoints" on page 125 for more information on setting breakpoints.

Adding Program Objects and Service Programs to a Debug Session

You can add more program objects and service programs to a debug session after starting the session.

To add **ILE program objects** and service programs to a debug session, use option 1 (Add program) and type the name of the program object on the first line of the Work with Module List display (see Figure 34 on page 122). The Work with Module List display can be accessed from the Display Module Source display by pressing F14 (Work with Module List). To add a service program, change the default program type from *PGM to *SRVPGM. There is no limit to the number of ILE program objects and service programs that can be included in a debug session at any given time.

To add **OPM program objects** to a debug session, you have two choices depending on the value specified for OPMSRC. If you specified OPMSRC(*YES), by using either STRDBG, the SET debug command, or CHGDBG, then you add an OPM program using the Work with Module List display. (Note that there will not be a module name listed for an OPM program.) There is no limit to the number of OPM programs that can be included in a debug session at one time when OPMSRC(*YES) is specified. If you specified OPMSRC(*NO), then you must use the Add Program (ADDPGM) command. Only 20 OPM programs can be in a debug session when OPMSRC(*NO) is specified.

Note: You cannot debug an OPM program with debug data from both an ILE and an OPM debug session. If an OPM program is already in an OPM debug session, you must first remove it from that session before adding it to the ILE debug session or stepping into it from a call statement. Similarly, if you want to debug it from an OPM debug session, you must first remove it from an ILE debug session.

```
                                Work with Module List
                                                              System:   ISERIES
Type options, press enter.
  1=Add program   4=Remove program   5=Display module source
  8=Work with module breakpoints
Program
Opt     Program/module     Library        Type
1        TEST_________     TESTLIB___     *PGM___
_        MYPGM1            TESTLIB        *PGM
_          MYPGM1                         *MODULE     Selected
_        USERDSP           DSPLIB         *SRVPGM
_          SAMPMDF                        *MODULE
_          GETUSER                        *MODULE

                                                                       Bottom
Command
===> ____________________________________________________________________________
F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F12=Cancel
```

Figure 34. Adding an ILE Program Object to a Debug Session

When you have finished adding program objects or service programs to the debug session, press F3 (Exit) from the Work with Module List display to return to the Display Module Source display.

Note: You must have *CHANGE authority to a program to add it to a debug session. ILE service programs can be added to a debug session only by using option 1 on the Work with Module List display. ILE service programs cannot be specified on the STRDBG command.

Removing Program Objects or Service Programs from a Debug Session

You can remove program objects or service programs from a debug session after starting the session.

To remove ILE program objects and service programs from a debug session, use option 4 (Remove program), next to the program object or service program you want to remove, on the Work with Module List display (see Figure 35 on page 123). The Work with Module List display can be accessed from the Display Module Source display by pressing F14 (Work with Module List).

To remove **OPM program objects** from a debug session, you have two choices depending on the value specified for OPMSRC. If you specified OPMSRC(*YES), by using either STRDBG, the SET debug command, or CHGDBG, then you remove an OPM program using the Work with Module display. (Note that there will not be a module name listed for an OPM program.) There is no limit to the number of OPM programs that can be removed from a debug session at one time when OPMSRC(*YES) is specified. If you specified OPMSRC(*NO), then you must use the Remove Program (RMVPGM) command. Only ten OPM programs can be in a debug session when OPMSRC(*NO) is specified.

```
                          Work with Module List
                                                                System:   ISERIES
Type options, press enter.
  1=Add program   4=Remove program   5=Display module source
  8=Work with module breakpoints
Program
Opt      Program/module     Library         Type
_         _____________     *LIBL_____      *PGM___
4         TEST              TESTLIB         *PGM
_           SAMPMDF                         *MODULE
_         MYPGM1            TESTLIB         *PGM
_           MYPGM1                          *MODULE     Selected
_         USERDSP           DSPLIB          *SRVPGM
_           SAMPMDF                         *MODULE
_           GETUSER                         *MODULE
                                                                       Bottom
Command
===> ____________________________________________________________________________
F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F12=Cancel
```

Figure 35. Removing an ILE Program Object from a Debug Session

When you have finished removing program objects or service programs from the debug session, press F3 (Exit) from the Work with Module List display to return to the Display Module Source display.

Note: You must have *CHANGE authority to a program to remove it to a debug session.

Viewing the Program Source

The Display Module Source display shows the source of an ILE program object or service program, one module object at a time. A module object's source can be shown if you created the module object with debug data, using one of the following debug view options:

- DBGVIEW(*STMT)
- DBGVIEW(*SOURCE)
- DBGVIEW(*LIST)
- DBGVIEW(*ALL)

The source of an OPM program can be shown if the following conditions are met:

1. The OPM program was compiled with OPTION(*LSTDBG) or OPTION(*SRCDBG). (Only RPG and COBOL programs can be compiled with *LSTDBG.)
2. The ILE debug environment is set to accept OPM programs; that is, the value of OPMSRC is *YES. (The system default is OPMSRC(*NO).)

There are two methods to change what is shown on the Display Module Source display:

- Change the module object that is shown
- Change the view of the module object that is shown.

The ILE source debugger remembers the last position in which the module object is displayed and displays it in the same position when a module object is re-displayed. Lines numbers that have breakpoints set are highlighted. When a breakpoint, step, or message causes the program to stop and the display to be shown, the source line where the event occurred will be highlighted.

Changing the Module Object that is Shown

You can change the module object that is shown on the Display Module Source display by using option 5 (Display module source) on the Work with Module List display. The Work with Module List display can be accessed from the Display Module Source display by pressing F14 (Work with Module List). The Work with Module List display is shown in Figure 36.

To select a module object, type 5 (Display module source) next to the module object you want to show. If you use this option with an ILE program object, the module object containing the source view is shown (if it exists). Otherwise, the first module object bound to the program object with debug data is shown. If you use this option with an OPM program object, then the source or listing view is shown (if available).

```
                              Work with Module List
                                                          System:   ISERIES
 Type options, press enter.
   1=Add program   4=Remove program   5=Display module source
   8=Work with module breakpoints
Program
Opt     Program/module     Library        Type
_        _____________     *LIBL_____     *PGM___
_        TEST              TESTLIB        *PGM
5          SAMPMDF                        *MODULE
_        MYPGM1            TESTLIB        *PGM
_          MYPGM1                         *MODULE     Selected
_        USERDSP           DSPLIB         *SRVPGM
_          SAMPMDF                        *MODULE
_          GETUSER                        *MODULE
                                                                      Bottom
Command
===> ____________________________________________________________________________
F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F12=Cancel
```

Figure 36. Display a Module View

Once you have selected the module object that you want to view, press Enter and the selected view will be shown in the Display Module Source display.

An alternate method of changing the module object that is shown is to use the DISPLAY debug command. On the debug command line, type:

```
DISPLAY MODULE module-name
```

The module object *module-name* will now be shown. The module object must exist in a program object that has been added to the debug session.

Changing the View of the Module Object that is Shown

Several different views of an ILE COBOL module object are available depending on the values you specify when you create an ILE COBOL module object. These views are:

- ILE COBOL Listing view
- ILE COBOL Source view

You can change the view of the module object that is shown on the Display Module Source display through the Select View display. The Select View display can be accessed from the Display Module Source display by pressing F15 (Select View). The Select View display is shown in Figure 37 on page 125. The current view is listed at the top of the window, and the other views that are available are

shown below. Each module object in a program object or service program can have a different set of views available, depending on the debug options used to create it.

To select a view, type 1 (Select) next to the view you want to show.

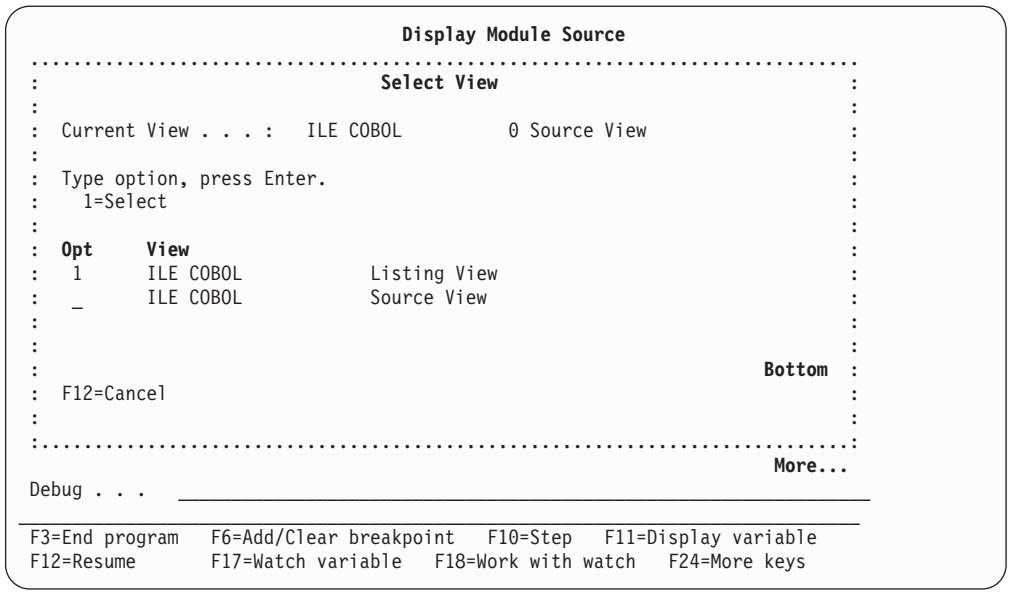

Figure 37. Changing a View of a Module Object

After you have selected the view of the module object that you want to show, press Enter and the selected view of the module object will be shown in the Display Module Source display.

Setting and Removing Breakpoints

You can use breakpoints to halt a program object or service program at a specific point when it is running. An **unconditional breakpoint** stops the program object or service program at a specific statement. A **conditional breakpoint** stops the program object or service program when a specific condition at a specific statement is met.

There are two types of breakpoints: job and thread. Each **thread** in a threaded application may have it's own thread breakpoint at the same position at the same time. Both a job breakpoint and a thread breakpoint can be unconditional or conditional. In general, there is one set of debug commands and Function keys for job breakpoints and another for thread breakpoints. For the rest of this section on breakpoints, the word breakpoint refers to both job and thread, unless specifically mentioned otherwise.

When the program object or service program stops, the Display Module Source display is shown. The appropriate module object is shown with the source positioned at the line where the breakpoint occurred. This line is highlighted. At this point, you can evaluate variables, set more breakpoints, and run any of the debug commands.

You should know the following characteristics about breakpoints before using them:

- If a breakpoint is bypassed by, for example with the GO TO statement, that breakpoint is not processed.

- When a breakpoint is set on a statement, the breakpoint occurs before that statement is processed.
- When a statement with a conditional breakpoint is reached, the conditional expression associated with the breakpoint is evaluated before the statement is processed.
- Breakpoint functions are specified through debug commands.

  These functions include:
  - Adding breakpoints
  - Removing breakpoints
  - Displaying breakpoint information
  - Resuming the running of a program object or service program after a breakpoint has been reached
- You can either have a job breakpoint or a thread breakpoint on a specified position at the same time, but not both.

Setting and Removing Unconditional Job Breakpoints

You can set or remove an unconditional job breakpoint by using:
- F6 (Add/Clear breakpoint) from the Display Module Source display
- F13 (Work with Module Breakpoints) from the Display Module Source display
- The BREAK debug command to set a job breakpoint
- The CLEAR debug command to remove a job breakpoint

The simplest way to set and remove an unconditional job breakpoint is to use F6 (Add/Clear breakpoint) from the Display Module Source display.

To set an unconditional job breakpoint using F6 (Add/Clear breakpoint), place your cursor on the line to which you want to add the breakpoint and press F6 (Add/Clear Breakpoint). An unconditional job breakpoint is set on the line.

To remove an unconditional job breakpoint using F6 (Add/Clear breakpoint), place your cursor on the line from which you want to remove the job breakpoint and press F6 (Add/Clear Breakpoint). The job breakpoint is removed from the line.

Repeat the previous steps for each unconditional job breakpoint you want to set.

If the line on which you want to set a job breakpoint has multiple statements, pressing F6 (Add/Clear Breakpoint) will set the job breakpoint at the first statement on the line.

Note: If the line on which you want to set a job breakpoint is not a runnable statement, the job breakpoint will be set at the next runnable statement.

To remove an unconditional breakpoint using F13 (Work with module breakpoints), press F13 (Work with module breakpoints) from the Display Module Source display. A list of options appear which allow you to set or remove breakpoints. If you select 4 (Clear), a job breakpoint is removed from the line.

After the breakpoints are set, press F3 (End Program) to leave the Display Module Source display. You can also use F21 (Command Line) from the Display Module Source display to call the program from a command line.

Call the program object. When a breakpoint is reached, the program object or service program stops and the Display Module Source display is shown again. At this point, you can evaluate variables, set more breakpoints, and run any of the debug commands.

An alternate method of setting and removing unconditional job breakpoints is to use the BREAK and CLEAR debug commands.

To set an unconditional job breakpoint using the BREAK debug command, type:

```
BREAK line-number
```

on the debug command line. *line-number* is the number in the currently displayed view of the module object on which you want to set a breakpoint.

If the line on which you want to set a breakpoint has multiple statements, the BREAK debug command will set the breakpoint at the first statement on the line.

To remove an unconditional job breakpoint using the CLEAR debug command, type:

```
CLEAR line-number
```

on the debug command line. *line-number* is the line number in the currently displayed view of the module object from which you want to remove a breakpoint. When a job breakpoint is cleared, it is cleared for all threads.

Setting and Removing Unconditional Thread Breakpoints

You can set or remove an unconditional thread breakpoint by using:

- F13 (Work with Module Breakpoints) from the Display Module Source display
- The TBREAK debug command to set a thread breakpoint in the current thread
- The CLEAR debug command to remove a thread breakpoint.

Setting

Using the Work with Module Breakpoints Display: To set an unconditional thread breakpoint using the Work with Module Breakpoints display:

- Type 1 (Add) in the *Opt* field.
- In the *Thread* field, type the thread identifier.
- Fill in the remaining fields as if it were an unconditional job breakpoint.
- Press Enter.

Note: The *Thread* field is displayed when the DEBUG option on the SPAWN command is greater than or equal to one. For more information, see "Example of Using ILE COBOL in a Multithreaded Environment" on page 341.

Using the TBREAK Command: The TBREAK debug command has the same syntax as the BREAK debug command. Where the BREAK debug command sets a job breakpoint at the same position in all threads, the TBREAK debug command sets a thread breakpoint in a single thread—the current thread.

The current thread is the thread that is currently being debugged. Debug commands are issued to this thread. When a debug stop occurs, such as a

breakpoint, the current thread is set to the thread where the debug stop happened. The debug THREAD command and the Work with Debugged Threads display can be used to change the current thread.

Removing

To remove an unconditional thread breakpoint use the CLEAR debug command. When a thread breakpoint is cleared, it is cleared for the current thread only.

Setting and Removing Conditional Job Breakpoints

You can set or remove a conditional job breakpoint by using:

- The Work with Module Breakpoints display
- The BREAK debug command to set a job breakpoint
- The CLEAR debug command to remove a job breakpoint

Note: The relational operators supported for conditional breakpoints are <, >, =, =<, =>, and <>.

One way you can set or remove conditional job breakpoints is through the Work with Module Breakpoints display. The Work with Module Breakpoints display can be accessed from the Display Module Source display by pressing F13 (Work with module breakpoints). The Work with Module Breakpoints display is shown in Figure 38.

Setting

You can set conditional job breakpoints using the Work with Module Breakpoints display or using the BREAK debug command.

To set a conditional job breakpoint using the Work with Module Breakpoints display:

1. Type 1 (Add) in the *Opt* field.
2. Type the debugger line number, to which you want to set the breakpoint, in the *Line* field.
3. Type an conditional expression in the *Condition* field.
4. If a thread column is shown, before pressing Enter, type *JOB in the *Thread* field.
5. Press Enter.

```
                          Work with Module Breakpoints
                                                        System:   ISERIES
Program  . . . :   TEST                Library  . . . :   TESTLIB
  Module . . . :     SAMPMDF           Type . . . . . :   *PGM
Type options, press Enter.
  1=Add   4=Clear
Opt     Line       Condition
 1      35____     I=21_____________________________
 _      ______     _________________________________
```

Figure 38. Setting a Conditional Breakpoint

If the line on which you want to set a breakpoint has multiple statements, the breakpoint is set at the first statement on the line.

Note: If the line on which you want to set a breakpoint is not a runnable statement, the breakpoint will be set at the next runnable statement.

Once you have finished specifying all of the breakpoints that you want to set or remove, press F3 (Exit) to return to the Display Module Source display.

Then press F3 (End Program) to leave the Display Module Source display. You can also use F21 (Command Line) from the Display Module Source display to call the program object from a command line.

Run the program object or service program. When a statement with a conditional job breakpoint is reached, the conditional expression associated with the breakpoint is evaluated before the statement is run. If the result is false, the program object continues to run. If the result is true, the program object stops, and the Display Module Source display is shown. At this point, you can evaluate variables, set more breakpoints, and run any of the debug commands.

To set a conditional job breakpoint using the BREAK debug command, type:

```
BREAK line-number WHEN expression
```

on the debug command line. *line-number* is the line number in the currently displayed view of the module object on which you want to set a breakpoint and *expression* is the conditional expression that is evaluated when the breakpoint is encountered. The conditional expression can only be a simple expression. The term on the right hand side of the equation can only contain a single value. For example, I=21 is accepted but I=A+2 or I=3*2 are not accepted.

If the line on which you want to set a breakpoint has multiple statements, the BREAK debug command will set the breakpoint at the first statement on the line.

Example: For example, to set a conditional job breakpoint at debugger line 35:

1. Type 1 (Add) in the *Opt* field.
2. Type 35 in the *Line* field.
3. Type I=21 in the *Condition* field, and press Enter as shown in Figure 38 on page 128. (If a thread column is shown, before pressing Enter, type *JOB in the *Thread* field.)
4. Repeat the previous steps for each conditional job breakpoint you want to set.

Removing

You can remove conditional job breakpoints using the Work with Module Breakpoints display or using the CLEAR debug command.

To remove a conditional job breakpoint using the Work with Module Breakpoints Display, type 4 (Clear) in the *Opt* next to the breakpoint you want to remove, and press Enter. You can also remove unconditional breakpoints in this manner. Figure 38 on page 128 shows a typical display where 4 (Clear) could be entered in the *Opt* field.

Repeat the previous steps for each conditional job breakpoint you want to remove.

To remove a conditional job breakpoint using the CLEAR debug command, type:

```
CLEAR line-number
```

on the debug command line. *line-number* is line number in the currently displayed view of the module object from which you want to remove a job breakpoint.

Setting and Removing Conditional Thread Breakpoints

You can set or remove a conditional thread breakpoint by using:

- The Work with Module Breakpoints display
- The TBREAK debug command to set a conditional thread breakpoint in the current thread
- The CLEAR debug command to remove a conditional thread breakpoint.

Using the Work with Module Breakpoints Display

To set a conditional thread breakpoint using the Work with Module Breakpoints display:

1. Type 1 (Add) in the *Opt* field.
2. In the *Thread* field, type the thread identifier.
3. Fill in the remaining fields as if it were a conditional job breakpoint.
4. Press Enter.

To remove a conditional thread breakpoint using the Work with Module Breakpoints display:

1. Type 4 (Clear) in the *Opt* field next to the breakpoint you want to remove.
2. Press Enter.

Using the TBREAK or CLEAR Debug Commands

You use the same syntax for the TBREAK debug command as you would for the BREAK debug command. The difference between these commands is that the BREAK debug command sets a conditional job breakpoint at the same position in all threads, while the TBREAK debug command sets a conditional thread breakpoint in the current thread.

To remove a conditional thread breakpoint, use the CLEAR debug command. When a conditional thread breakpoint is removed, it is removed for the current thread only.

Removing All Breakpoints

You can remove all job and thread breakpoints, conditional and unconditional, from a program object that has a module object shown on the Display Module Source display by using the CLEAR PGM debug command. To use the debug command, type:

```
CLEAR PGM
```

on the debug command line. The breakpoints are removed from all of the modules bound to the program.

Setting and Removing Watch Conditions

You use a **watch condition** to request a job breakpoint when the contents of a specified variable (or an expression that relates to a substring or an array element) is changed from its current value. Setting watch conditions is similar to setting conditional job breakpoints, with these important differences:

- Watch conditions stop the program as soon as the value of a watched expression or variable changes from its current value.
- Conditional job breakpoints stop the program only if a variable changes to the value specified in the condition.

The debugger watches an expression or a variable through the contents of a **storage address**, computed at the time the watch condition is set. When the content at the storage address is changed from the value it had when the watch condition was set or when the last watch condition occurred, the program stops.

Note: After a watch condition has been registered, the new contents at the watched storage location are saved as the new current value of the corresponding expression or variable. The next watch condition will be registered if the new contents at the watched storage location change subsequently.

Characteristics of Watches

You should know the following characteristics about watches before working with them:

- Watches are monitored system-wide, with a maximum of 256 watches that can be active simultaneously. This number includes watches set by the system.

  Depending on overall system use, you may be limited in the number of watch conditions you can set at a given time. If you try to set a watch condition while the maximum number of active watches across the system is exceeded, you will receive an error message and the watch condition is not set.

  Note: If an expression or a variable crosses a page boundary, two watches are used internally to monitor the storage locations. Therefore, the maximum number of expressions or variables that can be watched simultaneously on a system-wide basis ranges from 128 to 256.
- Watch conditions can only be set when a program is stopped under debug, and the expression or variable to be watched is in scope. If this is not the case, an error message is issued when a watch is requested, indicating that the corresponding call stack entry does not exist.
- Once the watch condition is set, the address of a storage location watched does not change. Therefore, if a watch is set on a temporary location, it could result in spurious watch-condition notifications.

  An example of this is the automatic storage of an ILE COBOL procedure, which can be re-used after the procedure ends.

  A watch condition may be registered although the watched variable is no longer in scope. You must not assume that a variable is in scope just because a watch condition has been reported.
- Two watch locations in the same job must not overlap in any way. Two watch locations in different jobs must not start at the same storage address; otherwise, overlap is allowed. If these restrictions are violated, an error message is issued.

  Note: Changes made to a watched storage location are ignored if they are made by a job other than the one that set the watch condition.
- After the command is successfully run, your application is stopped if a program in your session changes the contents of the watched storage location, and the Display Module Source display is shown.

  If the program has debug data, and a source text view is available, it will be shown. The source line of the statement that was about to be run when the content change at the storage-location was detected is highlighted. A message indicates which watch condition was satisfied.

  If the program cannot be debugged, the text area of the display will be blank.
- Eligible programs are automatically added to the debug session if they cause the watch-stop condition.

- When multiple watch conditions are hit on the same program statement, only the first one will be reported.
- You can set watch conditions also when you are using service jobs for debugging, that is, when you debug one job from another job.

Setting Watch Conditions

Before you can set a watch condition, your program must be stopped under debug, and the expression or variable you want to watch must be in scope:

- To watch a global variable, you must ensure that the COBOL program in which the variable is defined is active before setting the watch condition.
- To watch a local variable, you must step into the COBOL program in which the variable is defined before setting the watch condition.

You can set a watch condition by using:

- F17 (Watch variable) to set a watch condition for a variable (a COBOL data item) on which the cursor is positioned
- The WATCH debug command with or without its parameters

Using the WATCH Command

If you use the WATCH command, it must be entered as a single command; no other debug commands are allowed on the same command line.

- To access the Work With Watch display shown below, type:

  ```
  WATCH
  ```

  on the debug command line, without any parameters.

```
                                Work with Watch
                                                        System:  DEBUGGER
Type options, press Enter.
  4=Clear 5=Display
Opt    Num      Variable                Address            Length
 -     1        KOUNT                   080090506F027004   4









                                                                    Bottom
Command
===>_____________________________________________________________________
F3=Exit  F4=Prompt  F5=Refresh   F9=Retrieve   F12=Cancel
```

Figure 39. Example of a Work with Watch Display

The Work with Watch display shows all watches currently active in the debug session. You can remove or display watches from this display. When you select Option 5 (Display), the Display Watch window shown in Figure 40 on page 133 displays information about the currently active watch.

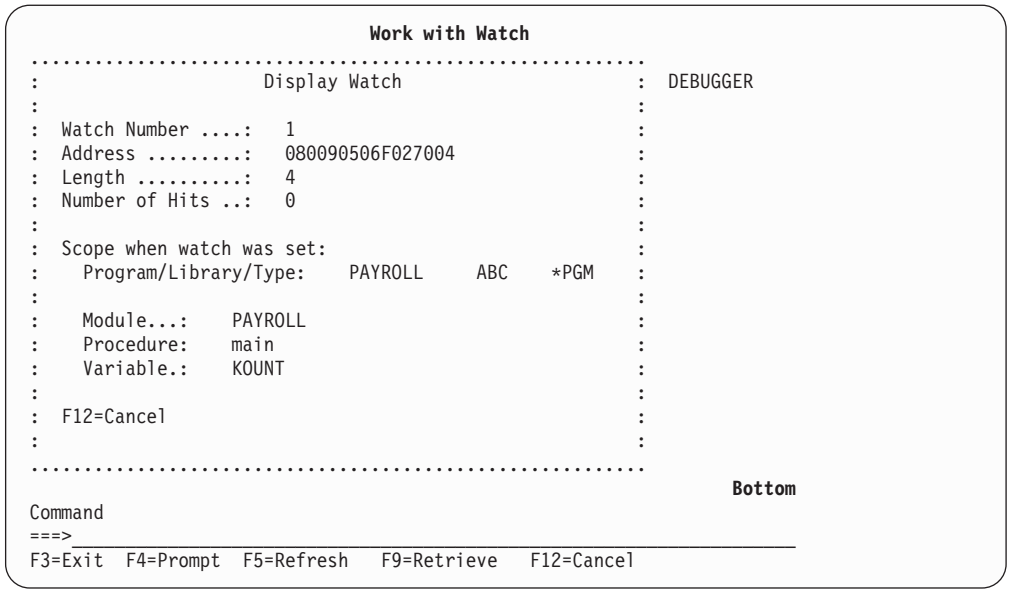

Figure 40. Example of a Display Watch Window

- To specify a variable or expression to be watched, do one of the following.
  - To specify a variable to be watched, type:

    ```
    WATCH SALARY
    ```

    on the debug command line, where SALARY is a variable.

    This command requests a breakpoint to be set if the value of SALARY is changed from its current value.

    The scope of the expression variables in a watch is defined by the most recently issued QUAL command.
  - To specify an expression to be watched:

    ```
    WATCH %SUBSTR(A 1 3)
    ```

    where A is part of a substring expression. For more information about substrings, refer to "Displaying a Substring of a Character String Variable" on page 141.

  Note: In ILE COBOL, only expressions that relate to array elements or substrings can be watched.
- To set a watch condition and specify a watch length, type:

  ```
  WATCH expression : watch length
  ```

  on a debug command line.

  Each watch allows you to monitor and compare a maximum of 128 bytes of contiguous storage. If the maximum length of 128 bytes is exceeded, the watch condition will not be set, and the debugger issues an error message.

  By default, the length of the expression type is also the length of the watch-comparison operation. The *watch-length parameter* overrides this default. It determines the number of bytes of an expression that should be compared to determine if a change in value has occurred.

For example, if a 4-byte binary integer is specified as the variable, without the watch-length parameter, the comparison length is four bytes. However, if the watch-length parameter is specified, it overrides the length of the expression in determining the watch length.

Displaying Active Watches

To display a system-wide list of active watches and show which job set them, type:

```
DSPDBGWCH
```

on a CL command line. This command displays the Display Debug Watches display shown below.

```
                          Display Debug Watches
                                                              System:  DEBUGGER
------------Job---------------        NUM     LENGTH     ADDRESS
MYJOBNAME1  MYUSERPRF1  123456          1          4     080090506F027004
JOB4567890  PRF4567890  222222          1          4     09849403845A2C32
JOB4567890  PRF4567890  222222          2          4     098494038456AA00
JOB         PROFILE     333333         14          4     040689578309AF09
SOMEJOB     SOMEPROFIL  444444          3          4     005498348048242A



                                                                      Bottom
Press Enter to continue

F3=Exit  F5=Refresh   F12=Cancel
```

Figure 41. Example of a Display Debug Watch Display

Note: This display does not show watch conditions set by the system.

Removing Watch Conditions

Watches can be removed in the following ways:

- The CLEAR command used with the WATCH keyword selectively ends one or all watches. For example, to clear the watch identified by *watch-number*, type:

  ```
  CLEAR WATCH watch-number
  ```

  The watch number can be obtained from the Work With Watches display.

  To clear all watches for your session, type:

  ```
  CLEAR WATCH ALL
  ```

  on a debug command line.

  Note: While the CLEAR PGM command removes all breakpoints in the program that contains the module being displayed, it has no effect on watches. You must explicitly use the WATCH keyword with the CLEAR command to remove watch conditions.
- The CL End Debug (ENDDBG) command removes watches set in the local job or in a service job.

  Note: ENDDBG will be called automatically in abnormal situations to ensure that all affected watches are removed.
- The initial program load (IPL) of your OS/400 system removes all watch conditions system-wide.

Example of Setting a Watch Condition

In this example, you watch a variable *kount* in program MYLIB/PAYROLL. To set the watch condition, type:

```
WATCH kount
```

on a debug line, accepting the default value for the watch-length.

If the value of the variable *kount* changes subsequently, the application stops and the Display Module Source display is shown, as illustrated in Figure 42.

```
                          Display Module Source
Program:   PAYROLL          Library:   MYLIB       Module:  PAYROLL
    42        * THE FOLLOWING 3 PARAGRAPHS CREATE INTERNALLY THE  *
    43        * RECORDS TO BE CONTAINED IN THE FILE, WRITES THEM  *
    44        * ON THE DISK, AND DISPLAYS THEM                    *
    45        ****************************************************
    46         STEP-2.
    47             ADD 1 TO KOUNT, NUMBR.
    48             MOVE ALPHA  (KOUNT) TO NAME-FIELD.
    49             MOVE DEPEND (KOUNT) TO NO-OF-DEPENDENTS.
    50             MOVE NUMBR          TO RECORD-NO.
    51         STEP-3.
    52             DISPLAY WORK-RECORD.
    53             WRITE RECORD-1 FROM WORK-RECORD.
    54         STEP-4.
    55             PERFORM STEP-2 THRU STEP-3 UNTIL KOUNT IS =
                                                                More...
Debug . . .  ____________________________________________________________
____________________________________________________________________________
F3=End program  F6=Add/Clear breakpoint  F10=Step  F11=Display variable
F12=Resume      F17=Watch variable  F18=Work with watch  F24=More keys
Watch number  1 at line 55, variable: KOUNT
```

Figure 42. Example of Message Stating WATCH Was Successfully Set

- The line number of the statement where the change to the watch variable was detected is highlighted. This is typically the first executable line *following* the statement that changed the variable.
- A message indicates that the watch condition was satisfied.

Note: If a text view is not available, a blank Display Module Source display is shown, with the same message as above in the message area.

The following programs cannot be added to the ILE debug environment:
1. ILE programs without debug data
2. OPM programs with non-source debug data only
3. OPM programs without debug data

In the first two cases, the stopped statement number is passed. In the third case, the stopped MI instruction is passed. The information is displayed at the bottom of a blank Display Module Source display as shown below. Instead of the line number, the statement or the instruction number is given.

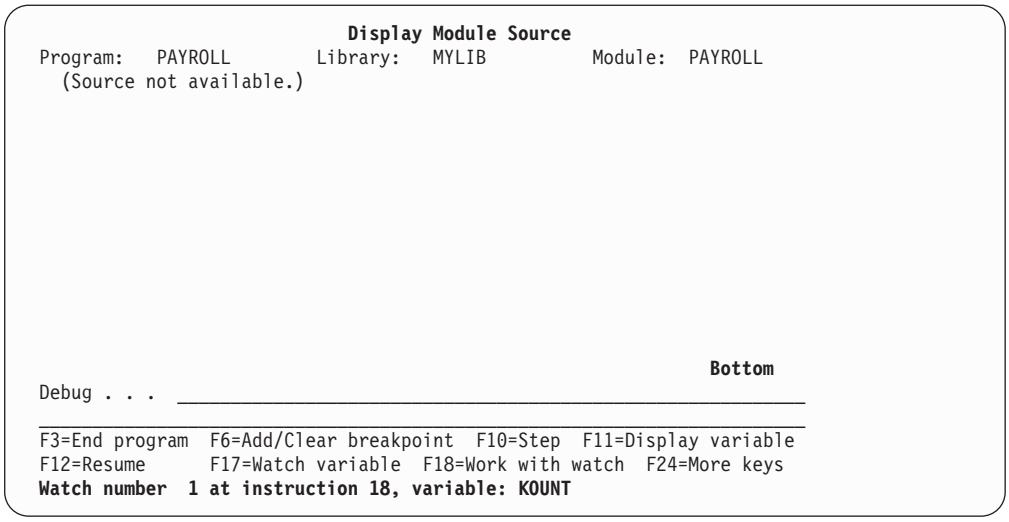

Figure 43. Example of a Display Module Source Display

Running a Program Object or ILE Procedure After a Breakpoint

After a breakpoint is encountered, you can resume running the program object or ILE procedure in two ways:

- resume running the program object or ILE procedure at the next statement after the breakpoint, and stop at the next breakpoint or when the program object ends.
- step through a specified number of statements after the breakpoint and stop the program object again.

Resuming a Program Object or ILE Procedure

After a breakpoint is encountered, you can resume running a program object or ILE procedure by pressing F12 (Resume) from the Display Module Source display. The program object or ILE procedure begins running on the next statement of the module object in which the program stopped. The program object or ILE procedure will stop again at the next breakpoint or when the program object ends.

Stepping Through the Program Object or ILE Procedure

After a breakpoint is encountered, you can run a specified number of statements of a program object or ILE procedure, then stop the program again and return to the Display Module Source display. The program object or ILE procedure begins running on the next statement of the module object in which the program stopped.

You can step into an OPM program if it has debug data available, and if the debug session accepts OPM programs for debugging.

You can step through a program object or ILE procedure by using:
- F10 (Step) or F22 (Step into) on the Display Module Source display
- The STEP debug command

The simplest way to step through a program object or ILE procedure one statement at a time is to use F10 (Step) or F22 (Step into) on the Display Module Source display. When you press F10 (Step) or F22 (Step into), the next statement of the module object shown in the Display Module Source display is run, and the

program object or ILE procedure is stopped again. If multiple statements are contained in a line on which F10 (Step) or F22 (Step into) is pressed, all of the statements on that line are run and the program object or ILE procedure is stopped at the next statement on the next line.

Note: You cannot specify the number of statements to step through when you use F10 (Step) or F22 (Step into). Pressing F10 (Step) or F22 (Step into) performs a single step.

Another way to step through a program object or ILE procedure is to use the STEP debug command. The STEP debug command allows you to run more than one statement in a single step. The default number of statements to run, using the STEP debug command, is one. To step through a program object or ILE procedure using the STEP debug command, type:

```
STEP number-of-statements
```

on the debug command line. *number-of-statements* is the number of statements that you want to run in the next step before the application is halted again. For example, if you type

```
STEP 5
```

on the debug command line, the next five statements of your program object or ILE procedure are run, then the program object or ILE procedure is stopped again and the Display Module Source display is shown.

When a CALL statement to another program object or ILE procedure is encountered in a debug session, you can:
- Step over the called program object or ILE procedure, or
- Step into the called program object or ILE procedure.

If you choose to **step over** the called program object or ILE procedure then the CALL statement and the called program object are run as a single step. The called program object or ILE procedure is run to completion before the calling program object or ILE procedure is stopped at the next step. Step over is the default step mode.

If you choose to **step into** the called program object or ILE procedure then each statement in the called program object or ILE procedure is run as a single step. If the next step at which the running program object or ILE procedure is to stop falls within the called program object or ILE procedure then the called program object or ILE procedure is halted at this point and the called program object or ILE procedure is shown in the Display Module Source display.

Stepping Over Program Objects or ILE Procedures

You can step over program objects or ILE procedures by using:
- F10 (Step) on the Display Module Source display
- The STEP OVER debug command

You can use F10 (Step) on the Display Module Source display to step over a called program object or ILE procedure in a debug session. If the next statement to be run is a CALL statement to another program object or ILE procedure, then pressing F10 (Step) will cause the called program object or ILE procedure to run to completion before the calling program object or ILE procedure is stopped again.

Alternately, you can use the STEP OVER debug command to step over a called program object or ILE procedure in a debug session. To use the STEP OVER debug command, type:

```
STEP number-of-statements OVER
```

on the debug command line. *number-of-statements* is the number of statements that you want to run in the next step before the application is halted again. If one of the statements that are run contains a CALL statement to another program object or ILE procedure, the ILE source debugger will step over the called program object or ILE procedure.

Stepping Into Program Objects or ILE Procedures

You can step into program objects or ILE procedure by using:

- F22 (Step into) on the Display Module Source display
- The STEP INTO debug command

You can use F22 (Step into) on the Display Module Source display to step into a called program object or ILE procedure in a debug session. If the next statement to be run is a CALL statement to another program object or ILE procedure then pressing F22 (Step into) will cause the first executable statement in the called program object or ILE procedure to be run. The called program object or ILE procedure will then be shown in the Display Module Source display.

Note: A called ILE program object or procedure must have debug data associated with it, in order for it to be shown in the Display Module Source display. A called OPM program object will be shown in the Display Module Source display if the ILE source debugger is set up to accept OPM programs, and the OPM program has debug data. (An OPM program has debug data if it was compiled with OPTION(*SRCDBG) or OPTION(*LSTDBG).)

Alternately, you can use the STEP INTO debug command to step into a called program object or ILE procedure in a debug session. To use the STEP INTO debug command, type:

```
STEP number-of-statements INTO
```

on the debug command line. *number-of-statements* is the number of statements of the program object or ILE procedure that you want to run in the next step before the program object or ILE procedure is halted again. If one of the statements that are run contains a CALL statement to another program object or ILE procedure, the debugger will step into the called program object or ILE procedure. Each statement in the called program object or ILE procedure will be counted in the step. If the step ends in the called program object or ILE procedure then the called program object or ILE procedure will then be shown in the Display Module Source display. For example, if you type

```
STEP 5 INTO
```

on the debug command line, the next five statements of the program object or ILE procedure are run. If the third statement is a CALL statement to another program object or ILE procedure then two statements of the calling program object or ILE procedure are run and the first three statements of the called program object or ILE procedure are run.

Displaying Variables, Constant-names, Expressions, Records, Group Items, and Arrays

You can display the value of variables, constant-names, expressions, group items, records, and arrays by using:
- F11 (Display variable) on the Display Module Source display
- The EVAL debug command

The scope of the variables used in the EVAL command is defined by using the QUAL command.

Note: ILE COBOL special registers are not supported by the ILE source debugger. Thus, the values contained in the ILE COBOL special registers cannot be displayed in a debug session. The ILE source debugger cannot evaluate the result of a COBOL function identifier.

Displaying Variables and Expressions

The simplest way to display the value of a variable is to use F11 (Display variable) on the Display Module Source display. To display a variable using F11 (Display variable), place your cursor on the variable that you want to display and press F11 (Display variable). The current value of the variable is shown on the message line at the bottom of the Display Module Source display. For example, if you want to see the value of variable *COUNTER* on line 221 of the module object shown in Figure 44, place you cursor on top of the variable and press F11 (Display variable). The current value of the variable *COUNTER* is shown on the message line.

```
                              Display Module Source
 Program:   TEST           Library:   TESTLIB        Module:   SAMPMDF
    213
    214         PROCEDURE-SECTION SECTION.
    215         FILL-TERMINAL-LIST.
    216             READ TERMINAL-FILE RECORD INTO LIST-OF-TERMINALS(COUNTER)
    217                 AT END
    218                     SET END-OF-TERMINAL-LIST TO TRUE
    219                     SUBTRACT 1 FROM COUNTER
    220                     MOVE COUNTER TO NO-OF-TERMINALS.
    221             ADD 1 TO COUNTER.
    222
    223         ACQUIRE-AND-INVITE-TERMINALS.
    224             ACQUIRE LIST-OF-TERMINALS(COUNTER) FOR MULTIPLE FILE.
    225             WRITE MULTIPLE-REC
    226                 FORMAT IS "SIGNON"
    227                 TERMINAL IS LIST-OF-TERMINALS(COUNTER).
                                                                  More...
 Debug . . .   ____________________________________________________________
_________________________________________________________________________
 F3=End program   F6=Add/Clear breakpoint   F10=Step   F11=Display variable
 F12=Resume      F17=Watch variable  F18=Work with watch  F24=More keys
 COUNTER = 89.
```

Figure 44. Displaying a Variable using F11 (Display variable)

In cases where you are evaluating records, group items, or arrays, the message returned when you press F11 (Display variable) may span several lines. Messages that span several lines are shown on the Evaluate Expression display to show the entire text of the message. Once you have finished viewing the message on the Evaluate Expression display, press Enter to return to the Display Module Source display.

You can also use the EVAL debug command to determine the value of a variable. First, you use the QUAL debug command to identify the line number of the variable that you want to show. Scoping rules for the variable are applied from this line.

Note: The default QUAL position is the current line.
To display the value of a variable using the EVAL debug command, type:

```
EVAL variable-name
```

on the debug command line. *variable-name* is the name of the variable that you want to display. The value of the variable is shown on the message line if the EVAL debug command is entered from the Display Module Source display and the value can be shown on a single line. Otherwise, the value of the variable is shown on the Evaluate Expression display.

For example, to display the value of the variable *COUNTER* on line 221 of the module object shown in Figure 44 on page 139, type:

```
EVAL COUNTER
```

The message line of the Display Module Source display shows `COUNTER = 89` as in Figure 45.

```
                                Display Module Source
 Program:   TEST           Library:   TESTLIB        Module:   SAMPMDF
    213
    214         PROCEDURE-SECTION SECTION.
    215         FILL-TERMINAL-LIST.
    216             READ TERMINAL-FILE RECORD INTO LIST-OF-TERMINALS(COUNTER)
    217                 AT END
    218                     SET END-OF-TERMINAL-LIST TO TRUE
    219                     SUBTRACT 1 FROM COUNTER
    220                     MOVE COUNTER TO NO-OF-TERMINALS.
    221             ADD 1 TO COUNTER.
    222
    223         ACQUIRE-AND-INVITE-TERMINALS.
    224             ACQUIRE LIST-OF-TERMINALS(COUNTER) FOR MULTIPLE FILE.
    225             WRITE MULTIPLE-REC
    226                 FORMAT IS "SIGNON"
    227                 TERMINAL IS LIST-OF-TERMINALS(COUNTER).
                                                                  More...
 Debug . . .   ____________________________________________________________
_____________________________________________________________________________
 F3=End program   F6=Add/Clear breakpoint   F10=Step   F11=Display variable
 F12=Resume      F17=Watch variable  F18=Work with watch  F24=More keys
 COUNTER = 89.
```

Figure 45. Displaying a Variable using the EVAL debug command

Displaying Variables as Hexadecimal Values

You can use the EVAL debug command to display the value of variables in hexadecimal format. To display a variable in hexadecimal format, type:

```
EVAL variable-name: x 32
```

on the debug command line. *variable-name* is the name of the variable that you want to display in hexadecimal format. 'x' specifies that the variable is to be displayed in hexadecimal format and '32' indicates that a dump of 32 bytes after the start of the variable is to be displayed. The hexadecimal value of the variable is shown on the Evaluate Expression display as in Figure 46 on page 141. If no length is specified after the 'x', the size of the variable is used as the length. A minimum of 16 bytes is always displayed. If the length of the variable is less than 16 bytes,

then the remaining space is filled with zeroes until the 16 byte boundary is reached.

```
                                  Evaluate Expression
 Previous debug expressions
 > BREAK 221
 > EVAL COUNTER
 COUNTER = 89.
 > EVAL B : X 32
            00000     F8F90000 00000000 00000000 00000000   - 89..............
            00010     00000000 00000000 00000000 00000000   - ................




                                                                          Bottom
 Debug . . .   ____________________________________________________________
_____________________________________________________________________________
 F3=Exit   F9=Retrieve   F12=Cancel   F19=Left   F20=Right   F21=Command entry
```

Figure 46. Displaying the Hexadecimal Value of a Variable using the EVAL debug command

Displaying a Substring of a Character String Variable

The ILE source debugger does not support the reference modification syntax of ILE COBOL. Instead, you can use the %SUBSTR operator with the EVAL command to display a substring of a character string variable. The %SUBSTR operator obtains the substring of a character string variable from a starting element position for some number of elements.

Note: The ILE source debugger does not support COBOL's reference modification syntax for handling substrings. You need to use the %SUBSTR operator of the ILE source debugger to handle substrings.

The syntax for the %SUBSTR operator is as follows:

```
%SUBSTR(identifier start-element number-of-elements)
```

where *identifier* must be a character string variable, and *start-element* and *number-of-elements* must be non-zero, positive integer literals. *identifier* can be a qualified, subscripted, or indexed variable. *start-element + number-of-elements - 1* cannot be greater than the total number of elements in *identifier*.

For example, you can obtain the first 10 elements of a 20-element character string by using %SUBSTR(char20 1 10). You can obtain the last 5 elements of a 8-element character string by using %SUBSTR(char8 4 5). In the case of a DBCS or DBCS-edited item, element refers to a DBCS character (in other words, a two-byte character).

You can use the %SUBSTR operator to assign a substring of a character string variable to another variable or substring of a variable. Data is copied from the source variable to the target variable from left to right. When the source or target variables or both are substrings, then the operand is the substring portion of the character string variable, not the entire character string variable. When the source and target variable are of different sizes, then the following truncation and padding rules apply:

- If the length of the source variable is greater than the length of the target variable, the character string is truncated to the length of the target variable.

- If the length of the source variable is less than the length of the target variable, the character string is left justified in the target variable and the remaining positions are filled with blanks.
- If the length of the source variable is equal to the length of the target variable, the two variables will be exact copies of one another after the assignment.

Note: It is possible to use a substring of the same character string variable in both the source variable and the target variable; however, if any portion of the target string overlaps the source string, an error will result.

Figure 47 shows some example of how the %SUBSTR operator can be used.

```
                                Evaluate Expression
Previous Debug expressions
> EVAL CHAR10
   CHAR10 = '10CHARLONG'
> EVAL CHARA
   CHARA = 'A'
> EVAL CHARA = %SUBSTR(CHAR10 3 5)
   CHARA = 'C'
> EVAL %SUBSTR(CHAR10 1 2) = 'A'
   CHAR10 = 'A CHARLONG'
> EVAL %SUBSTR(CHAR10 1 2) = 'XYZ'
   CHAR10 = 'XYCHARLONG'
> EVAL %SUBSTR(CHAR10 7 4) = 'ABCD'
   CHAR10 = 'XYCHARABCD'
> EVAL %SUBSTR(CHAR10 1 2) = %SUBSTR(CHAR10 7 4)
   CHAR10 = 'ABCHARABCD'
                                                                    Bottom
Debug . . .   ____________________________________________________________
_______________________________________________________________________________
F3=Exit   F9=Retrieve   F12=Cancel   F19=Left   F20=Right   F21=Command entry
```

Figure 47. Displaying a Substring of a Character String Variable using the %SUBSTR operator

Displaying the address of a level-01 or level-77 data item

You can use the ILE source debugger %ADDR operator with the EVAL command to display the address of a level-01 or level-77 data item. To display a level-01 or level-77 variable's address, type:

```
EVAL %ADDR(variable-name)
```

There is no dereference operator in ILE COBOL, but you still can display the area where the pointer data item points to as hexadecimal values or character values. To display the target area of a pointer data item as hexadecimal values, type:

```
EVAL pointer-name: x size
```

To display the target area of a pointer data item as character values, type:

```
EVAL pointer-name: c size
```

Displaying Records, Group Items, and Arrays

You can use the EVAL debug command to display structures, records, and arrays. Unless the record, group item, or array is on the current line, you must first qualify the record, group item, or array that you want to display by identifying its line number using the QUAL debug command. Refer to "Displaying Variables and Expressions" on page 139 for a description of how to use the QUAL debug command. To display a record, group item, or array, type:

```
EVAL data-name
```

on the debug command line. *data-name* is the name of the record, group item, or array that you want to display. The value of the record, group item, or array will be shown on the Evaluate Expression display.

The following example shows you how to display the contents of an ILE COBOL group item.

```
01  ACCOUNT.
    02  NUMBER              PIC 9(5).
    02  FULL-NAME.
        03  LAST-NAME       PIC X(20).
        03  FIRST-NAME      PIC X(10).
```

To display the contents of the group item *ACCOUNT*, type:

```
EVAL ACCOUNT
```

on the debug command line. The current contents of the group item *ACCOUNT* will be shown on the Evaluate Expression display as in Figure 48.

To display the contents of a single element of the group item *ACCOUNT*, such as element FIRST-NAME OF FULL-NAME OF ACCOUNT, type:

```
EVAL FIRST-NAME OF FULL-NAME OF ACCOUNT
```

on the debug command line. The current contents of the element *FIRST-NAME OF FULL-NAME OF ACCOUNT* will be shown on the Evaluate Expression display as in Figure 48. Press Enter to return to the Display Module Source display. You can also display elements using partially qualified names provided that the name is qualified sufficiently to resolve any name ambiguities.

```
                              Evaluate Expression
Previous Debug expressions
> EVAL ACCOUNT
  NUMBER OF ACCOUNT = 12345
  LAST-NAME OF FULL-NAME OF ACCOUNT = 'SMITH               '
  FIRST-NAME OF FULL-NAME OF ACCOUNT = 'JOHN      '
> EVAL FIRST-NAME OF FULL-NAME OF ACCOUNT
  FIRST-NAME OF FULL-NAME OF ACCOUNT = 'JOHN      '
```

Figure 48. Displaying a Group Item using the EVAL Debug Command

The following example shows you how to display the contents of an ILE COBOL array.

```
05  A       PIC X(5) OCCURS 5 TIMES.
```

To display the contents of the array *A*, type:

```
EVAL A
```

on the debug command line. The current contents of the array *A* will be shown on the Evaluate Expression display as in Figure 49 on page 144.

To display the contents of a range of elements of the array *A*, type:

```
EVAL A(2..4)
```

on the debug command line. The current contents of elements A(2), A(3), and A(4) of the array *A* will be shown on the Evaluate Expression display as in Figure 49 on page 144.

To display the contents of a single element of the array *A*, such as element A(4), type:

```
EVAL A(4)
```

on the debug command line. The current contents of the element *A(4)* will be shown on the Evaluate Expression display as in Figure 49. Press F3 (Exit) to return to the Display Module Source display.

Note: The subscript value specified on the EVAL debug command can only be a numeric value. For example, A(4) is accepted but A(I+2) or A(2*3) are not accepted.

```
                                  Evaluate Expression
Previous Debug expressions
> EVAL A
  A(1) = 'ONE  '
  A(2) = 'TWO  '
  A(3) = 'THREE'
  A(4) = 'FOUR '
  A(5) = 'FIVE '
> EVAL A(2..4)
  A(2) = 'TWO  '
  A(3) = 'THREE'
  A(4) = 'FOUR '
> EVAL A(4)
  A(4) = 'FOUR '
```

Figure 49. Displaying an Array using the EVAL Debug Command

Changing the Value of Variables

You can change the value of variables by using the EVAL command with an assignment operator. Unless the variable is on the current line, you must first qualify the variable that you want to change by identifying its line number using the QUAL debug command. Refer to "Displaying Variables and Expressions" on page 139 for a description of how to use the QUAL debug command. To change the value of the variable, type:

```
EVAL variable-name = value
```

on the debug command line. *variable-name* is the name of the variable that you want to change and *value* is an identifier, literal, or constant value that you want to assign to variable *variable-name*. For example,

```
EVAL COUNTER=3
```

changes the value of *COUNTER* to 3 and shows

```
COUNTER=3 = 3
```

on the message line of the Display Module Source display.

You can use the EVAL debug command to assign numeric, alphabetic, alphanumeric, DBCS, boolean, floating-point, and date-time data to variables provided they match the definition of the variable.

Note: If the value that is assigned to the variable using the EVAL debug command does not match the definition of the variable, a warning message is issued and the value of the variable is not changed.

If the value that is assigned to a variable is a character string, the following rules apply:

- The length of the character string being assigned to the variable must be the same as the length of the variable.
- If the length of the character string being assigned to the variable is less than the length of the variable, then the character string is left justified in the variable and the remaining positions are filled with blanks.
- If the length of the character string being assigned to the variable is greater than the length of the variable, then the character string is truncated to the length of the variable.

The following are examples of how various type of data can be assigned to variables using the EVAL debug command.

```
EVAL COUNTER=3                    (COUNTER is a numeric variable)
EVAL COUNTER=LIMIT                (LIMIT is another numeric variable)
EVAL END-OF-FILE='1'              (END-OF-FILE is a Boolean variable)
EVAL BOUNDARY=x'C9'               (BOUNDARY is an alphanumeric variable)
EVAL COMPUTER-NAME='ISERIES"      (COMPUTER-NAME is an alphanumeric variable)
EVAL INITIALS=%SUBSTR(NAME 17 3)  (INITIALS and NAME are alphanumeric variables)
EVAL DBCS-NAME= G'OEKIK2K3OF'       (K1K2K3 are DBCS characters)

EVAL LONG-FLOAT(3) = -30.0E-3
        (LONG-FLOAT is an array of 3 double-precision floating-point
         data items - COMP-2)

EVAL SHORT-FLOAT = 10
        (SHORT-FLOAT is a single-precision floating-point data item -
         COMP-1)
```

Note: You cannot assign a figurative constant to a variable using the EVAL debug command. Figurative constants are not supported by the EVAL debug command. You may be able to change the value of a constant item in PROCEDURE DIVISION using the EVAL debug command. But the result is unpredictable.

Equating a Name with a Variable, Expression, or Command

You can use the EQUATE debug command to equate a name with a variable, expression or debug command for shorthand use. You can then use that name alone or within another expression. If you use it within another expression, the value of the name is determined before the expression is evaluated. These names stay active until a debug session ends or a name is removed.

To equate a name with a variable, expression or debug command, type:

```
EQUATE shorthand-name definition
```

on the debug command line. *shorthand-name* is the name that you want to equate with a variable, expression, or debug command, and *definition* is the variable, expression, or debug command that you are equating with the name.

For example, to define a shorthand name called *DC* which displays the contents of a variable called *COUNTER*, type:

```
EQUATE DC EVAL COUNTER
```

on the debug command line. Now, each time *DC* is typed on the debug command line, the command EVAL *COUNTER* is performed.

The maximum number of characters that can be typed in an EQUATE command is 144. If a definition is not supplied and a previous EQUATE command defined the name, the previous definition is removed. If the name was not previously defined, an error message is shown.

To see the names that have been defined with the EQUATE debug command for a debug session, type:

```
DISPLAY EQUATE
```

on the debug command line. A list of the active names is shown on the Evaluate Expression display.

National Language Support for the ILE Source Debugger

When working with National Language Support for the ILE source debugger, the following conditions apply:

- When a view is displayed on the Display Module Source display, the ILE source debugger converts all data to the CCSID of the debug job.
- When assigning literals to variables, the ILE source debugger will not perform CCSID conversion on quoted literals (for example, 'abc'). Also, quoted literals are case sensitive.

When working with the source view, if the CCSID of the source file from which the source view is obtained is different from the CCSID of the module object, then the ILE source debugger may not recognize an ILE COBOL identifier containing invariant characters.

If either of the following conditions exist:

- The CCSID of the debug job is 290, 930, or 5026 (Japan Katakana)
- The code page of the device description used for debugging is 290, 930, or 5026 (Japan Katakana)

then debug commands, functions, and hexadecimal literals should be entered in uppercase. For example,

```
BREAK 16 WHEN var=X'A1B2'
EVAL var:X
```

However, when debugging ILE COBOL, ILE RPG, or ILE CL module objects, identifier names in debug commands are converted to uppercase by the source debugger, and therefore may be displayed differently.

Changing and Displaying Locale-Based Variables

In ILE COBOL an item of class date-time, or a numeric-edited item, could be based in whole or in part on a locale. For example, a date item could be defined like:

```
01 group-item.
   05 date1 FORMAT DATE SIZE 10 LOCALE is locale-french.
```

In this case the format of the date item and the CCSID of the characters that will form the contents of the date item will be based on the locale `locale-french`.

To create a locale, the locale must be described with a locale source member. Locale source is similar to COBOL source. It has a certain number of sections with predefined syntax and semantics, and just like COBOL source, must be compiled to form a locale object. To create a locale object, a CCSID must be specified, along

with the locale source member name, file, and library. For more information on creating locales, see “Creating Locales on the iSeries” on page 189.

This means that the COBOL data item `date1` could have a CCSID different than the job CCSID. The ILE source debugger has no way to determine the CCSID of `date1`, so it converts the CCSID of the data item to the job CCSID. This may cause the contents of the data item to display incorrectly. To see the correct contents of these types of data items, you can display them in hexadecimal. For example, to see the contents of `date1` in hexadecimal, you would type:

```
EVAL date-1:x
```

Support for User-Defined Data Types

Defining a data item in the DATA DIVISION as a user-defined data type does not change how the data is interpreted by the debugger. Data items defined using the TYPE clause behave exactly as if they had been defined without using the TYPE clause.

Part 2. ILE COBOL Programming Considerations

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Chapter 8. Working with Data Items

This chapter explains how to work with ILE COBOL numeric data, and how you can best represent numeric data and perform efficient arithmetic operations. Other topics include the use of intrinsic functions and working with items of class date-time. A list of topics are:

- "General ILE COBOL View of Numbers (PICTURE Clause)"
- "Computational Data Representation (USAGE Clause)" on page 152
- "Data Format Conversions" on page 160
- "Sign Representation and Processing" on page 161
- "Checking for Incompatible Data (Numeric Class Test)" on page 162
- "Performing Arithmetic" on page 163
- "Fixed-Point versus Floating-Point Arithmetic" on page 176
- "What is the Year 2000 Problem?" on page 179
- "Working with Date-Time Data Types" on page 181

General ILE COBOL View of Numbers (PICTURE Clause)

In general, you can view ILE COBOL numeric data in a way similar to character-string data—as a series of decimal digit positions. However, numeric items can have special properties, such as an arithmetic sign.

Defining Numeric Items

You define numeric items using the character "9" in the data description to represent the decimal digits of the number, instead of using an "X" as is done for alphanumeric items:

```
05  COUNT-X         PIC 9(4)   VALUE 25.
05  CUSTOMER-NAME   PIC X(20)  VALUE "Johnson".
```

You can code up to 18 digits in the PICTURE clause, as well as various other characters of special significance. The "S" in the following example makes the value signed.

```
05  PRICE           PIC S99V99.
```

The field can hold a positive or negative value. The "V" indicates the position of an implied decimal point. Neither "S" nor "V" are counted in the size of the item, nor do they require extra storage positions, unless the item is coded as USAGE DISPLAY with the SIGN IS SEPARATE clause. An exception is internal floating-point data (COMP-1 and COMP-2), for which there is no PICTURE clause. For example, an internal floating point data item is defined as follows:

```
05  GROMMET-SIZE-DEVIATION    USAGE COMP-1    VALUE 02.35E-5
```

For information on how you can control how the compiler handles floating-point data items, refer to the description of *FLOAT and *NOFLOAT under "CVTOPT Parameter" on page 35 and in "Using the PROCESS Statement to Specify Compiler Options" on page 49.

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Separate Sign Position (For Portability)

If you plan to port your program or data to a different machine, you might want to code the sign as a separate digit in storage:

```
05  PRICE            PIC S99V9   SIGN IS LEADING, SEPARATE.
```

This ensures that the convention your machine uses for storing a non-separate sign will not cause strange results when you use a machine that uses a different convention.

Extra Positions for Displayable Symbols (Numeric Editing)

You can also define numeric items with certain editing symbols (such as decimal points, commas, and dollar signs) to make the data easier to read and understand when displayed or printed on reports. For example:

```
05 PRICE          PIC   9(5)V99.
05 EDITED-PRICE   PIC  $ZZ,ZZ9V99.
   .
   .
   .
   MOVE PRICE to EDITED-PRICE
   DISPLAY EDITED-PRICE
```

If the contents of `PRICE` were 0150099 (representing the value 1,500.99), then `$ 1,500.99` would be displayed after the code is run.

How to Use Numeric-Edited Items as Numbers

Numeric-edited items are classified as alphanumeric data items, not as numbers. Therefore, they cannot be operands in arithmetic expressions or ADD, SUBTRACT, MULTIPLY, DIVIDE, and COMPUTE statements.

Numeric-edited items can be moved to numeric and numeric-edited items. In the following example, the numeric-edited item is *de-edited*, and its numeric value is moved to the numeric data item.

```
MOVE EDITED-PRICE to PRICE.
DISPLAY PRICE.
```

If these two statements were to immediately follow the statements shown in the previous example, then `PRICE` would be displayed as 0150099, representing the value 1,500.99.

Numeric-edited items can also be associated with a locale. When a MOVE is made to a numeric-edited item that is based on a locale, the result is edited according to that locale. The CCSID associated with a locale also affects the edited result, and when a program is run, the CCSIDs associated with the files, locales, and numeric-edited items used by a program are compared to see if conversion is necessary. For more information about how CCSIDs are treated at runtime, refer to "Runtime CCSID Considerations" on page 18.

For complete information on the data descriptions for numeric data, refer to *WebSphere Development Studio: ILE COBOL Reference*.

Computational Data Representation (USAGE Clause)

You can control how the computer internally stores your numeric data items by coding the USAGE clause in your data description entries. The numeric data you use in your program will be one of the formats available with ILE COBOL:

- External decimal (USAGE DISPLAY)

- Internal decimal (USAGE PACKED-DECIMAL or COMP-3)
- Binary (USAGE BINARY or COMP-4)
- External floating-point (USAGE DISPLAY)
- Internal floating-point (USAGE COMP-1, USAGE COMP-2)

COMP-4 is synonymous with BINARY, and COMP and COMP-3 are synonymous with PACKED-DECIMAL.

Regardless of which USAGE clause you use to control the computer's internal representation of the value, you use the same PICTURE clause conventions and decimal value in the VALUE clause, except for floating-point data.

External Decimal (USAGE DISPLAY) Items

When you code USAGE DISPLAY or omit the USAGE clause, each position (or byte) of storage contains one decimal digit. This corresponds to the format used for printing or displaying output, meaning that the items are stored in displayable form.

What USAGE DISPLAY Items Are For

External decimal items are primarily intended for receiving and sending numbers between your program and files, terminal, and printers. However, it is also acceptable to use external decimal items as operands and receivers in your program's arithmetic processing, and it is often convenient to program this way.

Should You Use Them for Arithmetic

If your program performs a lot of intensive arithmetic and efficiency is a high priority, you might want to use one of ILE COBOL's computational numeric data types for the data items used in the arithmetic.

The computer has to automatically convert displayable numbers to the *internal* representation of their numeric value before they can be used in arithmetic operations. Therefore, it is often more efficient to define your data items as computational items to begin with, rather than as DISPLAY items. For example:

```
05 COUNT-X          PIC S9V9(5)   USAGE COMP   VALUE 3.14159.
```

Internal Decimal (USAGE PACKED-DECIMAL or COMP-3)

Packed decimal format occupies 1 byte of storage for every two decimal places in the PICTURE description, except that the right-most byte contains only 1 digit and the sign. This format is most efficiently used when you code an odd number of digits in the PICTURE description, so that the left-most byte is fully used. Packed decimal format is handled as a fixed-point number for arithmetic purposes.

Why Use Packed Decimal

Packed decimal format:

- Requires less storage per digit than DISPLAY format requires.
- Is better suited for decimal alignment than binary format.
- Is converted to and from DISPLAY format more easily than binary format.
- Is well suited for containing arithmetic operands or results.

Binary (USAGE BINARY or COMP-4) Items

Binary format occupies 2, 4, or 8 bytes of storage, and is handled for arithmetic purposes as fixed-point number with the leftmost bit being the operational sign. For byte-reversed binary data, the sign bit is the leftmost bit of the rightmost byte.

How Much Storage BINARY Occupies

A PICTURE description with 4 or fewer decimal digits occupies 2 bytes; with 5 to 9 decimal digits, 4 bytes; with 10 to 18 decimal digits, 8 bytes.

Binary items are well suited for containing subscripts or reference modification start and length positions.

However, BINARY format is not as well suited for decimal alignment, so ILE COBOL converts BINARY numbers in arithmetic expressions to PACKED DECIMAL format. It is, therefore, preferable to use PACKED DECIMAL format for arithmetic expressions.

Using PACKED DECIMAL format over BINARY format is also preferable when converting numbers to display format. Converting a number from BINARY format to DISPLAY format is more difficult than converting a number from PACKED DECIMAL format to DISPLAY format.

Truncation of Binary Data (*STDTRUNC Compiler Option)

Use the *STDTRUNC and *NOSTDTRUNC compiler options (described in the "OPTION Parameter" on page "OPTION Parameter" on page 30). to indicate how BINARY and COMP-4 data is truncated.

Internal Floating-Point (USAGE COMP-1 and COMP-2) Items

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

On OS/400, COMP-1 and COMP-2 data items are represented in IEEE format.

A PICTURE clause is not allowed in the data description of floating-point data items, but you can provide an initial value using a floating-point literal in the VALUE clause:

```
05 COMPUTE-RESULT     USAGE COMP-1   VALUE 06.23E-24.
```

The characteristics of conversions between floating-point format and other number formats are discussed in the section, "Data Format Conversions" on page 160.

Floating-point format is well-suited for containing arithmetic operands and results, and for maintaining the highest level of accuracy in arithmetic.

For complete information on the data descriptions for numeric data, see *WebSphere Development Studio: ILE COBOL Reference*.

External Floating-Point (USAGE DISPLAY) Items

Displayable numbers coded in a floating-point format are called **external floating-point** items. Like external decimal items, you define external floating-point items explicitly with USAGE DISPLAY or implicitly by omitting the USAGE clause.

In the following example, `COMPUTE-RESULT` is implicitly defined as an external floating-point item. Each byte of storage contains one character (except for V).

```
05 COMPUTE-RESULT     PIC -9V(9)E-99.
```

The VALUE clause is not allowed in the data description for external floating-point items. Also, the minus signs (–) do not mean that the mantissa and exponent will always be negative numbers, but that when displayed the sign will appear as a blank for positive and a minus for negative. If a plus sign (+) were used, positive would be displayed as a plus sign and negative as a minus sign.

Just as with external decimal numbers, external floating-point numbers have to be converted (automatically by the compiler) to an internal representation of the numeric value before they can be operated on. External floating-point numbers are always converted to internal long floating-point format.

Creating User-Defined Data Types

In ILE COBOL, you can use the TYPEDEF clause to create **user-defined data types**. User-defined data types are not additions to the already available ILE COBOL data types, such as alphanumeric, numeric, boolean, and so on. User-defined data types (also known as **type definitions** or **type-names**) are actually entire elementary or group items that have been defined in the WORKING-STORAGE, LOCAL-STORAGE, LINKAGE or FILE section of a program, using the TYPEDEF clause. These type definitions act like templates that can then be used, using the TYPE clause, to define new data items. The new data item acquires all the characteristics of the user-defined data type. If the user-defined data type is a group item, then the new data item has subordinate elements of the same name, description, and hierarchy as those belonging to the user-defined data type.

User-defined data types can save you time and minimize source code because you don't have to redefine complex data structures that occur as part of the definition of two or more data items within your program. All you need to do is create one definition, and apply it to any subsequent definitions of the same type that you might need, by using the TYPE clause.

For example, imagine you are developing an inventory program for a small distributor, that distributes two types of items:

- Clothes. These come in many colors and sizes.
- Books. These come only with different titles.

Let's say the inventory program is going to count the amount on hand for each of the individual clothing items and books and store these in separate data items, and then also put the accumulated totals for the clothing and book inventories into separate data items.

Figure 50 on page 156 is an example of how you could use the TYPEDEF and TYPE clauses to save time and minimize source code for the WORKING-STORAGE section of a program like this.

This example creates a user-defined data type for clothing and books. Then it creates separate data items for the three different clothing items and two different book items, based on the user-defined data types. This is much easier and more efficient than having to re-code the definitions for each of the inventory types. There's less chance of making a mistake, too.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL           CBLGUIDE/SAMPTYPE        AISERIES   03/09/15 13:31:06        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.    SAMPTYPE.
          000300
          000400*****************************************************************
          000500* The following program demonstrates some of the funcitons
          000600* available with the TYPE and TYPEDEF clauses.
          000700*****************************************************************
          000800
    3     000900 ENVIRONMENT DIVISION.
    4     001000 CONFIGURATION SECTION.
    5     001100 SOURCE-COMPUTER.  IBM-ISERIES
    6     001200 OBJECT-COMPUTER.  IBM-ISERIES
    7     001300 INPUT-OUTPUT SECTION.
    8     001400 FILE-CONTROL.
    9     001500     SELECT DATA-IN
   10     001600         ASSIGN TO Database-INVDATA
   11     001700         ORGANIZATION IS INDEXED
   12     001800         record key is inv-type
          001900            with duplicates
   13     002000         ACCESS MODE IS SEQUENTIAL.
          002100
   14     002200     SELECT PRINTER-FILE
   15     002300         ASSIGN TO PRINTER-QPRINT
   16     002400         ORGANIZATION IS SEQUENTIAL
   17     002500         ACCESS MODE IS SEQUENTIAL.
          002600
   18     002700 DATA DIVISION.
   19     002800 FILE SECTION.
   20     002900 FD PRINTER-FILE.
   21     003000 01 PRINTER-REC.
   22     003100    05 PRINTER-RECORD    PIC X(132).
          003200
          003300*****************************************************************
          003400* define inventory type
          003500*****************************************************************
   23     003600 01 INV-TYPE-T IS TYPEDEF PIC S9(3) VALUE 0.
   24     003700    88 INV-TYPE-BOOK             VALUE 4, 5.
   25     003800    88 INV-TYPE-BOOK-001         VALUE 4.
   26     003900    88 INV-TYPE-BOOK-002         VALUE 5.
   27     004000    88 INV-TYPE-CLOTHES          VALUE 1, 2, 3.
   28     004100    88 INV-TYPE-CLOTHES-SWEATERS VALUE 1.
   29     004200    88 INV-TYPE-CLOTHES-SOCKS    VALUE 2.
   30     004300    88 INV-TYPE-CLOTHES-PANTS    VALUE 3.
          004400
   31     004500 FD DATA-IN.
   32     004600 01 DATA-IN-REC.
   33     004700    05 INV-TYPE          TYPE INV-TYPE-T.
   34     004800    05 FILLER            PIC X(80).
          004900
   35     005000 WORKING-STORAGE SECTION.
          005100*****************************************************************
          005200* Initialize END-OF-FILE flag to FALSE
          005300*****************************************************************
```

Figure 50. Example Showing How TYPEDEF and TYPE Clauses Can Be Used in a Program (Part 1 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPTYPE        AISERIES   03/09/15 13:31:06        Page      3
STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
       005400
  36   005500 01 END-OF-FILE PIC 1 VALUE B"0".
  37   005600    88 AT-END-OF-FILE VALUE B"1".
  38   005700 01 ITEM-PRICE-T TYPEDEF PIC S9(4)V9(2) value 0.
  39   005800 01 ITEM-COLOR-T TYPEDEF PIC S9(2) VALUE 1.
  40   005900    88 ITEM-COLOR-BLUE  VALUE 1.
  41   006000    88 ITEM-COLOR-RED   VALUE 2.
  42   006100    88 ITEM-COLOR-GREEN VALUE 3.
  43   006200 01 ITEM-SIZE-T    TYPEDEF PIC S9(2) VALUE 10.
  44   006300 01 ITEM-COUNTER-T TYPEDEF PIC S9(6) VALUE 0.
       006400
  45   006500 01 ITEM-B-T TYPEDEF.
  46   006600    05  ITEM-B-VALUE PIC s9(2).
  47   006700    88 ITEM-B-BLUE  VALUE 1.
  48   006800    88 ITEM-B-RED   VALUE 2.
  49   006900    88 ITEM-B-GREEN VALUE 3.
  50   007000 01 TEST-ITEM TYPE ITEM-B-T.
       007100
  51   007200 01 WORK-INV-TYPE  TYPE INV-TYPE-T.
       007300*****************************************************************
       007400* User-defined data type for items of clothing.
       007500* Items of clothing are INVENTORY-TYPE 1 through 3.
       007600*****************************************************************
       007700
  52   007800 01 CLOTHING-ITEM IS TYPEDEF.
  53   007900    05 CLOTHING-TYPE   TYPE INV-TYPE-T.
  54   008000    05 PRICE           TYPE ITEM-PRICE-T.
  55   008100    05 COLOR           TYPE ITEM-COLOR-T.
  56   008200    05 CLOTHING-SIZE   TYPE ITEM-SIZE-T.
  57   008300    05 FILLER PIC X(70).
       008400
  58   008500 01 SWEATERS TYPE CLOTHING-ITEM.
  59   008600 01 SOCKS TYPE CLOTHING-ITEM.
  60   008700 01 PANTS TYPE CLOTHING-ITEM.
       008800
       008900*****************************************************************
       009000* User-defined data type for books.
       009100* Books are INVENTORY-TYPE 4 through 5.
       009200*****************************************************************
       009300
  61   009400 01 BOOK-ITEM IS TYPEDEF.
  62   009500    05 BOOK-TYPE    TYPE INV-TYPE-T.
  63   009600    05 PRICE        TYPE ITEM-PRICE-T.
  64   009700    05 FILLER       PIC X(20).
  65   009800    05 BOOK-TITLE   PIC X(40).
  66   009900    05 FILLER       PIC X(14).
       010000
  67   010100 01 BOOK-001 TYPE BOOK-ITEM.
  68   010200 01 BOOK-002 TYPE BOOK-ITEM.
       010300
       010400*****************************************************************
       010500* Initialize all of the inventory counters.
       010600*****************************************************************
       010700
  69   010800 01 sweaters-count TYPE item-counter-t.
```

Figure 50. Example Showing How TYPEDEF and TYPE Clauses Can Be Used in a Program (Part 2 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPTYPE        AISERIES   03/09/15 13:31:06        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   70     010900 01 socks-count TYPE item-counter-t.
   71     011000 01 pants-count TYPE item-counter-t.
          011100
   72     011200 01 book-001-count TYPE item-counter-t.
   73     011300 01 book-002-count TYPE item-counter-t.
          011400
   74     011500 01 clothes-count TYPE item-counter-t.
   75     011600 01 book-count TYPE item-counter-t.
          011700
          011800*****************************************************************
          011900* Declare report variables.
          012000*****************************************************************
          012100
   76     012200 01 header-line.
   77     012300    05 FILLER   pic x(40) value spaces.
   78     012400    05 FILLER   pic x(52) value "Detailed Inventory Report".
   79     012500    05 FILLER   pic x(40) value spaces.
          012600
   80     012700 01 DETAIL-LINE.
   81     012800    05 FILLER             pic x(10) value spaces.
   82     012900    05 ITEM-DESCRIPTION   pic x(25) value spaces.
   83     013000    05 ITEM-QUANTITY      pic 9(6) blank when zero.
   84     013100    05 FILLER             pic x(92) value spaces.
          013200
          013300
   85     013400 PROCEDURE DIVISION.
          013500 MAIN-PAR.
   86     013600     OPEN INPUT DATA-IN
          013700          OUTPUT PRINTER-FILE.
          013800
          013900
          014000*****************************************************************
          014100* Read the first record.
          014200*****************************************************************
          014300
   87     014400     READ DATA-IN
          014500         AT END
   88     014600            SET AT-END-OF-FILE TO TRUE
          014700         NOT AT END
   89     014800            MOVE INV-TYPE TO WORK-INV-TYPE
          014900     END-READ.
          015000
          015100*****************************************************************
          015200* Tally each of the inventory types and move the amounts into
          015300* separate totals.
          015400*****************************************************************
          015500
   90     015600     PERFORM UNTIL AT-END-OF-FILE
   91     015700         EVALUATE TRUE
          015800         WHEN INV-TYPE-CLOTHES-SWEATERS OF WORK-INV-TYPE
   92     015900            ADD 1 TO sweaters-count
   93     016000            ADD 1 TO clothES-count
          016100         WHEN INV-TYPE-CLOTHES-SOCKS OF WORK-INV-TYPE
   94     016200            ADD 1 TO socks-count
   95     016300            ADD 1 TO clothES-count
```

Figure 50. Example Showing How TYPEDEF and TYPE Clauses Can Be Used in a Program (Part 3 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPTYPE        AISERIES   03/09/15 13:31:06        Page      5
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         016400         WHEN INV-TYPE-CLOTHES-PANTS OF WORK-INV-TYPE
   96    016500            ADD 1 TO pants-count
   97    016600            ADD 1 TO clothES-COUNT
         016700         WHEN INV-TYPE-BOOK-001 OF WORK-INV-TYPE
   98    016800            ADD 1 TO book-001-count
   99    016900            ADD 1 TO book-count
         017000         WHEN INV-TYPE-BOOK-002 OF WORK-INV-TYPE
  100    017100            ADD 1 TO book-002-count
  101    017200            ADD 1 TO book-count
         017300         END-EVALUATE
         017400
  102    017500         READ DATA-IN
         017600            AT END
  103    017700               SET AT-END-OF-FILE TO TRUE
         017800            NOT AT END
  104    017900               MOVE INV-TYPE TO WORK-INV-TYPE
         018000         END-READ
         018100     END-PERFORM.
         018200
         018300*************************************************************
         018400* Write report.
         018500*************************************************************
         018600
  105    018700     PERFORM REPORT-WRITE.
  106    018800     CLOSE DATA-IN
         018900           PRINTER-FILE.
  107    019000     STOP RUN.
         019100
         019200*************************************************************
         019300* Procedure to write report.
         019400*************************************************************
         019500
         019600 REPORT-WRITE.
  108    019700     WRITE PRINTER-REC FROM HEADER-LINE AFTER ADVANCING PAGE.
         019800
  109    019900     MOVE "BOOKS:"               TO ITEM-DESCRIPTION.
  110    020000     MOVE ZEROS                  TO ITEM-QUANTITY.
  111    020100     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         020200
  112    020300     MOVE "Best-seller Number 1:" TO ITEM-DESCRIPTION.
  113    020400     MOVE BOOK-001-COUNT          TO ITEM-QUANTITY.
  114    020500     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         020600
  115    020700     MOVE "Best-seller Number 2:" TO ITEM-DESCRIPTION.
  116    020800     MOVE BOOK-002-COUNT          TO ITEM-QUANTITY.
  117    020900     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         021000
  118    021100     MOVE "Total Books:"          TO ITEM-DESCRIPTION.
  119    021200     MOVE BOOK-COUNT              TO ITEM-QUANTITY.
  120    021300     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         021400
  121    021500     WRITE PRINTER-REC FROM HEADER-LINE AFTER ADVANCING PAGE.
         021600
  122    021700     MOVE "CLOTHES:"             TO ITEM-DESCRIPTION.
  123    021800     MOVE ZEROS                  TO ITEM-QUANTITY.
  124    021900     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         022000
  125    022100     MOVE "Sweaters:"            TO ITEM-DESCRIPTION.
  126    022200     MOVE SWEATERS-COUNT         TO ITEM-QUANTITY.
  127    022300     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         022400
  128    022500     MOVE "Socks:"               TO ITEM-DESCRIPTION.
  129    022600     MOVE SOCKS-COUNT            TO ITEM-QUANTITY.
  130    022700     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         022800
  131    022900     MOVE "Pants:"               TO ITEM-DESCRIPTION.
  132    023000     MOVE PANTS-COUNT            TO ITEM-QUANTITY.
  133    023100     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         023200
  134    023300     MOVE "Total Clothes:"       TO ITEM-DESCRIPTION.
  135    023400     MOVE CLOTHES-COUNT          TO ITEM-QUANTITY.
  136    023500     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
         023600
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 50. Example Showing How TYPEDEF and TYPE Clauses Can Be Used in a Program (Part 4 of 4)

Data Format Conversions

When the code in your program involves the interaction of items with different data formats, the compiler converts these items:

- Temporarily, for comparisons and arithmetic operations
- Permanently, for assignment to the receiver in a MOVE or COMPUTE statement.

What Conversion Means

A conversion is actually a move of a value from one data item to another. The compiler performs any conversions that are required during the execution of the arithmetic and comparison statements with the same rules that are used for MOVE and COMPUTE statements. The rules for moves are defined in *WebSphere Development Studio: ILE COBOL Reference*. When possible, the compiler performs the move to preserve the numeric *value* as opposed to a direct digit-for-digit move. (For more information on truncation and predicting the loss of significant digits, refer to "Conversions and Precision.")

Conversion Takes Time

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

Conversions and Precision

Conversion between fixed-point data formats (external decimal, packed decimal, and binary) are completed without loss of precision, as long as the target fields can contain all of the digits of the source operand.

Conversions Where Loss of Data is Possible

A loss of precision is possible in conversions between fixed-point data formats and floating-point data formats (short floating-point, long floating-point, and external floating-point). These conversions happen during arithmetic evaluations that have a mixture of both fixed-point and floating-point operands. (Because fixed-point and external floating-point items both have decimal characteristics, reference to fixed-point items in the following examples includes external floating-point items as well, unless stated otherwise.)

When converting from fixed-point to internal floating-point format, fixed-point numbers in base 10 are converted to the numbering system used internally, base 16.

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

When a USAGE COMP-1 data item is moved to a fixed-point data item with more than 6 digits, the fixed-point data item will receive only 6 significant digits, and the remaining digits will be zero.

Conversions that Preserve Precision: If a fixed-point data item with 6 or fewer digits is moved to a USAGE COMP-1 data item and then returned to the fixed-point data item, the original value is recovered.

If a USAGE COMP-1 data item is moved to a fixed-point data item of 6 or more digits and then returned to the USAGE COMP-1 data item, the original value is recovered.

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

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

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

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

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

It is possible that when external floating-point data is DISPLAYed or ACCEPTed, or when an external floating-point literal is MOVEed to an external floating-point data item, the external floating-point data item displayed, accepted, or received can be an inaccurate value. This is because the floating-point data type is an approximation. When an external floating-point literal is accepted, displayed, or moved, it is first converted to a true floating-point value (IEEE), which can also affect its accuracy. For example, consider the following MOVE:

```
77 external-float-1 PIC +9(3).9(13)E+9(3).
   MOVE +123455779012.34523E+297 to external-float-1.
   DISPLAY "EXTERNAL-FLOAT-1=" external-float-1.
```

The displayed result of the MOVE is:

```
EXTERNAL-FLOAT-1=+123.4557790123452E+306
```

Sign Representation and Processing

Sign representation affects the processing and interaction of your numeric data.

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

Positive: A, C, E, and F.

Negative: B and D.

Signs generated internally are F for positive and unsigned, and D for negative.

Given X'ds', where d represents the digit and s is the sign representation, the valid sign representations for internal decimal (USAGE PACKED-DECIMAL) ILE COBOL data are:

Positive: A, C, E, and F.

Negative: B and D.

Signs generated internally are F for positive and unsigned, and D for negative.

With the *CHGPOSSN Compiler Option

The ILE COBOL compiler option *CHGPOSSGN affects sign processing for external decimal and internal decimal data. *CHGPOSSGN has no effect on binary data or floating-point data. For more information, refer to the discussion of *CHGPOSSN on page "*NOCHGPOSSGN and *CHGPOSSGN" on page 34.

Positive signs generated by the compiler which are normally F become C on MOVE and arithmetic statements as well as the VALUE clause.

The *CHGPOSSGN compiler option is less effective than the default, *NOCHGPOSSGN, and should only be used when sharing data with MVS®, VM, or other systems with different preferred signs.

Checking for Incompatible Data (Numeric Class Test)

The compiler assumes that the values you supply for a data item are valid for the item's PICTURE and USAGE clause, and assigns the value you supply without checking for validity. When an item is given a value that is incompatible with its data description, references to that item in the PROCEDURE DIVISION will be undefined, and your results will be unpredictable.

Frequently, values are passed into your program and are assigned to items that have incompatible data descriptions for those values. For example, non-numeric data might be moved or passed into a field in your program that is defined as an unsigned number. In either case, these fields contain invalid data. Ensure that the contents of a data item conforms to its PICTURE and USAGE clauses before using the data item in any further processing steps.

How to Do a Numeric Class Test

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

```
LINKAGE SECTION.
01   COUNT-X     PIC 999.
   .
   .
   .
   PROCEDURE DIVISION USING COUNT-X.
     IF COUNT-X IS NUMERIC THEN DISPLAY "DATA IS GOOD".
   .
   .
   .
```

The numeric class test checks the contents of a data item against a set of values that are valid for the particular PICTURE and USAGE of the data item. For example, a packed decimal item would be checked for hexadecimal values X'0' through X'9' in the digit positions, and for a valid sign value in the sign position (whether separate or non-separate).

Performing Arithmetic

If ILE COBOL together with ILE run-time provide various features to perform arithmetic:

- ADD, SUBTRACT, MULTIPLY, DIVIDE, and COMPUTE statements (discussed in "COMPUTE and Other Arithmetic Statements").
- Arithmetic expressions (discussed in "Arithmetic Expressions" on page 164).
- Intrinsic functions (discussed in "Numeric Intrinsic Functions" on page 164).
- ILE callable services (APIs)

  ILE provides several groups of bindable APIs which are available to every ILE compiler. The math APIs include CEE4SIFAC to compute factorials, and CEESDCOS to compute cosine.

  For more information about the bindable APIs that you can use, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site
  -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

For the complete details of syntax and usage for ILE COBOL language constructs, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

COMPUTE and Other Arithmetic Statements

The general practice is to use the COMPUTE statement for most arithmetic evaluations rather than the ADD, SUBTRACT, MULTIPLY, and DIVIDE statements. This is because one COMPUTE statement can often be coded instead of several individual statements.

The COMPUTE statement assigns the result of an arithmetic expression to a data item:

```
COMPUTE Z = A + B / C ** D - E
```

or to many data items:

```
COMPUTE X Y Z = A + B / C ** D - E
```

When to Use Other Arithmetic Statements

Some arithmetic might be more intuitive using the other arithmetic statements. For example:

```
ADD 1 TO INCREMENT.
```

instead of:

```
COMPUTE INCREMENT = INCREMENT + 1.
```

Or,

```
SUBTRACT OVERDRAFT FROM BALANCE.
```

instead of:

```
COMPUTE BALANCE = BALANCE - OVERDRAFT.
```

Or,

```
ADD 1 TO INCREMENT-1, INCREMENT-2, INCREMENT-3.
```

instead of:

```
COMPUTE INCREMENT-1 = INCREMENT-1 + 1
COMPUTE INCREMENT-2 = INCREMENT-2 + 1
COMPUTE INCREMENT-3 = INCREMENT-3 + 1
```

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

Arithmetic Expressions

In the examples of COMPUTE shown above, everything to the right of the equal sign represents an arithmetic expression. Arithmetic expressions can consist of a single numeric literal, a single numeric data item, or a single Intrinsic Function reference. They can also consist of several of these items connected by arithmetic operators. These operators are evaluated in a hierarchic order.

Table 7. Operator Evaluation

Operator	Meaning	Order of Evaluation
Unary + or –	Algebraic sign	First
**	Exponentiation	Second
/ or *	Division or multiplication	Third
Binary + or –	Addition or subtraction	Last

Operators at the same level are evaluated from left to right; however, you can use parentheses with these operators to change the order in which they are evaluated. Expressions in parentheses are evaluated before any of the individual operators are evaluated. Parentheses, necessary or not, make your program easier to read.

In addition to using arithmetic expressions in COMPUTE statements, you can also use them in other places where numeric data items are allowed. For example, you can use arithmetic expressions as comparands in relation conditions:

```
IF (A + B) > (C - D + 5) THEN...
```

Numeric Intrinsic Functions

Intrinsic functions can return an alphanumeric, DBCS, numeric, boolean or date-time value.

Numeric intrinsic functions:

- Return a signed numeric value.
- Are considered to be temporary numeric data items.
- Can be used only in the places in the language syntax where expressions are allowed.
- Can save you time because you do not have to provide the arithmetic for the many common types of calculations that these functions cover. For more information on the practical application of intrinsic functions, refer to “Intrinsic Function Examples” on page 166.

Types of Numeric Functions

Numeric functions are classified into these categories:

Integer Those that return an integer.

Floating-Point Those that return a long floating-point value.

Argument Dependent
Return type depends on the arguments specified

The numeric functions available in ILE COBOL under these categories are listed in Table 8

Table 8. Types of Data that Numeric Functions Return

Integer	Floating-point	Argument Dependent
DATE-OF-INTEGER	ACOS	MAX *
DATE-TO-YYYYMMDD	ANNUITY	MIN *
DAY-OF-INTEGER	ASIN	RANGE
DAY-TO-YYYYDDD	ATAN	SUM
EXTRACT-DATE-TIME	COS	
FACTORIAL	LOG	
FIND-DURATION	LOG10	
INTEGER	MEAN	
INTEGER-OF-DATE	MEDIAN	
INTEGER-OF-DAY	MIDRANGE	
INTEGER-PART	NUMVAL	
LENGTH	NUMVAL-C	
MOD	PRESENT-VALUE	
ORD	RANDOM	
ORD-MAX	REM	
ORD-MIN	SIN	
YEAR-TO-YYYY	SQRT	
	STANDARD-DEVIATION	
	TAN	
	VARIANCE	

Note: * MAX and MIN can be alphanumeric.

Nesting Functions and Arithmetic Expressions

Numeric functions can be nested; you can reference one function as the argument of another. A nested function is evaluated independently of the outer function.

Because numeric functions and arithmetic expressions hold similar syntactic status, you can also nest an arithmetic expression as an argument to a numeric function:

```
COMPUTE X = FUNCTION MEAN (A, B, C / D).
```

In this example, there are only three function arguments: A, B and the arithmetic expression (C / D).

All Subscripting and Special Registers

Two other useful features of Intrinsic Functions are the ALL subscript and special registers.

You can reference all the elements of an array as function arguments by using the ALL subscript. This feature is used with tables.

The integer-type special registers are allowed as arguments wherever integer arguments are allowed.

Intrinsic Function Examples

You can use Intrinsic Functions to perform several different kinds of arithmetic as outlined in the table below:

Table 9. Types of Arithmetic that Numeric Functions Handle

Number Handling	Date/Time	Finance	Mathematics	Statistics
LENGTH	CURRENT-DATE	ANNUITY	ACOS	MEAN
MAX	DATE-OF-INTEGER	PRESENT	ASIN	MEDIAN
MIN	DAY-TO-YYYYDDD	-VALUE	ATAN	MIDRANGE
NUMVAL	DATE-TO-YYYYMM		COS	RANDOM
NUMVAL-C	DD		FACTORIAL	RANGE
ORD-MAX	DAY-OF-INTEGER		INTEGER	STANDARD
ORD-MIN	EXTRACT-DATE-		INTEGER-PART	-DEVIATION
	TIME		LOG	VARIANCE
	FIND-DURATION		LOG10	
	INTEGER-OF-DATE		MOD	
	INTEGER-OF-DAY		REM	
	WHEN-COMPILED		SIN	
	YEAR-TO-YYYY		SQRT	
			SUM	
			TAN	

The following examples and accompanying explanations show intrinsic functions in each of the categories listed in the preceding table.

General Number-Handling: Suppose you want to find the mean value of three prices (represented as alphanumeric items with dollar signs), put this value into a numeric field in an output record, and determine the length of the output record. You could use NUMVAL-C (a function that returns the numeric value of an alphanumeric string) and the MEAN function to do this:

```
01 X                 PIC 9(2).
01 PRICE1            PIC X(8)     VALUE "$8000".
01 PRICE2            PIC X(8)     VALUE "$4000".
01 PRICE3            PIC X(8)     VALUE "$6000".
01 OUTPUT-RECORD.
   05 PRODUCT-NAME   PIC X(20).
   05 PRODUCT-NUMBER PIC 9(9).
   05 PRODUCT-PRICE  PIC 9(6).
.
.
.
PROCEDURE DIVISION.
   COMPUTE PRODUCT-PRICE =
       FUNCTION MEAN (FUNCTION NUMVAL-C(PRICE1)
                      FUNCTION NUMVAL-C(PRICE2)
                      FUNCTION NUMVAL-C(PRICE3)).
       COMPUTE X = FUNCTION LENGTH(OUTPUT-RECORD).
```

Additionally, to ensure that the contents in PRODUCT-NAME are in uppercase letters, you could use the following statement:

```
    MOVE FUNCTION UPPER-CASE(PRODUCT-NAME) TO PRODUCT-NAME.
```

Date and Time: The following example shows how to calculate a due date that is 90 days from today. The first eight characters returned by the CURRENT-DATE function represent the date in a 4-digit year, 2-digit month, and 2-digit day format

(YYYYMMDD). In the example, this date is converted to its integer value. Then 90 is added to this value, and the integer is converted back to the YYYYMMDD format.

```
01 YYYYMMDD              PIC 9(8).
01 INTEGER-FORM          PIC S9(9).
   .
   .
   .
   MOVE FUNCTION CURRENT-DATE(1:8) TO YYYYMMDD.
   COMPUTE INTEGER-FORM = FUNCTION INTEGER-OF-DATE(YYYYMMDD).
   ADD 90 TO INTEGER-FORM.
   COMPUTE YYYYMMDD = FUNCTION DATE-OF-INTEGER(INTEGER-FORM).
   DISPLAY 'Due Date: ' YYYYMMDD.
```

You can also calculate a due date as a category date-time data item. For an example of this type of calculation, refer to "Example of Calculating a Due Date" on page 175.

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

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

```
01 SERIES-AMT1              PIC 9(9)V99     VALUE 100.
01 SERIES-AMT2              PIC 9(9)V99     VALUE 200.
01 SERIES-AMT3              PIC 9(9)V99     VALUE 300.
01 DISCOUNT-RATE            PIC S9(2)V9(6)  VALUE .10.
01 TODAYS-VALUE             PIC 9(9)V99.
.
.
.
COMPUTE TODAYS-VALUE =
FUNCTION
PRESENT-VALUE(DISCOUNT-RATE SERIES-AMT1 SERIES-AMT2
SERIES-AMT3).
```

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

```
01 LOAN               PIC 9(9)V99.
01 PAYMENT            PIC 9(9)V99.
01 INTEREST           PIC 9(9)V99.
01 NUMBER-PERIODS     PIC 99.
.
.
.
COMPUTE LOAN = 15000.
COMPUTE INTEREST = .12
COMPUTE NUMBER-PERIODS = 36.
COMPUTE PAYMENT =
LOAN * FUNCTION ANNUITY((INTEREST / 12) NUMBER-PERIODS).
```

Mathematics: The following ILE COBOL statement demonstrates how intrinsic functions can be nested, how arguments can be arithmetic expressions, and how previously complex mathematical calculations can be simply performed:

```
COMPUTE Z = FUNCTION LOG(FUNCTION SQRT (2 * X + 1))
+ FUNCTION REM(X 2)
```

Here, the remainder of dividing X by 2 is found with an intrinsic function, instead of using a DIVIDE statement with a REMAINDER clause.

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

```
01 TAX-S              PIC 99V999 VALUE .045.
01 TAX-T              PIC 99V999 VALUE .02.
01 TAX-W              PIC 99V999 VALUE .035.
01 TAX-B              PIC 99V999 VALUE .03.
01 AVE-TAX            PIC 99V999.
01 MEAN-TAX           PIC 99V999.
01 TAX-RANGE          PIC 99V999.
   .
   .
   .
COMPUTE AVE-TAX = FUNCTION MEAN(TAX-S TAX-W TAX-B)
COMPUTE MEDIAN-TAX = FUNCTION MEDIAN(TAX-S TAX-W TAX-B)
COMPUTE TAX-RANGE = FUNCTION RANGE(TAX-S TAX-W TAX-B)
```

Converting Data Items (Intrinsic Functions)

Intrinsic Functions are available to convert character-string data items to the following:

- Uppercase or lower case
- Reverse order
- Numbers
- Date-time data items
- UTF–8

Besides using Intrinsic Functions to convert characters, you can also use the INSPECT statement.

Converting to Uppercase or Lowercase (UPPER-CASE, LOWER-CASE)

This code:

```
01 ITEM-1             PIC X(30)     VALUE "Hello World!".
01 ITEM-2             PIC X(30).
   .
   .
   .
   DISPLAY ITEM-1.
   DISPLAY FUNCTION UPPER-CASE(ITEM-1).
   DISPLAY FUNCTION LOWER-CASE(ITEM-1).
   MOVE FUNCTION UPPER-CASE(ITEM-1) TO ITEM-2.
   DISPLAY ITEM-2.
```

would display the following messages on the terminal:

```
Hello World!
HELLO WORLD!
hello world!
HELLO WORLD!
```

The DISPLAY statements do not change the actual contents of ITEM-1 and only affect how the letters are displayed. However, the MOVE statement causes uppercase letters to be moved to the actual contents of ITEM-2.

Converting to Reverse Order (REVERSE)

The following code:

```
MOVE FUNCTION REVERSE(ORIG-CUST-NAME) TO ORIG-CUST-NAME.
```

would reverse the order of the characters in ORIG-CUST-NAME. For example, if the starting value were JOHNSON, the value after the statement is performed would be NOSNHOJ.

Converting to Numbers (NUMVAL, NUMVAL-C)

The NUMVAL and NUMVAL-C functions convert character strings to numbers. Use these functions to convert alphanumeric data items that contain free format character representation numbers to numeric form, and process them numerically. For example:

```
01 R            PIC X(20)   VALUE "- 1234.5678".
01 S            PIC X(20)   VALUE "-$12,345.67CR".
01 TOTAL        USAGE IS COMP-2.
   .
   .
   .
   COMPUTE TOTAL = FUNCTION NUMVAL(R) + FUNCTION NUMVAL-C(S).
```

The difference between NUMVAL and NUMVAL-C is that NUMVAL-C is used when the argument includes a currency symbol or comma, as shown in the example. You can also place an algebraic sign in front or in the rear, and it will be processed. The arguments must not exceed 18 digits (not including the editing symbols). For exact syntax rules, see the *WebSphere Development Studio: ILE COBOL Reference* manual.

Note: Both NUMVAL and NUMVAL-C return a long (double-precison) floating-point value. A reference to either of these functions, therefore, represents a reference to a numeric data item.

Why Use NUMVAL and NUMVAL-C?: When you use NUMVAL or NUMVAL-C, you do not need to statically declare numeric data in a fixed format and input data in a precise manner. For example, for this code:

```
   01 X         PIC S999V99   LEADING SIGN IS SEPARATE.
   .
   .
   .
   ACCEPT X FROM CONSOLE.
```

the user of the application must enter the numbers exactly as defined by the PICTURE clause. For example:

```
+001.23
-300.00
```

However, using the NUMVAL function, you could code:

```
   01 A         PIC X(10).
   01 B         PIC S999V99.
   .
   .
   .
   ACCEPT A FROM CONSOLE.
   COMPUTE B = FUNCTION NUMVAL(A).
```

and the input could be:

```
1.23
-300
```

Converting to Date-Time Data Items (CONVERT-DATE-TIME)

The CONVERT-DATE-TIME function takes an alphanumeric, numeric, or date-time item, and converts it to a date-time data item. The intrinsic functions can be used to:

- Convert dates, times, or timestamps from an alphanumeric (string) item to a date-time item
- Convert an item of category date in one format to another category date item, whose format is based on a locale.

For example, the following statement converts a non-numeric literal (an alphanumeric constant) to a category date data item:

```
MOVE FUNCTION CONVERT-DATE-TIME ('98/08/09' DATE '%y/%m/%d')
     TO DATE-1.
```

Conversion also occurs when comparing or moving numeric data items containing dates to date-time data items. For more information about the considerations for these types of moves, refer to "MOVE Considerations for Date-Time Data Items" on page 185.

When moving alphanumeric data items containing dates to date-time data items, no conversion is done: whatever characters are contained in the alphanumeric data item are moved to the date-time data item. It is the responsibility of the programmer to ensure that dates contained in alphanumeric data items are in the correct format before they are moved to date-time data items.

Converting to UTF-8 (UTF8STRING)

The UTF8STRING function converts character strings to UTF-8 (UCS Transformation Format 8). The UTF-8 coded form is represented by CCSID 1208. For example:

```
01 STR1 PIC X(3) VALUE "ABC".
01 VRR-X3 PIC X(3).
.
.
.
MOVE FUNCTION UTF8STRING(STR1) TO VRR-X3.
```

The contents of VRR-X3 would become `X"414243"`.

Evaluating Data Items (Intrinsic Functions)

Several Intrinsic Functions can be used in evaluating data items:

- CHAR and ORD for evaluating integers and single alphanumeric characters with respect to the collating sequence used in your program.
- MAX, MIN, ORD-MAX, and ORD-MIN for finding the largest and smallest items in a series of data items.
- LENGTH for finding the length of data items.
- WHEN-COMPILED for finding the date and time the program was compiled.
- TEST-DATE-TIME for determining if a date-time, alphanumeric, numeric packed, or zoned item is a valid date, time, or timestamp.

Evaluating Single Characters for Collating Sequence (CHAR, ORD)

If you want to know the ordinal position of a certain character in the collating sequence, reference the ORD function using the character in question as the argument, and ORD will return an integer representing that ordinal position. One convenient way to do this is to use the substring of a data item as the argument to ORD:

```
IF FUNCTION ORD (CUSTOMER-RECORD(1:1)) IS > 194 THEN ...
```

On the other hand, if you know what position in the collating sequence you want but do not know what character it corresponds to, then reference the CHAR function using the integer ordinal position as the argument, and CHAR will return the desired character:

```
INITIALIZE CUSTOMER-NAME REPLACING ALPHABETIC BY FUNCTION CHAR(65).
```

Returning Variable-Length Results with Alphanumeric Functions

The results of alphanumeric functions might be of varying lengths and values depending on the function arguments.

In the following example, the amount of data moved to R3 and the results of the COMPUTE statement depend on the values and sizes of R1 and R2:

```
01 R1            PIC X(10) VALUE "e".
01 R2            PIC X(05) VALUE "f".
01 R3            PIC X(05) VALUE "g".
01 R4            PIC X(20) VALUE SPACES.
01 L             PIC 99.
.
.
.
MOVE FUNCTION MEAN(R1 R2 R3) TO R4.
COMPUTE L = FUNCTION LENGTH(FUNCTION MEAN(R1 R2 R3)).
```

Here R2 is evaluated to the mean value. Therefore, assuming that the symbol ␣ represents a blank space, the string "f␣␣␣␣" would be moved to R4 (the unfilled character positions in R4 are padded with spaces), and L evaluates to the value of 5. If R1 were the value "f", then R1 would be the mean value, and the string "f␣␣␣␣␣␣␣␣␣" would be moved to R4 (the unfilled character positions in R4 would be padded with spaces); the value 10 would be assigned to L.

You might be dealing with variable-length output from alphanumeric functions. Plan you program code accordingly. For example, you might need to think about using variable-length record files when it is possible that the records you will be writing might be of different lengths:

```
   FILE SECTION.
FD OUTPUT-FILE.
01 CUSTOMER-RECORD     PIC X (80).
WORKING-STORAGE SECTION.
01 R1                     PIC X (50).
01 R2                     PIC X (70).
.
.
.
WRITE CUSTOMER-RECORD FROM FUNCTION MEAN(R1 R2 R3).
```

Finding the Largest or Smallest Data Item (MAX, MIN, ORD-MAX, ORD-MIN)

If you have two or more alphanumeric data items and want to know which data item contains the largest value (evaluated according to the collating sequence), use the MAX or ORD-MAX function, supplying the data items in question as

arguments. If you want to know which item contains the smallest value, you would use the MIN or ORD-MIN function.

MAX and MIN: The MAX and MIN functions simply return the contents of one of the variables you supply. For example, with these data definitions:

```
05 Arg1 Pic x(10) Value "THOMASSON ".
05 Arg2 Pic x(10) Value "THOMAS ".
05 Arg3 Pic x(10) Value "VALLEJO ".
```

the following statement;

```
Move Function Max(Arg1 Arg2 Arg3) To Customer-record(1:10)
```

would assign "VALLEJObbb" to the first ten character positions of Customer-record.

Note: We are representing a blank with "b".

If MIN were used instead, then "THOMASbbbb" would be returned.

ORD-MAX and ORD-MIN: The functions ORD-MAX and ORD-MIN return an integer that represents the ordinal position of the argument with the largest or smallest value in the list of arguments you have supplied (counting from the left). If the ORD-MAX function were used in the example above, you would receive a syntax error message at compile time, because you would be attempting to reference a numeric function in an invalid place (see *WebSphere Development Studio: ILE COBOL Reference*). The following is a valid example of the ORD-MAX function:

```
Compute x = Function Ord-max(Arg1 Arg2 Arg3)
```

This would assign the integer 3 to x, if the same arguments were used as in the previous example. If ORD-MIN were used instead, the integer 2 would be returned.

Note: This group of functions can also be used for numbers, in which case the algebraic values of the arguments are compared. For more information, see "Arithmetic Expressions" on page 164. The above examples would probably be more realistic if Arg1, Arg2 and Arg3 were instead successive elements of an array (table). For information on using table elements as function arguments, see "Processing Table Items" on page 178.

Returning Variable-Length Results with Alphanumeric Functions: The results of alphanumeric functions might be of varying lengths and values depending on the function arguments. In the following example, the amount of data moved to R3 and the results of the COMPUTE statement depend on the values and sizes of R1 and R2:

```
01 R1 Pic x(10) value "e".
01 R2 Pic x(05) value "f".
01 R3 Pic x(20) value spaces.
01 L Pic 99.
.
.
Move Function Max(R1 R2) to R3
Compute L = Function Length(Function Max(R1 R2))
```

Here, R2 is evaluated to be larger than R1. Therefore, assuming that the symbol b represents a blank space, the string "fbbbb" would be moved to R3 (the unfilled character positions in R3 are padded with spaces), and L evaluates to the value 5. If R1 were the value "g" then R1 would be larger than R2, and the string

"gbbbbbbbbb" would be moved to R3 (the unfilled character positions in R3 would
be padded with spaces); the value 10 would be assigned to L.

You might be dealing with variable-length output from alphanumeric functions.
Plan your program code accordingly. For example, you might need to think about
using variable-length record files when it is possible that the records you will be
writing might be of different lengths:

```
# File Section.
# FD Output-File.
# 01 Customer-Record Pic X(80).
# Working-Storage Section.
# 01 R1 Pic x(50).
# 01 R2 Pic x(70).
# .
# .
# Write Customer-Record from Function Max(R1 R2)
```

Finding the Length of Data Items (LENGTH)

The LENGTH function is useful in many programming contexts for determining the length of string items. The following ILE COBOL statement shows moving a data item, such as a customer name, into the particular field in a record that is for customer names:

```
MOVE CUSTOMER-NAME TO CUSTOMER-RECORD(1:FUNCTION LENGTH(CUSTOMER-NAME)).
```

Note: The LENGTH function can also be used on a numeric data item or a table entry.

LENGTH OF Special Register: In addition to the LENGTH function, another technique to find the length of a data item is to use the LENGTH OF special register.

There is a fundamental difference between the LENGTH OF special register and the LENGTH Intrinsic Function. FUNCTION LENGTH returns the length of an item in character positions, whereas LENGTH OF returns the length of an item in bytes. In most cases, this makes little difference except for items with a class of DBCS.

For example:

```
77 CUSTOMER-NAME PIC X(30).
77 CUSTOMER-LOCATION-ASIA PIC G(50).
```

Coding either `FUNCTION LENGTH(CUSTOMER-NAME)` or `LENGTH OF CUSTOMER-NAME` will return 30; however coding `FUNCTION LENGTH(CUSTOMER-LOCATION-ASIA)` will return 50, whereas `LENGTH OF CUSTOMER-LOCATION-ASIA` will return 100.

Whereas the LENGTH function can only be used where arithmetic expressions are allowed, the LENGTH OF special register can be used in a greater variety of contexts. For example, the LENGTH OF special register can be used as an argument to an Intrinsic Function that allows integer arguments. (An Intrinsic Function cannot be used as an operand to the LENGTH OF special register.) The LENGTH OF special register can also be used as a parameter in a CALL statement.

Finding the Date of Compilation (WHEN-COMPILED)

If you want to know the date and time the program was compiled as provided by the system on which the program was compiled, you can use the WHEN-COMPILED function. The result returned has 21 character positions with the first 16 positions in the format:

```
YYYYMMDDhhmmsshh
```

to show the four-digit year, month, day, and time (in hours, minutes, seconds, and hundredths of seconds) of compilation.

WHEN-COMPILED Special Register: The WHEN-COMPILED special register is another technique you can use to find the date and time of compilation. It has the format:

```
MM/DD/YYhh.mm.ss
```

The WHEN-COMPILED special register supports only a two-digit year and carries the time out only to seconds. The special register can only be used as the sending field in a MOVE statement.

Testing for Date-Time Data Items (TEST-DATE-TIME)

If you want to know if a date-time, alphanumeric, numeric packed, or zoned item is a valid date, time, or timestamp data item, you can use the TEST-DATE-TIME intrinsic function. It can be useful to test for valid date-time data items before completing a move or calculation using another date-time intrinsic function, such as ADD-DURATION, or SUBTRACT-DURATION. The following example shows how to test for date-time data items:

```
IF FUNCTION TEST-DATE-TIME (date-3 DATE) = B'1'
   MOVE DATE-3 TO CUTOFF-DATE.
```

Working with Date and Time Durations (ADD-DURATION, FIND-DURATION, SUBTRACT-DURATION)

You can use intrinsic functions to work with durations between dates, times, and timestamps. For example, if you have two dates, and you want to know how many months fall in between the two dates, you can use the FIND-DURATION function to calculate this. You can also calculate due dates and stale dates (dates that have passed) using the ADD-DURATION and SUBTRACT-DURATION intrinsic functions.

For more information on using date-time data items, refer to “Working with Date-Time Data Types” on page 181.

Example of Finding the Duration Between Two Dates: The following example shows how to calculate how many days fall between two dates in date-time format:

```
01 YYYYMMDD          FORMAT DATE "@Y%m%d".
01 EXPIRY-DATE       FORMAT DATE "%m/%d/@Y"  VALUE "10/31/1997".
01 DURATION          PIC S9(5).
   .
   .
   .
    MOVE FUNCTION CURRENT-DATE(1:8) TO YYYYMMDD.
    COMPUTE DURATION = FUNCTION FIND-DURATION (YYYYMMDD EXPIRY-DATE DAYS).
        IF DURATION <= 0 THEN
          DISPLAY 'Expiry date, ' EXPIRY-DATE ' has passed.'
        END-IF.
```

The FIND-DURATION intrinsic function above subtracts `YYYYMMDD` from `EXPIRY-DATE`. If the date in `YYYYMMDD` becomes later than October 31, 1997, then the duration will be returned as a negative value. A duration of zero days or a negative number of days would indicate an expiry.

Assuming that the current date is November 1, 1997, the output of the above program would be:

```
Expiry date 10/31/1997 has passed.
```

Example of Calculating a Due Date: The following example shows how to calculate a due date in a date-time format:

```
01 YYYYMMDD          FORMAT DATE "@Y%m%d".
01 DATE-TIME-FORM    FORMAT DATE "%m/%d/@Y".
   .
   .
   .
    MOVE FUNCTION CURRENT-DATE(1:8) TO YYYYMMDD.
    MOVE FUNCTION ADD-DURATION (YYYYMMDD DAYS 90) TO DATE-TIME-FORM.
    DISPLAY 'Due Date: ' DATE-TIME-FORM.
```

Assuming that the current date is October 8, 1997, the output of the above program would be:

```
Due Date: 01/06/1998
```

Example of Calculating a Stale Date: To calculate if a date is so far in the past that it invalidates the dated piece (such as a cheque), you could use the SUBTRACT-DURATION intrinsic function as follows:

```
01 YYYYMMDD                    FORMAT DATE "@Y%m%d".
01 STALE-DATE                  FORMAT DATE "%m/%d/@Y".
01 cheque-date                 FORMAT DATE "%m/%d/@Y"  VALUE "03/09/1997".
   .
   .
   .
    MOVE FUNCTION CURRENT-DATE(1:8) TO YYYYMMDD.
    MOVE FUNCTION SUBTRACT-DURATION (YYYYMMDD DAYS 180) TO STALE-DATE.
    IF STALE-DATE > cheque-date THEN
       DISPLAY 'Cheque date, ' cheque-date ', is stale-dated.'
       DISPLAY 'The stale-date is: ' STALE-DATE
    END-IF.
```

Assuming that the current date is October 8, 1997, the output of the above program would be:

```
Cheque date, 03/09/1997, is stale-dated.
The stale date is: 04/11/1997
```

Formatting Dates and Times Based On Locales (LOCALE-DATE, LOCALE-TIME)

A date or time can be formatted in a culturally appropriate way by using LOCALE functions. In the example below locale object (type *LOCALE) EN_US must be created in library QSYSLOCALE before running the COBOL program. For more information about how to create a locale object, refer to “Creating Locales on the iSeries” on page 189.

The LOCALE functions take an alphanumeric item (a character string) in the format of a date, for the LOCALE-DATE intrinsic function, or in the format of a time, for the LOCALE-TIME intrinsic function and return another alphanumeric item with the date or time formatted in a culturally appropriate way.

The argument for LOCALE-DATE must be an 8-byte character string in a date format specified by the CURRENT-DATE intrinsic function. The argument for LOCALE-TIME must be an 13-byte character string in a time format specified by the CURRENT-DATE intrinsic function, positions 9 through 21.

For example:

```
SPECIAL-NAMES.
    LOCALE "EN_US" IN LIBRARY "QSYSLOCALE" IS usa.
:
DISPLAY "Date is:"  FUNCTION LOCALE-DATE("19970908" usa).
DISPLAY "Time is:"  FUNCTION LOCALE-TIME("06345200+0000" usa).
```

would display:

```
Date is:  08/09/1997
Time is:  06:34:52
```

Note: To get the above result, locale USA must be in the GMT time zone.

In the above example, argument-1 for the LOCALE-DATE function, 19970908, represents the 4-digit year, followed by the month, followed by the day of the month. Argument-1 for the LOCALE-TIME function, 06345200+0000, represents the following:

- The first six digits are the hours, followed by the minutes, followed by the seconds.
- The seventh and eighth characters are the hundredths of seconds.
- The ninth character can be a plus or minus.
- The tenth and eleventh digits are the difference in hours from Greenwich Mean Time (GMT). (These two digits are not used by the LOCALE-TIME function.)
- The 12th and 13th digits are minutes.

Fixed-Point versus Floating-Point Arithmetic

Many statements in your program might involve arithmetic. For example, each of the following COBOL statements requires some kind of arithmetic evaluation:

- General arithmetic.

  ```
  COMPUTE REPORT-MATRIX-COL = (EMP-COUNT ** .5) + 1
  ADD REPORT-MATRIX-MIN TO REPORT-MATRIX-MAX GIVING
  REPORT-MATRIX-TOT.
  ```

- Expressions and functions.

  ```
  COMPUTE REPORT-MATRIX-COL = FUNCTION SQRT(EMP-COUNT) + 1
  COMPUTE CURRENT-DAY = FUNCTION DAY-OF-INTEGER(NUMBER-OF-DAYS + 1)
  ```

- Arithmetic comparisons.

  ```
  IF REPORT-MATRIX-COL < FUNCTION SQRT(EMP-COUNT) + 1
  IF CURRENT-DAY not = FUNCTION DAY-OF-INTEGER(NUMBER-OF-DAYS + 1)
  ```

  For each arithmetic evaluation in your program—whether it is a statement, an Intrinsic Function, an expression, or some combination of these nested within each other—how you code the arithmetic determines whether it will be floating-point or fixed-point evaluation.

The following discussion explains when arithmetic and arithmetic comparisons are evaluated in fixed-point and floating-point. For details on the precision of arithmetic evaluations, see “Conversions and Precision” on page 160.

Floating-Point Evaluations

In general, if your arithmetic evaluation has either of the characteristics listed below, it will be evaluated by the compiler in floating-point arithmetic:

- An operand or result field is floating-point.

A data item is floating-point if you code it as a floating-point literal, or if you define it as USAGE COMP-1, USAGE COMP-2, or as external floating-point (USAGE DISPLAY with a floating-point PICTURE).

An operand that is a nested arithmetic expression or a reference to numeric Intrinsic Function results in floating-point when:

- An argument in an arithmetic expression results in floating-point.
- The function is a floating-point function.
- The function is a mixed-function with one or more floating-point arguments.

- It is an argument to a floating-point function.

  Functions like COS and SIN are floating-point functions that expect one argument. Since these functions are floating-point functions, the argument will be calculated in floating-point.

Fixed-Point Evaluations

In general, if your arithmetic operation contains neither of the characteristics listed above for floating-point, it will be evaluated by the compiler in fixed-point arithmetic. In other words, your arithmetic evaluations will be handled by the compiler as fixed-point only if all your operands are given in fixed-point, and your result field is defined to be fixed-point. Nested arithmetic expression and function references must represent fixed-point values.

Arithmetic Comparisons (Relation Conditions)

If your arithmetic is a comparison (contains a relational operator), then the numeric expressions being compared—whether they are data items, arithmetic expressions, function references, or some combination of these—are really operands (comparands) in the context of the entire evaluation. This is also true of abbreviated comparisons; although one comparand might not explicitly appear, both are operands in the comparison. When you use expressions that contain comparisons in ILE COBOL, the expression is evaluated as floating-point if at least one of the comparands is, or resolves to, floating-point; otherwise, the expression is calculated as fixed-point.

For example, consider the following statement:

```
IF (A + B) = C or D = (E + F)
```

In the preceding example there are two comparisons, and therefore four comparands. If any of the four comparands is a floating-point value or resolves to a floating-point value, all arithmetic in the IF statement will be done in floating-point; otherwise all arithmetic will be done in fixed-point.

In the case of the EVALUATE statement:

```
EVALUATE (A + D)
  WHEN (B + E) THRU C
  WHEN (F / G) THRU (H * I)
    .
    .
    .
END-EVALUATE.
```

An EVALUATE statement can be rewritten into an equivalent IF statement, or series of IF statements. In this example, the equivalent IF statements are:

```
if ( (A + D) >= (B + E) ) AND
   ( (A + D) <= C)
if ( (A + D) >= (F / G) ) AND
   ( (A + D) <= (H * I) )
```

Thus, following these rules for the IF statement above, each IF statement's comparands must be looked at to determine if all the arithmetic in that IF statement will be fixed-point or floating-point.

Examples of Fixed-Point and Floating-Point Evaluations

For the examples shown in "Fixed-Point versus Floating-Point Arithmetic" on page 176, if you define the data items in the following manner:

```
 01  EMPLOYEE-TABLE.
     05  EMP-COUNT           PIC  9(4).
     05  EMPLOYEE-RECORD OCCURS 1 TO 1000 TIMES
                         DEPENDING ON EMP-COUNT.
         10 HOURS             PIC +9(5)E+99.
.
.
.
01  REPORT-MATRIX-COL       PIC  9(3).
01  REPORT-MATRIX-MIN       PIC  9(3).
01  REPORT-MATRIX-MAX       PIC  9(3).
01  REPORT-MATRIX-TOT       PIC  9(3).
01  CURRENT-DAY             PIC  9(7).
01  NUMBER-OF-DAYS          PIC  9(3).
```

- These evaluations would be done in floating-point arithmetic:

```
COMPUTE REPORT-MATRIX-COL = FUNCTION SQRT(EMP-COUNT) + 1
IF REPORT-MATRIX-TOT < FUNCTION SQRT(EMP-COUNT) + 1
```

- These evaluations would be done in fixed-point arithmetic:

```
 ADD REPORT-MATRIX-MIN TO REPORT-MATRIX-MAX GIVING REPORT-MATRIX-TOT.
 IF CURRENT-DAY NOT = FUNCTION DAY-OF-INTEGER((NUMBER-OF-DAYS) + 1)
COMPUTE REPORT-MATRIX-MAX =
FUNCTION MAX(REPORT-MATRIX-MAX REPORT-MATRIX-TOT)
```

Processing Table Items

You can process alphanumeric or numeric table items using intrinsic functions as long as the table item's data description is compatible with the function's argument requirements. The *WebSphere Development Studio: ILE COBOL Reference* describes the required data formats for the arguments of the various Intrinsic Functions.

Use a subscript or index to reference an individual data item as a function argument. Assuming `TABLE-ONE` is a 3X3 array of numeric items, you can find the square root of the middle element with a statement such as:

```
COMPUTE X = FUNCTION SQRT(TABLE-ONE(2,2)).
```

Processing Multiple Table Items (ALL Subscript)

You might often need to process the data in tables iteratively. For intrinsic functions that accept multiple arguments, you can use the ALL subscript to reference all the items in the table or single dimension of the table. The iteration is handled automatically, making your code shorter and simpler.

Example 1:

This example sums a cross section of Table-Two:

```
Compute Table-Sum = FUNCTION SUM (Table-Two(ALL, 3, ALL)))
```

Assuming that Table2 is a 2x3x2 array, the above statement would cause these elements to be summed:

```
Table-Two(1,3,1)
Table-Two(1,3,2)
Table-Two(2,3,1)
Table-Two(2,3,2)
```

Example 2:

This example computes values for all employees.

```
01 Employee-Table.
05 Emp-Count Pic s9(4) usage binary.
05 Emp-Record occurs 1 to 500 times
depending on Emp-Count.
10 Emp-Name Pic x(20).
10 Emp-Idme Pic 9(9).
10 Emp-Salary Pic 9(7)v99.
.
.
Procedure Division.
Compute Max-Salary = Function Max(Emp-Salary(ALL))
Compute I = Function Ord-Max(Emp-Salary(ALL))
Compute Avg-Salary = Function Mean(Emp-Salary(ALL))
Compute Salary-Range = Function Range(Emp-Salary(ALL))
Compute Total-Payroll = Function Sum(Emp-Salary(ALL))
```

Example 3:

Scalars and array arguments can be mixed for functions that accept multiple arguments:

```
Compute Table-Median = Function Median(Arg1 Table-One(ALL))
```

What is the Year 2000 Problem?

The year 2000 problem involves using two digits to represent the year. If the date fields in your program only have the last 2 digits of the year, on 1/1/2000 the current year will be represented as 00. That means the current year will be less than the previous year because 00 is less than 99.

Century support for the 21st Century has been added to ILE COBOL. This means that if you are retrieving a year with the last 2 digits in the range of 40 – 99, the digits “19” will be added as the prefix, and you will retrieve a four-digit year in the range of 1940 – 1999. Contrastingly, if you are retrieving a year with the last 2 digits in the range of 00 – 39, the digits “20” will be added as the prefix, and you will retrieve a four-digit year in the range of 2000 – 2039.

Long-Term Solution

To take your programs through the year 9999, you must eventually:

1. Change applications to retrieve a 4-digit year instead of a 2-digit year, using one of the following methods:
   - Using the new YYYYMMDD and YYYYDDD phrases of the ACCEPT statement to obtain a 4-digit year *or*
   - Using Intrinsic Functions to get 4-digit year date (such as CURRENT-DATE, DATE-OF-INTEGER and DAY-OF-INTEGER) *or*
   - Using Integrated Language Environment callable services to get 4-digit year dates
2. Increase the size of the data items that contain dates so that they can store a 4-digit year, or change the data items into date data items that hold a 4-digit year.

3. Rebuild databases with 4-digit years.

However, there is a short-term solution that is easier.

Short-Term Solution

If you cannot change all of your applications and data before the year 2000 you can leave your data alone and change your application to interpret 2-digit years as 4-digit years. This type of technique is generally referred to as **windowing**. With this technique you can take a 2-digit year and determine a 4-digit year based on a predefined 100-year window. For example, given the window 1940 to 2039:

- A 2-digit year of 92 would be 1992
- A 2-digit year of 02 would be 2002.

There are two ways to do windowing in ILE COBOL. You can perform the windowing yourself with the aid of the ILE COBOL intrinsic functions, or you can let ILE COBOL perform the windowing by changing your numeric or character dates into date data items.

If you want to do the windowing yourself, ILE COBOL provides a set of century window Intrinsic Functions, which allow 2-digit years to be interpreted in a 100-year window (because each 2-digit number can only occur once in any 100-year period). You select the period, give the Intrinsic Function a 2-digit year, or a date or day with a two-digit year, and the Intrinsic Function will return the appropriate value with a 4-digit year in that 100-year window.

The ILE COBOL compiler provides three century window intrinsic functions: YEAR-TO-YYYY, DAY-TO-YYYYDDD, and DATE-TO-YYYYMMDD. The YEAR-TO-YYYY Intrinsic Function takes a 2-digit year and returns a 4-digit year in a specified 100-year window. The other two Intrinsic Functions take a date that contains a 2-digit year and returns a date with a 4-digit year in a specified 100-year window. For the DAY-TO-YYYYDDD Intrinsic Function, the date taken is a 5-digit number with a format like that of the ACCEPT FROM DAY statement. Similarly, the DATE-TO-YYYYMMDD Intrinsic Functions takes a 6-digit number with a format like that of the ACCEPT FROM DATE statement.

Form more information about the century window Intrinsic Functions, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

In order for ILE COBOL to perform the windowing for you, you must change your character or numeric dates into date data items. In the code fragment below there are two numeric items that represent dates. The code is going to display a message if the current date is past the expiration date.

```
 01  my-dates.
* expiration-date is year 1997, month 10, day 9
     05  expiration-date  PIC S9(6)  VALUE 971009
               USAGE PACKED-DECIMAL.
* current-date-1 is year 2002, month 8, day 5
     05  current-date-1   PIC S9(6)  VALUE 020805
               USAGE PACKED-DECIMAL.
     IF current-date-1 > expiration-date THEN
       DISPLAY "items date is past expiration date"
     END-IF.
```

In the above code even though 2002 is greater than 1997, the numeric values 020805 is not greater than 971009, so the IF will evaluate to FALSE, and the DISPLAY statement will not be run. However, by changing the numeric dates to

date data items the DISPLAY statement will run. Notice that the size (in bytes) of both expiration-date and current-date-1 has not changed:

```
  01  my-dates.
* expiration-date is year 1997, month 10, day 9
     05  expiration-date  FORMAT DATE "%y%m%d" VALUE "971009"
               USAGE PACKED-DECIMAL.
* current-date-1 is year 2002, month 8, day 5
     05  current-date-1   FORMAT DATE "%y%m%d" VALUE "020805"
               USAGE PACKED-DECIMAL.
     IF current-date-1 > expiration-date THEN
       DISPLAY "items date is past expiration date"
     END-IF.
```

Advantage of Short-Term Solution

The advantage of the short-term solution is that you need to change only a few programs, and you do not need to change your databases. This approach is cheaper, quicker, and easier than the long-term solution.

However, you can use the century window Intrinsic Functions to convert your databases or files from 2-digit year dates to 4-digit year dates. You can do this by reading in the 2-digit year dates, interpreting them to get 4-digit years, and then rewriting the data into a copy of the original that has been expanded to hold the 4-digit year data. All new data would then go into the new file or database.

Disadvantages of the Short-Term Solution

This approach buys you only a few years, depending on the application. You still must eventually change all date programs and databases.

You cannot use the century window forever because a 2-digit year can only be unique in a given 100-year period. Over time you will need more than 100 years for your data window—in fact, many companies need more than 100 years now.

The reason that the century window buys you more time is that you know in any given section of ILE COBOL code whether you are trying to figure out if a date is old (the date is in the past) or if a due date has not yet been reached (the date is in the future). You can then use this knowledge to determine how to set your century window.

There are limitations, though. For example, the century window cannot solve the problem of trying to figure out how long a customer has been with your company, if the time-span is greater than 100 years and you only have 2-digit years in your dates. Another example is sorting. All of the records that you want to sort by date must have 4-digit year dates. For these problems and others, you need to use ACCEPT statements, Intrinsic Functions, or ILE date services which return a 4-digit year.

Working with Date-Time Data Types

Items of COBOL class date-time, include date, time, and timestamp items. These items are declared with the FORMAT clause of a data description entry. For example:

```
01  group-item.
    05 date1 FORMAT DATE "%m/%d/@Y".
    05 date2 FORMAT DATE.
    05 time1 FORMAT TIME SIZE 8 LOCALE german-locale.
    05 time2 FORMAT TIME "%H:%M:%S".
    05 time3 FORMAT TIME.
    05 timestamp1 FORMAT TIMESTAMP.
```

For items of class date-time the FORMAT clause is used in place of a PICTURE clause. In the example above, after the keyword FORMAT one of the words DATE, TIME, or TIMESTAMP appears. These words identify the category of the date-time item.

Note: The words DATE and TIME are reserved words; whereas, the word TIMESTAMP is a context-sensitive word.

After the reserved word or context-sensitive word that dictates the category of the date-time item a **format literal** may appear. A format literal is a non-numeric literal that describes the format of a date or time item.

In the case of data item `date1` the `%m` stands for months, `%d` for days, and the `@Y` for year (including a 2-digit century). The `%` and `@` character begin a specifier. The three specifiers used in the format literal of `date1` are part of a set of specifiers documented in *WebSphere Development Studio: ILE COBOL Reference*. A format literal is a combination of specifiers and separators. So again looking at `date1` there are two separators, both of which are the character `/`.

In the above example each specifier has a pre-determined size. For example data item `time2` has three specifiers: `%H`, `%M`, and `%S`, which stand for hours (2 digits), minutes (2 digits), and seconds (2 digits); as well as two specifiers both of which are the character `:`. Thus the total size of `time2` is 8 characters.

Separators and specifiers may come in any order in a format literal; and must obey the following rules:

- The total size of specifiers and separators must not exceed 256 bytes.
- Separators may be of any size and can be repeated.
- Each specifier can only appear once in a format literal.
- Specifier's are restricted to certain date-time categories. For example the specifier `%H` (hours) can not be used for a date item.
- Specifier's can not overlap. For example you can not specify `@C` (single digit century) with `@Y` a year with a two digit century.

In the above example neither `date2` nor `timestamp1` have format literals specified. Items of category timestamp can not have user defined format literals; however, they do have a default format literal of `@Y-%m-%d-%H.%M.%S.@Sm`. For an item of category date or time, if a format literal is not explicitly specified in the data description entry one can be specified in the SPECIAL-NAMES paragraph. An example is shown below:

```
SPECIAL-NAMES.  FORMAT OF DATE IS "@C:%y:%j",
                FORMAT OF TIME IS "%H:%M:%S:@Sm".
```

If the above SPECIAL-NAMES paragraph had been specified in the same program as group item `group-item`, the date format of `date2` would have been `@C:%y:%j`. On the other hand, if a SPECIAL-NAMES paragraph did not exist, the format of the date item would default to ISO. An ISO date has the format `@Y-%m-%d`. The only item of category time without a format literal (implicitly or explicitly defined) is `time3`, so if the above SPECIAL-NAMES paragraph did exist, `time3` would have the time format `%H:%M:%S:@Sm`. On the other hand, if no FORMAT OF TIME clause appeared in the SPECIAL-NAMES paragraph, the format would default to ISO. An ISO time has the format %H.%M.%S.

By default when COPY DDS declares items of class date-time it generates a PICTURE clause for an alphanumeric item. In order to change the PICTURE clause into a FORMAT clause, several new CVTOPT parameter values have been defined, these are:
- *DATE
- *TIME
- *TIMESTAMP.

When *DATE has been specified, any DDS date data types are converted to COBOL date items, for example, a FORMAT clause is generated instead of a PICTURE clause.

In DDS to specify the format of a date field, the DATFMT keyword can be specified. The DATFMT keyword can also be specified on zoned, packed, and character fields. For these types of fields, COPY DDS would normally generate a PICTURE clause for a numeric zoned, numeric packed, and alphanumeric data item, respectively. You can force COPY DDS to generate a FORMAT clause for these items by specifying the *CVTTODATE value of the CVTOPT parameter.

For a list of the DATFMT parameters allowed for zoned, packed, and character DDS fields, and their equivalent ILE COBOL format that is generated from COPY DDS when the CVTOPT(*CVTTODATE) conversion parameter is specified, refer to "Class Date-Time" on page 416.

As mentioned above, the FORMAT clause of a data description entry defines an item of class date-time. This data description entry can also contain one or more of the following clauses:
- OCCURS
- REDEFINES
- RENAMES
- SYNCHRONIZED
- TYPEDEF
- USAGE
- VALUE.

This same data description entry can have one or more 88 (condition-names) associated with it. The VALUE clause of the condition-name can contain a THRU phrase. The following clauses can refer to a class date-time data description entry:
- LIKE
- REDEFINES
- RENAMES
- TYPE.

The following code fragment shows various definitions of class date-time items:

```
01  TimestampT IS TYPEDEF
         FORMAT TIMESTAMP VALUE "1997-12-01-05.52.50.000000".
01  group-item.
    05  date1 FORMAT DATE OCCURS 3 TIMES VALUE "1997-05-08".
    05  date2 FORMAT DATE "@Y-%m-%d" VALUE "2001-09-08".
    05  date3 REDEFINES date2 FORMAT DATE.
       88  date3-key-dates VALUE "1997-05-01" THRU "2002-05-01".
    05  time1 FORMAT TIME "%H:%M" VALUE "14:10".
    05  time2 LIKE time1.
    05  timestamp1 TYPE TimestampT.
```

Each of the above clauses has various rules when used with an item of class date-time.

The SYNCHRONIZED clause can be specified for a date-time item; however, it is just treated as documentation (it does not align the item).

The USAGE clause for a date-time item can be DISPLAY or PACKED-DECIMAL for a date or time item; however, timestamps can only be USAGE DISPLAY. If a date-time item has a USAGE of PACKED-DECIMAL, then the format literal must contain specifiers only (no separators) and the specifiers must result in numeric digits.

The VALUE clause for a date-time item should be a non-numeric literal in the format of the date-time item. No checks are made at compile time to verify that the format of the VALUE clause non-numeric literal matches the FORMAT clause. It is up to the programmer to make sure the VALUE clause non-numeric literal is correct.

The level 88 (condition-names) associated with a date-time item can have a THRU phrase. The VALUE clause of a level-88 item associated with a date-time item should contain a non-numeric literal whose format matches the parent item. Level-88 items used in relational conditions result in a date-time comparison.

A LIKE clause that refers to a date-time item cannot modify its size. The LIKE clause causes the new item to inherit all the attributes of the FORMAT clause, including the SIZE and LOCALE clauses.

Date-time data items can be used with the following statements, clauses, and intrinsic functions:
- MOVE
- Implicit moves in the:
  - READ INTO
  - WRITE FROM
  - REWRITE FROM
  - RETURN INTO
  - RELEASE FROM
- Relation condition
- ACCEPT (Format 2)
- DISPLAY (All formats except extended DISPLAY)
- CALL USING and CALL GIVING
- Procedure Division USING and GIVING
- As a key in the OCCURS clause
- As a key in the SORT/MERGE
- RECORD KEY clause
- Expressions using ADDRESS OF, LENGTH OF, FORMAT OF, LOCALE OF
- The following intrinsic functions:
  - ADD-DURATION
  - CONVERT-DATE-TIME
  - EXTRACT-DATE-TIME
  - FIND-DURATION
  - SUBTRACT-DURATION
  - TEST-DATE-TIME
  - LENGTH.

Date-time data types can also be used in SORT (and MERGE) operations, however, some restrictions apply. For more information about these restrictions, refer to "Date-Time Data Type Considerations" on page 407.

MOVE Considerations for Date-Time Data Items

This section describes some of the considerations for using date-time data items in the MOVE statement and, statements where there is an implicit move (READ INTO, WRITE FROM, REWRITE FROM, RETURN INTO, and RELEASE FROM), and relation conditions:

- Translation of @p (am or pm) to upper-case (AM or PM)
- Conversion of 2-digit years to 4-digit years or centuries
- Overriding the default date window using the DATTIM process statement option
- Conversion of times to microseconds
- Time Zones.

Translation of @p to Uppercase

Time items can be defined with the `@p` conversion specifier. This specifier will be replaced with either AM or PM. However, the AM and PM can be any mix of upper and lower case characters. This means that in a statement that contains both source and receivers with the `@p` conversion specifier, the source can contain a mix of upper and lower case characters, but the receiver will always be translated into upper case characters. For example:

```
01 group-item.
   05 time1 FORMAT TIME "%I:%M @p" VALUE "06:20 am".
   05 time2 LIKE time1.
   MOVE time1 TO time2.
   DISPLAY "time2 = " time2.
```

In the above code, `time1` is the source for the MOVE statement, so its `@p` specifier can be a mix of upper and lower case, in this example it is lowercase `am`. The receiver, `time2`, which has a format identical to `time1`, will contain `@p` in upper case. Thus the output of the above program would be:

```
time2 = 06:20 AM
```

Conversion of 2-Digit Years to 4-Digit Years or Centuries

When you are moving or comparing 2-digit years to 4-digit years or centuries, or comparing 4-digit years or centuries to 2-digit years, ILE COBOL first converts the 2-digit year using a windowing algorithm. The default windowing algorithm used is as follows:

- If a 2-digit year is moved to a 4-digit year, the century (1st 2 digits of the year) are chosen as follows:
  - If the 2-digit year is greater than or equal to 40, the century used is 1900. In other words, 19 becomes the first 2 digits of the 4-digit year.
  - If the 2-digit year is less than 40, the century used is 2000. In other words, 20 becomes the first 2 digits of the 4-digit year.
- If a data item with a 4-digit year or century is moved to a 2-digit year, the first 2 digits of the year (the century) are truncated. If later, the date is modified and that 2-digit year is moved back to a 4-digit year, then the algorithm just described for a 2-digit to 4-digit year move is used and inaccuracy can result. The programmer must ensure that when these types of moves are made, that inaccuracy does not result. In other words, if there is a chance that inaccuracy can result, just move 2-digit years to 2-digit years and 4-digit years to 4-digit years.

Note: When an alphanumeric data item containing a date is moved to a date-time data item, no checking or conversion is done. The programmer must ensure that the alphanumeric date being moved is in the correct format.

To show you how this works, three date moves are done in this program:

```
ID DIVISION.
PROGRAM-ID. datmoves.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SPECIAL-NAMES.
     FORMAT DATE IS '%m/%d/%y'.
DATA DIVISION.
WORKING-STORAGE SECTION.
77  date1  format date Value '07/12/39'.
77  date2  format date '@Y/%m/%d'.
77  date3  format date '%y/%m/%d'.
01  ALPHA_USA_S    PIC X(08).
PROCEDURE DIVISION.
PARA1.
     move date1 to date2.  1
     display "date2 =" date2.
*
     move date2 to date3.  2
     display "date3 =" date3.
*
     move FUNCTION ADD-DURATION (date3 YEARS 1) to date2.  3
     display "date2 =" date2.
```

The output from this program is:

```
 date2 =2039/07/12
 date3 =39/07/12
 date2 =1940/07/12
```

In move 1, `date1` (containing the value `07/12/39`) is moved to `date2`. Because `date1` contains a 2-digit year that is less than 40, and it is moved to `date2`, which has a 4-digit year, the century used is 2000 and the 4-digit year becomes `2039`.

In move 2, a 4-digit year is moved to a 2-digit year, and the century (1st 2 digits of the year) is just truncated.

In move 3, a year is added to `date3` and it is then moved back to a 4-digit year. Because the year that was added moved the 2-digit year of the date out of the 21st century, the date becomes a 20th century date and is inaccurate. This move shows you how the windowing algorithm works, and how inaccuracies can result when moving dates between 4-digit and 2-digit year formats.

Overriding the Default Date Window Using the DATTIM Process Statement Option: Sometimes you may not be able to avoid moving dates between 4-digit and 2-digit years, and you know that inaccuracy will result based on the default windowing algorithm that ILE COBOL uses. You can use the DATTIM process statement option to change the default date window.

The syntax of the DATTIM process statement is:

Syntax

4-digit base century
This must be the first argument. Defines the base century that ILE COBOL uses for its windowing algorithm. If the DATTIM process statement option is not specified, 1900 is used.

The 4-digit-base-century also affects the interpretation of the `@C` conversion specifier. The `@C` conversion specifier represents a 1-digit century, whose value ranges between 0 and 9. A 0 for a 1-digit century represents a base century of 1900, 1 = 2000, ... 9 = 2800. So, a date data item whose format is `@C/%y/%m` and whose value is `1/12/05`, represents year 2012, the first day of month 5 (May). However, 0 of @C is really equal to the 4-digit base century. Thus, a DATTIM(2200, 40) would cause 0 = 2200, 1 = 2300 ..., 9 = 3100.

2-digit base year
This must be the second argument. Defines the base year that ILE COBOL uses for its windowing algorithm. If the DATTIM process statement option is not specified, 40 is used.

The default DATTIM(1900, 40) results in a 100-year window of 1940 through 2039. To solve the problem encountered in our previous example, we could set the DATTIM option in either of the following ways:

- Specifying DATTIM(1900 70) would result in a 100-year window of 1970 through 2069
- If we assume that all 2-digit years are in the 21st century we could specify DATTIM(2000 00), which would result in a 100-year window of 2000 through 2099.

Given either of these options on a PROCESS statement in the previous example, the output would be:

```
date2 =2039/07/12
date3 =39/07/12
date2 =2040/07/12
```

The only change in the output is the result of move **3** . If you remember from the previous example, the output was `date2 =1940/07/12`, which was an inaccurate result from moving an updated 2-digit date to a 4-digit date based on the default ILE COBOL windowing algorithm (base century of 1900 and base year of 40).

Performance Considerations for Date-Time Relational Conditions: When a date-time item is or compared to another date-time item in ILE COBOL, it is first stripped of all separators and converted to ISO format (no separators). The two date-time items are then compared, digit by digit. In the case of a date to date comparison, both dates are converted to `@Y%m%d` and then compared. Times would be converted to `%H%M%S`, and then compared. This means that to get the best performance for date-time compares, date-time items should be in ISO format.

Performance Considerations for Date-Time MOVEs: The format of a date-time item affects the amount of time a date-time move will take to complete. The three basic formats in order of best to worst performance are:

1. A date-time item whose format is equivalent to an iSeries DDS supported date, time, or timestamp format. Within this group, ISO formats are generally the best.
2. A non-locale based date-time item whose format is not part of 1.
3. A locale-based date-time item.

Conversion of Times to Microseconds

A time data item can contain one or more specifiers that contain fractions of a second. The four conversion specifiers that hold fractions of a second are:

@Sh Hundredths of a second

@Sm Millionths of a second (microseconds)

@So Thousandths of a second (milliseconds)

@St Tenths of a second

For example, a time data item might have the format `%H:%M:%S @So/@Sm`.

If there are two time data items and one is moved to the other, the specifiers that hold fractions of a second in the sending data item are all converted to one number, representing the number of microseconds. The microseconds are then converted to the appropriate fractions of a second in the receiving time data item.

Time Zones: Category time and timestamp data items are affected by time zones. ILE COBOLretrieves time zone information from the iSeries system value QUTCOFFSET (Coordinated Universal Time Offset, also known as Greenwich Mean Time offset), and from LC_TOD locale category. A time data item associated with a locale uses the time zone in the tzdiff keyword of the LC_TOD locale category. A time data item which is not associated with a locale and a timestamp data item are assumed to be in the time zone of the iSeries system. That is, in the time zone specified by the QUTCOFFSET system value.

So, for example:

```
SPECIAL-NAMES.
     LOCALE "EN_US" IN LIBRARY "QSYSLOCALE" IS USA.

⋮
01 GROUP-ITEM.
   05 SYSTEM-TIME-1 FORMAT TIME "%H:%M:%S" VALUE "14:32:10".
   05 LOCALE-TIME-1 FORMAT TIME SIZE 8 IS LOCALE USA.

⋮
   MOVE SYSTEM-TIME-1 TO LOCALE-TIME-1.
```

The locale source for EN_US that is shipped with an iSeries system has a default tzdiff value of 0. However, this can be changed by the user by copying the locale source to a different source physical file. In the MOVE statement above, the data item `SYSTEM-TIME-1` is not associated with any locale, so its time zone is dictated by the QUTCOFFSET system value. The data item `LOCALE-TIME-1` is associated with locale `EN_US` in library `QSYSLOCALE`. This means that its time zone is dictated by the LC_TOD locale category of this locale. During the MOVE statement, the resulting time in `LOCALE-TIME-1` will be adjusted by the difference in the time zones between `SYSTEM-TIME-1` and `LOCALE-TIME-1`.

ILE COBOL does not take into consideration Daylight Savings Time. To accommodate this, you would have to update the Coordinated Universal Time Offset in the LC_TOD locale category and in QUTCOFFSET to account for this time difference.

Other intrinsic functions that take time zones into consideration are: FIND-DURATION, LOCALE-TIME, and CONVERT-DATE-TIME.

Working With Locales

A **locale** identifies formatting information that is culturally specific. For a specific cultural region, this information describes the valid alphabetic characters, collating sequence, number formats and currency amounts, and date and time formats.

Locale information is grouped into locale categories that control specific aspects of the runtime of a program. These locale categories are:

Locale-Category Name	Behavior Affected
LC_CTYPE	Defines character types, such as upper-case, lower-case, space, digit, and punctuation. Affects the behavior of locale-based numeric-edited, date, and time items, as well as locale-based intrinsic functions.
LC_COLLATE	Defines the collating sequence.
LC_TIME	Defines the date and time conventions, such as calendar used, time zone, and days of the week. Affects the behavior of date and time data items whose format is based on a locale, and intrinsic functions that return date and time items.
LC_NUMERIC	Defines numeric formats.
LC_MONETARY	Defines the monetary names, symbols, punctuation, and other details. Affects locale-based numeric-edited items.
LC_MESSAGES	Defines the format for informative and diagnostic messages, and interactive responses.
LC_TOD	Defines time zone difference, time zone name, and Daylight Savings Time start and end (iSeries-specific). It also affects the behavior of locale-based time data items, intrinsic functions that return time items, and intrinsic functions that format times based on locales.
LC_ALL	All locale categories, including all of those previously defined in this list. This category may include categories and cultural elements not used by ILE COBOL.

The locale categories LC_MESSAGES, LC_COLLATE, and LC_NUMERIC are not used directly by ILE COBOL. However, these categories can be SET and queried, in order that applications can use it.

Creating Locales on the iSeries

On the iSeries system, *LOCALE objects are created with the CRTLOCALE command, specifying the name of the file member containing the locale's definition source, and the CCSID to be used for mapping the characters of the locale's character set to their hexadecimal values.

A locale definition source member contains information about a language environment. This information is divided into a number of distinct categories which are described in the previous section. One locale definition source member characterizes one language environment.

Characters are represented in a locale definition source member with their symbolic names. The mapping between the symbolic names, the characters they represent and their associated hexadecimal values are based on the CCSID value specified on the CRTLOCALE command. The locale definition source members can be found on the AS/400 system in library QSYSLOCALE.

For more information about how locales of type *LOCALE are created, see "Using Coded Character Set Identifiers" on page 16.

Setting a Current Locale for Your Application

All ILE COBOL applications running on the AS/400 and using locales of type *LOCALE have a current locale that is scoped to the activation group of the program. The current locale determines the behavior of locale-based numeric-edited, locale-based date and time data items, and locale intrinsic functions, that do not specify a locale mnemonic-name. The current locale can be set explicitly using the SET LOCALE statement. See the *WebSphere Development Studio: ILE COBOL Reference* for more information on using the SET LOCALE statement.

If the current locale is not set explicitly using SET LOCALE, it is implicitly set by the ILE COBOL runtime at program activation time. This is the same default locale that you can set using the DEFAULT keyword in Format 8 of the SET statement. Here is how the ILE COBOL runtime sets the current locale when a program is activated:

- If the user profile has a value for the LOCALE parameter other than *NONE (the default) or *SYSVAL, that value will be used for the application's current locale.
- If the value of the LOCALE parameter in the user profile is *NONE, the default ILE COBOL locale will become the current locale.
- If the value of the LOCALE parameter in the user profile is *SYSVAL, the locale associated with the system value QLOCALE will be used for the program's current locale.
- If the value of QLOCALE is *NONE, the default ILE COBOL locale will become the current locale.

The current locale used by ILE COBOL is shared with ILE C compiler and ILE C++ compiler. This means that the ILE C compiler setlocale function that changes the current locale for ILE C compiler programs also affects the current locale for ILE COBOL programs, and the other way around.

For more information about how locales of type *LOCALE are enabled, see "Using Coded Character Set Identifiers" on page 16.

Identification and Scope of Locales

The times at which a locale is identified, and the scope of its effect after being identified are:

- When a run unit is activated, the default locale is identified and remains the current locale for that run unit until it is changed within the run unit by a SET statement. After the locale has been changed from the default, the default can be made the current locale again by using the DEFAULT keyword in Format 8 of the SET statement.
- For the LOCALE-DATE and LOCALE-TIME intrinsic functions, the current locale is identified at the beginning of each statement that references any of these functions, and is used for the evaluation of the function during that statement. For more information about these intrinsic functions, refer to the *WebSphere Development Studio: ILE COBOL Reference*.
- When a LOCALE phrase is used in a PICTURE clause or a FORMAT clause, and the mnemonic-name-1 is *not* specified, the current locale is identified once at the start of each statement that edits or de-edits the data item.

Note: Switching locales between the editing and de-editing of a given data item can result in unpredictable behavior. You are responsible for ensuring that the locale used for de-editing is the same as the locale used for editing.

- When a LOCALE phrase is used in a PICTURE clause or a FORMAT clause, and mnemonic-name-1 *is* specified, the current locale is the one associated with the mnemonic-name in the SPECIAL-NAMES paragraph. It must be identified anytime before the first reference in a source unit to a data item requiring its use. Its scope is that source unit.
- For a SET statement, the locale specified in the FROM phrase becomes the current locale for the run unit, until it is changed again by another SET statement.

LC_MONETARY Locale Category

In ILE COBOL, there is a subset of PICTURE-editing symbols for locale-based numeric-edited data items that correspond to definitions that can be made in the LC_MONETARY locale category. These symbols are: `9`, `.`, `$`, and `cs` (currency symbol). For more information about these locale-based PICTURE-editing symbols, refer to the *WebSphere Development Studio: ILE COBOL Reference*. This section describes the LC_MONETARY locale category and relates each of the ILE COBOL locale-based PICTURE-editing symbols to the keywords used to define this locale category.

The LC_MONETARY category of a locale definition source file defines rules and symbols for formatting monetary numeric information. This category begins with an LC_MONETARY category header and ends with an END LC_MONETARY category trailer.

All operands for the LC_MONETARY category keywords are defined as string or integer values. String values are bounded by double-quotation marks (""). All values are separated from the keyword they define by one or more spaces. Two adjacent double-quotation marks indicate an undefined string value. A -1 indicates an undefined integer value. The following keywords are recognized in the LC_MONETARY category:

int_curr_symbol
Specifies the string used for the international currency symbol. The operand for the int_curr_symbol keyword is a four-character string. The first three characters contain the alphabetic international-currency symbol. The fourth character specifies a character separator between the international currency symbol and a monetary quantity. Specifies the string used for the local currency symbol. This keyword is not used by ILE COBOL.

currency_symbol
Specifies the string used for the local currency symbol. In ILE COBOL, this keyword is used along with several other keywords to format the `cs` locale-based PICTURE-editing symbol. Refer to "p_cs_precedes", "p_sep_by_space", "n_cs_precedes", and "n_sep_by_space".

mon_decimal_point
Specifies the string used for the decimal delimiter used to format monetary quantities. In ILE COBOL, this corresponds to the `.` locale-based PICTURE-editing symbol.

mon_thousands_sep
Specifies the string used for grouping digits to the left of the decimal delimiter in formatted monetary quantities.

mon_grouping

Defines the size of each group of digits in formatted monetary quantities. The operand for the mon_grouping keyword consists of a sequence of semicolon-separated integers. Each integer specifies the number of digits in a group. The initial integer defines the size of the group immediately to the left of the decimal delimiter. The following integers define succeeding groups to the left of the previous group. If the last digit is not -1, subsequent grouping is performed using the previous digit. If the last digit is -1, grouping is only performed for the number of groups specified.

The following is an example of the interpretation of the mon_grouping keyword. Assuming the value to be formatted is 123456789 and the operand for the mon_thousands_sep keyword is comma (,), the following results occur:

mon_grouping Value	Formatted Value
3;-1	123456,789
3	123,456,789
3;2	12,34,56,789
3;2;-1	134,56,789

positive_sign

Specifies the string used to indicate a nonnegative-valued formatted monetary quantity. In ILE COBOL, this corresponds to the + locale-based PICTURE-editing symbol.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the + locale-based PICTURE-editing symbol. Refer to ″negative_sign″, ″p_sign_posn″, and ″n_sign_posn″.

negative_sign

Specifies the string used to indicate a negative-valued formatted monetary quantity.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the + locale-based PICTURE-editing symbol. Refer to ″positive_sign″, ″p_sign_posn″, and ″n_sign_posn″.

int_frac_digits

Specifies an integer value representing the number of fractional digits (those after the decimal delimiter) to be displayed in a formatted monetary quantity using the int_curr_symbol value. This keyword is not used by ILE COBOL.

frac_digits

Specifies an integer value representing the number of fractional digits (those after the decimal delimiter) to be displayed in a formatted monetary quantity using the currency_symbol value. This keyword is not used by ILE COBOL.

p_cs_precedes

Specifies an integer value indicating whether the int_curr_symbol or currency_symbol string precedes or follows the value for a non-negative formatted monetary quantity. The following integer values are recognized:

0 Indicates that the currency symbol follows the monetary quantity.

1 Indicates that the currency symbol precedes the monetary quantity.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the cs locale-based PICTURE-editing symbol. Refer to ″currency_symbol″, ″p_sep_by_space″, ″n_cs_precedes″, and ″n_sep_by_space″.

p_sep_by_space
Specifies an integer value indicating whether the int_curr_symbol or currency_symbol string is separated by a space from a non-negative formatted monetary quantity. The following integer values are recognized:

0 Indicates that no space separates the currency symbol from the monetary quantity.

1 Indicates that a space separates the currency symbol from the monetary quantity.

2 Indicates that a space separates the currency symbol and the positive_sign string, if adjacent.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the cs locale-based PICTURE-editing symbol. Refer to″currency_symbol″, ″p_cs_precedes″, ″n_cs_precedes″, and ″n_sep_by_space″.

n_cs_precedes
Specifies an integer value indicating whether the int_curr_symbol or currency_symbol string precedes or follows the value for a negative formatted monetary quantity. The following integer values are recognized:

0 Indicates that the currency symbol follows the monetary quantity.

1 Indicates that the currency symbol precedes the monetary quantity.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the cs locale-based PICTURE-editing symbol. Refer to ″currency_symbol″, ″p_cs_precedes″, ″p_sep_by_space″, and ″n_sep_by_space″.

n_sep_by_space
Specifies an integer value indicating whether the int_curr_symbol or currency_symbol string is separated by a space from a negative formatted monetary quantity. The following integer values are recognized:

0 Indicates that no space separates the currency symbol from the monetary quantity.

1 Indicates that a space separates the currency symbol from the monetary quantity.

2 Indicates that a space separates the currency symbol and the negative_sign string, if adjacent.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the cs locale-based PICTURE-editing symbol. Refer to ″currency_symbol″, ″p_cs_precedes″, ″p_sep_by_space″, and ″n_cs_precedes″.

p_sign_posn
Specifies an integer value indicating the positioning of the positive_sign string for a non-negative formatted monetary quantity. The following integer values are recognized:

0 Indicates that parenthesis enclose both the monetary quantity and the int_curr_symbol or currency_symbol string.

1 Indicates that the positive_sign string precedes the quantity and the int_curr_symbol or currency_symbol string.

2 Indicates that the positive_sign string follows the quantity and the int_curr_symbol or currency_symbol string.

3 Indicates that the positive_sign string immediately precedes the int_curr_symbol or currency_symbol string.

4 Indicates that the positive_sign string immediately follows the int_curr_symbol or currency_symbol string.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the + locale-based PICTURE-editing symbol. Refer to ″positive_sign″, ″negative_sign″, and ″n_sign_posn″.

n_sign_posn
Specifies an integer value indicating the positioning of the negative_sign string for a negative formatted monetary quantity. The following integer values are recognized:

0 Indicates that parenthesis enclose both the monetary quantity and the int_curr_symbol or currency_symbol string.

1 Indicates that the negative_sign string precedes the quantity and the int_curr_symbol or currency_symbol string.

2 Indicates that the negative_sign string follows the quantity and the int_curr_symbol or currency_symbol string.

3 Indicates that the negative_sign string immediately precedes the int_curr_symbol or currency_symbol string.

4 Indicates that the negative_sign string immediately follows the int_curr_symbol or currency_symbol string.

Note: In ILE COBOL, this keyword is used along with several other keywords to format the + locale-based PICTURE-editing symbol. Refer to ″positive_sign″, ″negative_sign″, and ″p_sign_posn″.

Producing Unique Monetary Formats—Example

A unique customized monetary format can be produced by changing the value of a single statement. For example, the following table shows the results of using all combinations of defined values for the p_cs_precedes, p_sep_by_space, and p_sign_posn statements:

Table 10. Results of Various Locale Variable Value Combinations

		p_sep_by_space		
		2	**1**	**0**
p_cs_precedes = 1	p_sign_posn = 0	($1.25)	($ 1.25)	($1.25)
	p_sign_posn = 1	+ $1.25	+$ 1.25	+$1.25
	p_sign_posn = 2	$1.25 +	$ 1.25+	$1.25+
	p_sign_posn = 3	+ $1.25	+$ 1.25	+$1.25
	p_sign_posn = 4	$ +1.25	$+ 1.25	$+1.25

Table 10. Results of Various Locale Variable Value Combinations (continued)

		p_sep_by_space		
		2	**1**	**0**
p_cs_precedes = 0	p_sign_posn = 0	(1.25 $)	(1.25 $)	(1.25$)
	p_sign_posn = 1	+1.25 $	+1.25 $	+1.25$
	p_sign_posn = 2	1.25$ +	1.25 $+	1.25$+
	p_sign_posn = 3	1.25+ $	1.25 +$	1.25+$
	p_sign_posn = 4	1.25$ +	1.25 $+	1.25$+

LC_MONETARY—Example

The following is an example of the LC_MONETARY category listed in a locale definition source file:

```
LC_MONETARY
#
int_curr_symbol    "<U><S><D>"
currency_symbol    "<dollar-sign>"
mon_decimal_point  "<period>"
mon_thousands_sep  "<comma>"
mon_grouping       3;-1
positive_sign      "<plus-sign>"
negative_sign      "<hyphen>"
int_frac_digits    2
frac_digits        2
p_cs_precedes      1
p_sep_by_space     2
n_cs_precedes      1
n_sep_by_space     2
p_sign_posn        3
n_sign_posn        3
#
END LC_MONETARY
```

LC_TIME Category

In ILE COBOL the LC_TIME category is used to format date and time items that are based on a locale. Like other locale categories, LC_TIME consists of a series of keywords followed by their operands. The LC_TIME keyword ″d_fmt″ specifies the format of locale based date data items. The LC_TIME keyword ″t_fmt″ specifies the format of locale based time data items.

The following section gives a more detailed description of all the LC_TIME category keywords, including those not currently used by ILE COBOL. The descriptions below mention several conversion specifiers such as %a and %c that are currently not supported by ILE COBOL.

The LC_TIME category of a locale definition source file defines rules and symbols for formatting time and date information. This category begins with an LC_TIME category header and terminates with an END LC_TIME category trailer.

All operands for the LC_TIME category keywords are defined as string or integer values. String values are bounded by double quotation marks (""). All values are separated from the keyword they define by one or more spaces. Two adjacent double quotation marks indicate an undefined string value. A -1 indicates an undefined integer value. Field descriptors are used by commands and subroutines that query the LC_TIME category to represent elements of time and date formats. The following keywords are recognized in the LC_TIME category:

abday Defines the abbreviated weekday names corresponding to the %a field descriptor. Recognized values consist of seven semicolon-separated strings. The first string corresponds to the abbreviated name for the first day of the week (Sun), the second to the abbreviated name for the second day of the week, and so on.

day Defines the full spelling of the weekday names corresponding to the %A field descriptor. Recognized values consist of seven semicolon-separated strings. The first string corresponds to the full spelling of the name of the first day of the week (Sunday), the second to the name of the second day of the week, and so on. This keyword is not used by ILE COBOL.

abmon
Defines the abbreviated month names corresponding to the %b field descriptor. Recognized values consist of 12 semicolon-separated strings. The first string corresponds to the abbreviated name for the first month of the year (Jan), the second to the abbreviated name for the second month of the year, and so on. This keyword is not used by ILE COBOL.

mon Defines the full spelling of the month names corresponding to the %B field descriptor. Recognized values consist of 12 semicolon-separated strings. The first string corresponds to the full spelling of the name for the first month of the year (January), the second to the full spelling of the name for the second month of the year, and so on. This keyword is not used by ILE COBOL.

d_t_fmt
Defines the string used for the standard date and time format corresponding to the %c field descriptor. The string can contain any combination of characters, field descriptors, or escape sequences. This keyword is not used by ILE COBOL.

d_fmt Defines the string used for the standard date format corresponding to the %x field descriptor. The string can contain any combination of characters, field descriptors, or escape sequences. Following is an example of how the d_fmt keyword can be constructed:

%D The %D indicates a %m/%d/%y date format.

%d-%m-%y

%m/%d/%Y

t_fmt Defines the string used for the standard time format corresponding to the %X field descriptor. The string can contain any combination of characters, field descriptors, or escape sequences. Following is an example of how the t_fmt keyword can be constructed:

%H:%M:%S

%H.%M.%S

am_pm
Defines the strings used to represent ante meridian (before noon) and post meridian (after noon) corresponding to the %p field descriptor. Recognized values consist of two strings separated by a ; (semicolon). The first string corresponds to the ante meridian designation, the last string to the post meridian designation.

t_fmt_ampm
Defines the string used for the standard 12-hour time format that includes an am_pm value (%p field descriptor). This statement corresponds to the

%r field descriptor. The string can contain any combination of characters and field descriptors. This keyword is not used by ILE COBOL.

era Defines how the years are counted and displayed for each era in a locale, corresponding to the %E field descriptor modifier. For each era, there must be one string in the following format:

```
direction:offset:start_date:end_date:era_name:era_format
```

This keyword is not used by ILE COBOL.

The variables for the era-string format are defined as follows:

direction
Specifies a - (minus sign) or + (plus sign) character. The plus character indicates that years count in the positive direction when moving from the start date to the end date. The minus character indicates that years count in the negative direction when moving from the start date to the end date.

offset Specifies a number representing the first year of the era.

start_date
Specifies the starting date of the era in the yyyy/mm/dd format, where yyyy, mm, and dd are the year, month, and day, respectively. Years prior to the year AD 1 are represented as negative numbers. For example, an era beginning March 5th in the year 100 BC would be represented as -100/03/05.

end_date
Specifies the ending date of the era in the same form used for the start_date variable or one of the two special values -* or +*. A -* value indicates that the ending date of the era extends backward to the beginning of time. A +* value indicates that the ending date of the era extends forward to the end of time. Therefore, the ending date can be chronologically before or after the starting date of the era. For example, the strings for the Christian eras AD and BC would be entered as follows:

```
+:0:0000/01/01:+*:AD:%o %N
+:1:-0001/12/31:-*:BC:%o %N
```

era_name
Specifies a string representing the name of the era that is substituted for the %EC field descriptor.

era_format
Specifies a string for formatting the %EY field descriptor.

An **era** value consists of one string for each era. If more than one era was specified, each era string is separated by a ; (semicolon).

era_d_fmt
Defines the string used to represent the date in alternate-era format corresponding to the %Ex field descriptor. The string can contain any combination of characters and field descriptors.

era_t_fmt
Defines the string used to represent the time in alternate-era format corresponding to the %EX field descriptor. The string can contain any combination of characters and field descriptors.

era_d_t_fmt
Defines the string used to represent the date and time in alternate-era format corresponding to the %Ec field descriptor. The string can contain any combination of characters and field descriptors.

alt_digits
Defines alternate strings for digits corresponding to the %O field descriptor. Recognized values consist of a group of strings separated by ; (semicolons). The first string represents the alternate string for zero, the second string represents the alternate string for one, and so on. A maximum of 100 alternate strings can be specified.

Escape Sequences

The following are escape sequences allowed for the d_t_fmt, d_fmt, and t_fmt keyword values:

**** Represents the backslash character.

\a Represents the alert character.

\b Represents the backspace character.

\f Represents the form-feed character.

\n Represents the newline character.

\r Represents the carriage-return character.

\t Represents the tab character.

\v Represents the vertical-tab character.

LC_TIME Example

The following is an example of a LC_TIME category in a locale definition source file:

```
LC_TIME
#
#Abbreviated weekday names (%a)
abday   "<S><u><n>";"<M><o><n>";"<T><u><e>";"<W><e><d>";\
        "<T><h><u>";"<F><r><i>";"<S><a><t>"
#
#Full weekday names (%A)
day     "<S><u><n><d><a><y>";"<M><o><n><d><a><y>";\
        "<T><u><e><s><d><a><y>";"<W><e><d><n><e><s><d><a><y>";\
        "<T><h><u><r><s><d><a><y>";"<F><r><i><d><a><y>";\
        "<S><a><t><u><r><d><a><y>"
#
#Abbreviated month names (%b)
abmon   "<J><a><n>";"<F><e><b>";"<M><a><r>";"<A><p><r>";\
        "<M><a><y>";"<J><u><n>";"<J><u><l>";"<A><u><g>";\
        "<S><e><p>";"<O><c><t>";"<N><o><v>";"<D><e><c>"
#
#Full month names (%B)
mon     "<J><a><n><u><a><r><y>";"<F><e><b><r><u><a><r><y>";\
        "<M><a><r><c><h>";"<A><p><r><i><l>";"<M><a><y>";\
        "<J><u><n><e>";"<J><u><l><y>";"<A><u><g><u><s><t>";\
        "<S><e><p><t><e><m><b><e><r>";"<O><c><t><o><b><e><r>";\
        "<N><o><v><e><m><b><e><r>";"<D><e><c><e><m><b><e><r>"
#
#Date and time format (%c)
d_t_fmt "%a_%bf%d %H:%M:%S %Y"
#
#Date format (%x)
d_fmt   "%m/%d/%y"
#
#Time format (%X)
```

```
t_fmt   "%H:%M:%S"
#
#Equivalent of AM/PM (%p)
am_pm   "<A><M>";"<P><M>"
#
#12-hour time format (%r)
t_fmt_ampm   "%I:%M:%Sm%p"
#
era     "+:0:0000/01/01:+*:AD:%EC";\
        "+:1:-0001/12/31:-*:BC:%Ey";
era_d_fmt  ""
alt_digits    "<0><t><h>";"<1><s><t>";"<2><n><d>";"<3><r><d>";\
              "<4><t><h>";"<5><t><h>";"<6><t><h>";"<7><t><h>";\
              "<8><t><h>";"<9><t><h>";"<1><0><t><h>"
#
END LC_TIME
```

LC_TOD Category

In ILE COBOL, the LC_TOD locale category dictates the timezone for a locale based time item. In particular the tzdiff keyword specifies the difference between the local time and Greenwich mean time. This information is used when moving or comparing a locale based time item to another time (locale or non-locale based). The tzdiff keyword is the only LC_TOD keyword currently used by ILE COBOL.

The LC_TOD category defines the rules used to define the start and end time of daylight savings time, the difference between local time and Greenwich Mean time, the time zone name, and the daylight savings time name. This category is an IBM extension and must appear after all other category definitions in the source file.

All the operands for the LC_TOD category are defined as string or integer values. String values are bounded by double-quotation marks (""). All values are separated from the keyword they define by one or more spaces. Two adjacent double-quotation marks indicate an undefined string value. A 0 (zero) indicates an undefined integer value. The following keywords are recognized in the LC_TOD category.

tzdiff Specifies an integer value representing the time zone difference in minutes. It is the difference between the local time and Greenwich mean time.

tname Specifies the string used for the time zone name.

dstname
Specifies the string used for the daylight savings time name.

dststart
Specifies a set of four integers representing the start date for the daylight savings time. The operand for the dststart keyword consists of a sequence of four comma-separated integers in the following format:

```
month,week,day,time
```

The variables for the dststart format are defined as:

month Specifies an integer value representing the month of the year when Daylight Savings Time (DST) takes effect. This value ranges from 1 to 12, with 1 corresponding to January, and 12 corresponding to December.

week Specifies an integer value representing the week of the month when DST takes effect. This value ranges from -4 to 4, with -4 corresponding to the fourth week of the month counting from the

end of the month and 4 corresponding to the fourth week of the month counting from the beginning of the month.

day Specifies an integer value representing the day of the month when DST takes effect or if the week keyword is not 0 (zero), then this is the day of the week when DST takes effect. This value ranges from 1 to the last day of the month or 1 to the last day of the week.

time Specifies an integer value representing the number of seconds after 12 midnight, local standard time, when DST takes effect. This value ranges from 0 to 86399.

dstend

Specifies a set of four integers representing the end date for the daylight savings time. The operand for the dstend keyword consists of a sequence of four comma-separated integers in the following format:

```
month,week,day,time
```

The variables for the dstend format are defined as:

month Specifies an integer value representing the month of the year when Daylight Savings Time (DST) ends. This value ranges from 1 to 12, with 1 corresponding to January, and 12 corresponding to December.

week Specifies an integer value representing the week of the month when DST ends. This value ranges from -4 to 4, with -4 corresponding to the fourth week of the month counting from the end of the month and 4 corresponding to the fourth week of the month counting from the beginning of the month.

day Specifies an integer value representing the day of the month when DST ends or if the week keyword is not 0 (zero), then this is the day of the week when DST ends. This value ranges from 1 to the last day of the month or 1 to the last day of the week.

time Specifies an integer value representing the number of seconds after 12 midnight, local standard time, when DST takes effect. This value ranges from 0 to 86399.

dstshift

Specifies an integer value representing the daylight savings time shift in seconds.

LC_TOD Example

The following is an example of a LC_TOD category in a locale definition source file:

```
LC_TOD
#
tzdiff    360
tname     "<C><e><n><t><r><a><l>"
dstname   "<P><D><T>"
#Set daylight savings time to start on 3rd week of October at
#midnight on Saturday.
dststart  10,3,6,0
#Set daylight savings time to end on April 23, at midnight.
dstend    4,0,23,0
dstshift  3600
#
END LC_TOD
```

Chapter 9. Calling and Sharing Data Between ILE COBOL Programs

Sometimes an application is simple enough to be coded as a single, self-sufficient program. In many cases, however, an application's solution will consist of several, separately compiled programs used together.

The OS/400 system provides communication between ILE COBOL programs, and between ILE COBOL and non-ILE COBOL programs.

This chapter describes:

- Various methods used to call another ILE COBOL program
- How control is transferred back to the calling program once the called program has finished running
- How to pass data between the calling program and called program
- How to cancel an ILE COBOL program.

Run Time Concepts

A program object is created from one or more module objects. Each program object has one and only one module object designated as the main entry point when the program object is activated. When a module object is created by the ILE COBOL compiler,a PEP is generated which calls the outermost ILE COBOL program contained in the compilation unit. When you bind multiple module objects together to create a program object, you must specify which module object contains the PEP of the program object being created. You do this by identifying the module object in the ENTMOD parameter of the CRTPGM command. The PEP of this module object becomes the PEP for the program object.

When a program object is activated using a dynamic program call, the PEP is given control. The PEP then calls the UEP which is the outermost ILE COBOL program in the module object that is to be performed first. Refer to the *ILE Concepts* book for a discussion on PEPs and UEPs.

Activation and Activation Groups

The process of getting a program object or service program ready to run is called **activation**. Activation is done by the system when a program object is called. Because service programs are not called in their entirety, they are activated during the call to a program object that directly or indirectly requires their services. ILE procedures within service programs are called using static procedure calls; they cannot be called using dynamic program calls.

Activation does the following functions:

- It uniquely allocates the static data needed by the program object or service program
- It changes the symbolic links to used service programs into links to physical addresses.

When activation allocates the storage necessary for the static variables used by a program object, the space is allocated from an **activation group**. Each activation

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group has a name. The name of the activation group is supplied by the user (or by the system when *NEW is specified). You can specify, at the time the program object or service program is created using CRTPGM or CRTSRVPGM, the activation group in which the program object or service program is to be activated. Refer to *ILE Concepts* for a more detailed discussion on activation and activation groups.

COBOL Run Unit

A COBOL **run unit** is a set of one or more programs that function as a unit at run time to provide a problem solution. A COBOL run unit is an independent entity that can be executed without communicating with, or being coordinated with, any other run unit except that it can process data files and messages or set and test switches that are used by other run units. A run unit can also contain program objects and service programs created from module objects that are created from the compilation of programs written in languages other than ILE COBOL.

In ILE, a COBOL run unit is composed of program objects and service programs that all run in a single ILE activation group. To preserve OPM COBOL/400 compatible run unit semantics, your ILE COBOL application must meet the following conditions:

- Each ILE COBOL compilation unit must be compiled and then bound into a single program object.
- All run unit participants (ILE COBOL or other ILE programs/procedures) must run in a single ILE activation group.

  Note: You should use a named ILE activation group in which to run your application in order to properly maintain COBOL run unit semantics. By using a named ILE activation group for all participating program objects, you need not specify a particular ILE COBOL program object to be the main program before your application is run.

  On the other hand, if a particular ILE COBOL program object is known to be main program before your application is run, you can specify the *NEW attribute for the ACTGRP option when creating a *PGM object using the ILE COBOL program as the UEP. All other participating program objects should specify the *CALLER attribute for the ACTGRP option.
- The oldest invocation of the ILE activation group (corresponding to the run unit) must be that of ILE COBOL. This is the main program of the run unit.

If these conditions are not met, there may be a control boundary that binds the scope of the STOP RUN so that the state of the entire application is not refreshed.

Note: The above condition dictates that an ILE COBOL program running in the *DFTACTGRP is generally run in a run unit that is not compatible with an OPM COBOL/400 run unit.

Control Boundaries

All ILE languages, including ILE COBOL, use a common mechanism called the **call stack** for transferring control to and from called ILE procedures or OPM program objects. The call stack consists of a last-in, first-out list of call stack entries, one entry for each called ILE procedure or program object. Each call stack entry has

information about the automatic variables for the ILE procedure, and other resources scoped to the call stack entry such as condition handlers and cancel handlers.

In ILE COBOL, each ILE COBOL program or nested program that is called has one call stack entry. Each declarative that is called also has its own call stack entry.

A call adds a new entry on the stack for the called ILE procedure or OPM program object and passes control to the called object. A return removes the call stack entry and passes control back to the called ILE procedure or program object in the previous call stack entry.

In ILE, you can create an application that runs program objects in multiple activation groups. You can call an ILE COBOL program object that is running in a different activation group from that of the calling program. In this case, the call stack entry for the called program object is known as a **control boundary**. A control boundary is defined as any ILE call stack entry for which the immediately preceding call stack entry is for an ILE procedure or program object in a different activation group. An ILE call stack entry for which the immediately preceding call stack entry is for an OPM program object is also a control boundary.

If the called program object is the first program object to be activated in a particular activation group, then its call stack entry is known as a **hard control boundary**. If the called program object, which is a control boundary, is not the first program object to be activated in an activation group, then its call stack entry is known as a **soft control boundary**. The main program of a run unit that is compatible with and OPM COBOL/400 run unit is found at the hard control boundary of the activation group.

When a STOP RUN statement (or a GOBACK statement in a main ILE COBOL program) is encountered in a called ILE COBOL program, control is transferred to the caller of the control boundary. In a run unit that is compatible with an OPM COBOL/400 run unit, STOP RUN will end the run unit.

An implicit COMMIT operation is performed on files under commitment control if commitment control is scoped to the activation group and the activation ends normally with no errors closing the files. A ROLLBACK operation is performed if the activation group ends abnormally or there are errors closing the files. Nothing happens if commitment control is scoped to the job.

The control boundary is also where an unhandled error is turned into a function check. When the function check is again unhandled, then, at the control boundary, it will be changed to the generic ILE failure condition, CEE9901, and sent to the caller of the control boundary.

Main Programs and Subprograms

The first program in the activation group to be activated begins the COBOL run unit, and is the **main program**. The main program is at the hard control boundary of the activation group. No specific source statements or options identify an ILE COBOL program as a main program or a subprogram.

A **subprogram** is a program in the run unit below the main program in the call stack. For more information about program stacks and other terms concerning interprogram communication, see the *CL Programming* manual.

Initialization of Storage

The first time an ILE COBOL program in a run unit is called, its storage is initialized. Storage is initialized again under the following conditions:

- The PROGRAM-ID paragraph of the ILE COBOL program possesses the INITIAL clause. Storage is reinitialized each time the program is called.
- The run unit is ended, then reinitiated.
- The program is canceled (using the CANCEL statement for ILE COBOL) and then called again.
- The end of section-name and paragraph-name branching addresses (set by previous PERFORM statements) are always re-initialized each time the program is called.

Transferring Control to Another Program

In the Procedure Division, a program can call another program (generally called a subprogram in COBOL terms), and this called program may itself call another program. The program that calls another program is referred to as the **calling** program, and the program it calls is referred to as the **called** program.

The called ILE COBOL program starts running at the top of the non-declarative part of the Procedure Division. If a called ILE COBOL program does not have a Procedure Division or does not have a non-declarative part in the Procedure Division, it will simply return to the calling ILE COBOL program.

When the called program processing is completed, the program can either transfer control back to the calling program or end the run unit. The run unit is ended after STOP RUN is issued and the nearest control boundary is a hard control boundary. If the nearest control boundary is a soft control boundary, then control returns to the caller of the control boundary but the run unit remains active.

A called program must not directly or indirectly call its caller (such as program X calling program Y; program Y calling program Z; and program Z then calling program X). This is called a **recursive** call. ILE COBOL does **not** allow recursion in
non-recursive main programs or subprograms. Recursive calls are only allowed if you code the RECURSIVE clause on the recursively invoked program's PROGRAM-ID paragraph. If you try to recursively call a COBOL program that does not have the RECURSIVE clause coded on its PROGRAM-ID paragraph, a
run time error message is generated.

Calling an ILE COBOL Program

To call another ILE COBOL program, you can use one of the following methods:

- Calls to nested programs
- Static procedure calls
- Dynamic program calls.

Calls to nested programs allow you to create applications using structured programming techniques. They can also be used in place of PERFORM procedures to prevent unintentional modification of data items. Calls to nested programs can be made using either the CALL *literal* or CALL *identifier* statement. For more information on nested programs, see "Calling Nested Programs" on page 207.

A **static procedure call** transfers control to a called ILE COBOL program that is bound by copy or by reference into the same program object as the calling ILE

COBOL program. Static procedure calls can be made using the CALL *literal* or CALL *procedure-pointer* statements. A static procedure call can be used to call any of the following:

- An ILE procedure within the same module object
- A nested ILE COBOL program (using CALL *literal*)
- An ILE procedure in a separate module object that has been bound to the calling ILE COBOL program
- An ILE procedure in a separate service program.

A **dynamic program call** transfers control to a called ILE COBOL program that has been bound into a separate program object from the calling ILE COBOL program. The called ILE COBOL program must be the UEP of the program object. Only the ILE COBOL program that is the UEP of the program object can be called from another ILE COBOL program that is in a different program object. ILE COBOL programs, other than the one designated as the UEP, are only visible within the program object. With a dynamic program call, the called program object is activated the first time it is called within the activation group. Dynamic program calls can be made using the CALL *literal*, CALL *identifier*, or CALL *procedure-pointer-data-item* statements. Use the SET *procedure-pointer-data-item* TO ENTRY *program-object-name* statement to set the *procedure-pointer-data-item* before using the CALL *procedure-pointer-data-item* statement.

For additional information on static procedure calls and dynamic program calls, see "Using Static Procedure Calls and Dynamic Program Calls" on page 210.

Identifying the Linkage Type of Called Programs and Procedures

When calling another ILE COBOL program that is not in the same module object as the calling program and the call is made through a CALL *literal* statement, you must specify whether the called program is an ILE program object or an ILE procedure.

You identify whether you are calling a program object or a procedure by specifying the linkage type of the call.

The LINKAGE type of call can be specified explicitly or it can be forced by specifying a phrase that is associated with a particular linkage. For example, the IN LIBRARY phrase forces a call to be a LINKAGE program. In the instances where there is not a phrase that forces a linkage, there are three ways to explicitly specify a linkage. They are listed in order of precedence:

1. The LINKAGE phrase of the CALL, CANCEL, or SET...ENTRY statements
   - To call or cancel a program object, specify LINKAGE TYPE IS PROGRAM in the CALL, CANCEL, or SET...ENTRY statement.

```
PROCEDURE DIVISION.
.
.
.
    CALL LINKAGE TYPE IS PROGRAM literal-1
.
.
.
    CALL LINKAGE PROGRAM literal-2 IN LIBRARY literal-3
.
.
.
    CANCEL LINKAGE PROGRAM literal-2 IN LIBRARY literal-3
```

```
⋮
            CANCEL LINKAGE TYPE IS PROGRAM literal-1
```

- To call or cancel a procedure, specify LINKAGE TYPE IS PROCEDURE in the CALL, CANCEL statement, or SET...ENTRY statement. The IN LIBRARY phrase cannot be specified for a CALL, CANCEL, or a SET statement with a LINKAGE TYPE IS PROCEDURE phrase. The IN LIBRARY phrase is used to specify an OS/400 library name for a program object (*PGM).

```
       PROCEDURE DIVISION.

⋮
            CALL LINKAGE TYPE IS PROCEDURE literal-1

⋮
            CANCEL LINKAGE TYPE IS PROCEDURE literal-1
```

2. The LINKAGE TYPE clause of the SPECIAL-NAMES paragraph
   - To call or cancel a program object, specify LINKAGE TYPE IS PROGRAM FOR *literal-1* in the SPECIAL-NAMES paragraph where *literal-1* is the name of the program object you are calling. You do not need to specify the LINKAGE TYPE keyword with the CALL, CANCEL, or SET...ENTRY statement when the linkage has been defined in the SPECIAL-NAMES paragraph.

```
      ENVIRONMENT DIVISION.
        CONFIGURATION SECTION.

⋮
        SPECIAL-NAMES.
            LINKAGE TYPE IS PROGRAM FOR literal-1.

⋮
        PROCEDURE DIVISION.

⋮
            CALL literal-1.

⋮
            CANCEL literal-1.
```

   - To call or cancel a procedure, specify LINKAGE TYPE IS PROCEDURE FOR *literal-1* in the SPECIAL-NAMES paragraph where *literal-1* is the name of the procedure you are calling. You do not need to specify the LINKAGE TYPE phrase with the CALL, CANCEL, or SET...ENTRY statement. When the linkage has been defined in the SPECIAL-NAMES paragraph.

```
      ENVIRONMENT DIVISION.
        CONFIGURATION SECTION.

⋮
        SPECIAL-NAMES.
            LINKAGE TYPE IS PROCEDURE FOR literal-1.

⋮
        PROCEDURE DIVISION.

⋮
            CALL literal-1.

⋮
            CANCEL literal-1.
```

3. the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands, or the associated PROCESS statement option.
   - The LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands allows you to specify, at compile time, the linkage type for all external CALL *literal-1*, CANCEL *literal-1*, or SET *procedure-pointer-data-item* TO ENTRY *literal-1* statements in the ILE COBOL program. You do not need to specify the LINKAGE TYPE clause in the SPECIAL-NAMES paragraph or the LINKAGE TYPE phrase with the CALL, CANCEL, or SET...ENTRY statement when the linkage has been defined by the LINKLIT parameter of CRTCBLMOD or CRTBNDCBL.
   - To create a module that calls program objects, type:

     ```
     CRTCBLMOD MODULE(MYLIB/XMPLE1)
     SRCFILE(MYLIB/QCBLLESRC)  SRCMBR(XMPLE1)
     LINKLIT(*PGM)
     ```

   - To create a module which calls procedures, type:

     ```
     CRTCBLMOD MODULE(MYLIB/XMPLE1)
     SRCFILE(MYLIB/QCBLLESRC)  SRCMBR(XMPLE1)
     LINKLIT(*PRC)
     ```

   - You code the CALL and CANCEL statements as follows when using the LINKLIT parameter of CRTCBLMOD to specify linkage type:

     ```
             PROCEDURE DIVISION.

     ⋮
                  CALL literal-1.

     ⋮
                  CANCEL literal-1.
     ```

Calling Nested Programs

Nested programs give you a method to create modular functions for your application and maintain structured programming techniques. Nested programs allow you to define multiple separate functions, each with its own controlled scope, within a single compilation unit. They can be used like PERFORM procedures with the additional ability to protect **local** data items.

Nested programs are contained in the same module as their calling program when they are compiled. Therefore, nested programs always run in the same activation group as their calling programs.

Structure of Nested Programs

An ILE COBOL program may **contain** other ILE COBOL programs. The **contained** programs may themselves contain yet other programs. A contained program may be **directly** or **indirectly** contained within a program.

Figure 51 on page 208 describes a nested program structure with directly and indirectly contained programs.

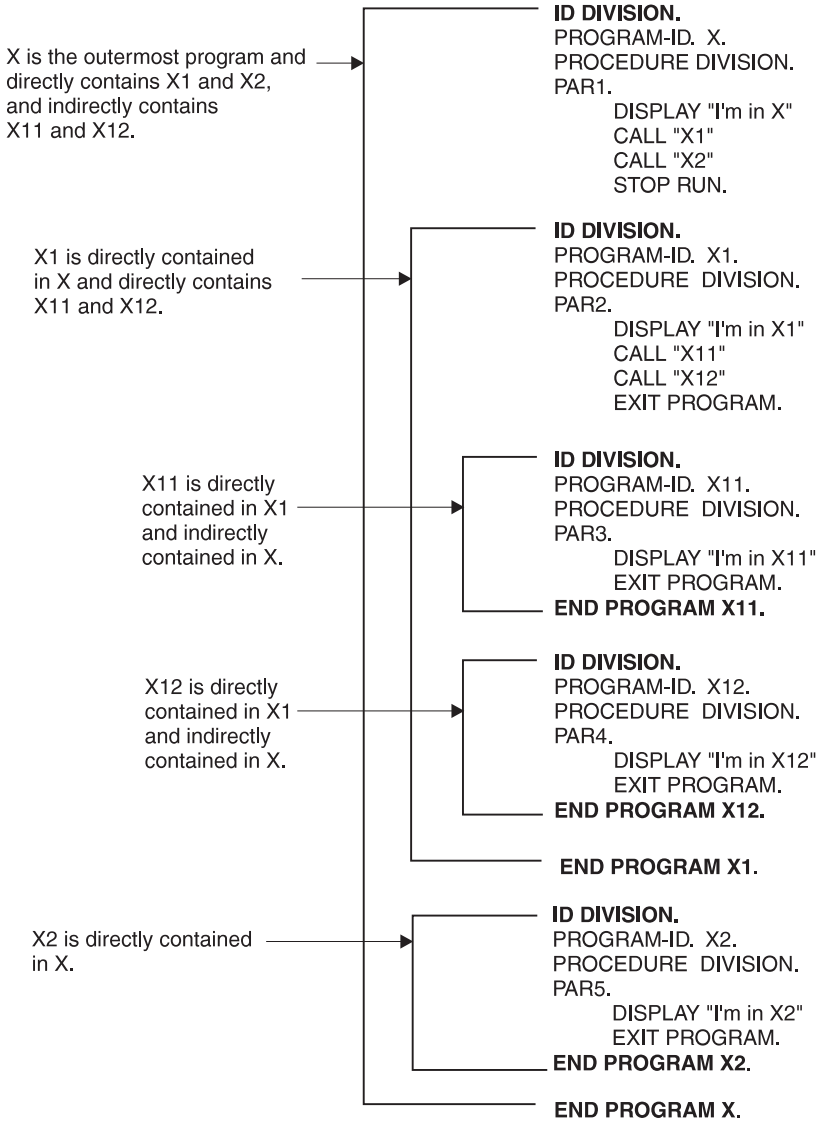

Figure 51. Nested Program Structure with Directly and Indirectly Contained Programs

Conventions for Using Nested Program Structure

There are several conventions that apply when using nested program structures.

1. The Identification Division is required in each program. All other divisions are optional.
2. Program name in the PROGRAM-ID paragraph must be unique.
3. Names of nested programs can be any valid COBOL word or a nonnumeric literal.
4. Nested programs can not have a Configuration Section. The outermost program must specify any Configuration Section options that may be required.
5. Each nested program is included in the containing program immediately before its END PROGRAM header (see Figure 51).
6. Each ILE COBOL program must be terminated by an END PROGRAM header.
7. Nested programs can only be called or canceled from an ILE COBOL program in the same module object.

8. Calls to nested programs can only be made using either a CALL *literal* or CALL *identifier* statement. Calls to nested programs cannot be made using CALL *procedure-pointer*. Calls to nested programs follow the same rules as static procedure calls.

Calling Hierarchy for Nested Programs

A nested program may only be called by its directly containing program, unless the nested program is identified as COMMON in its PROGRAM-ID paragraph. In that case, the COMMON program may also be called by any program that is contained (directly or indirectly) within the same program as the one directly containing the COMMON program. Recursive calls are only allowed for nested programs that have the RECURSIVE clause, or when the nested program's direct or indirect containing program has the RECURSIVE clause.

Figure 52 shows the outline of a nested structure with some contained programs identified as COMMON.

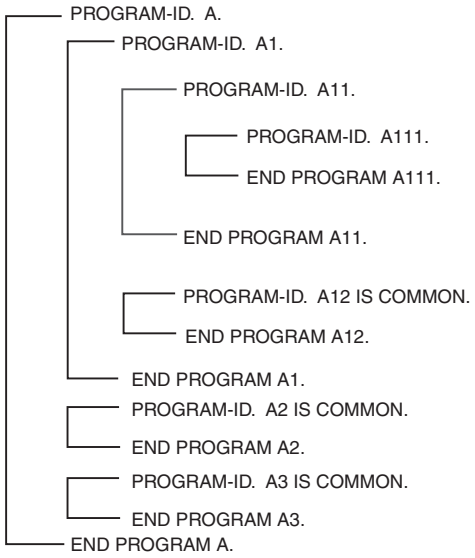

Figure 52. Nested Program Structure with Directly and Indirectly Contained Programs

The following table describes the **calling hierarchy** for the structure that is shown in Figure 52. Notice that A12, A2, and A3 are identified as COMMON and the resulting differences in calls associated with them.

Table 11. Calling Hierarchy for Nested Structures with COMMON Programs

This Program	Can call these programs	And can be called by these programs
A	A1, A2, A3	None
A1	A11, A12, A2, A3	A
A11	A111, A12, A2, A3	A1
A111	A12, A2, A3	A11
A12	A2, A3	A1, A11, A111
A2	A3	A, A1, A11, A111, A12, A3
A3	A2	A, A1, A11, A111, A12, A2

You should note that:

- A2 cannot call A1 because A1 is not COMMON and is not directly contained in A2
- A111 cannot call A11 because that would be a recursive call, unless A11, or A1, or A has a RECURSIVE clause in its PROGRAM-ID paragraph.
- A1 can call A2 because A2 is COMMON
- A1 can call A3 because A3 is COMMON.

Scope of Names within a Nested Structure

There are two classes of names within nested structures—**local** and **global**. The class will determine whether a name is known beyond the scope of the program which declares it.

Local Names: Names are local unless declared to be GLOBAL (except the program name). These local names are not visible or accessible to any program outside of the one where they were declared; this includes both contained and containing programs.

Global Names: A name that is specified as global (by using the GLOBAL clause) is visible and accessible to the program in which it is declared, and to all the programs that are directly and indirectly contained within the program. This allows the contained programs to share common data and files from the containing program, simply by referencing the name of the item.

Any item that is subordinate to the global item (including condition names and indexes) is automatically global.

The same name may be declared with the GLOBAL clause multiple times, providing that each declaration occurs in a different program. Be aware that masking, or hiding, a name within a nested structure is possible by having the same name occur within different programs of the same containing structure.

Searching for Name Declarations: When a name is referenced within a program, a search is made to locate the declaration for that name. The search begins within the program that contains the reference and continues **outward** to containing programs until a match is found. The search follows this process:

1. Declarations within the program are searched first.
2. If no match is found, then **only** global declarations are searched in successive outer containing programs.
3. The search ends when the first matching name is found, otherwise an error exists if no match is found.

Using Static Procedure Calls and Dynamic Program Calls

The following discussion applies to separately compiled subprograms only, not to nested programs. For information about calls within a nested program structure, see “Calling Nested Programs” on page 207.

The binding process differs, depending on whether your ILE COBOL program uses static procedure calls or dynamic program calls. When a static procedure call is used to call an ILE COBOL subprogram, it must first be compiled into a module object and then bound, by copy or by reference, into the same program object as the calling ILE COBOL program. When a dynamic program call is used to call an ILE COBOL subprogram, the ILE COBOL subprogram must be compiled and bound as a separate program object. For more information on the binding process, see the *ILE Concepts* book.

Static procedure calls offer performance advantages over dynamic program calls.

When an ILE COBOL subprogram is called using a static procedure call, it is already activated, since it is bound in the same program object as the calling program, and it is performed immediately upon receiving control from the calling ILE COBOL program.

When an ILE COBOL subprogram is called using a dynamic program call, many other tasks may need to be performed before the called ILE COBOL program is actually performed. These tasks include the following:

- If the activation group in which the called ILE COBOL program is to be activated does not exist, it must first be created before the called ILE COBOL program can be activated in it.
- If the called ILE COBOL program has not been previously activated, it must first be activated before it can be performed. Activating the called ILE COBOL program also implies activating all service programs bound (directly or indirectly) to it. Activation involves performing the following functions:
  - Uniquely allocating the static data needed by the program object or service program
  - changing the symbolic links to used service programs into links to physical addresses.

Thus, a dynamic program call is slower than a static procedure call due to the cost of activation the first time it is performed in an activation group.

Dynamic program calls and static procedure calls also differ in the number of operands that can be passed from the calling ILE COBOL program to the called ILE COBOL program. You can pass up to 255 operands using a dynamic program call. With a static procedure call, you can pass up to 400 operands.

Arguments that are designated as OMITTED or as having associated operational descriptors can only be passed using a static procedure call. These arguments cannot be passed using dynamic program calls.

Performing Static Procedure Calls using CALL literal

You can perform a static procedure call by using the CALL *literal* statement (where *literal* is the name of a subprogram). There are three ways to specify that the call is to be a static procedure call. They are listed in order of precedence:

Note: The IN LIBRARY phrase is incompatible with a static procedure call.

1. Use the LINKAGE phrase of the CALL statement.
   - You specify LINKAGE TYPE IS PROCEDURE in the CALL statement to ensure that the called program will be invoked using a static procedure call.

```
PROCEDURE DIVISION.
⋮
    CALL LINKAGE TYPE IS PROCEDURE literal-1
```

2. Use the LINKAGE TYPE clause of the SPECIAL-NAMES paragraph.
   - You specify LINKAGE TYPE IS PROCEDURE FOR *literal-1* in the SPECIAL-NAMES paragraph where *literal-1* is the name of the ILE COBOL program you are calling. You do not need to specify the LINKAGE TYPE phrase with the CALL statement when the linkage has been specified in the SPECIAL-NAMES paragraph.

```
       ENVIRONMENT DIVISION.
         CONFIGURATION SECTION.

  ⋮
         SPECIAL-NAMES.
              LINKAGE TYPE IS PROCEDURE FOR literal-1.

  ⋮
         PROCEDURE DIVISION.

  ⋮
              CALL literal-1.
```

3. Use the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands, or the associated PROCESS statement option.
   - You specify *PRC with the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands, at compile time, to indicate that static procedure calls are to take place for all external CALL *literal-1* statements in the ILE COBOL program. You do not need to specify the LINKAGE TYPE clause in the SPECIAL-NAMES paragraph or the LINKAGE TYPE phrase with the CALL or CANCEL statement when the linkage has been defined by the LINKLIT parameter of CRTCBLMOD.

     ```
     CRTCBLMOD MODULE(MYLIB/XMPLE1)
     SRCFILE(MYLIB/QCBLLESRC)  SRCMBR(XMPLE1)
     LINKLIT(*PRC)
     ```

   - You code the CALL statements as follows when using the LINKLIT parameter of CRTCBLMOD to specify linkage type:

     ```
         PROCEDURE DIVISION.

     ⋮
              CALL literal-1.
     ```

Performing Dynamic Program Calls using CALL literal

You can perform a dynamic program call by using the CALL *literal* statement (where *literal* is the name of a subprogram) or the CALL *identifier* statement. Refer to "Using CALL identifier" on page 213 for more information about CALL *identifier*. There are three ways, using CALL *literal*, to specify that the call is to be a dynamic program call. They are listed in order of precedence:

1. Use the LINKAGE phrase of the CALL statement.
   - You specify LINKAGE TYPE IS PROGRAM in the CALL statement to ensure that the called program will be invoked using a dynamic program call.

     ```
         PROCEDURE DIVISION.

     ⋮
              CALL LINKAGE TYPE IS PROGRAM literal-1
     ```

2. Use the LINKAGE TYPE clause of the SPECIAL-NAMES paragraph.
   - You specify LINKAGE TYPE IS PROGRAM FOR *literal-1* in the SPECIAL-NAMES paragraph where *literal-1* is the name of the ILE COBOL program you are calling. You do not need to specify the LINKAGE TYPE phrase with the CALL statement when the linkage has been specified in the SPECIAL-NAMES paragraph.

     ```
       ENVIRONMENT DIVISION.
         CONFIGURATION SECTION.

     ⋮
         SPECIAL-NAMES.
              LINKAGE TYPE IS PROGRAM FOR literal-1.
     ```

```
⋮
        PROCEDURE DIVISION.
⋮
             CALL literal-1.
```

3. Use the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands, or the associated PROCESS statement option.
   - You specify *PGM with the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands, at compile time, to indicate that dynamic program calls are to take place for all external CALL *literal-1* statements in the ILE COBOL program. You do not need to specify the LINKAGE TYPE clause in the SPECIAL-NAMES paragraph or the LINKAGE TYPE phrase with the CALL or CANCEL statement when the linkage has been defined by the LINKLIT parameter of CRTCBLMOD.

     ```
     CRTCBLMOD MODULE(MYLIB/XMPLE1)
     SRCFILE(MYLIB/QCBLLESRC)  SRCMBR(XMPLE1)
     LINKLIT(*PGM)
     ```

   - You code the CALL statements as follows when using the LINKLIT parameter of CRTCBLMOD to specify linkage type:

     ```
             PROCEDURE DIVISION.
     ⋮
                  CALL literal-1.
     ```

A dynamic program call activates the subprogram at run time. Use a dynamic call statement when:

- You want to simplify maintenance tasks and take advantage of code re-usability.

  When a subprogram is changed, all module objects, except for service programs, that call it statically and are bound by copy must be re-bound. If they are bound by reference, they do not need to be re-bound provided that the interface between the subprogram and the module objects is unchanged. If the changed subprogram is called dynamically, then only the changed subprogram needs to be re-bound. Thus, dynamic calls make it easier to maintain one copy of a subprogram with a minimum amount of binding.
- The subprograms called with the CALL *literal* are used infrequently or are very large.

  If the subprograms are called only on a few conditions, dynamic calls can activate the subprograms only when needed.

  If the subprograms are very large or there are many of them, use of static calls might require a larger working set size in main storage.

Using CALL identifier

You can use CALL *identifier* (where *identifier* is not a procedure-pointer) to call a nested ILE COBOL program or to call a program object. The contents of the identifier determine, at run time, whether a nested program is called or a program object is called. If the contents of the identifier match the name of a visible nested program, then the call is directed to the nested program. Otherwise, a dynamic program call is made to a program object with the name specified in the contents of the identifier.

An IN LIBRARY phrase specified on a CALL identifier forces the call to be to a program object.

An open pointer that associates a CALL identifier (and any associated IN LIBRARY item) with an object is set the first time you use the identifier in a CALL statement.

If you carry out a call by an identifier to a program object that you subsequently delete or rename, you must use the CANCEL statement to null the open pointer associated with the identifier. This ensures that when you next use the identifier to call your program object, the associated open pointer will be set again.

The following example shows how to apply the CANCEL statement to an identifier:

```
MOVE "ABCD" TO IDENT-1.
CALL IDENT-1.
CANCEL IDENT-1.
```

If you apply the CANCEL statement directly to the literal "ABCD", you do *not* null the open pointer associated with IDENT-1. Instead, you can continue to call program ABCD simply by using IDENT-1 in your CALL statement.

The value of the open pointer also changes if you change the value of the CALL identifier and perform a call using this new value. The value of the open pointer is also affected by any associated IN LIBRARY item. If a different library is specified for a CALL to IDENT-1 than on a previous call to IDENT-1, the open pointer is reset.

Using CALL procedure-pointer

You can perform a static procedure call or a dynamic program call using the CALL *procedure-pointer* statement.

Before using the CALL *procedure-pointer* statement, you must set the *procedure-pointer* data item to an address value. The *procedure-pointer* data item can be set to the outermost COBOL program (an ILE procedure), an ILE procedure in another compilation unit, or a program object. You use the Format 6 SET Statement to set the value of the *procedure-pointer* data item.

You specify LINKAGE TYPE IS PROCEDURE in the SET statement to set the *procedure-pointer* data item to an ILE procedure.

You specify LINKAGE TYPE IS PROGRAM in the SET statement to set the *procedure-pointer* data item to a program object.

You can also use the LINKAGE TYPE clause of the SPECIAL-NAMES paragraph or the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands to determine the type of the object to which the *procedure-pointer* data item is set. Refer to “Identifying the Linkage Type of Called Programs and Procedures” on page 205 for more information on setting the linkage type using the LINKAGE TYPE clause of the SPECIAL-NAMES paragraph or the LINKLIT parameter of the CRTCBLMOD and CRTBNDCBL commands.

You code the SET statement and CALL statement as follows when using CALL *procedure-pointer* to perform a static procedure call:

```
        PROCEDURE DIVISION.
⋮
             SET procedure-pointer
                 TO ENTRY LINKAGE TYPE IS PROCEDURE literal-1.
```

```
           ⋮
                    CALL procedure-pointer.
```

You code the SET statement and CALL statement as follows when using CALL *procedure-pointer* to perform a dynamic program call:

```
           PROCEDURE DIVISION.

           ⋮
                    SET procedure-pointer
                        TO ENTRY LINKAGE TYPE IS PROGRAM literal-1.

           ⋮
                    CALL procedure-pointer.
```

Using Recursive Calls

Code the RECURSIVE clause on the PROGRAM-ID clause so your program can be recursively reentered while a previous invocation is still active. Below is an example of how you could use the RECURSIVE clause to make a program a recursive program, and how a Local-Storage Section data item can be used in a recursive program.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               MYLIB/FACTORIAL          ISERIES    03/09/15 17:25:51        Page      2
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID. FACTORIAL RECURSIVE.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600    SOURCE-COMPUTER. IBM-ISERIES.
    6     000700    OBJECT-COMPUTER. IBM-ISERIES.
          000800
    7     000900 DATA DIVISION.
    8     001000 WORKING-STORAGE SECTION.
    9     001100 01 NUMB PIC 9(4) VALUE 5.
   10     001200 01 FACT PIC 9(8) VALUE 0.
          001300
   11     001400 LOCAL-STORAGE SECTION.
   12     001500 01 NUM PIC 9(4).
          001600
   13     001700 PROCEDURE DIVISION.
   14     001800     MOVE NUMB TO NUM.
   15     001900     IF NUMB = 0
   16     002000         MOVE 1 TO FACT
          002100     ELSE
   17     002200         SUBTRACT 1 FROM NUMB
   18     002300         CALL "FACTORIAL"
   19     002400         MULTIPLY NUM BY FACT
          002500     END-IF.
   20     002600     DISPLAY NUM "! = " FACT.
   21     002700     GOBACK.
   22     002800 END PROGRAM FACTORIAL.
                       * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 53. Example of a recursive call to calculate the factorial of a number

Returning from an ILE COBOL Program

You can issue a STOP RUN, EXIT PROGRAM, or GOBACK statement to return control from a called ILE COBOL program.

You must know if an ILE COBOL program is a main program or a subprogram to determine how control is returned from a called program when an error occurs, or a program ends. See “Main Programs and Subprograms” on page 203 for a description of main programs and subprograms.

Returning from a Main Program

To return control from a main program, you use either STOP RUN, GOBACK, or EXIT PROGRAM with the CONTINUE phrase. The STOP RUN and GOBACK statements end the run unit, and control is returned to the caller of the main program. EXIT PROGRAM without the CONTINUE phrase cannot be used to return control from a main program. When EXIT PROGRAM without the CONTINUE phrase is encountered in a main program, no operation is performed and processing continues at the next statement in the main program.

Returning from a *NEW Activation Group

When the STOP RUN, GOBACK, or an EXIT PROGRAM with the CONTINUE phrase are performed from a called main ILE COBOL program in a *NEW activation group, the activation group is ended when control is returned to the calling program. The activation group will close all files and return all resources] back to the system.

As a result of the activation group ending, the called ILE COBOL program is placed in its initial state.

Returning from a Named Activation Group

When an EXIT PROGRAM with the CONTINUE phrase is performed from a called main ILE COBOL program in a named activation group, the activation group remains active and control is returned to the calling program. All files and resources in the activation group are left in their last used state.

When the STOP RUN or GOBACK statements are performed from a called main ILE COBOL program in a named activation group, the activation group is ended when control is returned to the calling program. The activation group will close all files and return all resources back to the system.

Returning from the Default (*DFTACTGRP) Activation Group

When the STOP RUN or GOBACK statements are performed from a called main ILE COBOL program in the default (*DFTACTGRP) activation group, the activation group remains active and control is returned to the calling program. All files and resources used in the activation group are left in their last used state.

Returning from a Subprogram

To return control from a subprogram, the subprogram may end with an EXIT PROGRAM, a GOBACK, or a STOP RUN statement. If the subprogram ends with an EXIT PROGRAM or a GOBACK statement, control returns to its immediate caller without ending the run unit. An implicit EXIT PROGRAM statement is generated if there is no next executable statement in a called program. If the subprogram ends with a STOP RUN statement, all programs in the run unit up to the nearest control boundary are ended, and control returns to the program prior to the control boundary.

A subprogram is usually left in its **last-used state** when it ends with EXIT PROGRAM or GOBACK. The next time it is called in the run unit, its internal values will be as they were left, except that all PERFORM statements are considered to be complete and will be reset to their initial values. In contrast, a main program is initialized each time it is called. There are two exceptions:

- A subprogram that is dynamically called and then canceled will be in the initial state the next time it is called.
- A program, which has the INITIAL clause specified in its PROGRAM-ID paragraph, will be in the initial state each time it is called.

Maintaining OPM COBOL/400 Run Unit Defined STOP RUN Semantics

To have the STOP RUN statement behave in a manner which is compatible with an OPM COBOL/400 run unit, your ILE COBOL application must be created using specific conditions. Refer to "COBOL Run Unit" on page 202 for a description of these conditions.

Examples of Returning from an ILE COBOL Program

The following examples illustrate the behavior of EXIT PROGRAM, STOP RUN, and GOBACK in various combinations of Named, *NEW, and *DFTACTGP activation groups.

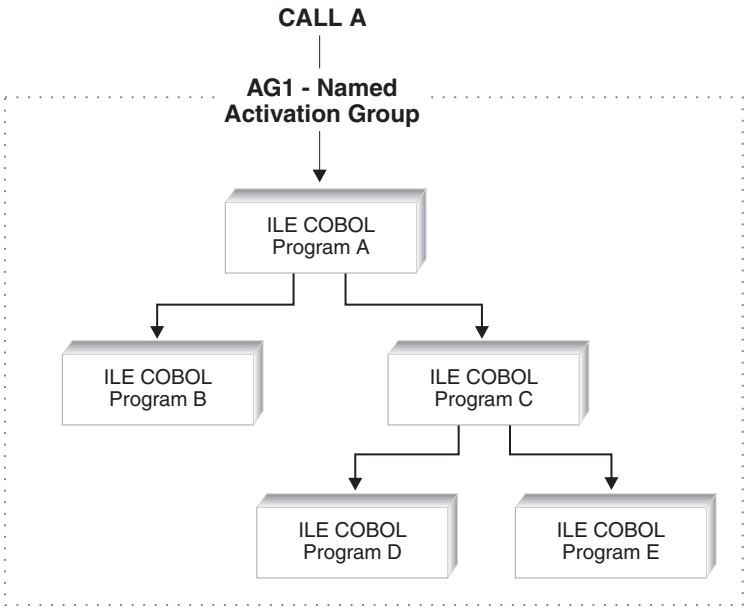

Figure 54. Example of EXIT PROGRAM, STOP RUN, and GOBACK behavior in a Single Named Activation Group

Statement	Program A	Program B	Program C	Program D	Program E
EXIT PROGRAM	1	4	4	2	2
STOP RUN	3	3	3	3	3
GOBACK	3	4	4	2	2

1 No operation is processed if an EXIT PROGRAM without the CONTINUE phrase is coded because the statement is in a main program. Processing continues with the next statement in the program. An EXIT PROGRAM with the CONTINUE phrase returns control to the caller of Program A, and leaves the activation group active. All files and resources used in the activation group are left in their last used state.

2 The activation group remains active and control is returned to Program C. All files and resources used in the activation group are left in their last used state.

3 The activation group is ended and control is returned to the caller of the main program. The activation group will close all files scoped to the activation group. Any pending commit operations scoped to the activation

group will be implicitly committed. All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

4 The activation group remains active and control is returned to Program A. All files and resources used in the activation group are left in their last used state.

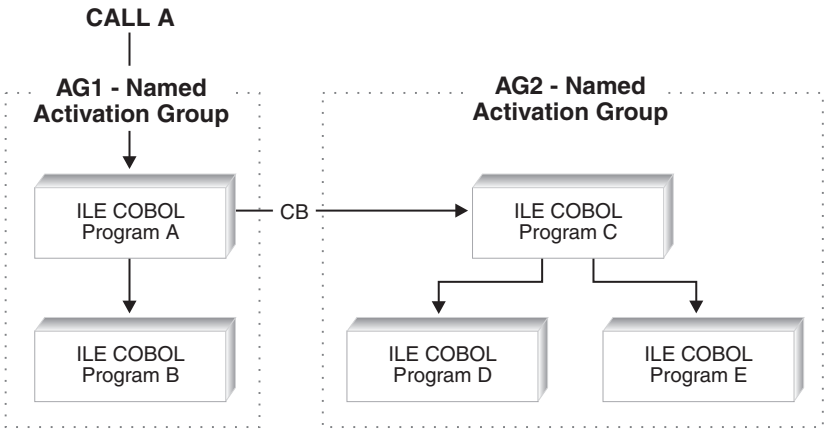

Figure 55. Example of EXIT PROGRAM, STOP RUN, and GOBACK behavior in Two Named Activation Groups

Statement	Program A	Program B	Program C	Program D	Program E
EXIT PROGRAM	1	5	1	2	2
STOP RUN	3	3	4	4	4
GOBACK	3	5	4	2	2

1 If an EXIT PROGRAM statement without the CONTINUE phrase was used, no operation is processed because the statement is in a main program. Processing continues with the next statement in the program. If an EXIT PROGRAM statement with the CONTINUE phrase was used, the activation group remains active and control is returned to the calling program or command. All files and resources used in the activation group are left in their last used state.

2 The activation group remains active and control is returned to Program C. All files and resources used in the activation group are left in their last used state.

3 The activation group is ended and control is returned to the caller of the main program. The activation group will close all files scoped to the activation group. Any pending commit operations scoped to the activation group will be implicitly committed. All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

4 The activation group is ended and control is returned to Program A. The activation group will close all files scoped to the activation group. Any pending commit operations scoped to the activation group will be implicitly committed. All resources allocated to the activation group will be

returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

5 The activation group remains active and control is returned to Program A. All files and resources used in the activation group are left in their last used state.

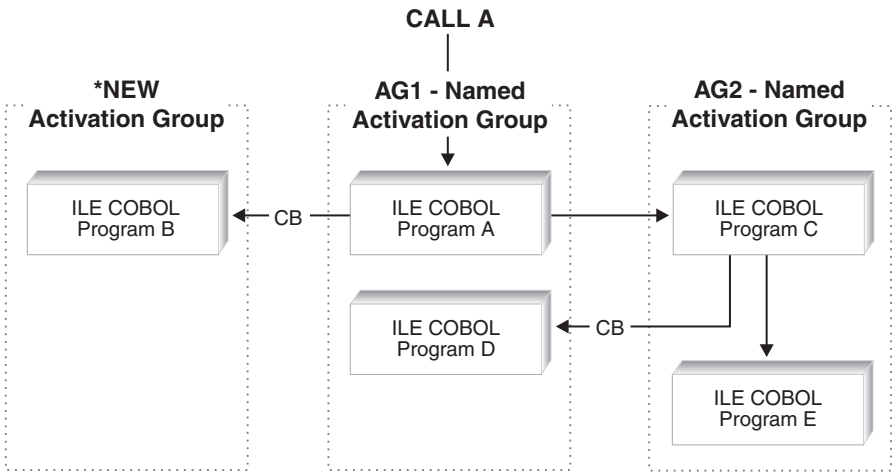

*Figure 56. Example of EXIT PROGRAM, STOP RUN, and GOBACK behavior in multiple *NEW and Named Activation Groups*

Statement	Program A	Program B	Program C	Program D	Program E
EXIT PROGRAM	1	5	1	2	2
STOP RUN	3	4	4	2	4
GOBACK	3	4	4	2	2

1 If an EXIT PROGRAM statement without the CONTINUE phrase was used, no operation is processed because the statement is in a main program. Processing continues with the next statement in the program. If an EXIT PROGRAM statement with the CONTINUE phrase was used, the activation group remains active and control is returned to the calling program or command. All files and resources used in the activation group are left in their last used state.

2 The activation group remains active and control is returned to Program C. All files and resources used in the activation group are left in their last used state.

3 The activation group is ended and control is returned to the caller of the main program. The activation group will close all files scoped to the activation group. Any pending commit operations scoped to the activation group will be implicitly committed. All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

4 The activation group is ended and control is returned to Program A. The activation group will close all files scoped to the activation group. Any

pending commit operations scoped to the activation group will be implicitly committed. All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

5 If an EXIT PROGRAM statement without the CONTINUE phrase was used, no operation is processed because the statement is in a main program. Processing continues with the next statement in the program.

If an EXIT PROGRAM statement with the CONTINUE phrase was used, control is returned to the calling program or command. In a *NEW activation group, when a main program returns control to the caller, the activation group is ended. The activation group will close all files scoped to the activation group. Any pending commit operation scoped to the activation group will be implicitly committed.

All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

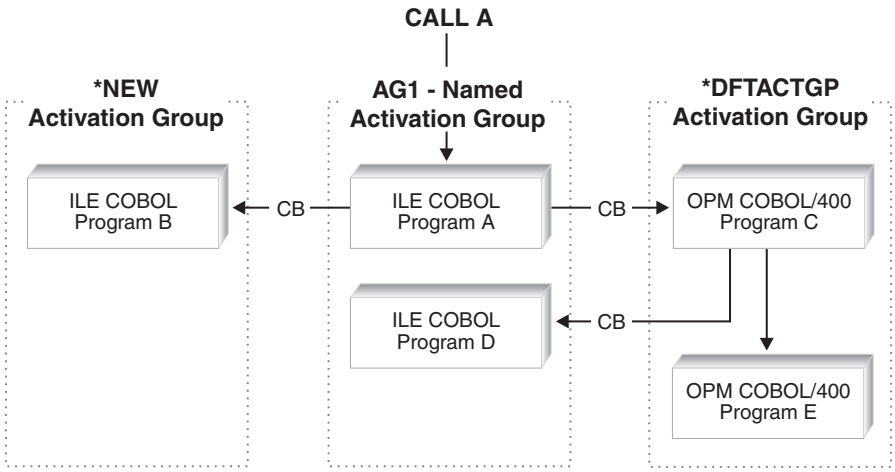

*Figure 57. Example of EXIT PROGRAM, STOP RUN, and GOBACK behavior in *NEW, Named, and *DFTACTGP Activation Groups*

Statement	Program A	Program B	Program C	Program D	Program E
EXIT PROGRAM	1	6	7	2	2
STOP RUN	3	4	5	2	5
GOBACK	3	4	5	2	2

1 If an EXIT PROGRAM statement without the CONTINUE phrase was used, no operation is processed because the statement is in a main program. Processing continues with the next statement in the program. If an EXIT PROGRAM statement with the CONTINUE phrase was used, the activation group remains active and control is returned to the calling program or command. All files and resources used in the activation group are left in their last used state.

2 The activation group remains active and control is returned to Program C. All files and resources used in the activation group are left in their last used state.

3 The activation group is ended and control is returned to the caller of the main program. The activation group will close all files scoped to the activation group. Any pending commit operations scoped to the activation group will be implicitly committed. All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

4 The activation group is ended and control is returned to Program A. The activation group will close all files scoped to the activation group. Any pending commit operations scoped to the activation group will be implicitly committed. All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

5 The activation group remains active and control is returned to Program A. All files that were opened by Program C or Program E are closed. Any pending commit operations for files opened by Program C or Program E will be implicitly committed. Storage is freed for Program C and Program E.

6 If an EXIT PROGRAM statement without the CONTINUE phrase was used, no operation is processed because the statement is in a main program. Processing continues with the next statement in the program.

If an EXIT PROGRAM statement with the CONTINUE phrase was used, control is returned to the calling program or command.

In a *NEW activation group, when a main program returns control to the caller, the activation group is ended. The activation group will close all files scoped to the activation group. Any pending commit operation scoped to the activation group will be implicitly committed.

All resources allocated to the activation group will be returned back to the system. As a result of the activation group ending, all programs that were active in the activation group are placed in their initial state.

7 No operation is processed because the statement is in a main program. Processing continues with the next statement in the program.

Passing Return Code Information (RETURN-CODE Special Register)

You can use the RETURN-CODE special register to pass and receive return codes between ILE COBOL programs. You can set the RETURN-CODE special register before returning from a called ILE COBOL program.

When used in nested programs, the RETURN-CODE special register is implicitly defined as GLOBAL in the outermost ILE COBOL program. Any changes made to the RETURN-CODE special register is global to all ILE COBOL programs within the module object.

When an ILE COBOL program returns to its caller, the contents of its RETURN-CODE special register are transferred into the RETURN-CODE special register of the calling program.

When control is returned from a main ILE COBOL program to the operating system, the RETURN-CODE special register contents are returned as a user return code.

Passing and Sharing Data Between Programs

There are many ways to pass or share data between ILE COBOL programs:

- Data can be declared as GLOBAL so that it can be used by nested programs.
- Data can be returned to a calling program using the RETURNING phrase of the CALL statement.
- Data can be passed to a called program BY REFERENCE, BY VALUE, or BY CONTENT when the CALL statement is run.
- Data that is declared as EXTERNAL can be shared by separately compiled programs. EXTERNAL data can also be shared between nested ILE COBOL programs within a module object.
- Files that are declared as EXTERNAL can be shared by separately compiled programs. EXTERNAL files can also be shared between nested ILE COBOL programs within a module object.
- Pointers can be used when you want to pass and receive addresses of dynamically-located data items.
- Data can be passed using Data Areas.

Comparing Local and Global Data

The concept of local and global data applies only to nested programs.

Local data is accessible only from within the program in which the local data is declared. Local data is not visible or accessible to any program outside of the one where it is declared; this includes both contained and containing programs.

All data is considered to be local data unless it is explicitly declared as being global data.

Global data is accessible from within the program in which the global data is declared or from within any other nested programs which are directly or indirectly contained in the program that declared the global data.

Data-names, file-names and record-names can be declared as global.

To declare a data-name as global, specify the GLOBAL clause either in the data description entry by which the data-name is declared or in another entry to which that data description entry is subordinate.

To declare a file-name as global, specify the GLOBAL clause in the file description entry for that file-name.

To declare a record-name as global, specify the GLOBAL clause in the record description entry by which the record-name is declared or, in the case of record description entries in the File Section, specify the GLOBAL clause in the file description entry for the file-name associated with the record description entry.

For a detailed description of the GLOBAL clause, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Passing Data Using CALL...BY REFERENCE, BY VALUE, or BY CONTENT

BY REFERENCE means that any changes made by the subprogram to the variables it received are visible by the calling program.

BY CONTENT means that the calling program is passing only the **contents** of the *literal* or *identifier*. With a CALL...BY CONTENT, the called program cannot change the value of the *literal* or *identifier* in the calling program, even if it modifies the parameters it received.

BY VALUE means that the calling program is passing the value of the *literal*, or *identifier*, not a reference to the sending item. The called program can change the parameter in the called program. However, because the subprogram has access only to a temporary copy of the sending item, those changes don't affect the argument in the calling program.

Whether you pass data items BY REFERENCE, BY VALUE, or BY CONTENT depends on what you want your program to do with the data:

- If you want the definition of the argument of the CALL statement in the calling program and the definition of the parameter in the called program to share the same memory, specify:

  ```
  CALL...BY REFERENCE identifier
  ```

  Any changes made by the subprogram to the parameter affect the argument in the calling program.
- If you want to pass the address of a record area to a called program, specify:

  ```
  CALL...BY REFERENCE ADDRESS OF record-name
  ```

  The subprogram receives the ADDRESS OF special register for the record-name you specify.

  You must define the record name as a level-01 or level-77 item in the Linkage Section of the called and calling programs. A separate ADDRESS OF special register is provided for each record in the Linkage Section.
- If you want to pass the address of any data item in the DATA DIVISION to a called program, specify:

  ```
  CALL...BY CONTENT ADDRESS OF data-item-name
  ```
- If you do not want the definition of the argument of the CALL statement in the calling program and the definition of the parameter in the called subprogram to share the same memory, specify:

  ```
  CALL...BY CONTENT identifier
  ```
- If you want to pass data to ILE programs that require BY VALUE parameters use:

  ```
  CALL...BY VALUE item
  ```
- If you want to pass a numeric integer of various lengths specify:

  ```
  CALL...BY VALUE integer-1 SIZE integer-2
  ```

  The numeric integer is passed as a binary value of length integer-2. The SIZE phrase is optional. If not specified, integer-1 is passed as a 4 byte binary number.
- If you want to call an ILE C, C++ or RPG function with a function return value, use:

  ```
  CALL...RETURNING identifier
  ```

- If you want to pass a literal value to a called program, specify:

  ```
  CALL...BY CONTENT literal
  ```

  The called program cannot change the value of the literal.
- If you want to pass the length of a data item, specify:

  ```
  CALL...BY CONTENT LENGTH OF identifier
  ```

  The calling program passes the length of *identifier* from its LENGTH OFspecial register.
- If you want to pass both a data item and its length to a subprogram, specify a combination of BY REFERENCE and BY CONTENT. For example:

  ```
  CALL 'ERRPROC' USING BY REFERENCE A
       BY CONTENT LENGTH OF A.
  ```
- If you do not want the called program to receive a corresponding argument or if you want the called program to use the default value for the argument, specify the OMITTED phrase in place of the data item on the CALL...BY REFERENCE or CALL...BY CONTENT statement. For example:

  ```
  CALL...BY REFERENCE OMITTED
  CALL...BY CONTENT OMITTED
  ```

  In the called program, you can use the CEETSTA API to determine if a specified parameter is OMITTED or not.
- If you want to pass data items with **operational descriptors**, specify the LINKAGE TYPE IS PRC...USING ALL DESCRIBED clause in the SPECIAL-NAMES paragraph. Then use the CALL...BY REFERENCE, CALL...BY CONTENT or CALL...BY VALUE statement to pass the data. Operational descriptors provide descriptive information to the called ILE procedure in cases where the called ILE procedure cannot precisely anticipate the form of the data items being passed. You use operational descriptors when they are expected by a called ILE procedure written in a different ILE language and when they are expected by an ILE bindable API. Refer to the *ILE Concepts* book for more information about operational descriptors. For example:

  ```
  SPECIAL-NAMES.  LINKAGE TYPE PRC FOR 'ERRPROC'
                  USING ALL DESCRIBED.

  ⋮
  CALL 'ERRPROC' USING BY REFERENCE identifier.
  ```

  or

  ```
  SPECIAL-NAMES.  LINKAGE TYPE PRC FOR 'ERRPROC'
                  USING ALL DESCRIBED.

  ⋮
  CALL 'ERRPROC' USING BY CONTENT identifier.
  ```

Data items in a calling program can be described in the Linkage Section of all the programs it calls directly or indirectly. In this case, storage for these items is allocated in the outermost calling program.

Describing Arguments in the Calling Program

The data that is passed from a calling program is called an **argument**. In the calling program, the arguments are described in the Data Division in the same manner as other data items in the Data Division. Unless they are in the Linkage Section, storage is allocated for these items in the calling program. If you reference data in a file, the file must be open when the data is referenced. Code the USING clause of the CALL statement to pass the arguments.

Describing Parameters in the Called Program

The data that is received in a called program is called a **parameter**. In the called program, parameters are described in the Linkage Section. Code the USING clause after the PROCEDURE-DIVISION header to receive the parameters.

Writing the Linkage Section in the Called Program: You must know what is being passed from the calling program and set up the Linkage Section in the called program to accept it. To the called program, it doesn't matter which clause of the CALL statement you use to pass the data (BY REFERENCE, BY VALUE or BY CONTENT). In all cases, the called program must describe the data it is receiving. It does this in the Linkage Section.

The number of *data-names* in the *identifier* list of a called program should not be greater than the number of *data-names* in the *identifier* list of the calling program. There is a one-to-one positional correspondence; that is, the first *identifier* of the calling program is passed to the first *identifier* of the called program, and so forth. The ILE COBOL compiler does not enforce consistency in terms of number of arguments and number of parameters nor does it enforce consistency in terms of type and size between an argument and its corresponding parameter.

Any inconsistencies in terms of number of arguments and number of parameters may result in runtime exceptions. For a dynamic program call, when the number of arguments is greater than the number of parameters, a runtime exception is generated in the calling program when the CALL statement is attempted. This exception can be captured if the ON EXCEPTION phrase is specified on the CALL statement.

When the number of arguments is less than the number of parameters, a runtime exception is not generated in the calling program when the CALL statement is performed. Instead, a pointer exception is generated in the called program when it tries to access an unsupplied parameter.

If an argument was passed BY VALUE, the PROCEDURE DIVISION header of the subprogram must indicate that:

```
PROCEDURE DIVISION USING BY VALUE DATA-ITEM.
```

If an argument was passed BY REFERENCE or BY CONTENT, the PROCEDURE DIVISION header does not need to indicate how the argument was passed. The header can either be:

```
PROCEDURE DIVISION USING DATA-ITEM
```

or:

```
PROCEDURE DIVISION USING BY REFERENCE DATA-ITEM
```

Grouping Data to be Passed

Consider grouping all the data items you want to pass between programs and putting them under one level-01 item. If you do this, you can pass a single level-01 record between programs. For an example of this method, see Figure 58 on page 226.

To make the possibility of mismatched records even smaller, put the level-01 record in a copy member, and copy it in both programs. (That is, copy it in the Working-Storage Section of the calling program and in the Linkage Section of the called program.)

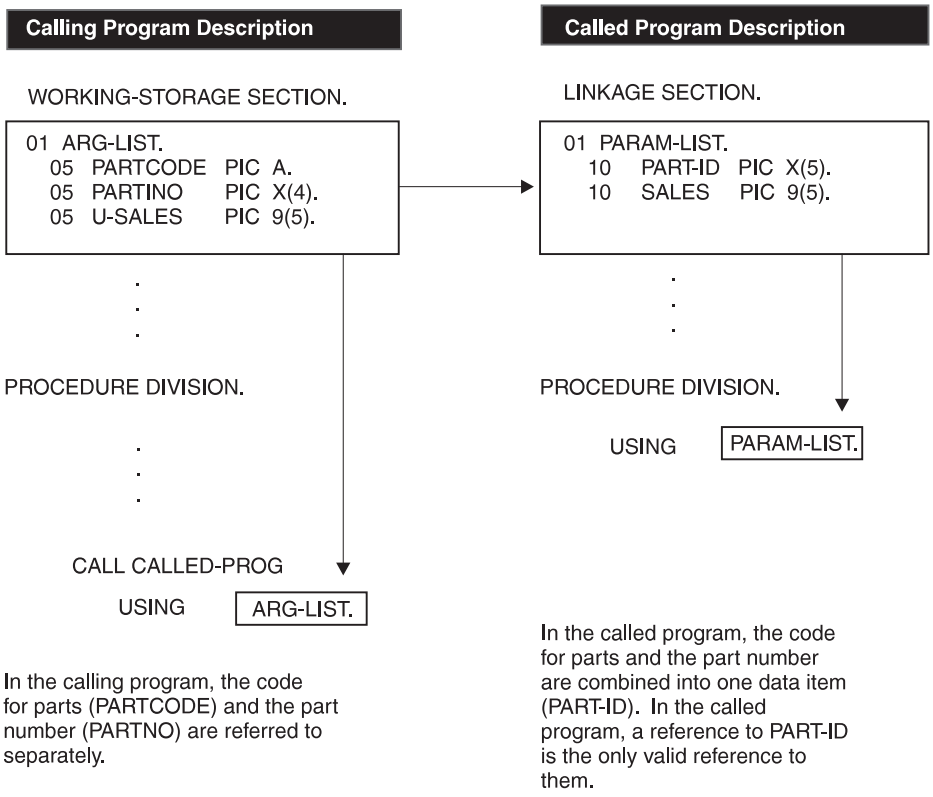

Figure 58. Common Data Items in Subprogram Linkage

Sharing EXTERNAL Data

Separately compiled ILE COBOL programs (including programs within a sequence of ILE COBOL source programs) can share data items by using the EXTERNAL clause. This EXTERNAL data is handled as weak exports. Refer to *ILE Concepts* for further information about strong and weak exports.

You specify the EXTERNAL clause on the 01-level data description in the Working-Storage Section of the ILE COBOL program, and the following rules apply:

1. Items subordinate to an EXTERNAL group item are themselves EXTERNAL.
2. The name used for the data item cannot be used on another EXTERNAL item within the same program.
3. The VALUE clause cannot be specified for any group item, or subordinate item, that is EXTERNAL.
4. EXTERNAL data cannot be initialized and its initial value at runtime is undefined. If your application requires that EXTERNAL data items be intialized, it is recommended that they are explicitly initialized in the main program.

Any ILE COBOL program within a run unit, having the same data description for the item as the program containing the item, can access and process the data item. For example, if program A had the following data description:

```
01 EXT-ITEM1          PIC 99 EXTERNAL.
```

Program B could access the data item by having the identical data description in its Working-Storage Section.

The size must be the same for the same named EXTERNAL data item in all module objects declaring it. If different sized EXTERNAL data items with the same name are declared in multiple ILE COBOL programs in a compilation unit, the longest size is used to represent the data item.

Also, when different sized EXTERNAL data items of the same name are represented in multiple program objects or service programs that are activated in the same activation group, and the later activated program object or service program has a larger size for the same named EXTERNAL data item, then the activation of the later activated program object or service program will fail.

The type consistency across data items of the same name that are declared in multiple ILE COBOL programs is not enforced by the ILE COBOL compiler. You are responsible for ensuring that the usage of these data items is consistent.

Remember, any program that has access to an EXTERNAL data item can change its value. Do not use this clause for data items you need to protect.

Sharing EXTERNAL Files

Using the EXTERNAL clause for files allows separately compiled programs within the run unit to have access to common files. These EXTERNAL files are handled as weak exports. Refer to *ILE Concepts* for further information about strong and weak exports.

When an EXTERNAL file is defined in multiple ILE COBOL programs, once it is opened by one of these ILE COBOL programs, it is accessible to all of the programs. Similarly, if one of the programs closes the EXTERNAL file, its is no longer accessible by any of the programs.

For multiple ILE COBOL programs in multiple module objects, a runtime consistency check is made the first time the ILE COBOL program declaring a given EXTERNAL file is called to see if the definition in that module object is consistent with the definitions in already called ILE COBOL programs in other module objects. If any inconsistency is found, then a runtime exception message is issued.

The example in Figure 59 on page 228 shows some of the advantages of using EXTERNAL files:

- The main program can reference the record area of the file, even though the main program does not contain any input-output statements.
- Each subprogram can control a single input-output function, such as OPEN or READ.
- Each program has access to the file.

The following table gives the program (or subprogram) name for the example in Figure 59 on page 228 and describes its function.

Table 12. Program Names for Input-Output Using EXTERNAL Files Example

Name	Function
EF1MAIN	This is the main program. It calls all the subprograms and then verifies the contents of a record area.

Table 12. Program Names for Input-Output Using EXTERNAL Files Example (continued)

Name	Function
EF1OPENO	This program opens the external file for output and checks the File Status Code.
EF1WRITE	This program writes a record to the external file and checks the File Status Code.
EF1OPENI	This program opens the external file for input and checks the File Status Code.
EF1READ	This program reads record from the external file and checks the File Status Code.
EF1CLOSE	This program closes the external file and checks the File Status Code.

The sample program also uses the EXTERNAL clause for a data item in the Working-Storage Section. This item is used for checking File Status Codes.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/EXTLFL          ISERIES1   03/09/15 13:11:39        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  EF1MAIN.
          000300*
          000400* This is the main program that controls
          000500* the external file processing.
          000600*
          000700
    3     000800 ENVIRONMENT DIVISION.
    4     000900 INPUT-OUTPUT SECTION.
    5     001000 FILE-CONTROL.
    6     001100      SELECT EF1
    7     001200         ASSIGN TO DISK-EFILE1
    8     001300         FILE STATUS IS EFS1
    9     001400         ORGANIZATION IS SEQUENTIAL.
          001500
   10     001600 DATA DIVISION.
   11     001700 FILE SECTION.
   12     001800 FD  EF1 IS EXTERNAL
          001900            RECORD CONTAINS 80 CHARACTERS.
   13     002000 01  EF-RECORD-1.
   14     002100     05  EF-ITEM-1     PIC X(80).
          002200
   15     002300 WORKING-STORAGE SECTION.
   16     002400 01  EFS1              PIC 99 EXTERNAL.
          002500
   17     002600 PROCEDURE DIVISION.
          002700 EF1MAIN-PROGRAM SECTION.
          002800 MAINLINE.
   18     002900      CALL "EF1OPENO"
   19     003000      CALL "EF1WRITE"
   20     003100      CALL "EF1CLOSE"
   21     003200      CALL "EF1OPENI"
   22     003300      CALL "EF1READ"
   23     003400      IF EF-RECORD-1 = "First Record" THEN
   24     003500         DISPLAY "First record correct"
          003600      ELSE
   25     003700         DISPLAY "First record incorrect"
   26     003800         DISPLAY "Expected:  First Record"
   27     003900         DISPLAY "Found:    " EF-RECORD-1
          004000      END-IF
   28     004100      CALL "EF1CLOSE"
   29     004200      GOBACK.
   30     004300 END PROGRAM EF1MAIN.
          004400
          004600
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 59. Input-Output Using EXTERNAL Files (Part 1 of 6)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/EXTLFL          ISERIES1   03/09/15 13:11:39        Page      5
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     004700 IDENTIFICATION DIVISION.
    2     004800 PROGRAM-ID.  EF1OPENO.
          004900*
          005000* This program opens the external file for output.
          005100*
          005200
    3     005300 ENVIRONMENT DIVISION.
    4     005400 INPUT-OUTPUT SECTION.
    5     005500 FILE-CONTROL.
    6     005600      SELECT EF1
    7     005700         ASSIGN TO DISK-EFILE1
    8     005800         FILE STATUS IS EFS1
    9     005900         ORGANIZATION IS SEQUENTIAL.
          006000
   10     006100 DATA DIVISION.
   11     006200 FILE SECTION.
   12     006300 FD  EF1 IS EXTERNAL
          006400            RECORD CONTAINS 80 CHARACTERS.
   13     006500 01  EF-RECORD-1.
   14     006600     05  EF-ITEM-1     PIC X(80).
          006700
   15     006800 WORKING-STORAGE SECTION.
   16     006900 01  EFS1              PIC 99 EXTERNAL.
          007000
   17     007100 PROCEDURE DIVISION.
          007200 EF1OPENO-PROGRAM SECTION.
          007300 MAINLINE.
   18     007400      OPEN OUTPUT EF1
   19     007500      IF EFS1 NOT = 0 THEN
   20     007600         DISPLAY "File Status " EFS1 " on OPEN OUTPUT"
   21     007700         STOP RUN
          007800      END-IF
   22     007900      GOBACK.
   23     008000 END PROGRAM EF1OPENO.
          008100
          008300
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 59. Input-Output Using EXTERNAL Files (Part 2 of 6)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/EXTLFL          ISERIES1   03/09/15 13:11:39        Page      8
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     008400 IDENTIFICATION DIVISION.
    2     008500 PROGRAM-ID.  EF1WRITE.
          008600*
          008700* This program writes a record to the external file.
          008800*
          008900
    3     009000 ENVIRONMENT DIVISION.
    4     009100 INPUT-OUTPUT SECTION.
    5     009200 FILE-CONTROL.
    6     009300      SELECT EF1
    7     009400         ASSIGN TO DISK-EFILE1
    8     009500         FILE STATUS IS EFS1
    9     009600         ORGANIZATION IS SEQUENTIAL.
          009700
   10     009800 DATA DIVISION.
   11     009900 FILE SECTION.
   12     010000 FD  EF1 IS EXTERNAL
          010100           RECORD CONTAINS 80 CHARACTERS.
   13     010200 01  EF-RECORD-1.
   14     010300     05  EF-ITEM-1     PIC X(80).
          010400
   15     010500 WORKING-STORAGE SECTION.
   16     010600 01  EFS1              PIC 99 EXTERNAL.
          010700
   17     010800 PROCEDURE DIVISION.
          010900 EF1WRITE-PROGRAM SECTION.
          011000 MAINLINE.
   18     011100      MOVE "First record" TO EF-RECORD-1
   19     011200      WRITE EF-RECORD-1
   20     011300      IF EFS1 NOT = 0 THEN
   21     011400         DISPLAY "File Status " EFS1 " on WRITE"
   22     011500         STOP RUN
          011600      END-IF
   23     011700      GOBACK.
   24     011800 END PROGRAM EF1WRITE.
          011900
          012100
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 59. Input-Output Using EXTERNAL Files (Part 3 of 6)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/EXTLFL          ISERIES1   03/09/15 13:11:39        Page     11
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     012200 IDENTIFICATION DIVISION.
    2     012300 PROGRAM-ID.  EF1OPENI.
          012400*
          012500* This program opens the external file for input.
          012600*
          012700
    3     012800 ENVIRONMENT DIVISION.
    4     012900 INPUT-OUTPUT SECTION.
    5     013000 FILE-CONTROL.
    6     013100      SELECT EF1
    7     013200         ASSIGN TO DISK-EFILE1
    8     013300         FILE STATUS IS EFS1
    9     013400         ORGANIZATION IS SEQUENTIAL.
          013500
   10     013600 DATA DIVISION.
   11     013700 FILE SECTION.
   12     013800 FD  EF1 IS EXTERNAL
          013900            RECORD CONTAINS 80 CHARACTERS.
   13     014000 01  EF-RECORD-1.
   14     014100     05  EF-ITEM-1     PIC X(80).
          014200
   15     014300 WORKING-STORAGE SECTION.
   16     014400 01  EFS1              PIC 99 EXTERNAL.
          014500
   17     014600 PROCEDURE DIVISION.
          014700 EF1OPENI-PROGRAM SECTION.
          014800 MAINLINE.
   18     014900      OPEN INPUT EF1
   19     015000      IF EFS1 NOT = 0 THEN
   20     015100         DISPLAY "File Status " EFS1 " on OPEN INPUT"
   21     015200         STOP RUN
          015300      END-IF
   22     015400      GOBACK.
   23     015500 END PROGRAM EF1OPENI.
          015600
          015800
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 59. Input-Output Using EXTERNAL Files (Part 4 of 6)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/EXTLFL          ISERIES1   03/09/15 13:11:39        Page     14
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     015900 IDENTIFICATION DIVISION.
    2     016000 PROGRAM-ID.  EF1READ.
          016100*
          016200* This program reads a record from the external file.
          016300*
          016400
    3     016500 ENVIRONMENT DIVISION.
    4     016600 INPUT-OUTPUT SECTION.
    5     016700 FILE-CONTROL.
    6     016800      SELECT EF1
    7     016900         ASSIGN TO DISK-EFILE1
    8     017000         FILE STATUS IS EFS1
    9     017100         ORGANIZATION IS SEQUENTIAL.
          017200
   10     017300 DATA DIVISION.
   11     017400 FILE SECTION.
   12     017500 FD  EF1 IS EXTERNAL
          017600           RECORD CONTAINS 80 CHARACTERS.
   13     017700 01  EF-RECORD-1.
   14     017800     05  EF-ITEM-1     PIC X(80).
          017900
   15     018000 WORKING-STORAGE SECTION.
   16     018100 01  EFS1              PIC 99 EXTERNAL.
          018200
   17     018300 PROCEDURE DIVISION.
          018400 EF1READ-PROGRAM SECTION.
          018500 MAINLINE.
   18     018600      READ EF1
   19     018700      IF EFS1 NOT = 0 THEN
   20     018800         DISPLAY "File Status " EFS1 " on READ"
   21     018900         STOP RUN
          019000      END-IF
   22     019100      GOBACK.
   23     019200 END PROGRAM EF1READ.
          019300
          019500
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 59. Input-Output Using EXTERNAL Files (Part 5 of 6)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/EXTLFL          ISERIES1   03/09/15 13:11:39        Page     17
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     019600 IDENTIFICATION DIVISION.
    2     019700 PROGRAM-ID.  EF1CLOSE.
          019800*
          019900* This program reads a record from the external file.
          020000*
          020100
    3     020200 ENVIRONMENT DIVISION.
    4     020300 INPUT-OUTPUT SECTION.
    5     020400 FILE-CONTROL.
    6     020500      SELECT EF1
    7     020600         ASSIGN TO DISK-EFILE1
    8     020700         FILE STATUS IS EFS1
    9     020800         ORGANIZATION IS SEQUENTIAL.
          020900
   10     021000 DATA DIVISION.
   11     021100 FILE SECTION.
   12     021200 FD  EF1 IS EXTERNAL
          021300           RECORD CONTAINS 80 CHARACTERS.
   13     021400 01  EF-RECORD-1.
   14     021500     05  EF-ITEM-1     PIC X(80).
          021600
   15     021700 WORKING-STORAGE SECTION.
   16     021800 01  EFS1              PIC 99 EXTERNAL.
          021900
   17     022000 PROCEDURE DIVISION.
          022100 EF1CLOSE-PROGRAM SECTION.
          022200 MAINLINE.
   18     022300      CLOSE EF1
   19     022400      IF EFS1 NOT = 0 THEN
   20     022500         DISPLAY "File Status " EFS1 " on CLOSE"
   21     022600         STOP RUN
          022700      END-IF
   22     022800      GOBACK.
   23     022900 END PROGRAM EF1CLOSE.
          023000
          023100
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 59. Input-Output Using EXTERNAL Files (Part 6 of 6)

Passing Data Using Pointers

You can use a pointer within an ILE COBOL program when you want to pass and receive addresses of a dynamically-located data item.

For a full description of how pointers are used in an ILE COBOL program, refer to Chapter 13, “Using Pointers in an ILE COBOL Program,” on page 311.

Passing Data Using Data Areas

A data area is an OS/400 object used to communicate data such as variable values between programs within a job and between jobs. A data area can be created and declared to a program before it is used in that program or job. For information on how to create and declare a data area, see the *CL Programming* manual.

Using Local Data Area

The local data area can be used to pass any desired information between programs in a job. This information may be free-form data, such as informal messages, or may consist of a fully structured or formatted set of fields.

Internal and external floating-point data items can be passed using the local data area. Internal floating-point numbers written to the local data area using a DISPLAY statement are converted to external floating-point numbers.

The system automatically creates a local data area for each job. The local data area is defined outside the ILE COBOL program as an area of 1024 bytes.

When a job is submitted, the submitting job's local data area is copied into the submitted job's local data area. If there is no submitting job, the local data area is initialized to blanks.

An ILE COBOL program can access the local data area for its job with the ACCEPT and DISPLAY statements, using a mnemonic name associated with the environment-name LOCAL-DATA.

There is only one local data area associated with each job. Even if several work stations are acquired by a single job, only one local data area exists for that job. There is *not* a local data area for each workstation.

Using Data Areas You Create

You can pass data between programs using data areas that you create. This information may be free-form data, such as informal messages, or may consist of a fully structured or formatted set of fields. You specify the library and the name of the data area when you create it.

Using the Data Area formats (as opposed to the Local Data Area formats) of the ACCEPT and DISPLAY statements, you can access these data areas. The FOR phrase allows you to specify the name of the data area. Optionally, you can specify an IN LIBRARY phrase to indicate the OS/400 library where the data area exists. If the IN LIBRARY phrase is not specified, the library defaults to *LIBL.

When you use the DISPLAY statement to write data to a data area you have created, it is locked by the system with a LEAR (Lock Exclusive Allow Read) lock before any data is written to the data area. If any other lock exists on the data area, the LEAR lock is not applied, and the data area is not written. By specifying the WITH LOCK phrase, you can keep the data area locked after the Display operation has completed.

When you use the ACCEPT statement to retrieve data from a data area you have created, the system applies an LSRD (Lock Shared for Read) lock to prevent the data area from being changed while it is read. After the read is complete, the LSRD lock is removed, and a LEAR lock is placed on the data area if a WITH LOCK phrase was specified.

For both the ACCEPT and DISPLAY statements, if a WITH LOCK phrase was not specified, any LEAR lock held prior to the statement will be removed.

In ILE COBOL only one LEAR lock will be placed on a data area while the COBOL Run unit (activation group) is active. If any data areas remain locked when an activation group ends, the locks are removed.

An ON EXCEPTION condition can exist for several reasons:

- Data area specified in the FOR phrase:
  - Cannot be found
  - You do not have authority to the data area
  - The data area was locked in a previous activation group or in another job
- AT position:
  - Was less than 1 or greater than the length of the data area.

Internal and external floating-point data items can be passed using a data area. Internal floating-point numbers written to the data area using a DISPLAY statement are converted to external floating-point numbers.

ILE COBOL supports decimal (*DEC), character (*CHAR), logical (*LGL), and DDM (*DDM) data areas. Regardless of the type of data area, information is moved to and from a data area left-justified. When referencing a decimal data area, or a logical data area, the AT position, if specified, must be 1.

Data is moved in packed format to and from a decimal data area. A decimal data area is created with a specified number of total digits and decimal digits. This same number of digits must be declared in an ILE COBOL program accessing the decimal data area. For example:

- CL command to create the data area:

```
CRTDTAARA DTAARA(QGPL/DECDATA) TYPE(*DEC) LEN(5 2)
```

- Partial ILE COBOL program to access data area:

```
WORKING-STORAGE SECTION.
01 data-value.
   05 returned-packed1  pic s9(3)v9(2) packed-decimal.
PROCEDURE DIVISION.
      move 345.67 to returned-packed1.
      DISPLAY  data-value UPON data-area
         FOR "DECDATA" LIBRARY "QGPL".
      ACCEPT   data-value FROM data-area
         FOR "DECDATA" LIBRARY "QGPL".
```

Using Program Initialization Parameters (PIP) Data Area

The PIP data area is used by a prestart job. Generally, a prestart job is a job from a remote system under ICF that you start and keep ready to run until you call it.

If you use a prestart job, you do not have to wait for a program that you call to go through job initiation processing. Job initiation is performed before a program can actually start. Because job initiation has already taken place, a prestart job allows your program to start more quickly after the program start request is received.

An ILE COBOL program can access the PIP data area for its job with the ACCEPT statement, using a mnemonic name associated with the function-name PIP-DATA.

The PIP data area is a 2 000-byte alphanumeric item and contains parameters received from a calling program. It provides the program initialization parameters that, in non-prestart jobs, is provided through Standard COBOL parameters.

You use a Format 5 ACCEPT statement to access the PIP data area, similar to the way in which you use a Format 4 ACCEPT statement to read from the local data area. Note that you cannot update the PIP data area using ILE COBOL. See the *WebSphere Development Studio: ILE COBOL Reference* for detailed syntax information.

For more information regarding prestart jobs and the PIP data area, refer to the *CL Programming* manual.

Effect of EXIT PROGRAM, STOP RUN, GOBACK, and CANCEL on Internal Files

The following statements affect the state of a file differently:

- An EXIT PROGRAM statement does not change the status of any of the files in a run unit unless:

  - The ILE COBOL program issuing the EXIT PROGRAM has the INITIAL attribute. If it has the INITIAL attribute, then all internal files defined in that program are closed.
  - An EXIT PROGRAM statement with the AND CONTINUE RUN UNIT phrase is issued in the main program of a *NEW activation group. In this case, control returns from the main program to the caller, which, in turn, causes the *NEW activation group to end, closing all of the files scoped to the activation group.
- A STOP RUN statement returns control to the caller of the program at the nearest control boundary. If this is a hard control boundary, the activation group (run unit) will end, and all files scoped to the activation group will be closed.
- A GOBACK statement issued from a main program (which is always at a hard control boundary) behaves the same as the STOP RUN statement. A GOBACK statement issued from a subprogram behaves the same as the EXIT PROGRAM statement. It does not change the status of any of the files in a run unit unless the ILE COBOL program issuing the GOBACK has the INITIAL attribute. If it has the INITIAL attribute, then all internal files defined in that program are closed.
- A CANCEL statement resets the storage that contains information about the internal file. If the program has internal files that are open when the CANCEL statement is processed, those internal files are closed when that program is canceled. The program can no longer use the files unless it reopens them. If the canceled program is called again, the program considers the file closed. If the program opens the file, a new linkage to the file is established.

Canceling an ILE COBOL Program

A subprogram, unless it has the INITIAL attribute, is left in its last-used state when it ends with EXIT PROGRAM or GOBACK. A subprogram that uses the EXIT PROGRAM statement with the AND CONTINUE RUN UNIT phrase is also left in its last-used state. The next time it is called in the run unit, its internal values will be as they were left, except for PERFORM statements, which are reset.

To reset the internal values of a subprogram to their initial state before it is called again, you must cancel the subprogram. Canceling the subprogram ensures that the next time the subprogram is called, it will be entered in its initial state.

Canceling from Another ILE COBOL Program

In ILE COBOL, you use the CANCEL statement to cancel a subprogram. The subprogram must be in the same activation group as the program that is canceling it in order for the CANCEL statement to work.

After a CANCEL statement for a called subprogram has been executed, that subprogram no longer has a logical connection to the program. The contents of data items in EXTERNAL data records and EXTERNAL files described by the subprogram are not changed when a subprogram is canceled. If a CALL statement is executed later in the run unit naming the same subprogram, that subprogram will be entered in its initial state.

Called subprograms may contain CANCEL statements; however, a called subprogram must not contain a CANCEL statement that directly or indirectly cancels its calling program or any other program higher than itself in the calling hierarchy. If a called subprogram attempts to cancel its calling program, the CANCEL statement in the subprogram is ignored.

A program named in a CANCEL statement must not refer to any program that has been called and has not yet returned control to the calling program. A program can cancel any program that has been called and already returned from, provided that they are in the same activation group. For example:

```
A calls B and B calls C          When A receives control,
                                 it can cancel C.
A calls B and A calls C          When C receives control,
                                 it can cancel B.
```

Note: When canceling a program object that contains multiple ILE COBOL programs, only the ILE COBOL program associated with the PEP of the program object is canceled.

Refer to the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the CANCEL statement.

Canceling from Another Language

You can cancel an outermost ILE COBOL program from ILE RPG, ILE C, and ILE CL, by calling its cancel procedure using a static procedure call. The name of the cancel procedure is formed by taking the name of the outermost ILE COBOL program and adding the suffix `_reset`.

You cannot cancel an ILE COBOL program from an OPM COBOL/400 program or an OPM RPG/400 program.

Do not use the Reclaim Resources (RCLSRC) CL command to cancel an ILE COBOL program. If RCLRSC is issued within an ILE activation group, it will cause an exception. For more information on the RCLRSC command, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://www.ibm.com/eserver/iseries/infocenter.

Chapter 10. COBOL and the eBusiness World

This chapter describes how you can use ILE COBOL as part of an eBusiness solution. It includes:

- "COBOL and XML"
- "COBOL and MQSeries, V5.2"
- "COBOL and Java Programs" on page 240

COBOL and XML

The Extensible Markup Language (XML) is a subset of SGML that is developed by the World Wide Web Consortium (W3C). Its goal is to enable generic SGML to be served, received, and processed on the Web in the way that is now possible with HTML. XML has been designed for ease of implementation and for interoperability with both SGML and HTML. You can use XML as both a datastore and I/O mechanism.

A well-formedness XML parser has been added into ILE COBOL, for more information see Chapter 11, "Processing XML Documents," on page 265.

For more information about XML, see `http://www.w3.org/XML`

IBM has developed two tools which can be used to integrate XML and COBOL programs. IBM's XML for C++ parser (XML4C) is a validating XML parser written in a portable subset of C++. It consists of three shared libraries (2 code and 1 data) which provide classes for parsing, generating, manipulating, and validating XML documents.

In order to use the parser with procedural languages such as C, COBOL and RPG, you will also need XML Interface for RPG. This wrapper interface allows ILE C, RPG and COBOL programs on the iSeries server to interface with the XML parser.

Both these products are constantly evolving. They are available through alphaWorks, which gives early adopters direct access to IBM's emerging "alpha-code" technologies. You can download alpha code and participate in online discussions with IBM's researchers and developers. For the latest information about these alpha technologies, including hardware and software requirments, see `http://www.alphaWorks.ibm.com/`

COBOL and MQSeries, V5.2

IBM MQSeries, V5.2 messaging products enable application integration by helping business applications to exchange information across different platforms by sending and receiving data as messages. They take care of network interfaces, assure 'once only' delivery of messages, deal with communications protocols, dynamically distribute workload across available resources, handle recovery after system problems, and help make programs portable. MQSeries, V5.2 is available on over 35 platforms.

With MQSeries for AS/400, V5.2, your ILE COBOL program can communicate with other programs on the same platform or a different platform using the same messaging product. For more information on MQSeries for AS/400, V5.2, including

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hardware and software requirements, please see **ibm.com**/software/ts/mqseries/platforms/os400/

For several examples of iSeries COBOL applications using the MQSeries, V5.2 API, see *MQSeries Application Programming Guide*, SC33-0807-12. This manual is also available online, at **ibm.com**/software/ts/mqseries/library/manualsa/

COBOL and Java Programs

The Java Native Interface (JNI) allows Java code inside a Java Virtual Machine (JVM) to interoperate with applications and libraries that are written in other programming languages, such as COBOL, RPG, C, C++, and Assembler. This chapter describes how to make COBOL and Java programs work together, using the JNI.

You can also use the following components of the IBM Toolbox for Java to combine COBOL and Java programs:

- The ProgramCall class in the IBM Toolbox for Java uses the OS/400 Host Server Program Call driver to call OS/400 program objects.
- Program Call Markup Language (PCML) is a tag language based on the Extensible Markup Language (XML). You can generate tags that fully describe the input and output parameters for ILE COBOL programs that are called by your Java application by specifying the PGMINFO and INFOSTMF parameters on the COBOL command. The IBM Toolbox for Java includes an application programming interface (API) that interprets the PCML, calls the program, and simplifies the retrieval of data returned from the iSeries machine.

For more information about these approaches, refer to the *Java* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site - http://www.ibm.com/eserver/iseries/infocenter.

System Requirements

In order to to integrate COBOL and Java programs, consider the following requiremnts:

- IBM Qshell Interpreter is a no-charge option of OS/400 (5769-SS1, option 30).
- AS/400 Developer Kit for Java is a WebSphere Development Studio for iSeries component and can be specified at installation time.
- IBM's Java 2 Software Development Kit (J2SDK), Standard Edition v1.2.2 is shipped with WebSphere Development Studio for iSeries. If you choose to use a different Java Development Kit, then it must be version 1.2 or higher to ensure the functionality of all pieces of Java code.
- IBM Toolbox for Java is required to use IBM Toolbox for Java classes, including PCML. It is provided with WebSphere Development Studio for iSeries component and can be specified at installation time.

COBOL and PCML

A COBOL program can be called from a Java application using a Program Call Markup Language (PCML) source file that describes the input and output parameters for the COBOL program. The Java application can use PCML by constructing a ProgramCallDocument object with a reference to the PCML source file. See **Programming->Java->IBM Toolbox for Java->Program Call Markup Language** in the iSeries 400 Information Center at

http://www.ibm.com/eserver/iseries/infocenter for more information on how to use PCML with Java. PCML handles the data type conversions between the COBOL format and the Java format.

The ILE COBOL compiler will generate PCML source for your COBOL program when you specify the PGMINFO(*PCML) compiler parameter along with the INFOSTMF compiler parameter to specify the name of an IFS output file to receive the generated PCML. PCML is generated based on the contents of the Procedure Division USING and GIVING/RETURNING phrases and the contents of the LINKAGE section in your COBOL program. 13 shows the support in PCML for the COBOL datatypes:

Table 13. COBOL Datatypes and Corresponding PCML Support

COBOL Data Type	COBOL Format	Supported in PCML	PCML Data Type	Length	Precision	Count
Character	X(n)	Yes	character	n		
	A(n)	Yes	character	n		
	X(n) OCCURS DEPENDING ON M	Yes	structure			m
	A(n) OCCURS DEPENDING ON m	Yes	structure			m
Numeric	9(n) DISPLAY	Yes	zoned decimal	n	0	
	S9(n-p)V9(p) DISPLAY	Yes	zoned decimal	n	p	
	9(n-p)V9(p) PACKED-DECIMAL see note 3	Yes	packed decimal	n	p	
	S9(n-p)V9(p) PACKED-DECIMAL see note 3	Yes	packed decimal	n	p	
	9(4) BINARY see notes 1, 2	Yes	integer	2	16	
	S9(4) BINARY see notes 1, 2	Yes	integer	2	15	
	9(9) BINARY see notes 1, 2	Yes	integer	4	32	
	S9(9) BINARY see notes 1, 2	Yes	integer	4	31	
	S9(18) BINARY see notes 1, 2	Yes	integer	8	63	
	9(18) BINARY see notes 1, 2	not supported				
	USAGE COMP-1	Yes	float	4		
	USAGE COMP-2	Yes	float	8		
UCS2	N(n) see note 4	Yes	UCS-2/graphics	n		
	N(n) OCCURS DEPENDING ON m see note 4	Yes	structure			m

Table 13. COBOL Datatypes and Corresponding PCML Support (continued)

Graphic	G(n)	Yes	UCS-2/graphics	n		
	G(n) OCCURS DEPENDING ON M	Yes	structure			m
Index	USAGE INDEX	Yes	integer	4	31	
Boolean	1	not supported				
Date	FORMAT DATE	not supported				
Time	FORMAT TIME	not supported				
Timestamp	FORMAT TIMESTAMP	not supported				
Pointer	USAGE POINTER	not supported				
Procedure Pointer	PROCEDURE POINTER	not supported				

Notes:

1. To reduce truncation, specify NOSTDTRUNC on the PROCESS statement. NOSTDTRUNC should always be specified when passing BINARY data items.
2. BINARY, COMP-4, and COMPUTATIONAL-4 are equivalent and map to the same PCML.
3. PACKED-DECIMAL, COMP-3, COMPUTATIONAL-3, COMP, and COMPUTATIONAL are equivalent and map to the same PCML (unless COMPASBIN PROCESS option is specified, see "PROCESS Statement Options" on page 56 for more information).
4. PIC N is a national (UCS2) item if USAGE NATIONAL is specified or if USAGE is not specified and the NATIONAL compiler option is specified, otherwise USAGE DISPLAY-1 (DBCS) is implied.

PCML will be generated for all parameters specifed in the PROCEDURE DIVISION header USING phrase. PCML will be generated for a parameter specified in the GIVING/RETURNING phrase for this header. An error will be issued if the GIVING/RETURNING item is not a 4 byte binary integer. Items specified in the USING phrase that are defined as "inputoutput" in the generated PCML can be used to return information to the calling program. For the calling program (eg JAVA program) to see the contents of the RETURN-CODE special register, the RETURN-CODE special register must be specified on the USING phrase of the PROCEDURE DIVISION header. The object data item for an OCCURS DEPENDING ON (ODO) must be defined in the linkage section and be specified as a parameter in the PROCEDURE DIVISION header USING phrase for PCML to be correctly generated for the ODO subject data item.

A PCML comment will be generated for renamed/redefined items.

Example:

The following is an example COBOL source program and corresponding PCML generated for this program:

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL          TESTLIB/MYPCML        ISERIES1   03/09/15 12:09:25       Page      2
                                 S o u r c e
STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME  CHG DATE
     1     000100 IDENTIFICATION DIVISION.
     2     000200 PROGRAM-ID.     MYPGM4.
           000300
     3     000400 DATA DIVISION.
     4     000500 WORKING-STORAGE SECTION.
     5     000600 01 RETN-VAL PIC S9(8) USAGE COMP-4.
           000700
     6     000800 LINKAGE SECTION.
     7     000900 01 PARM-LIST.
     8     001000    05 EMPL OCCURS 5 TIMES.
     9     001100      10 NAMES      PIC A(20).
    10     001200      10 ADDRESSES  PIC X(60).
    11     001300      10 PHN-NUM    PIC 9(11) DISPLAY.
    12     001400    05 NUM-1A     PIC S9(5)V9(3)  PACKED-DECIMAL.
    13     001500    05 NUM-2A     PIC 9(5)V9(3)   COMP.
    14     001600    05 TAB-NUM-3A PIC S9(5)V9(3)  COMP OCCURS 10 TIMES.
    15     001700    05 NUM-4A     PIC 9(5)V9(3)   COMP-3.
    16     001800    05 NUM-5A     PIC S9(5)V9(3)  COMP-3.
    17     001900    05 NUM-6A     PIC 9(4)        BINARY.
    18     002000    05 NUM-7A                     COMP-1.
    19     002100    05 NUM-8A                     COMP-2.
    20     002200    05 INTLNAME   PIC N(10)       NATIONAL.
           002300
           002400*****************************************************************
           002500* Test PCML for arrays of basic supported types.
           002600*****************************************************************
    21     002700 PROCEDURE DIVISION USING BY REFERENCE PARM-LIST
           002800     GIVING    RETN-VAL.
           002900 MAIN-LINE.
    22     003000     MOVE 1 TO RETN-VAL.
    23     003100     DISPLAY "THIS PGM TO BE CALLED BY A JAVA PGM".
    24     003200     STOP RUN.
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 60. PCML Source Program

The following is an example of PCML that is generated when the program is compiled with options PGMINFO(*PCML) and INFOSTMF('/dirname/mypgm4.pcml') specified on the CRTBNDCBL command:

```
# <pcml version="4.0">
#
#    <!-- COBOL program: MYPCML  -->
#    <!-- created: 02/03/21 12:09:25 -->
#    <!-- source: TESTLIB/QCBLLESRC(MYPCML) -->
#    <programname="MYPCML" path="/QSYS.LIB/TESTLIB.LIB/MYPCML.PGM" returnvalue="integer">
#
#       <struct name="PARM-LIST" usage="inputoutput">
#
#          <struct name="EMPL" usage="inherit" count="5">
#
#             <data name="NAMES" type="char" length="20" usage="inherit">
#             <data name="ADDRESSES" type="char" length="60" usage="inherit">
#             <data name="PHN-NUM" type="zoned" length="11" precision="0" usage="inherit">
#          </struct>
#          <data name="NUM-1A" type="packed" length="8" precision="3" usage="inherit">
#          <data name="NUM-2A" type="packed" length="8" precision="3" usage="inherit">
#          <data name="TAB-NUM-3A" type="packed" length="8" precision="3" count="10"
# usage="inherit">
#          <data name="NUM-4A" type="packed" length="8" precision="3" usage="inherit">
#          <data name="NUM-5A" type="packed" length="8" precision="3" usage="inherit">
#          <data name="NUM-6A" type="int" length="2" precision="16" usage="inherit">
#          <data name="NUM-7A" type="float" length="4" usage="inherit">
#          <data name="NUM-8A" type="float" length="8" usage="inherit">
#          <data name="INTLNAME" type="char" length="10" chartype="twobyte" ccsid="13488" usage="inherit">
#       </struct>
#       <data name="RETN-VAL" type="int" length="4" precision="32" passby="value"
# usage="output">
#    </program></pcml>
```

COBOL and JNI

Calling a COBOL Program from a Java Program

To call a COBOL program from a Java program, perform the following steps:

- "Code the COBOL Program"
- "Create the COBOL Module" on page 248
- "Create a Service Program" on page 249
- "Code the Java Program" on page 250
- "Compile the Java Program" on page 251.

Code the COBOL Program: This section describes how to code a COBOL program that is called by a Java program. The guidelines are illustrated in two sample COBOL programs. A later section shows two Java programs that interact with these COBOL programs.

If your COBOL program will be called by a Java program:

1. Use the PROCESS statement NOMONOPRC (for case-sensitive names) and the option THREAD(SERIALIZE). When the COBOL program is invoked from a Java program, it will run in a Java thread. Specify the NOSTDTRUNC Process option to preserve the content of binary data items.
2. Identify the COBOL program with a name that consists of:
   - The prefix `Java_`
   - A mangled fully-qualified class name
   - An underscore (_) separator
   - A mangled method name
   - For an overloaded native method, two underscores (__) followed by the mangled argument signature.
3. Copy the predefined interface function table into the program. For a listing of the predefined interface function table, see "Member JNI" on page 259.
4. To pass a variable from a COBOL program to a Java program, specify the BY VALUE phrase on the CALL. Receive the following arguments, in the following order:
   a. The JNI interface pointer
   b. A reference to the Java class (for a static native method) or to the object (for a nonstatic native method)
   c. Any additional arguments that are required. These arguments correspond to regular Java method arguments.

   Note that COBOL and Java data types are not completely equivalent. See "COBOL and Java Data Types" on page 258.

```
 PROCESS NOMONOPRC NOSTDTRUNC OPTIONS THREAD (SERIALIZE). 1

*** COBOL native program called from Java
*** static method

  IDENTIFICATION DIVISION.
  PROGRAM-ID.    "Java_Hello_displayHello".     2
  Author.
  INSTALLATION.   IBM Toronto Lab.
  DATE-WRITTEN.
  DATE-COMPILED.

  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  SOURCE-COMPUTER.    IBM-ISERIES
  OBJECT-COMPUTER.    IBM-ISERIES

  INPUT-OUTPUT SECTION.
  FILE-CONTROL.

  DATA DIVISION.
  FILE SECTION.
  WORKING-STORAGE SECTION.

  01 IS-COPY     PIC 1.
  01 NAME-PTR            USAGE POINTER.
  01 NAME-LENGTH PIC 9(4) BINARY.
  01 I           PIC 9(4) BINARY.

  01 NAME-X.
       05 CHAR-X OCCURS 20 TIMES PIC X.

  LINKAGE SECTION.

*** JNI interface function table

  COPY JNI.      3

  01 NAME.
       05 CHAR OCCURS 20 TIMES PIC N USAGE NATIONAL.

  01 ENV-PTR              USAGE POINTER.
  01 CLASS-REF   PIC S9(9) BINARY.
  01 TITLE-CODE  PIC S9(9) BINARY.
  01 NAME-REF    PIC S9(9) BINARY.

  01 INTERFACE-PTR        USAGE POINTER.
```

Figure 61. COBOL Program HELLO (Part 1 of 2)

```
  PROCEDURE DIVISION USING BY VALUE ENV-PTR      4a
                                    CLASS-REF    4b
                                    TITLE-CODE   4c
                                    NAME-REF.    4c

 MAIN-LINE SECTION.
 MAIN-PROGRAM-LOGIC.

             SET ADDRESS OF INTERFACE-PTR TO ENV-PTR.
             SET ADDRESS OF JNI-NATIVE-INTERFACE TO INTERFACE-PTR.

*** Callback JNI interface function GET-STRING-LENGTH to
*** retrieve the name length

             CALL GET-STRING-LENGTH USING BY VALUE ENV-PTR      4
                                                   NAME-REF
                                    RETURNING INTO NAME-LENGTH.

*** Callback JNI interface function GET-STRING-CHARS to
*** retrieve the name characters

              CALL GET-STRING-CHARS USING BY VALUE ENV-PTR      4
                                                   NAME-REF
                                                   IS-COPY
                                    RETURNING INTO NAME-PTR.

             SET ADDRESS OF NAME TO NAME-PTR.
             INITIALIZE NAME-X.

             PERFORM VARYING I FROM 1 BY 1 UNTIL (I > NAME-LENGTH)
                   MOVE CHAR(I) TO CHAR-X(I)
             END-PERFORM.

             EVALUATE TITLE-CODE
                   WHEN  1
                                 DISPLAY "Hello, Mr. ", NAME-X
                   WHEN  2
                                 DISPLAY "Hello, Ms. ", NAME-X
                   WHEN OTHER
                                 DISPLAY "Hello, ", NAME-X
             END-EVALUATE.

             GOBACK.
```

Figure 61. COBOL Program HELLO (Part 2 of 2)

```
  PROCESS NOMONOPRC NOSTDTRUNC OPTIONS THREAD(SERIALIZE).      1

*** COBOL native program called from Java
*** instance method

  IDENTIFICATION DIVISION.
  PROGRAM-ID.    "Java_Bye_displayBye".      2
  Author.
  INSTALLATION.   IBM Toronto Lab.
  DATE-WRITTEN.
  DATE-COMPILED.

  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  SOURCE-COMPUTER.    IBM-ISERIES
  OBJECT-COMPUTER.    IBM-ISERIES

  INPUT-OUTPUT SECTION.
  FILE-CONTROL.

  DATA DIVISION.
  FILE SECTION.

  WORKING-STORAGE SECTION.

  01 IS-COPY     PIC 1.
  01 NAME-PTR            USAGE POINTER.
  01 NAME-LENGTH PIC 9(4) BINARY.
  01 I           PIC 9(4) BINARY.

  01 NAME-X.
       05 CHAR-X OCCURS 20 TIMES PIC X.

  LINKAGE SECTION.

*** JNI interface function table

  COPY JNI.      3

  01 NAME.
       05 CHAR OCCURS 20 TIMES PIC N USAGE NATIONAL.

  01 ENV-PTR              USAGE POINTER.
  01 OBJECT-REF  PIC S9(9) BINARY.
  01 TITLE-CODE  PIC S9(9) BINARY.
  01 NAME-REF    PIC S9(9) BINARY.

  01 INTERFACE-PTR        USAGE POINTER.
```

Figure 62. COBOL Program BYE (Part 1 of 2)

```
  PROCEDURE DIVISION USING BY VALUE ENV-PTR      4
                                    OBJECT-REF
                                    TITLE-CODE
                                    NAME-REF.

  MAIN-LINE SECTION.
  MAIN-PROGRAM-LOGIC.

               SET ADDRESS OF INTERFACE-PTR TO ENV-PTR.
               SET ADDRESS OF JNI-NATIVE-INTERFACE TO INTERFACE-PTR.

*** Callback JNI interface function GET-STRING-LENGTH to
*** retrieve the name length

               CALL GET-STRING-LENGTH USING BY VALUE ENV-PTR      4
                                                     NAME-REF
                                  RETURNING INTO NAME-LENGTH.

*** Callback JNI interface function GET-STRING-CHARS to
*** retrieve the name characters

              CALL GET-STRING-CHARS USING BY VALUE ENV-PTR      4
                                                   NAME-REF
                                                   IS-COPY
                                  RETURNING INTO NAME-PTR.

               SET ADDRESS OF NAME TO NAME-PTR.
               INITIALIZE NAME-X.

               PERFORM VARYING I FROM 1 BY 1 UNTIL (I > NAME-LENGTH)
                       MOVE CHAR(I) TO CHAR-X(I)
               END-PERFORM.

               EVALUATE TITLE-CODE
                      WHEN  1
                                   DISPLAY "Bye, Mr. ", NAME-X
                      WHEN  2
                                   DISPLAY "Bye, Ms. ", NAME-X
                      WHEN  OTHER
                                   DISPLAY "Bye, ", NAME-X
               END-EVALUATE.

               GOBACK.
```

Figure 62. COBOL Program BYE (Part 2 of 2)

Create the COBOL Module: To create a COBOL module, use the CRTCBLMOD command, as shown in the examples on the two following screens.

```
                      Create COBOL Module (CRTCBLMOD)

Type choices, press Enter.

Module . . . . . > BYE           Name, *PGMID
  Library  . . . . . >   *CURLIB     Name, *CURLIB
Source file  . . . . . > QCBLLESRC     Name
  Library  . . . . . >   *LIBL       Name, *LIBL, *CURLIB
Source member  . . . . . > BYE           Name, *MODULE
Source stream file . . . . . .
Output . . . . . .   *PRINT       *PRINT, *NONE
Generation severity level  . . .   30           0-30
Text 'description' . . . . . .   *SRCMBRTXT


                          Additional Parameters

Replace module . . . . . > *YES          *YES, *NO




                                                                      Bottom
F3=Exit   F4=Prompt   F5=Refresh   F10=Additional parameters   F12=Cancel
F13=How to use this display        F24=More keys
```

```
                      Create COBOL Module (CRTCBLMOD)

Type choices, press Enter.

Module . . . . . > HELLO         Name, *PGMID
  Library  . . . . . >   *CURLIB     Name, *CURLIB
Source file  . . . . . > QCBLLESRC     Name
  Library  . . . . . >   *LIBL       Name, *LIBL, *CURLIB
Source member  . . . . . > HELLO         Name, *MODULE
Source stream file . . . . . .
Output . . . . . .   *PRINT       *PRINT, *NONE
Generation severity level  . . .   30           0-30
Text 'description' . . . . . .   *SRCMBRTXT


                          Additional Parameters

Replace module . . . . . > *YES          *YES, *NO




                                                                      Bottom
F3=Exit   F4=Prompt   F5=Refresh   F10=Additional parameters   F12=Cancel
F13=How to use this display        F24=More keys
```

Create a Service Program: Bind the module or modules into a service program, using the CRTSRVPGM command as shown below. Specify the EXPORT option.

```
                    Create Service Program (CRTSRVPGM)

Type choices, press Enter.

Service program  . . . . . . . . . SRVPGM       > HELLOBYE
  Library  . . . . . . . . . . . .                >   *CURLIB
Module . . . . . . . . . . . . . . MODULE       > HELLO
  Library  . . . . . . . . . . . .                >   *CURLIB
                         + for more values      > BYE
                                                 >   *CURLIB
Export . . . . . . . . . . . . . . EXPORT       > *ALL
Export source file . . . . . . . . SRCFILE        QSRVSRC
  Library  . . . . . . . . . . . .                  *LIBL
Export source member . . . . . . . SRCMBR         *SRVPGM
Text 'description' . . . . . . . . TEXT           *BLANK




                                                                        More...
F3=Exit   F4=Prompt   F5=Refresh   F12=Cancel   F13=How to use this display
F24=More keys
```

Code the Java Program: This section describes how to code a Java program that calls a COBOL program. The guidelines are illustrated in two sample Java programs, which call the COBOL programs that were shown in a previous section.

Java source files are stored in the Integrated File System (IFS). You can use the stream file editor, EDTF, to edit these files.

If your Java program will call a COBOL program:

1. Make a static initializing call to the system method `System.loadLibrary` to load the COBOL service program that you created in the previous step. (In this example, the service program is named HELLOBYE.)
2. Declare the COBOL method with the keyword `native`. For the body of the native method, specify only a semicolon. This indicates that the implementation is omitted.

   You can specify the short name (the name without the argument signature). The JVM will look for a method with this name in the native library; if that fails, the JVM will look for the long name. If you want to overload another native method, use the long name. If a native method has the same name as a Java method, you do not need to specify the long name because the Java method will not exist in the native library.

```
class Hello {
        static {
                System.loadLibrary("HELLOBYE");      1
        }

        static native void displayHello(int parm1, String parm2);      2

        public static void main(String[ ] args) {
              int titleCode;
              String name;

              switch (args.length) {
              case 1:
                           titleCode = Integer.parseInt(args[0]);
                           name = "Someone";
                           break;
              case 2:
                           titleCode = Integer.parseInt(args[0]);
                           name = args[1];
                           break;
              default:
                           titleCode = 0;
                           name = "Someone";
                           break;
              }
              displayHello(titleCode, name);
              Bye bye = new Bye( );
              bye.displayBye(titleCode, name);
        }
}
```

Figure 63. Java Program Hello.java

```
class Bye {
         static {
                 System.loadLibrary("HELLOBYE");      1
         }
         static native void displayBye(int parm1, String parm2);      2
}
```

Figure 64. Java Program Bye.java

Compile the Java Program: To compile the Java source programs, you can enter the Qshell interpreter (QSH) and issue the following commands:

```
javac Hello.java

javac Bye.java
```

Invoke theJava program: To invoke the Java source programs, you can enter the Qshell interpreter (QSH) and issue the following commands:

```
>java Hello
Hello, Someone
Bye, Someone
>java Hello 1
Hello, Mr. Someone
Bye, Mr. Someone
>java Hello 2 USA
Hello, Ms. USA
Bye, Ms. USA
```

You can use the javah tool to generate header files for the Java programs. These header files are used by C and C++ compilers, not by the COBOL compiler, but you might find them useful for checking the naming of native programs.

```
javah -jni Hello

javah -jni Bye
```

Calling Java Methods from a COBOL Program

To call a Java method from a COBOL program, perform the following steps:

- "Code the COBOL Program"
- "Create the COBOL Program" on page 257
- "Code the Java Program" on page 257
- "Compile the Java Program" on page 257

Code the COBOL Program

This section describes how to code a COBOL program that calls Java methods. The guidelines are illustrated in a sample COBOL program and a sample Java program.

If your COBOL program will call a Java method:

1. Use the PROCESS statement NOMONOPRC (for case-sensitive names) and the option THREAD(SERIALIZE).
2. Copy the JDKINIT and JNI members. For listings of these members, see "Member JNI" on page 259 and "Member JDK11INIT" on page 264.
3. Call the appropriate Java invocation API functions. The following API functions are available:
   - JNI_GetDefaultJavaVMInitArgs( )
   - JNI_GetCreatedJavaVMs( )
   - JNI_CreateJavaVM( )
   - DestroyJavaVM( )
   - AttachCurrentThread( )
   - DetachCurrentThread( )

   For detailed information about the parameters associated with these invocation API functions, refer to *Java Native Interface Specification Release 1.1 (Revised May, 1997)*.

   In the example below:
   a. Specify the classpath for the JVM.
   b. The JVM is invoked.
   c. The `DestroyJavaVM( )` procedure unloads the JVM and reclaims its resources.

COBOL Program HELLOWORLD

```
PROCESS MAP NOMONOPRC OPTIONS THREAD(SERIALIZE).     1

Author.
INSTALLATION.   IBM Toronto Lab.
DATE-WRITTEN.
DATE-COMPILED.

ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER.    IBM-ISERIES.
OBJECT-COMPUTER.    IBM-ISERIES.

INPUT-OUTPUT SECTION.
```

```
 FILE-CONTROL.

 DATA DIVISION.
 FILE SECTION.

 WORKING-STORAGE SECTION.

*** JDK 1.2 VM initialization arguments

 01 VM-INIT-ARGS.
    05  VERSION             PIC S9(9) BINARY VALUE 65538.
    05  NUMBER-OF-OPTIONS   PIC S9(9) BINARY.
    05  OPTIONS-PTR                          USAGE POINTER.
    05  FILLER              PIC  X(1).

 01 VM-OPTIONS.
    05  OPTIONS-STRING-PTR                   USAGE POINTER.
    05  EXTRA-INFO-PTR                       USAGE POINTER.

***

 01 JVM-PTR                            USAGE POINTER.
 01 ENV-PTR                            USAGE POINTER.

 01 RC1                      PIC S9(9) BINARY VALUE 1.
 01 RC2                      PIC S9(9) BINARY VALUE 1.
 01 RC3                      PIC S9(9) BINARY VALUE 1.

 01 CLASS-NAME               PIC X(30).
 01 CLASS-NAME-PTR                     USAGE POINTER.

 01 METHOD-NAME              PIC X(30).
 01 METHOD-NAME-PTR                    USAGE POINTER.

 01 SIGNATURE-NAME           PIC X(30).
 01 SIGNATURE-NAME-PTR                 USAGE POINTER.


*** CLASSPATH Parameters
 01 CLASSPATH                PIC X(500).

*** Object Reference Variables
 01 MY-CLASS-REF             PIC S9(9) BINARY.
 01 STRING-CLASS-REF         PIC S9(9) BINARY.
 01 METHOD-ID                PIC S9(9) BINARY.
 01 INIT-METHOD-ID           PIC S9(9) BINARY.
 01 STATIC-METHOD-ID         PIC S9(9) BINARY.
 01 OBJECT-REF               PIC S9(9) BINARY.
 01 ARG-REF                  PIC S9(9) BINARY.
 01 STRING-REF               PIC S9(9) BINARY.

*** Parameter Array for calling METHODA
 01 PARM-ARRAY.
    05 PARM-ARRAY-ELEMENT OCCURS 10 TIMES.
       10 PARM-ARRAY-ELEMENT-VALUE  PIC S9(9) BINARY.
       10 FILLER                    PIC X(4).

 01 PARM-ARRAY-PTR                    USAGE POINTER.


 LINKAGE SECTION.

*** JNI interface function table

 COPY JNI.    2
```

```
 01 INTERFACE-PTR                    USAGE POINTER.
 01 JVM                    PIC S9(9) BINARY.


 PROCEDURE DIVISION.

 MAIN-LINE SECTION.
 MAIN-PROGRAM-LOGIC.

*** In V5R3, the procedure call JNI_GetDefaultJavaVMInitArgs
*** is no longer required.
*** Retrieve default JVM initiliazion arguments
*
*      SET VM-ARGS-PTR TO ADDRESS OF VM-INIT-ARGS.
*      CALL PROCEDURE "JNI_GetDefaultJavaVMInitArgs"
*           USING VM-INIT-ARGS
*           RETURNING INTO RC1.
*
*      DISPLAY RC1.
*
*** Append my classpath (:/home/myclass) to CLASSPATH
*
*      SET ADDRESS OF CLASSPATH-DEFAULT TO CLASSPATH.
*

       STRING FUNCTION UTF8STRING("-Djava.class.path=/home/myclass")
3a                      DELIMITED BY SIZE
              X"00" DELIMITED BY SIZE
         INTO CLASSPATH

       SET OPTIONS-STRING-PTR TO ADDRESS OF CLASSPATH.
       MOVE 1 TO NUMBER-OF-OPTIONS.
       SET OPTIONS-PTR TO ADDRESS OF VM-OPTIONS.

*** Load and initializes the Java VM
3b
       CALL PROCEDURE "JNI_CreateJavaVM"
            USING JVM-PTR ENV-PTR VM-INIT-ARGS
            RETURNING INTO RC2.

       DISPLAY RC2.

       SET ADDRESS OF INTERFACE-PTR TO ENV-PTR.
       SET ADDRESS OF JNI-NATIVE-INTERFACE TO INTERFACE-PTR.

*** Callback JNI interface function FIND-CLASS "HelloWorld"

       STRING FUNCTION UTF8STRING("HelloWorld") DELIMITED BY SIZE
              X"00" DELIMITED BY SIZE
         INTO CLASS-NAME.

       SET CLASS-NAME-PTR TO ADDRESS OF CLASS-NAME.

       CALL FIND-CLASS USING BY VALUE ENV-PTR
                                      CLASS-NAME-PTR
                      RETURNING INTO MY-CLASS-REF.

       DISPLAY MY-CLASS-REF.

*** Callback JNI interface function FIND-CLASS "java/lang/String"

       STRING FUNCTION UTF8STRING("java/lang/String")
                    DELIMITED BY SIZE
              X"00" DELIMITED BY SIZE
         INTO CLASS-NAME.

       SET CLASS-NAME-PTR TO ADDRESS OF CLASS-NAME.
```

```
           CALL FIND-CLASS USING BY VALUE ENV-PTR
                                          CLASS-NAME-PTR
                           RETURNING INTO STRING-CLASS-REF.

           DISPLAY STRING-CLASS-REF.

      *** Callback JNI interface function GET-METHOD-ID "<init>"
      *** to retrieve constructor method ID

           STRING FUNCTION UTF8STRING("<init>") DELIMITED BY SIZE
                  X"00" DELIMITED BY SIZE
             INTO METHOD-NAME.

           STRING FUNCTION UTF8STRING("()V") DELIMITED BY SIZE
                  X"00" DELIMITED BY SIZE
             INTO SIGNATURE-NAME.

           SET METHOD-NAME-PTR TO ADDRESS OF METHOD-NAME.
           SET SIGNATURE-NAME-PTR TO ADDRESS OF SIGNATURE-NAME.

           CALL GET-METHOD-ID USING BY VALUE ENV-PTR
                                             MY-CLASS-REF
                                             METHOD-NAME-PTR
                                             SIGNATURE-NAME-PTR
                              RETURNING INTO INIT-METHOD-ID.

           DISPLAY INIT-METHOD-ID.

      *** Callback JNI interface function NEW-OBJECT "HelloWorld"

           CALL NEW-OBJECT USING BY VALUE ENV-PTR
                                          MY-CLASS-REF
                                          INIT-METHOD-ID
                           RETURNING INTO OBJECT-REF.

           DISPLAY OBJECT-REF.

      *** Callback JNI interface function GET-STATIC-METHOD-ID "main"

           STRING FUNCTION UTF8STRING("main") DELIMITED BY SIZE
                  X"00" DELIMITED BY SIZE
             INTO METHOD-NAME.

           STRING FUNCTION UTF8STRING("([Ljava/lang/String;)V")
                        DELIMITED BY SIZE
                  X"00" DELIMITED BY SIZE
             INTO SIGNATURE-NAME.

           SET METHOD-NAME-PTR TO ADDRESS OF METHOD-NAME.
           SET SIGNATURE-NAME-PTR TO ADDRESS OF SIGNATURE-NAME.

           CALL GET-STATIC-METHOD-ID USING BY VALUE ENV-PTR
                                                    MY-CLASS-REF
                                                    METHOD-NAME-PTR
                                                    SIGNATURE-NAME-PTR
                                       RETURNING INTO STATIC-METHOD-ID.

           DISPLAY STATIC-METHOD-ID.

      *** Callback JNI interface function NEW-OBJECT-ARRAY

           CALL NEW-OBJECT-ARRAY USING BY VALUE ENV-PTR
                                                0
                                                STRING-CLASS-REF
                                                0
                                  RETURNING INTO ARG-REF.
```

```
           DISPLAY ARG-REF.

      *** Callback JNI interface function CALL-STATIC-VOID-METHODA

           SET PARM-ARRAY-PTR TO ADDRESS OF PARM-ARRAY.

           INITIALIZE PARM-ARRAY.

           MOVE ARG-REF TO PARM-ARRAY-ELEMENT-VALUE(1).

           CALL CALL-STATIC-VOID-METHODA USING BY VALUE ENV-PTR
                                                        MY-CLASS-REF
                                                    STATIC-METHOD-ID
                                                        PARM-ARRAY-PTR.

      *** Callback JNI interface function GET-METHOD-ID "display"

           STRING FUNCTION UTF8STRING("display") DELIMITED BY SIZE
                  X"00" DELIMITED BY SIZE
             INTO METHOD-NAME.

           STRING FUNCTION UTF8STRING("([II)V") DELIMITED BY SIZE
                  X"00" DELIMITED BY SIZE
             INTO SIGNATURE-NAME.

           SET METHOD-NAME-PTR TO ADDRESS OF METHOD-NAME.
           SET SIGNATURE-NAME-PTR TO ADDRESS OF SIGNATURE-NAME.

           CALL GET-METHOD-ID USING BY VALUE ENV-PTR
                                             MY-CLASS-REF
                                             METHOD-NAME-PTR
                                             SIGNATURE-NAME-PTR
                              RETURNING INTO METHOD-ID.

           DISPLAY METHOD-ID.

      *** Callback JNI interface function NEW-INT-ARRAY

           CALL NEW-INT-ARRAY USING BY VALUE ENV-PTR
                                             10
                              RETURNING INTO ARG-REF.

           DISPLAY ARG-REF.

      *** Callback JNI interface function CALL-VOID-METHODA

           SET PARM-ARRAY-PTR TO ADDRESS OF PARM-ARRAY.

           INITIALIZE PARM-ARRAY.

           MOVE ARG-REF TO PARM-ARRAY-ELEMENT-VALUE(1).
           MOVE 2       TO PARM-ARRAY-ELEMENT-VALUE(2).

           CALL CALL-VOID-METHODA USING BY VALUE ENV-PTR
                                                 OBJECT-REF
                                                 METHOD-ID
                                                 PARM-ARRAY-PTR.

      *** Destroy the Java VM
3c

           SET ADDRESS OF JVM TO JVM-PTR.

           CALL PROCEDURE "DestroyJavaVM"
                USING JVM
                RETURNING INTO RC3.
```

```
            DISPLAY RC3.

            GOBACK.
```

Create the COBOL Program

To create a COBOL module, use the CRTBNDCBL command, as shown below.

```
                    Create Bound COBOL Program (CRTBNDCBL)

 Type choices, press Enter.

 Program  . . . . . . . . . . . . > HELLOWORLD    Name, *PGMID
   Library  . . . . . . . . . . .     *CURLIB     Name, *CURLIB
 Source file  . . . . . . . . . . > QCBLLESRC     Name
   Library  . . . . . . . . . . .>    *CURLIB     Name, *LIBL, *CURLIB
 Source member  . . . . . . . . . > HELLOWORLD    Name, *PGM
 Source stream file . . . . . . .
 Output . . . . . . . . . . . . .   *PRINT        *PRINT, *NONE
 Generation severity level  . . .   30           0-30
 Text 'description' . . . . . . .   *SRCMBRTXT


                           Additional Parameters

 Replace program  . . . . . . . . > *YES          *YES, *NO




                                                                       Bottom
 F3=Exit   F4=Prompt   F5=Refresh   F10=Additional parameters   F12=Cancel
 F13=How to use this display        F24=More keys
```

Code the Java Program

```
class HelloWorld {

     public static void main(String[] args) {

          System.out.println("Hello World");

     }

     void display(int[] args, int i) {

          System.out.println("Length of integer array is " + args.length);
          System.out.println("Value of integer variable is " + i);
          System.out.println("Bye World");

     }

}
```

Figure 65. Java Program HelloWorld.java

Compile the Java Program

To compile the Java source program, you can enter the Qshell interpreter (QSH) and issue the following command:

```
javac HelloWorld.java
```

COBOL and Java Data Types

The following table shows the COBOL data type that corresponds to each Java primitive type.

Table 14. Comparison of COBOL and Java Data Types

Java Primitive Type	Description	Java Data Range	COBOL Data Type	COBOL Data Range
boolean	unsigned 8 bits	0 (false) or 1 (true)	PIC 9(4) BINARY	0 to 255
byte	signed 8 bits	-128 to 127	PIC X	-128 to 127
char	unsigned 16 bits	0 ('\u0000') to 65535 ('\uffff')	PIC N USAGE NATIONAL	0 ('\u0000') to 65535 ('\uffff')
short	signed 16 bits	-32768 to 32767	PIC S9(4) BINARY [1]	-32768 to 32767
int	signed 32 bits	-2147483648 to 2147483647	PIC S9(9) BINARY [1]	-2147483648 to 2147483647
long	signed 64 bits	-9223372036854775808 to 9223372036854775807	PIC S9(18) BINARY [1]	-9223372036854775808 to 9223372036854775807
float	32 bits	1.40239846e-45f to 3.40282347e+38f	USAGE COMP-1	0.14012985e-44 to 0.34028235e39
double	64 bits	4.94065645841246544e-324 to 1.79769313486231570e+308	USAGE COMP-2	.11125369292536009e-307 to .17976931348623155e+309
void	n/a	n/a	n/a	n/a

Notes:

1. To preserve truncation for short, int, and long primitive types, you must specify NOSTDTRUNC on the PROCESS statement.

The COBOL and Java data ranges are similar.

- For boolean, byte, char, short, and int, the COBOL range is identical to the Java range or larger.
- For float and double, the COBOL data range depends on the machine implementation.
- Void has no COBOL equivalent.

A Java reference type consists of a class, an interface and an array. A reference type is passed as a Java int type argument.

```
01 JBOOLEAN          TYPEDEF PIC 9(4) BINARY.
01 JBYTE             TYPEDEF PIC X.
01 JCHAR             TYPEDEF PIC N USAGE NATIONAL.
01 JSHORT            TYPEDEF PIC S9(4) BINARY.      (and NOSTDTRUNC on PROCESS statement)
01 JINT              TYPEDEF PIC S9(9) BINARY.      (and NOSTDTRUNC on PROCESS statement)
01 JLONG             TYPEDEF PIC S9(18) BINARY.     (and NOSTDTRUNC on PROCESS statement)
01 JFLOAT            TYPEDEF USAGE COMP-1.
01 JDOUBLE           TYPEDEF USAGE COMP-2.
```

Figure 66. Defining Java Data Types

JNI Copy Members for COBOL

These layouts are the COBOL implementation of the JNI interface function table. They can be found in library QSYSINC. For more information about the

parameters associated with each JNI function, refer to *Java Native Interface Specification Release 1.1 (Revised May, 1997).*

- "Member JNI"
- "Member JDK11INIT" on page 264.

Member JNI

```
*** COBOL copybook for JNI native interface
*** based on Java Native Interface Specification Release 1.1
*** (Revised May, 1997)

01 JNI-NATIVE-INTERFACE.

     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 GET-VERSION                     USAGE PROCEDURE-POINTER.

     05 DEFINE-CLASS                    USAGE PROCEDURE-POINTER.
     05 FIND-CLASS                      USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 GET-SUPERCLASS                  USAGE PROCEDURE-POINTER.
     05 IS-ASSIGNABLE-FROM              USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.

     05 THROW                           USAGE PROCEDURE-POINTER.
     05 THROW-NEW                       USAGE PROCEDURE-POINTER.
     05 EXCEPTION-OCCURRED              USAGE PROCEDURE-POINTER.
     05 EXCEPTION-DESCRIBE              USAGE PROCEDURE-POINTER.
     05 EXCEPTION-CLEAR                 USAGE PROCEDURE-POINTER.
     05 FATAL-ERROR                     USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.

     05 NEW-GLOBAL-REF                  USAGE PROCEDURE-POINTER.
     05 DELETE-GLOBAL-REF               USAGE PROCEDURE-POINTER.
     05 DELETE-LOCAL-REF                USAGE PROCEDURE-POINTER.
     05 IS-SAME-OBJECT                  USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.
     05 FILLER                          USAGE PROCEDURE-POINTER.

     05 ALLOC-OBJECT                    USAGE PROCEDURE-POINTER.
     05 NEW-OBJECT                      USAGE PROCEDURE-POINTER.
     05 NEW-OBJECTV                     USAGE PROCEDURE-POINTER.
     05 NEW-OBJECTA                     USAGE PROCEDURE-POINTER.

     05 GET-OBJECT-CLASS                USAGE PROCEDURE-POINTER.
     05 IS-INSTANCE-OF                  USAGE PROCEDURE-POINTER.

     05 GET-METHOD-ID                   USAGE PROCEDURE-POINTER.

     05 CALL-OBJECT-METHOD              USAGE PROCEDURE-POINTER.
     05 CALL-OBJECT-METHODV             USAGE PROCEDURE-POINTER.
     05 CALL-OBJECT-METHODA             USAGE PROCEDURE-POINTER.
```

Figure 67. Member JNI (Part 1 of 5)

```
     05 CALL-BOOLEAN-METHOD           USAGE PROCEDURE-POINTER.
     05 CALL-BOOLEAN-METHODV          USAGE PROCEDURE-POINTER.
     05 CALL-BOOLEAN-METHODA          USAGE PROCEDURE-POINTER.
     05 CALL-BYTE-METHOD              USAGE PROCEDURE-POINTER.
     05 CALL-BYTE-METHODV             USAGE PROCEDURE-POINTER.
     05 CALL-BYTE-METHODA             USAGE PROCEDURE-POINTER.
     05 CALL-CHAR-METHOD              USAGE PROCEDURE-POINTER.
     05 CALL-CHAR-METHODV             USAGE PROCEDURE-POINTER.
    05 CALL-CHAR-METHODA              USAGE PROCEDURE-POINTER.
    05 CALL-SHORT-METHOD              USAGE PROCEDURE-POINTER.
    05 CALL-SHORT-METHODV             USAGE PROCEDURE-POINTER.
    05 CALL-SHORT-METHODA             USAGE PROCEDURE-POINTER.
    05 CALL-INT-METHOD                USAGE PROCEDURE-POINTER.
    05 CALL-INT-METHODV               USAGE PROCEDURE-POINTER.
    05 CALL-INT-METHODA               USAGE PROCEDURE-POINTER.
    05 CALL-LONG-METHOD               USAGE PROCEDURE-POINTER.
    05 CALL-LONG-METHODV              USAGE PROCEDURE-POINTER.
    05 CALL-LONG-METHODA              USAGE PROCEDURE-POINTER.
    05 CALL-FLOAT-METHOD              USAGE PROCEDURE-POINTER.
    05 CALL-FLOAT-METHODV             USAGE PROCEDURE-POINTER.
    05 CALL-FLOAT-METHODA             USAGE PROCEDURE-POINTER.
    05 CALL-DOUBLE-METHOD             USAGE PROCEDURE-POINTER.
    05 CALL-DOUBLE-METHODV            USAGE PROCEDURE-POINTER.
    05 CALL-DOUBLE-METHODA            USAGE PROCEDURE-POINTER.
    05 CALL-VOID-METHOD               USAGE PROCEDURE-POINTER.
    05 CALL-VOID-METHODV              USAGE PROCEDURE-POINTER.
    05 CALL-VOID-METHODA              USAGE PROCEDURE-POINTER.

    05 CALL-NONVIRTUAL-OBJECT-METHOD  USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-OBJECT-METHODV USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-OBJECT-METHODA USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BOOLEAN-METHOD USAGE PROCEDURE-POINTER.

*** Note that the naming of the following 2 procedures deviates
*** slightly from the others due to the 30 character field
*** name limitation.
    05 CALL-NONVIRTUAL-BOOLEAN-MTHDV  USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BOOLEAN-MTHDA  USAGE PROCEDURE-POINTER.

    05 CALL-NONVIRTUAL-BYTE-METHOD    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BYTE-METHODV   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BYTE-METHODA   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-CHAR-METHOD    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-CHAR-METHODV   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-CHAR-METHODA   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-SHORT-METHOD   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-SHORT-METHODV  USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-SHORT-METHODA  USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-INT-METHOD     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-INT-METHODV    USAGE PROCEDURE-POINTER.
```

Figure 67. Member JNI (Part 2 of 5)

```
    05 CALL-NONVIRTUAL-INT-METHODA     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-LONG-METHOD     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-LONG-METHODV    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-LONG-METHODA    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-FLOAT-METHOD    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-FLOAT-METHODV   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-FLOAT-METHODA   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-DOUBLE-METHOD   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BOOLEAN-MTHDA   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BYTE-METHOD     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BYTE-METHODV    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-BYTE-METHODA    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-CHAR-METHOD     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-CHAR-METHODV    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-CHAR-METHODA    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-SHORT-METHOD    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-SHORT-METHODV   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-SHORT-METHODA   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-INT-METHOD      USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-INT-METHODV     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-INT-METHODA     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-LONG-METHOD     USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-LONG-METHODV    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-LONG-METHODA    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-FLOAT-METHOD    USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-FLOAT-METHODV   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-FLOAT-METHODA   USAGE PROCEDURE-POINTER.
    05 CALL-NONVIRTUAL-DOUBLE-METHOD   USAGE PROCEDURE-POINTER.
    05 SET-CHAR-FIELD                  USAGE PROCEDURE-POINTER.
    05 SET-SHORT-FIELD                 USAGE PROCEDURE-POINTER.
    05 SET-INT-FIELD                   USAGE PROCEDURE-POINTER.
    05 SET-LONG-FIELD                  USAGE PROCEDURE-POINTER.
    05 SET-FLOAT-FIELD                 USAGE PROCEDURE-POINTER.
    05 SET-DOUBLE-FIELD                USAGE PROCEDURE-POINTER.

    05 GET-STATIC-METHOD-ID            USAGE PROCEDURE-POINTER.

    05 CALL-STATIC-OBJECT-METHOD       USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-OBJECT-METHODV      USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-OBJECT-METHODA      USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-BOOLEAN-METHOD      USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-BOOLEAN-METHODV     USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-BOOLEAN-METHODA     USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-BYTE-METHOD         USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-BYTE-METHODV        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-BYTE-METHODA        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-CHAR-METHOD         USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-CHAR-METHODV        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-CHAR-METHODA        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-SHORT-METHOD        USAGE PROCEDURE-POINTER.
```

Figure 67. Member JNI (Part 3 of 5)

```
    05 CALL-STATIC-SHORT-METHODV       USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-SHORT-METHODA       USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-INT-METHOD          USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-INT-METHODV         USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-INT-METHODA         USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-LONG-METHOD         USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-LONG-METHODV        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-LONG-METHODA        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-FLOAT-METHOD        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-FLOAT-METHODV       USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-FLOAT-METHODA       USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-DOUBLE-METHOD       USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-DOUBLE-METHODV      USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-DOUBLE-METHODA      USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-VOID-METHOD         USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-VOID-METHODV        USAGE PROCEDURE-POINTER.
    05 CALL-STATIC-VOID-METHODA        USAGE PROCEDURE-POINTER.
    05 GET-STATIC-FILED-ID             USAGE PROCEDURE-POINTER.

    05 GET-STATIC-OBJECT-FIELD         USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-BOOLEAN-FIELD USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-BYTE-FIELD    USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-CHAR-FIELD    USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-SHORT-FIELD   USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-INT-FIELD     USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-LONG-FIELD    USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-FLOAT-FIELD   USAGE PROCEDURE-POINTER.
    05 GET-STATIC-OBJECT-DOUBLE-FIELD  USAGE PROCEDURE-POINTER.

    05 SET-STATIC-OBJECT-FIELD         USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-BOOLEAN-FIELD USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-BYTE-FIELD    USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-CHAR-FIELD    USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-SHORT-FIELD   USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-INT-FIELD     USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-LONG-FIELD    USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-FLOAT-FIELD   USAGE PROCEDURE-POINTER.
    05 SET-STATIC-OBJECT-DOUBLE-FIELD  USAGE PROCEDURE-POINTER.

    05 NEW-STRING                      USAGE PROCEDURE-POINTER.
    05 GET-STRING-LENGTH               USAGE PROCEDURE-POINTER.
    05 GET-STRING-CHARS                USAGE PROCEDURE-POINTER.
    05 RELEASE-STRING-CHARS            USAGE PROCEDURE-POINTER.

    05 NEW-STRING-UTF                  USAGE PROCEDURE-POINTER.
    05 GET-STRING-UTF-LENGTH           USAGE PROCEDURE-POINTER.
    05 GET-STRING-UTF-CHARS            USAGE PROCEDURE-POINTER.
    05 RELEASE-STRING-UTF-CHARS        USAGE PROCEDURE-POINTER.

    05 GET-ARRAY-LENGTH                USAGE PROCEDURE-POINTER.
```

Figure 67. Member JNI (Part 4 of 5)

```
05 NEW-OBJECT-ARRAY               USAGE PROCEDURE-POINTER.
05 GET-OBJECT-ARRAY-ELEMENT       USAGE PROCEDURE-POINTER.
05 SET-OBJECT-ARRAY-ELEMENT       USAGE PROCEDURE-POINTER.

05 NEW-BOOLEAN-ARRAY              USAGE PROCEDURE-POINTER.
05 NEW-BYTE-ARRAY                 USAGE PROCEDURE-POINTER.
05 NEW-CHAR-ARRAY                 USAGE PROCEDURE-POINTER.
05 NEW-SHORT-ARRAY                USAGE PROCEDURE-POINTER.
05 NEW-INT-ARRAY                  USAGE PROCEDURE-POINTER.
05 NEW-LONG-ARRAY                 USAGE PROCEDURE-POINTER.
05 NEW-FLOAT-ARRAY                USAGE PROCEDURE-POINTER.
05 NEW-DOUBLE-ARRAY               USAGE PROCEDURE-POINTER.

05 GET-BOOLEAN-ARRAY-ELEMENTS     USAGE PROCEDURE-POINTER.
05 GET-BYTE-ARRAY-ELEMENTS        USAGE PROCEDURE-POINTER.
05 GET-CHAR-ARRAY-ELEMENTS        USAGE PROCEDURE-POINTER.
05 GET-SHORT-ARRAY-ELEMENTS       USAGE PROCEDURE-POINTER.
05 GET-INT-ARRAY-ELEMENTS         USAGE PROCEDURE-POINTER.
05 GET-LONG-ARRAY-ELEMENTS        USAGE PROCEDURE-POINTER.
05 GET-FLOAT-ARRAY-ELEMENTS       USAGE PROCEDURE-POINTER.
05 GET-DOUBLE-ARRAY-ELEMENTS      USAGE PROCEDURE-POINTER.

05 RELEASE-BOOLEAN-ARRAY-ELEMENTS USAGE PROCEDURE-POINTER.
05 RELEASE-BYTE-ARRAY-ELEMENTS    USAGE PROCEDURE-POINTER.
05 RELEASE-CHAR-ARRAY-ELEMENTS    USAGE PROCEDURE-POINTER.
05 RELEASE-SHORT-ARRAY-ELEMENTS   USAGE PROCEDURE-POINTER.
05 RELEASE-INT-ARRAY-ELEMENTS     USAGE PROCEDURE-POINTER.
05 RELEASE-LONG-ARRAY-ELEMENTS    USAGE PROCEDURE-POINTER.
05 RELEASE-FLOAT-ARRAY-ELEMENTS   USAGE PROCEDURE-POINTER.
05 RELEASE-DOUBLE-ARRAY-ELEMENTS  USAGE PROCEDURE-POINTER.

05 GET-BOOLEAN-ARRAY-REGION       USAGE PROCEDURE-POINTER.
05 GET-BYTE-ARRAY-REGION          USAGE PROCEDURE-POINTER.
05 GET-CHAR-ARRAY-REGION          USAGE PROCEDURE-POINTER.
05 GET-SHORT-ARRAY-REGION         USAGE PROCEDURE-POINTER.
05 GET-INT-ARRAY-REGION           USAGE PROCEDURE-POINTER.
05 GET-LONG-ARRAY-REGION          USAGE PROCEDURE-POINTER.
05 GET-FLOAT-ARRAY-REGION         USAGE PROCEDURE-POINTER.
05 GET-DOUBLE-ARRAY-REGION        USAGE PROCEDURE-POINTER.
05 SET-BOOLEAN-ARRAY-REGION       USAGE PROCEDURE-POINTER.
05 SET-BYTE-ARRAY-REGION          USAGE PROCEDURE-POINTER.
05 SET-CHAR-ARRAY-REGION          USAGE PROCEDURE-POINTER.
05 SET-SHORT-ARRAY-REGION         USAGE PROCEDURE-POINTER.
05 SET-INT-ARRAY-REGION           USAGE PROCEDURE-POINTER.
05 SET-LONG-ARRAY-REGION          USAGE PROCEDURE-POINTER.
05 SET-FLOAT-ARRAY-REGION         USAGE PROCEDURE-POINTER.
05 SET-DOUBLE-ARRAY-REGION        USAGE PROCEDURE-POINTER.

05 REGISTER-NATIVES               USAGE PROCEDURE-POINTER.
05 UNREGISTER-NATIVES             USAGE PROCEDURE-POINTER.

05 MONITOR-ENTER                  USAGE PROCEDURE-POINTER.
05 MONITOR-EXIT                   USAGE PROCEDURE-POINTER.

05 GET-JAVA-VM                    USAGE PROCEDURE-POINTER.
```

Figure 67. Member JNI (Part 5 of 5)

Member JDK11INIT

```
*** COBOL copybook for JDK 1.1 VM initialization arguments
*** based on Java Native Interface Specification Release 1.1
*** (Revised May, 1997)

 01 VM-INIT-ARGS.
       05  VERSION           PIC S9(9) BINARY VALUE 65537.
       05  FILLER            PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
       05  PROPERTIES                  USAGE PROCEDURE-POINTER.
       05  CHECK-SOURCE      PIC S9(9) BINARY.
       05  NATIVE-STACK-SIZE PIC S9(9) BINARY.
       05  JAVA-STACK-SIZE   PIC S9(9) BINARY.
       05  MIN-HEAP-SIZE     PIC S9(9) BINARY.
       05  MAX-HEAP-SIZE     PIC S9(9) BINARY.
       05  VERIFY-MODE       PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
       05  CLASSPATH                   USAGE POINTER.
       05  MESSAGE-HOOK                USAGE PROCEDURE-POINTER.
       05  EXIT-HOOK                   USAGE PROCEDURE-POINTER.
       05  ABORT-HOOK                  USAGE PROCEDURE-POINTER.
       05  ENABLE-CLASSIC-GC PIC S9(9) BINARY.
       05  ENABLE-VERBOSE-GC PIC S9(9) BINARY.
       05  DISABLE-ASYNC-GC  PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
       05  FILLER            PIC S9(9) BINARY.
```

Figure 68. Member JDK11INIT

Chapter 11. Processing XML Documents

You can process XML documents from your COBOL program by using the XML PARSE statement. The XML PARSE statement is the COBOL language interface to the high-speed XML parser, which is part of the COBOL run time. Processing an XML document involves control being passed to and received from the XML parser. You start this exchange of control with the XML PARSE statement, which specifies a processing procedure that receives control from the XML parser to handle the parser events. You use special registers in your processing procedure to exchange information with the parser.

Use these COBOL facilities to process XML documents:

- XML PARSE statement to begin the XML parse and to identify the document and your processing procedure
- Processing procedure to control the parse: receive and process the XML events and associated document fragments and optionally handle exceptions
- Special registers to receive and pass information:
  - XML-CODE to determine the status of XML parsing
  - XML-EVENT to receive the name of each XML event
  - XML-TEXT to receive XML document fragments from an alphanumeric document
  - XML-NTEXT to receive XML document fragments from a national document

RELATED CONCEPTS
"XML parser in COBOL"

RELATED TASKS
"Accessing XML documents" on page 267
"Parsing XML documents" on page 267
"Processing XML events" on page 268
"Handling errors in XML documents" on page 282
"Understanding XML document encoding" on page 281

RELATED REFERENCE
Appendix F, "XML reference material," on page 611
XML specification (www.w3c.org/XML/)

XML parser in COBOL

ILE COBOL provides an event-based interface that enables you to parse XML documents and transform them to COBOL data structures. The XML parser finds fragments (associated with XML events) within the document, and your processing procedure acts on these fragments. You code your procedure to handle each XML event. Throughout this operation, control passes back and forth between the parser and your procedure.

You start this exchange with the parser by using the XML PARSE statement, in which you designate your processing procedure. Execution of this XML PARSE statement begins the parse and establishes your processing procedure with the parser. Each execution of your procedure causes the XML parser to continue analyzing the XML document and report the next event, passing back to your procedure the fragment

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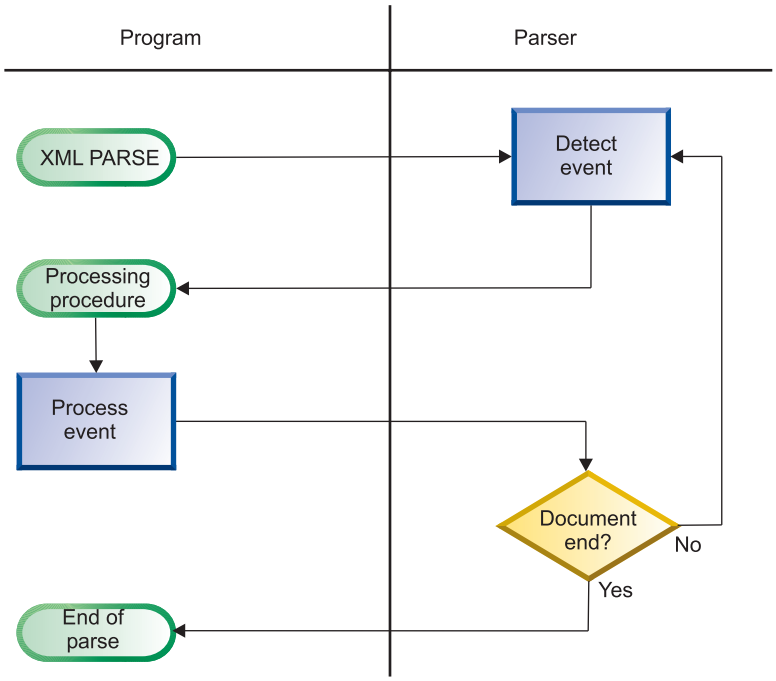
that it finds, such as the start of a new element. You can also specify on the XML PARSE statement two imperative statements to which you want control to be passed at the end of the parse: one when a normal end occurs and one when an exception condition exists.

This figure gives a high-level overview of the basic exchange of control between the parser and your program:

XML parsing flow overview



Normally, parsing continues until the entire XML document has been parsed.

When the XML parser parses XML documents, it checks them for most aspects of well formedness as defined in the XML specification. A document is well formed if it adheres to the XML syntax and follows some additional rules such as proper use of end tags and uniqueness of attribute names.

RELATED TASKS
"Accessing XML documents" on page 267
"Parsing XML documents" on page 267
"Writing procedures to process XML" on page 274
"Handling errors in XML documents" on page 282
"Understanding XML document encoding" on page 281

RELATED REFERENCE
XML specification (www.w3c.org/XML/)
"XML conformance" on page 619

Accessing XML documents

Before you can parse an XML document with an XML PARSE statement, you must make the document available to your program. The most likely method of acquiring the document is by retrieval from an MQSeries message, a CICS transient queue or communication area.

If the XML document that you want to parse is held in a file, use ordinary COBOL facilities to place the document into a data item in your program:

- A FILE-CONTROL entry to define the file to your program
- The OPEN statement to open the file
- The READ statement to read all the records from the file into an alphanumeric or national data item that is defined in the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION of your program
- Optionally the STRING statement to string all of the separate records together into one continuous stream, to remove extraneous blanks, and to handle variable-length records

Alternatively, you can copy the XML document to an IFS stream file, and use format 2 of the XML PARSE statement to access and parse the document.

RELATED TASKS
CICS for iSeries Application Programming Guide:
http://publib.boulder.ibm.com/iseries/v5r2/ic2924/books/sm05/c4154541.pdf

Parsing XML documents

To parse XML documents, when the XML document is in a data item, use the XML PARSE statement, as in the following example:

```
XML PARSE XMLDOCUMENT
    PROCESSING PROCEDURE XMLEVENT-HANDLER
  ON EXCEPTION
     DISPLAY 'XML document error ' XML-CODE
     STOP RUN
  NOT ON EXCEPTION
     DISPLAY 'XML document was successfully parsed.'
END-XML
```

In the XML PARSE statement you first identify the data item (XMLDOCUMENT in the example) that contains the XML document character stream. In the DATA DIVISION, you can declare the identifier as an alphanumeric data item or as a national data item. If it is alphanumeric, its contents must be encoded with one of the supported single-byte EBCDIC or ASCII character sets. If it is a national data item, its contents must be encoded with Unicode UCS-2 CCSID 13488. Alphanumeric XML documents that do not contain an encoding declaration are parsed with the CCSID of the COBOL source member, or if COBOL source is in an IFS stream file, the CCSID of the stream file is used.

Next you specify the name of the procedure (XMLEVENT-HANDLER in the example) that is to handle the XML events from the document.

In addition, you can specify either or both of the following imperative statements to receive control at the end of the parse:

- ON EXCEPTION, to receive control when an unhandled exception occurs
- NOT ON EXCEPTION, to receive control otherwise

You can end the XML PARSE statement with END-XML. Use this scope terminator to nest your XML PARSE statement in a conditional statement or in another XML PARSE statement.

The exchange of control between the XML parser and your processing procedure continues until one of the following occurs:

- The entire XML document has been parsed, indicated by the END-OF-DOCUMENT event.
- The parser detects an error in the document and signals an EXCEPTION event. Your processing procedure does not reset the special register XML-CODE to zero before returning to the parser.
- You terminate the parsing process deliberately by setting the special register XML-CODE to -1 before returning to the parser.

RELATED TASKS

"Understanding XML document encoding" on page 281

RELATED REFERENCES

XML PARSE statement (*ILE COBOL Language Reference*)
Control flow (*ILE COBOL Language Reference*)

Processing XML events

Use the XML-EVENT special register to determine the event that the parser passes to your processing procedure. XML-EVENT contains an event name such as 'START-OF-ELEMENT'. The parser passes the content for the event in special register XML-TEXT or XML-NTEXT, depending on the type of the XML identifier in your XML PARSE statement.

The events are shown in basically the order that they would occur for this sample XML document. The text shown under "Sample XML text" comes from this sample; exact text is shown between these delimiters: <<>>:

```
<?xml version="1.0" encoding="ibm-1140" standalone="yes" ?>
<!--This document is just an example-->
<sandwich>
  <bread type="baker&apos;s best" />
  <?spread please use real mayonnaise ?>
  <meat>Ham &amp; turkey</meat>
  <filling>Cheese, lettuce, tomato, etc.</filling>
  <![CDATA[We should add a <relish> element in future!]]>
</sandwich>junk
```

START-OF-DOCUMENT

Description
Occurs once, at the beginning of parsing the document. XML text is the entire document, including any line-control characters, such as LF (Line Feed) or NL (New Line).

Sample XML text
The text for this sample is 336 characters in length.

VERSION-INFORMATION

Description
Occurs within the optional XML declaration for the version information. XML text contains the version value. An *XML*

declaration is XML text that specifies the version of XML being used and the encoding of the document.

Sample XML text

```
<<1.0>>
```

ENCODING-DECLARATION

Description

Occurs within the XML declaration for the optional encoding declaration. XML text contains the encoding value.

Sample XML text

```
<<ibm-1140>>
```

STANDALONE-DECLARATION

Description

Occurs within the XML declaration for the optional standalone declaration. XML text contains the standalone value.

Sample XML text

```
<<yes>>
```

DOCUMENT-TYPE-DECLARATION

Description

Occurs when the parser finds a document type declaration (DTD). Document type declarations begin with the character sequence '<!DOCTYPE' and end with a '>' character, with some fairly complicated grammar rules describing the content in between. (See the *XML specification* for details.) For this event, XML text contains the entire declaration, including the opening and closing character sequences. This is the only event where XML text includes the delimiters.

Sample XML text

The sample does not have a document type declaration.

COMMENT

Description

Occurs for any comments in the XML document. XML text contains the data between the opening and closing comment delimiters, '<!--' and '-->', respectively.

Sample XML text

```
<<This document is just an example>>
```

START-OF-ELEMENT

Description

Occurs once for each element start tag or empty element tag. XML text is set to the element name.

Sample XML text

In the order that they occur as START-OF-ELEMENT events:

1. <<sandwich>>
2. <<bread>>
3. <<meat>>
4. <<filling>>

ATTRIBUTE-NAME

Description

Occurs for each attribute in an element start tag or empty element tag, after recognizing a valid name. XML text contains the attribute name.

Sample XML text

<<type>>

ATTRIBUTE-CHARACTERS

Description

Occurs for each fragment of an attribute value. XML text contains the fragment. An attribute value normally consists of a single string only, even if it is split across lines. The attribute value might consist of multiple events, however.

Sample XML text

In the order that they occur as ATTRIBUTE-CHARACTERS events:

1. <<baker>>
2. <<s best>>

Notice that the value of the 'type' attribute in the sample consists of three fragments: the string 'baker', the single character ''', and the string 's best'. The single character ''' fragment is passed separately as an ATTRIBUTE-CHARACTER event.

ATTRIBUTE-CHARACTER

Description

Occurs in attribute values for the predefined entity references '&', ''', '>', '<', and '"'. See the *XML specification* for details of predefined entities.

Sample XML text

<<'>>

ATTRIBUTE-NATIONAL-CHARACTER

Description

Occurs in attribute values for numeric character references (Unicode code points or "scalar values") of the form '&#dd..;' or '&#hh..;', where 'd' and 'h' represent decimal and hexadecimal digits, respectively.

Sample XML text
The sample does not contain a numeric character reference.

END-OF-ELEMENT

Description
Occurs once for each element end tag or empty element tag when the parser recognizes the closing angle bracket of the tag.

Sample XML text
```
<<bread>>
```

PROCESSING-INSTRUCTION-TARGET

Description
Occurs when the parser recognizes the name following the processing instruction (PI) opening character sequence, '<?'. PIs allow XML documents to contain special instructions for applications.

Sample XML text
```
<<spread>>
```

PROCESSING-INSTRUCTION-DATA

Description
Occurs for the data following the PI target, up to but not including the PI closing character sequence, '?>'. XML text contains the PI data, which includes trailing, but not leading white space characters.

Sample XML text
```
<<please use real mayonnaise >>
```

CONTENT-CHARACTERS

Description
This event represents the principal part of an XML document: the character data between element start and end tags. XML text contains this data, which usually consists of a single string only, even if it is split across lines. If the content of an element includes any references or other elements, the complete content might consist of several events. The parser also uses the CONTENT-CHARACTERS event to pass the text of CDATA sections to your program.

Sample XML text
In the order that they occur as CONTENT-CHARACTERS events:

1. `<<Ham >>`
2. `<< turkey>>`
3. `<<Cheese, lettuce, tomato, etc.>>`
4. `<<We should add a <relish> element in future!>>`

Notice that the content of the 'meat' element in the sample consists of the string 'Ham ', the character '&' and the string ' turkey'. The

single character '&' fragment is passed separately as a CONTENT-CHARACTER event. Also notice the trailing and leading spaces, respectively, in these two string fragments.

CONTENT-CHARACTER

Description

Occurs in element content for the predefined entity references '&', ''', '>', '<', and '"'. See the *XML specification* for details of predefined entities.

Sample XML text

<<&>>

CONTENT-NATIONAL-CHARACTER

Description

Occurs in element content for numeric character references (Unicode code points or "scalar values") of the form '&#dd..;' or '&#hh..;', where 'd' and 'h' represent decimal and hexadecimal digits, respectively.

Sample XML text

The sample does not contain a numeric character reference.

END-OF-ELEMENT

Description

Occurs once for each element end tag or empty element tag when the parser recognizes the closing angle bracket of the tag. XML text contains the element name.

Sample XML text

In the order that they occur as END-OF-ELEMENT events:

1. <<bread>>
2. <<meat>>
3. <<filling>>
4. <<sandwich>>

START-OF-CDATA-SECTION

Description

Occurs at the start of a CDATA section. CDATA sections begin with the string '<![CDATA[' and end with the string ']]>'. Such sections are used to "escape" blocks of text containing characters that would otherwise be recognized as XML markup. XML text always contains the opening character sequence '<![CDATA['. The parser passes the content of a CDATA section between these delimiters as a single CONTENT-CHARACTERS event.

Sample XML text

<<<![CDATA[>>

END-OF-CDATA-SECTION

Description
Occurs when the parser recognizes the end of a CDATA section.

Sample XML text
<<]]>>>

UNKNOWN-REFERENCE-IN-ATTRIBUTE

Description
Occurs within attribute values for entity references other than the five predefined entity references, as shown for ATTRIBUTE-CHARACTER above.

Sample XML text
The sample does not have any unknown entity references.

UNKNOWN-REFERENCE-IN-CONTENT

Description
Occurs within element content for entity references other than the predefined entity references, as shown for CONTENT-CHARACTER above.

Sample XML text
The sample does not have any unknown entity references.

END-OF-DOCUMENT

Description
Occurs when document parsing has completed

Sample XML text
XML text is empty for the END-OF-DOCUMENT event.

EXCEPTION

Description
Occurs when an error in processing the XML document is detected. For encoding conflict exceptions, which are signaled before parsing begins, XML-TEXT is either zero-length or contains just the encoding declaration value from the document.

Sample XML text
The part of the document that was parsed up to and including the point where the exception (the superfluous 'junk' after the <sandwich> element end tag) was detected.

RELATED REFERENCE
XML-EVENT (*ILE COBOL Language Reference*)
4.6 Predefined entities (*XML specification* at www.w3.org/TR/REC-xml#sec-predefined-ent)
2.8 Prolog and document type declaration (*XML specification* at www.w3.org/TR/REC-xml#sec-prolog-dtd)

Writing procedures to process XML

In your processing procedure, code the statements to handle XML events.

For each event that the parser encounters, it passes information to your processing procedure in several special registers, as shown in the following table. Use these registers to populate your data structures and to control your processing.

Table 15. **Special registers used by the XML parser**

Special register	Contents	Implicit definition and usage
XML-EVENT[1]	The name of the XML event	PICTURE X(30) USAGE DISPLAY VALUE SPACE
XML-CODE	An exception code or zero for each XML event	PICTURE S9(9) USAGE BINARY VALUE ZERO
XML-TEXT[1]	Text (corresponding to the event that the parser encountered) from the XML document if you specify an alphanumeric data item for the XML PARSE identifier	Variable-length alphanumeric data item; 16,000,000 byte size limit
XML-NTEXT[1]	Text (corresponding to the event that the parser encountered) from the XML document if you specify a national data item for the XML PARSE identifier	Variable-length national data item; 16,000,000 byte size limit
1. You cannot use this special register as a receiving data item.		

When used in nested programs, these special registers are implicitly defined as GLOBAL in the outermost program.

Understanding the contents of XML-CODE

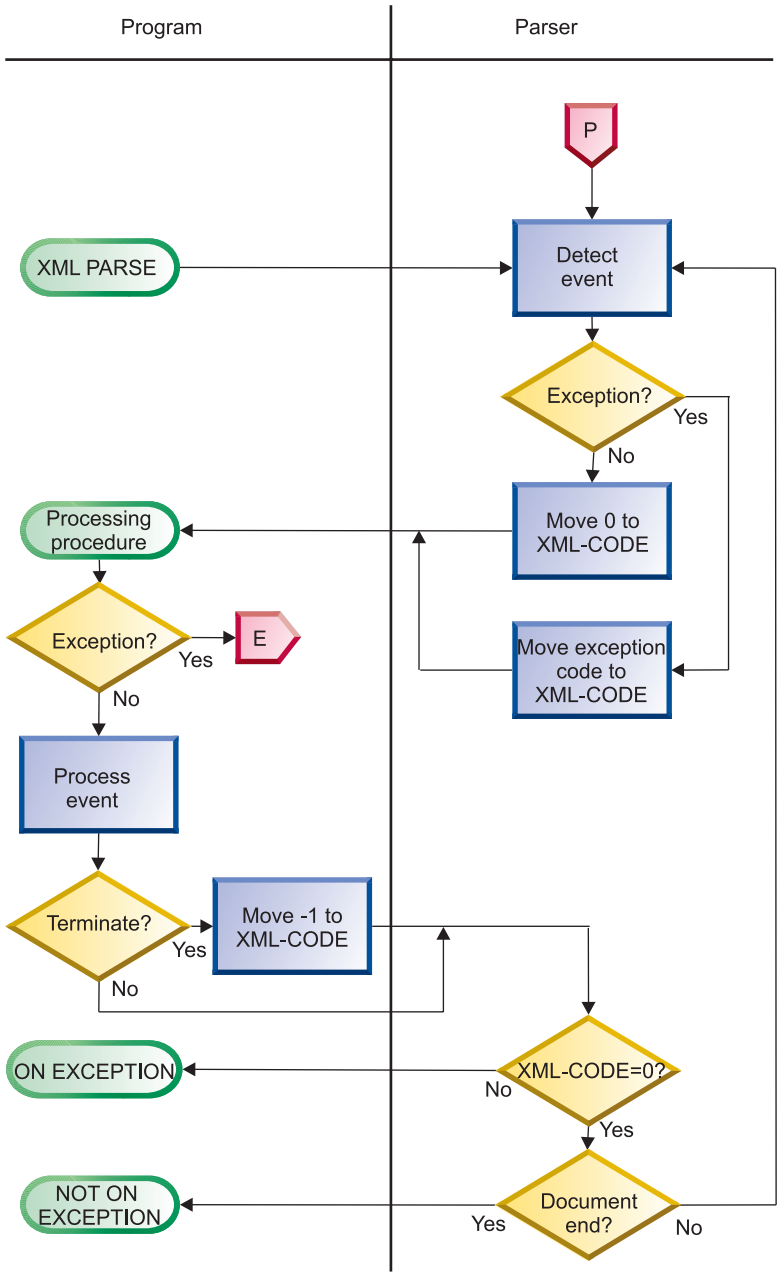
When the parser returns control to your XML PARSE statement, XML-CODE contains the most recent value set by the parser or your processing procedure.

For all events except the EXCEPTION event, the value of the XML-CODE special register is zero. If you set the XML-CODE special register to -1 before you return control to the XML parser for an event other than EXCEPTION, processing stops with a user-initiated exception indicated by the returned XML-CODE value of -1. The result of changing the XML-CODE to any other nonzero value before returning from any event is undefined.

For the EXCEPTION event, special register XML-CODE contains the exception code.

The following figure shows the flow of control between the parser and your processing procedure and how XML-CODE is used to pass information between the two. The off-page connectors, such as P , connect the multiple charts in this chapter. In particular, E in the following figure connects to the chart Control flow for XML exceptions, and P connects from XML CCSID exception flow control.

Control flow between XML parser and program, showing XML-CODE usage



Using XML-TEXT and XML-NTEXT

The special registers XML-TEXT and XML-NTEXT are mutually exclusive. The type of XML identifier that you specify determines which special register is set, except for the ATTRIBUTE-NATIONAL-CHARACTER and CONTENT-NATIONAL-CHARACTER events. For these events, XML-NTEXT is set regardless of the data item that you specify for the XML PARSE identifier.

When the parser sets XML-TEXT, XML-NTEXT is undefined (length of 0). When the parser sets XML-NTEXT, XML-TEXT is undefined (length of 0).

To determine how many national characters XML-NTEXT contains, use the LENGTH function. LENGTH OF XML-NTEXT contains the number of bytes, rather than characters, used by XML-NTEXT.

Transforming XML text to COBOL data items

Because XML data is neither fixed length nor fixed format, you need to use special techniques when you move the XML data to COBOL data items.

For alphanumeric items, decide whether the XML data should go at the left (default) end of your COBOL item, or at the right end. If it should go at the right end, specify the `JUSTIFIED RIGHT` clause in the declaration of the COBOL item.

Give special consideration to numeric XML values, particularly "decorated" monetary values such as '$1,234.00' and '$1234'. These mean the same thing in XML but have completely different declarations as COBOL sending fields. Use this technique:

- For simplicity and vastly increased flexibility, use the following for alphanumeric XML data:
  - Function `NUMVAL` to extract and decode simple numeric values from XML data representing plain numbers
  - Function `NUMVAL-C` to extract and decode numeric values from XML data representing monetary quantities

  Note, however, that use of these functions is at the expense of performance.

Restriction on your processing procedure

Your processing procedure must not directly execute an `XML PARSE` statement. However, if your processing procedure passes control to an outermost program using a `CALL` statement, the target method or program can execute the same or a different `XML PARSE` statement. You can also execute the same XML statement or different XML statements simultaneously from a program that is executing on multiple threads.

Ending your processing procedure

The compiler inserts a return mechanism after the last statement in your processing procedure. You can code a `STOP RUN` statement in your processing procedure to terminate the run unit. However, the `GOBACK` or `EXIT PROGRAM` statements do not return control to the parser. Using either statement in your processing procedure results in a severe error.

"Examples: parsing XML"

RELATED REFERENCES

"XML exceptions that allow continuation" on page 611
"XML exceptions that do not allow continuation" on page 615
XML-CODE (*ILE COBOL Language Reference*)
XML-EVENT (*ILE COBOL Language Reference*)
XML-NTEXT (*ILE COBOL Language Reference*)
XML-TEXT (*ILE COBOL Language Reference*)

Examples: parsing XML

This example shows the basic organization of an `XML PARSE` statement and a processing procedure, where the XML document is in a COBOL data item. The XML document is given in the source so that you can follow the flow of the parse. The output of the program is given below. Compare the document to the output of the program to follow the interaction of the parser and the processing procedure and to match events to document fragments.

Example: parsing XML from a data item

```
 Process APOST
 Identification division.
   Program-id. xmlsampl1.

 Data division.
  Working-storage section.
*****************************************************************
* XML document, encoded as initial values of data items.        *
*****************************************************************
   1 xml-document.
    2 pic x(39) value '<?xml version="1.0" encoding="ibm-37"'.
    2 pic x(19) value ' standalone="yes"?>'.
    2 pic x(39) value '<!--This document is just an example-->'.
    2 pic x(10) value '<sandwich>'.
    2 pic x(35) value '  <bread type="baker&apos;s best"/>'.
    2 pic x(41) value '  <?spread please use real mayonnaise  ?>'.
    2 pic x(31) value '  <meat>Ham &amp; turkey</meat>'.
    2 pic x(40) value '  <filling>Cheese, lettuce, tomato, etc.'.
    2 pic x(10) value '</filling>'.
    2 pic x(35) value '  <![CDATA[We should add a <relish>'.
    2 pic x(22) value ' element in future!]]>'.
    2 pic x(31) value '  <listprice>$4.99 </listprice>'.
    2 pic x(27) value '  <discount>0.10</discount>'.
    2 pic x(11) value '</sandwich>'.
   1 xml-document-length computational pic 999.

*****************************************************************
* Sample data definitions for processing numeric XML content.   *
*****************************************************************
   1 current-element pic x(30).
   1 list-price computational pic 9v99 value 0.
   1 discount computational pic 9v99 value 0.
   1 display-price pic $$9.99.

 Procedure division.
  mainline section.

     XML PARSE xml-document PROCESSING PROCEDURE xml-handler
       ON EXCEPTION
         display 'XML document error ' XML-CODE
       NOT ON EXCEPTION
         display 'XML document successfully parsed'
     END-XML

*****************************************************************
*    Process the transformed content and calculate promo price.  *
*****************************************************************
     display ' '
     display '-----++++++++++ Using information from XML '
         '++++++++++-----'
     display ' '
     move list-price to display-price
     display '  Sandwich list price: ' display-price
     compute display-price = list-price * (1 - discount)
     display '  Promotional price:   ' display-price
     display '  Get one today!'

     goback.

  xml-handler section.
     evaluate XML-EVENT
* ==> Order XML events most frequent first
       when 'START-OF-ELEMENT'
         display 'Start element tag: <' XML-TEXT '>'
         move XML-TEXT to current-element
       when 'CONTENT-CHARACTERS'
         display 'Content characters: <' XML-TEXT '>'
```

```
* ==> Transform XML content to operational COBOL data item...
         evaluate current-element
           when 'listprice'
* ==> Using function NUMVAL-C...
             compute list-price = function numval-c(XML-TEXT)
           when 'discount'
             compute discount = function numval-c(XML-TEXT)
         end-evaluate
       when 'END-OF-ELEMENT'
         display 'End element tag: <' XML-TEXT '>'
         move spaces to current-element
       when 'START-OF-DOCUMENT'
         compute xml-document-length = function length(XML-TEXT)
         display 'Start of document: length=' xml-document-length
             ' characters.'
       when 'END-OF-DOCUMENT'
         display 'End of document.'
       when 'VERSION-INFORMATION'
         display 'Version: <' XML-TEXT '>'
       when 'ENCODING-DECLARATION'
         display 'Encoding: <' XML-TEXT '>'
       when 'STANDALONE-DECLARATION'
         display 'Standalone: <' XML-TEXT '>'
       when 'ATTRIBUTE-NAME'
         display 'Attribute name: <' XML-TEXT '>'
       when 'ATTRIBUTE-CHARACTERS'
         display 'Attribute value characters: <' XML-TEXT '>'
       when 'ATTRIBUTE-CHARACTER'
         display 'Attribute value character: <' XML-TEXT '>'
       when 'START-OF-CDATA-SECTION'
         display 'Start of CData: <' XML-TEXT '>'
       when 'END-OF-CDATA-SECTION'
         display 'End of CData: <' XML-TEXT '>'
       when 'CONTENT-CHARACTER'
         display 'Content character: <' XML-TEXT '>'
       when 'PROCESSING-INSTRUCTION-TARGET'
         display 'PI target: <' XML-TEXT '>'
       when 'PROCESSING-INSTRUCTION-DATA'
         display 'PI data: <' XML-TEXT '>'
       when 'COMMENT'
         display 'Comment: <' XML-TEXT '>'
       when 'EXCEPTION'
         compute xml-document-length = function length (XML-TEXT)
         display 'Exception ' XML-CODE ' at offset '
             xml-document-length '.'
       when other
         display 'Unexpected XML event: ' XML-EVENT '.'
     end-evaluate
     .
 End program xmlsampl1.
```

Output from parse example: From the following output you can see which events of the parse came from which fragments of the document:

```
Start of document: length=390 characters.
Version: <1.0>
Encoding: <ibm-37>
Standalone: <yes>
Comment: <This document is just an example>
Start element tag: <sandwich>
Content characters: <  >
Start element tag: <bread>
Attribute name: <type>
Attribute value characters: <baker>
Attribute value character: <'>
Attribute value characters: <s best>
End element tag: <bread>
```

```
Content characters: <  >
PI target: <spread>
PI data: <please use real mayonnaise  >
Content characters: <  >
Start element tag: <meat>
Content characters: <Ham >
Content character: <&>
Content characters: < turkey>
End element tag: <meat>
Content characters: <  >
Start element tag: <filling>
Content characters: <Cheese, lettuce, tomato, etc.>
End element tag: <filling>
Content characters: <  >
Start of CData: <<![CDATA[>
Content characters: <We should add a <relish> element in future!>
End of CData: <]]>>
Content characters: <  >
Start element tag: <listprice>
Content characters: <$4.99 >
End element tag: <listprice>
Content characters: <  >
Start element tag: <discount>
Content characters: <0.10>
End element tag: <discount>
End element tag: <sandwich>
End of document.
XML document successfully parsed

-----++++++++++ Using information from XML **********-----

  Sandwich list price:  $4.99
  Promotional price:    $4.49
  Get one today!
```

Example: parsing XML from an IFS file

This example shows an XML PARSE statement that parses an XML document located in an IFS file. The output from the program is the same as in the previous example. The IFS file must have a valid CCSID. The end of each line in the IFS file must have only a CR (carriage return) and not a LF (line feed).

```
 Process APOST
 Identification division.
   Program-id. xmlsampl2.

 Data division.
  Working-storage section.
*****************************************************************
* XML document, encoded as initial values of data items.        *
*****************************************************************
   1 xml-id pic x(27) value '/home/user1/xmlsampldoc.xml'.
   1 xml-document-length computational pic 999.

*****************************************************************
* Sample data definitions for processing numeric XML content.   *
*****************************************************************
   1 current-element pic x(30).
   1 list-price computational pic 9v99 value 0.
   1 discount computational pic 9v99 value 0.
   1 display-price pic $$9.99.

 Procedure division.
  mainline section.

     XML PARSE FILE-STREAM xml-id PROCESSING PROCEDURE xml-handler
```

```
        ON EXCEPTION
          display 'XML document error ' XML-CODE
        NOT ON EXCEPTION
          display 'XML document successfully parsed'
      END-XML

*****************************************************************
*    Process the transformed content and calculate promo price.  *
*****************************************************************
      display ' '
      display '-----++++++++++ Using information from XML '
          '++++++++++-----'
      display ' '
      move list-price to display-price
      display '  Sandwich list price: ' display-price
      compute display-price = list-price * (1 - discount)
      display '  Promotional price:   ' display-price
      display '  Get one today!'

      goback.

   xml-handler section.
      evaluate XML-EVENT
* ==> Order XML events most frequent first
        when 'START-OF-ELEMENT'
          display 'Start element tag: <' XML-TEXT '>'
          move XML-TEXT to current-element
        when 'CONTENT-CHARACTERS'
          display 'Content characters: <' XML-TEXT '>'
* ==> Transform XML content to operational COBOL data item...
          evaluate current-element
            when 'listprice'
* ==> Using function NUMVAL-C...
              compute list-price = function numval-c(XML-TEXT)
            when 'discount'
              compute discount = function numval-c(XML-TEXT)
          end-evaluate
        when 'END-OF-ELEMENT'
          display 'End element tag: <' XML-TEXT '>'
          move spaces to current-element
        when 'START-OF-DOCUMENT'
          compute xml-document-length = function length(XML-TEXT)
          display 'Start of document: length=' xml-document-length
              ' characters.'
        when 'END-OF-DOCUMENT'
          display 'End of document.'
        when 'VERSION-INFORMATION'
          display 'Version: <' XML-TEXT '>'
        when 'ENCODING-DECLARATION'
          display 'Encoding: <' XML-TEXT '>'
        when 'STANDALONE-DECLARATION'
          display 'Standalone: <' XML-TEXT '>'
        when 'ATTRIBUTE-NAME'
          display 'Attribute name: <' XML-TEXT '>'
        when 'ATTRIBUTE-CHARACTERS'
          display 'Attribute value characters: <' XML-TEXT '>'
        when 'ATTRIBUTE-CHARACTER'
          display 'Attribute value character: <' XML-TEXT '>'
        when 'START-OF-CDATA-SECTION'
          display 'Start of CData: <' XML-TEXT '>'
        when 'END-OF-CDATA-SECTION'
          display 'End of CData: <' XML-TEXT '>'
        when 'CONTENT-CHARACTER'
          display 'Content character: <' XML-TEXT '>'
        when 'PROCESSING-INSTRUCTION-TARGET'
          display 'PI target: <' XML-TEXT '>'
        when 'PROCESSING-INSTRUCTION-DATA'
```

```
          display 'PI data: <' XML-TEXT '>'
        when 'COMMENT'
          display 'Comment: <' XML-TEXT '>'
        when 'EXCEPTION'
          compute xml-document-length = function length (XML-TEXT)
          display 'Exception ' XML-CODE ' at offset '
              xml-document-length '.'
        when other
          display 'Unexpected XML event: ' XML-EVENT '.'
      end-evaluate
      .
 End program xmlsampl2.
```

Here is the IFS file for this example, from /home/user1/xmlsampldoc.xml.

```
<?xml version="1.0" encoding="ibm-37"
  standalone="yes"?>
<!--This document is just an example-->
<sandwich>
 <bread type="baker&apos;s best"/>
 <?spread please use real mayonnaise  ?>
 <meat>Ham &amp; turkey</meat>
 <filling>Cheese, lettuce, tomato, etc.
</filling>
 <![CDATA[We should add a <relish> element in future!]]>
 <listprice>$4.99 </listprice>
 <discount>0.10</discount>
</sandwich>
```

Understanding XML document encoding

The XML PARSE statement supports only XML documents that contain one of the following types of data items:

- National data items that are encoded using Unicode UCS-2
- Alphanumeric data items that are encoded using one of the supported single-byte EBCDIC or ASCII character sets

If your XML document includes an encoding declaration, ensure that it is consistent with the encoding information provided by your XML PARSE statement and with the basic encoding of the document. The parser determines the encoding of a document by using up to three sources of information in the following order:

1. The initial characters of the document
2. The encoding information provided by your XML PARSE statement
3. If step 2 succeeds, an encoding declaration in the document

Thus if the XML document begins with an XML declaration that includes an encoding declaration specifying one of the supported code pages, the parser honors the encoding declaration if it does not conflict with either the basic document encoding or the encoding information from the XML PARSE statement.

If the XML document does not have an XML declaration, or if the XML declaration omits the encoding declaration, the parser uses the encoding information from your XML PARSE statement to process the document, as long as it does not conflict with the basic document encoding.

The parser signals an XML exception event if it finds a conflict among these sources.

Specifying the code page

You can specify the encoding information for the document in the XML declaration, with which most XML documents begin. This is an example of an XML declaration that includes an encoding declaration:

```
<?xml version="1.0" encoding="ibm-1140" ?>
```

Specify the encoding declaration in either of the following ways:

- Specify the CCSID number (with or without any number of leading zeros), prefixed by any of the following (in any mixture of uppercase or lowercase):
  - IBM-
  - IBM_
  - CCSID-
  - CCSID_
- Use one of the following supported aliases (in any mixture of uppercase or lowercase):

Table 16. **Aliases for XML encoding declarations**

Code page	Supported aliases
037	EBCDIC-CP-US, EBCDIC-CP-CA, EBCDIC-CP-WT, EBCDIC-CP-NL
500	EBCDIC-CP-BE, EBCDIC-CP-CH
813	iso-8859-7, iso_8859-7
819	iso-8859-1, iso_8859-1
920	iso-8859-9, iso_8859-9

Parsing documents in other code pages

You can parse XML documents that are encoded in code pages other than the explicitly supported single-byte code pages by converting them to Unicode UCS-2 in a national data item, using the `MOVE` statement. You can then convert the individual pieces of document text passed to your processing procedure in special register `XML-NTEXT` back to the original code page as necessary, using the `MOVE` statement.

RELATED REFERENCES

Coded character sets for XML documents (*ILE COBOL Language Reference*)

Handling errors in XML documents

Use these facilities to handle errors in your XML document:

- Your processing procedure
- The `ON EXCEPTION` phrase of your `XML PARSE` statement
- Special register `XML-CODE`

When the XML parser detects an error in an XML document, it generates an XML exception event. The parser returns this exception event by passing control to your processing procedure along with the following information:

- The special register `XML-EVENT` contains `'EXCEPTION'`.
- The special register `XML-CODE` contains the numeric exception code.
- `XML-TEXT` contains the document text up to and including the point where the exception was detected.

If the value of the error code is within one of the following ranges:

- 1-99
- 100,001-165,535
- 200,001-265,535

you might be able to handle the exception in your processing procedure and continue the parse. If the error code has any other nonzero value, the parse cannot continue. The exceptions for encoding conflicts (50-99 and 300-499) are signaled before the parse of the document is started. For these exceptions, `XML-TEXT` is either zero length or contains just the encoding declaration value from the document.

Exceptions in the range 1-49 are fatal errors according to the XML specification, therefore the parser does not continue normal parsing even if you handle the exception. However the parser does continue scanning for further errors until it reaches the end of the document or encounters an error that does not allow continuation. For these exceptions, the parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.

Use the following figure to understand the flow of control between the parser and your processing procedure. It illustrates how you can handle certain exceptions and how you use `XML-CODE` to identify the exception. The off-page connectors, such as , connect the multiple charts in this chapter. In particular, in the following figure connects to the chart XML CCSID exception flow control. Within this figure / serves both as an off-page and an on-page connector.

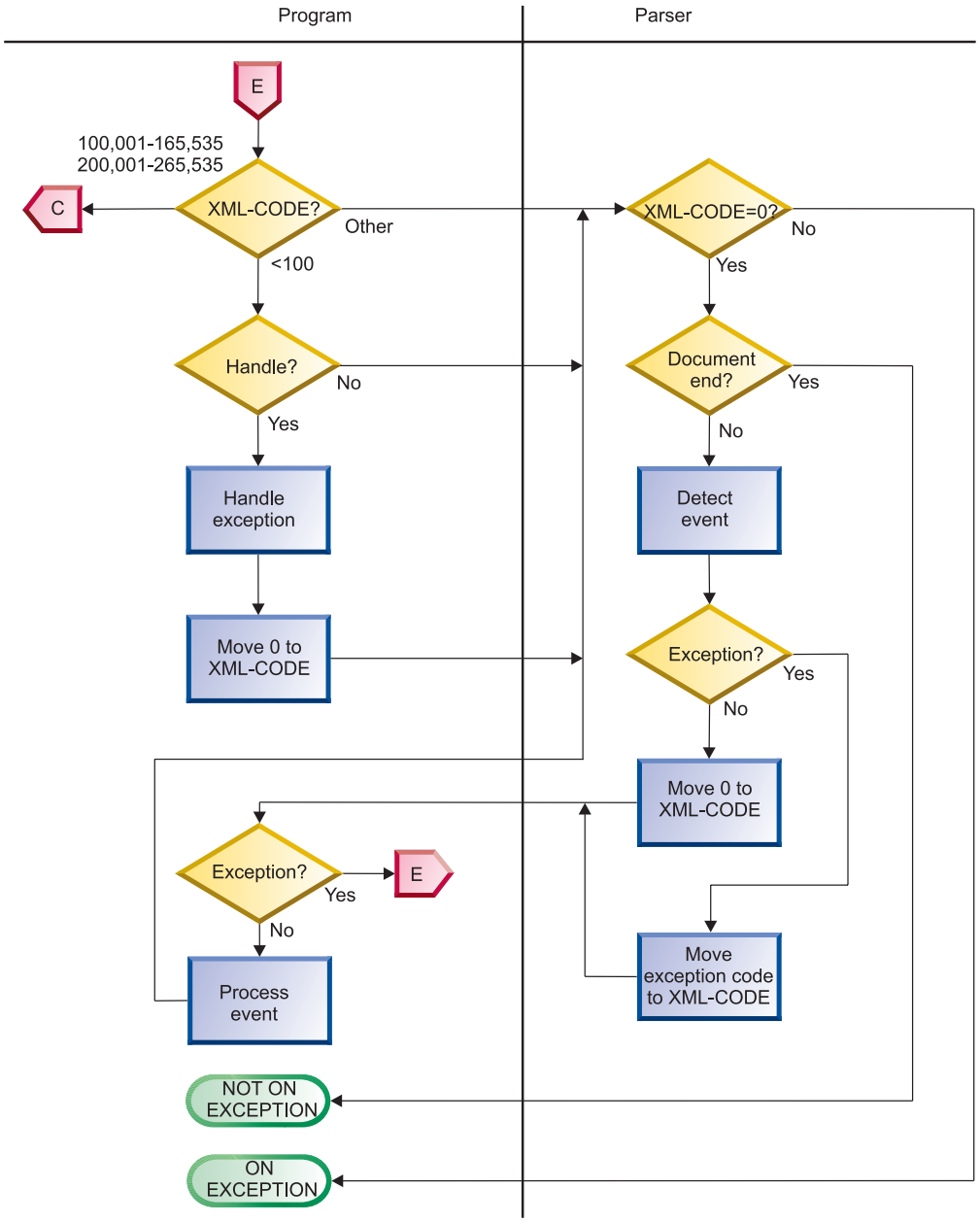


Figure 69. **Control flow for XML exceptions**

Unhandled exceptions

If you do not want to handle the exception, return control to the parser without changing the value of `XML-CODE`. The parser then transfers control to the statement that you specify on the `ON EXCEPTION` phrase. If you do not code an `ON EXCEPTION` phrase, control is transferred to the end of the `XML PARSE` statement.

Handling exceptions

To handle the exception event in your processing procedure, do these steps:

1. Use the contents of `XML-CODE` to guide your actions.
2. Set `XML-CODE` to zero to indicate that you have handled the exception.
3. Return control to the parser. The exception condition then no longer exists.

If no unhandled exceptions occur before the end of parsing, control is passed to the statement that you specify on the NOT ON EXCEPTION phrase (normal end of parse). If you do not code a NOT ON EXCEPTION phrase, control is passed to the end of the XML PARSE statement. The special register XML-CODE contains zero.

You can handle exceptions in this way only if the exception code passed in XML-CODE is within one of the following ranges:

- 1-99
- 100,001-165,535
- 200,001-265,535

Otherwise, the parser signals no further events, and passes control to the statement that you specify on your ON EXCEPTION phrase. In this case, XML-CODE contains the original exception number, even if you set XML-CODE to zero in your processing procedure before returning control to the parser.

If you return control to the parser with XML-CODE set to a nonzero value different from the original exception code, the results are undefined.

Terminating the parse

You can terminate parsing deliberately by setting XML-CODE to -1 in your processing procedure before returning to the parser from any normal XML event (that is, not an EXCEPTION event). You can use this technique when you have seen enough of the document for your purposes or have detected some irregularity in the document that precludes further meaningful processing.

In this case, the parser does not signal any further events, although an exception condition exists. Therefore control returns to your ON EXCEPTION phrase, if you have specified it. There you can test if XML-CODE is -1, which indicates that you terminated the parse deliberately. If you do not specify an ON EXCEPTION phrase, control returns to the end of the XML PARSE statement.

You can also terminate parsing after any exception XML event by returning to the parser without changing XML-CODE. The result is similar to the result of deliberate termination, except that the parser returns to the XML PARSE statement with XML-CODE containing the exception number.

CCSID conflict exception

A special case applies to exception events where the exception code in XML-CODE is in the range 100,001 through 165,535 or 200,001 through 265,535. These ranges of exception codes indicate that the CCSID of the document (determined by examining the beginning of the document, including any encoding declaration) conflicts with the CCSID for the XML PARSE statement.

In this case you can determine the CCSID of the document by subtracting 100,000 or 200,000 from the value of XML-CODE (depending on whether it is an EBCDIC CCSID or ASCII CCSID, respectively). For instance, if XML-CODE contains 101,140, the CCSID of the document is 1140.

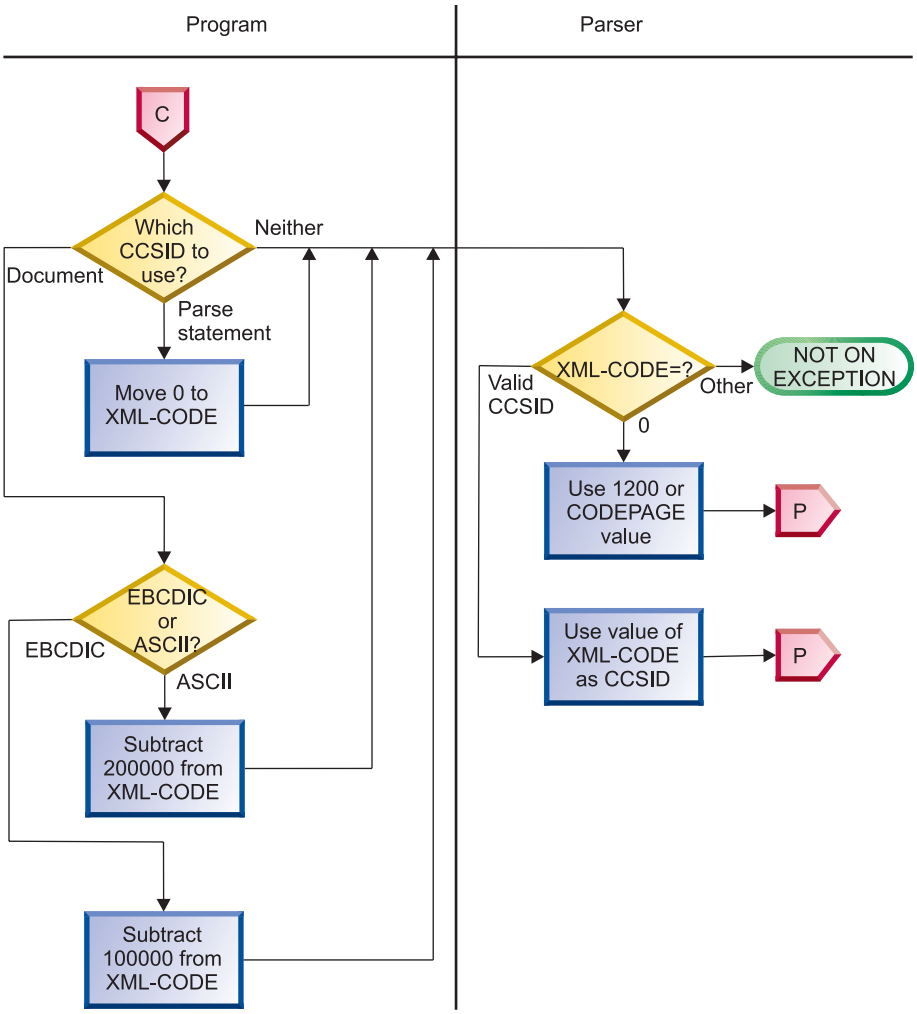
The CCSID for your XML PARSE statement depends on the type of the XML PARSE identifier. If the identifier is a national data item, the CCSID is 13488, indicating Unicode. If the XML PARSE identifier is alphanumeric, the CCSID is that of the COBOL source member.

The parser takes one of three actions after returning from your processing procedure for a CCSID conflict exception event:

- If you set XML-CODE to zero, the parser uses the CCSID for the XML PARSE statement: 13488 for national items; the CCSID of the COBOL source member, otherwise.
- If you set XML-CODE to the CCSID of the document (that is, the original XML-CODE value minus 100,000 or 200,000 appropriately), the parser uses the CCSID of the document. This is the only case where the parser continues when XML-CODE has a nonzero value upon returning from your processing procedure.
- Otherwise, the parser stops processing the document, and returns control to your XML PARSE statement with an exception condition. XML-CODE contains the exception code that was originally passed to the exception event.

The following figure illustrates these actions. The off-page connectors, such as , connect the multiple charts in this chapter. In particular, in the following figure connects to Control flow between XML parser and program, showing XML-CODE usage and connects from Control flow for XML exceptions.

XML CCSID exception flow control



RELATED REFERENCES

"XML exceptions that allow continuation" on page 611

| “XML exceptions that do not allow continuation” on page 615
| Appendix F, “XML reference material,” on page 611

| XML-CODE (*ILE COBOL Language Reference*)

Chapter 12. Calling and Sharing Data with Other Languages

ILE COBOL can call or be called by other ILE, OPM, and EPM languages.

This chapter describes:

- How to call and pass data to another language from ILE COBOL
- How control is returned to ILE COBOL from the other language
- How to issue a CL command from an ILE COBOL program
- How to include Structured Query Language (SQL) statements in your ILE COBOL program.

In general:

- If your ILE COBOL program is **calling** another language, use a CALL statement with the USING phrase that points to the items that will constitute the parameter list. Control is returned to your program at the next statement after the CALL statement (unless the called program or any program called by it terminates the run unit).
- If your ILE COBOL program is **being called** with parameters by another language, you need a USING phrase on the PROCEDURE DIVISION statement, and a Linkage Section that describes the parameters to be received. Your ILE COBOL program can return control to the calling program with a GOBACK statement or an EXIT PROGRAM statement.
- Your ILE COBOL program can terminate the run unit with a STOP RUN statement or GOBACK statement provided that the nearest control boundary is a hard control boundary; the run unit will not be terminated if the nearest control boundary is a soft control boundary.

  For a full description of how to call an ILE COBOL program from another language, refer to that language's programming guide.

One consideration for you when passing or receiving data with non-ILE COBOL programs is the matching of the parameter lists. If your ILE COBOL program is calling a non-ILE COBOL program, you must understand what is expected in the way of input, and set up your data items accordingly. If your program is being called, you must know what will be passed, and set up your Linkage Section to accept it.

Another consideration for you is the treatment of the RETURN-CODE special register. The RETURN-CODE special register cannot be set by a non-ILE COBOL program. When the RETURN-CODE special register contains an incorrect value after control has been returned from a called program, set the RETURN-CODE special register to a meaningful value before your ILE COBOL program returns control to its caller. Otherwise, an incorrect return code will be passed back to its caller.

Calling ILE C and VisualAge C++ Programs and Procedures

Note: All references to ILE C in this section also apply to VisualAge C++.

An ILE COBOL program can call ILE C programs and procedures using dynamic program calls or static procedure calls.

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When a dynamic program call is used to call an ILE C program, the ILE C program must be compiled and bound as a separate program object. When a static procedure call is used to call an ILE C procedure, the ILE C procedure must first be compiled into a module object and then bound to the calling ILE COBOL program. In ILE C, an ILE procedure corresponds to an ILE C function. Refer to the *WebSphere Development Studio: ILE C/C++ Programmer's Guide* for a description of compiling and binding ILE C programs and procedures.

You call an ILE C program or procedure from an ILE COBOL program by using the CALL *literal* statement (were *literal* is the name of the ILE C program or procedure). To call the ILE C program or procedure, you write the CALL *literal* statement in the same way as you would if you were calling another ILE COBOL subprogram. See "Using Static Procedure Calls and Dynamic Program Calls" on page 210 for detailed information about how to write the CALL statement in your ILE COBOL program to call an ILE C program using dynamic program calls or static procedure calls.

You can also call an ILE C program from an ILE COBOL program by using the CALL *identifier* statement. See "Using CALL identifier" on page 213 for more information on CALL *identifier*.

Alternately, you can use CALL *procedure-pointer* to call an ILE C program or procedure from an ILE COBOL program. See "Using CALL procedure-pointer" on page 214 for more information on CALL *procedure-pointer*. A procedure-pointer in ILE COBOL is similar to a function pointer in ILE C. You can pass a procedure-pointer as a argument on the CALL statement from ILE COBOL to an ILE C function and have the ILE C function define its parameter as a function pointer.

You can only call an ILE C function that returns a value if the RETURNING phrase of the ILE COBOL CALL statement has been specified.

Two or more ILE C programs in the same activation group can interact with each other's runtime resources. Refer to the *WebSphere Development Studio: ILE C/C++ Programmer's Guide* for a description of how this is accomplished. Therefore, you should ensure that the ILE C programs you call from your ILE COBOL program are designed to work together in the same activation group. Two ILE C programs in the same activation group can share things like `errno`, signal vectors, and storage pools. If your ILE COBOL program needs to call more than one ILE C programs that are not designed to share the same run time then specify a different name for the activation group in which the ILE C program will run.

ILE C allows recursion but ILE COBOL does not for default program type. You need to use a RECURSIVE clause in PROGRAM-ID paragraph to make a COBOL program become a recursive program. If an ILE C function calls an ILE COBOL non recursive program recursively, a runtime error message will be generated from the ILE COBOL program.

To call an ILE C function from an ILE COBOL program, the name of the ILE C function being called may need to be case-sensitive, longer than 10 characters (up to 256 characters), and contain some special characters. In this case, use a static procedure call and compile your ILE COBOL program with the *NOMONOPRC value of the OPTION parameter of the CRTCBLMOD or CRTBNDCBL commands.

When a ILE C++ compiler procedure is called from ILE COBOL, the keywords extern "COBOL" or extern "C" should be placed on the ILE C++ compiler function

prototype, to prevent the mangling of the ILE C++ compiler function name. Use extern ″C″ if ILE COBOL is passing BY VALUE arguments to ILE C++ compiler.

Passing Data to an ILE C Program or Procedure

You can pass data to a called ILE C program or procedure by using CALL...BY REFERENCE, CALL...BY VALUE, or CALL...BY CONTENT. Refer to “Passing Data Using CALL...BY REFERENCE, BY VALUE, or BY CONTENT” on page 223 for a description of how to use CALL...BY REFERENCE, CALL...BY VALUE or CALL...BY CONTENT.

When data is passed to the ILE C program using CALL...BY REFERENCE, a pointer to the data item is placed into the argument list that is accepted by the ILE C program.

When data is passed to the ILE C program using CALL...BY CONTENT, the value of the data item is copied to a temporary location and then a pointer containing the address of the copy's temporary location is placed into the argument list that is accepted by the ILE C program.

For CALL...BY VALUE, the value of the item is placed into the argument list that is accepted by the ILE C program. CALL...BY VALUE can be used to call ILE C procedures but not ILE C program objects.

In your ILE COBOL program, you describe the arguments that you want to pass to the ILE C program or procedure, in the Data Division in the same manner as you describe other data items in the Data Division. Refer to “Passing and Sharing Data Between Programs” on page 222 for a description of how to describe the arguments that you want to pass.

When the called ILE C program object begins running, the function `main` is automatically called. Every ILE C program object must have one function named `main`. When you pass parameters to the ILE C program object, you must declare two parameters with the function `main`. Although any name can be given to these parameters, they are usually referred to as *argc* and *argv*. The first parameter, *argc* (argument count), has type `int` and indicates how may arguments were supplied on the CALL statement that called the ILE C program object. The second parameter, *argv* (argument vector), has type array of pointers to `char` array objects.

The value of *argc* indicates the number of pointers in the array *argv*. If a program name is available, the first element in *argv* points to a character array that contains the program name of the invocation name of the ILE C program that is being run. The remaining elements in *argv* contain pointers to the parameters being passed to the called ILE C program. The last element, *argv[argc]*, always contains `NULL`.

Refer to the *WebSphere Development Studio: ILE C/C++ Programmer's Guide* for further information on describing parameters in the called ILE C program or procedure.

Data Type Compatibility between ILE C and ILE COBOL

ILE C and ILE COBOL have different data types. When you want to pass data between programs written in ILE C and ILE COBOL, you must be aware of these differences. Some data types in ILE C and ILE COBOL have no direct equivalent in the other language.

Table 17 on page 292 shows the ILE COBOL data type compatibility with ILE C.

Table 17. ILE COBOL Data Type Compatibility with ILE C

ILE COBOL	ILE C declaration in prototype	Length	Description
PIC X(n).	char[n] or char *	n	A character field where n=1 to 16 711 568
FORMAT DATE literal.	char[6]	6	A date field.
PIC X(5).	char[5]	5	A day field.
PIC X.	char	1	A day-of-week field.
FORMAT TIME literal.	char[8]	8	A time field.
FORMAT TIMESTAMP.	char[n]	26	A timestamp field.
PIC G(n)	char[2n]	2n	A graphic field.
PIC 1 INDIC ..	char	1	An indicator.
PIC S9(n) DISPLAY	char[n]	n	A zoned decimal.
PIC S9(n-p)V9(p) COMP-3	decimal(n,p)	n/2+1	A packed decimal.
PIC S9(n-p)V9(p) PACKED-DECIMAL.	decimal(n,p)	n/2+1	A packed decimal.
PIC S9(4) COMP-4.	short int	2	A 2-byte signed integer with a range of -9999 to +9999.
PIC S9(4) BINARY.	short int	2	A 2-byte signed integer with a range of -9999 to +9999.
PIC S9(9) COMP-4.	int	4	A 4-byte signed integer with a range of -999999999 to +999999999.
PIC S9(9) BINARY.	int	4	A 4-byte signed integer with a range of -999999999 to +999999999.
PIC S9(9) COMP-4.	long int	4	A 4-byte signed integer with a range of -999999999 to +999999999.
PIC S9(9) BINARY.	long int	4	A 4-byte signed integer with a range of -999999999 to +999999999.
PIC S9(18) COMP-4.	long long	8	An 8-byte integer.
PIC S9(18) BINARY.	long long	8	An 8-byte integer.
05 VL-FIELD. 10 i PIC S9(4) COMP-4. 10 data PIC X(n).	_Packed struct {short i; char[n]}	n+2	A variable length field where i is the intended length and n is the maximum length.
05 n PIC 9(9) COMP-4. 05 x redefines n PIC X(4).	struct {unsigned int : n}x;	4	Bitfields can be manipulated using hex literals.
01 record 05 field1... 05 field2...	struct	n	A structure. Use the _Packed qualifier on the struct. Structures passed should be passed as a pointer to the structure if you want to change the contents of the structure.
USAGE IS POINTER	*	16	A pointer.
PROCEDURE-POINTER	pointer to function	16	A 16-byte pointer to a procedure.
USAGE IS INDEX	int	4	A 4-byte integer.

Table 17. ILE COBOL Data Type Compatibility with ILE C (continued)

ILE COBOL	ILE C declaration in prototype	Length	Description
REDEFINES	union.element	n	An element of a union.
OCCURS	data_type[n]	n*(length of data_type)	An array.
USAGE IS COMP-1	float	4	A 4-byte floating-point.
USAGE IS COMP-2	double	8	An 8-byte floating-point.
Not supported.	long double	8	An 8-byte long double.
Not supported.	enum	1, 2, 4	Enumeration.
Note: For all COMP-4 and BINARY data items, the range limitations indicated only apply when the *STDTRUNC value of the OPTION parameter of the CRTCBLMOD or CRTBNDCBL command is specified. If *NOSTDTRUNC is used, the range constraints need not be observed.			

Sharing External Data with an ILE C Program or Procedure

External data can be shared between an ILE COBOL program and an ILE C program. In order for the data item to be shared, it must be defined with the same name and description in the ILE COBOL program and the ILE C program. If the external data that is to be shared between the ILE C program and the ILE COBOL program is defined with different sizes in the programs, then the size of the external data item will be forced to that defined with the `extern` keyword in the ILE C program.

The ILE COBOL program and the ILE C program must be statically bound together in order for the external data item to be shared.

In the ILE COBOL program, the data item must be described with the EXTERNAL clause in the Working Storage Section. See "Sharing EXTERNAL Data" on page 226 or refer to the section on the EXTERNAL clause in the ILE C for a further description of how external data is used in an ILE COBOL program.

In the ILE C program, the data item must be declared using the `extern` keyword. Refer to *WebSphere Development Studio: ILE C/C++ Programmer's Guide* for a detailed description of the `extern` keyword.

Returning Control from an ILE C Program or Procedure

The `return` keyword in ILE C causes control to be returned to the caller. If the ILE C `return` keyword returns something other than void, the ILE COBOL CALL statement must have a returning phrase. In addition, the data type and length of the item returned from ILE C must match the data type and length of the RETURNING phrase identifier of the COBOL call statement.

When `return` is issued from an ILE C program, it may cause the ILE activation group in which the called ILE C program is running to end. If the ILE C program was defined to run in a *NEW activation group then when `return` is issued near a hard control boundary, the activation group in which the ILE C program was running is ended. If the ILE C program was defined to run in a *CALLER activation group or a named activation group then when `return` is issued, the activation group in which the ILE C program was running remains active. A subsequent call to the ILE C program in this activation group will find the ILE C program in its last used state.

The `exit(n)` function can cause control to be returned to the nearest control boundary. An exception condition can cause an exception handler to be invoked or cause control to be returned to the nearest control boundary.

When the ILE C program is running in a different named activation group than the calling ILE COBOL program, `exit(n)` or an unhandled exception cause the following to happen. If `exit(n)` or an unhandled exception occur near a hard control boundary, the activation group in which the ILE C program is running is ended. If they occur near a soft control boundary, the activation group remains active. If an unhandled exception ends the activation group in which the ILE C program is running, the CEE9901 escape message is raised in the calling ILE COBOL program's activation group.

When the ILE C program and the calling ILE COBOL program are running in the same activation group, `exit(n)` or an unhandled exception cause the following to happen. If `exit(n)` or an unhandled exception occur near a hard control boundary, the activation group, including the ILE COBOL program, is ended. If an unhandled exception ends the activation group in which both the ILE C program and the ILE COBOL program are running, the CEE9901 escape message is issued to the program prior to the hard control boundary. If `exit(n)` or an unhandled exception occur near a soft control boundary, all programs and procedures, including the ILE COBOL program, between the ILE C program from which the `exit(n)` is made and the program at the soft control boundary, are ended.

Control is returned to your ILE COBOL program at the next statement after the CALL statement if the called program ends without an exception. If the called program ends with an exception then an exception handling procedure identified in your ILE COBOL program may be invoked. Refer to Chapter 15, "ILE COBOL Error and Exception Handling," on page 345 for a full description of transferring control to an exception handling procedure.

The called program can also send an escape message past the calling ILE COBOL program skipping it altogether. In this case, the invocation of the ILE COBOL program is canceled. Canceling the invocation is similar to returning from the ILE COBOL program.

Examples of an ILE C Procedure Call from an ILE COBOL Program

Each example consists of an ILE COBOL program that calls an ILE C procedure.

Sample Code for ILE C Procedure Call Example 1

Example 1 has two code samples:

C1 QCSRC
An ILE C procedure that is bound to the ILE COBOL program.

CBL1 QCBLLESRC
An ILE COBOL procedure that calls the bound ILE C procedure.

The sample code for C1 QCSRC is shown in Figure 70 on page 295.

```
/* C1 QCSRC --- ILE C Procedure */
#include <stdio.h>
#include <stdlib.h>
void C1(char *result)
{
    *(result+9) = '*';
    *(result+10) = '#';
    return;
}
```

Figure 70. Source code for C1 QCSRC

The sample code for CBL1 QCBLLESRC is shown in Figure 71.

```
      ******************************************************************
      * cbl1 qcbllesrc
      *
      * Description:
      *
      *   COBOL source with ILE C procedure call.
      *
      ******************************************************************
       Identification Division.
        Program-Id.    cbl1.
        Author.        Author's Name.
        Installation.  IBM Toronto Lab
        Date-Written.  July 14, 1998.
        Date-Compiled. Will be replaced by compile date.
       Environment Division.
        Configuration Section.
         Source-Computer.   IBM-ISERIES.
         Object-Computer.   IBM-ISERIES.
         Special-Names.
       INPUT-OUTPUT SECTION.

       File-Control.
       Data Division.
        Working-Storage Section.
         01  RESULT-STRING    PIC X(20)       VALUE ALL "X".

       Procedure Division.

       TEST1-INIT.
           DISPLAY RESULT-STRING.
           CALL PROCEDURE "C1" USING RESULT-STRING.
           DISPLAY RESULT-STRING.
           STOP RUN.
      *----------------------------------------------------------------
      * Output before call
      * XXXXXXXXXXXXXXXXXXXX
      * Output after call
      * XXXXXXXXX*#XXXXXXXXX
```

Figure 71. Source code for CBL1 QCBLLESRC

Sample Code for ILE C Procedure Call Example 2

Example 2 has two code samples:

CPROC1 QCSRC
: An ILE C procedure that is bound to the ILE COBOL program.

VARG1 QCBLLESRC

An ILE COBOL procedure that calls the bound ILE C procedure.

The sample code for CPROC1 QSRC is shown in Figure 72.

```
/* CPROC1 QCSRC --- ILE C Procedure */
#include <stdio.h>

int inner(va_list);

int CPROC1(int p0, ...)
{
    int rc;
    va_list args;
    va_start(args,p0);
    rc = inner(args);
    va_end(args);
    return rc;
}

int inner(va_list v) {
    int p1,p2,p3=0;
    int p4,p5,p6=0;
    int p7,p8,p9=0;
    p1 = va_arg(v,int);
    p2 = va_arg(v,int);
    p3 = va_arg(v,int);
    p4 = va_arg(v,int);
    p5 = va_arg(v,int);
    p6 = va_arg(v,int);
    p7 = va_arg(v,int);
    p8 = va_arg(v,int);
    p9 = va_arg(v,int);
    printf("In inner with p1=%d p2=%d p3=%d\n",
                              p1,   p2,   p3);
    printf("In inner with p4=%d p5=%d p6=%d\n",
                              p4,   p5,   p6);
    printf("In inner with p7=%d p8=%d p9=%d\n",
                              p7,   p8,   p9);
    return(p1 + p2 + p3 + p4 + p5 + p6 + p7 + p8 + p9);
}
```

Figure 72. Source code for CPROC1 QSRC

The sample code for VARG1 QCBLLESRC is shown in Figure 73 on page 297.

```
*****************************************************************
* cbl1 qcbllesrc
*
* Description:
*
*   COBOL source with ILE C procedure call.
*
*****************************************************************
       IDENTIFICATION DIVISION.

 PROGRAM-ID.     VARG1.

*** This program demonstrates how to call a C procedure
*** using variable-length argument list.

 AUTHOR.
 INSTALLATION.   IBM Toronto Lab.
 DATE-WRITTEN.
 DATE-COMPILED.

 ENVIRONMENT DIVISION.

 CONFIGURATION SECTION.

 SOURCE-COMPUTER. IBM-ISERIES.
 OBJECT-COMPUTER. IBM-ISERIES.
   SPECIAL-NAMES. LINKAGE PROCEDURE FOR "CPROC1"
                          USING ALL DESCRIBED.

 INPUT-OUTPUT SECTION.
 FILE-CONTROL.
 DATA DIVISION.
 FILE SECTION.
 WORKING-STORAGE SECTION.

 01 PARM0                   PIC S9(9) BINARY VALUE 0.
 01 PARM1                   PIC S9(9) BINARY VALUE 1.
 01 PARM2                   PIC S9(9) BINARY VALUE 2.
 01 PARM3                   PIC S9(9) BINARY VALUE 3.
 01 PARM4                   PIC S9(9) BINARY VALUE 4.
 01 PARM5                   PIC S9(9) BINARY VALUE 5.
 01 PARM6                   PIC S9(9) BINARY VALUE 6.
 01 PARM7                   PIC S9(9) BINARY VALUE 7.
 01 PARM8                   PIC S9(9) BINARY VALUE 8.
 01 PARM9                   PIC S9(9) BINARY VALUE 9.
 01 RC1                     PIC S9(9) BINARY VALUE 0.

 PROCEDURE DIVISION.

 MAIN.

       CALL PROCEDURE "CPROC1" USING BY VALUE
                                PARM0
                                PARM1
                                PARM2
                                PARM3
                                PARM4
                                PARM5
                                PARM6
                                PARM7
                                PARM8
                                PARM9
            RETURNING INTO RC1.
       GOBACK.
```

Figure 73. Source code for VARG1 QCBLLESRC

Creating and Running the ILE C Procedure Call Examples

To create and run ILE C procedure call example 1, follow these steps:

1. Create one ILE COBOL module and one ILE C module.
   - To create the ILE COBOL module CBL1, type
     ```
     CRTCBLMOD  MODULE(CBL1) SRCFILE(*CURLIB/QCBLLESRC)
     ```
   - To create the ILE C module C1, type
     ```
     CRTCMOD    MODULE(C1) SRCFILE(*CURLIB/QCSRC)
     ```
2. Create a program using the two modules
   ```
   CRTPGM     PGM(CBL1) MODULE(*CURLIB/CBL1 *CURLIB/C1)
   ```
3. Call the program
   ```
   CALL       PGM(*CURLIB/CBL1)
   ```

To create and run ILE C procedure call example 2, follow these steps:

1. Create one ILE COBOL module and one ILE C module:
   - To create the ILE COBOL module VARG1, type
     ```
     CRTCBLMOD  MODULE(VARG1) SRCFILE(*CURLIB/QCBLLESRC)
     ```
   - To create the ILE C module CPROC1, type
     ```
     CRTCMOD    MODULE(CPROC1) SRCFILE(*CURLIB/QCSRC)
     ```
2. Create a program using the two modules:
   ```
   CRTPGM     PGM(VARG1) MODULE(*CURLIB/VARG1 *CURLIB/CPROC1)
   ```
3. Call the program:
   ```
   CALL       PGM(*CURLIB/VARG1)
   ```

Example of an ILE C Program Call from an ILE COBOL Program

This example consists of an ILE COBOL program that calls an ILE C program.

Sample Code for ILE C Program Call Example

The example has two code samples:

C2 QCSRC
An ILE C program.

CBL2 QCBLLESRC
An ILE COBOL program with an ILE C program call.

The sample code for C2 QCSRC is shown in Figure 74.

```
/* C2 QCSRC --- ILE C Program */
#include <stdio.h>
#include <stdlib.h>
void main(int argc, char *argv[])
{
    *(argv[1]+9) = '*';
    *(argv[1]+10) = '#';
    return;
}
```

Figure 74. Source code for C2 QCSRC

The sample code for CBL2 QCBLLESRC is shown in Figure 75.

```
      ******************************************************************
      * cbl2 qcbllesrc
      *
      * Description:
      *
      *   COBOL source with ILE C program call.
      *
      ******************************************************************
       Identification Division.
        Program-Id.    cbl2.
        Author.        Author's Name.
        Installation.  IBM Toronto Lab
        Date-Written.  July 14, 1998.
        Date-Compiled. Will be replaced by compile date.
       Environment Division.
        Configuration Section.
         Source-Computer.   IBM-ISERIES.
         Object-Computer.   IBM-ISERIES.
         Special-Names.
       INPUT-OUTPUT SECTION.

       File-Control.
       Data Division.
        Working-Storage Section.
         01  RESULT-STRING    PIC X(20)       VALUE ALL "X".

       Procedure Division.

       TEST1-INIT.
           DISPLAY RESULT-STRING.
           CALL "C2" USING BY REFERENCE RESULT-STRING.
           DISPLAY RESULT-STRING.
           STOP run.
      *----------------------------------------------------------------------
      * Output before call
      * XXXXXXXXXXXXXXXXXXXX
      * Output after call
      * XXXXXXXXX*#XXXXXXXXX
```

Figure 75. Source code for CBL2 QCBLLESRC

Creating and Running the ILE C Program Call Example

To create and run the ILE C program call example, follow these steps:

1. Create one ILE COBOL program and one ILE C program
   - To create the ILE COBOL program CBL2, type

     ```
     CRTBNDCBL  PGM(CBL2) SRCFILE(*CURLIB/QCBLLESRC)
     ```

   - To create the ILE C program C2, type

     ```
     CRTBNDC    PGM(C2) SRCFILE(*CURLIB/QCSRC)
     ```

2. Call the ILE COBOL program

   ```
   CALL       PGM(*CURLIB/CBL2)
   ```

Calling ILE RPG Programs and Procedures

An ILE COBOL program can call ILE RPG programs and procedures using dynamic program calls or static procedure calls.

When a dynamic program call is used to call an ILE RPG program, the ILE RPG program must be compiled and bound as a separate program object. When a static

procedure call is used to call an ILE RPG procedure, the ILE RPG procedure must first be compiled into a module object and then bound to the calling ILE COBOL program. Refer to the *WebSphere Development Studio: ILE RPG Programmer's Guide* for a description of compiling and binding ILE RPG programs and procedures.

You call an ILE RPG program or procedure from an ILE COBOL program by using the CALL *literal* statement (where *literal* is the name of the ILE RPG program or procedure). To call the ILE RPG program or procedure, you write the CALL *literal* statement in the same way as you would if you were calling another ILE COBOL subprogram. See "Using Static Procedure Calls and Dynamic Program Calls" on page 210 for detailed information about how to write the CALL statement in your ILE COBOL program to call an ILE RPG program using dynamic program calls or static procedure calls.

You can also call an ILE RPG program from an ILE COBOL program by using the CALL *identifier* statement. See "Using CALL identifier" on page 213 for more information on CALL *identifier*.

Passing Data to an ILE RPG Program or Procedure

You can pass data to a called ILE RPG program or procedure by using CALL...BY REFERENCE, CALL...BY VALUE, or CALL...BY CONTENT. Refer to "Passing Data Using CALL...BY REFERENCE, BY VALUE, or BY CONTENT" on page 223 for a description of how to use CALL...BY REFERENCE, CALL...BY VALUE or CALL...BY CONTENT.

When data is passed to the ILE RPG program using CALL...BY REFERENCE, a pointer to the data item is placed into the argument list that is accepted by the ILE RPG program. When data is passed to the ILE RPG program using CALL...BY CONTENT, the value of the data item is copied to a temporary location and then a pointer containing the address of the copy's temporary location is placed into the argument list that is accepted by the ILE RPG program. For CALL...BY VALUE, the value of the item is placed into the argument list that is accepted by the ILE RPG program. CALL...BY VALUE can be used to call ILE RPG procedures but not ILE RPG program objects.

In your ILE COBOL program, you describe the arguments that you want to pass to the ILE RPG program or procedure, in the Data Division in the same manner as you describe other data items in the Data Division. Refer to "Passing and Sharing Data Between Programs" on page 222 for a description of how to describe the arguments that you want to pass.

In the called ILE RPG program, you describe the parameters that you want to receive from the ILE COBOL program using the `PARM` operation. Each receiving parameter is defined in a separate `PARM` operation. You specify the name of the parameter in the Result field. The Factor 1 and Factor 2 entries are optional and indicate variables or literals. The value from the Factor 1 field is transferred from the Result field entry when the call occurs. The value from the Factor 2 field is placed in the Result field entry upon return.

Another method of defining parameters in an ILE RPG program is to specify them in a prototype. Each parameter is defined on a separate definition specification. For parameters passed BY REFERENCE, no special keywords are necessary. For parameters passed BY VALUE, the `VALUE` keyword is used. Refer to the *WebSphere Development Studio: ILE RPG Programmer's Guide* for more information on how to describe the arguments in an ILE RPG program.

Data Type Compatibility between ILE RPG and ILE COBOL

ILE RPG and ILE COBOL have different data types. When you want to pass data between programs written in ILE RPG and ILE COBOL, you must be aware of these differences. Some data types in ILE RPG and ILE COBOL have no direct equivalent in the other language.

Table 18 shows the ILE COBOL data type compatibility with ILE RPG.

Table 18. ILE COBOL Data Type Compatibility with ILE RPG

ILE COBOL	ILE RPG I-Spec, D-Spec, or C-Spec	Length	Description
PIC X(n).	blank or A in data type column, n in length column, and blank in decimal position column	n	A character field where n=1 to 32 767
PIC 1 INDIC ..	*INxxxx	1	An indicator.
PIC S9(n) DISPLAY	S in data type column or blank in data type column, n in length column, and 0 in decimal position column	n	A zoned decimal.
PIC S9(n-p)V9(p) COMP-3	P in data type column, n in length column, and p in decimal position column	n/2 + 1	A packed decimal.
PIC S9(n-p)V9(p) PACKED-DECIMAL.	P in data type column, n in length column, and p in decimal position column	n/2 + 1	A packed decimal.
Not supported	I in data type column, 3 in length column, and 0 in decimal position column	1	A 1-byte signed integer with a range of -128 to 127
Not supported	U in data type column, 3 in length column, and 0 in decimal position column	1	A 1-byte unsigned integer with a range of 0 to 255
PIC S9(4) COMP-4.	B in data type column, 4 in length column, and 0 in decimal position column	2	A 2-byte signed integer with a range of -9999 to +9999.
PIC S9(4) BINARY.	B in data type column, 4 in length column, and 0 in decimal position column	2	A 2-byte signed integer with a range of -9999 to +9999.
PIC S9(4) BINARY. *NOSTDTRUNC option	I in data type column, 5 in length column, and 0 in decimal position column	2	A 2-byte signed integer with a range of -32768 to 32767
Not supported	U in data type column, 5 in length column, and 0 in decimal position column	2	A 2-byte unsigned integer with a range of 0 to 65535
PIC S9(9) COMP-4.	B in data type column, 9 in length column, and 0 in decimal position column	4	A 4-byte signed integer with a range of -999999999 to +999999999.
PIC S9(9) BINARY.	B in data type column, 9 in length column, and 0 in decimal position column	4	A 4-byte signed integer with a range of -999999999 to +999999999.
PIC S9(9) BINARY. *NOSTDTRUNC option	I in data type column, 10 in length column, and 0 in decimal position column	4	A 4-byte signed integer with a range of -2147483648 to 2147483647

Table 18. ILE COBOL Data Type Compatibility with ILE RPG (continued)

ILE COBOL	ILE RPG I-Spec, D-Spec, or C-Spec	Length	Description
Not supported	U in data type column, 10 in length column, and 0 in decimal position column	4	A 4-byte unsigned integer with a range of 0 to 4294967295
PIC S9(18) COMP-4.	I in data type column, 20 in length column, and 0 in decimal position column	8	An 8-byte signed integer with a range of -9223372036854775808 to 9223372036854775807.
PIC S9(18) BINARY.	I in data type column, 20 in length column, and 0 in decimal position column	8	An 8-byte signed integer with a range of -9223372036854775808 to 9223372036854775807.
Not supported	U in data type column, 20 in length column, and 0 in decimal position column	8	An 8-byte unsigned integer with a range of 0 to 18446744073709551615.
USAGE IS COMP-1	F in data type column, 4 in length column	4	A 4-byte internal floating-point field.
USAGE IS COMP-2	F in data type column, 8 in length column.	8	An 8-byte internal floating-point field.
05 VL-FIELD. 10 i PIC S9(4) COMP-4. 10 data PIC X(n).	A in data type column, n in length column. Keyword VARYING.	n+2	A variable length field where i is the intended length and n is the maximum length.
05 n PIC 9(9) COMP-4. 05 x redefines n PIC X(4).	U in data type column, 4 in length column. To manipulate move to unsigned field in data structure overlaid by character array and use bit operations on each byte.	4	Bitfields can be manipulated using hex literals.
01 record 05 field1... 05 field2...	data structure	n	A structure. Structures passed should be passed as a pointer to the structure if you want to change the contents of the structure.
USAGE IS POINTER	* in data type column	16	A pointer.
PROCEDURE-POINTER	* in data type column and keyword PROCPTR	16	A 16-byte pointer to a procedure.
USAGE IS INDEX	I in data type column, length is 10, 0 in decimal position	4	A 4-byte integer.
REDEFINES	data structure subfield	n	An element of a union.
OCCURS	Keyword OCCURS or keyword DIM	n*(length of data_type)	An array.
FORMAT DATE	D in data type column	n	A date data type.
FORMAT TIME	T in data type column	n	A time data type.
FORMAT TIMESTAMP	Z in data type column	n	A timestamp data type.
PIC G(n)	G in data type column	n*2	A graphic (double-byte) data type.
Not supported	C in data type column	n*2	A UCS-2 (Universal Character Set) data type.

Returning Control from an ILE RPG Program or Procedure

When returning from an ILE RPG main procedure, the RETURN operation code causes control to be returned to the caller. If, prior to executing the RETURN operation code, the SETON operation code is used to set the LR indicator, the called ILE RPG program is reset to its initial state upon return to the caller. Otherwise, the called ILE RPG program is left in its last used state.

When returning from an ILE RPG subprocedure, the RETURN operation code causes control to be returned to the caller. If the procedure returns a value, the returned value is specified in the extended factor 2 of the RETURN operation. If the subprocedure returns a value, the COBOL CALL statement should have a RETURNING phrase.

Note: The LR indicator has no meaning when returning from a subprocedure.

Control is returned to your ILE COBOL program at the next statement after the CALL statement if the called program ends without an exception. If the called program ends with an exception then control is returned to the exception handling procedure identified in your ILE COBOL program. Refer to Chapter 15, "ILE COBOL Error and Exception Handling," on page 345 for a full description of transferring control to an exception handling procedure.

The called program can also send an escape message past the calling ILE COBOL program skipping it altogether. In this case, the invocation of the ILE COBOL program is canceled. Canceling the invocation is similar to returning from the ILE COBOL program.

Calling ILE CL Programs and Procedures

An ILE COBOL program can call ILE CL programs and procedures using dynamic program calls or static procedure calls.

When a dynamic program call is used to call an ILE CL program, the ILE CL program must be compiled and bound as a separate program object. When a static procedure call is used to call an ILE CL procedure, the ILE CL procedure must first be compiled into a module object and then bound to the calling ILE COBOL program. Refer to the *CL Programming* for a description of compiling and binding ILE CL programs and procedures.

You call an ILE CL program or procedure from an ILE COBOL program by using the CALL *literal* statement (where *literal* is the name of the ILE CL program or procedure). To call the ILE CL program or procedure, you write the CALL *literal* statement in the same way as you would if you were calling another ILE COBOL subprogram. See "Using Static Procedure Calls and Dynamic Program Calls" on page 210 for detailed information about how to write the CALL statement in your ILE COBOL program to call an ILE CL program using dynamic program calls or static procedure calls.

You can also call an ILE CL program from an ILE COBOL program by using the CALL *identifier* statement. See "Using CALL identifier" on page 213 for more information on CALL *identifier*.

Passing Data to an ILE CL Program or Procedure

You can pass data to a called ILE CL program or procedure by using CALL...BY REFERENCE or CALL...BY CONTENT. Refer to "Passing Data Using CALL...BY

REFERENCE, BY VALUE, or BY CONTENT" on page 223 for a description of how to use CALL...BY REFERENCE or CALL...BY CONTENT.

When data is passed to the ILE CL program using CALL...BY REFERENCE, a pointer to the data item is placed into the argument list that is accepted by the ILE CL program. When data is passed to the ILE CL program using CALL...BY CONTENT, the value of the data item is copied to a temporary location and then a pointer containing the address of the copy's temporary location is placed into the argument list that is accepted by the ILE CL program.

In your ILE COBOL program, you describe the arguments that you want to pass to the ILE CL program or procedure, in the Data Division in the same manner as you describe other data items in the Data Division. Refer to "Passing and Sharing Data Between Programs" on page 222 for a description of how to describe the arguments that you want to pass.

In the called ILE CL program, you describe the parameters that you want to receive from the ILE COBOL program on the PARM parameter of the PGM statement. The order in which the receiving parameters are listed in the PARM parameter must the same as the order in which they are listed on the CALL statement in the ILE COBOL program. In addition to the position of the parameters, you must pay careful attention to their length and type. Parameters listed in the called ILE CL program must be declared as the same length and type as they are in the calling ILE COBOL program.

You use DCL statements to describe the receiving parameters in the called ILE CL program. The order of the DCL statements is not important. Only the order in which the parameters are specified on the PGM statement determines what variables are received. The following example shows how parameters are described in the called ILE CL program.

```
PGM PARM(&P1 &P2);
DCL VAR(&P1); TYPE(*CHAR) LEN(32)
DCL VAR(&P2); TYPE(*DEC) LEN(15 5)
.
.
.
RETURN
ENDPGM
```

Refer to the *CL Programming* for a description of how to describe parameters in an ILE CL program.

Data Type Compatibility between ILE CL and ILE COBOL

ILE CL and ILE COBOL have different data types. When you want to pass data between programs written in ILE CL and ILE COBOL, you must be aware of these differences. Some data types in ILE CL and ILE COBOL have no direct equivalent in the other language.

Table 19 shows the ILE COBOL data type compatibility with ILE CL.

Table 19. ILE COBOL Data Type Compatibility with ILE CL

ILE COBOL	ILE CL	Length	Description
PIC X(n).	TYPE(*CHAR) LEN(n)	n	A character field where n=1 to 32 766.

Table 19. ILE COBOL Data Type Compatibility with ILE CL (continued)

ILE COBOL	ILE CL	Length	Description
01 flag PIC 1. 88 flag-on VALUE B'1'. 88 flag-off VALUE B'0'.	TYPE(*LGL)	1	Holds '1' or '0'.
PIC S9(n-p)V9(p) COMP-3.	TYPE(*DEC) LEN(n p)	n/2+1	A packed decimal. Maximum value for n=15. Maximum value for p=9.
PIC S9(n-p)V9(p) PACKED-DECIMAL.	TYPE(*DEC) LEN(n p)	n/2+1	A packed decimal. Maximum value for n=15. Maximum value for p=9.
USAGE IS COMP-1	Not Supported.	4	A 4-byte internal floating-point.
USAGE IS COMP-2	Not Supported.	8	An 8-byte internal floating-point.

Returning Control from an ILE CL Program or Procedure

The RETURN command in ILE CL causes control to be returned to the caller.

Control is returned to your ILE COBOL program at the next statement after the CALL statement if the called program ends without an exception. If the called program ends with an exception then control is returned to the exception handling procedure identified in your ILE COBOL program. Refer to Chapter 15, "ILE COBOL Error and Exception Handling," on page 345 for a full description of transferring control to an exception handling procedure.

The called program can also send an escape message past the calling ILE COBOL program skipping it altogether. In this case, the invocation of the ILE COBOL program is canceled. Canceling the invocation is similar to returning from the ILE COBOL program.

Calling OPM Languages

Programs written in OPM languages such as OPM COBOL/400 or OPM RPG/400® can only be called from ILE COBOL using dynamic program calls. OPM programs cannot be statically bound to ILE COBOL programs. If you attempt to call an OPM program using a static procedure call, you will receive an error message. At bind time, you will receive a warning message from the binder for an unresolved reference to the static procedure call. If you disregard the warning message and create the ILE program object, you will get a exception when the static procedure call is attempted at run time.

You call an OPM program from an ILE COBOL program by using the CALL *literal* statement (were *literal* is the name of the OPM program). To call the OPM program, you write the CALL *literal* statement in the same way as you would if you were calling another ILE COBOL subprogram using a dynamic program call. See "Performing Dynamic Program Calls using CALL literal" on page 212 for detailed information about how to write the CALL statement in your ILE COBOL program to call an OPM program using dynamic program calls.

You can also call an OPM program from an ILE COBOL program by using the CALL *identifier* statement. See "Using CALL identifier" on page 213 for more information on CALL *identifier*.

Programs written in OPM languages can only be run in the Default Activation Group (*DFTACTGRP).

You can call an ILE COBOL program from an OPM program by using the same call semantics as you would for calling another OPM program.

External data cannot be shared between OPM programs and ILE COBOL programs.

Calling OPM COBOL/400 Programs

OPM COBOL/400 programs can only be run in the Default Activation Group (*DFTACTGRP). ILE COBOL programs can be run in the Default Activation Group (*DFTACTGRP), in *NEW ILE activation groups, and in named ILE activation groups.

Note: CRTPGM does not allow *DFTACTGRP to be explicitly specified in the ACTGRP parameter but it does allow *CALLER to be specified in the ACTGRP parameter. Specifying *CALLER in the ACTGRP parameter allows an ILE COBOL program called from an OPM COBOL/400 program (or any OPM program) to be run in the Default Activation Group. This is the only way for an ILE COBOL program to run in the Default Activation Group. An ILE COBOL program cannot be the hard control boundary in the Default Activation Group.

When a mixed language application of OPM COBOL/400 and ILE COBOL programs is run, the following scenario must be adhered to in order to most closely mimic an OPM COBOL/400 run unit:

- All participating programs must run in the Default Activation Group (*DFTACTGRP).
- The first COBOL program to be activated in the activation group must be an OPM COBOL/400 program.
- STOP RUN must be issued by an OPM COBOL/400 program or GOBACK must be issued by an OPM COBOL/400 main program, to end the run unit.
- An exception causing an implicit STOP RUN, if any, must be handled in such a way that the implicit STOP RUN is triggered by OPM COBOL/400.

For a mixed language application of OPM COBOL/400 and ILE COBOL programs running in the Default Activation Group, each ILE COBOL program is considered to be a non-COBOL program by the OPM COBOL/400 programs and each OPM COBOL/400 program is considered to be a non-COBOL program by the ILE COBOL programs. Also, each ILE COBOL program that is called by an OPM COBOL/400 program generates a soft control boundary by which the scope of the STOP RUN issued by the ILE COBOL program is bound.

When STOP RUN is issued by the ILE COBOL program, control is returned to the OPM COBOL/400 program without refreshing the state of the ILE COBOL program and the OPM COBOL/400 run unit is not ended. When STOP RUN is issued from an OPM COBOL/400 program, control is returned to the caller of the current main OPM COBOL/400 program and the OPM COBOL/400 run unit is ended.

For a mixed language application of OPM COBOL/400 and ILE COBOL programs where an ILE COBOL program is running in a *NEW or named ILE activation group and the OPM COBOL/400 program is running in the Default Activation

Group, the effect of STOP RUN issued by the ILE COBOL program depends on whether the nearest control boundary is a hard control boundary or a soft control boundary. If it is a hard control boundary then control is returned to the caller of the hard control boundary and its *NEW or named ILE activation group is ended. If it is a soft control boundary then control is returned to the caller of the soft control boundary but the *NEW or named ILE activation group of the ILE COBOL program remains active.

Note: This scenario does not conform to an OPM COBOL/400 run unit.

Calling EPM Languages

Programs written in EPM languages such as EPM C/400®, Pascal, and FORTRAN can be called from an ILE COBOL program through a CALL to QPXXCALL.

In the following example, an ILE COBOL program uses QPXXCALL to call a Pascal procedure.

```
5722WDS V5R3M0 030905 LN  IBM ILE COBOL               CBLGUIDE/COBTOPAS       ISERIES1   03/09/15 13:38:36       Page      2
                                Source
  STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
     1     000100 IDENTIFICATION DIVISION.
     2     000200 PROGRAM-ID. COBTOPAS.
     3     000300 ENVIRONMENT DIVISION.
     4     000400 CONFIGURATION SECTION.
     5     000500   SOURCE-COMPUTER. IBM-ISERIES
     6     000600   OBJECT-COMPUTER. IBM-ISERIES
     7     000700 DATA DIVISION.
     8     000800 WORKING-STORAGE SECTION.
     9     000900 01  PARAMETER-LIST.
    10     001000     05  ENTRY-NAME   PIC X(100)         VALUE "SQUARE".
    11     001100     05  ENTRY-ID     PIC X(10)          VALUE "*MAIN".
    12     001200     05  PROG-NAME    PIC X(20)          VALUE "MATH".
    13     001300     05  A-REAL       PIC S9(9)  COMP-4  VALUE 0.
    14     001400     05  CLEAN        PIC S9(9)  COMP-4  VALUE 0.
    15     001500     05  INPT         PIC S99            VALUE 0.
    16     001600 PROCEDURE DIVISION.
           001700 MAINLINE.
    17     001800     DISPLAY "ENTER AREA NUMBER:".
    18     001900     ACCEPT INPT.
    19     002000     MOVE INPT TO A-REAL.
    20     002100     CALL "QPXXCALL" USING ENTRY-NAME
           002200                           ENTRY-ID
           002300                           PROG-NAME
           002400                           A-REAL.
    21     002500     DISPLAY A-REAL.
    22     002600     CALL "QPXXDLTE" USING CLEAN.
    23     002700     STOP RUN.
           002800
                          * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 76. Calling a Pascal procedure from an ILE COBOL program.

```
segment MATH;
procedure SQUARE ( var X : integer ) ; external ;
procedure SQUARE;
   begin
   X := X * X
end; .
```

Figure 77. Pascal entry-point that is to be called from an ILE COBOL program.

Pascal allows an ILE COBOL program to call a Pascal procedure as a subprogram. To do this, specify the Pascal procedure with the EXTERNAL directive (see Figure 77). In the above example, the first invocation the ENTRY-ID parameter of QPXXCALL will establish a Pascal Main Environment. You can use QPXXDLTE to clean up Pascal

Reentrant and Main Environments. Passing zero in the CLEAN parameter to QPXXDLTE causes the current Pascal Main Environment to be deleted.

You can call an ILE COBOL program from an EPM program by using the same call semantics as you would for calling another EPM program.

External data cannot be shared between EPM programs and ILE COBOL programs.

Issuing a CL Command from an ILE COBOL Program

You can issue a CL command from an ILE COBOL program through a dynamic program call to QCMDEXC.

In the following example program, the CALL to QCMDEXC (at sequence number 000160) results in the processing of the Add Library List Entry (ADDLIBLE) CL command (at sequence number 000110). The successful completion of the CL command results in the addition of the library, COBOLTEST, to the library list.

```
 5722WDS V5R3M0  030905 LN  IBM ILE COBOL      CBLGUIDE/CMDXMPLE    ISERIES1   03/09/15 13:40:28    Page    2
                            S o u r c e

STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
     1     000100 IDENTIFICATION DIVISION.
     2     000200 PROGRAM-ID. CMDXMPLE.
     3     000300 ENVIRONMENT DIVISION.
     4     000400 CONFIGURATION SECTION.
     5     000500   SOURCE-COMPUTER. IBM-ISERIES
     6     000600   OBJECT-COMPUTER. IBM-ISERIES
     7     000700 DATA DIVISION.
     8     000800 WORKING-STORAGE SECTION.
     9     000900 01  PROGRAM-VARIABLES.
    10     001000     05  CL-CMD       PIC X(33)
            001100                     VALUE "ADDLIBLE COBOLTEST".
    11     001200     05  PACK-VAL     PIC 9(10)V9(5) COMP-3
            001300                     VALUE 18.
    12     001400 PROCEDURE DIVISION.
            001500 MAINLINE.
    13     001600     CALL "QCMDEXC" USING CL-CMD PACK-VAL.
    14     001700     STOP RUN.
            001800
                       * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 78. Issuing a CL command from an ILE COBOL program.

For more information about QCMDEXC, see the *CL Programming*.

Including Structured Query Language (SQL) Statements in Your ILE COBOL Program

The syntax for SQL statements embedded in an ILE COBOL source program is:

Imbedding SQL Statements

If the member type for the source program is SQLCBLLE when the COBOL syntax checker encounters an SQL statement, the statement is passed to the SQL syntax checker. If an error is detected, a message is returned.

If an SQL statement is encountered, and if the member type is not SQLCBLLE a message is returned indicating that an ILE COBOL statement is in error.

If there are errors in the embedded SQL statement as well as errors in the preceding ILE COBOL statements, the SQL error message will only be displayed after the preceding COBOL errors are corrected.

You can create SQL programs for use with your ILE COBOL programs. The SQL cursor used by your ILE COBOL program may be scoped to either the module object or the activation group. You specify the SQL cursor scoping through the CLOSQLCSR parameter of the Create SQL Program commands (CRTSQLxxx).

For more information about SQL statements and SQL cursors, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://www.ibm.com/eserver/iseries/infocenter.

Calling an ILE API to Retrieve Current Century

The following example, Figure 79, shows how to retrieve a four-digit year using the ILE bindable API, Get Current Local Time(CEELOCT). This API retrieves the current local time in three formats. The third format is the Gregorian date, the first four characters of which are the year.

The next section, "Using Intrinsic Functions or the ACCEPT Statement to Retrieve Current Century" on page 310, discusses how you can also use several of the intrinsic functions, and the ACCEPT statement to do the same thing.

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. DATE1.
* Example program to get the 4 digit year in ILE COBOL for ISERIES
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
   SOURCE-COMPUTER. IBM-ISERIES
   OBJECT-COMPUTER. IBM-ISERIES
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01 date-vars.
    05 lilian            pic 9(9) usage binary.
    05 lilian-time-stamp usage comp-2.
    05 gregorian-date.
       10 greg-year      pic x(4).
       10 greg-month     pic x(2).
       10 greg-day       pic x(2).
       10 greg-time      pic x(9).
       10 filler         pic x(6).
 PROCEDURE DIVISION.
 TEST-PARA.
     call procedure "CEELOCT" using
         lilian lilian-time-stamp
         gregorian-date.
     display "date is " gregorian-date.
     display "year " greg-year.
     display "month " greg-month.
     STOP RUN.
```

Figure 79. Example of Retrieving Current Century.

Using Intrinsic Functions or the ACCEPT Statement to Retrieve Current Century

You can also use one of the following intrinsic functions to retrieve the current century or a 4-digit year:

CURRENT-DATE
Returns the current 4-digit year, as well as other information about the current date and time.

DATE-OF-INTEGER
Takes an integer date, the number of days since December 31, 1600, and returns a Gregorian date with a 4-digit year in the form YYYYMMDD.

DAY-OF-INTEGER
Takes an integer date, the number of days since December 31, 1600, and returns a Julian date with a 4-digit year in the form YYYYDDD.

DATE-TO-YYYYMMDD
Converts a 2-digit year Gregorian date to a 4-digit year Gregorian date.

DAY-TO-YYYYDDD
Converts a 2-digit year Julian date to a 4-digit year Julian date.

EXTRACT-DATE-TIME
Extracts a part of the date or time information contained in a date, time or timestamp item. The year is extracted as a 4-digit year or a 1-digit century.

YEAR-TO-YYYY
Converts a 2-digit year to a 4-digit year.

The FROM DATE YYYYMMDD phrase of the ACCEPT statement can be used to retrieve a 4-digit year Gregorian date from the system. The FROM DAY YYYYDDD phrase of the ACCEPT statement can be used to retrieve a 4-digit year Julian date from the system.

Calling IFS API

You can call the IFS API from an ILE COBOL program. The IFS API should be checked to ensure whether operational descriptors are needed in the COBOL program or not. If needed, the operational descriptors should be specified in the SPECIAL-NAMES paragraph.

Figure 80 is an example of a call to IFS API:

```
SPECIAL NAMES.
 LINKAGE TYPE PROCEDURE FOR "open" USING ALL DESCRIBED.


 ... more declaration and procedure statements

 CALL "open" USING ...
```

Figure 80. Calling IFS API

Chapter 13. Using Pointers in an ILE COBOL Program

You can use a **pointer** (a data item in which address values can be stored) within an ILE COBOL program when you want to pass and receive addresses of data items, ILE procedures, or program objects.

This chapter describes:
- How to define and redefine pointers
- How to initialize pointers
- How to read and write pointers
- How to manipulate data using pointers.

Defining Pointers

You can define pointers in two ways:

- A pointer to a data item. This pointer is defined with the USAGE POINTER clause. The resulting data item is called a **pointer data item**.
- A pointer to an ILE COBOL program, an ILE procedure, or a program object. This pointer is defined with the USAGE PROCEDURE-POINTER clause. The resulting data item is called a **procedure-pointer data item**.

On the AS/400 system, pointers are 16 bytes long.

ILE COBOL pointer data items point to system space objects. One part of the pointer describes its attributes, such as to which AS/400 space object it is pointing. Another part of the pointer contains the offset into the AS/400 system space object.

ILE COBOL procedure-pointer data items are AS/400 **open pointers**. Open pointers have the ability to be used as other types of AS/400 pointers. In particular, when an ILE COBOL procedure-pointer data item is set to a program object, the open pointer will contain an AS/400 system pointer. When an ILE COBOL procedure-pointer data item is set to an ILE procedure, the open pointer will contain an AS/400 procedure pointer.

A pointer a 16-byte elementary item that can be compared for equality, or used to set the value of other pointer items.

A pointer data item can be used only in:
- A SET statement (Formats 5 and 7 only)
- A relation condition
- The USING phrase of a CALL statement, or the Procedure Division header
- The operand for the LENGTH OF and ADDRESS OF special registers.

A procedure-pointer data item can be used only in:
- A SET statement (Format 6 only)
- A relation condition
- The USING phrase of a CALL statement, or the Procedure Division header
- The operand for the LENGTH OF and ADDRESS OF special registers
- The CALL statement as a target.

If pointers are used in a relational condition, the only valid operators are equal to, or not equal to.

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Because pointer data items are not simply binary numbers on the AS/400 system, manipulating pointers as integers does not work.

Pointer data items are defined explicitly with the USAGE IS POINTER clause, and are implicit when using an ADDRESS OF special register or the ADDRESS OF an item.

If a group item is described with the USAGE IS POINTER clause, the elementary items within the group item are pointer data items. The group itself is not a pointer data item, and cannot be used in the syntax where a pointer data item is allowed. If a group item is described with the USAGE PROCEDURE-POINTER clause, the same rules apply. The USAGE clause of an elementary item cannot contradict the USAGE clause of a group to which the item belongs.

Pointers can be part of a group that is referred to in a MOVE statement or an input/output statement; however, if a pointer is part of a group, there is no conversion of pointer values to another form of internal representation when the statement is executed.

Using ILE C and other languages, you can declare pointers to teraspace memory. ILE C requires a special compile-time option to address this type of storage, but ILE COBOL can always address this storage if compiled with a target release of V4R4M0 or later. For more information on pointers in teraspace, see the *ILE Concepts* publication.

Pointer Alignment

Pointers can be defined at any level (except 88) in the File, Working-Storage, or Linkage sections of a program.

When a pointer is referenced on the iSeries server, it must be on a 16-byte storage boundary. **Pointer alignment** refers to the ILE COBOL compiler's process of positioning pointer items within a group item to offsets that are multiples of 16 bytes from the beginning of the record. If a pointer item is not on a 16-byte boundary, a pointer alignment exception is sent to the ILE COBOL program. In general, pointer alignment exceptions occur in the Linkage Section, where it is up to the user to align these items.

In the File and Working-Storage sections, the compiler ensures that this exception does not occur by adding implicit FILLER items. Every time an implicit FILLER item is added by the compiler, a warning is issued. In the Linkage Section, no implicit FILLER items are added by the compiler; however, warnings are issued indicating how many bytes of FILLER would have been added had the group item appeared in the File or Working-Storage sections.

You can define a data item as a pointer by specifying the USAGE IS POINTER clause or the USAGE IS PROCEDURE-POINTER clause as shown in the following example:

```
ID DIVISION.
PROGRAM-ID. PROGA.
WORKING-STORAGE SECTION.
 77  APTR USAGE POINTER.
 77  APROC-PTR USAGE PROCEDURE-POINTER.
 01  AB.
     05 BPTR  USAGE POINTER.
     05 BVAR  PIC S9(3) PACKED-DECIMAL.
LINKAGE SECTION.
```

```
01  AVAR.
    05 CVAR  PIC X(30).
PROCEDURE DIVISION.
     SET APTR TO ADDRESS OF AVAR.
     SET APROC-PTR TO ENTRY "PROGA".
```

In the above example, AVAR is an 01-level data item, so the ADDRESS OF AVAR is the ADDRESS OF special register. Because a special register is an actual storage area, the SET statement moves the contents of ADDRESS OF AVAR into pointer data item APTR.

In the above example, if the SET statement used ADDRESS OF CVAR, no special register exists. Instead, the pointer data item APTR is assigned the calculated address of CVAR.

In the above example, the second SET statement is setting procedure-pointer data item APROC-PTR to the outermost ILE COBOL program ″PROGA″.

Writing the File Section and Working-Storage Section for Pointer Alignment

In the File Section and Working-Storage Section, all 01-level items and 77-level items (and some 66-level items) are placed on 16-byte boundaries.

Within a group structure, pointers must also occur on a 16-byte boundary. To ensure this, the ILE COBOL compiler adds FILLER items immediately before the pointers. To avoid these FILLER items, you should place pointers at the beginning of a group item.

If the pointer is part of a table, the first item in the table is placed on a 16-byte boundary. To ensure that all subsequent occurrences of the pointer fall on a 16-byte boundary, a FILLER item is added to the end of the table if necessary.

An example of pointer alignment follows:

```
WORKING-STORAGE SECTION.
 77  APTR USAGE POINTER.
 01  AB.
     05 ALPHA-NUM PIC X(10).
     05 BPTR  USAGE PROCEDURE-POINTER.
 01  EF.
     05 ARRAY-1 OCCURS 3 TIMES.
        10 ALPHA-NUM-TWO PIC X(14).
        10 CPTR  USAGE POINTER.
        10 ALPHA-NUM-THREE PIC X(5).
```

In the above example, APTR is a pointer data item. The 77-level item, therefore, is placed on a 16-byte boundary. The group item AB is an 01-level item and is automatically placed on a 16-byte boundary. Within the group item AB, BPTR is not on a 16-byte boundary. To align it properly, the compiler inserts a 6-byte FILLER item after ALPHA-NUM. Finally, CPTR requires a FILLER of 2 bytes to align its first occurrence. Because ALPHA-NUM-THREE is only 5 bytes long, another 11-byte FILLER must be added to the end of ARRAY-1 to align all subsequent occurrences of CPTR.

When a pointer is defined in the File Section, and a file does not have blocking in effect, each 01-level item will be on a 16-byte boundary. If a file has blocking in effect, only the first record of a block is guaranteed to be on a 16-byte boundary.

Thus pointers should not be defined for files with blocking in effect. For more information on blocking, refer to "Unblocking Input Records and Blocking Output Records" on page 391.

Redefining Pointers

A pointer data item or procedure-pointer data item may be the subject or object of a REDEFINES clause.

When a pointer is the subject of a REDEFINES clause, the object data item must be on a 16-byte boundary. For example:

```
WORKING-STORAGE SECTION.
 01  AB.
     05 ALPHA-NUM PIC X(16).
     05 APTR REDEFINES ALPHA-NUM USAGE POINTER.
     05 BPTR  USAGE POINTER.
     05 CPTR REDEFINES BPTR USAGE POINTER.
```

In the above example, both APTR and CPTR are pointer data items that redefine 16-byte aligned items. In the following example, the redefined item would result in a severe compiler error:

```
WORKING-STORAGE SECTION.
 01  EF.
     05 ALPHA-NUM PIC X(5).
     05 HI.
        10 ALPHA-NUM-TWO PIC X(11).
        10 APTR  USAGE POINTER.
     05 BPTR REDEFINES HI USAGE POINTER.
```

In the above example, APTR is aligned on a 16-byte boundary. That is, the ILE COBOL compiler did not need to add FILLER items to align APTR. The group item HI is not on a 16-byte boundary, and so neither is pointer data item BPTR. Because the ILE COBOL compiler cannot add FILLER items to place BPTR on a 16-byte boundary, a severe error will result.

In the following example, similar to the above, the ILE COBOL compiler is able to place the pointer data item on a 16-byte boundary:

```
WORKING-STORAGE SECTION.
 01  EF.
     05 ALPHA-NUM PIC X(5).
     05 HI.
        10 ALPHA-NUM-TWO PIC X(11).
        10 APTR  USAGE POINTER.
        10 ALPHA-NUM-THREE PIC X(5).
     05 KL REDEFINES HI.
        10 BPTR USAGE POINTER.
```

In the above example, group item KL is not on a 16-byte boundary; however, the compiler adds an 11-byte FILLER before pointer data item BPTR to ensure that it falls on a 16-byte boundary.

Initializing Pointers Using the NULL Figurative Constant

The NULL figurative constant represents a value used to indicate that data items defined with USAGE IS POINTER, USAGE IS PROCEDURE-POINTER, ADDRESS OF, or the ADDRESS OF special register do not contain a valid address. For example:

```
WORKING-STORAGE SECTION.
 77 APTR  USAGE POINTER VALUE NULL.
PROCEDURE DIVISION.
    IF APTR = NULL THEN
       DISPLAY 'APTR IS NULL'
    END-IF.
```

In the above example, pointer APTR is set to NULL in the Working-Storage section. The comparison in the procedure division will be true and the display statement is executed.

On the AS/400 system, the initial value of a pointer data item or procedure-pointer data item with or without a VALUE clause of NULL, equals NULL.

Reading and Writing Pointers

Pointers can be defined in the File Section, and can be set and used as can any other Working-Storage pointer data items. There are, however, some restrictions:

- If a file has blocking in effect, only the first record of a block is guaranteed to be on a 16-byte boundary. Thus pointers should not be defined for files with blocking in effect.
- A record containing pointers can be written to a file; however, on subsequent reading of that record, the pointer data items and procedure-pointer data items equal NULL.

Using the LENGTH OF Special Register with Pointers

The LENGTH OF special register contains the number of bytes used by an identifier. It returns a value of 16 for a pointer data item or procedure-pointer data item.

You can use LENGTH OF in the Procedure Division anywhere a numeric data item having the same definition as the implied definition of the LENGTH OF special register is used; however, LENGTH OF cannot be used as a subscript or a receiving data item. LENGTH OF has the implicit definition:

```
USAGE IS BINARY, PICTURE 9(9)
```

The following example shows how you can use LENGTH OF with pointers:

```
WORKING-STORAGE SECTION.
 77  APTR  USAGE POINTER.
 01  AB.
     05  BPTR  USAGE PROCEDURE-POINTER.
     05  BVAR  PIC S9(3) PACKED-DECIMAL.
     05  CVAR  PIC S9(3) PACKED-DECIMAL.
PROCEDURE DIVISION.
     MOVE LENGTH OF AB TO BVAR.
     MOVE LENGTH OF BPTR TO CVAR.
```

In the above example, the length of group item AB is moved to variable BVAR. BVAR has a value of 20 because BPTR is 16 bytes long, and both variables BVAR and CVAR are 2 bytes long. CVAR receives a value of 16.

You can also use the LENGTH OF special register to set up data structures within user spaces, or to increment addresses received from another program. To see an example of a program that uses the LENGTH OF special register to define data structures within user spaces, refer to Figure 82 on page 319.

Setting the Address of Linkage Section Items

Generally, when one ILE COBOL program calls another, operands are passed from the calling ILE COBOL program to the called ILE COBOL program in the following manner:

- The calling program uses the CALL USING statement to pass operands to the called program, and
- The called program specifies the USING phrase in the Procedure Division header.

For each operand that is listed on the CALL USING statement in the calling ILE program, there must be a corresponding operand that is specified by the USING phrase in the Procedure Division of the called program.

When using the ADDRESS OF special register, you no longer need to ensure a one-to-one mapping between the USING phrases of the two programs. For those data items in the Linkage Section that are not specified in the USING phrase of the Procedure Division header, you can use a SET statement to specify the starting address of the data structure. Once the SET statement is run, the data item can be freely referred to since the address of the data item is already set. For an example of a SET statement used in this manner, refer to Figure 83 on page 320. In Figure 83 on page 320, **15** and **16** illustrates how the SET statement is used to set the starting address of the data structures *ls-header-record* and *ls-user-space* at the beginning of the user space.

Using ADDRESS OF and the ADDRESS OF Special Register

When you specify ADDRESS OF in an ILE COBOL program, the compiler determines whether to use the calculated address of a data item, referred to as ADDRESS OF, or the ADDRESS OF special register. The ADDRESS OF special register is the starting address of the data structure from which all calculated addresses are determined. Because the ADDRESS OF special register is the starting address of a structure, it must be an 01-level or 77-level data item. If you reference modify this data item, it is no longer the starting address of the data structure. It is a calculated address, or ADDRESS OF. If you are taking the ADDRESS OF an elementary item, and the ADDRESS OF the 01-level item has been set to NULL, a pointer exception (MCH3601) results.

You cannot use the calculated ADDRESS OF where an item can be changed. Only the ADDRESS OF special register can be changed. For example, in Figure 83 on page 320, the SET statement at **17** uses the ADDRESS OF special register because it is an 01-level item. At **18** , ADDRESS OF is used because, although it is an 01-level item, it is reference-modified.

Using Pointers in a MOVE Statement

Elementary pointers cannot be moved using the MOVE statement; a SET statement must be used; however, pointers are implicitly moved when they are part of a group item.

When compiling a MOVE statement, the ILE COBOL compiler generates code to maintain (a pointer MOVE) or not maintain (a non-pointer MOVE) pointers within a group item.

A pointer MOVE is done when all of the following conditions are met:

1. The source or receiver of a MOVE statement contains a pointer

2. Both of the items are at least 16 bytes long
3. The data items are properly aligned
4. The data items are alphanumeric or group items.

Of the conditions listed above, determining if two data items are properly aligned can be the most difficult.

Note: A pointer MOVE is slower than using the SET statement to move a pointer.

Items must be on the same offset relative to a 16-byte boundary for a pointer MOVE to occur. (A warning is issued if this is not true.)

The following example shows three data structures, and the results when a MOVE statement is issued:

```
WORKING-STORAGE SECTION.
  01  A.
      05  B      PIC X(10).
      05  C.
          10  D      PIC X(6).
          10  E      POINTER.
  01  A2.
      05  B2     PIC X(6).
      05  C2.
          10  D2     PIC X(10).
          10  E2     POINTER.
 01  A3.
     05  B3     PIC X(22).
     05  C3.
         10  D3     PIC X(10).
         10  E3     POINTER.
PROCEDURE DIVISION.
MOVE  A  to A2. 1
MOVE  A  to A3. 1
MOVE  C  to C2. 2
MOVE  C2 to C3. 3
```

Figure 81. Using Pointers in a MOVE Statement

1 This results in a pointer MOVE because the offset of each group item to be moved is zero. Pointer integrity is maintained.

2 This results in a non-pointer MOVE, because the offsets do not match. The offset of group item C is 10, and the offset of group item C2 is 6. Pointer integrity is not maintained.

3 This results in a pointer MOVE, because the offset of group item C2 is 6, and the offset of C3 relative to a 16-byte boundary is also 6. (When the offset is greater than 16, the offset relative to a 16-byte boundary is calculated by dividing the offset by 16. The remainder is the relative offset. In this case, the offset was 22, which, when divided by 16, leaves a remainder, or relative offset, of 6.) Pointer integrity is maintained.

If a group item contains a pointer, and the ILE COBOL compiler cannot determine the offset relative to a 16-byte boundary, the ILE COBOL compiler issues a warning message, and the pointer move is attempted. However, pointer integrity may not be maintained. The ILE COBOL compiler cannot determine the offset if the item is defined in the Linkage

Section, or if the item is reference-modified with an unknown starting position. You must ensure that pointer alignment is maintained, or a machine check error may result.

The ILE COBOL compiler places all 01-level and 77-level items on a 16-byte boundary whether or not they contain pointers.

Using Pointers in a CALL Statement

When a pointer data item or procedure-pointer data item is passed in a CALL statement, the item is treated as all other USING items. In other words, when a pointer data item is passed BY REFERENCE (or BY CONTENT), a pointer to the pointer data item (or copy of the pointer data item) is passed to the called program. When a pointer data item is passed BY VALUE the contents of the pointer data item is placed on the call stack. Procedure-pointer data items are passed similarly.

Special consideration must be given when a CALL statement with the BY CONTENT phrase is used to pass pointers and group items containing pointers. This is similar to the case of a MOVE statement. For a CALL...BY CONTENT, an implicit MOVE of an item is done to create it in a temporary area. To ensure pointer alignment on this pointer MOVE, the ILE COBOL compiler or run time must determine the offset of the BY CONTENT item relative to the 16-byte boundary. For the best performance, the BY CONTENT item should be coded in such a way that the ILE COBOL compiler can determine this offset.

The ILE COBOL run time has to determine the offset of an item relative to a 16-byte boundary when the BY CONTENT item is:
- Reference modified with an unknown starting position, or
- Defined in the Linkage Section.

When an operand is reference-modified, the offset is the reference modification starting position minus one, plus the operand's offset within the data structure. When an operand is in the Linkage Section, its offset can be determined from the calling program.

To avoid pointer alignment problems, pass items using BY REFERENCE.

Adjusting the Value of Pointers

The following example shows you how to adjust the value of a pointer by increasing it UP BY or decreasing it DOWN BY an integer value. This method of changing the value of a pointer can be useful when you are accessing items in a table that is referenced by a pointer data item.

```
WORKING-STORAGE SECTION.
 01 A.
    05 ARRAY-USER-INFO OCCURS 300 TIMES.
       10  USER-NAME PIC X(10).
       10  USER-ID   PIC 9(7).
    01 ARRAY-PTR USAGE IS POINTER.
LINKAGE SECTION.
01  USER-INFO.
    05 USER-NAME LIKE USER-NAME OF ARRAY-USER-INFO.
    05 USER-ID LIKE USER-ID OF ARRAY-USER-INFO.
PROCEDURE DIVISION.
      SET ARRAY-PTR TO ADDRESS OF ARRAY-USER-INFO(200). [1]
      SET ADDRESS OF USER-INFO TO ARRAY-PTR. [2]
```

```
SET ARRAY-PTR UP BY LENGTH OF USER-INFO. [3]
SET ADDRESS OF USER-INFO TO ARRAY-PTR. [4]
MOVE "NEW NAME" TO USER-NAME OF USER-INFO.[5]
```

Notes:

1. The first SET statement places the address of the 200th element of the ARRAY-USER-INFO array into the pointer ARRAY-PTR.
2. The second SET statement gives data item USER-INFO the same address as the 200th element of the ARRAY-USER-INFO array.
3. The third SET statement increments the address contained in pointer ARRAY-PTR by the length of one element of the array.
4. The fourth SET statement gives data item USER-INFO the same address as the 201st element of the ARRAY-USER-INFO array (in other words, up one element from the second SET statement).
5. This move is the same as:

   ```
   MOVE "NEW NAME" to USER-NAME OF ARRAY-USER-INFO (201).
   ```

For a complete definition of the SET statement, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Accessing User Spaces Using Pointers and APIs

The following example shows how you can use pointers to access user spaces and to chain records together.

POINTA is a program that reads customer names and addresses into a user space, and then displays the information in a list. The program assumes that the customer information exists in a file called POINTACU.

The customer address field is a variable-length field, to allow for lengthy addresses.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* THIS IS THE CUSTOMER INFORMATION FILE  - POINTACUST
     A
     A
     A          R FSCUST                    TEXT('CUSTOMER MASTER RECORD')
     A            FS_CUST_NO     8S00       TEXT('CUSTOMER NUMBER')
     A                                       ALIAS(FS_CUST_NUMBER)
     A            FS_CUST_NM     20         TEXT('CUSTOMER NAME')
     A                                       ALIAS(FS_CUST_NAME)
     A            FS_CUST_AD     100        TEXT('CUSTOMER ADDRESS')
     A                                       ALIAS(FS_CUST_ADDRESS)
     A                                       VARLEN
```

Figure 82. Example Using Pointers to Access User Spaces -- DDS

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL         CBLGUIDE/POINTA     ISERIES1   03/09/15 13:43:25        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         000100 PROCESS varchar  1
    1    000200 ID DIVISION.
         000300* This program reads in a file of variable length records
         000400*  into a user space.  It then shows the records on
         000500*  the display.
    2    000600 PROGRAM-ID. pointa.
    3    000700 ENVIRONMENT DIVISION.
    4    000800 CONFIGURATION SECTION.
    5    000900 SPECIAL-NAMES. CONSOLE IS CRT,
    7    001000                CRT STATUS IS ws-crt-status.  2
    8    001100 INPUT-OUTPUT SECTION.
    9    001200 FILE-CONTROL.
   10    001300     SELECT cust-file ASSIGN TO DATABASE-pointacu
   12    001400            ORGANIZATION IS SEQUENTIAL
   13    001500            FILE STATUS IS ws-file-status.
   14    001600 DATA DIVISION.
   15    001700 FILE SECTION.
   16    001800 FD  cust-file.
   17    001900 01  fs-cust-record.
         002000* copy in field names turning underscores to dashes
         002100*  and using alias names
         002200 COPY DDR-ALL-FORMATS-I OF pointacu.
   18   +000001       05  POINTACU-RECORD PIC X(130).                                    <-ALL-FMTS
        +000002*    I-O FORMAT:FSCUST     FROM FILE POINTACU   OF LIBRARY CBLGUIDE      <-ALL-FMTS
        +000003*                          CUSTOMER MASTER RECORD                        <-ALL-FMTS
   19   +000004       05  FSCUST        REDEFINES POINTACU-RECORD.                      <-ALL-FMTS
   20   +000005           06 FS-CUST-NUMBER        PIC S9(8).                          <-ALL-FMTS
        +000006*                 CUSTOMER NUMBER                                       <-ALL-FMTS
   21   +000007           06 FS-CUST-NAME          PIC X(20).                          <-ALL-FMTS
        +000008*                 CUSTOMER NAME                                         <-ALL-FMTS
   22   +000009           06 FS-CUST-ADDRESS.  3                                       <-ALL-FMTS
        +000010*                 (Variable length field)                               <-ALL-FMTS
   23   +000011                49 FS-CUST-ADDRESS-LENGTH                              <-ALL-FMTS
        +000012                                   PIC S9(4) COMP-4.                    <-ALL-FMTS
   24   +000013                49 FS-CUST-ADDRESS-DATA                                <-ALL-FMTS
        +000014                                   PIC X(100).                          <-ALL-FMTS
        +000015*                 CUSTOMER ADDRESS                                      <-ALL-FMTS
   25    002300 WORKING-STORAGE SECTION.
   26    002400 01  ws-file-status.
   27    002500     05 ws-file-status-1 PIC X.
   28    002600        88  ws-file-stat-good   VALUE "0".
   29    002700        88  ws-file-stat-at-end VALUE "1".
   30    002800     05 ws-file-status-2 PIC X.
   31    002900 01  ws-crt-status.  4
   32    003000     05 ws-status-1           PIC 9(2).
   33    003100        88 ws-status-1-ok       VALUE 0.
   34    003200        88 ws-status-1-func-key VALUE 1.
   35    003300        88 ws-status-1-error    VALUE 9.
   36    003400     05 ws-status-2           PIC 9(2).
   37    003500        88 ws-func-03           VALUE 3.
   38    003600        88 ws-func-07           VALUE 7.
   39    003700        88 ws-func-08           VALUE 8.
   40    003800     05 ws-status-3           PIC 9(2).
```

Figure 83. Example Using Pointers to Access User Spaces (Part 1 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/POINTA          ISERIES1   03/09/15 13:43:25        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   41     003900 01  ws-params.  5
   42     004000     05  ws-space-ptr         POINTER.  6
   43     004100     05  ws-space.
   44     004200       10  ws-space-name      PIC X(10) VALUE "MYSPACE".
   45     004300       10  ws-space-lib       PIC X(10) VALUE "QTEMP".
   46     004400     05  ws-attr              PIC X(10) VALUE "PF".
   47     004500     05  ws-init-size         PIC S9(5) VALUE 32000 BINARY.
   48     004600     05  ws-init-char         PIC X     VALUE SPACE.
   49     004700     05  ws-auth              PIC X(10) VALUE "*ALL".
   50     004800     05  ws-text              PIC X(50) VALUE
          004900                               "Customer Information Records".
   51     005000     05  ws-replace           PIC X(10) VALUE "*YES".
   52     005100     05  ws-err-data.  7
   53     005200         10 ws-input-l        PIC S9(6) BINARY VALUE 16.
   54     005300         10 ws-output-l       PIC S9(6) BINARY.
   55     005400         10 ws-exception-id   PIC X(7).
   56     005500         10 ws-reserved       PIC X(1).
          005600
   57     005700 77  ws-accept-data           PIC X   VALUE SPACE.
   58     005800   88 ws-acc-blank             VALUE SPACE.
   59     005900   88 ws-acc-create-space      VALUE "Y", "y".
   60     006000   88 ws-acc-use-prv-space     VALUE "N", "n".
   61     006100   88 ws-acc-delete-space      VALUE "Y", "y".
   62     006200   88 ws-acc-save-space        VALUE "N", "n".
          006300
   63     006400 77  ws-prog-indicator        PIC X   VALUE "G".
   64     006500   88  ws-prog-continue       VALUE "G".
   65     006600   88  ws-prog-end            VALUE "C".
   66     006700   88  ws-prog-loop           VALUE "L".
          006800
   67     006900 77  ws-line                  PIC 99.
          007000* error message line
   68     007100 77  ws-error-msg             PIC X(50) VALUE SPACES.
          007200* more address information indicator
   69     007300 77  ws-plus                  PIC X.
          007400* length of address information to display
   70     007500 77  ws-temp-size             PIC 9(2).
          007600
   71     007700 77  ws-current-rec           PIC S9(4) VALUE 1.
   72     007800 77  ws-old-rec               PIC S9(4) VALUE 1.
   73     007900 77  ws-old-space-ptr         POINTER.
          008000* max number of lines to display
   74     008100 77  ws-displayed-lines       PIC S99 VALUE 20.
          008200* line on which to start displaying records
   75     008300 77  ws-start-line            PIC S99 VALUE 5.
          008400* variables to create new record in space
   76     008500 77  ws-addr-inc              PIC S9(4) PACKED-DECIMAL.
   77     008600 77  ws-temp                  PIC S9(4) PACKED-DECIMAL.
   78     008700 77  ws-temp-2                PIC S9(4) PACKED-DECIMAL.
          008800* pointer to previous record
   79     008900 77  ws-cust-prev-ptr         POINTER VALUE NULL.
   80     009000 LINKAGE SECTION.
   81     009100 01 ls-header-record.  8
   82     009200    05  ls-hdr-cust-ptr            USAGE POINTER.
          009300* number of records read in from file
```

Figure 83. Example Using Pointers to Access User Spaces (Part 2 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/POINTA          ISERIES1   03/09/15 13:43:25        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   83     009400    05  ls-record-counter           PIC S9(3) BINARY.
   84     009500    05  FILLER                      PIC X(14).  9
   85     009600 01 ls-user-space.  10
   86     009700     05  ls-customer-rec.
          009800* pointer to previous customer record
   87     009900         10 ls-cust-prev-ptr        USAGE POINTER.
   88     010000         10 ls-cust-rec-length      PIC S9(4) BINARY.
   89     010100         10 ls-cust-name            PIC X(20).
   90     010200         10 ls-cust-number          PIC S9(8).
          010300* total length of this record including filler bytes
          010400*  to make sure next record on 16 byte boundary
   91     010500         10 ls-cust-address-length  PIC S9(4) BINARY.
   92     010600     05  ls-cust-address-data       PIC X(116).
          010700
          010800* Size of ls-user-space is 16 more than actually needed.
          010900* This allows the start address of the next record
          011000* to be established without exceeding the declared size.
          011100* The size is 16 bigger to allow for pointer alignment.
          011200
   93     011300 PROCEDURE DIVISION.
          011400* note no need for "USING" entry on PROC... DIV.
   94     011500 DECLARATIVES.
          011600 cust-file-para SECTION.
          011700     USE AFTER ERROR PROCEDURE ON cust-file.
          011800 cust-file-para-2.
   95     011900     MOVE "Error XX on file pointacu" TO ws-error-msg.
   96     012000     MOVE ws-file-status TO ws-error-msg(7:2).
          012100 END DECLARATIVES.
          012200
          012300 main-program section.
          012400 mainline.
          012500* keep reading initial display until entered data correct
   97     012600     SET ws-prog-loop TO TRUE.
   98     012700     PERFORM initial-display THRU read-initial-display
          012800         UNTIL NOT ws-prog-loop.
          012900* if want to continue with program and want to create
          013000*   customer information area, fill the space with
          013100*   records from the customer file
   99     013200     IF ws-prog-continue AND
          013300        ws-acc-create-space THEN
  100     013400       PERFORM read-customer-file
  101     013500       MOVE 1 TO ws-current-rec
          013600* set ptr to header record
  102     013700       SET ADDRESS OF ls-header-record TO ws-space-ptr
          013800* set to first customer record in space
  103     013900       SET ADDRESS OF ls-user-space TO ls-hdr-cust-ptr
          014000     END-IF.
  104     014100     IF ws-prog-continue THEN
  105     014200       PERFORM main-loop UNTIL ws-prog-end
          014300     END-IF.
          014400 end-program.
  106     014500     PERFORM clean-up.
  107     014600     STOP RUN.
          014700
          014800 initial-display.  11
```

Figure 83. Example Using Pointers to Access User Spaces (Part 3 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/POINTA          ISERIES1   03/09/15 13:43:25        Page      5
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  108     014900     DISPLAY "Create Customer Information Area" AT 0118 WITH
          015000                BLANK SCREEN REVERSE-VIDEO
          015100             "Create customer information area (Y/N)=>   <="
          015200                AT 1015
          015300             "F3=Exit" AT 2202.
  109     015400     IF ws-error-msg NOT = SPACES THEN
  110     015500       DISPLAY ws-error-msg at 2302 with beep highlight
  111     015600       MOVE SPACES TO ws-error-msg
          015700     END-IF.
          015800
          015900 read-initial-display.  12
  112     016000     ACCEPT ws-accept-data AT 1056 WITH REVERSE-VIDEO
          016100       ON EXCEPTION
  113     016200         IF ws-status-1-func-key THEN
  114     016300           IF ws-func-03 THEN
  115     016400             SET ws-prog-end TO TRUE
          016500           ELSE
  116     016600             MOVE "Invalid Function Key" TO ws-error-msg
          016700           END-IF
          016800         ELSE
  117     016900           MOVE "Unknown Error" TO ws-error-msg
          017000         END-IF
          017100       NOT ON EXCEPTION
  118     017200         IF ws-acc-create-space THEN
  119     017300           PERFORM create-space THRU set-space-ptrs
  120     017400           SET ws-prog-continue TO TRUE
          017500         ELSE
  121     017600           IF ws-acc-use-prv-space THEN
  122     017700             PERFORM get-space
  123     017800             IF ws-space-ptr = NULL
  124     017900               MOVE "No Customer Information Area" TO ws-error-msg
          018000             ELSE
  125     018100               PERFORM set-space-ptrs
  126     018200               SET ws-prog-continue TO TRUE
          018300             END-IF
          018400           ELSE
  127     018500             MOVE "Invalid Character Entered" TO ws-error-msg
          018600           END-IF
          018700         END-IF
          018800     END-ACCEPT.
          018900
          019000 create-space.
  128     019100     CALL "QUSCRTUS" USING ws-space, ws-attr, ws-init-size,  13
          019200                           ws-init-char, ws-auth, ws-text,
          019300                           ws-replace, ws-err-data.
          019400
          019500* checks for errors in creating the space could be added here
          019600
          019700 get-space.
  129     019800     CALL "QUSPTRUS" USING ws-space, ws-space-ptr, ws-err-data.  14
          019900
          020000 set-space-ptrs.
          020100* set header record to beginning of space
  130     020200     SET ADDRESS OF ls-header-record  15
          020300         ADDRESS OF ls-user-space  16
```

Figure 83. Example Using Pointers to Access User Spaces (Part 4 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/POINTA          ISERIES1   03/09/15 13:43:25        Page      6
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         020400          TO ws-space-ptr.
         020500* set first customer record after header record
  131    020600      SET ADDRESS OF ls-user-space TO  17
         020700          ADDRESS OF ls-user-space(LENGTH OF ls-header-record  18
         020800                                  + 1:1).
         020900* save ptr to first record in  header record
  132    021000      SET ls-hdr-cust-ptr TO ADDRESS OF ls-user-space.
         021100
         021200 delete-space.
  133    021300      CALL "QUSDLTUS" USING ws-space, ws-err-data.  19
         021400
         021500 read-customer-file.
         021600* read all records from customer file and move into space
  134    021700      OPEN INPUT cust-file.
  135    021800      IF ws-file-stat-good THEN
  136    021900        READ cust-file AT END CONTINUE
         022000        END-READ
  138    022100        PERFORM VARYING ls-record-counter FROM 1 BY 1
         022200              UNTIL not ws-file-stat-good
  139    022300          SET  ls-cust-prev-ptr  TO ws-cust-prev-ptr
         022400*  Move information from file into space
  140    022500          MOVE fs-cust-name      TO ls-cust-name
  141    022600          MOVE fs-cust-number    TO ls-cust-number
  142    022700          MOVE fs-cust-address-length  TO ls-cust-address-length
  143    022800          MOVE fs-cust-address-data(1:fs-cust-address-length)
         022900               TO ls-cust-address-data(1:ls-cust-address-length)
         023000*  Save ptr to current record
  144    023100          SET  ws-cust-prev-ptr  TO ADDRESS OF ls-user-space
         023200*  Make sure next record on 16 byte boundary
  145    023300          ADD LENGTH OF ls-customer-rec  20
         023400              ls-cust-address-length TO 1 GIVING ws-addr-inc
  146    023500          DIVIDE ws-addr-inc BY 16 GIVING ws-temp
         023600              REMAINDER ws-temp-2
  147    023700          SUBTRACT ws-temp-2 FROM 16 GIVING ws-temp
         023800*  Save total record length in user space
  148    023900          ADD ws-addr-inc TO ws-temp GIVING ls-cust-rec-length
  149    024000          SET ADDRESS OF ls-user-space
         024100           TO ADDRESS OF ls-user-space(ls-cust-rec-length + 1:1)
         024200*  Get next record from file
  150    024300          READ cust-file AT END CONTINUE
         024400          END-READ
         024500        END-PERFORM
         024600*  At the end of the loop have one more record than really
         024700*   have
  152    024800        SUBTRACT 1 FROM ls-record-counter
         024900      END-IF.
  153    025000      CLOSE cust-file.
         025100
         025200 main-loop.  21
         025300* write the records to the display until F3 entered
  154    025400      DISPLAY "Customer Information" AT 0124 WITH
         025500                 BLANK SCREEN REVERSE-VIDEO
         025600               "Cust     Customer Name        Customer"
         025700                  AT 0305
         025800               " Address"
```

Figure 83. Example Using Pointers to Access User Spaces (Part 5 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/POINTA          ISERIES1   03/09/15 13:43:25        Page      7
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         025900             "Number"   AT 0405
         026000             "F3=Exit" AT 2202.
         026100* if a pending error put on the display
  155    026200     IF ws-error-msg NOT = SPACES THEN
  156    026300       DISPLAY ws-error-msg at 2302 with beep highlight
  157    026400       MOVE SPACES TO ws-error-msg
         026500     END-IF.
         026600* if in the middle of the list put F7 on the display
  158    026700     IF ws-current-rec > 1 THEN   22
  159    026800       DISPLAY "F7=Back" AT 2240
         026900     END-IF.
         027000* save the current record
  160    027100     MOVE ws-current-rec TO ws-old-rec.
  161    027200     SET  ws-old-space-ptr TO ADDRESS OF ls-user-space.   23
         027300* move each record to the display
  162    027400     PERFORM VARYING ws-line FROM  ws-start-line BY 1
         027500         UNTIL ws-line > ws-displayed-lines or
         027600               ws-current-rec > ls-record-counter
         027700* if address is greater than display width show "+"
  163    027800         IF ls-cust-address-length > 40 THEN
  164    027900           MOVE "+" TO ws-plus
  165    028000           MOVE 40 TO ws-temp-size
         028100         ELSE
  166    028200           MOVE ls-cust-address-length TO ws-temp-size
  167    028300           MOVE SPACE TO ws-plus
         028400         END-IF
  168    028500         DISPLAY ls-cust-number at line ws-line column 5
         028600                 ls-cust-name ls-cust-address-data with
         028700                   size ws-temp-size ws-plus at line
         028800                   ws-line column 78
         028900* get next record in the space
  169    029000         ADD 1 TO ws-current-rec
  170    029100         SET ADDRESS OF ls-user-space
         029200          TO ADDRESS OF ls-user-space
         029300            (ls-cust-rec-length + 1:1)
         029400     END-PERFORM.
         029500* if can go forward put F8 on the display
  171    029600     IF ws-current-rec < ls-record-counter THEN   22
  172    029700       DISPLAY "F8=Forward" AT 2250
         029800     END-IF.
         029900* check to see if continue, exit, or get next records or
         030000*   previous records
  173    030100     SET ws-acc-blank to TRUE.
  174    030200     ACCEPT ws-accept-data WITH SECURE   24
         030300       ON EXCEPTION
  175    030400         IF ws-status-1-func-key THEN
  176    030500           IF ws-func-03 THEN
  177    030600             SET ws-prog-end TO TRUE
         030700           ELSE
  178    030800            IF ws-func-07 THEN
  179    030900             PERFORM back-screen
         031000            ELSE
  180    031100            IF ws-func-08 THEN
  181    031200             PERFORM forward-screen
         031300            ELSE
```

Figure 83. Example Using Pointers to Access User Spaces (Part 6 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/POINTA          ISERIES1   03/09/15 13:43:25        Page      8
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  182     031400             MOVE "Invalid Function Key" TO ws-error-msg
  183     031500             MOVE ws-old-rec TO ws-current-rec
  184     031600             SET ADDRESS OF ls-user-space TO ws-old-space-ptr
          031700            END-IF
          031800          END-IF
          031900        ELSE
  185     032000          MOVE "Unknown Error" TO ws-error-msg
  186     032100          MOVE ws-old-rec TO ws-current-rec
  187     032200          SET ADDRESS OF ls-user-space TO ws-old-space-ptr
          032300        END-IF
          032400      NOT ON EXCEPTION
  188     032500        MOVE ws-old-rec TO ws-current-rec
  189     032600        SET ADDRESS OF ls-user-space TO ws-old-space-ptr
          032700    END-ACCEPT.
          032800
          032900 clean-up.
          033000* do clean up for program
          033100* keep reading end display until entered data correct
  190     033200    SET ws-prog-loop to TRUE.
  191     033300    SET ws-acc-blank to TRUE.
  192     033400    PERFORM final-display THRU read-final-display   25
          033500        UNTIL NOT ws-prog-loop.
          033600
          033700 final-display.
  193     033800    DISPLAY "Delete Customer Information Area" AT 0118 WITH   26
          033900                BLANK SCREEN REVERSE-VIDEO
          034000             "Delete customer information area (Y/N)=>   <="
          034100                AT 1015
          034200             "F3=Exit" AT 2202.
  194     034300    IF ws-error-msg NOT = SPACES THEN
  195     034400      DISPLAY ws-error-msg at 2302 with beep highlight
  196     034500      MOVE SPACES TO ws-error-msg
          034600    END-IF.
          034700
          034800 read-final-display.
  197     034900    ACCEPT ws-accept-data AT 1056 WITH REVERSE-VIDEO
          035000      ON EXCEPTION
  198     035100        IF ws-status-1-func-key THEN
  199     035200          IF ws-func-03 THEN
  200     035300            SET ws-prog-end TO TRUE
          035400          ELSE
  201     035500            MOVE "Invalid Function Key" TO ws-error-msg
          035600          END-IF
          035700        ELSE
  202     035800          MOVE "Unknown Error" TO ws-error-msg
          035900        END-IF
          036000      NOT ON EXCEPTION
  203     036100        IF ws-acc-delete-space THEN
  204     036200          PERFORM delete-space
  205     036300          SET ws-prog-continue TO TRUE
          036400        ELSE
  206     036500          IF ws-acc-save-space THEN
  207     036600            SET ws-prog-continue TO TRUE
          036700          ELSE
  208     036800            MOVE "Invalid Character Entered" TO ws-error-msg
```

Figure 83. Example Using Pointers to Access User Spaces (Part 7 of 8)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/POINTA         ISERIES1   03/09/15 13:43:25       Page      9
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         036900           END-IF
         037000         END-IF
         037100     END-ACCEPT.
         037200
         037300 back-screen.  27
  209    037400     IF ws-old-rec <= 1 THEN
  210    037500       MOVE "Top of customer records" TO ws-error-msg
  211    037600       MOVE ws-old-rec TO ws-current-rec  28
  212    037700       SET ADDRESS OF ls-user-space TO ws-old-space-ptr
         037800     ELSE
  213    037900       MOVE ws-old-rec TO ws-current-rec  28
  214    038000       SET ADDRESS OF ls-user-space TO ws-old-space-ptr
  215    038100       PERFORM VARYING ws-line FROM ws-start-line BY 1
         038200         UNTIL ws-line > ws-displayed-lines or
         038300               ws-current-rec <= 1
         038400* Back up one record at a time
  216    038500         SET ws-cust-prev-ptr TO ls-cust-prev-ptr  29
  217    038600         SET ADDRESS OF ls-user-space TO ws-cust-prev-ptr
  218    038700         SUBTRACT 1 FROM ws-current-rec
         038800       END-PERFORM
         038900     END-IF.
         039000
         039100 forward-screen.  30
         039200* if current record greater or equal to the max records
         039300*   print error, have reached max records
  219    039400     IF ws-current-rec >= ls-record-counter
  220    039500       MOVE "No more customer records" TO ws-error-msg
  221    039600       MOVE ws-old-rec TO ws-current-rec
  222    039700       SET ADDRESS OF ls-user-space TO ws-old-space-ptr
         039800     ELSE
  223    039900       MOVE ws-current-rec TO ws-old-rec
  224    040000       SET ws-old-space-ptr TO ADDRESS OF ls-user-space
         040100     END-IF.
         040200
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 83. Example Using Pointers to Access User Spaces (Part 8 of 8)

2 CRT STATUS IS specifies a data name into which a status value is placed after the termination of an extended ACCEPT statement. In this example, the STATUS key value is used to determine which function key was pressed.

3 *fs-cust-address* is a variable-length field. To see meaningful names here rather than FILLER, specify *VARCHAR for the CVTOPT parameter of the CRTCBLMOD or CRTBNDCBL commands, or VARCHAR in the PROCESS statement, as shown in **1** . For more information about variable-length fields, refer to "Declaring Data Items Using SAA Data Types" on page 414.

4 CRT STATUS as mentioned in **2** is defined here.

5 The *ws-params* structure contains the parameters used when calling the APIs to access user spaces.

6 *ws-space-ptr* defines a pointer data item set by the API QUSPTRUS. This points to the beginning of the user space, and is used to set the addresses of items in the Linkage Section.

7 *ws-err-data* is the structure for the error parameter for the user space APIs. Note that the *ws-input-l* is zero, meaning that any exceptions are signalled to the program, and not passed in the error code parameter. For more information on error code parameters, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

8 The first data structure (*ls-header-record*) to be defined in the user space.

9 FILLER is used to maintain pointer alignment, because it makes *Is-header-record* a multiple of 16 bytes long.

10 The second data structure (*ls-user-space*) to be defined in the user space.

11 *initial-display* shows the Create Customer Information Area display.

12 *read-initial-display* reads the first display, and determines if the user chooses to continue or end the program. If the user continues the program by pressing Enter, then the program checks *ws-accept-data* to see if the customer information area is to be created.

13 QUSCRTUS is an API used to create user spaces.

14 QUSPTRUS is an API used to return a pointer to the beginning of a user space.

15 Maps the first data structure (*ls-header-record*) over the beginning of the user space.

16 Maps the second data structure (*ls-user-space*) over the beginning of the user space.

17 Uses ADDRESS OF special register

18 Uses ADDRESS OF, not the ADDRESS OF special register, because it is reference modified.

19 QUSDLTUS is an API used to delete a user space.

20 The following four arithmetic statements calculate the total length of each record, and ensure that each record is a multiple of 16 bytes in length.

21 *main-loop* puts up the Customer Information display.

22 These statements determine if the program should display function keys F7 and F8.

23 Saves a pointer to the first customer record on the display.

24 This ACCEPT statement waits for input from the Customer Information display. Based on the function key pressed, it calls the appropriate paragraph to display the next set of records (*forward-screen*), or the previous set of records (*back-screen*), or sets an indicator to end the routine if F3 is pressed.

25 The clean up routine displays the Delete Customer Information Area display until an appropriate key is pressed.

26 This statement puts up the Delete Customer Information Area display.

27 Each record contains a pointer to the previous customer record. The ADDRESS OF special register points to the current customer record. By changing the ADDRESS OF special register, the current customer record is changed.

back-screen moves the current record pointer backward one record at a time **29** , by moving the pointer to the previous customer record into the pointer to the current customer record (ADDRESS OF). Before moving backward one record at a time, the program sets the current customer record to the first record currently displayed **28** .

30 *forward-screen* sets *ws-old-space-ptr* (which points to the first record in the display) to point to the current record (which is after the last record displayed.)

A user space always begins on a 16-byte boundary, so the method illustrated here ensures that **all** records are aligned. *ls-cust-rec-length* is also used to chain the records together.

When you run POINTA, you see the following displays:

```
CMDSTR                          Start Commands
Select one of the following:
  Commands
     1. Start QSH                                                  QSH
     2. Start RPC Binder Daemon                                    RPCBIND
     4. Start AppDict Services/400                                 STRADS
     7. Start AFP Utilities                                        STRAFPU
     8. Start Advanced Print Function                              STRAPF

    10. Start BEST/1 Planner                                       STRBEST
    11. Start BGU                                                  STRBGU
    12. Start Calendar Service                                     STRCALSRV
    13. Start COBOL Debug                                          STRCBLDBG
    14. Start CICS/400                                             STRCICS
                                                                      More...
Selection or command
===>call pointa

F3=Exit   F4=Prompt   F9=Retrieve   F12=Cancel   F16=Major menu
(C) COPYRIGHT IBM CORP. 1980, 1998.
Output file POINTSCREE created in library HORNER.                          +
```

```
                 Create Customer Information Area


              Create customer information area (Y/N)=> y <=









 F3=Exit
```

```
                     Customer Information
  Cust     Customer Name        Customer  Address
  Number
  00000001 Bakery Unlimited     30 Bake Way, North York
  00000002 Window World         150 Eglinton Ave E., North York, Ontario
  00000003 Jons Clothes         101 Park St, North Bay, Ontario, Canada
  00000004 Pizza World          254 Main Street, Toronto, Ontario          +
  00000005 Marv's Auto Body     9 George St, Peterborough, Ontario, Cana   +
  00000006 Jack's Snacks        23 North St, Timmins, Ontario, Canada
  00000007 Video World          14 Robson St, Vancouver, B.C, Canada
  00000008 Pat's Daycare        8 Kingston Rd, Pickering, Ontario, Canad   +
  00000009 Mary's Pies          3 Front St, Toronto, Ontario, Canada
  00000010 Carol's Fashions     19 Spark St, Ottawa, Ontario, Canada
  00000011 Grey Optical         5 Lundy's Lane, Niagara Falls, Ont. Cana   +
  00000012 Fred's Forage        33 Dufferin St, Toronto, Ontario, Canada   +
  00000013 Dave's Trucking      15 Water St, Guelph, Ontario, Canada
  00000014 Doug's Music         101 Queen St. Toronto, Ontario, Canada     +
  00000015 Anytime Copiers      300 Warden Ave, Scarborough, Ontario, Ca   +
  00000016 Rosa's Ribs          440 Avenue Rd, Toronto, Ontario, Canada
F3=Exit                                      F8=Forward
```

```
                    Customer Information
  Cust     Customer Name        Customer  Address
  Number
  00000017 Picture It           33 Kingston Rd, Ajax, Ontario, Canada
  00000018 Paula's Flowers      144 Pape Ave, Toronto, Ontario, Canada
  00000019 Mom's Diapers        101 Ford St, Toronto, Ontario, Canada
  00000020 Chez Francois        1202 Rue Ste Anne, Montreal, PQ, Canada
  00000021 Vetements de Louise  892 Rue Sherbrooke, Montreal E, PQ, Cana   +
  00000022 Good Eats            355 Lake St, Port Hope, Ontario, Canada









F3=Exit                              F7=Back
```

```
                    Customer Information
  Cust     Customer Name        Customer  Address
  Number
  00000001 Bakery Unlimited     30 Bake Way, North York
  00000002 Window World         150 Eglinton Ave E., North York, Ontario
  00000003 Jons Clothes         101 Park St, North Bay, Ontario, Canada
  00000004 Pizza World          254 Main Street, Toronto, Ontario          +
  00000005 Marv's Auto Body     9 George St, Peterborough, Ontario, Cana   +
  00000006 Jack's Snacks        23 North St, Timmins, Ontario, Canada
  00000007 Video World          14 Robson St, Vancouver, B.C, Canada
  00000008 Pat's Daycare        8 Kingston Rd, Pickering, Ontario, Canad   +
  00000009 Mary's Pies          3 Front St, Toronto, Ontario, Canada
  00000010 Carol's Fashions     19 Spark St, Ottawa, Ontario, Canada
  00000011 Grey Optical         5 Lundy's Lane, Niagara Falls, Ont. Cana   +
  00000012 Fred's Forage        33 Dufferin St, Toronto, Ontario, Canada   +
  00000013 Dave's Trucking      15 Water St, Guelph, Ontario, Canada
  00000014 Doug's Music         101 Queen St. Toronto, Ontario, Canada     +
  00000015 Anytime Copiers      300 Warden Ave, Scarborough, Ontario, Ca   +
  00000016 Rosa's Ribs          440 Avenue Rd, Toronto, Ontario, Canada
F3=Exit                                        F8=Forward
```

```
                      Delete Customer Information Area


                  Delete customer information area (Y/N)=> y <=









F3=Exit
```

```
CMDSTR                          Start Commands
Select one of the following:
  Commands
     1. Start QSH                                                  QSH
     2. Start RPC Binder Daemon                                    RPCBIND
     4. Start AppDict Services/400                                 STRADS
     7. Start AFP Utilities                                        STRAFPU
     8. Start Advanced Print Function                              STRAPF
    10. Start BEST/1 Planner                                       STRBEST
    11. Start BGU                                                  STRBGU
    12. Start Calendar Service                                     STRCALSRV
    13. Start COBOL Debug                                          STRCBLDBG
    14. Start CICS/400                                             STRCICS
                                                                      More...
Selection or command
===> endcpyscn

F3=Exit   F4=Prompt   F9=Retrieve   F12=Cancel   F16=Major menu
(C) COPYRIGHT IBM CORP. 1980, 1998.
```

Processing a Chained List Using Pointers

A typical application for using pointer data items is in processing a chained list (a series of records where each one points to the next).

For this example, picture a chained list of data that is composed of individual salary records. Figure 84 shows one way to visualize how these records are linked in storage:

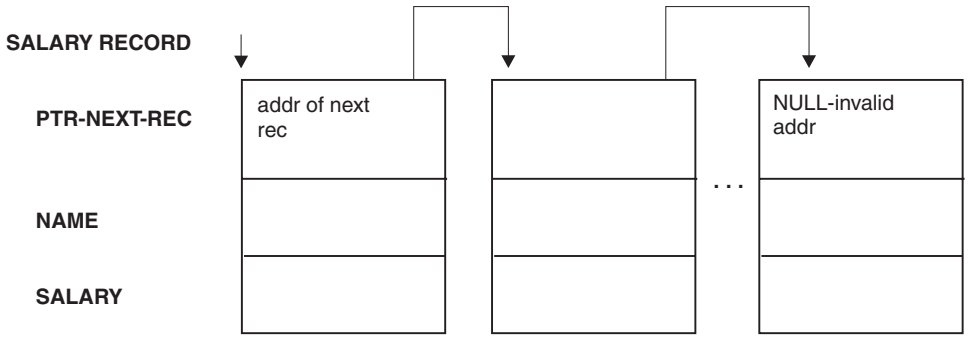

Figure 84. Representation of a Chained List Ending with NULL

The first item in each record (except for the last record) points to the next record. The first item in the last record, in order to indicate that it is the last record, contains a null value instead of an address.

The high-level logic of an application that processes these records might look something like this:

```
OBTAIN ADDRESS OF FIRST RECORD IN CHAINED LIST FROM ROUTINE
CHECK FOR END OF THE CHAINED LIST
DO UNTIL END OF THE CHAINED LIST
   PROCESS RECORD
   GO ON TO THE NEXT RECORD
END
```

Figure 85 on page 332 contains an outline of the processing program, CHAINLST, used in this example of processing a chained list.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/CHAINLST       ISERIES1   03/09/15 13:45:02       Page      2
                                Source
  STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
     1     000100 IDENTIFICATION DIVISION.
     2     000200 PROGRAM-ID. CHAINLST.
     3     000300 ENVIRONMENT DIVISION.
     4     000400 DATA DIVISION.
           000500*
     5     000600 WORKING-STORAGE SECTION.
     6     000700 77  PTR-FIRST         POINTER  VALUE IS NULL.
     7     000800 77  DEPT-TOTAL        PIC 9(4) VALUE IS 0.
           000900*
     8     001000 LINKAGE SECTION.
     9     001100 01  SALARY-REC.
    10     001200   05  PTR-NEXT-REC    POINTER.
    11     001300   05  NAME            PIC X(20).
    12     001400   05  DEPT            PIC 9(4).
    13     001500   05  SALARY          PIC 9(6).
    14     001600 01  DEPT-X            PIC 9(4).
           001700*
    15     001800 PROCEDURE DIVISION USING DEPT-X.
           001900 CHAINLST-PROGRAM SECTION.
           002000 MAINLINE.
           002100*
           002200* FOR EVERYONE IN THE DEPARTMENT RECEIVED AS DEPT-X,
           002300* GO THROUGH ALL OF THE RECORDS IN THE CHAINED LIST BASED ON THE
           002400* ADDRESS OBTAINED FROM THE PROGRAM CHAINANC
           002500* AND ACCUMULATE THE SALARIES.
           002600* IN EACH RECORD, PTR-NEXT-REC IS A POINTER TO THE NEXT RECORD
           002700* IN THE LIST; IN THE LAST RECORD, PTR-NEXT-REC IS NULL.
           002800* DISPLAY THE TOTAL.
           002900*
    16     003000     CALL "CHAINANC" USING PTR-FIRST
    17     003100     SET ADDRESS OF SALARY-REC TO PTR-FIRST
           003200*
    18     003300     PERFORM WITH TEST BEFORE UNTIL ADDRESS OF SALARY-REC = NULL
    19     003400        IF DEPT = DEPT-X THEN
    20     003500           ADD SALARY TO DEPT-TOTAL
           003600        END-IF
    21     003700        SET ADDRESS OF SALARY-REC TO PTR-NEXT-REC
           003800     END-PERFORM
           003900*
    22     004000     DISPLAY DEPT-TOTAL
    23     004100     GOBACK.
           004200
                          * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 85. ILE COBOL Program for Processing a Chained List

Passing Pointers between Programs and Procedures

To obtain the address of the first SALARY-REC record area, the CHAINLST program calls the program CHAINANC:

```
CALL "CHAINANC" USING PTR-FIRST
```

PTR-FIRST is defined in WORKING-STORAGE in the calling program (CHAINLST) as a pointer data item:

```
WORKING-STORAGE SECTION.
77  PTR-FIRST         POINTER  VALUE IS NULL.
```

Upon return from the call to CHAINANC, PTR-FIRST contains the address of the first record in the chained list.

PTR-FIRST is initially defined as having a null value as a logic check. If an error occurs with the call, and PTR-FIRST never receives the value of the address of the first record in the chain, a null value remains in PTR-FIRST and, according to the logic of the program, the records will not be processed.

NULL is a figurative constant used to assign the value of a non-valid address to pointer items. It can be used in the VALUE IS NULL clause, in the SET statement, and as an operand in a relation condition with a pointer.

The Linkage Section of the calling program contains the description of the records in the chained list. It also contains the description of the department code that is passed through the USING phrase of the CALL statement.

```
LINKAGE SECTION.
01  SALARY-REC.
  05  PTR-NEXT-REC    POINTER.
  05  NAME            PIC X(20).
  05  DEPT            PIC 9(4).
  05  SALARY          PIC 9(6).
01  DEPT-X            PIC 9(4).
```

To base the record description SALARY-REC on the address contained in PTR-FIRST, use a SET statement:

```
CALL "CHAINANC" USING PTR-FIRST
SET ADDRESS OF SALARY-REC TO PTR-FIRST
```

Check for the End of the Chained List

The chained list in this example is set up so that the last record contains an address that is not valid. To do this, the pointer data item in the last record would be assigned the value NULL.

A pointer data item can be assigned the value NULL in three ways:

- A pointer data item can be defined with a VALUE IS NULL clause in its data definition.
- NULL can be the sending field in a SET statement.
- The initial value of a pointer data item with or without a VALUE clause of NULL equals NULL.

In the case of a chained list in which the pointer in the last record contains a null value, the code to check for the end of the list would be:

```
IF PTR-NEXT-REC = NULL

⋮

(logic for end of chain)
```

If you have not reached the end of the list, process the record and move on to the next record.

In the program CHAINLST, this test for the end of the chained list is accomplished with a “do while” structure:

```
PERFORM WITH TEST BEFORE UNTIL ADDRESS OF SALARY-REC = NULL
 IF DEPT = DEPT-X
   THEN ADD SALARY TO DEPT-TOTAL
   ELSE CONTINUE
 END-IF
 SET ADDRESS OF SALARY-REC TO PTR-NEXT-REC
END-PERFORM
```

Processing the Next Record

To move on to the next record, set the address of the record in the Linkage Section to be equal to the address of the next record. This is accomplished through the pointer data item sent as the first field in SALARY-REC:

```
SET ADDRESS OF SALARY-REC TO PTR-NEXT-REC
```

Then repeat the record-processing routine, which will process the next record in the chained list.

Incrementing Addresses Received from Another Program

The data passed from a calling program might contain header information that you want to ignore (for example, in data received from a CICS/400® application that is not migrated to the command level).

Because pointer data items are not numeric, you cannot directly perform arithmetic on them. You can, however, use the SET verb to increment the passed address in order to bypass header information.

You could set up the Linkage Section as follows:

```
LINKAGE SECTION.
01  RECORD-A.
  05  HEADER          PIC X(16).
  05  REAL-SALARY-REC PIC X(30).

⋮

01  SALARY-REC.
  05  PTR-NEXT-REC    POINTER.
  05  NAME            PIC X(20).
  05  DEPT            PIC 9(4).
  05  SALARY          PIC 9(6).
```

Within the Procedure Division, base the address of SALARY-REC on the address of REAL-SALARY-REC:

```
SET ADDRESS OF SALARY-REC TO ADDRESS OF REAL-SALARY-REC
```

SALARY-REC is now based on the address of RECORD-A + 16.

Passing Entry Point Addresses with Procedure-Pointers

You can use procedure-pointer data items, defined with the USAGE IS PROCEDURE-POINTER clause, to pass the entry address of a program in a format required by certain ILE callable services.

For example, to have a user-written error handling routine take control when an exception condition occurs during program execution, you must first pass the entry address of an ILE procedure, such as an outermost ILE COBOL program, to CEEHDLR, a condition management ILE callable service, to have it registered.

Procedure-pointer data items can be set to contain the entry address for the following types of programs:

- An outermost ILE COBOL program
- An ILE procedure written in another ILE language
- An ILE program object or an OPM program object.

Note: A procedure-pointer data item cannot be set to the address of a nested ILE COBOL program.

A procedure-pointer data item can only be set using Format 6 of the SET statement.

For a complete definition of the USAGE IS PROCEDURE-POINTER clause and the SET statement, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Chapter 14. Preparing ILE COBOL Programs for Multithreading

In the iSeries environment, programs may run within the **threads** of processes. ILE COBOL supports multithreaded execution by means of the THREAD PROCESS statement option (see ""THREAD Option"" on page 56). In order to understand this chapter's discussion of ILE COBOL support for multithreading, you need to be familiar with the following terms:

Job On the iSeries system, a job represents a process. The operating system and multithreading applications can handle execution flow within a job. Multiple jobs can run concurrently, and programs running within a job can share resources. A job is the container for the memory and resources of the program.

Thread
Within a job, an application can initiate one or more threads. Within a thread, control is transferred between executing programs.

Run-unit
On the iSeries system, a run-unit represents the program activation group. A run unit can contain muliple threads. When a COBOL run-unit ends in a multithreaded environment, the job also ends. Within a run-unit, ILE COBOL programs can call non-ILE COBOL programs, and vice versa.

Program Invocation Instance
Within a thread, control is transferred between separate ILE COBOL and non-ILE COBOL programs. For example, an ILE COBOL program can CALL another ILE COBOL program or an ILE C program. Each separately invoked (as in, CALLed) program is a program invocation instance. Program invocation instances of a particular program might exist in multiple threads within a given job.

The following illustration shows the relationships between jobs, threads, run-units, and program invocation instances:

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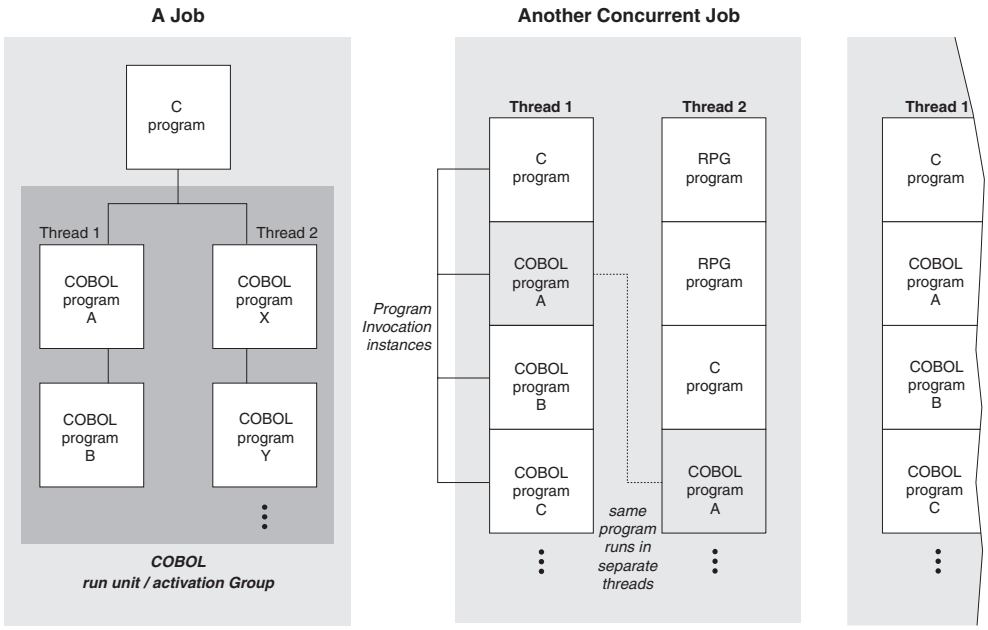

Figure 86. Schematic Illustration of Multithreading Concepts

ILE COBOL does not have a COBOL statement to support initiating or managing program threads, but COBOL programs can use APIs to do this. ILE COBOL programs can run in threads in a multithreaded environment. In other words, ILE COBOL programs can be invoked by other applications such that they are running in multiple threads within a job or as multiple program invocation instances within a thread.

The remainder of this chapter contains information that will help you prepare your ILE COBOL programs for multithreaded environments.

This chapter describes:
- How Language Elements Are Interpreted in a Multithreaded Environment
- When to Choose THREAD for Multithreading Support
- Control Transfer within a Multithreaded Environment
- An Example of Using ILE COBOL in a Multithreaded Environment.

How Language Elements Are Interpreted in a Multithreaded Environment

Because your ILE COBOL programs can be run as separate threads within a job, be aware that language elements might be interpreted in two ways:

Run-unit scope
: The language element persists for the duration of the ILE COBOL run-unit execution and is available to other programs within the thread.

Program invocation instance scope
: The language element persists only within a particular program invocation instance.

These two types of scope are important in two contexts:

Reference
Describes where an item can be referenced from. For example, if a data item has run-unit reference scope, any program invocation instance in the run unit can reference the data item.

State Describes how long an item persists in storage. For example, if a data item has program invocation instance state scope, it will remain in storage only while the program invocation instance is running.

The following table summarizes the reference and state scope of various ILE COBOL language elements:

Language Element	Reference Scope	State Scope
ADDRESS-OF special register	Same as associated record	Program invocation instance
DB-FORMAT-NAME special register	Run-unit	Program invocation instance
DEBUG-ITEM special register	Syntax checked only	
Files	Run-unit	Run-unit
FORMAT OF special register	Same as associated identifier	Same as associated identifier
Index data	Program	Program invocation instance
LENGTH OF special register	Same as associated identifier	Same as associated identifier
LINAGE-COUNTER special register	Same as associated file	Same as associated file
LINKAGE-SECTION data	Run-unit	Based on scope of underlying data
LOCALE OF special register	Same as associated identifier	Same as associated identifier
RETURN-CODE	Run-unit	Program invocation instance
WHEN-COMPILED special register	Run-unit	Run-unit
WORKING-STORAGE data	Run-unit	Run-unit
SORT-RETURN special register	Run-unit	Program invocation instance

Working with Run-Unit Scoped Elements

Run-unit scoped elements have storage that can be shared across modules. Examples of shared storage are:

- External and shared files
- External data items
- CALL BY REFERENCE between modules

Within a run unit, every module has a lock, and ILE COBOL ensures that only one copy of a module is running at a time in the run unit. If you have resources with run-unit scope, it is your responsibility to synchronize access to that data from multiple threads using logic in the application. You can do one or both of the following:

- Structure the application such that run-unit scoped resources are not accessed simultaneously from multiple threads.
- If you are going to access resources simultaneously from separate threads, synchronize access using facilities provided by C or by platform functions such as the Pthread mutex support or the MI built-in functions for creating and handling mutexes. For more information, refer to the to the Multithreaded Applications document, listed under the **Programming** topic, at the following URL:

  `http://www.as400.ibm.com/infocenter/`

Working with Program Invocation Instance Scoped Elements

With these language elements, storage is allocated for each individual program invocation instance. Therefore, even if a program is invoked multiple times among multiple threads, each time it is invoked it will be allocated separate storage. For example, if program X is invoked in two or more threads, each program invocation instance of X gets its own set of resources, such as storage.

Because the storage associated with these language elements is program invocation instance scoped, data is protected from access across threads and you do not have to concern yourself with access synchronization. However, this data cannot be shared between invocations of programs unless it is explicitly passed.

Choosing THREAD for Multithreading Support

Select SERIALIZE on the THREAD option of the PROCESS statement for multithreading support. Compiling with SERIALIZE prepares the ILE COBOL run-time environment for threading support. However, compiling with SERIALIZE may reduce program performance. You must compile all of the programs in the run unit with SERIALIZE; you cannot mix programs compiled with SERIALIZE and those compiled with NOTHREAD in one run unit.

The default option is THREAD(NOTHREAD). For more information about the THREAD PROCESS statement options, see ""THREAD Option"" on page 56.

Language Restrictions under THREAD

When THREAD(SERIALIZE) is in effect, the following language elements are not supported and are flagged by the compiler with a severe error message (of severity 30):

- ALTER statement
- GO TO statement without a procedure name
- INITIAL phrase in PROGRAM-ID paragraph
- STOP literal statement
- STOP RUN
- WITH DEBUGGING MODE clause

Use of DDM data areas is not allowed in a multithreaded environment.

It is recommended that you do not use UPSI switches in a multithreaded environment, since it is possible for one thread to set a switch and another thread to set it again before the first thread has checked it.

Control Transfer within a Multithreaded Environment

Be aware of the following control transfer issues when writing ILE COBOL programs for a multithreaded environment:

CALL and CANCEL

As is the case in single-threaded environments, a program invoked is in its initial state the first time it is called within a run unit and the first time it is called after a CANCEL to the CALLED program.

EXIT PROGRAM
EXIT PROGRAM returns to the caller of the program without terminating the thread in all cases. EXIT PROGRAM from a main program is treated as a comment.

GOBACK
Same as EXIT PROGRAM, except that GOBACK from a main program returns to the caller. This determination can be made if all ILE COBOL programs invoked within the run unit have returned to their invokers via GOBACK or EXIT PROGRAM.

Limitations on ILE COBOL in a Multithreaded Environment

Some ILE COBOL applications depend on subsystems or other applications. In a multithreaded environment, these dependencies result in some limitations on ILE COBOL programs:

SORT/MERGE
SORT and MERGE should only be active in one thread at a time. However, this is not enforced by the COBOL run-time environment— it must be controlled by the application.

External and shared files
External and shared files should not be accessed or updated simultaneously from multiple threads. However, this is not enforced by the COBOL run-time environment— it must be controlled by the application.

In general, synchronizing access to resources visible to an application within a run unit is the responsibility of the application.

Example of Using ILE COBOL in a Multithreaded Environment

This example consists of an ILE COBOL main procedure that creates two ILE COBOL threads, waits for the ILE COBOL threads to finish, then exits.

Sample Code for the Multithreading Example

The example has three code samples:

THRCBL QCBLLESRC
An ILE COBOL main procedure that creates the ILE COBOL threads, waits for them to finish, then exits.

SUBA QCBLLESRC
An ILE COBOL procedure that is called by the thread created by THRCBL.

SUBB QCBLLESRC
A second ILE COBOL procedure that is called by the thread created by THRCBL.

The sample code for THRCBL QCBLLESRC is shown in Figure 87 on page 342.

```
       PROCESS NOMONOPRC OPTIONS THREAD(SERIALIZE).
       IDENTIFICATION DIVISION.
       PROGRAM-ID. THRCBL.
       ENVIRONMENT DIVISION.
       CONFIGURATION SECTION.
         special-names.  system-console is oper1.
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01 pthread_attr_t typedef.
          05 FILLER PIC 9(8) usage binary occurs 4 times.
          05 FILLER USAGE POINTER.
       01 pthread_t typedef.
          05 FILLER USAGE POINTER.
          05 FILLER PIC 9(8) usage binary.
          05 FILLER PIC 9(8) usage binary.
          05 FILLER PIC 9(8) usage binary.
          05 FILLER PIC 9(8) usage binary.
          05 FILLER USAGE POINTER.
       01 PROC-SUBA-PTR USAGE PROCEDURE-POINTER.
       01 PROC-SUBB-PTR USAGE PROCEDURE-POINTER.
       01 attr type pthread_attr_t.
       01 rc PIC 9(8) usage binary value 0.
       01 group1.
          05 thread type pthread_t occurs 10 times.
       01 joinStatus0 USAGE POINTER.
       01 joinStatus1 USAGE POINTER.
       PROCEDURE DIVISION.
       TEST1-INIT.
           SET PROC-SUBA-PTR TO ENTRY PROCEDURE "SUBA".
           SET PROC-SUBB-PTR TO ENTRY PROCEDURE "SUBB".

      * Create a thread attributes object
           call procedure "pthread_attr_init" using attr
                          returning rc.

      * Define threads to be joinable
           call procedure "pthread_attr_setdetachstate" using attr
                          by value 0 size 4
                          returning rc.
```

Figure 87. Source code for THRCBL QCBLLESRC (Part 1 of 2)

```
* Start creating thread(s)
     call procedure "pthread_create" using thread(1) attr
                    by value PROC-SUBA-PTR omitted
                    returning rc.
     call procedure "pthread_create" using thread(2) attr
                    by value PROC-SUBB-PTR omitted
                    returning rc.
* Start joining thread(s)
     call procedure "pthread_join" using by value thread(1)
                     by reference joinStatus0
                     returning rc.
     call procedure "pthread_join" using by value thread(2)
                     by reference joinStatus1
                     returning rc.

* Destroy thread attributes object
     call procedure "pthread_attr_destroy" using attr
                     returning rc.
```

Figure 87. Source code for THRCBL QCBLLESRC (Part 2 of 2)

The sample code for SUBA QCBLLESRC is shown in Figure 88.

```
PROCESS NOMONOPRC OPTIONS THREAD(SERIALIZE).
IDENTIFICATION DIVISION.
PROGRAM-ID. SUBA.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
  special-names.  system-console is oper1.
DATA DIVISION.
WORKING-STORAGE SECTION.
01 one-line pic x(11).
PROCEDURE DIVISION.
TEST1-INIT.
    move "IN SUBA" TO ONE-LINE.
    DISPLAY one-line UPON oper1.
```

Figure 88. Source code for SUBA QCBLLESRC

The sample code for SUBB QCBLLESRC is shown in Figure 89

```
PROCESS NOMONOPRC OPTIONS THREAD(SERIALIZE).
IDENTIFICATION DIVISION.
PROGRAM-ID. SUBB.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
  special-names.  system-console is oper1.
DATA DIVISION.
WORKING-STORAGE SECTION.
01 one-line pic x(11).
PROCEDURE DIVISION.
TEST1-INIT.
    move "IN SUBB" TO ONE-LINE.
    DISPLAY one-line UPON oper1.
```

Figure 89. Source code for SUBB QCBLLESRC

Creating and Running the Multithreading Example

To create and run the multithreading example, follow these steps:

1. Create three ILE COBOL modules
   - To create the ILE COBOL module THRCBL, type

     ```
     CRTCBLMOD MODULE(THRCBL) SRCFILE(*CURLIB/QCBLLESRC) DBGVIEW(*ALL)
     ```
   - To create the ILE COBOL module SUBA, type

     ```
     CRTCBLMOD MODULE(SUBA) SRCFILE(*CURLIB/QCBLLESRC) DBGVIEW(*ALL)
     ```
   - To create the ILE COBOL module SUBB, type

     ```
     CRTCBLMOD MODULE(SUBB) SRCFILE(*CURLIB/QCBLLESRC) DBGVIEW(*ALL)
     ```
2. Create a program THREAD using the three modules
   - To create the THREAD program, type

     ```
     CRTPGM PGM(THREAD) MODULE(*CURLIB/THRCBL *CURLIB/SUBA *CURLIB/SUBB)
     ```
3. Create a SPAWN command to call the multithreaded program THREAD

   ```
   SPAWN MYLIB/THREAD DEBUG(2)
   ```

   For information on how to create a SPAWN command, refer to the Multithreaded Applications document, listed under the **Programming** topic, at the following URL: http://www.ibm.com/eserver/iseries/infocenter
4. To display the output of the program, type DSPMSG QSYSOPR. The output depends on which thread runs first and will show the sequence of the threads as:

   ```
   IN SUBB
   IN SUBA
   ```

   or as,

   ```
   IN SUBA
   IN SUBB
   ```

Chapter 15. ILE COBOL Error and Exception Handling

ILE COBOL contains special elements to help you anticipate and correct error conditions that can occur when your program is running. Even if your code is flawless, errors may occur in the system facilities that your program uses.

You can anticipate possible error conditions by putting code into your program to handle them. If error-handling code is not present in your program, your program could behave in a manner that you did not anticipate, data files could be corrupted, and incorrect output may be produced. Without error-handling code, you may not even be aware that a problem exists.

The action taken by your error-handling code can vary from attempting to cope with the situation and continue, to issuing a message, to halting the program. At a minimum, coding an error message to identify an error condition is a good idea.

When you run an ILE COBOL program, several types of errors can occur. The ILE COBOL statement active at the time of a given error causes certain ILE COBOL clauses or phrases to be run.

This chapter discusses how to:
- Use error-handling bindable APIs
- Initiate deliberate dumps
- Handle errors in string operations
- Handle errors in arithmetic operations
- Handle errors in input-output operations
- Handle errors in sort/merge operations
- Handle exceptions on the CALL statement
- Create user-written error-handling routines.

ILE Condition Handling

On the AS/400 system, there are several ways that programs can communicate status to one another. One of the main methods is to send an OS/400 message.

There are several type of OS/400 messages. These include inquiry, informational, completion, escape, and notify. For example, the final message sent by the ILE COBOL compiler when a compilation is successful is LNC0901,

```
Program program-name created in library library-name on date at time.
```

Message LNC0901 is a completion message. If a compilation fails, you will receive message LNC9001,

```
Compile failed.  Program-name not created.
```

Message LNC9001 is an escape message.

An ILE condition and an OS/400 message are quite similar. Any escape, status, notify, or function check message is a condition, and every ILE condition has an associated OS/400 message.

Like OS/400 messages, which can be handled by declaring and enabling a message monitor, an ILE condition can be handled by registering an **ILE condition handler**.

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An ILE condition handler allows you to register an exception handling procedure at run time that is given control when an exception occurs. To register an exception handler, use the Register a User-Written Condition Handler (CEEHDLR) bindable API.

When a program object or an ILE procedure is called, a new call stack entry is created. Associated with each call stack entry is a call message queue. This call message queue is a program message queue if a program object is called, or a procedure message queue if an ILE procedure is called. In ILE, you can send a message to a program object or ILE procedure by sending a message to its call stack entry.

Similarly, you can signal a condition to a program object or ILE procedure by signalling a condition to its call stack entry. You can signal a condition to a program object by using ILE bindable APIs. Refer to the section on ILE bindable APIs in *ILE Concepts* for a list of Condition Management bindable APIs.

Each call stack entry can have several ILE condition handlers registered. When multiple ILE condition handlers are registered for the same call stack entry, the system calls these handlers in last-in-first-out (LIFO) order. These ILE condition handlers can also be registered at different priority levels. Only a few of these priorities are available to ILE COBOL. There are approximately ten distinct priorities ranging from 85 to 225. ILE condition handlers are called in increasing priority order.

In ILE, if an exception condition is not handled at a particular call stack entry, the unhandled exception message is percolated to the previous call stack entry message queue. When this happens, exception processing continues at the previous call stack entry. Percolation of an unhandled exception condition continues until either a control boundary is reached or the exception message is handled. An unhandled exception message is converted to a function check when it is percolated to the control boundary.

The function check exception message can then be handled by the call stack entry that issued the original exception condition or it is percolated to the control boundary. If the function check is handled, normal processing continues and exception processing ends. If the function check is percolated to the control boundary, ILE considers the application to have ended with an unexpected error. The generic failure exception message, CEE9901, is sent by ILE to the caller of the control boundary.

When an exception condition occurs in a program object or an ILE procedure, it is first handled by the registered ILE condition handler for the call stack entry of the program object or ILE procedure. If there is no registered ILE condition handler for the call stack entry, then the exception condition is handled by HLL-specific error handlers. HLL-specific error handlers are language features defined for handling errors. HLL-specific error handling in ILE COBOL includes the USE declarative for I/O error handling and imperatives in statement-scoped condition phrases such as ON SIZE ERROR and INVALID KEY.

If the exception condition is not handled by the HHL-specific error handling, then the unhandled exception condition is percolated to the previous call stack entry message queue, as described above.

For more information on ILE condition handling, refer to the sections on error handling, and exception and condition management in the *ILE Concepts* book.

Ending an ILE COBOL Program

An ILE COBOL program can be ended by the following:

- A ILE COBOL statement (EXIT PROGRAM, STOP RUN, or GOBACK)
- A reply to an inquiry message
- An implicit STOP RUN or EXIT PROGRAM statement
- Another ILE language's equivalent of the ILE COBOL STOP RUN statement. For example, ILE C's `exit()` function.
- Another ILE language's equivalent of the ILE COBOL abnormal STOP RUN statement. For example, ILE C's `abort()` function.
- An escape message that is sent past the calling ILE COBOL program by the called ILE procedure or program object.
- Ending, by the called ILE procedure or program object, of the activation group in which the calling ILE COBOL program is running.

A STOP RUN statement is implied when a main ILE COBOL program has no next executable statement (implicit EXIT PROGRAM for a ILE COBOL subprogram), that is, when processing falls through the last statement of a program.

Inquiry messages can be issued in response to a ILE COBOL statement (namely a STOP literal), but they are usually issued when a severe error occurs in a program, or when a ILE COBOL operation does not complete successfully. (Examples are LNR7205, LNR7207, and LNR7208.) Inquiry messages allow you to determine what action to take after an exception error has occurred.

There are four common replies to a COBOL inquiry message: C, D, F, and G (cancel, cancel and dump, cancel and full dump, continue). The first three cause (as their final steps) an implicit abnormal STOP RUN.

An implicit or explicit STOP RUN statement, or a GOBACK statement in the main ILE COBOL program, causes the termination-imminent condition to be signalled to the nearest control boundary. The termination-imminent condition can be handled in two ways:

- Through a registered error handler before it reached the control boundary, or

  Note: To register an exception handler, use the Register a User-Written Condition Handler (CEEHDLR) bindable API. Refer to *ILE Concepts* for more information on exception handlers.
- If it reached the control boundary, then all programs after the control boundary are ended, and control returns to the program before the control boundary.

If this control boundary is a hard control boundary, then the activation group (run unit) will end.

If the STOP RUN is abnormal and a hard control boundary is reached, the CEE9901 escape message is issued to the program before the control boundary.

Using Error Handling Bindable Application Programming Interfaces (APIs)

There are two level at which errors can be handled in ILE COBOL. First, the condition handlers registered at each priority level have a chance to handle the condition. If the condition remains unhandled when the control boundary is reached, a function check condition is sent. Each ILE COBOL ILE procedure has an

ILE condition handler registered at priority level 205 to handle a function check. This function check condition handler will issue a COBOL inquiry message, unless handled by the following bindable APIs:

- Retrieve COBOL Error Handler (QlnRtvCobolErrorHandler)

  The Retrieve COBOL Error Handler (QlnRtvCobolErrorHandler) API allows you to retrieve the name of the current ILE COBOL error-handling procedure for the activation group from which the API is called.
- Set COBOL Error Handler (QlnSetCobolErrorHandler)

  The Set COBOL Error Handler (QlnSetCobolErrorHandler) API allows you to specify the identity of an ILE COBOL error-handling procedure for the activation group from which the API is called.

These APIs only affect exception handling within ILE COBOL programs. For detailed information on all of these APIs, refer to the section about COBOL APIs in the *CL and APIs* section of the *Programming* category in the **iSeries Information Center** at this Web site -http://www.ibm.com/eserver/iseries/infocenter.

Note: The *NOMONOPRC value must be specified on the OPTION parameter of the CRTCBLMOD or CRTBNDCBL commands in order to use these APIs.

Initiating Deliberate Dumps

You can use the Dump COBOL (QlnDumpCobol) bindable API to deliberately cause a formatted dump of an ILE COBOL program. The QlnDumpCobol API accepts six parameters which define the:

- Program object name
- Library name
- Module object name
- Program object type
- Dump type
- Error code.

The following are some examples of how to call the QlnDumpCobol API and the resultant operations:

```
WORKING-STORAGE SECTION.
01  ERROR-CODE.
    05  BYTES-PROVIDED     PIC S9(6)  BINARY VALUE ZERO.
    05  BYTES-AVAILABLE    PIC S9(6)  BINARY VALUE ZERO.
    05  EXCEPTION-ID       PIC X(7).
    05  RESERVED-X         PIC X.
    05  EXCEPTION-DATA     PIC X(64).
01  PROGRAM-NAME           PIC X(10).
01  LIBRARY-NAME           PIC X(10).
01  MODULE-NAME            PIC X(10).
01  PROGRAM-TYPE           PIC X(10).
01  DUMP-TYPE              PIC X.
PROCEDURE DIVISION.
    MOVE LENGTH OF ERROR-CODE  TO BYTES-PROVIDED.
    MOVE "MYPROGRAM"           TO PROGRAM-NAME.
    MOVE "TESTLIB"             TO LIBRARY-NAME.
    MOVE "MYMOD1"              TO MODULE-NAME.
    MOVE "*PGM"                TO PROGRAM-TYPE.
    MOVE "D"                   TO DUMP-TYPE.
    CALL PROCEDURE "QlnDumpCobol"  USING PROGRAM-NAME,
                                         LIBRARY-NAME, MODULE-NAME,
                                         PROGRAM-TYPE, DUMP-TYPE,
                                         ERROR-CODE.
```

This would provide a formatted dump of COBOL identifiers (option D) for the module object MYMOD1 in program object MYPROGRAM in library TESTLIB.

```
WORKING-STORAGE SECTION.
01  ERROR-CODE.
    05  BYTES-PROVIDED     PIC S9(6)  BINARY VALUE ZERO.
    05  BYTES-AVAILABLE    PIC S9(6)  BINARY VALUE ZERO.
    05  EXCEPTION-ID       PIC X(7).
    05  RESERVED-X         PIC X.
    05  EXCEPTION-DATA     PIC X(64).
01  PROGRAM-NAME           PIC X(10).
01  LIBRARY-NAME           PIC X(10).
01  MODULE-NAME            PIC X(10).
01  PROGRAM-TYPE           PIC X(10).
01  DUMP-TYPE              PIC X.
PROCEDURE DIVISION.
    MOVE LENGTH OF ERROR-CODE  TO BYTES-PROVIDED.
    MOVE "*SRVPGM"             TO PROGRAM-TYPE.
    MOVE "F"                   TO DUMP-TYPE.
    CALL PROCEDURE "QlnDumpCobol"  USING OMITTED, OMITTED,
                                         OMITTED, PROGRAM-TYPE,
                                         DUMP-TYPE, ERROR-CODE.
```

This would provide a formatted dump of COBOL identifiers and file related information (option F) for the service program that called the QlnDumpCobol API.

If any of the input parameters to the QlnDumpCobol API contain data that is not valid, the dump is not performed and an error message is generated or exception data is returned. An error message is generated if the BYTES-PROVIDED field contains zero. If the BYTES-PROVIDED field contains a value other than zero, then exception data is returned in the ERROR-CODE parameter and no error message is generated.

For detailed information on the QlnDumpCobol API, refer to the section about COBOL APIs in the *CL and APIs* section of the *Programming* category in the **iSeries Information Center** at this Web site
-http://www.ibm.com/eserver/iseries/infocenter.

Program Status Structure

The program status structure is a predefined structure containing subfields that provide you with error information when an error occurs in your program. You access these subfields by using the PROGRAM STATUS clause to specify the data item(s) that will receive the error information. Refer to the *WebSphere Development Studio: ILE COBOL Reference* for details on the program status structure and the PROGRAM STATUS clause.

Handling Errors in String Operations

When stringing or unstringing data, an error might occur. Both the STRING and UNSTRING statements provide an ON OVERFLOW phrase to handle typical string overflow error conditions. For the STRING statement, the ON OVERFLOW phrase will be run when the implicit or explicit pointer value is:

- Less than 1
- Greater than the length of the receiving field.

For the UNSTRING statement, the ON OVERFLOW phrase will be run when:

- The implicit or explicit pointer value is less than 1
- The implicit or explicit pointer value is greater than the length of the sending field

- All receiving fields have been acted upon, and the sending field still contains unexamined characters.

Any other error conditions not handled by the ON OVERFLOW phrase will generally result in MCH messages. Such messages will typically be handled by the function check condition handler. To prevent the function check condition handler from being called, you can register your own condition handler, using the CEEHDLR API, to catch the MCH messages.

You use the ON OVERFLOW phrase of the STRING or UNSTRING statement to identify the error-handling steps that you want to perform when an overflow condition occurs. If you do not have an ON OVERFLOW clause on the STRING or UNSTRING statement, control passes to the next sequential statement, and you are not notified of the incomplete operation.

Refer to the STRING and UNSTRING statements in the *WebSphere Development Studio: ILE COBOL Reference* for further information about the ON OVERFLOW phrase.

Handling Errors in Arithmetic Operations

Arithmetic operations can cause certain typical errors to occur. These typical errors generally result in MCH messages.

The ON SIZE ERROR Phrase

The ON SIZE ERROR phrase of the ADD, SUBTRACT, MULTIPLY, DIVIDE, and COMPUTE statement will:

- Enable binary and decimal overflow messages to be issued. The binary and decimal overflow message is MCH1210. The decimal division by zero message is MCH1211.
- Register a condition handler to catch the binary, decimal, and floating-point overflow messages, as well as other arithmetic MCH messages. Floating-point overflow messages include MCH1206 (overflow) and MCH1207 (underflow).

  Unlike binary and decimal overflow messages, floating-point overflow is not enabled by the existence of an ON SIZE ERROR phrase. Floating-point overflow is enabled or disabled at the job level. By default, floating-point overflow messages are always issued. Thus, ILE COBOL will ignore these messages, except when an ON SIZE ERROR phrase is coded. To enable or disable floating-point overflow, see the section “Handling Errors in Floating-Point Computations” on page 351.

ILE COBOL registers the above mentioned condition handler at priority level 85. A user condition handler, which is registered at priority level 165, will only receive control if the above mentioned condition handler does not handle the exception.

When no ON SIZE ERROR phrase is coded, the binary and decimal overflow messages will not be issued, and floating-point overflow messages will be ignored. All other arithmetic MCH messages will typically be handled by the function check condition handler unless a user condition handler has been registered using the CEEHDLR API.

A size error condition occurs in the following situations:

- The result of the arithmetic operation is larger than the fixed-point field that is to hold it

- Division by zero
- Zero raised to the zero power
- Zero raised to a negative number
- A negative number raised to a fractional power
- Floating-point overflow or underflow.

During arithmetic operations, typical errors are size errors (MCH1210) and decimal data errors (MCH1202). Most MCH errors are not directly detected by ILE COBOL; they are detected by the operating system and result in system messages. ILE COBOL then monitors for these messages, setting internal bits that determine whether to run a SIZE ERROR imperative statement or issue a runtime message (LNR7200) to end the program.

To prevent the LNR7200 message from being sent, a user condition handler can be registered using the CEEHDLR API to handle the MCH messages or an ILE COBOL error handler can be coded using the COBOL bindable APIs to handle the LNR72xx inquiry messages.

ILE COBOL does detect errors that result from division by zero during an arithmetic operation. If detected by ILE COBOL, these errors cause the SIZE ERROR imperative statement to run.

System message MCH1210 generally occurs when moving one binary or decimal numeric field to another, and the receiver is too small. This error is monitored by ILE COBOL, and also results in the running of the SIZE ERROR imperative statement.

LNR7200 is a run-time message that is usually issued when an unmonitored severe error occurs in your ILE COBOL program.

System message MCH1202 is a typical example of an unmonitored severe error. This kind of error results in the ILE COBOL run-time message LNR7200 (or LNR7204 if the error occurs in a program called by a ILE COBOL program). System messages MCH3601 and MCH0601 are other examples of unmonitored severe errors.

Handling Errors in Floating-Point Computations

OS/400 provides a group of Computation Attributes (CA) MI instructions to retrieve information about floating-point operations and to change the way floating-point operations behave. For example, the SETCA (Set Computational Attributes) MI instruction can prevent certain floating-point exceptions from occurring, as well as indicating whether or not rounding is done. By default, the result of a floating-point operation is *always* rounded, and all of the exceptions, except for Invalid Operand are signalled.

The exceptions that can be prevented are floating-point:

1. Overflow
2. Underflow
3. Zero divide
4. Inexact result
5. Invalid operand

For ON SIZE ERROR phrase handling, ILE COBOL requires that the first 3 exceptions must be signaled.

ILE COBOL also requires rounding to the nearest decimal position to take place, which means if you used the CA MI instructions to prevent rounding, the extra digits would be dropped, leaving you with an inexact result.

Handling Errors in Input-Output Operations

Error handling helps you during the processing of input-output statements by catching severe errors that might not otherwise be noticed. For input-output operations, there are several important error-handling phrases and clauses. These are as follows:

- AT END phrase
- INVALID KEY phrase
- NO DATA phrase
- USE AFTER EXCEPTION/ERROR declarative procedure
- FILE STATUS clause.

During input-output operations, errors are detected by the system, which sends messages; the messages are then monitored by ILE COBOL. As well, ILE COBOL will detect some errors during an input-output operation without system support. Regardless of how an error is detected during an input-output operation, the result will always be an internal file status of other than zero, a runtime message, or both.

An important characteristic of error handling is the issuing of a runtime message when an error occurs during the processing of an input-output statement if there is no AT END/INVALID KEY phrase in the input-output statement, USE AFTER EXCEPTION/ERROR procedure, or FILE STATUS clause in the SELECT statement for the file.

One thing to remember about input-output errors is that you choose whether or not your program will continue running after a less-than-severe input-output error occurs. ILE COBOL does not perform corrective action. If you choose to have your program continue (by incorporating error-handling code into your design), you must also code the appropriate error-recovery procedure.

Besides the error-handling phrases and clauses that specifically relate to input-output statements, user defined ILE condition handlers and ILE COBOL error handling APIs can also be used to handle I/O errors.

For each I/O statement, ILE COBOL registers a condition handler to catch the various I/O related conditions. These condition handlers are registered at priority level 185 which allows user defined condition handlers to receive control first.

As mentioned above, an ILE COBOL runtime message is issued when an error occurs and no appropriate AT END, INVALID KEY, USE procedure, or FILE STATUS clause exists for a file. The message, LNR7057, is an escape message. This message can be handled by a user-defined condition handler. If no condition handler can handle this message, message LNR7057 will be resent as a function check.

ILE COBOL has a function check condition handler that will eventually issue inquiry message LNR7207 unless an ILE COBOL error handling API has been defined.

Processing of Input-Output Verbs

The following diagram shows when the USE procedure and the (NOT) AT END, (NOT) INVALID KEY, and NO DATA imperative statements are run.

The file status shown here refers to the internal file status.

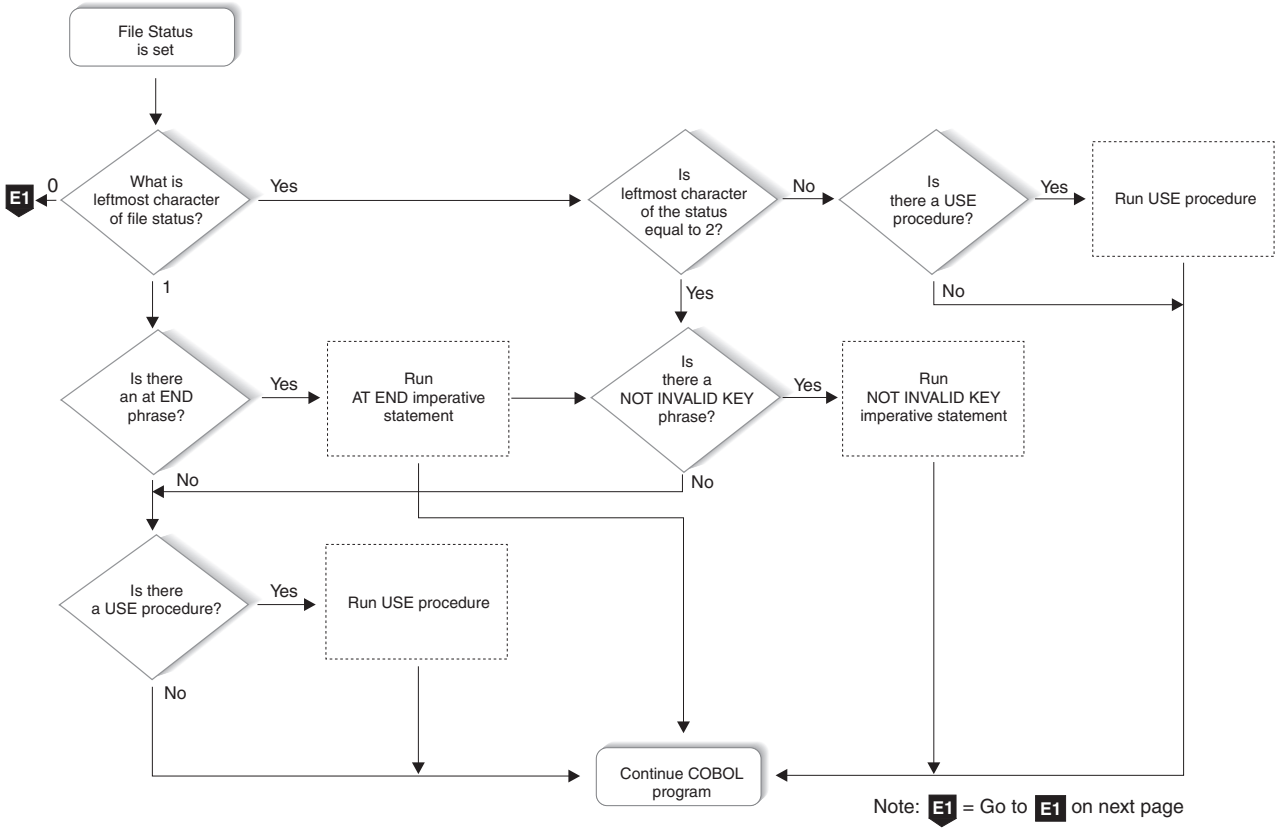

Figure 90. Processing of I/O Verbs (Part 1 of 2)

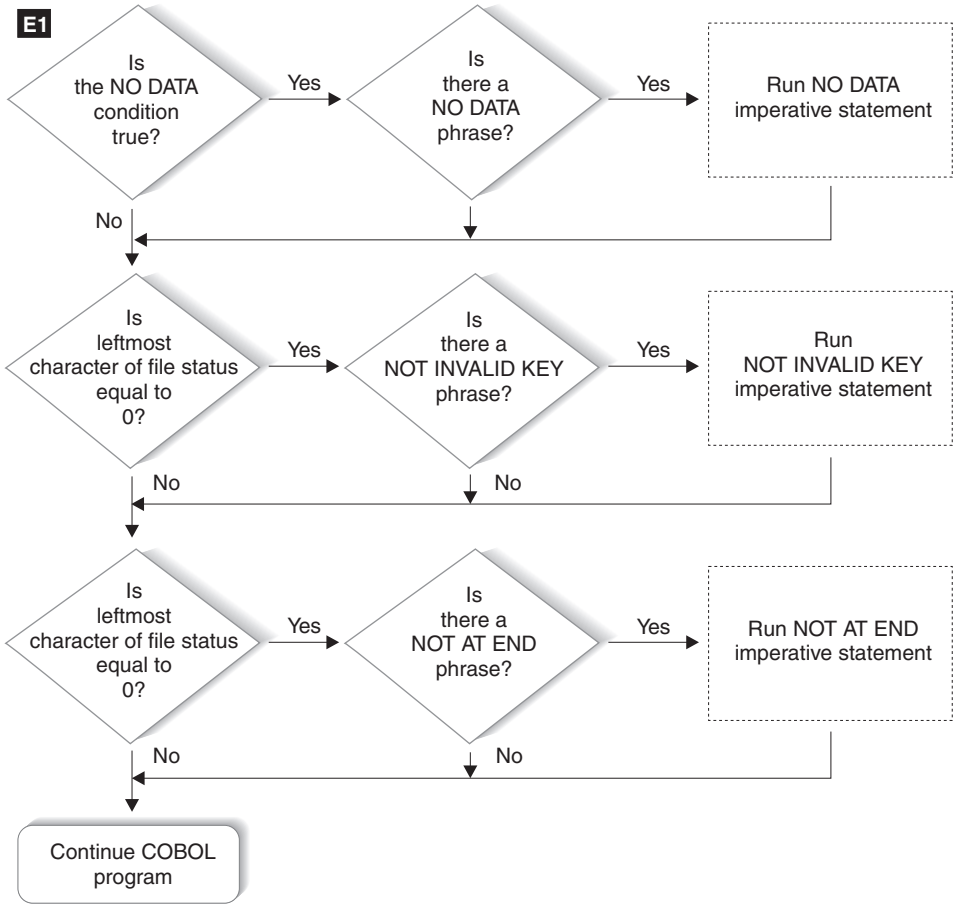

Figure 90. Processing of I/O Verbs (Part 2 of 2)

Note: Follow the parts of the diagram that apply to your statements.

Detecting End-of-File Conditions (AT END Phrase)

An end-of-file condition may or may not represent an error. In many designs, reading sequentially to the end of a file is done intentionally, and the AT END condition is expected.

In some cases, however, the end-of-file condition will reflect an error. You code the AT END phrase of the READ statement to handle either case, according you your program design.

If you code an AT END phrase, the imperative statement identified by the phrase is performed when an end-of-file condition occurs. If you do not code an AT END phrase, the associated USE AFTER EXCEPTION/ERROR declarative is performed.

Any NOT AT END phrase that you code is performed only if the READ statement completed successfully. If the READ operation fails because of any condition other than end-of-file, neither the AT END nor the NOT AT END phrase is performed. Instead, control passes to the end of the READ statement after performing the associated USE AFTER EXCEPTION/ERROR declarative procedure.

If you have coded neither an AT END phrase nor a USE AFTER EXCEPTION/ERROR declarative procedure, but you have coded a STATUS KEY clause for the file, control passes to the next sequential instruction after the

input-output statement that detected the end-of-file condition. At this point, your code should look at the status key and take some appropriate action to handle the error.

Detecting Invalid Key Conditions (INVALID KEY Phrase)

The imperative statement identified by the INVALID KEY phrase will be given control in the event that an input-output error occurs because of a faulty index key or relative key. You can include INVALID KEY phrases on READ, START, WRITE, REWRITE, and DELETE statements for indexed and relative files.

The INVALID KEY phrases differ from USE AFTER EXCEPTION/ERROR declaratives in these ways:

- INVALID KEY phrases operate for only limited types of errors, whereas the USE AFTER EXCEPTION/ERROR declarative encompasses most forms of errors.
- INVALID KEY phrases are coded directly onto the input-output verb, whereas the USE AFTER EXCEPTION/ERROR declaratives are coded separately.
- INVALID KEY phrases are specific to one single input-output operation, whereas the USE AFTER EXCEPTION/ERROR declaratives are more general.

If you specify the INVALID KEY phrase in an input-output statement that causes an invalid key condition, control is transferred to the imperative statement identified by the INVALID KEY phrase. In this case, any USE AFTER EXCEPTION/ERROR declaratives you have coded are not performed.

Any NOT INVALID KEY phrase that you specify is performed only if the statement completes successfully. If the operation fails because of any condition other than invalid key, neither the INVALID KEY nor NOT INVALID KEY phrase is performed. Instead, control passes to the end of the input-output statement after performing any associated USE AFTER EXCEPTION/ERROR declaratives.

Use the FILE STATUS clause in conjunction with the INVALID KEY phrase to evaluate the status key and determine the specific invalid key condition.

For example, assume you have a file containing master customer records and you need to update some of these records with information in a transaction update file. You will read each transaction record, find the corresponding record in the master file, and make the necessary updates. The records in both files each contain a field for a customer number, and each record in the master file has a unique customer number.

The FILE-CONTROL entry for the master file of commuter records includes statements defining indexed organization, random access, MASTER-COMMUTER-NUMBER as the prime record key, and COMMUTER-FILE-STATUS as the file status key. The following example illustrates how you can use the FILE STATUS clause in conjunction with the INVALID KEY phrase to more specifically determine the cause of an input-output statement failure.

```
.
. (read the update transaction record)
.
MOVE "TRUE" TO TRANSACTION-MATCH
MOVE UPDATE-COMMUTER-NUMBER TO MASTER-COMMUTER-NUMBER
READ MASTER-COMMUTER-FILE INTO WS-CUSTOMER-RECORD
   INVALID KEY
```

```
            DISPLAY "MASTER CUSTOMER RECORD NOT FOUND"
            DISPLAY "FILE STATUS CODE IS: " COMMUTER-FILE-STATUS
            MOVE "FALSE" TO TRANSACTION-MATCH
        END-READ
```

Using EXCEPTION/ERROR Declarative Procedures (USE Statement)

You can code one or more USE AFTER EXCEPTION/ERROR declarative procedures in your ILE COBOL program that will be given control if an input-output error occurs. You can have:

- Individual procedures for each file open mode (whether INPUT, OUTPUT, I-O, or EXTEND)
- Individual procedures for each particular file.
- Individual procedures for groups of files.

Place each such procedure in the declaratives section of the Procedure Division of your program. Refer to the *WebSphere Development Studio: ILE COBOL Reference* for details about how to write a declarative.

In your procedure, you can choose to attempt corrective action, retry the operation, continue, or end the program. Your can use the USE AFTER EXCEPTION/ERROR declarative procedure in combination with the status key if you want further analysis of the error.

For GLOBAL files, each ILE COBOL program can have its own USE AFTER EXCEPTION/ERROR declarative procedure.

USE AFTER EXCEPTION/ERROR declarative can themselves be declared GLOBAL. Special precedence rules are followed when multiple declaratives may be performed on an I/O error. In applying these rules, only the first qualifying declarative will be selected for execution. The declarative that is selected must satisfy the rules for execution of that declarative. The order of precedence for selecting a declarative is:

1. A file-specific declarative (one of the form USE AFTER ERROR ON *file-name-1*) within the program that contains the statement that caused the qualifying condition
2. A mode-specific declarative (one of the form USE AFTER ERROR ON INPUT) within the program that contains the statement that caused the qualifying condition
3. A file-specific declarative that specifies the GLOBAL phrase, and is within the program directly containing the program that was last examined for a qualifying condition
4. A mode-specific declarative that specifies the GLOBAL phrase, and is within the program directly containing the program that was last examined for a qualifying condition.
5. Rules 3 and 4 apply recursively back through the parents in the nest of programs.

Write a USE AFTER EXCEPTION/ERROR declarative procedure if you want to return control to your program after an error occurs. If you don't write such a procedure, your job may be cancelled or abnormally ended after an error occurs.

Each USE AFTER EXCEPTION/ERROR declarative procedure runs as a separate invocation from that of other declarative procedures and the non-declarative part of the same ILE COBOL program. Thus, if you call the CEEHDLR API to register

an ILE condition handler from a declarative procedure, that ILE condition handler is invoked only for exceptions that occur in the USE AFTER EXCEPTION/ERROR declarative procedure and not for exceptions that occur in any other part of the ILE COBOL program.

Determining the Type of Error Through the File Status Key

The file status key is updated after each input-output operation on a file by placing values in the two digits of the file status key. In general, a zero in the first digit indicates a successful operation, and a zero in both digits means ″nothing abnormal to report″.

You must provide a FILE-CONTROL entry to specify the organization and access method for each file used by your ILE COBOL program. You can also code a FILE STATUS clause in this entry.

The FILE STATUS clause designates one or two data items (coded in the WORKING-STORAGE section) to hold a copy of the result of an I/O operation. Your copy of the first of these items is called the external file status. If you use a TRANSACTION file, you have a further record of the result called the external return code, which consists of the external major and minor return codes.

ILE COBOL keeps its information corresponding to these two data items in the ILE COBOL File Field Descriptor (FFD). ILE COBOL's copies of these two data items are called the internal file status and internal return code. In this chapter, *file status* and (*major*/*minor*) *return code* refer to ILE COBOL's copies unless otherwise specified.

During the processing of an I/O statement, the file status can be updated in one of three ways, as described below. The contents of the file status determine which error handling procedures to run.

Error handling procedures take control after an unsuccessful input or output operation, which is denoted by a file status of other than zero. Before any of these procedures run, the file status is copied into the external file status.

The file status is set in one of three ways:

- Method A (all files):

  ILE COBOL checks the contents of variables in file control blocks. If the contents are not what is expected, a file status of other than zero is set. Most file statuses set in this way result from checking the ILE COBOL File Field Descriptor (FFD) and the system User File Control Block (UFCB).
- Method B (transaction files):

  ILE COBOL checks the major and minor return codes from the system. If the major return code is not zero, the return code (consisting of major and minor return codes) is translated into a file status. If the major return code is zero, the file status may have been set by Method A or C.

  For subfile READ, WRITE, and REWRITE operations, only Methods A and C apply.

  For a list of return codes and their corresponding file statuses, see "File Structure Support Summary and Status Key Values" in the *WebSphere Development Studio: ILE COBOL Reference*.
- Method C (all files):

A message is sent by the system when ILE COBOL calls data management to perform an I/O operation. ILE COBOL then monitors for these messages and sets a file status accordingly. Each ILE COBOL I/O operation is handled by a routine within a service program, which is supplied with the ILE COBOL compiler. This routine then calls data management to perform the I/O operation. In most cases, a single message monitor is enabled around these call to the routine in the service program.

The message monitor for each I/O operation handles typical I/O exceptions resulting in CPF messages that begin with `The message monitor sets the file status based on the CPF message that it receives`. For a list of messages that the message monitor handles, see "File Structure Support Summary and Status Key Values" in the *WebSphere Development Studio: ILE COBOL Reference*.

Through the use of message monitors in this fashion, file status is set consistently for each type of I/O operation regardless of what other types of I/O operations you have in your program. Refer to "Handling Messages through Condition Handlers" on page 360 for more information on message monitors.

MAP 0010: How File Status is Set

001

– Start the I/O operation.
– Reset the internal file status.
– Method A: Check the contents of the variables in the file control blocks. (Check, for example, that the file has been opened properly.)

Are the variables in the file control blocks set as expected?
Yes No

002

– Set internal file status to indicate that an error has occurred.
– Continue at Step 006

003

– Call on data management to perform the I/O operation.

Does data management return an exception?
Yes No

004

– Method A: Check the contents of the variables in the file control blocks.

Are the variables in the file control blocks set as expected?
Yes No

005

– Set internal file status to indicate that an error has occurred.
– Continue at Step 006

006

– Move internal file status to external file status (specified in file status clause).
– Based on internal file status, run the error handling code.

007

Is the file a transaction file?
Yes No

008

– Method C: Set the internal file status according to the CPF message sent by data management.
– Continue at Step 004

009

Are major and minor return codes available from the system?
Yes No

010

- Method C: Set the internal file status according to the CPF message sent by data management.
- Continue at Step 004 on page 359

011

- Method B: Set the internal file status based on the major and minor return codes available from the system.
- Continue at Step 004 on page 359

Interpreting Major and Minor Return Codes

When you specify a TRANSACTION file in your program, the FILE STATUS clause of your SELECT statement can contain two data names: the external file status, and the external (major and minor) return code. As described under "Determining the Type of Error Through the File Status Key" on page 357, a file status can be set in one of three ways; however, return codes are set by the system after any transaction I/O that calls data management. Consequently, most error conditions that result in a system message also have an associated return code.

Return codes are similar to file status values. That is, CPF messages sent by the system are grouped together by the ILE COBOL run time exception handler and each group of CPF messages is used to set one or more file statuses. Similarly, each major return code is also generated by a group of CPF messages. (The minor return code is not necessarily the same.) The main difference between file statuses and return codes is that the grouping of CPF messages is different.

Although ILE COBOL only sets return codes for TRANSACTION files, other types of files (such as printer files) also set return codes. You can access the return codes for these files through an ACCEPT from I-O-FEEDBACK operation.

Handling Messages through Condition Handlers

A condition handler provides a way for an ILE procedure or program object to handle messages sent by the system or by another ILE procedure or program object. A condition handler can handle one or more messages.

In some respects, a condition handler resembles a USE procedure. Similar to the way in which a USE procedure specifies actions to take in response to an I/O error, a condition handler specifies an action to take when an error occurs during the processing of a machine interface (MI) instruction. An MI instruction error is signalled by a system message, and each ILE COBOL statement is composed of one or more MI instructions.

There are two types of condition handlers:

- One type of condition handler is active for the entire program. These condition handlers are designed to handle generic error conditions.
- The other type of condition handler is active on a statement by statement basis. A typical use of these condition handlers would be to monitor I/O operations.

These condition handlers set file statuses and indicate SIZE ERROR, END-OF-PAGE, and OVERFLOW conditions.

Handling Errors in Sort/Merge Operations

You use the SORT-RETURN special register to detect errors in SORT or MERGE operations. The SORT-RETURN special register contains a return code indicating the success or failure of a SORT or MERGE operation. The SORT-RETURN special register contains a return code of 0 if the operation was successful or 16 if the operation was unsuccessful.

You can set the SORT-RETURN special register to 16 in an error declarative or input/output procedure to end a SORT/MERGE operation before all of the records have been processed. The operation ends before a record is returned or released.

The SORT-RETURN special register has the implicit definition:

```
01     SORT-RETURN  GLOBAL   PIC S9(4) USAGE BINARY VALUE ZERO.
```

When used in a nested program, the SORT-RETURN special register is implicitly defined as GLOBAL in the outermost ILE COBOL program.

Refer to the SORT and MERGE statements in the *WebSphere Development Studio: ILE COBOL Reference* for further information about the SORT-RETURN special register.

Handling Exceptions on the CALL Statement

An exception condition occurs on a CALL statement when the CALL operation itself fails. For example, the system may be out of storage or it may be unable to locate the called program. In this case, if you do not have an ON EXCEPTION or ON OVERFLOW clause on the CALL statement, your application may abnormally end. You use the ON EXCEPTION or ON OVERFLOW clause to detect the exception condition, prevent the abnormal end, and perform your own error-handling routine. For example:

```
CALL "REPORTA"
   IN LIBRARY "MYLIB"
      ON EXCEPTION
          DISPLAY "Program REPORTA not available."
END-CALL
```

If program REPORTA is unavailable or cannot be found in library MYLIB, control will continue with the ON EXCEPTION clause.

The ON EXCEPTION and ON OVERFLOW phrases handle only the exceptions that result from the failure of the CALL operation itself.

The ON EXCEPTION conditions that are signalled by the CALL operation are handled by a condition handler registered at priority 130. At this priority level, only conditions signalled to the specific call stack entry where the CALL statement exists will be handled. At this priority level, user written condition handlers may not get a chance to see signalled conditions.

If you do not have ON EXCEPTION and ON OVERFLOW phrases on the CALL statements in your application and the CALL statement fails, then the exception is handled by ILE condition handling. See “ILE Condition Handling” on page 345 for an overview of ILE condition handling.

User-Written Error Handling Routines

You can handle most error conditions that might occur when a program is running by using the ON EXCEPTION phrase, the ON SIZE ERROR phrase, and other ILE COBOL language semantics. But in the event of an extraordinary error condition like a machine check, ILE COBOL will issue an inquiry message to allow you to determine what action should be taken after a severe error has occurred.

However, ILE COBOL, in conjunction with ILE provides a mechanism, through user-written ILE condition handlers, whereby extraordinary error conditions can be handled prior to issuing an inquiry message. ILE condition handling gives you the opportunity to write your own error-handling routines to handle error conditions which can allow your program to continue running.

User-written condition handlers have priority level 165. This priority level enables user written condition handlers a chance to see signalled conditions before input-output condition handlers or ILE debugger condition handlers.

In order to have ILE pass control to your own user-written error-handling routine, you must first identify and register its entry point to ILE. To register an exception handler, you pass a procedure-pointer to the Register in a User-Written Condition Handler (CEEHDLR) bindable API. If you want to use an ILE COBOL program as an exception handler, only the outermost ILE COBOL program can be registered. Since ILE COBOL does not allow recursion for non recursive programs, if you register an ILE COBOL program as an exception handler, you must ensure that it can only be called once in an activation group, or that it is a recursive program.

Refer to *ILE Concepts* for more information on exception handlers.
Procedure-pointer data items allow you to pass the entry address of procedure entry points to ILE services. For more information on procedure-pointer data items, see "Passing Entry Point Addresses with Procedure-Pointers" on page 334. Any number of user-written condition handlers can be registered. If more than one user-written condition handler is registered, the handlers are given control in last-in-first-out (LIFO) order.

User-written condition handlers can also be unregistered with the Unregister a User-Written Condition Handler (CEEHDLU) API.

Common Exceptions and Some of Their Causes

MCH1202 Decimal data error:

- A numeric elementary item has been used as a source when no valid data has been previously stored in it. The item should have a VALUE clause, or a MOVE statement should be used to initialize its value.
- An attempt has been made to place nonnumeric data in a numeric item.
- Bad data was written to a subfile earlier in the program. The subfile data is not validated until it is written to the display, so the 1202 error can occur on the WRITE of a subfile control record, but the bad data was actually put to the subfile earlier.

MCH0601 Pointer exceptions:

- Part of a Linkage section item extended beyond the space allocated.

  For example, if you set the address of a Linkage Section item, and one or more of its elementary data items extend beyond the space with a MOVE to the elementary data item, MCH0601 is issued.

For more information on using pointers, refer to Chapter 13, "Using Pointers in an ILE COBOL Program," on page 311.

MCH0602 Pointer alignment:

- The pointer alignment in the Working-Storage Section of the calling program does not match the alignment in the Linkage Section of the called program. Alignment must be on a 16-byte boundary.

  For more information on using pointers, refer to Chapter 13, "Using Pointers in an ILE COBOL Program," on page 311.

MCH0603 Range check error:

- Either the subscript value is less than the lower bound of the array, or greater than the upper bound of the array, or the compound operand defined a character string outside the bounds of the base character string.

MCH3601 Pointer error:

- A reference is made to a record or a field within a record and the associated file has been closed or has never been opened.

  For example, the OPEN for the file was unsuccessful and the processing of any other I/O statement for that file is attempted. The file status should be checked before any other I/O is attempted.

CPF2415 End of requests:

- An attempt has been made to accept input from the job input stream while the system is running in batch mode and no input is available.

Recovery After a Failure

Some recovery can take place after a failure. Two areas in which such recovery can take place are:

- Recovery of files with commitment control
- TRANSACTION file recovery.

Recovery of Files with Commitment Control

When the system is restarted after a failure, files under commitment control are automatically restored to their status at the last commitment boundary. For additional information about commitment control, see "Using Commitment Control" on page 393.

Commitment control can be scoped at two levels, the activation group level and the job level. Refer to the section "Commitment Control Scoping" in *ILE Concepts* for further information.

If a job or activation group ends abnormally (either because of user or system error), files under commitment control are restored as part of job or activation group termination to the files' status at the last commitment boundary. The commitment control boundary is determined by the commitment control scope chosen for the program.

Because files under commitment control are rolled back after system or process failure, this feature can be used to help in restarting. You can create a separate record to store data that may be useful should it become necessary to restart a job. This restart data can include items such as totals, counters, record key values, relative key values, and other relevant processing information from an application.

If you keep the restart data mentioned above in a file under commitment control, the restart data will also be permanently stored in the database when a COMMIT statement is issued. When a ROLLBACK occurs after job or process failure, you can retrieve a record of the extent of processing successfully processed before failure. Note that the above method is only a suggested programming technique and will not always be suitable, depending on the application.

TRANSACTION File Recovery

In some cases, you can recover from I/O errors on TRANSACTION files without intervention by the operator, or the varying off/varying on of workstations or communications devices.

For potentially recoverable I/O errors on TRANSACTION files, the system initiates action in addition to the steps that must be taken in the application program to attempt error recovery. For more information about action taken by the system, see the *Communications Management*.

By examining the file status after an I/O operation, the application program can determine whether a recovery from an I/O error on the TRANSACTION file is possible. If the File Status Key has a value of 9N, the application program may be able to recover from the I/O error. A recovery procedure must be coded as part of the application program and varies depending on whether a single device was acquired by the TRANSACTION file or whether multiple devices were attached.

For a file with one acquired device:

1. Close the TRANSACTION file with the I/O error.
2. Reopen the file.
3. Process the steps necessary to retry the failing I/O operation. This may involve a number of steps, depending on the type of program device used. (For example, if the last I/O operation was a READ, you may have to repeat one or more WRITE statements, which were processed prior to the READ statement.) For more information on recovery procedures, see the *ICF Programming* manual.

For a display file with multiple devices acquired:

1. DROP the program device that caused the I/O error on the TRANSACTION file.
2. ACQUIRE the same program device.
3. See Step 3 above.

For an ICF file with multiple devices acquired:

1. ACQUIRE the same program device.
2. See Step 3 above.

For a display file with multiple devices acquired:

Application program recovery attempts should typically be tried only once.

If the recovery attempt fails:

- If the file has only one program device attached, terminate the program through processing of the STOP RUN, EXIT PROGRAM or GOBACK statement, and attempt to locate the source of the error.
- If the file has multiple acquired program devices, you may want to do one of the following:

- Continue processing without the program device that caused the I/O error on the TRANSACTION file, and reacquire the device later.
- End the program.

For a description of major and minor return codes that may help in diagnosing I/O errors on the TRANSACTION file, see the *ICF Programming* manual.

Figure 92 on page 366 gives an example of an error recovery procedure.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A*  DISPLAY FILE FOR ERROR RECOVERY EXAMPLE
     A*
     A                                      INDARA
     A          R FORMAT1                   CF01(01 'END OF PROGRAM')
     A*
     A                                  12 28'ENTER INPUT '
     A            INPUTFLD       5   I 12 42
     A                                  20 26'F1 - TERMINATE'
```

Figure 91. Example of Error Recovery Procedure -- DDS

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL          CBLGUIDE/RECOVERY      ISERIES1   03/09/15 13:48:21        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  RECOVERY.
    3     000300 ENVIRONMENT DIVISION.
    4     000400 CONFIGURATION SECTION.
    5     000500 SOURCE-COMPUTER. IBM-ISERIES.
    6     000600 OBJECT-COMPUTER. IBM-ISERIES.
    7     000700 INPUT-OUTPUT SECTION.
    8     000800 FILE-CONTROL.
    9     000900     SELECT RECOVFILE
   10     001000         ASSIGN TO WORKSTATION-RECVFILE-SI
   11     001100         ORGANIZATION IS TRANSACTION
   12     001200         ACCESS MODE IS SEQUENTIAL
   13     001300         FILE STATUS IS STATUS-FLD, STATUS-FLD-2
   14     001400         CONTROL-AREA IS CONTROL-FLD.
   15     001500     SELECT PRINTER-FILE
   16     001600         ASSIGN TO PRINTER-QPRINT.
          001700
   17     001800 DATA DIVISION.
   18     001900 FILE SECTION.
   19     002000 FD  RECOVFILE.
   20     002100 01  RECOV-REC.
          002200     COPY DDS-ALL-FORMATS OF RECVFILE.
   21    +000001       05  RECVFILE-RECORD PIC X(5).                                    <-ALL-FMTS
         +000002*  INPUT FORMAT:FORMAT1    FROM FILE RECVFILE   OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000003*                                                                      <-ALL-FMTS
   22    +000004       05  FORMAT1-I     REDEFINES RECVFILE-RECORD.                   <-ALL-FMTS
   23    +000005           06 INPUTFLD              PIC X(5).                          <-ALL-FMTS
         +000006* OUTPUT FORMAT:FORMAT1    FROM FILE RECVFILE   OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000007*                                                                      <-ALL-FMTS
         +000008*      05  FORMAT1-O     REDEFINES RECVFILE-RECORD.                   <-ALL-FMTS
          002300
   24     002400 FD  PRINTER-FILE.
   25     002500 01  PRINTER-REC.
   26     002600    05  PRINTER-RECORD            PIC X(132).
          002700
   27     002800 WORKING-STORAGE SECTION.
          002900
   28     003000 01  I-O-VERB                     PIC X(10).
   29     003100 01  STATUS-FLD                   PIC X(2).
   30     003200    88  NO-ERROR                    VALUE "00".
   31     003300    88  ACQUIRE-FAILED              VALUE "9H".
   32     003400    88  TEMPORARY-ERROR             VALUE "9N".
   33     003500 01  STATUS-FLD-2                 PIC X(4).
   34     003600 01  CONTROL-FLD.
   35     003700    05  FUNCTION-KEY              PIC X(2).
   36     003800    05  PGM-DEVICE-NAME           PIC X(10).
   37     003900    05  RECORD-FORMAT             PIC X(10).
   38     004000 01  END-INDICATOR                PIC 1   INDICATOR 1
          004100                                   VALUE B"0".
   39     004200    88  END-NOT-REQUESTED          VALUE B"0".
   40     004300    88  END-REQUESTED              VALUE B"1".
   41     004400 01  USE-PROC-FLAG                PIC 1
          004500                                   VALUE B"1".
```

Figure 92. Example of Error Recovery Procedure (Part 1 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL          CBLGUIDE/RECOVERY     ISERIES1   03/09/15 13:48:21        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   42     004600    88  USE-PROC-NOT-EXECUTED        VALUE B"0".
   43     004700    88  USE-PROC-EXECUTED            VALUE B"1".
   44     004800 01  RECOVERY-FLAG                PIC 1
          004900                                     VALUE B"0".
   45     005000    88  NO-RECOVERY-DONE             VALUE B"0".
   46     005100    88  RECOVERY-DONE                VALUE B"1".
   47     005200 01  HEADER-LINE.
   48     005300    05  FILLER                     PIC X(60)
          005400                                     VALUE SPACES.
   49     005500    05  FILLER                     PIC X(72)
          005600                                     VALUE "ERROR REPORT".
   50     005700 01  DETAIL-LINE.
   51     005800    05  FILLER                     PIC X(15)
          005900                                     VALUE SPACES.
   52     006000    05  DESCRIPTION                PIC X(25)
          006100                                     VALUE SPACES.
   53     006200    05  DETAIL-VALUE               PIC X(92)
          006300                                     VALUE SPACES.
   54     006400 01  MESSAGE-LINE.
   55     006500    05  FILLER                     PIC X(15)
          006600                                     VALUE SPACES.
   56     006700    05  DESCRIPTION                PIC X(117)
          006800                                     VALUE SPACES.
   57     006900 PROCEDURE DIVISION.
   58     007000 DECLARATIVES.
          007100 HANDLE-ERRORS SECTION.
          007200     USE AFTER STANDARD ERROR PROCEDURE ON RECOVFILE.  1
          007300 DISPLAY-ERROR.
   59     007400     SET USE-PROC-EXECUTED TO TRUE.
   60     007500     WRITE PRINTER-REC FROM HEADER-LINE
          007600          AFTER ADVANCING PAGE
          007700     END-WRITE
   61     007800     MOVE "ERROR OCCURED IN" TO DESCRIPTION OF DETAIL-LINE.
   62     007900     MOVE I-O-VERB TO DETAIL-VALUE OF DETAIL-LINE.
   63     008000     WRITE PRINTER-REC FROM DETAIL-LINE
          008100          AFTER ADVANCING 5 LINES
          008200     END-WRITE
   64     008300     MOVE "FILE STATUS =" TO DESCRIPTION OF DETAIL-LINE.
   65     008400     MOVE STATUS-FLD TO DETAIL-VALUE OF DETAIL-LINE.  2
   66     008500     WRITE PRINTER-REC FROM DETAIL-LINE
          008600          AFTER ADVANCING 2 LINES
          008700     END-WRITE
   67     008800     MOVE "EXTENDED FILE STATUS =" TO DESCRIPTION OF DETAIL-LINE.
   68     008900     MOVE STATUS-FLD-2 TO DETAIL-VALUE OF DETAIL-LINE.
   69     009000     WRITE PRINTER-REC FROM DETAIL-LINE
          009100          AFTER ADVANCING 2 LINES
          009200     END-WRITE
   70     009300     MOVE "CONTROL-AREA =" TO DESCRIPTION OF DETAIL-LINE.
   71     009400     MOVE CONTROL-FLD TO DETAIL-VALUE OF DETAIL-LINE.
   72     009500     WRITE PRINTER-REC FROM DETAIL-LINE
          009600          AFTER ADVANCING 2 LINES
          009700     END-WRITE.
          009800 CHECK-ERROR.
   73     009900     IF TEMPORARY-ERROR AND NO-RECOVERY-DONE THEN
   74     010000         MOVE "***ERROR RECOVERY BEING ATTEMPTED***"  3
```

Figure 92. Example of Error Recovery Procedure (Part 2 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/RECOVERY        ISERIES1   03/09/15 13:48:21        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         010100              TO  DESCRIPTION OF MESSAGE-LINE
   75    010200          WRITE PRINTER-REC FROM MESSAGE-LINE
         010300              AFTER ADVANCING 3 LINES
         010400          END-WRITE
   76    010500          SET RECOVERY-DONE TO TRUE
   77    010600          DROP PGM-DEVICE-NAME FROM RECOVFILE
   78    010700          ACQUIRE PGM-DEVICE-NAME FOR RECOVFILE  4
         010800      ELSE
   79    010900          IF RECOVERY-DONE THEN  5
   80    011000              MOVE "***ERROR AROSE FROM RETRY AFTER RECOVERY***"
         011100                  TO  DESCRIPTION OF MESSAGE-LINE
   81    011200              WRITE PRINTER-REC FROM MESSAGE-LINE
         011300                  AFTER ADVANCING 3 LINES
         011400              END-WRITE
   82    011500              MOVE "***PROGRAM ENDED***"
         011600                  TO  DESCRIPTION OF MESSAGE-LINE
   83    011700              WRITE PRINTER-REC FROM MESSAGE-LINE
         011800                  AFTER ADVANCING 2 LINES
         011900              END-WRITE
   84    012000                  CLOSE RECOVFILE
         012100                        PRINTER-FILE
   85    012200                  STOP RUN
         012300          ELSE
   86    012400              SET NO-RECOVERY-DONE TO TRUE
         012500          END-IF
         012600      END-IF
   87    012700      MOVE "***EXECUTION CONTINUES***"
         012800          TO DESCRIPTION OF MESSAGE-LINE.
   88    012900      WRITE PRINTER-REC FROM MESSAGE-LINE
         013000          AFTER ADVANCING 2 LINES
         013100      END-WRITE.
         013200 END DECLARATIVES.
         013300
         013400 MAIN-PROGRAM SECTION.
         013500 MAINLINE.
   89    013600      MOVE "OPEN" TO I-O-VERB.
   90    013700      OPEN I-O     RECOVFILE
         013800           OUTPUT  PRINTER-FILE.
   91    013900      PERFORM I-O-PARAGRAPH UNTIL END-REQUESTED.  6
   92    014000      CLOSE RECOVFILE
         014100            PRINTER-FILE.
   93    014200      STOP RUN.
         014300
         014400 I-O-PARAGRAPH.
   94    014500      PERFORM UNTIL USE-PROC-NOT-EXECUTED OR NO-RECOVERY-DONE  7
   95    014600           MOVE "WRITE" TO I-O-VERB
   96    014700           SET USE-PROC-NOT-EXECUTED TO TRUE
   97    014800           WRITE RECOV-REC FORMAT IS "FORMAT1"
         014900                INDICATOR IS END-INDICATOR
         015000           END-WRITE
         015100      END-PERFORM
   98    015200      MOVE "READ" TO I-O-VERB.
   99    015300      SET USE-PROC-NOT-EXECUTED TO TRUE.
  100    015400      SET NO-RECOVERY-DONE TO TRUE.
  101    015500      READ RECOVFILE FORMAT IS "FORMAT1"
         015600          INDICATOR IS END-INDICATOR  8
         015700      END-READ
  102    015800      IF NO-ERROR THEN
  103    015900          PERFORM SOME-PROCESSING
         016000      END-IF.
         016100
         016200 SOME-PROCESSING.
         016300*    (Insert some database processing, for example.)
         016400
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 92. Example of Error Recovery Procedure (Part 3 of 3)

1 This defines processing that takes place when an I/O error occurs on RECOVFILE.

2 This prints out information to help in diagnosing the problem.

3 If the file-status equals 9N (temporary error), and no previous error recovery has been attempted for this I/O operation, error recovery is now attempted.

4 Recovery consists of dropping, then reacquiring, the program device on which the I/O error occurred.

5 To avoid program looping, recovery is not attempted now if it was attempted previously.

6 The mainline of the program consists of writing to and reading from a device until the user signals an end to the program by pressing F1.

7 If the WRITE operation failed but recovery was done, the WRITE is attempted again.

8 If the READ operation failed, processing will continue by writing to the device again, and then attempting the READ again.

Handling Errors in Operations Using Null-Capable Fields

When a null-capable field is referenced in a program, the ILE COBOL compiler does not check if the field is actually null or not. It is the responsibility of the programmer to ensure that fields referenced as null-capable actually contain or do not contain null values (in other words, a 0 or 1) in the null map and null key map for the fields. If a field is defined in a program as null-capable, but is not defined as null-capable in the database, no checking is done by ILE COBOL, and whatever is in the field is used at the time of execution. At program initialization, fields for externally described files are set to zero. For program described files, it is the programmer's responsibility to ensure that their null-capable fields are set to zero at program initialization.

If the file *is* null-capable, and the ALWNULL attribute has *not* been specified, when you attempt to read a record that has a null value, the read will fail with a file status of 90.

If the file *is not* null-capable and the ALWNULL attribute of the ASSIGN clause is specified, the null map and null key map are returned from the database as zeros. And, when the null maps and null key maps are passed to the database, they are ignored.

Handling Errors in Locale Operations

There are three types of locales in ILE COBOL:

- DEFAULT locale
- CURRENT locale
- Specific locales.

Specific locales are referenced in the SPECIAL-NAMES paragraph and in the SET LOCALE statement. An example of a specific locale in the SPECIAL-NAMES paragraph is:

```
 SPECIAL-NAMES.  LOCALE "MYLOCALE" IN LIBRARY "MYLIB" IS newlocale.
DATA DIVISION.
WORKING-STORAGE SECTION.
01 group-item.
   05  num-edit PIC $99.99 SIZE 8 LOCALE newlocale.
PROCEDURE DIVISION.
    MOVE 40 to num-edit.
```

In the above example a specific locale mnemonic-name `newlocale` has been defined. This mnemonic-name is used in the definition of variable `num-edit`. Since

the mnemonic-name is referenced in the program, the first time the above program is called, the ILE COBOL runtime tries to find the locale MYLOCALE in library MYLIB and load it into memory.

A locale on the iSeries system is an object of type *LOCALE, and like other iSeries objects exists within a library and has a specific authority assigned to it. Any locale mnemonic-name that is defined and referenced in the COBOL program will be resolved the first time the program is called. The possible types of failures include:

- Locale does not exist in the specified library
- Library for locale does not exist
- Not enough authority to the locale or locale library.

These types of failures are typical of most other iSeries objects. In any of the above scenarios an escape message (usually LNR7096) is issued. Once a locale object is located it must be loaded by the ILE COBOL run-time. Loading a locale object requires the allocation of various spaces, if space is not available an escape message is issued (usually LNR7070).

The SET LOCALE has several possible forms, the two basic forms that can reference a specific locale are:

```
 SPECIAL-NAMES.  LOCALE "ALOCALE" IS alocale.
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01 group-item.
    05 num-edit PIC +$9(4).99 SIZE 10 LOCALE alocale.
* num-edit2 is based on the current locale
    05 num-edit2 PIC +$9(4).99 SIZE 10 LOCALE.
    05 locale-name PIC X(10) VALUE "FRANCE".
    05 locale-lib  PIC X(10) VALUE "MYLIB".
    MOVE 345.67 TO num-edit.
* set the current locale to "ALOCALE" in library "*LIBL".
    SET LOCALE LC_ALL FROM alocale.
    MOVE 678.02 TO num-edit2.

* set the current locale to "FRANCE" in library "MYLIB".
    SET LOCALE LC_ALL FROM locale-name
        IN LIBRARY locale-lib.
    MOVE 678.02 TO num-edit2.
```

The first form references a locale mnemonic-name in the SPECIAL-NAMES paragraph, and just like in the previous example is resolved and loaded the first time the program is called. In the second SET statement, the locale name is taken from the contents of identifier locale-name and the library where the locale exists is taken from the contents of identifier locale-lib. In this case the resolve and load of the locale object is done when the SET statement is run. With this form of the SET statement if the locale can not be resolved an escape message (usually LNR7098) is issued. It is issued for the same type of reasons as LNR7096 mentioned previously.

Part 3. ILE COBOL Input-Output Considerations

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Chapter 16. Defining Files

This chapter describes how to:
- Define program-described files
- Define externally described files
- Describe files using Data Description Specifications (DDS)
- Use externally described files in an ILE COBOL program.

Types of File Descriptions

The key element for all I/O operations on the iSeries server is the file. The operating system maintains a description of each file that is used by a program. The description of the file to the operating system includes information about the type of file, such as database or a device, the length of the records in the file, and a description of each field and its attributes. The file is described at the field level to the operating system through IDDU, SQL/400® commands, or DDS. If you create a file (for instance, by using the CRTPF command) without specifying DDS for it, the file still has a field description. The single field has the same name as the file, and has the record length you specified in the create command.

You can define a file in two ways:
- A **program-described file** is described by the programmer at the field level in the Data Division within the ILE COBOL program.
- For an **externally described file**, the ILE COBOL compiler uses the description of the file on the system to generate the ILE COBOL source statements in the Data Division that describe the file at the field level within the ILE COBOL program. The file must be created before you compile the program.

Both externally described files and program-described files must be defined in the ILE COBOL program within the INPUT-OUTPUT SECTION and the FILE SECTION. Record descriptions in the FILE SECTION for externally described files are defined with the Format 2 COPY statement. Only field-level descriptions are extracted. When EXTERNALLY-DESCRIBED-KEY is specified as RECORD KEY, the fields that make up RECORD KEY are also extracted from DDS. For more information on the Format 2 COPY statement, see *WebSphere Development Studio: ILE COBOL Reference*.

Actual file processing within the Procedure Division is the same, if the file is externally described or program-described.

Defining Program-Described Files

Records and fields for a program-described file are described by coding record descriptions directly in the FILE SECTION of the ILE COBOL program instead of using the Format 2 COPY statement.

The file must exist on the system before the program can run. The only exception is when you use dynamic file creation, by specifying OPTION(*CRTF) on the CRTCBLMOD/CRTBNDCBL command. For more information, refer to the description of the OPTION parameter in “Parameters of the CRTCBLMOD Command” on page 28.

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To create a file, use one of the Create File commands. DDS can be used with the Create File commands. For an ILE COBOL indexed file, a keyed access path must be created. Specify a key in DDS when the file is created. The record key in the ILE COBOL program must match the key defined when the file was created. If these key values do not match, the file operation may still proceed, but with the wrong record key being passed to the system. If the wrong record key happens to contain an apparently correct key value, the input/output operation will be performed successfully, but on the wrong data. Thus, the integrity of your data may be compromised. To prevent this problem from happening, you should use externally described files whenever possible.

Defining Externally Described Files

The external description for a file includes:

- The record format specifications that contain a description of the fields in a record
- Access path specifications that describe how the records are to be retrieved.

These specifications come from the external file description and from the OS/400 command you use to create the file.

Externally described files offer the following advantages over program-described files:

- Less coding in ILE COBOL programs. If the same file is used by many programs, the fields can be defined once to the operating system, and then used by all the programs. This eliminates the need to code a separate record description for each program that uses the file.
- Reduces the chance of programming error. You can often update programs by changing the file's record format and then recompiling the programs that use the file without changing any coding in the program.
- Level checking of the file description. A level check of the description of the file in the ILE COBOL program and the actual file on the system is performed when the file is opened (unless LVLCHK(*NO) is specified on the create file command or an override command). If the description of the file in the program does not match the actual file, the open operation will fail with a file status of 39.
- For indexed files, if EXTERNALLY-DESCRIBED-KEY is specified in the RECORD KEY clause, you can ensure that the record key occupies the same position in the actual file as in your ILE COBOL program's description of the file. Also, you can use noncontiguous keys, which is not possible with program-described files.
- Improved documentation. Programs using the same files use consistent record format and field names.
- Any editing to be processed on externally described output files can be specified in DDS.

Before you can use an externally described file in your program, you must create a DDS to describe the file and create the actual file itself.

Describing Files Using Data Description Specifications (DDS)

You can use Data Description Specifications (DDS) to describe files at the field level to the operating system. In DDS, each record format in an externally described file is identified by a unique record format name.

The record format specifications describe the fields in a record and the location of the fields in a record. The fields are located in the record in the order specified in DDS. The field description generally includes the field name, the field type (character, binary, external decimal, internal decimal, internal floating-point), and the field length (including the number of decimal positions in a numeric field). Instead of being specified in the record format for a physical or logical file, the field attributes can be defined in a field reference file. (See Figure 93 on page 376.)

The keys for a record format are specified in DDS. When you use a Format 2 COPY statement, a table of comments is generated in the source program listing showing how the keys for the format are defined in DDS.

In addition, DDS keywords can be used to:

- Specify edit codes for a field (EDTCDE)
- Specify that duplicate key values are not allowed for the file (UNIQUE)
- Specify a text description for a record format or a field (TEXT).

For a complete list of the DDS keywords that are valid for a database file, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A**FLDREF    DSTREF     DISTRIBUTION APPLICATION FIELDS REFERENCE
     A          R DSTREF                   TEXT('DISTRIBUTION FIELD REF')
     A* COMMON FIELDS USED AS REFERENCE
   1 A            BASDAT         6  0       EDTCDE(Y)
     A                                      TEXT('BASE DATE FIELD')
     A* FIELDS USED BY CUSTOMER MASTER FILE
   2 A            CUST           5          CHECK(MF)
     A                                      COLHDG('CUSTOMER' 'NUMBER')
     A            NAME          20          COLHDG('CUSTOMER NAME')
   3 A            ADDR      R               REFFLD(NAME)
     A                                      COLHDG('CUSTOMER ADDRESS')
     A            CITY      R               REFFLD(NAME)
     A                                      COLHDG('CUSTOMER CITY')
   2 A            STATE          2          CHECK(MF)
     A                                      COLHDG('STATE')
     A            SRHCOD         6          CHECK(MF)
     A                                      COLHDG('SEARCH' 'CODE')
     A                                      TEXT('CUSTOMER NUMBER SEARCH CODE')
   2 A            ZIP            5  0       CHECK(MF)
     A                                      COLHDG('ZIP' 'CODE')
   4 A            CUSTYP         1  0       RANGE(1 5)
     A                                      COLHDG('CUST' 'TYPE')
     A                                      TEXT('CUSTOMER TYPE 1=GOV 2=SCH 3=B+
     A                                      US 4=PT 5=OTH')
   5 A            ARBAL          8  2       COLHDG('ACCTS REC' 'BALANCE')
     A                                      EDTCDE(J)
   6 A            ORDBAL    R               REFFLD(ARBAL)
     A                                      COLHDG('A/R AMT IN' 'ORDER FILE')
     A            LSTAMT    R               REFFLD(ARBAL)
     A                                      COLHDG('LAST' 'AMOUNT' 'PAID')
   7 A                                      TEXT('LAST AMOUNT PAID IN A/R')
     A            LSTDAT    R               REFFLD(ARBAL)
     A                                      COLHDG('LAST' 'DATE' 'PAID  ')
     A                                      TEXT('LAST DATE PAID IN A/R')
     A            CRDLMT         8  2       COLHDG('CUSTOMER' 'CREDIT' 'LIMIT')
     A                                      EDTCDE(J)
     A            SLSYR         10  2       COLHDG('CUSTOMER' 'SALES' 'THIS YEAR')
     A                                      EDTCDE(J)
     A            SLSLYR        10  2       COLHDG('CUSTOMER' 'SALES' 'LAST YEAR')
     A                                      EDTCDE(J)
```

Figure 93. Example of a Field Reference File

This example of a field reference file (Figure 93) shows the definitions of the fields that are used by the CUSMSTL (customer master logical) file, which is shown in Figure 94 on page 377. The field reference file normally contains the definitions of fields that are used by other files. The following text describes some of the entries for this field reference file.

1 The BASDAT field is edited by the Y edit code, as indicated by the keyword EDTCDE (Y). If this field is used in an externally described output file for a ILE COBOL program, the COBOL-generated field is compatible with the data type specified in the DDS. The field is edited when the record is written. When the field is used in a program-described output file, compatibility with the DDS fields in the file is the user's responsibility. When DDS is not used to create the file, appropriate editing of the field in the ILE COBOL program is also the user's responsibility.

2 The CHECK(MF) entry specifies that the field is a mandatory fill field when it is entered from a display workstation. Mandatory fill means that all characters for the field must be entered from the display workstation.

3 The ADDR and CITY fields share the same attributes that are specified for the NAME field, as indicated by the REFFLD keyword.

4 The RANGE keyword, which is specified for the CUSTYP field, ensures that the only valid numbers that can be entered into this field from a display work station are 1 through 5.

5 The COLHDG keyword provides a column head for the field if it is used by the Application Development ToolSet tools.

6 The ARBAL field is edited by the J edit code, as indicated by the keyword EDTCDE(J).

7 A text description (TEXT keyword) is provided for some fields. The TEXT keyword is used for documentation purposes and appears in various listings.

Using Externally Described Files in an ILE COBOL Program

You can incorporate the file description in your program by coding a Format 2 COPY statement. The information from the external description is then retrieved by the ILE COBOL compiler, and an ILE COBOL data structure is generated.

The following pages provide examples of DDS usage and the ILE COBOL code that would result from the use of a Format 2 COPY statement. (See the *WebSphere Development Studio: ILE COBOL Reference* for a detailed description of the Format 2 COPY statement.)

- Figure 94 shows the DDS for a logical file and Figure 95 on page 378 shows the ILE COBOL code generated.
- Figure 96 on page 379 describes the same file but includes the ALIAS keyword, and Figure 97 on page 380 shows the ILE COBOL code generated.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
   1 A** LOGICAL  CUSMSTL   CUSTOMER MASTER FILE
     A                                      2 UNIQUE
     A       3 R CUSREC                       PFILE(CUSMSTP)
     A                                        TEXT('CUSTOMER MASTER RECORD')
     A           CUST
     A           NAME
     A           ADDR
     A           CITY
     A           STATE
     A           ZIP
     A           SRHCOD
     A           CUSTYP
     A           ARBAL
     A           ORDBAL
     A           LSTAMT
     A           LSTDAT
     A           CRDLMT
     A           SLSYR       5
     A           SLSLYR
     A       4 K CUST
```

Figure 94. Example of Data Description Specifications for a Logical File

1 A logical file for processing the customer master physical file (CUSMSTP) is defined and named CUSMSTL.

2 The UNIQUE keyword indicates that duplicate key values for this file are not allowed.

3 One record format (CUSREC) is defined for the CUSMSTL file, which is to be based upon the physical file CUSMSTP.

4 The CUST field is identified as the key field for this file.

5 If field attributes (such as length, data type, and decimal positions) are not specified in the DDS for a logical file, the attributes are obtained from the corresponding field in the physical file. Any field attributes specified in the DDS for the logical file override the attributes for the corresponding field in the physical file. The definition of the fields in the physical file could refer to a field reference file. A field reference file is a data description file consisting of field names and their definitions, such as size and type. When a field reference file is used, the same fields that are used in multiple record formats have to be defined only once in the field reference file. For more information on field reference files, see the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Figure 93 on page 376 shows an example of a field reference file that defines the attributes of the fields used in the database file.

```
                              S o u r c e

STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN S COPYNAME   CHG DATE


  18     000200 01  CUSTOMER-INVOICE-RECORD.
         000210     COPY DDS-CUSREC OF CUSMSTL.
         +000001*    I-O FORMAT:CUSREC     FROM FILE CUSMSTL    OF LIBRARY TESTLIB           CUSREC
         +000002*                          CUSTOMER MASTER RECORD                           CUSREC
         +000003*           USER SUPPLIED KEY BY RECORD KEY CLAUSE                          CUSREC
  19     +000004       05  CUSREC.                                                          CUSREC
  20     +000005           06 CUST                   PIC X(5).                             CUSREC
         +000006*                 CUSTOMER NUMBER                                         CUSREC
  21     +000007           06 NAME                   PIC X(25).                            CUSREC
         +000008*                 CUSTOMER NAME                                           CUSREC
  22     +000009           06 ADDR                   PIC X(20).                            CUSREC
         +000010*                 CUSTOMER ADDRESS                                        CUSREC
  23     +000011           06 CITY                   PIC X(20).                            CUSREC
         +000012*                 CUSTOMER CITY                                           CUSREC
  24     +000013           06 STATE                  PIC X(2).                             CUSREC
         +000014*                 STATE                                                   CUSREC
  25     +000015           06 ZIP                    PIC S9(5)       COMP-3.               CUSREC
         +000016*                 ZIP CODE                                                CUSREC
  26     +000017           06 SRHCOD                 PIC X(6).                             CUSREC
         +000018*                 CUSTOMER NUMBER SEARCH CODE                             CUSREC
  27     +000019           06 CUSTYP                 PIC S9(1)       COMP-3.               CUSREC
         +000020*                 CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT              CUSREC
  28     +000021           06 ARBAL                  PIC S9(6)V9(2)  COMP-3.               CUSREC
         +000022*                 ACCOUNTS REC. BALANCE                                   CUSREC
  29     +000023           06 ORDBAL                 PIC S9(6)V9(2)  COMP-3.               CUSREC
         +000024*                 A/R AMT. IN ORDER FILE                                  CUSREC
  30     +000025           06 LSTAMT                 PIC S9(6)V9(2)  COMP-3.               CUSREC
         +000026*                 LAST AMT. PAID IN A/R                                   CUSREC
  31     +000027           06 LSTDAT                 PIC S9(6)       COMP-3.               CUSREC
         +000028*                 LAST DATE PAID IN A/R                                   CUSREC
  32     +000029           06 CRDLMT                 PIC S9(6)V9(2)  COMP-3.               CUSREC
         +000030*                 CUSTOMER CREDIT LIMIT                                   CUSREC
  33     +000031           06 SLSYR                  PIC S9(8)V9(2)  COMP-3.               CUSREC
         +000032*                 CUSTOMER SALES THIS YEAR                                CUSREC
  34     +000033           06 SLSLYR                 PIC S9(8)V9(2)  COMP-3.               CUSREC
         +000034*                 CUSTOMER SALES LAST YEAR                                CUSREC
```

Figure 95. Example of the Results of the Format 2 COPY Statement (DDS)

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A** LOGICAL  CUSMSTL   CUSTOMER MASTER FILE
     A                                     UNIQUE
     A          R CUSREC                   PFILE(CUSMSTP)
     A                                     TEXT('CUSTOMER MASTER RECORD')
     A            CUST                     ALIAS(CUSTOMER_NUMBER)
     A            NAME                   1 ALIAS(CUSTOMER_NAME)
     A            ADDR                     ALIAS(ADDRESS)
     A            CITY
     A            STATE
     A            ZIP
     A            SRHCOD                   ALIAS(SEARCH_CODE)
     A            CUSTYP                   ALIAS(CUSTOMER_TYPE)
     A            ARBAL                    ALIAS(ACCT_REC_BALANCE)
     A            ORDBAL
     A            LSTAMT
     A            LSTDAT
     A            CRDLMT
     A            SLSYR
     A            SLSLYR
     A          K CUST
```

Figure 96. Example of Data Description Specifications with ALIAS

1 This is the name associated with the ALIAS keyword, which will be included in the program. Available through the DDS ALIAS option, an alias is an alternative name that allows a data name of up to 30 characters to be included in an ILE COBOL program.

```
                              S o u r c e

STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN S COPYNAME   CHG DATE


  18     002000 01  CUSTOMER-INVOICE-RECORD.
         002100     COPY DDS-CUSREC OF CUSMSTL ALIAS.
        +000001*    I-O FORMAT:CUSREC     FROM FILE CUSMSTL    OF LIBRARY TESTLIB           CUSREC
        +000002*                          CUSTOMER MASTER RECORD                            CUSREC
        +000003*          USER SUPPLIED KEY BY RECORD KEY CLAUSE                            CUSREC
  19    +000004       05  CUSREC.                                                          CUSREC
  20    +000005           06 CUSTOMER-NUMBER       PIC X(5).                               CUSREC
        +000006*                 CUSTOMER NUMBER                                          CUSREC
  21    +000007           06 CUSTOMER-NAME         PIC X(25).                              CUSREC
        +000008*                 CUSTOMER NAME                                            CUSREC
  22    +000009           06 ADDRESS-DDS           PIC X(20).                              CUSREC
        +000010*                 CUSTOMER ADDRESS                                         CUSREC
  23    +000011           06 CITY                  PIC X(20).                              CUSREC
        +000012*                 CUSTOMER CITY                                            CUSREC
  24    +000013           06 STATE                 PIC X(2).                               CUSREC
        +000014*                 STATE                                                    CUSREC
  25    +000015           06 ZIP                   PIC S9(5)       COMP-3.                 CUSREC
        +000016*                 ZIP CODE                                                 CUSREC
  26    +000017           06 SEARCH-CODE           PIC X(6).                               CUSREC
        +000018*                 CUSTOMER NUMBER SEARCH CODE                              CUSREC
  27    +000019           06 CUSTOMER-TYPE         PIC S9(1)       COMP-3.                 CUSREC
        +000020*                 CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT               CUSREC
  28    +000021           06 ACCT-REC-BALANCE      PIC S9(6)V9(2)  COMP-3.                 CUSREC
        +000022*                 ACCOUNTS REC. BALANCE                                    CUSREC
  29    +000023           06 ORDBAL                PIC S9(6)V9(2)  COMP-3.                 CUSREC
        +000024*                 A/R AMT. IN ORDER FILE                                   CUSREC
  30    +000025           06 LSTAMT                PIC S9(6)V9(2)  COMP-3.                 CUSREC
        +000026*                 LAST AMT. PAID IN A/R                                    CUSREC
  31    +000027           06 LSTDAT                PIC S9(6)       COMP-3.                 CUSREC
        +000028*                 LAST DATE PAID IN A/R                                    CUSREC
  32    +000029           06 CRDLMT                PIC S9(6)V9(2)  COMP-3.                 CUSREC
        +000030*                 CUSTOMER CREDIT LIMIT                                    CUSREC
  33    +000031           06 SLSYR                 PIC S9(8)V9(2)  COMP-3.                 CUSREC
        +000032*                 CUSTOMER SALES THIS YEAR                                 CUSREC
  34    +000033           06 SLSLYR                PIC S9(8)V9(2)  COMP-3.                 CUSREC
        +000034*                 CUSTOMER SALES LAST YEAR                                 CUSREC
```

Figure 97. Example of the Results of the Format 2 COPY Statement (DD) with the ALIAS Keyword

In addition to placing the external description of the file in the program through the use of the Format 2 COPY statement, you can also use standard record definition and redefinition to describe external files or to provide a group definition for a series of fields. It is the programmer's responsibility to ensure that program-described definitions are compatible with the external definitions of the file.

Figure 98 on page 381 shows how ILE COBOL programs can relate to files on the iSeries server, making use of external file descriptions from DDS.

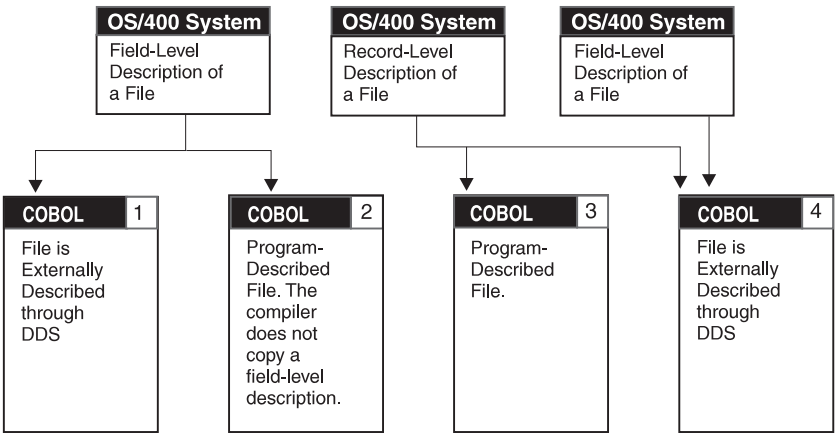


Figure 98. Example Showing How ILE COBOL Can Relate to iSeries Files

1 The ILE COBOL program uses the field level description of a file that is defined to the operating system. You code a Format 2 COPY statement for the record description. At compilation time, the compiler copies in the external field-level description and translates it into a syntactically correct ILE COBOL record description. The file must exist at compilation time.

2 An externally described file is used as a program-described file in the ILE COBOL program. The entire record description for the file is coded in the ILE COBOL program. This file does not have to exist at compilation time.

3 A file is described to the operating system as far as the record level only. The entire record description must be coded in the ILE COBOL program. This file does not have to exist at compilation time.

4 A file name can be specified at compilation time, and a different file name can be specified at run time. An ILE COBOL Format 2 COPY statement generates the record description for the file at compilation time. At run time, a different library list or a file override command can be used so that a different file is accessed by the program. The file description copied in at compilation time is used to describe the input records used at run time.

Note: For externally described files, the two file formats must be the same. Otherwise, a level check error will occur.

Specifying Nonkeyed and Keyed Record Retrieval

The description of an externally described file contains the access path that describes how records are to be retrieved from the file. Records can be retrieved based on an arrival sequence (nonkeyed) access path or on a keyed sequence access path. For a complete description of the access paths for an externally described database file, see the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

The **arrival sequence access path** is based on the order in which the records are stored in the file. Records are added only to the end of the file.

For the **keyed sequence access path**, the sequence in which records are retrieved from the file is based on the contents of the key fields defined in the DDS for the file. For example, in the DDS shown in Figure 94 on page 377, CUST is defined as the key field. The keyed sequence access path is updated whenever records are added, deleted, or when the contents of a key field change. For a keyed sequence

access path, one or more fields can be defined in the DDS to be used as the key fields for a record format. Not all record formats in a file have to have the same key fields. For example, an order header record can have the ORDER field defined as the key field, and the order detail records can have the ORDER and LINE fields defined as the key fields.

If you do not specify a format on the I/O operation then the key for a file is determined by the valid keys for the record formats in that file. The file's key is determined in the following manner:

- If all record formats in a file have the same number of key fields defined in DDS that are identical in attributes, the *key for the file* consists of all fields in the key for the record formats. (The corresponding fields do not have to have the same name.) For example, if the file has three record formats and the key for each record format consists of fields A, B, and C, the file's key consists of fields A, B, and C. That is, the file's key is the same as the records' key.
- If all record formats in the file do not have the same key fields, the key for the file consists of the key fields *common* to all record formats. For example, a file has three record formats and the key fields are defined as follows:
  - REC1 contains key field A.
  - REC2 contains key fields A and B.
  - REC3 contains key fields A, B, and C.

  Then the file's key is field A, the key field common to all record formats.
- If no key field is common to all record formats, any keyed reference to the file will always return the first record in the file.

In ILE COBOL, you must specify a RECORD KEY for an indexed file to identify the record you want to process. ILE COBOL compares the key value with the key of the file or record, and processes the specified operation on the record whose key matches the RECORD KEY value.

When RECORD KEY IS EXTERNALLY-DESCRIBED-KEY is specified:

- If the FORMAT phrase is specified, the compiler builds the search argument from the key fields in the record area for the specified format
- If the FORMAT phrase is not specified, the compiler builds the search argument from the key fields in the record area for the first record format defined in the program for that file.

Note: For a file containing multiple key fields to be processed in ILE COBOL, the key fields must be contiguous in the record format used by the ILE COBOL program, except when RECORD KEY IS EXTERNALLY-DESCRIBED-KEY is specified.

Level Checking the Externally Described Files

When an ILE COBOL program uses an externally described file, the operating system provides a level check function (LVLCHK). This function ensures that the formats of the file have not changed since compilation time.

The compiler always provides the information required by level checking when an externally described file is used (that is, when a record description was defined for the file by using the Format 2 COPY statement). Only those formats that were copied by the Format 2 COPY statement under the FD for a file are level checked. The level check function will be initiated at run time based on the selection made on the create, change, or override file commands. The default on the create file command is to request level checking. If level checking was requested, level

checking occurs on a record format basis when the file is opened. If a level check error occurs, ILE COBOL sets a file status of 39.

When LVLCHK(*NO) is specified on the CRTxxxF, CHGxxxF, or OVRxxxF CL commands, and the file is re-created using an existing format, existing ILE COBOL programs that use that format may not work without recompilation, depending on the changes to the format.

You should use extreme caution when using files in ILE COBOL programs without level checking. You risk program failure and data corruption if you use ILE COBOL programs without level checking or recompiling.

Note: The ILE COBOL compiler does not provide level checking for program-described files.

For more information on level checking, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://www.ibm.com/eserver/iseries/infocenter.

Chapter 17. Processing Files

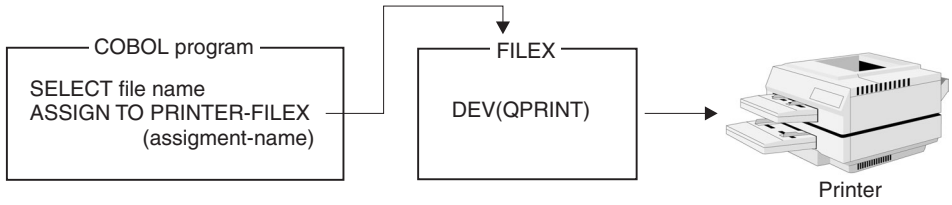
There are many ways in which files are used and processed by COBOL on the AS/400. This chapter describes how to:

- Associate files with input-output devices
- Change file attributes
- Redirect file input and output
- Lock and release files
- Unblock input records and block output records
- Share an open data path to access a file
- Use file status and feedback areas
- Use commitment control
- Sort and merge files
- Declare data items using CVTOPT data types.

Associating Files with Input-Output Devices

Files serve as the connecting link between a program and the device used for input and output. The actual device association is made at the time the file is opened. In some instances, this type of I/O control allows the user to change the attribute of the file (and, in some cases, change the device) used in a program without changing the program.

In the ILE COBOL language, the file name specified in the ASSIGNMENT-NAME entry of the ASSIGN clause of the file control entry is used to point to the file. This file name points to the system file description:



The ILE COBOL device name in the ASSIGN clause defines the ILE COBOL functions that can be processed on the selected file. At compilation time, certain ILE COBOL functions are valid only for a specific ILE COBOL device type; in this respect, ILE COBOL is device dependent. The following are examples of device dependency:

- SUBFILE operations are valid only for a WORKSTATION device.
- Indicators are valid only for WORKSTATION or FORMATFILE devices.
- LINAGE is valid only for a PRINTER device.
- OPEN INPUT WITH NO REWIND is valid only for a TAPEFILE device.

For example, assume that the file name FILEY is associated in the ILE COBOL program with the FORMATFILE device. The device FORMATFILE is an independent device type. Therefore, no line or page control specifications are valid so the ADVANCING phrase cannot be specified in the WRITE statement for a FORMATFILE file. When the program is run, the actual I/O device is specified in

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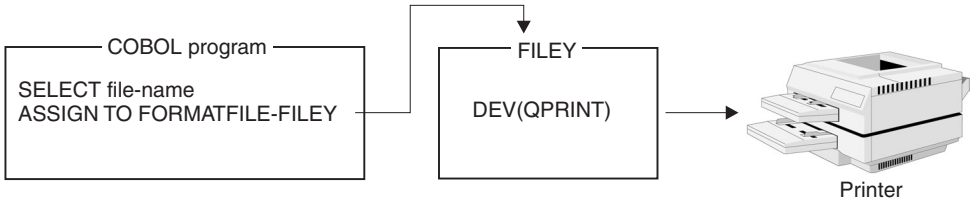
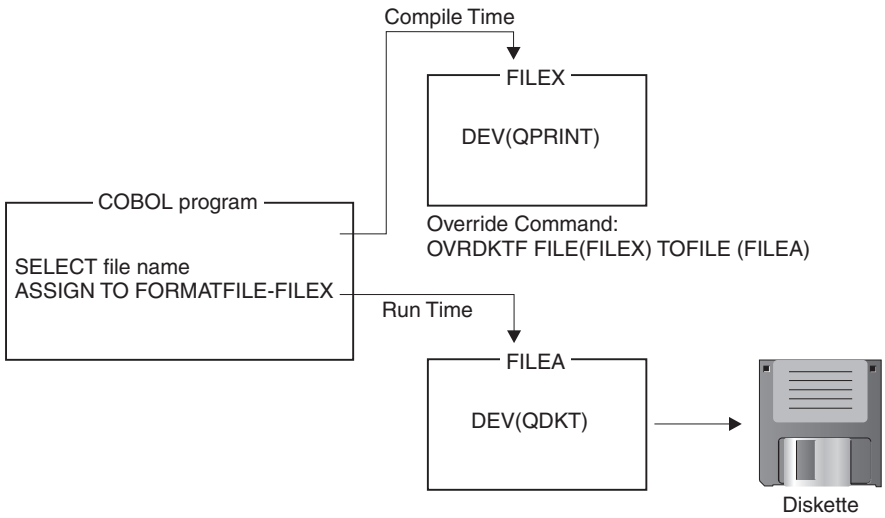
the description of FILEY. For example, the device might be a printer; only the default line and page control or those defined in the DDS would be used:



CL commands can be used to override a parameter in the specified file description or to redirect a file at compilation time or run time. File redirection allows the user to specify one file at compilation time and another file at run time:



In the preceding example, the Override to Diskette File (OVRDKTF) command allows the program to run with an entirely different device file than was specified at compilation time.

Note: FORMATFILE devices cannot be used for input. Overriding input/output from a device that allows input, such as a DISKETTE device, to a FORMATFILE device may result in unexpected results if an input operation is attempted.

Not all file overrides are valid. At run time, checking occurs to ensure that the specifications within the ILE COBOL program are valid for the file being processed. If the specifications passed by the ILE COBOL program in the file control block and the I/O request are incorrect, the I/O operation will fail. The OS/400 operating system allows some file redirections even if device specifics are contained in the program. For example, if the ILE COBOL device name is PRINTER and the actual file the program uses is not a printer, the operating system ignores the ILE COBOL print spacing and skipping specifications.

There are other file redirections that the operating system does not allow and that may cause the file to become unusable. For example, if the ILE COBOL device name is DATABASE or DISK and a keyed READ operation is specified in the program, the file becomes unusable if the actual file the program uses is not a disk or database file.

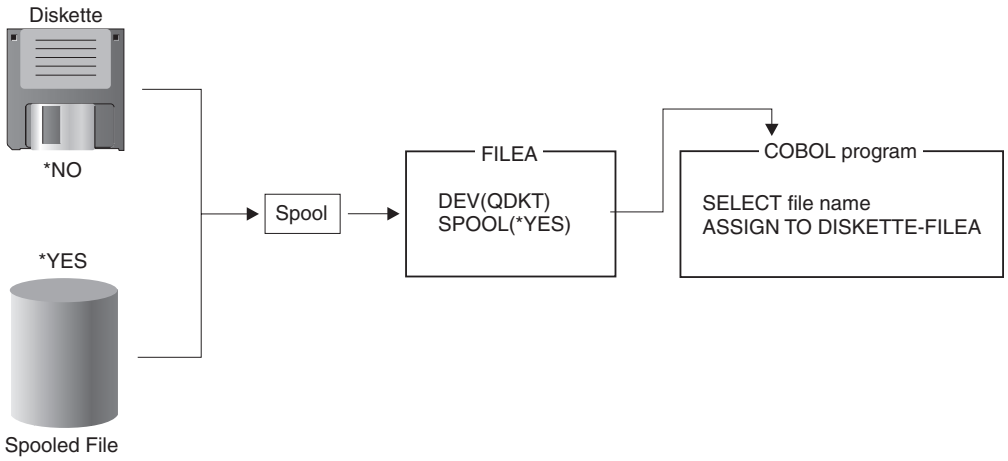
The AS/400 system provides for the use of input and output spooling functions. Each AS/400 file description contains a spool attribute that determines whether spooling is used for the file at run time. The ILE COBOL program is not aware that spooling is being used. The actual physical device from which a file is read or to which a file is written is determined by the spool reader or the spool writer. For more detailed information on spooling, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Specifying Input and Output Spooling

Input Spooling

Input spooling is valid only for inline data files in batch jobs. If the input data read by ILE COBOL comes from a spooled file, ILE COBOL is not aware of which device the data was spooled in from.

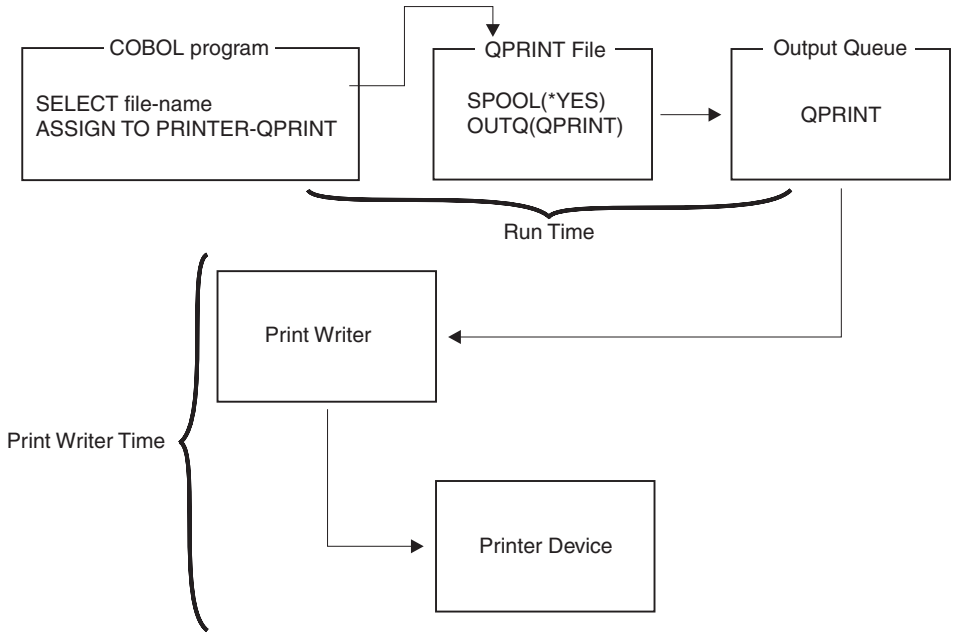
The data is read from a spooled inline file:



For more information on inline data files, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Output Spooling

Output spooling is valid for batch and interactive jobs. The description of the file that is specified in ILE COBOL by the system-name contains the specification for spooling as shown in the following example:



File override commands can be used at run time to override the spooling options that are specified in the file description, such as the number of copies to be printed. In addition, AS/400 spooling support allows you to redirect a file after the program has run. For example, you can direct printer output to a different device, such as a diskette.

Overriding File Attributes

You must specify any overrides before the file is opened by the ILE COBOL program. The system uses the file override command to determine the file to open and the attributes of the file. File overrides are scoped to the call level, the activation group level, or the job level.

For **call level** scoping, an override issued at a particular call level is effective for any invocations after the call level regardless of which activation group the invocations are in, and its effect ends when control is returned for the call level at which the override is issued.

For **activation group level** scoping, the override applies to all program objects running in that activation group and the override remains in effect until the activation group ends or the override is explicitly deleted.

Note: In the Default Activation Group (*DFTACTGRP), when activation group level scoping is specified, the override is actually scoped at the call level.

For **job level** scoping, the override applies to all program objects within the job, and it remains active until the job ends or the override is explicitly deleted.

Use the OVRSCOPE parameter of any override CL command to specify the scope of the override. If you do not explicitly specify the scope, the default scope of the override depends on where the override is issued. If the override is issued from the default activation group, it is scoped at the call level. If the override is issued from any other activation group, it is scoped to the activation group.

The simplest form of overriding a file is to override some attributes of the file. For example, FILE(OUTPUT) with COPIES(2) is specified when a printer file is created. Then, before the ILE COBOL program is run, the number of printed copies of output can be changed to 3. The override command is as follows:

```
OVRPRTF FILE(OUTPUT) COPIES(3)
```

Redirecting File Input and Output

Another form of file overriding is to redirect the ILE COBOL program to access a different file. When the override redirects the program to a file of the *same* type (such as a printer file to another printer file), the file is processed in the same manner as the original file.

When the override redirects the program to a file of a *different* type, the overriding file is processed in the same manner as the original file would have been processed. Device-dependent specifications in the ILE COBOL program that do not apply to the overriding device are ignored by the system.

Not all file redirections are valid. For example, an indexed file for an ILE COBOL program can only be overridden to another indexed file with a keyed access path.

Multiple member processing can be accomplished for a database file by overriding a database file to process all members. Note the following exceptions:

- A database source file used in the compilation of an ILE COBOL program cannot be overridden to process all members. Specifying OVRDBF MBR(*ALL) will result in the termination of the compilation.
- A database file used for a COPY statement cannot be overridden to process all members. Specifying OVRDBF MBR(*ALL) will cause the COPY statement to be ignored.

You must ensure that file overrides are applied properly. For more information on valid file redirections, the device dependent characteristics ignored, and the defaults assumed, refer to the *Programming* category in the **iSeries 400 Information Center** at this Web site
-http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Locking and Releasing Files

The operating system allows a lock state (exclusive, exclusive allow read, shared-for-update, shared-no-update, or shared-for-read) to be placed on a file used during a job step. You can place the file in a lock state with the Allocate Object (ALCOBJ) command.

By default, the operating system places the following lock states on database files when the files are opened by ILE COBOL programs:

OPEN Type	Lock State
INPUT	Shared-for-read
I-O	Shared-for-update
EXTEND	Shared-for-update
OUTPUT	Shared-for-update

The shared-for-read lock state allows another user to open the file with a lock state of shared-for-read, shared-for-update, shared-no-update, or exclusive-allow-read,

but the user cannot specify the exclusive use of the file. The shared-for-update lock state allows another user to open the file with a shared-for-read or shared-for-update lock state.

The operating system places the shared-for-read lock on the device file and an exclusive-allow-read lock state on the device. Another user can open the file but cannot use the same device.

Note: When an ILE COBOL program opens a physical file for OUTPUT, that file will be subject to an exclusive lock for the period of time necessary to clear the member.

For more information on allocating resources and the lock states, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Locking and Releasing Records

When a READ is performed by an ILE COBOL program on a database file and the file is opened for I-O, a lock is placed on that record so that another program cannot update it. That is, the record can be read by another program if it opens a file for input, but not if it opens the file for I-O. Similarly, after a successful START operation for a file opened in I-O mode, a lock will be placed on the record at which the file is positioned.

For information about the duration of record lock with and without commitment control, refer to Figure 99 on page 396.

To prevent the READ or START statements from locking records on files opened in I-O (update) mode, you can use the NO LOCK phrase. The READ WITH NO LOCK statement unlocks records locked by a previous READ statement or START statement. Also, the record read by the READ WITH NO LOCK statement is not locked. The START WITH NO LOCK statement unlocks records locked by a previous START statement or READ statement. For more information about this phrase, refer to the section on the READ and START statements in the *WebSphere Development Studio: ILE COBOL Reference*.

For a logical file based on one physical file, the lock is placed on the record in the physical file. If a logical file is based on more than one physical file, a lock is placed on one record in each physical file.

This lock applies not only to other programs, but also to the original program if it attempts to update the same underlying physical record through a second file.

Note: When a file with indexed or relative organization is opened for I-O, using random or dynamic access, a failed I/O operation on any of the I/O verbs except WRITE also unlocks the record. A WRITE operation is not considered an update operation; therefore, the record lock is not released.

For more information about releasing database records read for update, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Sharing an Open Data Path to Access a File

If you have already opened a file through another program in your routing step, your ILE COBOL program can use the same Open Data Path (ODP) to access the file.

Note: A job usually contains only one routing step. Routing steps are described in the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

The following rules apply to shared ODPs:

1. You must specify SHARE(*YES) in the command that creates the file (CRTxxxF), in a change command (CHGxxxF), or in an override (OVRxxxF) command for the file.
2. Once a file with a shared ODP has been opened for the first time by a program and remains open, subsequent shared OPEN operations within the same routing step run faster than standard OPEN operations. The speed of other I/O operations is not affected.
3. Your use of the file within your different programs should be consistent. Other programs using the same shared file will affect the current file position when they perform I/O operations on the file.

Unblocking Input Records and Blocking Output Records

A **block** contains more than one record. Unblocking of input records and blocking of output records occurs under the following conditions:

1. *NOBLK is specified on the OPTION parameter of the CRTCBLMOD or CRTBNDCBL commands (with or without a BLOCK CONTAINS clause) and **all** of the following conditions are met:
   a. ACCESS IS SEQUENTIAL is specified for the file.
   b. The file is opened only for INPUT or OUTPUT in that program.
   c. The file is assigned to DISK, DATABASE, DISKETTE, or TAPEFILE.
   d. No START statements are specified for the file.

   For RELATIVE organization, blocking is not performed for OPEN OUTPUT.

   If you specify BLOCK CONTAINS, it is ignored. The system determines the number of records to be blocked.
2. *BLK is specified on the OPTION parameter of the CRTCBLMOD or CRTBNDCBL commands (with or without a BLOCK CONTAINS clause) and **all** of the following conditions are met:
   a. ACCESS IS SEQUENTIAL or ACCESS IS DYNAMIC is specified for the file.
   b. The file is opened only for INPUT or OUTPUT in that program.
   c. The file is assigned to DISK, DATABASE, DISKETTE, or TAPEFILE.

   For RELATIVE organization, blocking is not performed for OPEN OUTPUT.

   The BLOCK CONTAINS clause controls the number of records to be blocked. In the case of DISKETTE files, the system always determines the number of records to be blocked.

Even when all of the above conditions are met, certain OS/400 restrictions can cause blocking and unblocking to not take affect. In these cases, performance improvements will not be realized.

If you are using dynamically accessed indexed files, you can use READ PRIOR and READ NEXT to perform blocking. When using READ PRIOR and READ NEXT to perform blocking, you cannot change direction while there are records remaining in the block. To clear the records from a block, specify a random operation, such as a random READ or a random START, or use a sequential READ FIRST or READ LAST.

If an illegal change of direction takes place, file status 9U results. No further I/O is possible until the file is closed and reopened.

You can override blocking at run time by specifying SEQONLY(*NO) for the OVRDBF command.

For disk and database files, when you use BLOCK CONTAINS, and if the blocking factor of zero is specified or calculated, the system determines the blocking factor.

There are certain instances in which the blocking factor you specify may be changed.

Where a block of records is written or read, the I-O feedback area contains the number of records in that block. The I-O-FEEDBACK area is not updated after each read or write for files where multiple records are blocked and unblocked by ILE COBOL. It is updated when the next block is read or written.

For database files with blocking in effect, you may not see all changes as they occur, if the changes are made in different programs.

Blocking is implicitly disabled if the file has alternate record keys.

For a description of the effect of blocking on changes to database files and changing the blocking factor, see the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Using File Status and Feedback Areas

To transfer data in the OPEN-FEEDBACK and I-O-FEEDBACK areas associated with an open file to an identifier, use the Format 3 ACCEPT statement. See the "ACCEPT Statement" section of the *WebSphere Development Studio: ILE COBOL Reference* for more information on specifying this statement.

FILE STATUS

When the FILE STATUS clause is specified, the system moves a value into the status key data item after each input/output request that explicitly or implicitly refers to this file. This 2-character value indicates the run status of the statement. When input records are unblocked and output records are blocked, file status values that are caused by OS/400 exceptions are set only when a block is processed. For more information about blocking records, refer to "Unblocking Input Records and Blocking Output Records" on page 391.

OPEN-FEEDBACK Area

The OPEN-FEEDBACK area is the part of the open data path (ODP) that contains information about the OPEN operation. This information is set during OPEN processing and is available as long as the file is open.

This area provides information about the file that the program is using. It contains:

- Information about the file that is currently open, such as file name and file type
- Information that depends on the type of file that is opened, such as printer size, screen size, diskette labels, or tape labels.

Note: OPTIONAL INPUT files that are successfully opened will not have any OPEN-FEEDBACK area information.

I-O-FEEDBACK Area

The system updates the I-O-FEEDBACK area each time a block transfers between the operating system and the program. A block can contain one or more records.

The I-O-FEEDBACK area is not updated after each read or write operation for files in which multiple records are blocked and unblocked by COBOL. If the I-O-FEEDBACK information is needed after each read or write operation in the program, the user can do either of the following:

- Prevent the compiler from generating blocking and unblocking code by not satisfying one of the conditions listed under "Unblocking Input Records and Blocking Output Records" on page 391.
- Specify SEQONLY(*NO) on the Override with database file (OVRDBF) CL command.

Preventing the compiler from generating blocking and unblocking code is more efficient than specifying SEQONLY(*NO).

Even when the compiler generates blocking and unblocking code, certain OS/400 restrictions can cause blocking and unblocking to not be processed. In these cases, a performance improvement will not be realized. However, the I-O-FEEDBACK area will be updated after each read or write operation.

The I-O-FEEDBACK area contains information about the last successful I-O operation, such as: device name, device type, AID character, and error information for some devices. This area consists of a common area and a device-dependent area. The device-dependent area varies in length and content depending on the device type to which the file is associated. This area follows the I-O-FEEDBACK common area and can be obtained by specifying the receiving identifier large enough to include the common area and the appropriate device-dependent area.

For a layout and description of the data areas contained in the OPEN-FEEDBACK and I-O-FEEDBACK areas, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Using Commitment Control

Commitment control is a function that allows:

- Synchronization of changes to database files within the same job

- Cancellation of changes that should not be permanently entered into the database
- Locking of records being changed until changes are complete
- Techniques for recovering from job or system failure.

In some applications, it is desirable to synchronize changes to database records. If the program determines the changes are valid, the changes are then permanently made to the database (a COMMIT statement is processed). If the changes are not valid, or if a problem occurs during processing, the changes can be canceled (a ROLLBACK statement is processed). (When a file is cleared after being opened for OUTPUT, processing of a ROLLBACK does not restore cleared records to the file.) Changes made to records in a file that is *not* under commitment control are always permanent. Such changes are never affected by subsequent COMMIT or ROLLBACK statements.

Each point where a COMMIT or ROLLBACK is successfully processed is a commitment boundary. (If no COMMIT or ROLLBACK has yet been issued in a program, a commitment boundary is created by the first open of any file under commitment control.) The committing or rolling back of changes only affects changes made since the previous commitment boundary.

The synchronizing of changes at commitment boundaries makes restart or recovery procedures after a failure easier. For more information, see "Recovery After a Failure" on page 363.

When commitment control is used for database files, records in those files are subject to one of the following lock levels:

- **high lock level**

  A high lock level is specified by the LCKLVL(*ALL) parameter of the Start Commitment Control (STRCMTCTL) CL command. With a high lock level (*ALL), *all* records accessed for files under commitment control, whether for input or output, are locked until a COMMIT or ROLLBACK is successfully processed.
- **cursor stability lock level**

  A cursor stability lock level is specified by the LCKLVL(*CS) parameter of the Start Commitment Control (STRCMTCTL) CL command. With a cursor stability lock level (*CS), every record accessed for files opened under commitment control is locked. A record that is read, but not changed or deleted, is unlocked when a different record is read. Records that are changed, added, or deleted are locked until a COMMIT or ROLLBACK statement is successfully processed.
- **low lock level**

  A low lock level is specified by the LCKLVL(*CHG) parameter of the Start Commitment Control (STRCMTCTL) CL command. With a low lock level (*CHG), every record read for update (for a file opened under commitment control) is locked. If a record is changed, added, or deleted, that record remains locked until a COMMIT or ROLLBACK statement is successfully processed. Records that are accessed for update operations but are released without being changed are unlocked.

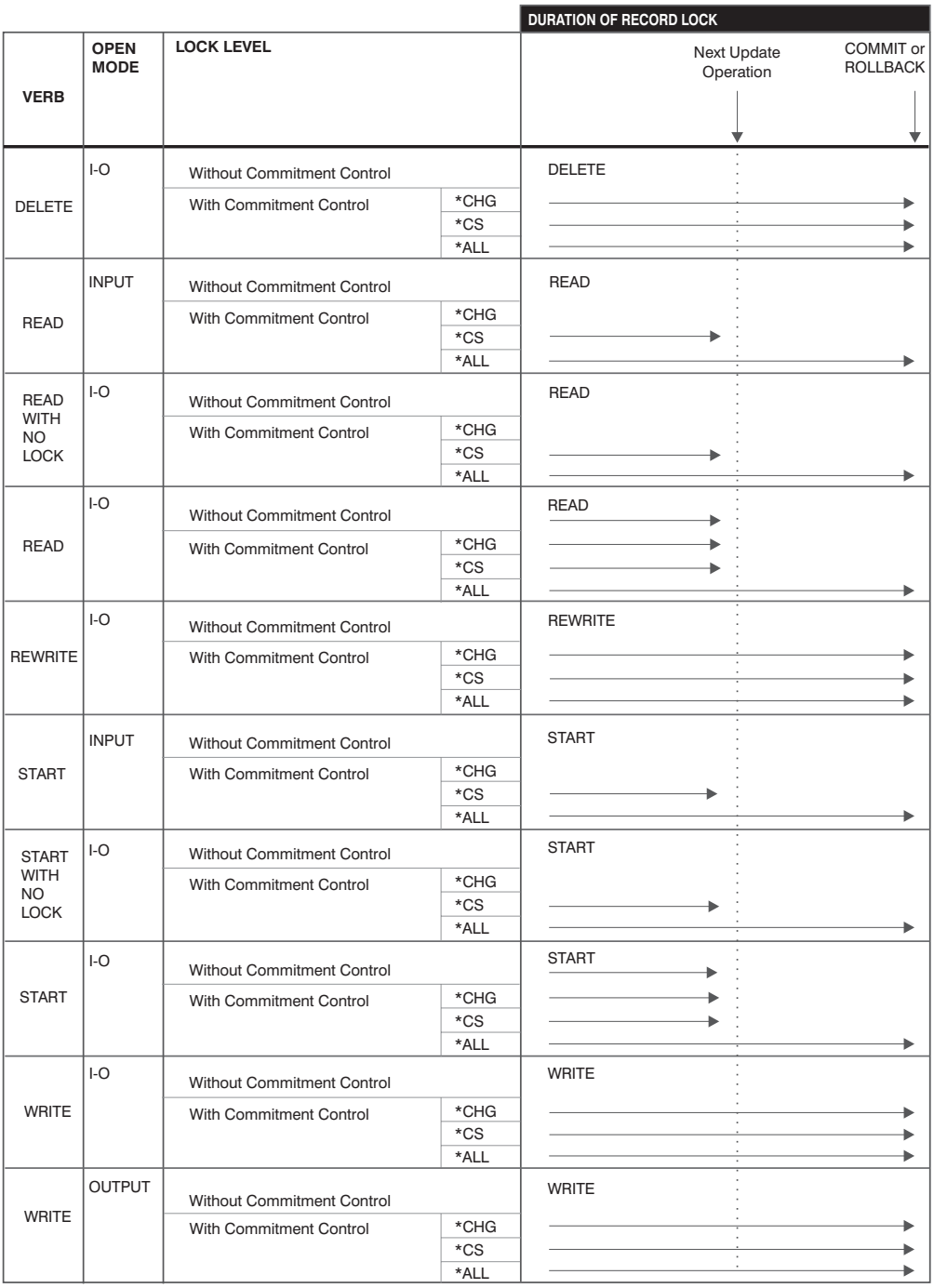
A locked record can only be modified within the same job and through the same physical or logical file.

The lock level also governs whether locked records can be read. With a high lock level (*ALL), you cannot read locked records in a database file. With a low lock

level (*CHG), you can read locked records in a database file, provided the file is opened as INPUT in your job, or opened as I-O and READ WITH NO LOCK is used.

Other jobs, where files are *not* under commitment control, can always read locked records, regardless of the lock level used, provided the files are opened as INPUT. Because it is possible in some cases for other jobs to read locked records, data can be accessed *before it is permanently committed to a database*. If a ROLLBACK statement is processed *after* another job has read locked records, the data accessed will not reflect the contents of the database.

Figure 99 on page 396 shows record locking considerations for files with and without commitment control.



Note: Update operations include a START, READ, REWRITE, or DELETE operation for the same file (regardless of whether it is successful or unsuccessful), and closing the file. A WRITE operation is not considered an update operation; therefore, no lock will be set or released as the result of a WRITE operation.

Figure 99. Record Locking Considerations with and without Commitment Control

A file under commitment control can be closed or opened without affecting the status of changes made since the last commitment boundary. A COMMIT must still be issued to make the changes permanent, or a ROLLBACK issued to cancel the changes. A COMMIT statement, when processed, leaves files in the same open or closed state as before processing.

If you have Version 2 Release 3 Modification 0 or earlier of the OS/400 licensed program, all files opened under the same commitment definition within a job must
be journaled to the same journal. If you have Version 3 Release 1 or later, this
restriction no longer applies in most situations. For more information about journal management and its related functions, and for more information about commitment control, refer to the *Backup and Recovery* manual.

Commitment control must also be specified outside ILE COBOL through the OS/400 control language (CL). The Start Commitment Control (STRCMTCTL) command establishes the capability for commitment control and sets the level of record locking at the high level (*ALL), the cursor stability level (*CS), or the low level (*CHG).

When commitment control is started by using the STRCMTCTL command, the system creates a **commitment definition**. Each commitment definition is known only to the job or the activation group within the job that issued the STRCMTCTL command, depending on the commitment control scoping. The commitment definition contains information pertaining to the resources being changed under commitment control within that job or activation group within the job. The commitment control information in the commitment definition is maintained by the system as the commitment resources change.

The STRCMTCTL command does not automatically initiate commitment control for a file. That file must also be specified in the COMMITMENT CONTROL clause of the I-O-CONTROL paragraph within the ILE COBOL program. The commitment control environment is normally ended by using the End Commitment Control (ENDCMTCTL) command. This causes any uncommitted changes for database files under commitment control to be canceled. (An implicit ROLLBACK is processed.) For more information on the STRCMTCTL and ENDCMTCTL commands, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site
-http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

For more information about commitment control, see the *Backup and Recovery* manual.

Note: The ability to prevent reading of uncommitted data that has been changed is a function of commitment control and is only available if you are running under commitment control. Normal (noncommitted) database support is not changed by the commitment control extension, and allows reading of locked records when a file that is opened only for input is read. Try to use files consistently. Typically, files should always be run under commitment control or never be run under commitment control.

Commitment Control Scoping

Multiple commitment definitions can be started and used by program objects running within a job. Each commitment definition for a job identifies a separate transaction that has resources associated with it. These resources can be committed or rolled back independently of all other commitment definitions started for the job.

The **scope** for a commitment definition indicates which programs, that run within the job, use that commitment definition. Commitment definitions can be scoped in two ways:
- At the activation group level

- At the job level.

You specify the scope for a commitment definition on the CMTSCOPE parameter of the STRCMTCTL command.

The default scope for a commitment definition is to the activation group of the program issuing the STRCMTCTL command. Only program objects that run within that activation group will use that commitment definition. The commitment definition started at the activation group level for the OPM default activation group is known as the default activation group (*DFTACTGRP) commitment definition. Each activation group may have its own commitment definition.

A commitment definition can also be scoped to the job. Any program object running in an activation group that does not have a commitment definition started at the activation group level uses the job level commitment definition. This occurs if the job level commitment definition has already been started by another program object for the job. Only a single job level commitment definition can be started for a job.

For a given activation group, only a single commitment definition can be used by the program objects that run within that activation group. Program objects that run within an activation group can use the commitment definition at either the job level or the activation group level. However, they cannot use both commitment definitions at the same time.

When an ILE COBOL program performs a commitment control operation, it does not directly indicate which commitment definition to use for the request. Instead, the system determines which commitment definition to use based on which activation group the requesting program object is running in.

Files associated with a commitment definition scoped to an ILE activation group will be closed and implicitly committed when the activation group ends normally. When an activation group ends abnormally, files associated with a commitment definition scoped to the activation group will be rolled back and closed.

Refer to the *ILE Concepts* book for further information about commitment control scoping.

Example of Using Commitment Control

Figure 102 on page 400 illustrates a possible usage of commitment control in a banking environment. The program processes transactions for transferring funds from one account to another. If no problems occur during the transaction, the changes are committed to the database file. If the transfer cannot take place because of improper account number or insufficient funds, a ROLLBACK is issued to cancel the changes.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* ACCOUNT MASTER PHYSICAL FILE -- ACCTMST
     A
     A                                     UNIQUE
     A          R ACCNTREC
     A            ACCNTKEY       5S
     A            NAME          20
     A            ADDR          20
     A            CITY          20
     A            STATE          2
     A            ZIP            5S
     A            BALANCE       10S 2
     A          K ACCNTKEY
```

Figure 100. Example of Use of Commitment Control -- Account Master File DDS

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* PROMPT SCREEN FILE NAME 'ACCTFMTS'
     A*
     A                                   1 INDARA
     A          R ACCTPMT
     A                                     TEXT('CUSTOMER ACCOUNT PROMPT')
     A
     A                                     CA01(15 'END OF PROGRAM')
     A                                     PUTRETAIN OVERLAY
     A                                   1  3'ACCOUNT MASTER UPDATE'
     A                                   3  3'FROM ACCOUTN NUMBER'
     A            ACCTFROM       5Y 0I  3 23CHECK(ME)
     A  99                                 ERRMSG('INVALID FROM ACCOUNT +
     A                                     NUMBER' 99)
     A  98                                 ERRMSG('INSUFFICIENT FUNDS IN FROM +
     A                                     ACCOUNT' 98)
     A                                   4  3'TO ACCOUNT NUMBER'
     A            ACCTTO         5Y 0I  4 23CHECK(ME)
     A  97                                 ERRMSG('INVALID TO ACCOUNT +
     A                                     NUMBER' 97)
     A                                   5  3'AMOUNT TRANSFERRED'
     A            TRANSAMT      10Y02I  5 23
     A          R ERRFMT
     A  96                               6  5'INVALID FILE STATUS'
     A  95                               7  5'INVALID KEY IN REWRITE'
     A  94                               8  5'EOF CONDITION IN READ'
```

Figure 101. Example of Use of Commitment Control -- Prompt Screen DDS

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL           CBLGUIDE/ACCOUNT     ISERIES1   03/09/15 13:53:23        Page      2
                             S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     ACCOUNT.
    3     000300 ENVIRONMENT DIVISION.
    4     000400 CONFIGURATION SECTION.
    5     000500 SOURCE-COMPUTER. IBM-ISERIES.
    6     000600 OBJECT-COMPUTER. IBM-ISERIES.
    7     000700 INPUT-OUTPUT SECTION.
    8     000800 FILE-CONTROL.
    9     000900     SELECT ACCOUNT-FILE  ASSIGN TO DATABASE-ACCTMST
   11     001000         ORGANIZATION IS INDEXED
   12     001100         ACCESS IS DYNAMIC
   13     001200         RECORD IS EXTERNALLY-DESCRIBED-KEY
   14     001300         FILE STATUS IS ACCOUNT-FILE-STATUS.
   15     001400     SELECT DISPLAY-FILE ASSIGN TO WORKSTATION-ACCTFMTS-SI  1
   17     001500         ORGANIZATION IS TRANSACTION.
          001600*****************************************************************
   18     001700 I-O-CONTROL.
   19     001800     COMMITMENT CONTROL FOR ACCOUNT-FILE.  2
          001900*****************************************************************
   20     002000 DATA DIVISION.
   21     002100 FILE SECTION.
   22     002200 FD  ACCOUNT-FILE.
   23     002300 01  ACCOUNT-RECORD.
          002400     COPY DDS-ALL-FORMATS OF ACCTMST.
   24    +000001       05  ACCTMST-RECORD PIC X(82).                                  <-ALL-FMTS
         +000002*    I-O FORMAT:ACCNTREC   FROM FILE ACCTMST    OF LIBRARY CBLGUIDE   <-ALL-FMTS
         +000003*                                                                    <-ALL-FMTS
         +000004*THE KEY DEFINITIONS FOR RECORD FORMAT  ACCNTREC                     <-ALL-FMTS
         +000005*  NUMBER              NAME               RETRIEVAL       ALTSEQ    <-ALL-FMTS
         +000006*   0001   ACCNTKEY                      ASCENDING         NO       <-ALL-FMTS
   25    +000007       05  ACCNTREC      REDEFINES ACCTMST-RECORD.                   <-ALL-FMTS
   26    +000008           06 ACCNTKEY              PIC S9(5).                      <-ALL-FMTS
   27    +000009           06 NAME                  PIC X(20).                      <-ALL-FMTS
   28    +000010           06 ADDR                  PIC X(20).                      <-ALL-FMTS
   29    +000011           06 CITY                  PIC X(20).                      <-ALL-FMTS
   30    +000012           06 STATE                 PIC X(2).                       <-ALL-FMTS
   31    +000013           06 ZIP                   PIC S9(5).                      <-ALL-FMTS
   32    +000014           06 BALANCE               PIC S9(8)V9(2).                 <-ALL-FMTS
          002500
   33     002600 FD  DISPLAY-FILE.
   34     002700 01  DISPLAY-REC.
          002800     COPY DDS-ALL-FORMATS OF ACCTFMTS.
   35    +000001       05  ACCTFMTS-RECORD PIC X(20).                                 <-ALL-FMTS
         +000002*  INPUT FORMAT:ACCTPMT    FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE  <-ALL-FMTS
         +000003*                          CUSTOMER ACCOUNT PROMPT                   <-ALL-FMTS
   36    +000004       05  ACCTPMT-I     REDEFINES ACCTFMTS-RECORD.                  <-ALL-FMTS
   37    +000005           06 ACCTFROM              PIC S9(5).                      <-ALL-FMTS
   38    +000006           06 ACCTTO                PIC S9(5).                      <-ALL-FMTS
   39    +000007           06 TRANSAMT              PIC S9(8)V9(2).                 <-ALL-FMTS
         +000008* OUTPUT FORMAT:ACCTPMT    FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE  <-ALL-FMTS
         +000009*                          CUSTOMER ACCOUNT PROMPT                   <-ALL-FMTS
         +000010*      05  ACCTPMT-O     REDEFINES ACCTFMTS-RECORD.                  <-ALL-FMTS
         +000011*  INPUT FORMAT:ERRFMT     FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE  <-ALL-FMTS
```

Figure 102. Example of Use of Commitment Control (Part 1 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ACCOUNT         ISERIES1   03/09/15 13:53:23        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        +000012*                                                                            <-ALL-FMTS
        +000013*      05  ERRFMT-I      REDEFINES ACCTFMTS-RECORD.                         <-ALL-FMTS
        +000014* OUTPUT FORMAT:ERRFMT     FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000015*                                                                            <-ALL-FMTS
        +000016*      05  ERRFMT-O      REDEFINES ACCTFMTS-RECORD.                         <-ALL-FMTS
         002900
   40    003000 WORKING-STORAGE SECTION.
   41    003100 77  ACCOUNT-FILE-STATUS           PIC X(2).
   42    003200 77  IND-ON                       PIC 1    VALUE B"1".
   43    003300 77  IND-OFF                      PIC 1    VALUE B"0".
   44    003400 01  DISPFILE-INDICS.
         003500     COPY DDS-ALL-FORMATS-INDIC OF ACCTFMTS.  3
   45   +000001       05  ACCTFMTS-RECORD.                                                 <-ALL-FMTS
        +000002*  INPUT FORMAT:ACCTPMT    FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000003*                          CUSTOMER ACCOUNT PROMPT                           <-ALL-FMTS
   46   +000004           06 ACCTPMT-I-INDIC.                                               <-ALL-FMTS
   47   +000005                07 IN15             PIC 1  INDIC 15.                       <-ALL-FMTS
        +000006*                          END OF PROGRAM                                    <-ALL-FMTS
   48   +000007                07 IN97             PIC 1  INDIC 97.                       <-ALL-FMTS
        +000008*                          INVALID TO ACCOUNT NUMBER                         <-ALL-FMTS
   49   +000009                07 IN98             PIC 1  INDIC 98.                       <-ALL-FMTS
        +000010*                          INSUFFICIENT FUNDS IN FROM ACCOUNT                <-ALL-FMTS
   50   +000011                07 IN99             PIC 1  INDIC 99.                       <-ALL-FMTS
        +000012*                          INVALID FROM ACCOUNT NUMBER                       <-ALL-FMTS
        +000013* OUTPUT FORMAT:ACCTPMT    FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000014*                          CUSTOMER ACCOUNT PROMPT                           <-ALL-FMTS
   51   +000015           06 ACCTPMT-O-INDIC.                                               <-ALL-FMTS
   52   +000016                07 IN97             PIC 1  INDIC 97.                       <-ALL-FMTS
        +000017*                          INVALID TO ACCOUNT NUMBER                         <-ALL-FMTS
   53   +000018                07 IN98             PIC 1  INDIC 98.                       <-ALL-FMTS
        +000019*                          INSUFFICIENT FUNDS IN FROM ACCOUNT                <-ALL-FMTS
   54   +000020                07 IN99             PIC 1  INDIC 99.                       <-ALL-FMTS
        +000021*                          INVALID FROM ACCOUNT NUMBER                       <-ALL-FMTS
        +000022*  INPUT FORMAT:ERRFMT     FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000023*                                                                            <-ALL-FMTS
        +000024*          06 ERRFMT-I-INDIC.                                                <-ALL-FMTS
        +000025* OUTPUT FORMAT:ERRFMT     FROM FILE ACCTFMTS   OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000026*                                                                            <-ALL-FMTS
   55   +000027           06 ERRFMT-O-INDIC.                                                <-ALL-FMTS
   56   +000028                07 IN94             PIC 1  INDIC 94.                       <-ALL-FMTS
   57   +000029                07 IN95             PIC 1  INDIC 95.                       <-ALL-FMTS
   58   +000030                07 IN96             PIC 1  INDIC 96.                       <-ALL-FMTS
         003600
   59    003700 PROCEDURE DIVISION.
   60    003800 DECLARATIVES.
         003900 ACCOUNT-ERR-SECTION SECTION.
         004000     USE AFTER STANDARD EXCEPTION PROCEDURE ON ACCOUNT-FILE.
         004100 ACCOUNT-ERR-PARAGRAPH.
   61    004200     IF ACCOUNT-FILE-STATUS IS NOT EQUAL "23" THEN
   62    004300         MOVE IND-ON TO IN96 OF ERRFMT-O-INDIC  4
         004400     ELSE
   63    004500         MOVE IND-ON TO IN95 OF ERRFMT-O-INDIC  5
         004600     END-IF
   64    004700     WRITE DISPLAY-REC FORMAT IS "ERRFMT"
         004800           INDICATORS ARE ERRFMT-O-INDIC
```

Figure 102. Example of Use of Commitment Control (Part 2 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ACCOUNT         ISERIES1   03/09/15 13:53:23        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        004900     END-WRITE
   65   005000     CLOSE DISPLAY-FILE
        005100           ACCOUNT-FILE.
   66   005200     STOP RUN.
        005300
        005400 DISPLAY-ERR-SECTION SECTION.
        005500     USE AFTER STANDARD EXCEPTION PROCEDURE ON DISPLAY-FILE.
        005600 DISPLAY-ERR-PARAGRAPH.
   67   005700     MOVE IND-ON TO IN94 OF ERRFMT-O-INDIC
   68   005800     WRITE DISPLAY-REC FORMAT IS "ERRFMT"
        005900          INDICATORS ARE ERRFMT-O-INDIC
        006000     END-WRITE
   69   006100     CLOSE DISPLAY-FILE
        006200           ACCOUNT-FILE.
   70   006300     STOP RUN.
        006400 END DECLARATIVES.
        006500
        006600 MAIN-PROGRAM SECTION.
        006700 MAINLINE.
   71   006800     OPEN I-O DISPLAY-FILE
        006900          I-O ACCOUNT-FILE.
   72   007000     MOVE ZEROS TO ACCTPMT-I-INDIC
        007100                   ACCTPMT-O-INDIC.
   73   007200     PERFORM WRITE-READ-DISPLAY.
   74   007300     PERFORM VERIFY-ACCOUNT-NO UNTIL IN15 EQUAL IND-ON.
   75   007400     CLOSE DISPLAY-FILE
        007500           ACCOUNT-FILE.
   76   007600     STOP RUN.
        007700
        007800 VERIFY-ACCOUNT-NO.
   77   007900     PERFORM VERIFY-TO-ACCOUNT.
   78   008000     IF IN97 OF ACCTPMT-O-INDIC EQUAL IND-OFF THEN
   79   008100         PERFORM VERIFY-FROM-ACCOUNT.
   80   008200     PERFORM WRITE-READ-DISPLAY.
        008300
        008400 VERIFY-FROM-ACCOUNT.
   81   008500     MOVE ACCTFROM TO ACCNTKEY.
   82   008600     READ ACCOUNT-FILE
   83   008700         INVALID KEY MOVE IND-ON TO IN99 OF ACCTPMT-O-INDIC
        008800     END-READ
   84   008900     IF IN99 OF ACCTPMT-O-INDIC EQUAL IND-ON THEN  6
        009000*
   85   009100         ROLLBACK
        009200*
        009300     ELSE
   86   009400         PERFORM UPDATE-FROM-ACCOUNT
        009500     END-IF.
        009600
        009700 VERIFY-TO-ACCOUNT.
   87   009800     MOVE ACCTTO TO ACCNTKEY.
   88   009900     READ ACCOUNT-FILE
   89   010000         INVALID KEY MOVE IND-ON TO IN97 OF ACCTPMT-O-INDIC  7
        010100     END-READ
   90   010200     IF IN97 OF ACCTPMT-O-INDIC EQUAL IND-ON THEN
        010300*
```

Figure 102. Example of Use of Commitment Control (Part 3 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/ACCOUNT        ISERIES1   03/09/15 13:53:23       Page      5
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   91     010400         ROLLBACK  8
          010500*
          010600     ELSE
   92     010700         PERFORM UPDATE-TO-ACCOUNT
          010800     END-IF.
          010900
          011000 UPDATE-TO-ACCOUNT.
   93     011100     ADD TRANSAMT TO BALANCE.
   94     011200     REWRITE ACCOUNT-RECORD.
          011300
          011400 UPDATE-FROM-ACCOUNT.
   95     011500     SUBTRACT TRANSAMT FROM BALANCE.
   96     011600     REWRITE ACCOUNT-RECORD.
   97     011700     IF BALANCE IS LESS THAN 0 THEN
   98     011800         MOVE IND-ON TO IN98 OF ACCTPMT-O-INDIC
          011900*
   99     012000         ROLLBACK  9
          012100*
          012200     ELSE
          012300*
  100     012400         COMMIT  10
          012500*
          012600     END-IF.
          012700
          012800 WRITE-READ-DISPLAY.
  101     012900     WRITE DISPLAY-REC FORMAT IS "ACCTPMT"
          013000         INDICATORS ARE ACCTPMT-O-INDIC  11
          013100     END-WRITE
  102     013200     MOVE ZEROS TO ACCTPMT-I-INDIC
          013300                   ACCTPMT-O-INDIC.
  103     013400     READ DISPLAY-FILE RECORD
          013500         INDICATORS ARE ACCTPMT-I-INDIC
          013600     END-READ.
          013700
          013800
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 102. Example of Use of Commitment Control (Part 4 of 4)

1 A separate indicator area is provided for the program.

2 The COMMITMENT CONTROL clause specifies files to be placed under commitment control. Any files named in this clause are affected by the COMMIT and ROLLBACK verbs.

3 The Format 2 COPY statement with the indicator attribute INDIC, defines data description entries in WORKING-STORAGE for the indicators to be used in the program.

4 IN96 is set if there is an invalid file status.

5 IN95 is set if there is an INVALID KEY condition on the REWRITE operation.

6 IN99 is set if the entered account number is invalid for the account from which money is being transferred.

7 IN97 is set if the entered account number is invalid for the account to which money is being transferred.

8 If an INVALID KEY condition occurs on the READ, a ROLLBACK is used and the record lock placed on the record after the first READ is released.

9 If the transfer of funds is not allowed (an indicator has been set), the ROLLBACK statement is processed. All changes made to database files under commitment control are canceled.

10 If the transfer of funds was valid (no indicators have been set), the COMMIT statement is processed, and all changes made to database files under commitment control become permanent.

11 The INDICATORS phrase is required for options on the work station display that are controlled by indicators.

Sorting and Merging Files

Arranging records in a particular sequence is a common requirement in data processing. Such record sequencing can be accomplished using sort or merge operations.

- The **sort** operation accepts unsequenced input and produces output in a specified sequence.
- The **merge** operation compares two or more sequenced files and combines them in sequential order.

To sort or merge files, you need to do the following:

1. Describe the input and output files, if any, for sorting or merging.
   - This is accomplished by selecting the files in the FILE-CONTROL paragraph of the INPUT-OUTPUT SECTION and by describing the file using FD (File Description) entries in the FILE SECTION of the DATA DIVISION.
2. Describe the sort files and merge files.
   - This is accomplished by selecting the sort or merge files in the FILE-CONTROL paragraph of the INPUT-OUTPUT SECTION and by describing the file using SD (Sort Description) entries in the FILE SECTION of the DATA DIVISION.
3. Specify the sort or merge operation.
   - This is accomplished by performing the SORT or MERGE statements in the PROCEDURE DIVISION.

Describing the Files

Sort files and merge files must be described with SELECT statements in the Environment Division and SD (Sort Description) entries in the Data Division. For example, see Figure 103 on page 405. The sort file or merge file described in an SD entry is the working file used during the sort or merge operation. You cannot execute any input/output statements for this file.

To describe files used for input to or output from a sort or merge operation, specify FD (File Description) entries in the Data Division. You can also sort or merge records that are defined only in the Working-Storage Section or Linkage Section. If you are only sorting or merging data items from the Working-Storage Section or Linkage Section and are not using files as input to or output from a sort or merge operation, you still need SD and FILE-CONTROL entries for the sort file or merge file.

Every SD entry must contain a record description, for example:

```
SD  SORT-WORK-1.
01  SORT-WORK-1-AREA.
    05  SORT-KEY-1      PIC X(10).
    05  SORT-KEY-2      PIC X(10).
    05  FILLER          PIC X(80).
```

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/SMPLSORT        ISERIES1   03/09/15 13:54:42        Page      2
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  SMPLSORT.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER. IBM-ISERIES
    6     000700 OBJECT-COMPUTER. IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
          001000*
          001100*    Assign name for a sort file is treated as documentation.
          001200*
    9     001300     SELECT SORT-WORK-1
   10     001400            ASSIGN TO DISK-SORTFILE1.
   11     001500     SELECT SORT-WORK-2
   12     001600            ASSIGN TO DISK-SORTFILE1.
   13     001700     SELECT INPUT-FILE
   14     001800            ASSIGN TO DISK-INFILE.
          001900
   15     002000 DATA DIVISION.
   16     002100 FILE SECTION.
   17     002200 SD  SORT-WORK-1.
   18     002300 01  SORT-WORK-1-AREA.
   19     002400     05  SORT-KEY-1             PIC X(10).
   20     002500     05  SORT-KEY-2             PIC X(10).
   21     002600     05  FILLER                 PIC X(80).
          002700
   22     002800 SD  SORT-WORK-2.
   23     002900 01  SORT-WORK-2-AREA.
   24     003000     05  SORT-KEY               PIC X(5).
   25     003100     05  FILLER                 PIC X(25).
          003200
   26     003300 FD INPUT-FILE.
   27     003400 01  INPUT-RECORD                PIC X(100).
          003500
          003600*    .
          003700*    .
          003800*    .
          003900
   28     004000 WORKING-STORAGE SECTION.
   29     004100 01  EOS-SW                      PIC X.
   30     004200 01  FILLER.
   31     004300     05  TABLE-ENTRY  OCCURS 100 TIMES
          004400                      INDEXED BY X1       PIC X(30).
          004500*    .
          004600*    .
          004700*    .
          004800
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 103. Environment and Data Division Entries for a Sort Program

The sort and merge files are processed with SORT or MERGE statements in the Procedure Division. The statement specifies the key field(s) within the record upon which the sort or merge is to be sequenced. You can specify a key or keys as ascending or descending, or when you specify more than one key, as a mixture of the two.

You can mix SORT and MERGE statements in the same ILE COBOL program. An ILE COBOL program can contain any number of sort or merge operations, each with its own independent input or output procedure.

You can perform more than one sort or merge operation in your ILE COBOL program, including:

- Multiple invocations of the same sort or merge operation
- Multiple different sort or merge operations.

However, one operation must be completed before another can begin.

Sorting Files

The **sort** operation accepts unsequenced input and produces output in a specified sequence.

You can specify **input** procedures to be performed on the sort records **before** they are sorted using the SORT...INPUT PROCEDURE statement.

You can specify **output** procedures to be performed on the sort records **after** they are sorted using the SORT...OUTPUT PROCEDURE statement.

You use input or output procedures to add, delete, alter, edit, or otherwise modify the records.

You can use the SORT statement to:

- Sort data items (including tables) in the Working-Storage Section or Linkage Section
- Read records directly into the new file without any preliminary processing using the SORT...USING statement
- Transfer sorted records directly to a file without further processing using the SORT...GIVING statement.

An ILE COBOL program containing a sort operation is usually organized so that one or more input files are read and operated on by an input procedure. Within the input procedure, a RELEASE statement places a record into the sort file. If you don't want to modify or process the records before the sorting operation begins, the SORT statement USING phrase releases the unmodified records from the specified input files to the new file.

After completion of the sorting operation, sorted records can be made available, one at a time, through a RETURN statement, for modification in an output procedure. If you don't want to modify or process the sorted records, the SORT statement GIVING option names the output file and writes the sorted records to an output file.

Refer to the *WebSphere Development Studio: ILE COBOL Reference* for further information on the SORT, RELEASE, and RETURN statements.

Merging Files

The **merge** operation compares two or more sequenced files and combines them in sequential order.

You have access to output procedures, used after merging, that can modify the output records using the MERGE...OUTPUT PROCEDURE statement.

Unlike the SORT statement, you cannot specify an input procedure in the MERGE statement; you must use the MERGE...USING statement.

It is not necessary to sequence input files prior to a merge operation. The merge operation sequences and combines them into one sequenced file.

When the MERGE statement is encountered in the Procedure Division, it begins the merge processing. This merge operation compares keys within the records of the input files, and passes the sequenced records, one at a time, to the RETURN statement of an output procedure or to the file named in the GIVING phrase.

If you want to process the merged records, they can be made available to your ILE COBOL program, one at a time, through a RETURN statement in an output procedure. If you don't want to modify or process the merged records, the MERGE statement GIVING phrase names the merged output file into which the merged records will be written.

Specifying the Sort Criteria

In the SORT statement, you specify the key on which the records will be sorted. The key must be defined in the record description of the records to be sorted. In the following example, notice that SORT-GRID-LOCATION and SORT-SHIFT are defined in the Data Division before they are used in the SORT statement.

```
 DATA DIVISION.

⋮
 SD  SORT-FILE.
 01  SORT-RECORD.
     05  SORT-KEY.
         10  SORT-SHIFT               PIC X(1).
         10  SORT-GRID-LOCATION       PIC X(2).
         10  SORT-REPORT              PIC X(3).
     05  SORT-EXT-RECORD.
         10  SORT-EXT-EMPLOYEE-NUM    PIC X(6).
         10  SORT-EXT-NAME            PIC X(30).
         10  FILLER                   PIC X(73).
 PROCEDURE DIVISION.

⋮
       SORT SORT-FILE
            ON ASCENDING KEY SORT-GRID-LOCATION SORT-SHIFT
            INPUT PROCEDURE 600-SORT3-INPUT
            OUTPUT PROCEDURE 700-SORT3-OUTPUT.

⋮
```

To sort on more than one key, as shown in the example above, list the keys in descending order of importance. The example also shows the use of an input procedure and an output procedure. Use an input procedure if you want to process the records before you sort them, and use an output procedure if you want to further process the records after you sort them.

Restrictions on Sort Key Length

There is no maximum number of keys, as long as the total length of the keys does not exceed 2000 bytes.

Floating-Point Considerations

Key data items may be floating-point for both the SORT (and MERGE) operations. If the key is an external floating-point item, it is treated as character data, which means that the sequence in which the records are sorted depends on the collating sequence used. If the key is an internal floating-point item, the sequence will be in numeric order.

Date-Time Data Type Considerations

Key data items may be of class date-time for both the SORT (and MERGE) operations. In general items of class date-time are only sorted as if they were date, time, and timestamp items for those items that match iSeries DDS date, time and timestamp formats; in all other cases they are treated as character data. Items of class date-time that are treated as character data ignore the collating sequence in

effect during the SORT or MERGE. For more information about using date-time data types in ILE COBOL programs, refer to "Working with Date-Time Data Types" on page 181.

The following is the list of DDS data types that are treated as date-time items for the purpose of sorting:
- DATE format *MDY
- DATE format *DMY
- DATE format *EUR
- DATE format *USA
- TIME format *USA.

Null-Value Considerations

Key data items may have null-values for both SORT (and MERGE) operations. In a database file, the null value occupies the highest value in the collating sequence. To be able to SORT (and MERGE) null-capable files containing null values, however, you need to first define the file as null-capable by specifying the ALWNULL keyword in the ASSIGN clause.

Alternate Collating Sequences

You can sort records on EBCDIC, ASCII, or another collating sequence. The default collating sequence is EBCDIC or the PROGRAM COLLATING SEQUENCE you specified in the Configuration Section. You can override the collating sequence named in the PROGRAM COLLATING SEQUENCE by using the COLLATING SEQUENCE phrase of the SORT statement. Consequently, you can use different collating sequences for multiple sorts in your program.

You can also specify the collating sequence that a program will use when it is run, at the time that you compile the ILE COBOL source program. You can specify the collating sequence to be used, through the SRTSEQ and LANGID parameters of the CRTCBLMOD and CRTBNDCBL commands. Refer to "Specifying National Language Sort Sequence in CRTCBLMOD" on page 47 for a description of how to specify the collating sequence at compile time. You can override the collating sequence specified at compile time by specifying the PROGRAM COLLATING SEQUENCE clause in the OBJECT-COMPUTER paragraph or by using the COLLATING SEQUENCE phrase of the SORT statement.

When you sort an ASCII file, you have to request the ASCII collating sequence. To do this, use the COLLATING SEQUENCE *alphabet-name* phrase of the SORT statement, where *alphabet-name* has been defined in the SPECIAL-NAMES paragraph as STANDARD-1. You can also specify this in the PROGRAM COLLATING SEQUENCE clause of the OBJECT-COMPUTER paragraph if no COLLATING SEQUENCE phrase is specified on the SORT or MERGE statement that overrides it.

Writing the Input Procedure

Use SORT...USING if you don't need to process the records in an input file(s) before they are released to the sort program. With SORT...USING *file-name*, the ILE COBOL compiler generates an input procedure to open the file, read the records, release the records to the sort program, and close the file.

The input file must not be open when the SORT statement is performed. If you want to process the records in the input file before they are released to the sort program, use the INPUT PROCEDURE option of the SORT statement.

Each input procedure must be represented as either a paragraph or a section. For example, to release records from a table in Working-Storage to the sort file, use the following:

```
 PROCEDURE DIVISION.

⋮
       SORT SORT-FILE
            ON ASCENDING KEY SORT-KEY
            INPUT PROCEDURE 600-SORT3-INPUT-PROC

⋮
 600-SORT3-INPUT-PROC SECTION.
       PERFORM WITH TEST AFTER
               VARYING X1 FROM 1 BY 1 UNTIL X1 = 100
            RELEASE SORT-RECORD  FROM  TABLE-ENTRY(X1)
       END-PERFORM.
```

An input procedure contains code for processing records and releasing them to the sort operation. You might want to use an input procedure to:

- Release data items to the sort file from Working-Storage
- Release records that have already been read in elsewhere in the program
- Read records from an input file, select or process them, and release them to the sort file.

To transfer records to the sort file, all input procedures must contain at least one RELEASE or RELEASE FROM statement.

Writing the Output Procedure

Use SORT...GIVING if you want to transfer the sorted records directly from the sort file into another file without any further processing. With SORT...GIVING *file-name*, the ILE COBOL compiler generates an output procedure to open the file, return the records, write the records, and close the file. At the time the SORT statement is performed, the file named with the GIVING phrase must not be open.

If you want to select, edit, or otherwise modify the sorted records before writing them from the sort work file into another file, use the OUTPUT PROCEDURE phrase of the SORT statement.

In the output procedure, you must use the RETURN statement to make each sorted record available to the output procedure. Your output procedure may then contain any statements necessary to process the records that are made available, one at a time, by the RETURN statement.

You can use RETURN INTO, instead of RETURN, to return and process records into Working-Storage or to an output area. You may also use the AT END phrase with the RETURN statement. The imperative statements on the AT END phrase are performed after all the records have been returned from the sort file.

Each output procedure must include at least one RETURN or RETURN INTO statement. Also, each output procedure must be represented as either a section or a paragraph.

Restrictions on the Input Procedures and Output Procedures

The following restrictions apply to the statements within input procedures and output procedures:

- The input procedures and output procedures must not contain any SORT or MERGE statements.
- The input procedures and output procedures must not contain any STOP RUN, EXIT PROGRAM, or GOBACK statements.
- A CALL statement to another program is permitted. The called program cannot perform a SORT or MERGE statement.
- You can use ALTER, GO TO, and PERFORM statements in the input procedures and output procedures to refer to procedure names outside the input procedure or output procedure; however, you must return to the input procedure or output procedure after a GO TO or PERFORM statement. Any COBOL procedure performed as a result of the GO TO statement or PERFORM statement must not contain any SORT or MERGE statements.
- The remainder of the Procedure Division must not contain any transfers of control to points inside the input procedure or output procedure (with the exception of the return of control from a Declarative Section).
- During a sort or merge operation, the SD data item is used. You should not use it in the output procedure before a RETURN statement is performed.

Determining Whether the Sort or Merge Was Successful

After a sort or merge operation is completed, a return code or completion code is stored in the SORT-RETURN special register. The SORT-RETURN special register contains a return code of 0 if the sort or merge operation was successful, or it contains 16 if the sort or merge operation was unsuccessful.

The contents of the SORT-RETURN special register changes after each SORT or MERGE statement is performed. You should test for successful completion after each SORT or MERGE statement. For example:

```
 PROCEDURE DIVISION.

⋮
       SORT SORT-WORK-2
            ON ASCENDING KEY SORT-KEY
            INPUT PROCEDURE 600-SORT3-INPUT-PROC
            OUTPUT PROCEDURE 700-SORT3-OUTPUT-PROC.
       IF SORT-RETURN NOT EQUAL TO 0
            DISPLAY "SORT ENDED ABNORMALLY. SORT-RETURN = " SORT-RETURN

⋮
 600-SORT3-INPUT-PROC SECTION.

⋮
 700-SORT3-OUTPUT-PROC SECTION.

⋮
```

Premature Ending of a Sort or Merge Operation

You can use the SORT-RETURN special register to end a sort or merge operation before it has completed. You set the SORT-RETURN special register to 16 in an error declarative or input/output procedure to end the sort or merge operation before all of the records have been processed. The sort or merge operation ends before a record is returned or released. Control then returns to the statement following the SORT or MERGE statement.

Sorting Variable Length Records

Files with variable length records have a minimum record length and a maximum record length, rather than a single record length.

If variable length records are being sorted or merged, all of the data items referenced by key data-names must be contained within the first *n* character positions of the record, where *n* is equal to the minimum record size specified for the file.

When processing the SORT statement, the ILE COBOL compiler will issue an error message if any KEY specified in the SORT statement falls in the record length beyond the minimum record size.

Sort records will be truncated when:

- The maximum record length of the input file record is greater than the maximum record length of the sort file record
- The maximum record length of the sort file record is greater than the maximum record length of the output file record.

A compile time error message is issued when truncation will occur; a diagnostic message is issued at run time.

Sort records will be padded with blanks when:

- The minimum record length of the input file record is less than the minimum record length of the sort file record
- The minimum record length of the sort file record is less than the minimum record length of the output file record.

A compile time informational message is issued when records will be padded with blanks; no message is issued at run time.

Example of Sorting and Merging Files

Figure 104 on page 412 illustrates the creation of sorted files of current sales and year-to-date sales.

First, the SORT statement for current sales is executed. The input procedure for this sorting operation is SCREEN-DEPT. The records are sorted in ascending order of department, and within each department, in descending order of net sales. The output for this sort is then printed.

After the sorting operation is completed, the current sales records are merged with the year-to-date sales records. The records in this file are merged in ascending order of department number and, within each department, in ascending order of employee numbers, and, for each employee, in ascending order of months to create an updated year-to-date master file.

When the merging process finishes, the updated year-to-date master file is printed.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/SORTMERG        ISERIES1   03/09/15 13:56:03        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  SORTMERGE.
          000300************************************************************
          000400* THIS IS A SORT/MERGE EXAMPLE USING AN INPUT PROCEDURE *
          000500************************************************************
    3     000600 ENVIRONMENT DIVISION.
    4     000700 CONFIGURATION SECTION.
    5     000800 SOURCE-COMPUTER. IBM-ISERIES
    6     000900 OBJECT-COMPUTER. IBM-ISERIES
    7     001000 INPUT-OUTPUT SECTION.
    8     001100 FILE-CONTROL.
    9     001200     SELECT WORK-FILE
   10     001300            ASSIGN TO DISK-WRK.
   11     001400     SELECT CURRENT-SALES-FILE-IN
   12     001500            ASSIGN TO DISK-CURRIN.
   13     001600     SELECT CURRENT-SALES-FILE-OUT
   14     001700            ASSIGN TO DISK-CURROUT.
   15     001800     SELECT YTD-SALES-FILE-IN
   16     001900            ASSIGN TO DISK-YTDIN.
   17     002000     SELECT YTD-SALES-FILE-OUT
   18     002100            ASSIGN TO DISK-YTDOUT.
   19     002200     SELECT PRINTER-OUT
   20     002300            ASSIGN TO PRINTER-PRTSUMM.
          002400
   21     002500 DATA DIVISION.
   22     002600 FILE SECTION.
   23     002700 SD  WORK-FILE.
   24     002800 01  SALES-RECORD.
   25     002900   05 EMPL-NO                 PIC 9(6).
   26     003000   05 DEPT                    PIC 9(2).
   27     003100   05 SALES                   PIC 9(7)V99.
   28     003200   05 NAME-ADDR               PIC X(61).
   29     003300   05 MONTH                   PIC X(2).
   30     003400 FD CURRENT-SALES-FILE-IN.
   31     003500 01 CURRENT-SALES-IN.
   32     003600   05 EMPL-NO                 PIC 9(6).
   33     003700   05 DEPT                    PIC 9(2).
   34     003800      88 ON-SITE-EMPLOYEE     VALUES 0 THRU 6, 8.
   35     003900   05 SALES                   PIC 9(7)V99.
   36     004000   05 NAME-ADDR               PIC X(61).
   37     004100   05 MONTH                   PIC X(2).
   38     004200 FD CURRENT-SALES-FILE-OUT.
   39     004300 01 CURRENT-SALES-OUT.
   40     004400   05 EMPL-NO                 PIC 9(6).
   41     004500   05 DEPT                    PIC 9(2).
   42     004600   05 SALES                   PIC 9(7)V99.
   43     004700   05 NAME-ADDR               PIC X(61).
   44     004800   05 MONTH                   PIC X(2).
   45     004900 FD YTD-SALES-FILE-IN.
   46     005000 01 YTD-SALES-IN.
   47     005100   05 EMPL-NO                 PIC 9(6).
   48     005200   05 DEPT                    PIC 9(2).
   49     005300   05 SALES                   PIC 9(7)V99.
```

Figure 104. Example of Use of SORT/MERGE (Part 1 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/SORTMERG        ISERIES1   03/09/15 13:56:03        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   50     005400   05 NAME-ADDR               PIC X(61).
   51     005500   05 MONTH                   PIC X(2).
   52     005600 FD YTD-SALES-FILE-OUT.
   53     005700 01 YTD-SALES-OUT.
   54     005800   05 EMPL-NO                  PIC 9(6).
   55     005900   05 DEPT                    PIC 9(2).
   56     006000   05 SALES                   PIC 9(7)V99.
   57     006100   05 NAME-ADDR               PIC X(61).
   58     006200   05 MONTH                   PIC X(2).
   59     006300 FD PRINTER-OUT.
   60     006400 01 PRINT-LINE.
   61     006500   05 RECORD-LABEL            PIC X(25).
   62     006600   05 DISK-RECORD-DISPLAY     PIC X(80).
          006700
   63     006800 WORKING-STORAGE SECTION.
   64     006900 01 SALES-FILE-IN-EOF-STATUS  PIC X        VALUE "F".
   65     007000    88 SALES-FILE-IN-END-OF-FILE           VALUE "T".
   66     007100 01 SALES-FILE-OUT-EOF-STATUS PIC X        VALUE "F".
   67     007200    88 SALES-FILE-OUT-END-OF-FILE          VALUE "T".
   68     007300 01 YTD-SALES-OUT-EOF-STATUS  PIC X        VALUE "F".
   69     007400    88 YTD-SALES-OUT-END-OF-FILE           VALUE "T".
          007500
   70     007600 PROCEDURE DIVISION.
          007700 MAIN-PROGRAM SECTION.
          007800 MAINLINE.
          007900
   71     008000     OPEN INPUT CURRENT-SALES-FILE-IN
          008100                CURRENT-SALES-FILE-OUT
          008200                YTD-SALES-FILE-OUT
          008300          OUTPUT PRINTER-OUT.
          008400*
          008500*    Sort current sales
          008600*
   72     008700     SORT WORK-FILE
          008800          ON ASCENDING KEY DEPT OF SALES-RECORD
          008900          ON DESCENDING KEY SALES OF SALES-RECORD
          009000          INPUT PROCEDURE SCREEN-DEPT
          009100          GIVING CURRENT-SALES-FILE-OUT.
   73     009200     READ CURRENT-SALES-FILE-OUT
   74     009300         AT END SET SALES-FILE-OUT-END-OF-FILE TO TRUE
          009400     END-READ.
   75     009500     PERFORM UNTIL SALES-FILE-OUT-END-OF-FILE
   76     009600         MOVE "SORTED CURRENT SALES "
          009700             TO RECORD-LABEL OF PRINT-LINE
   77     009800         MOVE CURRENT-SALES-OUT TO DISK-RECORD-DISPLAY
   78     009900         WRITE PRINT-LINE
   79     010000         READ CURRENT-SALES-FILE-OUT
   80     010100             AT END SET SALES-FILE-OUT-END-OF-FILE TO TRUE
          010200         END-READ
          010300     END-PERFORM.
          010400*
          010500*    Update yearly report
          010600*
   81     010700     MERGE WORK-FILE
          010800          ON ASCENDING KEY DEPT OF SALES-RECORD
```

Figure 104. Example of Use of SORT/MERGE (Part 2 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/SORTMERG        ISERIES1   03/09/15 13:56:03        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         010900          ON ASCENDING KEY EMPL-NO OF SALES-RECORD
         011000          ON ASCENDING KEY MONTH OF SALES-RECORD
         011100          USING YTD-SALES-FILE-IN
         011200                CURRENT-SALES-FILE-IN
         011300          GIVING YTD-SALES-FILE-OUT.
         011400*
         011500*    Print yearly report
         011600*
   82    011700     READ YTD-SALES-FILE-OUT
   83    011800         AT END SET YTD-SALES-OUT-END-OF-FILE TO TRUE
         011900     END-READ.
   84    012000     PERFORM UNTIL YTD-SALES-OUT-END-OF-FILE
   85    012100         MOVE "MERGED YTD SALES ",
         012200             TO RECORD-LABEL OF PRINT-LINE
   86    012300         MOVE YTD-SALES-OUT TO DISK-RECORD-DISPLAY
   87    012400         WRITE PRINT-LINE
   88    012500         READ YTD-SALES-FILE-OUT
   89    012600             AT END SET YTD-SALES-OUT-END-OF-FILE TO TRUE
         012700         END-READ
         012800     END-PERFORM.
         012900
   90    013000     CLOSE CURRENT-SALES-FILE-IN
         013100           CURRENT-SALES-FILE-OUT
         013200           YTD-SALES-FILE-OUT
         013300           PRINTER-OUT.
   91    013400     STOP RUN.
         013500
         013600 SCREEN-DEPT SECTION.
         013700 SCREEN-DEPT-PROCEDURE.
         013800
   92    013900     READ CURRENT-SALES-FILE-IN
   93    014000         AT END SET SALES-FILE-IN-END-OF-FILE TO TRUE
         014100     END-READ.
   94    014200     PERFORM UNTIL SALES-FILE-IN-END-OF-FILE
   95    014300         MOVE "UNSORTED CURRENT SALES ",
         014400             TO RECORD-LABEL OF PRINT-LINE
   96    014500         MOVE CURRENT-SALES-IN TO DISK-RECORD-DISPLAY
   97    014600         WRITE PRINT-LINE
   98    014700         IF ON-SITE-EMPLOYEE
   99    014800             MOVE CURRENT-SALES-IN TO SALES-RECORD
  100    014900             RELEASE SALES-RECORD
         015000         END-IF
  101    015100         READ CURRENT-SALES-FILE-IN
  102    015200             AT END SET SALES-FILE-IN-END-OF-FILE TO TRUE
         015300         END-READ
         015400     END-PERFORM.
         015500
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 104. Example of Use of SORT/MERGE (Part 3 of 3)

Declaring Data Items Using SAA Data Types

The ILE COBOL compiler allows you to convert variable-length fields from externally described files and SAA database data types to standard COBOL data items. The SAA data types you can convert are variable-length fields, date, time, timestamp fields, and DBCS-graphic and floating-point fields. ILE COBOL provides limited support for these variable-length fields.

Variable-length Fields

You can bring a variable-length field into your program if you specify *VARCHAR on the CVTOPT parameter of the CRTCBLMOD or CRTBNDCBL commands, or the VARCHAR option of the PROCESS statement. When *VARCHAR is specified, your ILE COBOL program will convert a variable-length field from an externally described file into an ILE COBOL group item.

An example of such a group item is:

```
06  ITEM1.
    49  ITEM1-LENGTH     PIC S9(4) COMP-4.
    49  ITEM1-DATA       PIC X(n).
```

where n represents the maximum length of the variable-length field. Within the program, the PIC S9(4) COMP-4 is treated like any other declaration of this type, and the PIC X(n) is treated as standard alphanumeric.

When *VARCHAR is not specified, variable-length fields are ignored and declared as FILLER fields in ILE COBOL programs. If *NOVARCHAR is specified, the item is declared as follows:

```
06  FILLER     PIC x(n+2).
```

For syntax information, see the CVTOPT parameter under "CVTOPT Parameter" on page 35.

Your program can perform any valid character operations on the generated data portion; however, because of the structure of the field, the length portion must be valid binary data. This data is not valid if it is negative, or greater than the maximum field length.

If the first two bytes of the field do not contain a valid binary number, an error will occur if you try to WRITE or REWRITE a record containing the field, and file status 90 is returned.

The following conditions apply when you specify variable-length fields:

- If a variable-length field is encountered when a Format 2 COPY statement is used in the Data Division, it is declared in an ILE COBOL program as a fixed-length character field.
- For single-byte character fields, the length of the declared ILE COBOL field is the number of single-byte characters in the DDS field plus 2 bytes.
- For DBCS-graphic data fields, the length of the declared ILE COBOL field is two times the number of DBCS-graphic characters in the DDS field plus 2 bytes. For more information on graphic data types, see "DBCS-Graphic Fields" on page 427. The two extra bytes in the ILE COBOL field contain a binary number that represents the current length of the variable-length field. Figure 105 shows the ILE COBOL field length of variable-length fields.

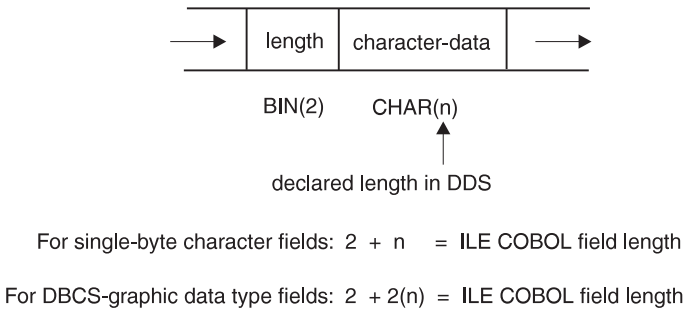


Figure 105. ILE COBOL Field Length of a Variable-Length Field

- Your ILE COBOL program can perform any valid character manipulation operations on the declared fixed-length field. However, because of the structure of the field, the first two bytes of the field must contain valid binary data (invalid current field-length data is less than 0, or greater than the DDS field

length). An error occurs for an input or output operation if the first two bytes of the field contain invalid field-length data; file status 90 is returned.

- If you do not specify *VARCHAR, you can encounter problems performing WRITE operations on variable-length fields, because you cannot assign a value to FILLER. The two-byte field may have a value (for example `X'4040'`) which gives a length beyond the range allowed for the field. This causes an I/O error.
- Variable length fields can not be used in a SORT/MERGE key as a variable length field. If the variable length field is used in a SORT/MERGE key, then the entire structure is compared as an alphanumeric data item.

To see an example of a program using variable-length fields, refer to "Examples of Using Variable-length DBCS-graphic Fields" on page 428.

Date, Time, and Timestamp Fields

In ILE COBOL programs, you can use DDS date, time, and timestamp fields in two ways:

- As date, time, or timestamp data items of class date-time
- As alphanumeric fields.

Class Date-Time

A DDS date, time, and timestamp field can be declared as a FILLER item in ILE COBOL or with its DDS name depending on the *DATETIME option of the CVTOPT parameter of CRTCBLMOD or CRTBNDCBL. If *NODATETIME is specified DDS date, time, and timestamp fields are declared as FILLER items in ILE COBOL. When *DATETIME is specified DDS date, time, and timestamp items are declared with their DDS names in ILE COBOL.

By default, DDS date, time, and timestamp fields create COBOL alphanumeric data items. That is, COPY DDS generates a PIC X(n) for each DDS date, time, or timestamp field. In order to generate a FORMAT clause, and thus create COBOL class date-time items, you must specify the CVTOPT values:

- *DATE for DDS date fields
- *TIME for DDS time fields
- *TIMESTAMP for DDS timestamp fields.

The equivalent PROCESS statement options for the above CVTOPT parameter values are DATE, TIME, and TIMESTAMP, respectively.

See "Working with Date-Time Data Types" on page 181 for more information of working with items of class date-time.

DDS zoned, packed, and character fields can have a DATFMT keyword. Normally, such fields will generate a PICTURE clause when a COPY DDS occurs. The resulting COBOL item will be a numeric zoned, a numeric packed, or an alphanumeric data type. However, you can use COPY DDS to generate a FORMAT clause for these items (in which case a COBOL date data item of class date-time is created). If you specify the *CVTTODATE value of the CVTOPT parameter, the DDS zoned, packed, and character fields with the DATFMT keyword will result in a date data item. The *NOCVTTODATE value of the CVTOPT parameter generates a numeric zoned, numeric packed, or alphanumeric field, respectively. These two values also exist on the PROCESS statement as CVTTODATE and NOCVTTODATE options.

Table 20 on page 417 and Table 21 on page 417 list the DATFMT parameters allowed for zoned, packed, and character DDS fields, and their equivalent ILE

COBOL format that is generated from COPY DDS when the CVTOPT(*CVTTODATE) conversion parameter is specified.

Table 20 is for character and zoned fields; USAGE DISPLAY is assumed.

Table 20. DATFMT Parameters Allowed for Character and Zoned Fields

OS/400 Format	COBOL-Generated Format	Description	Format	Length
*MDY	%m%d%y	MonthDayYear	mmddyy	6
*DMY	%d%m%y	DayMonthYear	ddmmyy	6
*YMD	%y%m%d	YearMonthDay	yymmdd	6
*JUL	%y%j	Julian	yyddd	5
*ISO	@Y%m%d	International Standards Organization	yyyymmdd	8
*USA	%m%d@Y	IBM USA Standard	mmddyyyy	8
*EUR	%d%m@Y	IBM European Standard	ddmmyyyy	8
*JIS	@Y%m%d	Japanese Industrial Standard Christian Era	yyyymmdd	8
*CMDY	@C%m%d%y	CenturyMonthDayYear	cmmddyy	7
*CDMY	@C%d%m%y	CenturyDayMonthYear	cddmmyy	7
*CYMD	@C%y%m%d	CenturyYearMonthDay	cyymmdd	7
*MDYY	%m%d@Y	MonthDayYear	mmddyyyy	8
*DMYY	%d%m@Y	DayMonthYear	ddmmyyyy	8
*YYMD	@Y%m%d	YearMonthDay	yyyymmdd	8
*YM	%y%m	YearMonth	yymm	4
*MY	%m%y	MonthYear	mmyy	4
*YYM	@Y%m	YearMonth	yyyymm	6
*MYY	%m@Y	MonthYear	mmyyyy	6
*LONGJUL	@Y%j	Julian	yyyyddd	7

Table 21 is for packed fields; USAGE PACKED-DECIMAL is generated.

Table 21. DATFMT Parameters Allowed for Packed Fields

OS/400 Format	COBOL-Generated Format	Description	Format	Length
*MDY	%m%d%y	MonthDayYear	mmddyy	4
*DMY	%d%m%y	DayMonthYear	ddmmyy	4
*YMD	%y%m%d	YearMonthDay	yymmdd	4
*JUL	%y%j	Julian	yyddd	3
*ISO	@Y%m%d	International Standards Organization	yyyymmdd	5
*USA	%m%d@Y	IBM USA Standard	mmddyyyy	5
*EUR	%d%m@Y	IBM European Standard	ddmmyyyy	5
*JIS	@Y%m%d	Japanese Industrial Standard Christian Era	yyyymmdd	5
*CMDY	@C%m%d%y	CenturyMonthDayYear	cmmddyy	4
*CDMY	@C%d%m%y	CenturyDayMonthYear	cddmmyy	4

Table 21. DATFMT Parameters Allowed for Packed Fields (continued)

OS/400 Format	COBOL-Generated Format	Description	Format	Length
*CYMD	@C%y%m%d	CenturyYearMonthDay	cyymmdd	4
*MDYY	%m%d@Y	MonthDayYear	mmddyyyy	5
*DMYY	%d%m@Y	DayMonthYear	ddmmyyyy	5
*YYMD	@Y%m%d	YearMonthDay	yyyymmdd	5
*YM	%y%m	YearMonth	yymm	3
*MY	%m%y	MonthYear	mmyy	3
*YYM	@Y%m	YearMonth	yyyymm	4
*MYY	%m@Y	MonthYear	mmyyyy	4
*LONGJUL	@Y%j	Julian	yyyyddd	4

Class Alphanumeric

This section describes how to use date, time, and timestamp data items as alphanumeric fields in ILE COBOL programs. Contrast this with using date, time, or timestamp data items of class date-time as described in "Class Date-Time" on page 416.

By default, DDS date, time or timestamp fields are brought into an ILE COBOL program as fixed-length character fields. Your ILE COBOL program can perform any valid character operations on the fixed-length fields. These operations will follow the standard COBOL rules for alphanumeric data items. The *NODATE, *NOTIME, and *NOTIMESTAMP CVTOPT parameter values of the CRTCBLMOD and CRTBNDCBL commands will cause COPY DDS to generate alphanumeric COBOL data items. These CVTOPT parameter values also exist on the PROCESS statement as: NODATE, NOTIME, and NOTIMESTAMP respectively.

Date, time, and timestamp fields are brought into your program only if you specify the *DATETIME option of the CVTOPT parameter of CRTCBLMOD or CRTBNDCBL command, or the DATETIME option of the PROCESS statement. For a description and the syntax of the CVTOPT parameter, see "CVTOPT Parameter" on page 35. If *DATETIME is not specified, date, time, and timestamp fields are ignored and are declared as FILLER fields in your ILE COBOL program.

The date, time, and timestamp data types each have their own format.

If a field containing date, time, or timestamp information is updated by your program, and the updated information is to be passed back to your database, the format of the field must be exactly the same as it was when the field was retrieved from the database. If you do not use the same format, an error will occur. For information on valid formats for each data type, see the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

To obtain information on how to enter source statements using the CL commands, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

If you try to WRITE a record before moving an appropriate value to a date, time, or timestamp field, the WRITE operation will fail, and file status 90 will be

returned. An error will also occur for a READ or START operation that tries to use a key field that is a date, time, or timestamp field, and that does not have an appropriate value.

If you declare date, time or timestamp items in your program as FILLER, do not attempt to WRITE records containing these fields, since you will not be able to set them to values that will be accepted by the system.

DDS date, time, and timestamp fields which are generated as alphanumeric data types in ILE COBOL can be specified as a SORT/MERGE key; however, they will be compared as alphanumeric data items, not as date, time, and timestamp data items.

Examples of How the *DATETIME Compiler Option Works with *DATE

Figure 106 defines the DDS date item DATEITEM. This section only describes how DDS date items are affected.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
      A          R DATETIME
      A*
      A            VARITEM      100          VARLEN
      A*
      A            TIMEITEM       T          TIMFMT(*HMS)
      A            DATEITEM       L          DATFMT(*YMD)
      A            TIMESTAMP      Z
```

Figure 106. DDS File Defining Date and Time Fields

The following examples show you how the combinations in which the *DATETIME option of the CVTOPT parameter can be specified with the *DATE option of the CVTOPT parameter, and how these combinations affect the way in which DATEITEM is brought into the program.

Example 1: If *NODATETIME is specified with *NODATE, DATEITEM is brought into the program as follows:

```
05 FILLER    PIC X(8).
```

Example 2: If *DATETIME is specified with *NODATE, DATEITEM is brought into the program as follows:

```
05 DATEITEM    PIC X(8).
```

Example 3: If *DATETIME is specified with *DATE, DATEITEM is brought into the program as follows:

```
05 DATEITEM    FORMAT DATE '%y/%m/%d'.
```

Example 4: If *NODATETIME is specified with *DATE, DATEITEM is brought into the program as follows:

```
05 FILLER    FORMAT DATE '%y/%m/%d'.
```

Null-Capable Fields

Null-capable fields are fields that can hold null values. The **null value** is a special value that is distinct from all non-null values, indicating the absence of any information. For example, a null value is not the same as a value of zero, all blanks, or hex zeroes. It is not equal to any value, not even to other null values.

For each field in a database record, there is a one-byte value that indicates whether or not the field is null. If the field *is null*, it contains the value 1; if the field *is not null*, it contains the value 0. This string of values is called the **null map**, and there is one null map for each record in a null-capable database file. Each record format in a null-capable database file has its own null map.

If a file is also keyed, then it contains a **null key map**. A null key map is a separate string of similarly defined values: one for each field in the key. There is one null key map for each record in a keyed null-capable database file. Each record format in a keyed null-capable database file has its own null key map.

The values in a null map can be boolean or alphanumeric, depending on how you define the null map in the WORKING-STORAGE section. If you are using an externally described file, and you specify a COPY-DDS statement WITH NULL-MAP, then one or more null maps with boolean values will be set up for you. If you specify a COPY-DDS statement WITH NULL-MAP-ALPHANUM, then one or more null maps with alphanumeric values will be set up for you. A COPY-DDS statement WITH NULL-KEY-MAP will generate one or more null key maps with boolean values. If you are using a program-described file, you can define the null map as either boolean or alphanumeric in the WORKING-STORAGE section.

NULL-MAP-ALPHANUM extends the range of values that can be received into or sent from the null map to include values other than 0 or 1. Only a value of 1 in a null map field indicates that the field is null. For more information on values other than 0 or 1 that can be sent or received in the null map, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

When a database record containing null-capable fields is accessed by an ILE COBOL program, the record's null key map, if one exists, and the record's null map are copied to or from the program's copy of the null map (null key map) by specifying a NULL-MAP (NULL-KEY-MAP) phrase on an I/O statement. For more information about using the NULL-MAP and NULL-KEY-MAP phrases on an I/O statement, refer to *WebSphere Development Studio: ILE COBOL Reference*.

Null-capable file I/O, positioning to a record, and deleting a record in a null-capable keyed file are discussed in the following sections:

- "Using Null Maps and Null Key Maps in Input and Output Operations"
- "Positioning to a Null-Capable Record in a Database File" on page 421
- "Deleting a Null-Capable Record in a Database File" on page 421.

For more information about handling error conditions for null-capable fields, refer to "Handling Errors in Operations Using Null-Capable Fields" on page 369. For more information about defining null-capable fields, and using null-capable fields with the COPY DDS statement, refer to *WebSphere Development Studio: ILE COBOL Reference*.

Using Null Maps and Null Key Maps in Input and Output Operations

Input and output operations can be done on null-capable fields using the NULL-MAP IS or NULL-KEY MAP IS phrases in these I/O statements:

- READ (Formats 1, 2 and 3)

- WRITE (Formats 1 and 2)
- REWRITE (Format 1).

These phrases work with the system's data management settings of the null map and null key maps that define the record and its key. The settings specified in these phrases can be subscripted or reference modified.

If the ALWNULL attribute has been specified on the ASSIGN clause, and on a WRITE or REWRITE statement you do not specify a NULL-MAP IS phrase, then a string of B'0's are passed. All of the fields in the record are assumed to *not* be null. If the file is an indexed file and you have specified a NULL-MAP IS phrase, then you must also specify a NULL-KEY-MAP IS phrase. You must ensure that for key fields, the values in the null key map are the same as the corresponding values in the null map.

If the ALWNULL attribute has been specified on the ASSIGN clause, and on a READ statement you do not specify a NULL-MAP IS phrase, then the null map will contain the same values that it contained before the READ. The same happens for null-capable keys, if you have not specified the NULL-KEY-MAP IS phrase. If the file is an indexed file and you have specified a NULL-MAP IS phrase, then you must also specify a NULL-KEY-MAP IS phrase.

For more information about the I/O statements that allow you to work with null-capable fields, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Positioning to a Null-Capable Record in a Database File

To position to a null-capable record in a database file, use the NULL-KEY-MAP IS phrase in the START statement. The object of this phrase can be subscripted or reference modified. If one of the key fields referenced in the START statement is null-capable and the NULL-KEY-MAP IS phrase is not used, a null map with all zeroes is used instead.

For more information about using the NULL-KEY-MAP IS phrase to position to a null-capable record in a database, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Deleting a Null-Capable Record in a Database File

To delete a null-capable record in a database file, use the NULL-KEY-MAP IS phrase in the DELETE statement. The object of this phrase can subscripted or reference modified. If one of the key fields referenced in the DELETE statement is null-capable and the NULL-KEY-MAP IS phrase is not used, a null map with all zeros is used, instead.

For more information about using the NULL-KEY-MAP IS phrase to delete a null-capable record in a database, refer to the *WebSphere Development Studio: ILE COBOL Reference*.

Example of Using Null Maps and Null Key Maps

```
*...+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* THIS IS THE STUDENT INFORMATION FILE  - NULLSTDT
     A
     A          R PERSON
     A            FNAME         20
     A            LNAME         30
     A            MARK           3P         ALWNULL
```

Figure 107. Example of Use of Null Map and Null Key Map—Student Information File DDS

```
*...+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* THIS IS THE CAR INFORMATION FILE  - NULLCAR
     A
     A                                      UNIQUE
     A          R CARS
     A            CARMODEL      25A         ALWNULL
     A            YEAR           4P
     A            OPTIONS        2P
     A            PRICE          7P 2
     A          K CARMODEL
```

Figure 108. Example of Use of Null Map and Null Key Map—Car Information File DDS

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/NULLMAP         ISERIES1   03/09/15 14:20:55        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID. NULLMAP.
    3     000300 ENVIRONMENT DIVISION.
    4     000400 CONFIGURATION SECTION.
    5     000500  SOURCE-COMPUTER.   IBM-ISERIES
    6     000600  OBJECT-COMPUTER.   IBM-ISERIES
    7     000700 INPUT-OUTPUT SECTION.
    8     000800  FILE-CONTROL.
    9     000900      SELECT NULLSTDT
   10     001000          ASSIGN TO DATABASE-NULLSTDT-ALWNULL  1
   11     001100          ORGANIZATION IS SEQUENTIAL
   12     001200          ACCESS IS SEQUENTIAL
   13     001300          FILE STATUS IS NULLSTDT-STATUS.
   14     001400      SELECT NULLCAR
   15     001500          ASSIGN TO DATABASE-NULLCAR-ALWNULL
   16     001600          ORGANIZATION IS INDEXED
   17     001700          ACCESS IS DYNAMIC
   18     001800          RECORD KEY IS EXTERNALLY-DESCRIBED-KEY
   19     001900          FILE STATUS IS NULLCAR-STATUS.
   20     002000 DATA DIVISION.
   21     002100 FILE SECTION.
   22     002200   FD NULLSTDT.
   23     002300   01 NULLSTDT-REC.
          002400      COPY DDS-ALL-FORMATS OF NULLSTDT.
   24    +000001       05  NULLSTDT-RECORD PIC X(52).                                    <-ALL-FMTS
         +000002*    I-O FORMAT:PERSON     FROM FILE NULLSTDT   OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000003*                                                                       <-ALL-FMTS
   25    +000004       05  PERSON        REDEFINES NULLSTDT-RECORD.                     <-ALL-FMTS
   26    +000005           06 FNAME                PIC X(20).                          <-ALL-FMTS
   27    +000006           06 LNAME                PIC X(30).                          <-ALL-FMTS
   28    +000007           06 MARK                 PIC S9(3)         COMP-3.  2        <-ALL-FMTS
         +000008*                  (Null-capable field)                                 <-ALL-FMTS
   29     002500   FD NULLCAR.
   30     002600   01 NULLCAR-REC.
          002700      COPY DDS-ALL-FORMATS OF NULLCAR.
   31    +000001       05  NULLCAR-RECORD PIC X(34).                                    <-ALL-FMTS
         +000002*    I-O FORMAT:CARS       FROM FILE NULLCAR    OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000003*                                                                       <-ALL-FMTS
         +000004*THE KEY DEFINITIONS FOR RECORD FORMAT  CARS                           <-ALL-FMTS
         +000005*  NUMBER              NAME               RETRIEVAL       ALTSEQ      <-ALL-FMTS
         +000006*   0001   CARMODEL                       ASCENDING         NO        <-ALL-FMTS
   32    +000007       05  CARS          REDEFINES NULLCAR-RECORD.                      <-ALL-FMTS
   33    +000008           06 CARMODEL             PIC X(25).                          <-ALL-FMTS
         +000009*                  (Null-capable field)                                 <-ALL-FMTS
   34    +000010           06 YEAR                 PIC S9(4)         COMP-3.           <-ALL-FMTS
   35    +000011           06 OPTIONS              PIC S9(2)         COMP-3.           <-ALL-FMTS
   36    +000012           06 PRICE                PIC S9(5)V9(2)    COMP-3.           <-ALL-FMTS
          002800
   37     002900 WORKING-STORAGE SECTION.
   38     003000 01 NULLSTDT-STATUS      PIC XX VALUE " ".
   39     003100 01 NULLCAR-STATUS      PIC XX VALUE " ".
   40     003200 01 NULLSTDT-NM.
          003300    COPY DDS-ALL-FORMATS OF NULLSTDT
```

Figure 109. Example of Use of Null Map and Null Key Map (Part 1 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/NULLMAP         ISERIES1   03/09/15 14:20:55       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
          003400           WITH NULL-MAP.  3
         +000001*    NULL MAP:  PERSON     FROM FILE NULLSTDT   OF LIBRARY CBLGUIDE          <-ALL-FMTS
         +000002*                                                                           <-ALL-FMTS
   41    +000003       05  PERSON-NM.  4                                                    <-ALL-FMTS
   42    +000004           06 FILLER               PIC X(2)  VALUE ZEROS.                  <-ALL-FMTS
   43    +000005           06 MARK-NF               PIC 1  VALUE B"0".  5                   <-ALL-FMTS
   44     003500 01 NULLCAR-NKM.
          003600    COPY DDS-ALL-FORMATS OF NULLCAR
          003700           WITH NULL-KEY-MAP
          003800           WITH NULL-MAP.
         +000001*    NULL MAP:  CARS       FROM FILE NULLCAR    OF LIBRARY CBLGUIDE          <-ALL-FMTS
         +000002*                                                                           <-ALL-FMTS
         +000003*   NULL KEY MAP:  6                                                        <-ALL-FMTS
   45    +000004       05  CARS-NKM.                                                       <-ALL-FMTS
   46    +000005           06 CARMODEL-NF           PIC 1  VALUE B"0".                      <-ALL-FMTS
   47    +000006       05  CARS-NM.                                                        <-ALL-FMTS
   48    +000007           06 CARMODEL-NF           PIC 1  VALUE B"0".                      <-ALL-FMTS
   49    +000008           06 FILLER                PIC X(3)  VALUE ZEROS.                  <-ALL-FMTS
          003900
   50     004000 PROCEDURE DIVISION.
          004100 MAINLINE.
   51     004200     OPEN OUTPUT NULLSTDT.
   52     004300     MOVE "JOHN"    TO FNAME OF PERSON.
   53     004400     MOVE "SMITH"   TO LNAME OF PERSON.
   54     004500     MOVE B"1"      TO MARK-NF OF PERSON-NM.  7
   55     004600     WRITE NULLSTDT-REC
          004700           NULL-MAP IS PERSON-NM.
   56     004800     CLOSE NULLSTDT.
          004900
   57     005000     OPEN INPUT  NULLSTDT.
   58     005100     MOVE " "       TO FNAME OF PERSON.
   59     005200     MOVE " "       TO LNAME OF PERSON.
   60     005300     MOVE B"0"      TO MARK-NF OF PERSON-NM.
   61     005400     READ NULLSTDT NULL-MAP IS PERSON-NM.
   62     005500     IF FNAME   OF PERSON    = "JOHN"  AND
          005600        LNAME   OF PERSON    = "SMITH" AND
          005700        MARK-NF OF PERSON-NM = B"1"    AND  8
          005800        NULLSTDT-STATUS     = "00"
   63     005900        DISPLAY "NAME IS CORRECT"
          006000     ELSE
   64     006100        DISPLAY "NAME IS NOT CORRECT"
          006200     END-IF.
   65     006300     CLOSE NULLSTDT.
          006400
   66     006500     OPEN EXTEND NULLSTDT.
   67     006600     MOVE "TOM"     TO FNAME OF PERSON.
   68     006700     MOVE "JONES"   TO LNAME OF PERSON.
   69     006800     MOVE B"1"      TO MARK-NF OF PERSON-NM.
   70     006900     WRITE NULLSTDT-REC NULL-MAP IS PERSON-NM.
   71     007000     CLOSE NULLSTDT.
          007100
   72     007200     OPEN INPUT  NULLSTDT.
   73     007300     MOVE " "       TO FNAME OF PERSON.
   74     007400     MOVE " "       TO LNAME OF PERSON.
   75     007500     MOVE B"0"      TO MARK-NF OF PERSON-NM.
```

Figure 109. Example of Use of Null Map and Null Key Map (Part 2 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/NULLMAP         ISERIES1   03/09/15 14:20:55        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        007600
   76   007700     READ NULLSTDT
        007800          NULL-MAP IS PERSON-NM.
   77   007900     READ NULLSTDT
        008000          NULL-MAP IS PERSON-NM.
   78   008100     IF FNAME   OF PERSON    = "TOM"   AND
        008200        LNAME   OF PERSON    = "JONES" AND
        008300        MARK-NF OF PERSON-NM = B"1"    AND
        008400        NULLSTDT-STATUS     = "00"
   79   008500        DISPLAY "NAME IS CORRECT"
        008600     ELSE
   80   008700        DISPLAY "NAME IS NOT CORRECT"
   81   008800        DISPLAY "NAME IS: " FNAME " " LNAME
        008900     END-IF.
   82   009000     CLOSE NULLSTDT.
        009100
   83   009200     OPEN EXTEND NULLSTDT.
   84   009300     MOVE "PETER"   TO FNAME OF PERSON.
   85   009400     MOVE "STONE"   TO LNAME OF PERSON.
   86   009500     MOVE B"1"      TO MARK-NF OF PERSON-NM.
   87   009600     WRITE NULLSTDT-REC
        009700           NULL-MAP IS PERSON-NM.
   88   009800     CLOSE NULLSTDT.
        009900
   89   010000     OPEN I-O NULLSTDT.
   90   010100     MOVE " "       TO FNAME OF PERSON.
   91   010200     MOVE " "       TO LNAME OF PERSON.
   92   010300     MOVE B"1"      TO MARK-NF OF PERSON-NM.
   93   010400     READ NULLSTDT
        010500          NULL-MAP IS PERSON-NM.
   94   010600     READ NULLSTDT
        010700          NULL-MAP IS PERSON-NM.
   95   010800     READ NULLSTDT
        010900          NULL-MAP IS PERSON-NM.
   96   011000     MOVE "BRICK" TO LNAME   OF PERSON.
   97   011100     MOVE B"0"    TO MARK-NF OF PERSON-NM.
   98   011200     REWRITE NULLSTDT-REC NULL-MAP IS PERSON-NM.
   99   011300     CLOSE NULLSTDT.
        011400
  100   011500     OPEN I-O   NULLSTDT.
  101   011600     MOVE " "       TO FNAME OF PERSON.
  102   011700     MOVE " "       TO LNAME OF PERSON.
  103   011800     MOVE B"1"      TO MARK-NF OF PERSON-NM.
  104   011900     READ NULLSTDT
        012000          NULL-MAP IS PERSON-NM.
  105   012100     READ NULLSTDT
        012200          NULL-MAP IS PERSON-NM.
  106   012300     READ NULLSTDT
        012400          NULL-MAP IS PERSON-NM.
  107   012500     IF FNAME   OF PERSON    = "PETER" AND
        012600        LNAME   OF PERSON    = "BRICK" AND
        012700        MARK-NF OF PERSON-NM = B"0"    AND
        012800        NULLSTDT-STATUS     ="00"
  108   012900        DISPLAY "NAME IS CORRECT"
        013000     ELSE
```

Figure 109. Example of Use of Null Map and Null Key Map (Part 3 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/NULLMAP         ISERIES1   03/09/15 14:20:55        Page      5
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  109     013100        DISPLAY "NAME IS NOT CORRECT"
  110     013200        DISPLAY "NAME IS: " FNAME " " LNAME
          013300     END-IF.
  111     013400     CLOSE NULLSTDT.
          013500*-------------------------------------------------------------*
          013600* WRITE records to indexed NULLCAR.                           *
          013700*-------------------------------------------------------------*
  112     013800     OPEN OUTPUT NULLCAR.
  113     013900     MOVE B"0"                TO CARMODEL-NF OF CARS-NKM.
  114     014000     MOVE B"0"                TO CARMODEL-NF OF CARS-NM.
  115     014100     MOVE "SUPERCAR"          TO CARMODEL    OF CARS.
  116     014200     MOVE 1995                TO YEAR        OF CARS.
  117     014300     MOVE 2                   TO OPTIONS     OF CARS.
  118     014400     MOVE 14799               TO PRICE       OF CARS.
  119     014500     WRITE NULLCAR-REC NULL-KEY-MAP IS CARS-NKM
          014600                       NULL-MAP IS CARS-NM.
  120     014700     MOVE "FASTCAR"           TO CARMODEL    OF CARS.
  121     014800     MOVE 1997                TO YEAR        OF CARS.
  122     014900     MOVE 5                   TO OPTIONS     OF CARS.
  123     015000     MOVE 18799               TO PRICE       OF CARS.
  124     015100     WRITE NULLCAR-REC NULL-KEY-MAP IS CARS-NKM
          015200                       NULL-MAP IS CARS-NM.  9
  125     015300     MOVE B"1"                TO CARMODEL-NF OF CARS-NKM.
  126     015400     MOVE B"1"                TO CARMODEL-NF OF CARS-NM.
  127     015500     MOVE 1996                TO YEAR        OF CARS.
  128     015600     MOVE 5                   TO OPTIONS     OF CARS.
  129     015700     MOVE 16199               TO PRICE       OF CARS.
  130     015800     WRITE NULLCAR-REC NULL-KEY-MAP IS CARS-NKM
          015900                       NULL-MAP IS CARS-NM.
  131     016000     CLOSE NULLCAR.
          016100
  132     016200     OPEN I-O NULLCAR.
  133     016300     MOVE B"0"                TO CARMODEL-NF OF CARS-NKM.
  134     016400     MOVE B"0"                TO CARMODEL-NF OF CARS-NM.
  135     016500     MOVE "SUPERCAR"          TO CARMODEL    OF CARS.
  136     016600     MOVE 0                   TO YEAR        OF CARS.
  137     016700     MOVE 0                   TO OPTIONS     OF CARS.
  138     016800     MOVE 0                   TO PRICE       OF CARS.
  139     016900     READ NULLCAR
          017000          NULL-KEY-MAP IS CARS-NKM
          017100          NULL-MAP     IS CARS-NM.
  140     017200     READ NULLCAR NEXT
          017300          NULL-KEY-MAP IS CARS-NKM
          017400          NULL-MAP     IS CARS-NM.
  141     017500     IF CARMODEL-NF OF CARS-NKM      = B"1"         AND
          017600        YEAR        OF CARS          = 1996         AND
          017700        OPTIONS     OF CARS          = 5            AND
          017800        PRICE       OF CARS          = 16199        AND
          017900        NULLCAR-STATUS             = "00"
  142     018000        DISPLAY "CAR IS CORRECT"
          018100     ELSE
  143     018200        DISPLAY "CAR IS NOT CORRECT"
  144     018300        DISPLAY "CAR IS: " CARMODEL " " YEAR " " OPTIONS " " PRICE
  145     018400        DISPLAY "NULLCAR-STATUS " NULLCAR-STATUS
          018500     END-IF.
  146     018600     CLOSE NULLCAR.
          018700
  147     018800     STOP RUN.
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 109. Example of Use of Null Map and Null Key Map (Part 4 of 4)

The sample program shown in Figure 109 on page 423 is an example of how to use null key maps and null maps in database files to track valid students and car models.

1 Defines the database file NULLSTDT as null-capable.

2 Defines data item MARK. The message (`Null-capable field`) appears below, since the field was defined as null-capable with the ALWNULL keyword in the DDS.

3 The null-capable DDS file NULLSTDT is brought into the program using the COPY DDS statement and the WITH NULL-MAP phrase.

4 The null map PERSON-NM is defined.

5 The data item MARK-NF is initialized to *not null* with a value of B″0″. A value of B″1″ in a null-capable field makes it null.

6 The null key map CARS-NKM is defined.

7 The record NULLSTDT-REC is written with the NULL-MAP IS PERSON-NM phrase, showing how the null map is used during a write operation. The NULL MAP IS phrase is also used in all of the other I/O operations.

8 The MARK-NF OF PERSON-NM data item is checked for a null value (B″1″).

9 The NULLCAR-REC record is written, and both the null key map and null map need to be referenced using the NULL-KEY-MAP IS and NULL-MAP IS phrases.

DBCS-Graphic Fields

The DBCS-graphic data type is a character string in which each character is represented by 2 bytes. The DBCS-graphic data type does not contain shift-out (SO) or shift-in (SI) characters. The difference between single-byte and DBCS-graphic data is shown in the following figure:

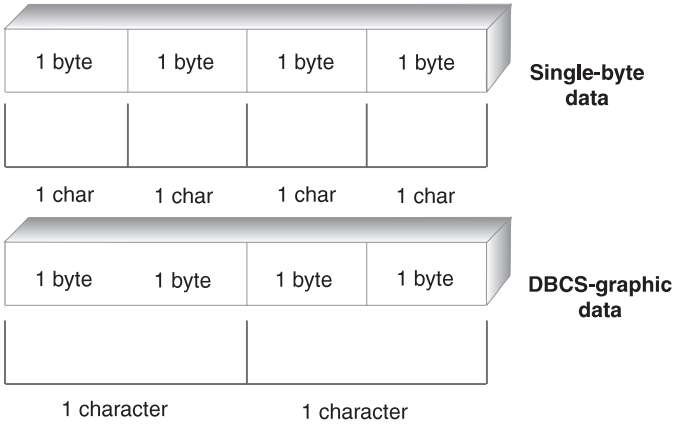


Figure 110. Comparing Single-byte and Graphic Data

DBCS-graphic data is brought into your ILE COBOL program only if you specify the *PICXGRAPHIC or *PICGGRAPHIC value on the CVTOPT parameter of the CRTCBLMOD or CRTBNDCBL commands, or the CVTPICXGRAPHIC or CVTPICGGRAPHIC option of the PROCESS statement. If you do not do this, graphic data is ignored and declared as FILLER fields in your ILE COBOL program. For a description and the syntax of the CVTOPT parameter, see "Parameters of the CRTCBLMOD Command" on page 28.

The following conditions apply when DBCS-graphic data is specified:

- DBCS-graphic data is copied into an ILE COBOL program as a fixed-length alphanumeric or DBCS field.
- Every DBCS-graphic data *character* has a length of 2 bytes.
- When *PICXGRAPHIC is specified, every fixed-length DBCS-graphic data *field* (for example, a field defined with PIC G(2) DISPLAY-1, as shown in Figure 110) has a length of the number of bytes in the field (a length of four bytes for the given example). When *PICGGRAPHIC is specified, every fixed-length

DBCS-graphic data field has a length of the number of double-byte characters (a length of two characters for the example).

Variable-length DBCS-graphic Fields

You can use variable-length fields in combination with DBCS-graphic data types, to specify variable-length DBCS-graphic data. To specify variable-length DBCS-graphic data, specify *VARCHAR and *PICXGRAPHIC for the CVTOPT parameter of the CRTCBLMOD or CRTBNDCBL commands, or the VARCHAR and CVTPICXGRAPHIC options for the PROCESS statement.

If you specify any of the following: CVTOPT(*NOVARCHAR *NOPICGGRAPHIC), CVTOPT(*NOVARCHAR *PICGGRAPHIC), CVTOPT(*NOVARCHAR *NOPICXGRAPHIC) or CVTOPT(*NOVARCHAR *PICXGRAPHIC) and the ILE COBOL compiler encounters a variable-length DBCS-graphic data item, the resulting program contains the following:

```
           06 FILLER           PIC X(2n+2).
      *         (Variable-length field)
```

where n is the number of characters in the DDS field.

If you specify CVTOPT(*VARCHAR *NOPICGGRAPHIC) or CVTOPT(*VARCHAR *NOPICXGRAPHIC), and the ILE COBOL compiler encounters a variable-length DBCS-graphic data item, the resulting program contains the following:

```
           06 NAME
      *         (Variable-length field)
              49 NAME-LENGTH       PIC S9(4) COMP-4.
      *                   (Number of 2-byte characters)
              49 FILLER            PIC X(2n).
```

where n is the number of DBCS characters in the DDS field.

If you specify CVTOPT(*VARCHAR *PICXGRAPHIC), and the ILE COBOL compiler encounters a variable-length DBCS-graphic data item, the resulting program contains the following:

```
           06 NAME
      *         (Variable-length field)
              49 NAME-LENGTH       PIC S9(4) COMP-4.
      *                   (Number of 2-byte characters)
              49 NAME-DATA         PIC X(2n).
```

where n is the number of DBCS characters in the DDS field.

If you specify CVTOPT(*VARCHAR *PICGGRAPHIC), and the ILE COBOL compiler encounters a variable-length DBCS-graphic data item, the resulting program contains the following:

```
           06 NAME
      *         (Variable-length field)
              49 NAME-LENGTH       PIC S9(4) COMP-4.
      *                   (Number of 2-byte characters)
              49 NAME-DATA         PIC G(n) DISPLAY-1.
```

where n is the number of DBCS characters in the DDS field.

Examples of Using Variable-length DBCS-graphic Fields

Figure 111 on page 429 shows an example of a DDS file that defines a variable-length DBCS-graphic data item. Figure 112 on page 429 shows the ILE COBOL program using a Format 2 COPY statement with *PICXGRAPHIC and the

resulting listing when the program is compiled. Figure 113 on page 430 shows the ILE COBOL program using variable length DBCS-graphic data items with *PICGGRAPHIC.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A          R SAMPLEFILE
     A*
     A            VARITEM      100          VARLEN
     A*
     A            TIMEITEM       T          TIMFMT(*HMS)
     A            DATEITEM       L          DATFMT(*YMD)
     A            TIMESTAMP      Z
     A*
     A            GRAPHITEM    100G
     A            VGRAPHITEM   100G         VARLEN
```

Figure 111. DDS File Defining a Variable-Length Graphic Data Field

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PGM1           ISERIES1   03/09/15 14:31:24        Page      2
                            S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        000100 process varchar datetime cvtpicxgraphic
    1   000200 Identification division.
    2   000300   Program-id.  pgm1.
        000400
    3   000500 Environment division.
    4   000600 Configuration section.
    5   000700   Source-computer.  ibm-iSeries
    6   000800   Object-computer.  ibm-iSeries
    7   000900 Input-output section.
    8   001000   File-control.
    9   001100     Select file1
   10   001200       assign to database-samplefi                                          00/08/15
   11   001300       organization is sequential
   12   001400       access is sequential
   13   001500       file status is fs1.
        001600
   14   001700 Data division.
   15   001800 File section.
   16   001900 fd  file1.
   17   002000 01  record1.
        002100 copy dds-all-formats of samplefi.                                          00/08/15
   18  +000001       05  SAMPLEFI-RECORD PIC X(546).                              <-ALL-FMTS
       +000002*    I-O FORMAT:SAMPLEFILE FROM FILE SAMPLEFI   OF LIBRARY CBLGUIDE  <-ALL-FMTS
       +000003*                                                                   <-ALL-FMTS
   19  +000004       05  SAMPLEFILE    REDEFINES SAMPLEFI-RECORD.                 <-ALL-FMTS
   20  +000005           06 VARITEM.                                              <-ALL-FMTS
       +000006*                 (Variable length field)                           <-ALL-FMTS
   21  +000007                49 VARITEM-LENGTH   PIC S9(4) COMP-4.              <-ALL-FMTS
   22  +000008                49 VARITEM-DATA     PIC X(100).                    <-ALL-FMTS
   23  +000009           06 TIMEITEM             PIC X(8).                       <-ALL-FMTS
       +000010*                 (Time field)                                      <-ALL-FMTS
   24  +000011           06 DATEITEM             PIC X(8).                       <-ALL-FMTS
       +000012*                 (Date field)                                      <-ALL-FMTS
   25  +000013           06 TIMESTAMP            PIC X(26).                      <-ALL-FMTS
       +000014*                 (Timestamp field)                                 <-ALL-FMTS
   26  +000015           06 GRAPHITEM            PIC X(200).                     <-ALL-FMTS
       +000016*                 (Graphic field)                                   <-ALL-FMTS
   27  +000017           06 VGRAPHITEM.                                           <-ALL-FMTS
       +000018*                 (Variable length field)                           <-ALL-FMTS
   28  +000019              49 VGRAPHITEM-LENGTH                                 <-ALL-FMTS
       +000020                                  PIC S9(4) COMP-4.                <-ALL-FMTS
       +000021*                 (Number of 2 byte Characters)                     <-ALL-FMTS
   29  +000022                49 VGRAPHITEM-DATA  PIC X(200).                    <-ALL-FMTS
       +000023*                 (Graphic field)                                   <-ALL-FMTS
   30   002200 Working-Storage section.
   31   002300 77  fs1      pic x(2).
        002400
   32   002500 Procedure division.
        002600 Mainline.
   33   002700     stop run.
                       * * * * *  E N D  O F  S O U R C E  * * * * *
```

*Figure 112. ILE COBOL Program Using Variable-Length DBCS-Graphic Data Items and *PICXGRAPHIC*

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/DBCSPICG        ISERIES1   03/09/05 14:48:02        Page      3
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         000100 process varchar datetime cvtpicggraphic                                                    00/08/21
    1    000200 Identification division.
    2    000300   Program-id.  dbcspicg.                                                                   00/08/21
         000400
    3    000500 Environment division.
    4    000600 Configuration section.
    5    000700   Source-computer.  ibm-iSeries
    6    000800   Object-computer.  ibm-iSeries
    7    000900 Input-output section.
    8    001000   File-control.
    9    001100     Select file1
   10    001200       assign to database-samplefi                                                         00/08/15
   11    001300       organization is sequential
   12    001400       access is sequential
   13    001500       file status is fs1.
         001600
   14    001700 Data division.
   15    001800 File section.
   16    001900 fd  file1.
   17    002000 01  record1.
         002100 copy dds-all-formats of samplefi.                                                          00/08/15
   18   +000001       05  SAMPLEFI-RECORD PIC X(546).                                    <-ALL-FMTS
        +000002*    I-O FORMAT:SAMPLEFILE FROM FILE SAMPLEFI   OF LIBRARY CBLGUIDE      <-ALL-FMTS
        +000003*                                                                        <-ALL-FMTS
   19   +000004       05  SAMPLEFILE    REDEFINES SAMPLEFI-RECORD.                     <-ALL-FMTS
   20   +000005           06 VARITEM.                                                  <-ALL-FMTS
        +000006*                (Variable length field)                                <-ALL-FMTS
   21   +000007                49 VARITEM-LENGTH   PIC S9(4) COMP-4.                   <-ALL-FMTS
   22   +000008                49 VARITEM-DATA     PIC X(100).                         <-ALL-FMTS
   23   +000009           06 TIMEITEM             PIC X(8).                           <-ALL-FMTS
        +000010*                (Time field)                                           <-ALL-FMTS
   24   +000011           06 DATEITEM             PIC X(8).                           <-ALL-FMTS
        +000012*                (Date field)                                           <-ALL-FMTS
   25   +000013           06 TIMESTAMP            PIC X(26).                          <-ALL-FMTS
        +000014*                (Timestamp field)                                      <-ALL-FMTS
   26   +000015           06 GRAPHITEM            PIC G(100) DISPLAY-1.               <-ALL-FMTS
        +000016*                (Graphic field)                                        <-ALL-FMTS
   27   +000017           06 VGRAPHITEM.                                               <-ALL-FMTS
        +000018*                (Variable length field)                                <-ALL-FMTS
   28   +000019                49 VGRAPHITEM-LENGTH                                    <-ALL-FMTS
        +000020                                PIC S9(4) COMP-4.                       <-ALL-FMTS
        +000021*                (Number of 2 byte Characters)                          <-ALL-FMTS
   29   +000022                49 VGRAPHITEM-DATA  PIC G(100) DISPLAY-1.               <-ALL-FMTS
        +000023*                (Graphic field)                                        <-ALL-FMTS
   30    002200 Working-Storage section.
   31    002300 77  fs1      pic x(2).
         002400
   32    002500 Procedure division.
         002600 Mainline.
   33    002700     stop run.
                    * * * * *  E N D  O F  S O U R C E  * * * * *
```

*Figure 113. ILE COBOL Program Using Variable-Length DBCS-Graphic Data Items and *PICGGRAPHIC*

Floating-point Fields

You can bring internal floating-point fields into your program if you specify *FLOAT on the CVTOPT parameter of the CRTCBLMOD or CRTBNDCBL commands, or the FLOAT option on the PROCESS statement.

When *FLOAT is specified, floating-point data types are brought into the program with their DDS names and a USAGE of COMP-1 (single-precision) or COMP-2 (double-precision). If you do not specify *FLOAT, floating-point data types are declared as FILLER fields with a USAGE of binary.

For example, if you specify *FLOAT for a single-precision floating-point field with the following DDS:

```
COMP1          9F         FLTPCN(*SINGLE)
```

the data item brought into the program is:

```
06  COMP1               COMP-1.
```

If you do not specify *FLOAT (or you specify *NOFLOAT) for the DDS specified above, the DDS field will be generated as follows:

```
06  FILLER      PIC 9(5)        COMP-4.
```

In general, floating-point data items can be used anywhere numeric decimal are used.

Chapter 18. Accessing Externally Attached Devices

This chapter describes how ILE COBOL interacts with externally attached devices. These devices are externally attached hardware such as printers, tape units, diskette units, display stations, and other systems.

You can access externally attached devices from ILE COBOL by using device files. **Device Files** are files that provide access to externally attached devices such as displays, printers, tapes, diskettes, and other systems that are attached by a communications line.

Types of Device Files

Before your ILE COBOL program can read or write to the devices on the system, a device description that identifies the hardware capabilities of the device to the operating system must be created when the device is configured. A device file specifies how a device can be used. By referring to a specific device file, your ILE COBOL program uses the device in the way that it is described to the system. The device file formats output data from your ILE COBOL program for presentation to the device, and formats input data from the device for presentation to your ILE COBOL program.

You use the device files listed in Table 22 to access the associated externally attached devices:

Table 22. Device files and their associated externally attached devices

Device File	Associated Externally Attached Device	CL commands	ILE COBOL Device Name	ILE COBOL Default File Name
Printer Files	Provide access to printer devices and describe the format of printed output.	CRTPRTF CHGPRTF OVRPRTF	PRINTER FORMATFILE	QPRINT
Tape Files	Provide access to data files which are stored on tape devices.	CRTTAPF CHGTAPF OVRTAPF	TAPEFILE	QTAPE
Diskette Files	Provide access to data files which are stored on diskette devices.	CRTDKTF CHGDKTF OVRDKTF	DISKETTE	QDKT
Display Files	Provide access to display devices.	CRTDSPF CHGDSPF OVRDSPF	WORKSTATION	
ICF Files	Allow a program on one system to communicate with a program on another system.	CRTICFF CHGICFF OVRICFF	WORKSTATION	

The device file contains the file description, which identifies the device to be used; it does not contain data.

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Accessing Printer Devices

You can create printed output on a printer device from an ILE COBOL program by issuing a WRITE statement to one or more printer files. You can use one of the IBM-supplied printer files, such as QPRINT, or you can create your own printer files using the Create Print File (CRTPRTF) command. For further information on the CRTPRTF command, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

To use a printer file in an ILE COBOL program, you must:

- Name the printer file through a file control entry in the FILE-CONTROL paragraph of the Environment Division
- Describe the printer file through a file description entry in the Data Division.

The file operations that are valid for a printer file are WRITE, OPEN, and CLOSE.

Naming Printer Files

To use a printer file in an ILE COBOL program, you must name the printer file through a file control entry in the FILE-CONTROL paragraph of the Environment Division. See the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the FILE-CONTROL paragraph. You can use more than one printer file in an ILE COBOL program but each printer file must have a unique name.

Printer files can be program-described files or externally-described files.

You name a program-described printer file in the FILE-CONTROL paragraph as follows:

```
FILE-CONTROL.
    SELECT printer-file-name
        ASSIGN TO PRINTER-printer_device_name
        ORGANIZATION IS SEQUENTIAL.
```

You name an externally described printer file in the FILE-CONTROL paragraph as follows:

```
FILE-CONTROL.
    SELECT printer-file-name
        ASSIGN TO FORMATFILE-printer_device_name
        ORGANIZATION IS SEQUENTIAL.
```

You use the SELECT clause to choose a file. This file must be identified by a FD entry in the Data Division.

You use the ASSIGN clause to associate the printer file with a printer device. You must specify a device type of PRINTER in the ASSIGN clause to use a program-described printer file. To use an externally-described printer file, you must specify a device type of FORMATFILE in the ASSIGN clause.

Use ORGANIZATION IS SEQUENTIAL in the file control entry when you name a printer file.

Describing Printer Files

Once you have named the printer file in the Environment Division, you must then describe the printer file through a file description entry in the Data Division. See

the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the File Description Entry. Use the Format 4 File Description Entry to describe a printer file.

Printer files can be program-described or externally described. Program-described printer files are assigned to a device of PRINTER. Externally described printer files are assigned to a device of FORMATFILE. Using FORMATFILE allows you to exploit the AS/400 function to its maximum, and using PRINTER allows for greater program portability.

The use of externally described printer files has the following advantages over program-described printer files:

- Multiple lines can be printed by one WRITE statement. When multiple lines are written by one WRITE statement and the END-OF-PAGE condition is reached, the END-OF-PAGE imperative statement is processed after all of the lines are printed. It is possible to print lines in the overflow area, and onto the next page before the END-OF-PAGE imperative statement is processed.

  Figure 116 on page 439 shows an example of an occurrence of the END-OF-PAGE condition through FORMATFILE.
- Optional printing of fields based on indicator values is possible.
- Editing of field values is easily defined.
- Maintenance of print formats, especially those used by multiple programs, is easier.

Use of the ADVANCING phrase for FORMATFILE files causes a compilation error to be issued. Advancing of lines is controlled in a FORMATFILE file through DDS keywords, such as SKIPA and SKIPB, and through the use of line numbers.

Describing Program-Described Printer Files

Program described printer files must be assigned to a device of PRINTER. A simple file description entry in the Data Division that describes a program described printer file looks as follows:

```
FD  print-file.
01  print-record              PIC X(132).
```

Using the LINAGE Clause to Handle Spacing and Paging Controls: You can request all spacing and paging controls be handled internally by compiler generated code by specifying the LINAGE clause in the file description entry of a program described printer file.

```
FD  print-file
    LINAGE IS integer-1 LINES
           WITH FOOTING AT integer-2
           LINES AT TOP integer-3
           LINES AT BOTTOM integer-4.
01  print-record              PIC X(132).
```

Paper positioning is done only when the first WRITE statement is run. The paper in the printer is positioned to a new physical page, and the LINAGE-COUNTER is set to 1. When the printer file is shared and other programs have written records to the file, the ILE COBOL WRITE statement is still considered to be the first WRITE statement. Paper positioning is handled by the ILE COBOL compiler even though it is not the first WRITE statement for that file.

All spacing and paging for WRITE statements is controlled internally. The physical size of the page is ignored when paper positioning is not properly defined for the ILE COBOL compiler. For a file that has a LINAGE clause and is assigned to

PRINTER, paging consists of spacing to the end of the logical page (page body) and then spacing past the bottom and top margins.

Use of the LINAGE clause degrades performance. The LINAGE clause should be used only as necessary. If the physical paging is acceptable, the LINAGE clause is not necessary.

Describing Externally Described Printer Files (FORMATFILE)

Externally described printer files must be assigned to a device of FORMATFILE. The term FORMATFILE is used because the FORMAT phrase is valid in WRITE statements for the file, and the data formatting is specified in the DDS for the file. A simple file description entry in the Data Division that describes an externally described printer file looks as follows:

```
FD  print-file.
01  print-record.
    COPY DDS-ALL-FORMATS-O OF print-file-dds.
```

Create a DDS for the FORMATFILE file you want to use. For information on creating a DDS, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Once you have created the DDS for the FORMATFILE file, use the Format 2 COPY statement to describe the layout of the printer file data record. When you compile your ILE COBOL program, the Format 2 COPY will create the Data Division statements to describe the printer file. Use the DDS-ALL-FORMATS-O option of the Format 2 COPY statement to generate one storage area for all formats.

When you have specified a device of FORMATFILE, you can obtain formatting of printed output in two ways:

1. Choose the formats to print and their order by using appropriate values in the FORMAT phrases specified for WRITE statements. For example, use one format once per page to produce a heading, and use another format to produce the detail lines on the page.
2. Choose the appropriate options to be taken when each format is printed by setting indicator values and passing these indicators through the INDICATOR phrase for the WRITE statement. For example, fields may be underlined, blank lines may be produced before or after the format is printed, or the printing of certain fields may be skipped.

The LINAGE clause should not be used for files assigned to FORMATFILE. If it is, then a compile time error message is issued indicating that the LINAGE clause has been ignored.

Writing to Printer Files

Before you can write to a printer file, you must first open the file. You use the Format 1 OPEN statement to open a printer file. A printer file must be opened for OUTPUT.

```
OPEN OUTPUT printer-file-name.
```

You use the WRITE statement to send output to a printer file. Use the Format 1 WRITE statement when you are writing to a program described printer file. Use the Format 3 WRITE statement when you are writing to an externally described printer file.

When the mnemonic-name associated with the function-name CSP is specified in the ADVANCING phrase of a WRITE statement for a printer file, it has the same effect as specifying ADVANCING 0 LINES. When the mnemonic-name associated with the function-name C01 is specified in the ADVANCING phrase of a WRITE statement for a printer file, it has the same effect as specifying ADVANCING PAGE.

The ADVANCING phrase cannot be specified in WRITE statements for files with an ASSIGN to device type FORMATFILE.

When you have finished using a printer file, you must close it. Use the Format 1 CLOSE statement to close the printer file. Once you close the file, it cannot be processed again until it is opened again.

```
CLOSE printer-file-name.
```

Example of Using FORMATFILE Files in an ILE COBOL Program

This program prints detailed employee records for all male employees from a personnel file. The input records are arranged in ascending order of employee number. Both the input file and output file are externally described.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* PHYSICAL FILE DDS FOR PERSONNEL FILE IN FORMATFILE EXAMPLE
     A
     A                                     UNIQUE
     A          R PERSREC
     A            EMPLNO         6S
     A            NAME          30
     A            ADDRESS1      35
     A            ADDRESS2      20
     A            BIRTHDATE      6
     A            MARSTAT        1
     A            SPOUSENAME    30
     A            NUMCHILD       2S
     A          K EMPLNO
```

Figure 114. Example of using FORMATFILE files in an ILE COBOL program -- Physical file DDS

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* PRINTER FILE DDS FOR FORMATFILE EXAMPLE
     A*
     A                                     1 INDARA REF(PERSFILE)
     A          R HEADING 2                  SKIPB(1) SPACE(3)  3
     A                                      15'PERSONNEL LISTING'
     A                                        UNDERLINE
     A                                      33'- ORDERED BY'
     A            ORDERTYPE     15          46
     A                                      80DATE EDTCDE(Y)
     A                                      93TIME   4
     A                                     115'PAGE:'
     A                                      +1PAGNBR EDTCDE(3)
     A*
     A          R DETAIL 5                   SPACEA(3) 6
     A*    LINE 1
     A                                       1'NAME:'
     A            NAME      R              11UNDERLINE
     A                                      55'EMPLOYEE NUMBER:'
     A            EMPLNO    R              73
     A                                      87'DATE OF BIRTH:'
     A            BIRTHDATE R             103SPACEA(1) 7
     A*    LINE 2
     A                                       1'ADDRESS:'
     A            ADDRESS1  R              11
     A                                      55'MARITAL STATUS:'
     A            MARSTAT   R              73
     A  01                                  87'SPOUSE''S NAME:'
     A  01 8      SPOUSENAMER             103
     A*    LINE 3
     A            ADDRESS2  R              11SPACEB(1)
     A                                      55'CHILDREN:'
     A            NUMCHILD  R              73EDTCDE(3) 9
```

Figure 115. Example of Using FORMATFILE Files in an ILE COBOL Program -- Printer File DDS

1 INDARA specifies that a separate indicator area is to be used for the file.

2 HEADING is the format name that provides headings for each page.

3 SKIPB(1) and SPACEA(3) are used to:
1. Skip to line 1 of the next page before format HEADING is printed.
2. Leave 3 blank lines after format HEADING is printed.

4 DATE, TIME, and PAGNBR are used to have the current date, time and page number printed automatically when format HEADING is printed.

5 DETAIL is the format name used to print the detail line for each employee in the personnel file.

6 SPACEA(3) causes three lines to be left blank after each employee detail line.

7 SPACEA(1) causes a blank line to be printed after the field BIRTHDATE is printed. As a result, subsequent fields in the same format are printed on a new line.

8 01 means that these fields are printed only if the ILE COBOL program turns indicator 01 on and passes it when format DETAIL is printed.

9 EDTCDE(3) is used to remove leading zeros when printing this numeric field.

```
5722WDS V5R3M0  030905 LN  IBM                 CBLGUIDE/FRMTFILE      ISERIES1   03/09/15 14:35:57        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     FRMTFILE.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER. IBM-ISERIES
    6     000700 OBJECT-COMPUTER. IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT PERSREPT ASSIGN TO FORMATFILE-PERSREPT-SI  1
   11     001100         ORGANIZATION IS SEQUENTIAL.
   12     001200     SELECT PERSFILE ASSIGN TO DATABASE-PERSFILE
   14     001300         ORGANIZATION IS INDEXED
   15     001400         ACCESS MODE IS SEQUENTIAL
   16     001500         RECORD IS EXTERNALLY-DESCRIBED-KEY.
          001600
   17     001700 DATA DIVISION.
   18     001800 FILE SECTION.
   19     001900 FD  PERSREPT.
   20     002000 01  PERSREPT-REC.
          002100     COPY DDS-ALL-FORMATS-O OF PERSREPT.  2
   21    +000001       05  PERSREPT-RECORD PIC X(130).                                    <-ALL-FMTS
         +000002* OUTPUT FORMAT:HEADING    FROM FILE PERSREPT   OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000003*                                                                        <-ALL-FMTS
   22    +000004       05  HEADING-O     REDEFINES PERSREPT-RECORD.                     <-ALL-FMTS
   23    +000005           06 ORDERTYPE             PIC X(15).                          <-ALL-FMTS
         +000006* OUTPUT FORMAT:DETAIL     FROM FILE PERSREPT   OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000007*                                                                        <-ALL-FMTS
   24    +000008       05  DETAIL-O      REDEFINES PERSREPT-RECORD.  3                   <-ALL-FMTS
   25    +000009           06 NAME                 PIC X(30).                          <-ALL-FMTS
   26    +000010           06 EMPLNO                PIC S9(6).                          <-ALL-FMTS
   27    +000011           06 BIRTHDATE             PIC X(6).                           <-ALL-FMTS
   28    +000012           06 ADDRESS1              PIC X(35).                          <-ALL-FMTS
   29    +000013           06 MARSTAT               PIC X(1).                           <-ALL-FMTS
   30    +000014           06 SPOUSENAME            PIC X(30).                          <-ALL-FMTS
   31    +000015           06 ADDRESS2              PIC X(20).                          <-ALL-FMTS
   32    +000016           06 NUMCHILD              PIC S9(2).                          <-ALL-FMTS
   33     002200 FD  PERSFILE.
   34     002300 01  PERSFILE-REC.
          002400     COPY DDS-ALL-FORMATS-O OF PERSFILE.
   35    +000001       05  PERSFILE-RECORD PIC X(130).                                    <-ALL-FMTS
         +000002*    I-O FORMAT:PERSREC    FROM FILE PERSFILE   OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000003*                                                                        <-ALL-FMTS
         +000004*THE KEY DEFINITIONS FOR RECORD FORMAT  PERSREC                         <-ALL-FMTS
         +000005*  NUMBER              NAME               RETRIEVAL       ALTSEQ       <-ALL-FMTS
         +000006*   0001   EMPLNO                        ASCENDING         NO          <-ALL-FMTS
   36    +000007       05  PERSREC       REDEFINES PERSFILE-RECORD.                     <-ALL-FMTS
   37    +000008           06 EMPLNO                PIC S9(6).                          <-ALL-FMTS
   38    +000009           06 NAME                  PIC X(30).                          <-ALL-FMTS
   39    +000010           06 ADDRESS1              PIC X(35).                          <-ALL-FMTS
   40    +000011           06 ADDRESS2              PIC X(20).                          <-ALL-FMTS
   41    +000012           06 BIRTHDATE             PIC X(6).                           <-ALL-FMTS
   42    +000013           06 MARSTAT               PIC X(1).                           <-ALL-FMTS
```

Figure 116. Example of Using FORMATFILE Files in an ILE COBOL Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM                          CBLGUIDE/FRMTFILE       ISERIES1   03/09/15 14:35:57       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   43    +000014           06 SPOUSENAME           PIC X(30).                               <-ALL-FMTS
   44    +000015           06 NUMCHILD             PIC S9(2).                               <-ALL-FMTS
         002500
   45    002600 WORKING-STORAGE SECTION.
   46    002700 77  HEAD-ORDER                   PIC X(15)
         002800                                   VALUE "EMPLOYEE NUMBER".
   47    002900 01  PERSREPT-INDICS.
         003000     COPY DDS-ALL-FORMATS-O-INDIC OF PERSREPT.  4
   48    +000001      05  PERSREPT-RECORD.                                                  <-ALL-FMTS
         +000002* OUTPUT FORMAT:HEADING    FROM FILE PERSREPT   OF LIBRARY CBLGUIDE          <-ALL-FMTS
         +000003*                                                                          <-ALL-FMTS
         +000004*          06 HEADING-O-INDIC.                                             <-ALL-FMTS
         +000005* OUTPUT FORMAT:DETAIL     FROM FILE PERSREPT   OF LIBRARY CBLGUIDE          <-ALL-FMTS
         +000006*                                                                          <-ALL-FMTS
   49    +000007           06 DETAIL-O-INDIC.                                              <-ALL-FMTS
   50    +000008                07 IN01            PIC 1  INDIC 01.                      <-ALL-FMTS
         003100
   51    003200 77  EOF-FLAG                     PIC X(1)
         003300                                   VALUE "0".
   52    003400    88  NOT-END-OF-FILE           VALUE "0".
   53    003500    88  END-OF-FILE               VALUE "1".
   54    003600 77  MARRIED                      PIC X(1)
         003700                                   VALUE "M".
         003800
   55    003900 PROCEDURE DIVISION.
         004000 MAIN-PROGRAM SECTION.
         004100 MAINLINE.
   56    004200     OPEN INPUT PERSFILE
         004300          OUTPUT PERSREPT.
   57    004400     PERFORM HEADING-LINE.
   58    004500     PERFORM UNTIL END-OF-FILE
   59    004600         READ PERSFILE
   60    004700             AT END SET END-OF-FILE TO TRUE
   61    004800             NOT AT END PERFORM PRINT-RECORD  5
         004900         END-READ
         005000     END-PERFORM
   62    005100     CLOSE PERSFILE
         005200           PERSREPT.
   63    005300     STOP RUN.
         005400
         005500 PRINT-RECORD.
   64    005600     MOVE CORR PERSREC TO DETAIL-O.  6
               *** CORRESPONDING items for statement 64:
               ***     EMPLNO
               ***     NAME
               ***     ADDRESS1
               ***     ADDRESS2
               ***     BIRTHDATE
               ***     MARSTAT
               ***     SPOUSENAME
               ***     NUMCHILD
               *** End of CORRESPONDING items for statement 64
   65    005700     IF MARSTAT IN PERSFILE-REC IS EQUAL MARRIED THEN  7
   66    005800         MOVE B"1" TO IN01 IN DETAIL-O-INDIC
         005900     ELSE
   67    006000         MOVE B"0" TO IN01 IN DETAIL-O-INDIC
         006100     END-IF
   68    006200     WRITE PERSREPT-REC FORMAT IS "DETAIL"  8
         006300         INDICATORS ARE DETAIL-O-INDIC
   69    006400         AT EOP PERFORM HEADING-LINE  9
         006500     END-WRITE.
         006600
         006700 HEADING-LINE.
   70    006800     MOVE HEAD-ORDER TO ORDERTYPE
   71    006900     WRITE PERSREPT-REC FORMAT IS "HEADING"
         007000     END-WRITE.
         007100
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 116. Example of Using FORMATFILE Files in an ILE COBOL Program (Part 2 of 2)

1 The externally described printer file is assigned to device FORMATFILE. SI indicates that a separate indicator area has been specified in the DDS.

2 The Format 2 COPY statement is used to copy the fields for the printer file into the program.

3 Note that, although the fields in format DETAIL will be printed on three separate lines, they are defined in one record.

4 The Format 2 COPY statement is used to copy the indicators used in the printer file into the program.

5 Paragraph PROCESS-RECORD processes PRINT-RECORD for each employee record.

6 All fields in the employee record are moved to the record for format DETAIL.

7 If the employee is married, indicator 01 is turned on; if not, the indicator is turned off, preventing the spouse's name field in DETAIL from being printed.

8 Format DETAIL is printed with indicator 01 passed to control printing.

9 If the number of lines per page has been exceeded, END-OF-PAGE occurs. The format HEADING is printed on a new page.

Accessing Files Stored on Tape Devices

You use **tape files** to read and write records on a tape device. Files stored on tape devices can be divided into the following two categories:

- **Sequential Single Volume:** A sequential file contained entirely on one volume. More than one file may be contained on this volume.
- **Sequential Multivolume:** A sequential file contained on more than one volume.

You can create your own tape files using the Create Tape File (CRTTAPF) command. For further information on the CRTTAPF command, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm. Alternately, you can use the default IBM-supplied tape file QTAPE. The tape file identifies the tape device to be used.

To use a file that is stored on a tape device, in your ILE COBOL program, you must:

- Name the file through a file control entry in the FILE-CONTROL paragraph of the Environment Division
- Describe the file through a file description entry in the Data Division.

You can only store a sequential file on a tape device because tape devices can only be accessed sequentially. Files stored on a tape device can have fixed or variable length records.

The file operations that are valid for a tape device are OPEN, CLOSE, READ, and WRITE.

Naming Files Stored on Tape Devices

To use a sequential file that is stored on a tape device, in your ILE COBOL program, you must name the file through a file control entry in the FILE-CONTROL paragraph of the Environment Division. See the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the FILE-CONTROL paragraph.

You name the file in the FILE-CONTROL paragraph as follows:

```
FILE-CONTROL.
    SELECT sequential-file-name
        ASSIGN TO TAPEFILE-tape_device_name
        ORGANIZATION IS SEQUENTIAL.
```

You use the SELECT clause to choose a file. This file must be identified by a FD entry in the Data Division.

You use the ASSIGN clause to associate the file with a tape device. You must specify a device type of TAPEFILE in the ASSIGN clause to use a tape file.

Use ORGANIZATION IS SEQUENTIAL in the file control entry when you name a file that you will access through a tape file.

Describing Files Stored on Tape Devices

Once you have named the sequential file in the Environment Division, you must then describe the file through a file description entry in the Data Division. See the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the File Description Entry. Use the Format 3 File Description Entry to describe a sequential file that is accessed through a tape file.

Tape files have no data description specifications (DDS). A sequential file that is stored on a tape device must be a program-described file. Your ILE COBOL program must describe the fields in the record format so the program can arrange the data received from or sent to the tape device in the manner specified by the tape file description.

A simple file description entry in the Data Division that describes a sequential file that is accessed through a tape file looks as follows:

```
FD  sequential-file-name.
01  sequential-file-record.
    05  record-element-1   PIC ... .
    05  record-element-2   PIC ... .
    05  record-element-3   PIC ... .
.
.
.
```

Describing Tape Files with Variable Length Records

You can store files that have variable length records on a tape device. You specify the Format 3 RECORD clause with the FD entry of the file to define the maximum and minimum record lengths for the file.

A simple file description entry in the Data Division that describes a sequential file with variable length records looks as follows:

```
FILE SECTION.
FD  sequential-file-name
    RECORD IS VARYING IN SIZE
              FROM integer-6 TO integer-7
              DEPENDING ON data-name-1.
01  minimum-sized-record.
    05  minimum-sized-element     PIC X(integer-6).
01  maximum-sized-record.
    05  maximum-sized-element     PIC X(integer-7).
⋮
WORKING-STORAGE SECTION.
```

```
77  data-name-1                 PIC 9(5).
:
```

The minimum record size of any record in the file is defined by *integer-6*. The maximum record size of any record in the file is defined by *integer-7*. Do not create records descriptions for the file which contain a record length that is less than that specified by *integer-6* nor a record length that is greater than that specified by *integer-7*. If any record descriptions break this rule, then a compile time error message is issued by the ILE COBOL compiler. The ILE COBOL compiler will then use the limits implied by the record description. The ILE COBOL compiler also issues a compile time error message when none of the record descriptions imply a record length that is as long as *integer-7*.

When a READ or WRITE statement is performed on a variable length record, the size of that record is defined by the contents of *data-name-1*.

Refer to the Format 3 RECORD clause in the *WebSphere Development Studio: ILE COBOL Reference* for a further description of how variable length records are handled.

Reading and Writing Files Stored on Tape Devices

Before you can read from or write to a file that is stored on a tape device, you must first open the file. You use the Format 1 OPEN statement to open the file. To read from a file stored on a tape device, you must open it in INPUT mode. To write to a file stored on a tape device, you must open it in OUTPUT or EXTEND mode. A file stored on a tape device **cannot** be opened in I-O mode. The following are examples of the OPEN statement.

```
OPEN INPUT sequential-file-name.
OPEN OUTPUT sequential-file-name.
OPEN EXTEND sequential-file-name.
```

You use the Format 1 READ statement to read a record from a sequential file stored on a tape device. The READ statement makes the next logical record from the file available to your ILE COBOL program. For a sequential multivolume file, if the end of volume is recognized during processing of the READ statement and the logical end of file has not been reached, the following actions are taken in the order listed:

1. The standard ending volume label procedure is processed.
2. A volume switch occurs.
3. The standard beginning volume label procedure is run.
4. The first data record of the next volume is made available.

Your ILE COBOL program will receive no indication that the above actions have occurred during the read operation.

You use the Format 1 WRITE statement to write a record to a sequential file stored on a tape device. For a sequential multivolume file, if the end of volume is recognized during processing of the WRITE statement, the following actions are taken in the order listed:

1. The standard ending volume label procedure is run.
2. A volume switch occurs.
3. The standard beginning volume label procedure is run.
4. The data record is written on the next volume.

No indication that an end of volume condition has occurred is returned to your ILE COBOL program.

When you have finished using a file stored on a tape device, you must close it. Use the Format 1 CLOSE statement to close the file. Once you close the file, it cannot be processed any longer until it is opened again.

```
CLOSE sequential-file-name.
```

The CLOSE statement also gives you the option of rewinding and unloading the volume.

Ordinarily, when the CLOSE statement is performed on a tape file, the volume is rewound. However, if you want the current volume to be left in its present position after the file is closed, specify the NO REWIND phrase on the CLOSE statement. When NO REWIND is specified, the reel is not rewound.

For sequential multivolume tape files, the REEL/UNIT FOR REMOVAL phrase causes the current volume to be rewound and unloaded. The system is then notified that the volume has been removed.

For further details on rewinding and unloading volumes, refer to the discussion on the Format 1 CLOSE statement in the *WebSphere Development Studio: ILE COBOL Reference*.

Reading and Writing Tape Files with Variable Length Records

When reading or writing variable length records to a tape file, ensure that the maximum variable length record is less than or equal to the maximum record length for the tape. The maximum record length for the tape is determined at the time that it is opened for OUTPUT. If the maximum record length on the tape is less than any of the variable length records being written to it, then these records will be truncated to the maximum record length for the tape.

You use the Format 1 READ statement to read a record from a sequential file stored on a tape device. The READ statement makes the next logical record from the file available to your ILE COBOL program.

If the READ operation is successful then *data-name-1*, if specified, will hold the number of the character positions of the record just read. If the READ operation is unsuccessful then *data-name-1* will hold the value it had before the READ operation was attempted.

When you specify the INTO phrase in the READ statement, the number of character positions in the current record that participate as the sending item in the implicit MOVE statement is determined by

- The contents of *data-name-1* if *data-name-1* is specified, or
- The number of character positions in the record just read if *data-name-1* is not specified.

When the READ statement is performed, if the number of character positions in the record that is read is less than the minimum record length specified by the record description entries for the file, the portion of the record area that is to the right of the last valid character read is filled with blanks. If the number of characters positions in the record that is read is greater than the maximum record length specified by the record description entries for the file, the record is truncated on the right to the maximum record size specified in the record description entries. A file status of 04 is returned when a record is read whose length falls outside the minimum or maximum record lengths defined in the file description entries for the file.

You use the Format 1 WRITE statement to write a variable length record to a sequential file stored on a tape device. You specify the length of the record to write in *data-name-1*. If you do not specify *data-name-1*, the length of the record to write is determined as follows:

- If the record contains an OCCURS...DEPENDING ON item, by the sum of the fixed portion and that portion of the table described by the number of occurrences at the time the WRITE statement is performed
- If the record does not contain an OCCURS...DEPENDING ON item, by the number of character positions in the record definition.

Accessing Files Stored on Diskette Devices

You use **diskette files** to read and write records on diskettes that are in the diskette device and that have been initialized in the basic, H, or I exchange format. File stored on diskette devices can be divided into the following two categories:

- **Sequential Single Volume:** A sequential file contained entirely on one diskette. More than one file may be contained on this diskette.
- **Sequential Multivolume:** A sequential file contained on more than one diskette.

You can create your own diskette files using the Create Diskette File (CRTDKTF) command. For further information on the CRTDKTF command, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm. Alternately, you can use the default IBM-supplied diskette file QDKT. The diskette file identifies the diskette device to be used.

To use a file that is stored on a diskette device, in your ILE COBOL program, you must:

- Name the file through a file control entry in the FILE-CONTROL paragraph of the Environment Division
- Describe the file through a file description entry in the Data Division.

You can only store a sequential file on a diskette device because diskette devices can only be accessed sequentially. The file operations that are valid for a diskette device are OPEN, CLOSE, READ, and WRITE.

Naming Files Stored on Diskette Devices

To use a sequential file that is stored on a diskette device, in your ILE COBOL program, you must name the file through a file control entry in the FILE-CONTROL paragraph of the Environment Division. See *WebSphere Development Studio: ILE COBOL Reference* for a full description of the FILE-CONTROL paragraph.

You name the file in the FILE-CONTROL paragraph as follows:

```
FILE-CONTROL.
    SELECT sequential-file-name
        ASSIGN TO DISKETTE-diskette_device_name
        ORGANIZATION IS SEQUENTIAL.
```

You use the SELECT clause to choose a file. This file must be identified by a FD entry in the Data Division.

You use the ASSIGN clause to associate the file with a diskette device. You must specify a device type of DISKETTE in the ASSIGN clause to use a diskette file.

Use ORGANIZATION IS SEQUENTIAL in the file control entry when you name a file that you will access through a diskette file.

Describing Files Stored on Diskette Devices

Once you have named the sequential file in the Environment Division, you must then describe the file through a file description entry in the Data Division. See *WebSphere Development Studio: ILE COBOL Reference* for a full description of the File Description Entry. Use the Format 2 File Description Entry to describe a sequential file that is accessed through a diskette file.

Diskette files have no data description specifications (DDS). A sequential file that is stored on a diskette device must be a program-described file. Your ILE COBOL program must describe the fields in the record format so the program can arrange the data received from or sent to the diskette device in the manner specified by the diskette file description.

A simple file description entry in the Data Division that describes a sequential file that is accessed through a diskette file looks as follows:

```
FD  sequential-file-name.
01  sequential-file-record.
    05  record-element-1   PIC ... .
    05  record-element-2   PIC ... .
    05  record-element-3   PIC ... .
⋮
```

Reading and Writing Files Stored on Diskette Devices

Before you can read from or write to a file that is stored on a diskette device, you must first open the file. You use the Format 1 OPEN statement to open the file. To read from a file stored on a diskette device, you must open it in INPUT mode. To write to a file stored on a diskette device, you must open it in OUTPUT or EXTEND mode. A file stored on a diskette device **cannot** be opened in I-O mode. The following are examples of the OPEN statement.

```
OPEN INPUT sequential-file-name.
OPEN OUTPUT sequential-file-name.
OPEN EXTEND sequential-file-name.
```

You use the Format 1 READ statement to read a record from a sequential file stored on a diskette device. The READ statement makes the next logical record from the file available to your ILE COBOL program.

When reading records from the input file, the record length you specify in your COBOL program should be the same as the record length found on the data file label of the diskette. If the record length specified in your COBOL program is not equal to the length of the records in the data file, the records are padded or truncated to the length specified in the program.

For a sequential multivolume file, if the end of volume is recognized during processing of the READ statement and the logical end of file has not been reached, the following actions are taken in the order listed:

1. The standard ending volume label procedure is processed.
2. A volume switch occurs.
3. The standard beginning volume label procedure is run.
4. The first data record of the next volume is made available.

Your ILE COBOL program will receive no indication that the above actions have occurred during the read operation.

You use the Format 1 WRITE statement to write a record to a sequential file stored on a diskette device.

When writing records to the output file, you must specify the record length in your COBOL program. When the record length specified in the program exceeds that for which the diskette is formatted, a diagnostic message is sent to your program, and the records are truncated. The maximum record lengths supported for diskette devices, by exchange type, are as follows:

Exchange Type	Maximum record length supported
Basic exchange	128 bytes
H exchange	256 bytes
I exchange	4096 bytes

For a sequential multivolume file, if the end of volume is recognized during processing of the WRITE statement, the following actions are taken in the order listed:
1. The standard ending volume label procedure is run.
2. A volume switch occurs.
3. The standard beginning volume label procedure is run.
4. The data record is written on the next volume.

No indication that an end of volume condition has occurred is returned to your COBOL program.

When you have finished using a file stored on a diskette device, you must close it. Use the Format 1 CLOSE statement to close the file. Once you close the file, it cannot be processed again until it is opened again.

```
CLOSE sequential-file-name.
```

Accessing Display Devices and ICF Files

You use display files to exchange information between your ILE COBOL program and a display device such as a workstation. A display file is used to define the format of the information that is to be presented on a display, and how that information is to be processed by the system on its way to and from the display. ILE COBOL uses TRANSACTION files to communicate interactively with a display device.

You use Intersystem Communication Function (ICF) files to allow a program on one system to communicate with a program on the same system or a remote system. ILE COBOL uses TRANSACTION files for intersystem communication.

See Chapter 20, “Using Transaction Files,” on page 497 for a discussion on how to use TRANSACTION files with display devices and ICF files.

Chapter 19. Using DISK and DATABASE Files

Database files, which are associated with the ILE COBOL devices of DATABASE and DISK, can be:

- Externally described files, whose fields are described to OS/400 through DDS
- Program-described files, whose fields are described in the program that uses the file.

Database files are created using the Create Physical File (CRTPF) or Create Logical File (CRTLF) CL commands. For a description of these commands, see the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

This chapter describes:
- The differences between DISK and DATABASE files
- The ways in which DISK and DATABASE files are organized
- The various methods of processing DISK and DATABASE files.

Differences between DISK and DATABASE Files

You use the device type DISK to associate a file in your ILE COBOL program with any physical database file or single format logical database file. When you choose DISK as the device type, you cannot use any ILE COBOL database extensions. The device type DISK does support dynamic file creation (except for indexed files) and variable length records.

You use the device type DATABASE to associate a file in your ILE COBOL program with any database file or DDM file. Choosing DATABASE as the device type allows you to use any ILE COBOL database extensions. These database extensions include the following:
- Commitment control
- Duplicate record keys
- Record formats
- Externally described files
- Null-capable files.

However, device type DATABASE does not support dynamic file creation or variable length records.

File Organization and iSeries File Access Paths

There are two types of access paths for accessing records in a file:
- Keyed sequence access path
- Arrival sequence access path.

A file with a **keyed sequence access path** can be processed in ILE COBOL as a file with SEQUENTIAL, RELATIVE, or INDEXED organization.

For a keyed sequence file to be processed as a relative file in ILE COBOL, it must be a physical file, or a logical file whose members are based on one physical file member. For a keyed sequence file to be processed as a sequential file in ILE

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COBOL, it must be a physical file, or a logical file that is based on one physical file member and that does not contain select/omit logic.

A file with an **arrival sequence access path** can be processed in ILE COBOL as a file with RELATIVE or SEQUENTIAL organization. The file must be a physical file or a logical file where each member of the logical file is based on only one physical file member.

When sequential access is specified for a logical file, records in the file are accessed through the default access path for the file.

File Processing Methods for DISK and DATABASE Files

DISK and DATABASE files can have the following organization:
- SEQUENTIAL
- RELATIVE
- INDEXED.

Each type of file organization uses unique file processing methods.

Processing Sequential Files

An ILE COBOL sequential file is a file in which records are processed in the order in which they were placed in the file, that is, in arrival sequence. For example, the tenth record placed in the file occupies the tenth record position and is the tenth record to be processed. To process a file as a sequential file, you must specify ORGANIZATION IS SEQUENTIAL in the SELECT clause, or omit the ORGANIZATION clause. A sequential file can only be accessed sequentially.

To write Standard COBOL programs that access a sequential file, you must create the file with certain characteristics. Table 23 lists these characteristics and what controls them.

Table 23. Characteristics of Sequential Files that are Accessible to Standard COBOL Programs

Characteristic	Control
The file must be a physical file.	Create the file using the CRTPF CL command.
The file cannot be a shared file.	Specify SHARE(*NO) on the CRTPF CL command.
No key can be specified for the file.	Do not include any line with K in position 17 in the Data Description Specifications (DDS) of the file.
The file must have a file type of DATA.	Specify FILETYPE(*DATA) on the CRTPF CL command.
Field editing cannot be used.	Do not specify the EDTCDE and EDTWRD keywords in the file DDS.
Line and position information cannot be specified.	Leave blanks in positions 39 to 44 of all field descriptions in the file DDS.
Spacing and skipping keywords cannot be speicifed.	Do not specify the SPACEA, SPACEB, SKIPA, or SKIPB keywords in the file DDS.
Indicators cannot be used.	Leave blanks in positions 9 to 16 of all lines in the file DDS.

Table 23. Characteristics of Sequential Files that are Accessible to Standard COBOL Programs (continued)

Characteristic	Control
System-supplied functions such as date, time, and page number cannot be used.	Do not specify the DATE, TIME, or PAGNBR keywords in the file DDS.
Select/omit level keywords cannot be used for the file.	Do not include any line with S or O in position 17 in the file DDS. Do not specify the COMP, RANGE, VALUES, or ALL keywords.
Records in the file cannot be reused.	Specify REUSEDLT(*NO) on the CRTPF CL command.
Records in the file cannot contain NULL fields	Do not specify the ALWNULL keyword in the file DDS.

The OPEN, READ, WRITE, REWRITE, and CLOSE statements are used to access data that is stored in a sequential file. Refer to the *WebSphere Development Studio: ILE COBOL Reference* for a description of each of these statements.

All physical database files with SEQUENTIAL organization, that are opened for OUTPUT are cleared.

To preserve the sequence of records in a file that you open in I-O (update) mode, do not create or change the file so that you can reuse the records in it. That is, do not use a Change Physical File (CHGPF) CL command bearing the REUSEDLT option.

Note: The ILE COBOL compiler does not check that the device associated with the external file is of the type specified in the device portion of assignment-name. The device specified in the assignment-name must match the actual device to which the file is assigned. See the "ASSIGN Clause" section of the *WebSphere Development Studio: ILE COBOL Reference* for more information.

Processing Relative Files

An ILE COBOL relative file is a file to be processed by a relative record number. To process a file by relative record number, you must specify ORGANIZATION IS RELATIVE in the SELECT statement for the file. A relative file can be accessed sequentially, randomly by record number, or dynamically. An ILE COBOL relative file cannot have a keyed access path.

To write Standard COBOL programs that access a relative file, you must create the file with certain characteristics. Table 24 lists these characteristics and what controls them.

Table 24. Characteristics of Relative Files that are Accessible to Standard COBOL Programs

Characteristic	Control
The file must be a physical file.[1]	Create the file using the CRTPF CL command.
The file cannot be a shared file.	Specify SHARE(*NO) on the CRTPF CL command.

Table 24. Characteristics of Relative Files that are Accessible to Standard COBOL Programs (continued)

Characteristic	Control
No key can be specified for the file.	Do not include any line with K in position 17 in the Data Description Specifications (DDS) of the file.
A starting position for retrieving records cannot be specified.	Do not issue the OVRDBF CL command with the POSITION parameter.
Select/omit level keywords cannot be used for the file.	Do not include any line with S or O in position 17 in the file DDS. Do not specify the COMP, RANGE, VALUES, or ALL keywords.
Records in the file cannot be reused.	Specify REUSEDLT(*NO) on the CRTPF CL command.
Records in the file cannot contain NULL fields.	Do not specify the ALWNULL keyword in the file DDS.
Note: [1] A logical file whose members are based on one physical file can be used as an ILE COBOL relative file.	

The OPEN, READ, WRITE, START, REWRITE, DELETE, and CLOSE statements are used to access data that is stored in a relative file. Refer to the *WebSphere Development Studio: ILE COBOL Reference* for a description of each of these statements. The START statement applies only to files that are opened for INPUT or I-O and are accessed sequentially or dynamically.

For relative files that are accessed sequentially, the SELECT clause KEY phrase is ignored except for the START statement. If the KEY phrase is not specified on the START statement, the RELATIVE KEY phrase in the SELECT clause is used and KEY IS EQUAL is assumed.

For relative files that are accessed randomly or dynamically, the SELECT clause RELATIVE KEY phrase is used.

The NEXT phrase can be specified only for the READ statement for a file with SEQUENTIAL or DYNAMIC access mode. If NEXT is specified, the SELECT clause KEY phrase is ignored. The RELATIVE KEY data item is updated with the relative record number for files with sequential access on READ operations.

All physical database files that are opened for OUTPUT are cleared. Database files with RELATIVE organization, and with dynamic or random access mode, are also initialized with deleted records. Lengthy delays in OPEN OUTPUT processing are normal for extremely large relative files (over 1 000 000 records) that are accessed in dynamic or random access mode because the files are being initialized with deleted records. The length of time it takes to open a file with initialization depends on the number of records in the file.

When the first OPEN statement for the file is not OPEN OUTPUT, relative files should be cleared and initialized with deleted records before they are used. The RECORDS parameter of the INZPFM command must specify *DLT. Overrides are applied when the clear and initialize operations are processed by ILE COBOL, but not when they are processed with CL commands. For more information, see the discussion of the CLRPFM and INZPFM commands in the *CL and APIs* section of

the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

New relative files opened for OUTPUT in sequential access mode are treated differently. Table 25 summarizes conditions affecting them.

Table 25. Initialization of Relative Output Files

File Access and CL Specifications	Conditions at Opening Time	Conditions at Closing Time	File Boundary
Sequential *INZDLT		Records not written are initialized.[1]	All increments.
Sequential *INZDLT *NOMAX size		CLOSE succeeds.[1] File status is 0Q.[2]	Up to boundary of records written.
Sequential *NOINZDLT			Up to boundary of records written.
Random or dynamic	Records are initialized. File is open.		All increments.
Random or dynamic *NOMAX size	OPEN fails. File status is 9Q.[3]		File is empty.

Notes:

1. Lengthy delays are normal when there remains an extremely large number of records (over 1 000 000) to be initialized to deleted records when the CLOSE statement runs.
2. To extend a file boundary beyond the current number of records, but remaining within the file size, use the INZPFM command to add deleted records before processing the file. You need to do this if you receive a file status of 0Q, and you still want to add more records to the file. Any attempt to extend a relative file beyond its current size results in a boundary violation.
3. To recover from a file status of 9Q, use the CHGPF command as described in the associated run-time message text.

For an ILE COBOL file with an organization of RELATIVE, the Reorganize Physical File Member (RGZPFM) CL command can:

- Remove all deleted records from the file. Because ILE COBOL initializes all relative file records to deleted records, any record that has not been explicitly written will be removed from the file. The relative record numbers of all records after the first deleted record in the file will change.
- Change the relative record numbers if the file has a key and the arrival sequence is changed to match a key sequence (with the KEYFILE parameter).

In addition, a Change Physical File (CHGPF) CL command bearing the REUSEDLT option can change the order of retrieved or written records when the file is operated on sequentially, because it allows the reuse of deleted records.

Processing Indexed Files

An indexed file is a file whose default access path is built on key values. One way to create a keyed access path for an indexed file is by using DDS.

An indexed file is identified by the ORGANIZATION IS INDEXED clause of the SELECT statement.

The key fields identify the records in an indexed file. The user specifies the key field in the RECORD KEY clause of the SELECT statement. The RECORD KEY

data item must be defined within a record description for the indexed file. If there are multiple record descriptions for the file, only one need contain the RECORD KEY data name. However, the same positions within the record description that contains the RECORD KEY data item are accessed in the other record descriptions as the KEY value for any references to the other record descriptions for that file.

Alternate keys can also be specified with the ALTERNATE RECORD KEY clause. Using alternate keys, you can access the indexed file to read records in a sequence other than the prime key sequence.

An indexed file can be accessed sequentially, randomly by key, or dynamically.

To write Standard COBOL programs that access an indexed file, you must create the file with certain characteristics. Table 26 lists these characteristics and what controls them.

Table 26. Characteristics of Indexed Files that are Accessible to Standard COBOL Programs

Characteristic	Control
The file must be a physical file.	Create the file using the CRTPF CL command.
The file cannot be a shared file.	Specify SHARE(*NO) on the CRTPF CL command.
A key must be defined for the file.	Define at least one key field in the Data Description Specifications (DDS) of the file, using a line with K in position 17.
Keys must be contiguous within the record.	Specify a single key field in the file DDS, or specify key fields that immediately follow each other in descending order of key significance.
Key fields must be alphanumeric. They cannot be numeric.	Specify A or H in position 35 when defining any field that is to be used as a DDS key field.
The value of the key used for sequencing must include all 8 bits of every byte.	Specify alphanumeric key fields.
The file cannot have records with duplicate key values.	Specify the UNIQUE keyword in the file DDS.
Keys must be in ascending sequence.	Do not specify the DESCEND keyword in the file DDS.
A starting position for retrieving records cannot be specified.	Do not issue the OVRDBF CL command with the POSITION parameter.
Select/omit level keywords cannot be used for the file.	Do not include any line with S or O in position 17 in the file DDS. Do not specify the COMP, RANGE, VALUES, or ALL keywords.
Records in the file cannot contain NULL fields.	Do not specify the ALWNULL keyword in the file DDS.

The OPEN, READ, WRITE, START, REWRITE, DELETE, and CLOSE statements are used to access data that is stored in an indexed file. Refer to the *WebSphere Development Studio: ILE COBOL Reference* for a description of each of these statements. When accessing indexed files, the FORMAT phrase is optional for DATABASE files, and not allowed for DISK files. If the FORMAT phrase is not specified, the default format name of the file is used. The default format name of

the file is the first format name defined in the file. The special register, DB-FORMAT-NAME, can be used to retrieve the format name used on the last successful I/O operation.

When you read records sequentially from an indexed file, the records will be returned in arrival sequence or in keyed sequence depending on how the file is described in your ILE COBOL program. To retrieve the records in arrival sequence, use

```
ORGANIZATION IS SEQUENTIAL
ACCESS IS SEQUENTIAL
```

with the SELECT statement for the indexed file. To retrieve the records in keyed sequence (typically in ascending order), use

```
ORGANIZATION IS INDEXED
ACCESS IS SEQUENTIAL
```

with the SELECT statement for the indexed file.

For indexed files that are accessed sequentially, the SELECT clause KEY phrase is ignored except for the START statement. If the KEY phrase is not specified on the START statement, the RECORD KEY phrase in the SELECT clause is used and KEY IS EQUAL is assumed.

For indexed files that are accessed randomly or dynamically, the SELECT clause KEY phrase is used except for the START statement. If the KEY phrase is not specified on the START statement, the RECORD KEY phrase in the SELECT clause is used and KEY IS EQUAL is assumed.

NEXT, PRIOR, FIRST, or LAST can be specified for the READ statement for DATABASE files with DYNAMIC access. NEXT can also be specified for the READ statement for DATABASE files with SEQUENTIAL access. If NEXT, PRIOR, FIRST, or LAST is specified, the SELECT clause KEY phrase is ignored.

All physical database files with INDEXED organization that are opened for OUTPUT are cleared.

Valid RECORD KEYs

The DDS for the file specifies the fields to be used as the key field. If the file has multiple key fields, the key fields must be contiguous in each record unless RECORD KEY IS EXTERNALLY-DESCRIBED-KEY is specified.

When the DDS specifies only one key field for the file, the RECORD KEY must be a single field of the same length as the key field defined in the DDS.

If a Format 2 COPY statement is specified for the file, the RECORD KEY clause must specify one of the following:

- The name used in the DDS for the key field with -DDS added to the end, if the name is a COBOL reserved word.
- The data name defined in a program-described record description for the file, with the same length and in the same location as the key field defined in the DDS.
- EXTERNALLY-DESCRIBED-KEY. This keyword specifies that the keys defined in the DDS for each record format are to be used for accessing the file. These keys can be noncontiguous. They can be defined at different positions within one record format.

When the DDS specifies multiple contiguous key fields, the RECORD KEY data name must be a single field with its length equal to the sum of the lengths of the multiple key fields in the DDS. If a Format 2 COPY statement is specified for the file, there must also be a program-described record description for the file that defines the RECORD KEY data name with the proper length and at the proper position in the record.

Contiguous items are consecutive elementary or group items in the Data Division that are contained in a single data hierarchy.

Referring to a Partial Key

A START statement allows the use of a partial key. The KEY IS phrase is required.

Refer to the "START Statement" in the *WebSphere Development Studio: ILE COBOL Reference* for information about the rules for specifying a search argument that refers to a partial key.

Figure 117 on page 457 shows an example of START statements using a program-described file.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/STRTPGMD        ISERIES1  03/09/15 14:41:49        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID. STRTPGMD.
           000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600   SOURCE-COMPUTER. IBM-ISERIES.
    6     000700   OBJECT-COMPUTER. IBM-ISERIES.
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT FILE-1 ASSIGN TO DISK-NAMES                                                  00/08/15
   11     001100     ACCESS IS DYNAMIC RECORD KEY IS FULL-NAME IN FILE-1
   13     001200     ORGANIZATION IS INDEXED.
           001300
   14     001400 DATA DIVISION.
   15     001500 FILE SECTION.
   16     001600 FD  FILE-1.
   17     001700 01  RECORD-DESCRIPTION.
   18     001800     03 FULL-NAME.
   19     001900        05 LAST-AND-FIRST-NAMES.
   20     002000           07 LAST-NAME             PIC X(20).
   21     002100           07 FIRST-NAME            PIC X(20).
   22     002200        05 MIDDLE-NAME              PIC X(20).
   23     002300     03 LAST-FIRST-MIDDLE-INITIAL-NAME REDEFINES FULL-NAME
           002400                                   PIC X(41).
   24     002500     03 REST-OF-RECORD             PIC X(50).
           002600
   25     002700 PROCEDURE DIVISION.
           002800 MAIN-PROGRAM SECTION.
           002900 MAINLINE.
   26     003000     OPEN INPUT FILE-1.
           003100*
           003200* POSITION THE FILE STARTING WITH RECORDS THAT HAVE A LAST NAME OF
           003300* "SMITH"
   27     003400     MOVE "SMITH" TO LAST-NAME.
   28     003500     START FILE-1 KEY IS EQUAL TO LAST-NAME
   29     003600           INVALID KEY DISPLAY "NO DATA IN SYSTEM FOR " LAST-NAME
   30     003700                       GO TO ERROR-ROUTINE
           003800     END-START.
           003900*          .
           004000*          .
           004100*          .
           004200*
           004300* POSITION THE FILE STARTING WITH RECORDS THAT HAVE A LAST NAME OF
           004400* "SMITH" AND A FIRST NAME OF "ROBERT"
   31     004500     MOVE "SMITH" TO LAST-NAME.
   32     004600     MOVE "ROBERT" TO FIRST-NAME.
   33     004700     START FILE-1 KEY IS EQUAL TO LAST-AND-FIRST-NAMES
   34     004800           INVALID KEY DISPLAY "NO DATA IN SYSTEM FOR "
           004900                               LAST-AND-FIRST-NAMES
   35     005000                       GO TO ERROR-ROUTINE
           005100     END-START.
           005200*          .
           005300*          .
```

Figure 117. START Statements Using a Program-Described File (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/STRTPGMD       ISERIES1  03/09/15 14:41:49       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
          005400*          .
          005500*
          005600* POSITION THE FILE STARTING WITH RECORDS THAT HAVE A LAST NAME OF
          005700* "SMITH", A FIRST NAME OF "ROBERT", AND A MIDDLE INITIAL OF "M"
          005800
    36    005900     MOVE "SMITH" TO LAST-NAME.
    37    006000     MOVE "ROBERT" TO FIRST-NAME.
    38    006100     MOVE "M" TO MIDDLE-NAME.
    39    006200     START FILE-1 KEY IS EQUAL TO LAST-FIRST-MIDDLE-INITIAL-NAME
    40    006300           INVALID KEY DISPLAY "NO DATA IN SYSTEM FOR "
          006400                               LAST-FIRST-MIDDLE-INITIAL-NAME
    41    006500                       GO TO ERROR-ROUTINE
          006600     END-START.
          006700
          006800
          006900 ERROR-ROUTINE.
    42    007000     STOP RUN.
                     * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 117. START Statements Using a Program-Described File (Part 2 of 2)

Figure 118 and Figure 119 on page 459 show an example of START statements using an externally described file.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A                                      UNIQUE
     A          R RDE                       TEXT('RECORD DESCRIPTION')
     A            FNAME         20          TEXT('FIRST NAME')
     A            MINAME         1          TEXT('MIDDLE INITIAL NAME')
     A            MNAME         19          TEXT('REST OF MIDDLE NAME')
     A            LNAME         20          TEXT('LAST NAME')
     A            PHONE         10  0       TEXT('PHONE NUMBER')
     A            DATA          40          TEXT('REST OF DATA')
     A          K LNAME
     A          K FNAME
     A          K MINAME
     A          K MNAME
```

Figure 118. START Statements Using an Externally Described File -- DDS

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/STRTEXTD        ISERIES1   03/09/15 14:43:17        Page      2
                           S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID. STRTEXTD.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600   SOURCE-COMPUTER. IBM-ISERIES
    6     000700   OBJECT-COMPUTER. IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT FILE-1 ASSIGN TO DATABASE-NAMES
   11     001100     ACCESS IS DYNAMIC RECORD KEY IS EXTERNALLY-DESCRIBED-KEY
   13     001200     ORGANIZATION IS INDEXED.
          001300
   14     001400 DATA DIVISION.
   15     001500 FILE SECTION.
   16     001600 FD  FILE-1.
   17     001700 01  RECORD-DESCRIPTION.
          001800     COPY DDS-RDE OF NAMES.
         +000001*    I-O FORMAT:RDE        FROM FILE NAMES      OF LIBRARY CBLGUIDE          RDE
         +000002*                          RECORD DESCRIPTION                                RDE
         +000003*THE KEY DEFINITIONS FOR RECORD FORMAT  RDE                                  RDE
         +000004*  NUMBER              NAME               RETRIEVAL       ALTSEQ           RDE
         +000005*   0001   LNAME                          ASCENDING         NO             RDE
         +000006*   0002   FNAME                          ASCENDING         NO             RDE
         +000007*   0003   MINAME                         ASCENDING         NO             RDE
         +000008*   0004   MNAME                          ASCENDING         NO             RDE
   18    +000009       05  RDE.                                                            RDE
   19    +000010           06 FNAME                PIC X(20).                             RDE
         +000011*                FIRST NAME                                               RDE
   20    +000012           06 MINAME               PIC X(1).                              RDE
         +000013*                MIDDLE INITIAL NAME                                      RDE
   21    +000014           06 MNAME                PIC X(19).                             RDE
         +000015*                REST OF MIDDLE NAME                                      RDE
   22    +000016           06 LNAME                PIC X(20).                             RDE
         +000017*                LAST NAME                                                RDE
   23    +000018           06 PHONE                PIC S9(10)        COMP-3.              RDE
         +000019*                PHONE NUMBER                                             RDE
   24    +000020           06 DATA-DDS             PIC X(40).                             RDE
         +000021*                REST OF DATA                                             RDE
   25     001900 66  MIDDLE-NAME RENAMES MINAME THRU MNAME.
          002000
   26     002100 PROCEDURE DIVISION.
          002200 MAIN-PROGRAM SECTION.
          002300 MAINLINE.
   27     002400     OPEN INPUT FILE-1.
          002500*
          002600* POSITION THE FILE STARTING WITH RECORDS THAT HAVE A LAST NAME
          002700* OF "SMITH"
   28     002800     MOVE "SMITH" TO LNAME.
   29     002900     START FILE-1 KEY IS EQUAL TO LNAME
   30     003000           INVALID KEY DISPLAY "NO DATA IN SYSTEM FOR " LNAME
   31     003100                       GO TO ERROR-ROUTINE
          003200     END-START.
```

Figure 119. START Statements Using an Externally Described File (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/STRTEXTD       ISERIES1   03/09/15 14:43:17       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         003300*          .
         003400*          .
         003500*          .
         003600*
         003700* POSITION THE FILE STARTING WITH RECORDS THAT HAVE A LAST NAME
         003800* OF "SMITH" AND A FIRST NAME OF "ROBERT"
   32    003900     MOVE "SMITH" TO LNAME.
   33    004000     MOVE "ROBERT" TO FNAME.
   34    004100     START FILE-1 KEY IS EQUAL TO LNAME, FNAME
   35    004200           INVALID KEY DISPLAY "NO DATA IN SYSTEM FOR "
         004300                               LNAME " " FNAME
   36    004400                       GO TO ERROR-ROUTINE
         004500     END-START.
         004600*          .
         004700*          .
         004800*          .
         004900*
         005000* POSITION THE FILE STARTING WITH RECORDS THAT HAVE A LAST NAME OF
         005100* "SMITH", A FIRST NAME OF "ROBERT", AND A MIDDLE INITIAL OF "M"
   37    005200     MOVE "SMITH" TO LNAME.
   38    005300     MOVE "ROBERT" TO FNAME.
   39    005400     MOVE "M" TO MINAME.
   40    005500     START FILE-1 KEY IS EQUAL TO LNAME, FNAME, MINAME
   41    005600           INVALID KEY DISPLAY "NO DATA IN SYSTEM FOR "
         005700                               LNAME SPACE FNAME SPACE MINAME
   42    005800                       GO TO ERROR-ROUTINE
         005900     END-START.
         006000
         006100
         006200 ERROR-ROUTINE.
   43    006300     STOP RUN.
                    * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 119. START Statements Using an Externally Described File (Part 2 of 2)

Alternate Record Keys

Alternate keys are associated with alternate indexes, which can be temporary or permanent.

A temporary alternate index is one that ILE COBOL creates when the file is opened. When the file is closed, the temporary index no longer exists. By default, ILE COBOL will not create temporary indexes. You must specify the CRTARKIDX option to use temporary alternate indexes.

However, if ILE COBOL is able to find a permanent index, it still uses the permanent index instead of creating a temporary one. A permanent alternate index is one that persists even when the ILE COBOL program ends. Permanent indexes are associated with logical files, so you must create logical files before you can use permanent indexes in your COBOL program.

The DDS specification for the logical file should be the same as the specification for the physical file except for the key field(s). The key field(s) for the logical files should be defined to match the corresponding alternate key data-item. Note that the ILE COBOL program does not refer to these logical files in any way.

The use of permanent indexes will have a performance improvement over temporary ones. The length and starting position of the alternate key data-item within the record area must match the length and starting position of the corresponding DDS field. This DDS field also cannot be a keyed field since DDS key fields are associated with the prime key. If the alternate key data-item maps to multiple DDS fields, the starting position of the alternate key data-item must match the first DDS field, and the length of the alternate key data-item must be equal to the sum of the lengths of all the DDS fields that make up this key.

The EXTERNALLY-DESCRIBED-KEY clause cannot be specified for files that also have alternate keys.

The key used for any specific input-output request is known as the key of reference. The key of reference can be changed with the READ or START statements.

Processing Logical File as Indexed Files

When a logical file with multiple record formats, each having associated key fields, is processed as an indexed file in ILE COBOL, the following restrictions and considerations apply:

- The FORMAT phrase must be specified on all WRITE statements for the file unless a Record Format Selector Program exists and has been specified in the FMTSLR parameter of the Create Logical File (CRTLF) command, the Change Logical File (CHGLF) command, or the Override Database File (OVRDBF) command.
- If the access mode is RANDOM or DYNAMIC, and the DUPLICATES phrase is not specified for the file, the FORMAT phrase must be specified on all DELETE and REWRITE statements.
- When the FORMAT phrase is not specified, only the portion of the RECORD KEY data item that is common to all record formats for the file is used by the system as the key for the I/O statement. When the FORMAT phrase is specified, only the portion of the RECORD KEY data item that is defined for the specified record format is used by the system as the key.
- When *NONE is specified as the first key field for any format in a file, records can only be accessed sequentially. When a file is read randomly:
  - If a format name is specified, the first record with the specified format is returned.
  - If a format name is not specified, the first record in the file is returned.

  In both cases, the value of the RECORD KEY data item is ignored.
- For a program-defined key field:
  - Key fields within each record format must be contiguous.
  - The first key field for each record format must begin at the same relative position within each record.
  - The length of the RECORD KEY data item must be equal to the length of the longest key for any format in the file.
- For an EXTERNALLY-DESCRIBED-KEY:
  - Key fields within each record format can be noncontiguous.
  - The key fields can be defined at different positions within one record format.

Figure 120 on page 462 and Figure 121 on page 462 show examples of how to use DDS to describe the access path for indexed files.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A          R FORMATA                   PFILE(ORDDTLP)
     A                                      TEXT('ACCESS PATH FOR INDEXED FILE')
     A            FLDA          14
     A            ORDERN         5S 0
     A            FLDB          101
     A          K ORDERN
```

Figure 120. Using Data Description Specifications to Define the Access Path for an Indexed File

Data description specifications can be used to create the access path for a program-described indexed file.

In the DDS, shown in Figure 120, for the record format FORMATA for the logical file ORDDTLL, the field ORDERN, which is five digits long, is defined as the key field. The definition of ORDERN as the key field establishes the keyed access path for this file. Two other fields, FLDA and FLDB, describe the remaining positions in this record as character fields.

The program-described input file ORDDTLL is described in the FILE-CONTROL section in the SELECT clause as an indexed file.

The ILE COBOL descriptions of each field in the FD entry must agree with the corresponding description in the DDS file. The RECORD KEY data item must be defined as a five-digit numeric integer beginning in position 15 of the record.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A          R FORMATA                   PFILE(ORDDTLP)
     A                                      TEXT('ACCESS PATH FOR INDEXED FILE')
     A            FLDA          14
     A            ORDERN         5S 0
     A            ITEM           5
     A            FLDB          96
     A          K ORDERN
     A          K ITEM
```

Figure 121. Data Description Specifications for Defining the Access Path (a Composite Key) of an Indexed File

In this example, the DDS, shown in Figure 121, defines two key fields for the record format FORMAT in the logical file ORDDTLL. For the two fields to be used as a composite key for a program-described indexed file, the key fields must be contiguous in the record.

The ILE COBOL description of each field must agree with the corresponding description in the DDS file. A 10-character item beginning in position 15 of the record must be defined in the RECORD KEY clause of the file-control entry. The ILE COBOL descriptions of the DDS fields ORDERN and ITEM would be subordinate to the 10-character item defined in the RECORD KEY clause.

For more information on the use of format selector programs and on logical file processing, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Processing Files with Descending Key Sequences

Files created with a descending keyed sequence (in DDS) cause the READ statement NEXT, PRIOR, FIRST, and LAST phrases to work in a fashion exactly opposite that of a file with an ascending key sequence. You can specify a descending key sequence in the DDS with the DESCEND keyword in positions 45 to 80 beside a key field. In **descending key sequence**, the data is arranged in order from the highest value of the key field to the lowest value of the key field.

For example, READ FIRST retrieves the record with the highest key value, and READ LAST retrieves the record with the lowest key value. READ NEXT retrieves the record with the next lower key value. Files with a descending key sequence also cause the START qualifiers to work in the opposite manner. For example, START GREATER THAN positions the current record pointer to a record with a key less than the current key.

Processing Files with Variable Length Records

Variable length records are only supported for database files associated with device type DISK.

Describing DISK Files with Variable Length Records

You specify the Format 2 RECORD clause with the FD entry of the file to define the maximum and minimum record lengths for the file.

A simple file description entry in the Data Division that describes a sequential file with variable length records looks as follows:

```
FILE SECTION.
FD  sequential-file-name
    RECORD IS VARYING IN SIZE
              FROM integer-6 TO integer-7
              DEPENDING ON data-name-1.
01  minimum-sized-record.
    05  minimum-sized-element     PIC X(integer-6).
01  maximum-sized-record.
    05  maximum-sized-element     PIC X(integer-7).
⋮
WORKING-STORAGE SECTION.
77  data-name-1                   PIC 9(5).
⋮
```

The minimum record size of any record in the file is defined by *integer-6*. The maximum record size of any record in the file is defined by *integer-7*. Do not create record descriptions for the file that contain a record length that is less than that specified by *integer-6* nor a record length that is greater than that specified by *integer-7*. If any record descriptions break this rule, then a compile time error message is issued by the ILE COBOL compiler. The ILE COBOL compiler also issues a compile time error message when none of the record descriptions contain a record length that is as long as *integer-7*.

For **indexed files** that contain variable length records, the prime record key must be contained within the first 'n' character positions of the record, where 'n' is the minimum record size specified for the file. When processing the FD entry, the ILE COBOL compiler will check that any RECORD KEY falls within the fixed part of the record. If any key violates this rule, an error message is issued.

Opening DISK Files with Variable Length Records

The following conditions must be met for the OPEN statement to be successfully performed on a database file with variable length records:

- The formats being opened in the file must contain one variable length field at the end of the format
- The sum of the fixed length fields in all formats being opened must be the same
- The minimum record length must be greater than or equal to the sum of the fixed length fields for all formats, and less than or equal to the maximum record length for the file
- If the file is being opened for keyed sequence processing then the key must not contain any variable length fields.

If any of the above conditions are not satisfied, an error message will be generated, file status 39 will be returned, and the open operation will fail.

If an open operation is attempted on a database file with SHARE(*YES) which is already open but with a different record length than the current open operation, an error message will be generated and file status 90 will be returned.

Reading and Writing DISK Files with Variable Length Records

When a READ, WRITE, or REWRITE statement is performed on a variable length record, the size of that record is defined by the contents of *data-name-1*.

Refer to the Format 2 RECORD clause in the *WebSphere Development Studio: ILE COBOL Reference* for a further description of how variable length records are handled.

You use the READ statement to read a variable length record from a database file. If the READ operation is successful then *data-name-1*, if specified, will hold the number of the character positions of the record just read. If the READ operation is unsuccessful then *data-name-1*, will hold the value it had before the READ operation was attempted.

When you specify the INTO phrase in the READ statement, the number of character positions in the current record that participate as the sending item in the implicit MOVE statement is determined by

- The contents of *data-name-1* if *data-name-1* is specified, or
- The number of character positions in the record just read if *data-name-1* is not specified.

When the READ statement is performed, if the number of character positions in the record that is read is less than the minimum record length specified by the record description entries for the file, the portion of the record area that is to the right of the last valid character read is filled with blanks. If the number of characters positions in the record that is read is greater than the maximum record length specified by the record description entries for the file, the record is truncated on the right to the maximum record size specified in the record description entries. A file status of 04 is returned when a record is read whose length falls outside the minimum or maximum record lengths defined in the RECORD clause in the file description entry for the file.

You use the WRITE or REWRITE statements to write a variable length record to a database file. You specify the length of the record to write in *data-name-1*. If you do not specify *data-name-1*, the length of the record to write is determined as follows:

- If the record contains an OCCURS...DEPENDING ON item, by the sum of the fixed portion and that portion of the table described by the number of occurrences at the time the WRITE statement is performed

- If the record does not contain an OCCURS...DEPENDING ON item, by the number of character positions in the record definition.

Examples of Processing DISK and DATABASE Files

The following sample programs illustrate the fundamental programming techniques associated with each type of iSeries file organization. These examples are intended to be used for tutorial purposes only, and to illustrate the input/output statements necessary for certain access methods. Other ILE COBOL features (the use of the PERFORM statement, for example) are used only incidentally. The programs illustrate:

- Sequential File Creation
- Sequential File Updating and Extension
- Relative File Creation
- Relative File Updating
- Relative File Retrieval
- Indexed File Creation
- Indexed File Updating.

Sequential File Creation

This program creates a sequential file of employee salary records. The input records are arranged in ascending order of employee number. The output file has the identical order.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/CRTSEQ          ISERIES1   03/09/15 14:46:40        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  CRTSEQ.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER.   IBM-ISERIES
    6     000700 OBJECT-COMPUTER.   IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT INPUT-FILE ASSIGN TO DISK-FILEA
   11     001100         FILE STATUS IS INPUT-FILE-STATUS.
   12     001200     SELECT OUTPUT-FILE ASSIGN TO DISK-FILEB
   14     001300         FILE STATUS IS OUTPUT-FILE-STATUS.
   15     001400 DATA DIVISION.
   16     001500 FILE SECTION.
   17     001600 FD  INPUT-FILE.
   18     001700 01  INPUT-RECORD.
   19     001800     05  INPUT-EMPLOYEE-NUMBER      PICTURE 9(6).
   20     001900     05  INPUT-EMPLOYEE-NAME        PICTURE X(28).
   21     002000     05  INPUT-EMPLOYEE-CODE        PICTURE 9.
   22     002100     05  INPUT-EMPLOYEE-SALARY      PICTURE 9(6)V99.
   23     002200 FD  OUTPUT-FILE.
   24     002300 01  OUTPUT-RECORD.
   25     002400     05  OUTPUT-EMPLOYEE-NUMBER     PICTURE 9(6).
   26     002500     05  OUTPUT-EMPLOYEE-NAME       PICTURE X(28).
   27     002600     05  OUTPUT-EMPLOYEE-CODE       PICTURE 9.
   28     002700     05  OUTPUT-EMPLOYEE-SALARY     PICTURE 9(6)V99.
          002800
   29     002900 WORKING-STORAGE SECTION.
   30     003000 77  INPUT-FILE-STATUS              PICTURE XX.
   31     003100 77  OUTPUT-FILE-STATUS             PICTURE XX.
   32     003200 77  OP-NAME                        PICTURE X(7).
   33     003300 01  INPUT-END                      PICTURE X VALUE SPACE.
   34     003400     88  THE-END-OF-INPUT           VALUE "E".
          003500
   35     003600 PROCEDURE DIVISION.
   36     003700 DECLARATIVES.
          003800 INPUT-ERROR SECTION.
          003900      USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          004000 INPUT-ERROR-PARA.
   37     004100      DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, "FOR INPUT-FILE".
   38     004200      DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
   39     004300      DISPLAY "PROCESSING ENDED".
   40     004400      STOP RUN.
          004500
          004600 OUTPUT-ERROR SECTION.
          004700      USE AFTER STANDARD ERROR PROCEDURE ON OUTPUT-FILE.
          004800 OUTPUT-ERROR-PARA.
   41     004900      DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, "FOR OUTPUT-FILE".
   42     005000      DISPLAY "FILE STATUS IS ", OUTPUT-FILE-STATUS.
   43     005100      DISPLAY "PROCESSING ENDED".
   44     005200      STOP RUN.
          005300 END DECLARATIVES.
```

Figure 122. Example of a Sequential File of Employee Salary Records (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/CRTSEQ          ISERIES1   03/09/15 14:46:40        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         005400
         005500 MAIN-PROGRAM SECTION.
         005600 MAINLINE.
   45    005700     MOVE "OPEN" TO OP-NAME.
   46    005800     OPEN INPUT INPUT-FILE
         005900          OUTPUT OUTPUT-FILE.
         006000
   47    006100     MOVE "READ" TO OP-NAME.
   48    006200     READ INPUT-FILE INTO OUTPUT-RECORD
   49    006300         AT END SET THE-END-OF-INPUT TO TRUE
         006400     END-READ.
         006500
   50    006600     PERFORM UNTIL THE-END-OF-INPUT
   51    006700         MOVE "WRITE" TO OP-NAME
   52    006800         WRITE OUTPUT-RECORD
   53    006900         MOVE "READ" TO OP-NAME
   54    007000         READ INPUT-FILE INTO OUTPUT-RECORD
   55    007100             AT END SET THE-END-OF-INPUT TO TRUE
         007200         END-READ
         007300     END-PERFORM.
         007400
   56    007500     MOVE "CLOSE" TO OP-NAME.
   57    007600     CLOSE INPUT-FILE
         007700           OUTPUT-FILE.
   58    007800     STOP RUN.
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 122. Example of a Sequential File of Employee Salary Records (Part 2 of 2)

Sequential File Updating and Extension

This program updates and extends the file created by the CRTSEQ program. The INPUT-FILE and the MASTER-FILE are each read. When a match is found between INPUT-EMPLOYEE-NUMBER and MST-EMPLOYEE-NUMBER, the input record replaces the original record. After the MASTER-FILE is processed, new employee records are added to the end of the file.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/UPDTSEQ         ISERIES1   03/09/15 14:48:09        Page      2
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  UPDTSEQ.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER.  IBM-ISERIES
    6     000700 OBJECT-COMPUTER.  IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT INPUT-FILE ASSIGN TO DISK-FILES
   11     001100         FILE STATUS IS INPUT-FILE-STATUS.
   12     001200     SELECT MASTER-FILE ASSIGN TO DISK-MSTFILEB
   14     001300         FILE STATUS IS MASTER-FILE-STATUS.
          001400
   15     001500 DATA DIVISION.
   16     001600 FILE SECTION.
   17     001700 FD  INPUT-FILE.
   18     001800 01  INPUT-RECORD.
   19     001900     05  INPUT-EMPLOYEE-NUMBER      PICTURE 9(6).
   20     002000     05  INPUT-EMPLOYEE-NAME        PICTURE X(28).
   21     002100     05  INPUT-EMPLOYEE-CODE        PICTURE 9.
   22     002200     05  INPUT-EMPLOYEE-SALARY      PICTURE 9(6)V99.
   23     002300 FD  MASTER-FILE.
   24     002400 01  MASTER-RECORD.
   25     002500     05 MST-EMPLOYEE-NUMBER         PICTURE 9(6).
   26     002600     05 MST-EMPLOYEE-NAME           PICTURE X(28).
   27     002700     05 MST-EMPLOYEE-CODE           PICTURE 9.
   28     002800     05 MST-EMPLOYEE-SALARY         PICTURE 9(6)V99.
   29     002900 WORKING-STORAGE SECTION.
   30     003000 77  INPUT-FILE-STATUS             PICTURE XX.
   31     003100 77  MASTER-FILE-STATUS            PICTURE XX.
   32     003200 77  OP-NAME                       PICTURE X(12).
   33     003300 01  INPUT-END                     PICTURE X VALUE SPACE.
   34     003400     88 THE-END-OF-INPUT           VALUE "E".
   35     003500 01  MASTER-END                    PICTURE X VALUE SPACE.
   36     003600     88 THE-END-OF-MASTER          VALUE "E".
   37     003700 PROCEDURE DIVISION.
   38     003800 DECLARATIVES.
          003900 INPUT-ERROR SECTION.
          004000      USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          004100 INPUT-ERROR-PARA.
   39     004200      DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, "FOR INPUT-FILE".
   40     004300      DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
   41     004400      DISPLAY "PROCESSING ENDED".
   42     004500      STOP RUN.
          004600
          004700 I-O-ERROR SECTION.
          004800      USE AFTER STANDARD ERROR PROCEDURE ON MASTER-FILE.
          004900 I-O-ERROR-PARA.
   43     005000      DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, "FOR MASTER-FILE".
   44     005100      DISPLAY "FILE STATUS IS ", MASTER-FILE-STATUS.
   45     005200      DISPLAY "PROCESSING ENDED".
   46     005300      STOP RUN.
```

Figure 123. Example of a Sequential File Update Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/UPDTSEQ        ISERIES1   03/09/15 14:48:09       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         005400 END DECLARATIVES.
         005500
         005600 MAIN-PROGRAM SECTION.
         005700 MAINLINE.
   47    005800        MOVE "OPEN" TO OP-NAME.
   48    005900        OPEN INPUT INPUT-FILE
         006000             I-O   MASTER-FILE.
         006100
   49    006200       PERFORM READ-INPUT-FILE.
   50    006300       PERFORM READ-MASTER-FILE.
   51    006400       PERFORM PROCESS-FILES UNTIL THE-END-OF-INPUT.
         006500
   52    006600       MOVE "CLOSE" TO OP-NAME.
   53    006700       CLOSE MASTER-FILE
         006800             INPUT-FILE.
   54    006900       STOP RUN.
         007000
         007100 READ-INPUT-FILE.
   55    007200       MOVE "READ" TO OP-NAME.
   56    007300       READ INPUT-FILE
   57    007400           AT END SET THE-END-OF-INPUT TO TRUE
         007500       END-READ.
         007600
         007700 READ-MASTER-FILE.
   58    007800       MOVE "READ" TO OP-NAME.
   59    007900       READ MASTER-FILE
         008000           AT END
   60    008100              SET THE-END-OF-MASTER TO TRUE
   61    008200              MOVE "AT END CLOSE" TO OP-NAME
   62    008300              CLOSE MASTER-FILE
   63    008400              MOVE "OPEN EXTEND" TO OP-NAME
   64    008500              OPEN EXTEND MASTER-FILE
         008600       END-READ.
         008700
         008800 PROCESS-FILES.
   65    008900     IF THE-END-OF-MASTER THEN
   66    009000         WRITE MASTER-RECORD FROM INPUT-RECORD
   67    009100         PERFORM READ-INPUT-FILE
         009200     ELSE
   68    009300         IF MST-EMPLOYEE-NUMBER
         009400            LESS THAN INPUT-EMPLOYEE-NUMBER THEN
   69    009500              PERFORM READ-MASTER-FILE
         009600        ELSE
   70    009700           IF MST-EMPLOYEE-NUMBER EQUAL INPUT-EMPLOYEE-NUMBER THEN
   71    009800              MOVE "REWRITE" TO OP-NAME
   72    009900              REWRITE MASTER-RECORD FROM INPUT-RECORD
   73    010000              PERFORM READ-INPUT-FILE
   74    010100              PERFORM READ-MASTER-FILE
         010200           ELSE
   75    010300               DISPLAY "ERROR RECORD -> ", INPUT-EMPLOYEE-NUMBER
   76    010400               PERFORM READ-INPUT-FILE
         010500           END-IF
         010600        END-IF
         010700     END-IF.
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 123. Example of a Sequential File Update Program (Part 2 of 2)

Relative File Creation

This program creates a relative file of summary sales records using sequential access. Each record contains a five-year summary of unit and dollar sales for one week of the year; there are 52 records within the file, each representing one week.

Each input record represents the summary sales for one week of one year. The records for the first week of the last five years (in ascending order) are the first five input records. The records for the second week of the last five years are the next five input records, and so on. Thus, five input records fill one output record.

The `RELATIVE KEY` for the `RELATIVE-FILE` is not specified because it is not required for sequential access unless the START statement is used. (For updating, however,

the key is INPUT-WEEK.)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/UPDTSEQ         ISERIES1   03/09/15 14:48:09        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.   CRTREL.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER.   IBM-ISERIES
    6     000700 OBJECT-COMPUTER.   IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT RELATIVE-FILE ASSIGN TO DISK-FILED
   11     001100         ORGANIZATION IS RELATIVE
   12     001200         ACCESS IS SEQUENTIAL
   13     001300         FILE STATUS RELATIVE-FILE-STATUS.
   14     001400     SELECT INPUT-FILE ASSIGN TO DISK-FILEC
   16     001500         ORGANIZATION IS SEQUENTIAL
   17     001600         ACCESS IS SEQUENTIAL
   18     001700         FILE STATUS INPUT-FILE-STATUS.
          001800
   19     001900 DATA DIVISION.
   20     002000 FILE SECTION.
   21     002100 FD  RELATIVE-FILE.
   22     002200 01  RELATIVE-RECORD-01.
   23     002300     05  RELATIVE-RECORD OCCURS 5 TIMES INDEXED BY REL-INDEX.
   24     002400         10  RELATIVE-YEAR          PICTURE 99.
   25     002500         10  RELATIVE-WEEK          PICTURE 99.
   26     002600         10  RELATIVE-UNIT-SALES    PICTURE S9(6).
   27     002700         10  RELATIVE-DOLLAR-SALES  PICTURE S9(9)V99.
   28     002800 FD  INPUT-FILE.
   29     002900 01  INPUT-RECORD.
   30     003000     05  INPUT-YEAR                PICTURE 99.
   31     003100     05  INPUT-WEEK                PICTURE 99.
   32     003200     05  INPUT-UNIT-SALES          PICTURE S9(6).
   33     003300     05  INPUT-DOLLAR-SALES        PICTURE S9(9)V99.
          003400
   34     003500 WORKING-STORAGE SECTION.
   35     003600 77  RELATIVE-FILE-STATUS          PICTURE XX.
   36     003700 77  INPUT-FILE-STATUS             PICTURE XX.
   37     003800 77  OP-NAME                       PICTURE X(5).
   38     003900 01  WORK-RECORD.
   39     004000     05  WORK-YEAR                 PICTURE 99 VALUE 00.
   40     004100     05  WORK-WEEK                 PICTURE 99.
   41     004200     05  WORK-UNIT-SALES           PICTURE S9(6).
   42     004300     05  WORK-DOLLAR-SALES         PICTURE S9(9)V99.
   43     004400 01  INPUT-END                     PICTURE X VALUE SPACE.
   44     004500     88  THE-END-OF-INPUT          VALUE "E".
          004600
   45     004700 PROCEDURE DIVISION.
   46     004800 DECLARATIVES.
          004900 INPUT-ERROR SECTION.
          005000       USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          005100 INPUT-ERROR-PARA.
   47     005200     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INPUT-FILE ".
   48     005300     DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
```

Figure 124. Example of a Relative File Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/CRTREL          ISERIES1   03/09/15 14:49:23        Page      3
  STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    49     005400     DISPLAY "PROCESSING ENDED"
    50     005500     STOP RUN.
           005600
           005700 OUTPUT-ERROR SECTION.
           005800       USE AFTER STANDARD ERROR PROCEDURE ON RELATIVE-FILE.
           005900 OUTPUT-ERROR-PARA.
    51     006000     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR RELATIVE-FILE".
    52     006100     DISPLAY "FILE STATUS IS ", RELATIVE-FILE-STATUS.
    53     006200     DISPLAY "PROCESSING ENDED"
    54     006300     STOP RUN.
           006400 END DECLARATIVES.
           006500
           006600 MAIN-PROGRAM SECTION.
           006700 MAINLINE.
    55     006800     MOVE "OPEN" TO OP-NAME.
    56     006900     OPEN INPUT INPUT-FILE
           007000          OUTPUT RELATIVE-FILE.
           007100
    57     007200     SET REL-INDEX TO 1.
    58     007300     MOVE "READ" TO OP-NAME.
    59     007400     READ INPUT-FILE
    60     007500         AT END SET THE-END-OF-INPUT TO TRUE
           007600     END-READ.
           007700
    61     007800     PERFORM UNTIL THE-END-OF-INPUT
    62     007900         MOVE INPUT-RECORD TO RELATIVE-RECORD (REL-INDEX)
    63     008000         IF REL-INDEX NOT = 5
    64     008100             SET REL-INDEX UP BY 1
           008200         ELSE
    65     008300             SET REL-INDEX TO 1
    66     008400             MOVE "WRITE" TO OP-NAME
    67     008500             WRITE RELATIVE-RECORD-01
           008600         END-IF
           008700
    68     008800         MOVE "READ" TO OP-NAME
    69     008900         READ INPUT-FILE
    70     009000             AT END SET THE-END-OF-INPUT TO TRUE
           009100         END-READ
           009200     END-PERFORM.
           009300
    71     009400     CLOSE RELATIVE-FILE
           009500           INPUT-FILE.
    72     009600     STOP RUN.
           009700
                          * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 124. Example of a Relative File Program (Part 2 of 2)

Relative File Updating

This program uses sequential access to update the file of summary sales records created in the CRTREL program. The updating program adds a record for the new year and deletes the oldest year's records from RELATIVE-FILE.

The input record represents the summary sales record for one week of the preceding year. The RELATIVE KEY for the RELATIVE-FILE is in the input record as INPUT-WEEK.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/UPDTREL         ISERIES1   03/09/15 14:50:35        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  UPDTREL.
           000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER.   IBM-ISERIES
    6     000700 OBJECT-COMPUTER.   IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT RELATIVE-FILE ASSIGN TO DISK-FILED
   11     001100         ORGANIZATION IS RELATIVE
   12     001200         ACCESS IS SEQUENTIAL
   13     001300         RELATIVE KEY INPUT-WEEK
   14     001400         FILE STATUS RELATIVE-FILE-STATUS.
   15     001500     SELECT INPUT-FILE ASSIGN TO DISK-FILES2
   17     001600         ORGANIZATION IS SEQUENTIAL
   18     001700         ACCESS IS SEQUENTIAL
   19     001800         FILE STATUS INPUT-FILE-STATUS.
           001900
   20     002000 DATA DIVISION.
   21     002100 FILE SECTION.
   22     002200 FD  RELATIVE-FILE.
   23     002300 01  RELATIVE-RECORD                PICTURE X(105).
   24     002400 FD  INPUT-FILE.
   25     002500 01  INPUT-RECORD.
   26     002600     05  INPUT-YEAR                 PICTURE 99.
   27     002700     05  INPUT-WEEK                 PICTURE 99.
   28     002800     05  INPUT-UNIT-SALES           PICTURE S9(6).
   29     002900     05  INPUT-DOLLAR-SALES         PICTURE S9(9)V99.
           003000
   30     003100 WORKING-STORAGE SECTION.
   31     003200 77  RELATIVE-FILE-STATUS           PICTURE XX.
   32     003300 77  INPUT-FILE-STATUS              PICTURE XX.
   33     003400 77  OP-NAME                        PICTURE X(7).
   34     003500 01  WORK-RECORD.
   35     003600     05  FILLER                     PICTURE X(21).
   36     003700     05  CURRENT-WORK-YEARS         PICTURE X(84).
   37     003800     05  NEW-WORK-YEAR.
   38     003900     10  WORK-YEAR                  PICTURE 99.
   39     004000     10  WORK-WEEK                  PICTURE 99.
   40     004100     10  WORK-UNIT-SALES            PICTURE S9(6).
   41     004200     10  WORK-DOLLAR-SALES          PICTURE S9(9)V99.
   42     004300 66  WORK-OUT-RECORD RENAMES
           004400     CURRENT-WORK-YEARS THROUGH NEW-WORK-YEAR.
   43     004500 01  INPUT-END                      PICTURE X VALUE SPACE.
   44     004600     88  THE-END-OF-INPUT           VALUE "E".
           004700
   45     004800 PROCEDURE DIVISION.
   46     004900 DECLARATIVES.
          005000 INPUT-ERROR SECTION.
          005100       USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          005200 INPUT-ERROR-PARA.
   47     005300     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INPUT-FILE ".
```

Figure 125. Example of a Relative File Update Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/UPDTREL        ISERIES1   03/09/15 14:50:35       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   48     005400     DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
   49     005500     DISPLAY "PROCESSING ENDED"
   50     005600     STOP RUN.
          005700
          005800 I-O-ERROR SECTION.
          005900       USE AFTER STANDARD ERROR PROCEDURE ON RELATIVE-FILE.
          006000 I-O-ERROR-PARA.
   51     006100     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR RELATIVE-FILE".
   52     006200     DISPLAY "FILE STATUS IS ", RELATIVE-FILE-STATUS.
   53     006300     DISPLAY "PROCESSING ENDED"
   54     006400     STOP RUN.
          006500 END DECLARATIVES.
          006600
          006700 MAIN-PROGRAM SECTION.
          006800 MAINLINE.
   55     006900     MOVE "OPEN" TO OP-NAME.
   56     007000     OPEN INPUT INPUT-FILE
          007100          I-O RELATIVE-FILE.
          007200
   57     007300     MOVE "READ" TO OP-NAME.
   58     007400     READ RELATIVE-FILE INTO WORK-RECORD
   59     007500         AT END SET THE-END-OF-INPUT TO TRUE
          007600     END-READ.
   60     007700     READ INPUT-FILE INTO NEW-WORK-YEAR
   61     007800         AT END SET THE-END-OF-INPUT TO TRUE
          007900     END-READ.
          008000
   62     008100     PERFORM UNTIL THE-END-OF-INPUT
   63     008200        MOVE "REWRITE" TO OP-NAME
   64     008300        REWRITE RELATIVE-RECORD FROM WORK-OUT-RECORD
          008400
   65     008500        MOVE "READ" TO OP-NAME
   66     008600        READ RELATIVE-FILE INTO WORK-RECORD
   67     008700            AT END SET THE-END-OF-INPUT TO TRUE
          008800        END-READ
   68     008900        READ INPUT-FILE INTO NEW-WORK-YEAR
   69     009000            AT END SET THE-END-OF-INPUT TO TRUE
          009100        END-READ
          009200     END-PERFORM.
          009300
   70     009400     MOVE "CLOSE" TO OP-NAME.
   71     009500     CLOSE INPUT-FILE
          009600           RELATIVE-FILE.
   72     009700     STOP RUN.
          009800
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 125. Example of a Relative File Update Program (Part 2 of 2)

Relative File Retrieval

This program, using dynamic access, retrieves the summary file created by the CRTREL program.

The records of the INPUT-FILE contain one required field (INPUT-WEEK), which is the RELATIVE KEY for RELATIVE-FILE, and one optional field (END-WEEK). An input record containing data in INPUT-WEEK and spaces in END-WEEK requests a printout for that one specific RELATIVE-RECORD; the record is retrieved through random access. An input record containing data in both INPUT-WEEK and END-WEEK requests a printout of all the RELATIVE-FILE records within the RELATIVE KEY range of INPUT-WEEK through END-WEEK inclusive. These records are retrieved through sequential access.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/RTRVREL         ISERIES1   03/09/15 14:51:40        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  RTRVREL.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER.   IBM-ISERIES
    6     000700 OBJECT-COMPUTER.   IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT RELATIVE-FILE ASSIGN TO DISK-FILED
   11     001100         ORGANIZATION IS RELATIVE
   12     001200         ACCESS IS DYNAMIC
   13     001300         RELATIVE KEY INPUT-WEEK
   14     001400         FILE STATUS IS RELATIVE-FILE-STATUS.
   15     001500     SELECT INPUT-FILE ASSIGN TO DISK-FILEF
   17     001600         FILE STATUS IS INPUT-FILE-STATUS.
   18     001700     SELECT PRINT-FILE ASSIGN TO PRINTER-QSYSPRT
   20     001800         FILE STATUS IS PRINT-FILE-STATUS.
          001900
   21     002000 DATA DIVISION.
   22     002100 FILE SECTION.
   23     002200 FD  RELATIVE-FILE.
   24     002300 01  RELATIVE-RECORD-01.
   25     002400     05  RELATIVE-RECORD OCCURS 5 TIMES INDEXED BY REL-INDEX.
   26     002500         10  RELATIVE-YEAR         PICTURE 99.
   27     002600         10  RELATIVE-WEEK         PICTURE 99.
   28     002700         10  RELATIVE-UNIT-SALES   PICTURE S9(6).
   29     002800         10  RELATIVE-DOLLAR-SALES PICTURE S9(9)V99.
   30     002900 FD  INPUT-FILE.
   31     003000 01  INPUT-RECORD.
   32     003100     05 INPUT-WEEK                 PICTURE 99.
   33     003200     05  END-WEEK                  PICTURE 99.
   34     003300 FD  PRINT-FILE.
   35     003400 01  PRINT-RECORD.
   36     003500     05 PRINT-WEEK                 PICTURE 99.
   37     003600     05 FILLER                     PICTURE X(5).
   38     003700     05 PRINT-YEAR                 PICTURE 99.
   39     003800     05 FILLER                     PICTURE X(5).
   40     003900     05 PRINT-UNIT-SALES           PICTURE ZZZ,ZZ9.
   41     004000     05 FILLER                     PICTURE X(5).
   42     004100     05 PRINT-DOLLAR-SALES         PICTURE $$$$,$$$,$$$.99.
          004200
   43     004300 WORKING-STORAGE SECTION.
   44     004400 77  RELATIVE-FILE-STATUS         PICTURE XX.
   45     004500 77  INPUT-FILE-STATUS            PICTURE XX.
   46     004600 77  PRINT-FILE-STATUS            PICTURE XX.
   47     004700 77  HIGH-WEEK                    PICTURE 99 VALUE 53.
   48     004800 77  OP-NAME                      PICTURE X(9).
   49     004900 01  INPUT-END                    PICTURE X(9).
   50     005000     88  THE-END-OF-INPUT         VALUE "E".
          005100
   51     005200 PROCEDURE DIVISION.
   52     005300 DECLARATIVES.
```

Figure 126. Example of a Relative File Retrieval Program (Part 1 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/RTRVREL         ISERIES1   03/09/15 14:51:40        Page      3
  STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
          005400 RELATIVE-FILE-ERROR SECTION.
          005500          USE AFTER STANDARD ERROR PROCEDURE ON RELATIVE-FILE.
          005600 RELATIVE-ERROR-PARA.
    53    005700     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR RELATIVE-FILE".
    54    005800     DISPLAY "FILE STATUS IS ", RELATIVE-FILE-STATUS.
    55    005900     DISPLAY "PROCESSING ENDED"
    56    006000     STOP RUN.
          006100
          006200 INPUT-FILE-ERROR SECTION.
          006300          USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          006400 INPUT-ERROR-PARA.
    57    006500     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INPUT-FILE ".
    58    006600     DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
    59    006700     DISPLAY "PROCESSING ENDED"
    60    006800     STOP RUN.
          006900
          007000 PRINT-FILE-ERROR SECTION.
          007100          USE AFTER STANDARD ERROR PROCEDURE ON PRINT-FILE.
          007200 PRINT-ERROR-MSG.
    61    007300     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR PRINT-FILE ".
    62    007400     DISPLAY "FILE STATUS IS ", PRINT-FILE-STATUS.
    63    007500     DISPLAY "PROCESSING ENDED"
    64    007600     STOP RUN.
          007700 END DECLARATIVES.
          007800
          007900 MAIN-PROGRAM SECTION.
          008000 MAINLINE.
    65    008100     MOVE "OPEN" TO OP-NAME.
    66    008200     OPEN INPUT INPUT-FILE
          008300                RELATIVE-FILE
          008400          OUTPUT PRINT-FILE.
          008500
    67    008600     MOVE SPACES TO PRINT-RECORD.
    68    008700     PERFORM READ-INPUT-FILE.
    69    008800     PERFORM CONTROL-PROCESS THRU READ-INPUT-FILE
          008900                             UNTIL THE-END-OF-INPUT.
          009000
    70    009100     MOVE "CLOSE" TO OP-NAME.
    71    009200     CLOSE RELATIVE-FILE
          009300          INPUT-FILE
          009400          PRINT-FILE.
    72    009500     STOP RUN.
          009600
          009700 CONTROL-PROCESS.
    73    009800     IF (END-WEEK = SPACES OR END-WEEK = 00)
    74    009900         MOVE "READ" TO OP-NAME
    75    010000         READ RELATIVE-FILE
    76    010100         PERFORM PRINT-SUMMARY VARYING REL-INDEX FROM 1 BY 1
          010200                               UNTIL REL-INDEX > 5
          010300     ELSE
    77    010400         MOVE "READ" TO OP-NAME
    78    010500         READ RELATIVE-FILE
    79    010600         PERFORM READ-REL-SEQ
          010700              UNTIL RELATIVE-WEEK(1) GREATER THAN END-WEEK
          010800         END-IF.
```

Figure 126. Example of a Relative File Retrieval Program (Part 2 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/RTRVREL         ISERIES1   03/09/15 14:51:40       Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
          010900
          011000 READ-INPUT-FILE.
   80     011100     MOVE "READ" TO OP-NAME.
   81     011200     READ INPUT-FILE
   82     011300         AT END SET THE-END-OF-INPUT TO TRUE
          011400     END-READ.
          011500
          011600 READ-REL-SEQ.
   83     011700     PERFORM PRINT-SUMMARY VARYING REL-INDEX FROM 1 BY 1
          011800                           UNTIL REL-INDEX > 5.
   84     011900     MOVE "READ NEXT" TO OP-NAME.
   85     012000     READ RELATIVE-FILE NEXT RECORD
   86     012100         AT END MOVE HIGH-WEEK TO RELATIVE-WEEK(1)
          012200     END-READ.
          012300
          012400 PRINT-SUMMARY.
   87     012500     MOVE RELATIVE-YEAR (REL-INDEX) TO PRINT-YEAR.
   88     012600     MOVE RELATIVE-WEEK (REL-INDEX) TO PRINT-WEEK.
   89     012700     MOVE RELATIVE-UNIT-SALES (REL-INDEX) TO PRINT-UNIT-SALES.
   90     012800     MOVE RELATIVE-DOLLAR-SALES(REL-INDEX) TO PRINT-DOLLAR-SALES.
   91     012900     MOVE "WRITE" TO OP-NAME.
   92     013000     WRITE PRINT-RECORD AFTER ADVANCING 2 LINES
          013100     END-WRITE.
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 126. Example of a Relative File Retrieval Program (Part 3 of 3)

Indexed File Creation

This program creates an indexed file of summary records for bank depositors. The key within each indexed file record is INDEX-KEY (the depositor's account number); the input records are ordered in ascending sequence upon this key. Records are read from the input file and transferred to the indexed file record area. The indexed file record is then written.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/CRTIND          ISERIES1   03/09/15 14:52:38        Page      2
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  CRTIND.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER. IBM-ISERIES
    6     000700 OBJECT-COMPUTER. IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT INDEXED-FILE ASSIGN TO DISK-INDEXFILE
   11     001100         ORGANIZATION IS INDEXED
   12     001200         ACCESS IS SEQUENTIAL
   13     001300         RECORD KEY IS INDEX-KEY
   14     001400         FILE STATUS IS INDEXED-FILE-STATUS.
   15     001500     SELECT INPUT-FILE ASSIGN TO DISK-FILEG
   17     001600         FILE STATUS IS INPUT-FILE-STATUS.
          001700
   18     001800 DATA DIVISION.
   19     001900 FILE SECTION.
   20     002000 FD  INDEXED-FILE.
   21     002100 01  INDEX-RECORD.
   22     002200     05  INDEX-KEY                   PICTURE X(10).
   23     002300     05  INDEX-FLD1                  PICTURE X(10).
   24     002400     05  INDEX-NAME                  PICTURE X(20).
   25     002500     05  INDEX-BAL                   PICTURE S9(5)V99.
   26     002600 FD  INPUT-FILE.
   27     002700 01  INPUT-RECORD.
   28     002800     05  INPUT-KEY                   PICTURE X(10).
   29     002900     05  INPUT-NAME                  PICTURE X(20).
   30     003000     05  INPUT-BAL                   PICTURE S9(5)V99.
   31     003100 WORKING-STORAGE SECTION.
   32     003200 77  INDEXED-FILE-STATUS             PICTURE XX.
   33     003300 77  INPUT-FILE-STATUS               PICTURE XX.
   34     003400 77  OP-NAME                         PICTURE X(7).
   35     003500 01  INPUT-END                       PICTURE X VALUE SPACES.
   36     003600     88  THE-END-OF-INPUT            VALUE "E".
          003700
   37     003800 PROCEDURE DIVISION.
   38     003900 DECLARATIVES.
          004000 INPUT-ERROR SECTION.
          004100       USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          004200 INPUT-ERROR-PARA.
   39     004300     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INPUT-FILE ".
   40     004400     DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
   41     004500     DISPLAY "PROCESSING ENDED"
   42     004600     STOP RUN.
          004700
          004800 OUTPUT-ERROR SECTION.
          004900       USE AFTER STANDARD ERROR PROCEDURE ON INDEXED-FILE.
          005000 OUTPUT-ERROR-PARA.
   43     005100     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INDEXED-FILE ".
   44     005200     DISPLAY "FILE STATUS IS ", INDEXED-FILE-STATUS.
   45     005300     DISPLAY "PROCESSING ENDED"
```

Figure 127. Example of an Indexed File Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/CRTIND         ISERIES1   03/09/15 14:52:38       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   46     005400     STOP RUN.
          005500 END DECLARATIVES.
          005600
          005700 MAIN-PROGRAM SECTION.
          005800 MAINLINE.
   47     005900     MOVE "OPEN" TO OP-NAME.
   48     006000     OPEN INPUT INPUT-FILE
          006100         OUTPUT INDEXED-FILE.
          006200
   49     006300     MOVE "READ" TO OP-NAME.
   50     006400     READ INPUT-FILE
   51     006500          AT END SET THE-END-OF-INPUT TO TRUE
          006600     END-READ.
          006700
   52     006800     PERFORM UNTIL THE-END-OF-INPUT
   53     006900         MOVE INPUT-KEY TO INDEX-KEY
   54     007000         MOVE INPUT-NAME TO INDEX-NAME
   55     007100         MOVE INPUT-BAL TO INDEX-BAL
   56     007200         MOVE SPACES TO INDEX-FLD1
   57     007300         MOVE "WRITE" TO OP-NAME
   58     007400         WRITE INDEX-RECORD
          007500
   59     007600         MOVE "READ" TO OP-NAME
   60     007700         READ INPUT-FILE
   61     007800              AT END SET THE-END-OF-INPUT TO TRUE
          007900         END-READ
          008000     END-PERFORM.
          008100
   62     008200     MOVE "CLOSE" TO OP-NAME.
   63     008300     CLOSE INPUT-FILE
          008400           INDEXED-FILE.
   64     008500     STOP RUN.
          008600
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 127. Example of an Indexed File Program (Part 2 of 2)

Indexed File Updating

This program, using dynamic access, updates the indexed file created in the CRTIND program.

The input records contain the key for the record, the depositor name, and the amount of the transaction.

When the input record is read, the program determines if it is:

- A transaction record (in which case, all fields of the record are filled)
- A record requesting sequential retrieval of a specific generic class (in which case, only the INPUT-GEN-FLD field of the input record contains data).

Random access is used for updating and printing the transaction records. Sequential access is used for retrieving and printing all records within one generic class.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/UPDTIND         ISERIES1  03/09/15 14:54:04        Page      2
                                 S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.  UPDTIND.
           000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER. IBM-ISERIES
    6     000700 OBJECT-COMPUTER. IBM-ISERIES
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT INDEXED-FILE ASSIGN TO DISK-INDXFILE
   11     001100         ORGANIZATION IS INDEXED
   12     001200         ACCESS IS DYNAMIC
   13     001300         RECORD KEY IS INDEX-KEY
   14     001400         FILE STATUS IS INDEXED-FILE-STATUS.
   15     001500     SELECT INPUT-FILE ASSIGN TO DISK-FILEH
   17     001600         FILE STATUS IS INPUT-FILE-STATUS.
   18     001700     SELECT PRINT-FILE ASSIGN TO PRINTER-OSYSPRT
   20     001800         FILE STATUS IS PRINT-FILE-STATUS.
           001900
   21     002000 DATA DIVISION.
   22     002100 FILE SECTION.
   23     002200 FD  INDEXED-FILE.
   24     002300 01  INDEX-RECORD.
   25     002400     05  INDEX-KEY.
   26     002500       10    INDEX-GEN-FLD    PICTURE X(5).
   27     002600       10    INDEX-DET-FLD    PICTURE X(5).
   28     002700     05  INDEX-FLD1           PICTURE X(10).
   29     002800     05  INDEX-NAME           PICTURE X(20).
   30     002900     05  INDEX-BAL            PICTURE S9(5)V99.
   31     003000 FD  INPUT-FILE.
   32     003100 01  INPUT-REC.
   33     003200     05  INPUT-KEY.
   34     003300       10  INPUT-GEN-FLD      PICTURE X(5).
   35     003400       10  INPUT-DET-FLD      PICTURE X(5).
   36     003500     05  INPUT-NAME           PICTURE X(20).
   37     003600     05  INPUT-AMT            PICTURE S9(5)V99.
   38     003700 FD  PRINT-FILE
           003800     LINAGE 12 LINES FOOTING AT 9.
   39     003900 01  PRINT-RECORD-1.
   40     004000     05  PRINT-KEY            PICTURE X(10).
   41     004100     05  FILLER               PICTURE X(5).
   42     004200     05  PRINT-NAME           PICTURE X(20).
   43     004300     05  FILLER               PICTURE X(5).
   44     004400     05  PRINT-BAL            PICTURE $$$,$$9.99-.
   45     004500     05  FILLER               PICTURE X(7).
   46     004600     05  PRINT-AMT            PICTURE $$$,$$9.99-.
   47     004700     05  FILLER               PICTURE X(5).
   48     004800     05  PRINT-NEW-BAL        PICTURE $$$,$$9.99-.
   49     004900 01  PRINT-RECORD-2           PICTURE X(89).
           005000
   50     005100 WORKING-STORAGE SECTION.
   51     005200 77  INDEXED-FILE-STATUS      PICTURE XX.
   52     005300 77  INPUT-FILE-STATUS        PICTURE XX.
```

Figure 128. Example of an Indexed File Update Program (Part 1 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/UPDTIND         ISERIES1  03/09/15 14:54:04        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   53     005400 77  PRINT-FILE-STATUS        PICTURE XX.
   54     005500 77  OP-NAME                  PICTURE X(9).
   55     005600 77  LINES-TO-FOOT            PICTURE 99.
   56     005700 01  PAGE-HEAD.
   57     005800     05  FILLER               PICTURE X(38) VALUE SPACES.
   58     005900     05  FILLER               PICTURE X(13) VALUE "UPDATE REPORT".
   59     006000     05  FILLER               PICTURE X(38) VALUE SPACES.
   60     006100 01  COLUMN-HEAD.
   61     006200     05  FILLER               PICTURE X(6)  VALUE "KEY ID".
   62     006300     05  FILLER               PICTURE X(9)  VALUE SPACES.
   63     006400     05  FILLER               PICTURE X(4)  VALUE "NAME".
   64     006500     05  FILLER               PICTURE X(21) VALUE SPACES.
   65     006600     05  FILLER               PICTURE X(11) VALUE "CUR BALANCE".
   66     006700     05  FILLER               PICTURE X(6)  VALUE SPACES.
   67     006800     05  FILLER               PICTURE X(13) VALUE "UPDATE AMOUNT".
   68     006900     05  FILLER               PICTURE X(4)  VALUE SPACES.
   69     007000     05  FILLER               PICTURE X(11) VALUE "NEW BALANCE".
   70     007100     05  FILLER               PICTURE X(4)  VALUE SPACES.
   71     007200 01  PAGE-FOOT.
   72     007300     05  FILLER               PICTURE X(81)  VALUE SPACES.
   73     007400     05  FILLER               PICTURE A(6)   VALUE "PAGE  ".
   74     007500     05  PG-NUMBER            PICTURE 99     VALUE 00.
          007600
   75     007700 01  INPUT-END               PICTURE X VALUE SPACE.
   76     007800     88  THE-END-OF-INPUT              VALUE "E".
          007900
   77     008000 PROCEDURE DIVISION.
   78     008100 DECLARATIVES.
          008200 INPUT-ERROR SECTION.
          008300       USE AFTER STANDARD ERROR PROCEDURE ON INPUT-FILE.
          008400 INPUT-ERROR-PARA.
   79     008500     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INPUT-FILE ".
   80     008600     DISPLAY "FILE STATUS IS ", INPUT-FILE-STATUS.
   81     008700     DISPLAY "PROCESSING ENDED"
   82     008800     STOP RUN.
          008900
          009000 I-O-ERROR SECTION.
          009100       USE AFTER STANDARD ERROR PROCEDURE ON INDEXED-FILE.
          009200 I-O-ERROR-PARA.
   83     009300     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR INDEXED-FILE ".
   84     009400     DISPLAY "FILE STATUS IS ", INDEXED-FILE-STATUS.
   85     009500     DISPLAY "PROCESSING ENDED"
   86     009600     STOP RUN.
          009700
          009800 OUTPUT-ERROR SECTION.
          009900       USE AFTER STANDARD ERROR PROCEDURE ON PRINT-FILE.
          010000 OUTPUT-ERROR-PARA.
   87     010100     DISPLAY "UNEXPECTED ERROR ON ", OP-NAME, " FOR PRINT-FILE ".
   88     010200     DISPLAY "FILE STATUS IS ", PRINT-FILE-STATUS.
   89     010300     DISPLAY "PROCESSING ENDED"
   90     010400     STOP RUN.
          010500 END DECLARATIVES.
          010600
          010700 MAIN-PROGRAM SECTION.
          010800 MAINLINE.
```

Figure 128. Example of an Indexed File Update Program (Part 2 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/UPDTIND         ISERIES1  03/09/15 14:54:04        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   91     010900     MOVE "OPEN" TO OP-NAME.
   92     011000     OPEN INPUT INPUT-FILE
          011100         I-O INDEXED-FILE
          011200         OUTPUT PRINT-FILE.
          011300
   93     011400     PERFORM PAGE-START.
   94     011500     PERFORM READ-INPUT-FILE.
   95     011600     PERFORM PROCESS-DATA THRU READ-INPUT-FILE
          011700                         UNTIL THE-END-OF-INPUT.
   96     011800     PERFORM PAGE-END.
          011900
   97     012000     MOVE "CLOSE" TO OP-NAME.
   98     012100     CLOSE INPUT-FILE
          012200           INDEXED-FILE
          012300           PRINT-FILE.
   99     012400     STOP RUN.
          012500
          012600 PROCESS-DATA.
  100     012700     IF INPUT-DET-FLD EQUAL SPACES
  101     012800         MOVE INPUT-GEN-FLD TO INDEX-GEN-FLD
  102     012900         MOVE "START" TO OP-NAME
  103     013000         START INDEXED-FILE
          013100              KEY IS NOT LESS THAN INDEX-GEN-FLD
          013200         END-START
  104     013300         PERFORM SEQUENTIAL-PROCESS
          013400             UNTIL INPUT-GEN-FLD NOT EQUAL INDEX-GEN-FLD
          013500     ELSE
  105     013600         MOVE INPUT-KEY TO INDEX-KEY
  106     013700         MOVE "READ" TO OP-NAME
  107     013800         READ INDEXED-FILE
  108     013900         IF INPUT-GEN-FLD EQUAL INDEX-GEN-FLD THEN
  109     014000             MOVE INDEX-KEY TO PRINT-KEY
  110     014100             MOVE INDEX-NAME TO PRINT-NAME
  111     014200             MOVE INDEX-BAL TO PRINT-BAL
  112     014300             MOVE INPUT-AMT TO PRINT-AMT
  113     014400             ADD INPUT-AMT TO INDEX-BAL
  114     014500             MOVE INDEX-BAL TO PRINT-NEW-BAL
  115     014600             PERFORM PRINT-DETAIL
  116     014700             MOVE "REWRITE" TO OP-NAME
  117     014800             REWRITE INDEX-RECORD
          014900         END-IF
          015000     END-IF.
          015100
          015200 READ-INPUT-FILE.
  118     015300     MOVE "READ" TO OP-NAME.
  119     015400     READ INPUT-FILE
  120     015500         AT END SET THE-END-OF-INPUT TO TRUE
          015600     END-READ.
          015700
          015800 SEQUENTIAL-PROCESS.
  121     015900     MOVE "READ NEXT" TO OP-NAME.
  122     016000     READ INDEXED-FILE NEXT RECORD
  123     016100         AT END MOVE HIGH-VALUE TO INDEX-GEN-FLD
          016200     END-READ.
  124     016300     IF INPUT-GEN-FLD EQUAL INDEX-GEN-FLD THEN
```

Figure 128. Example of an Indexed File Update Program (Part 3 of 4)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/UPDTIND         ISERIES1  03/09/15 14:54:04        Page      5
  STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   125     016400         MOVE INDEX-KEY TO PRINT-KEY
   126     016500         MOVE INDEX-NAME TO PRINT-NAME
   127     016600         MOVE INDEX-BAL TO PRINT-NEW-BAL
   128     016700         PERFORM PRINT-DETAIL
           016800     END-IF.
           016900
           017000 PRINT-DETAIL.
   129     017100     MOVE "WRITE" TO OP-NAME.
   130     017200     WRITE PRINT-RECORD-1
           017300          AT END-OF-PAGE
   131     017400          PERFORM PAGE-END THROUGH PAGE-START
           017500     END-WRITE.
   132     017600     MOVE SPACES TO PRINT-RECORD-1.
           017700
           017800 PAGE-END.
   133     017900     MOVE "WRITE" TO OP-NAME.
   134     018000     ADD 1 TO PG-NUMBER.
   135     018100     SUBTRACT LINAGE-COUNTER OF PRINT-FILE FROM 12
           018200          GIVING LINES-TO-FOOT.
   136     018300     MOVE SPACES TO PRINT-RECORD-1.
   137     018400     WRITE PRINT-RECORD-1
           018500          AFTER ADVANCING LINES-TO-FOOT
           018600     END-WRITE.
   138     018700     WRITE PRINT-RECORD-2 FROM PAGE-FOOT
           018800          BEFORE ADVANCING PAGE
           018900     END-WRITE.
           019000
           019100 PAGE-START.
   139     019200     WRITE PRINT-RECORD-2 FROM PAGE-HEAD
           019300          AFTER ADVANCING 1 LINE
           019400     END-WRITE.
   140     019500     MOVE SPACES TO PRINT-RECORD-2.
   141     019600     WRITE PRINT-RECORD-2 FROM COLUMN-HEAD
           019700          AFTER ADVANCING 1 LINE
           019800     END-WRITE.
   142     019900     MOVE SPACES TO PRINT-RECORD-2.
                          * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 128. Example of an Indexed File Update Program (Part 4 of 4)

OS/400 System Files

The OS/400 system has four categories of files:

- Database files
- Device files
- DDM files
- Save files.

Database files allow information to be permanently stored on the system. A database file is subdivided into groups of records called members. There are two types of database files:

- A **physical file** is a file that contains data records (similar to disk files on other systems).
- A **logical file** is a database file through which data from one or more physical files can be accessed. The format and organization of this data is different from that of the data in the physical files. Each logical file can define a different access path (index) for the data in the physical files, and can exclude and reorder the fields defined in the physical files.

A database physical file can exist on one OS/400 system or on multiple OS/400 systems. If a database physical file exists on more than one OS/400system, it is called a **distributed physical file** or a **distributed file**. Since a logical file is based on one or more physical files, if the underlying physical file is distributed, then the logical file is also a distributed file.

To access a distributed file from an ILE COBOL program, you OPEN the distributed file; no other intermediate file is required, and no knowledge is required of the OS/400 systems that have a part of the distributed file.

Contrast this to a Distributed Data Management (DDM) file which identifies the name of a database file that exists on a remote system. In ILE COBOL, to OPEN the remote database file, you actually open the local DDM file Thus, a DDM file combines the characteristics of a device file and a database file. As a device file, the DDM file refers to a remote location name, local location name, device name, mode, and a remote network ID to identify a remote system as the target system. The DDM file appears to the application program as a database file and serves as the access device between the ILE COBOL program and a remote file.

Since a DDM file identifies a remote database file, and since database files can be distributed files, a DDM file can refer to a distributed file.

For more information about DDM files and distributed files, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Distributed Data Management (DDM) Files

An ILE COBOL file assigned to a device of DISK or DATABASE can refer to a DDM file.

A DDM file is a file on the local (or source) system that contains the information needed to access a data file on a target system. It is not a data file that can be accessed by a program for database operations. Instead, when an ILE COBOL program running on a source system opens a DDM file, the file information is used by DDM to locate the remote file whose data is to be accessed.

A DDM file is created by the Create DDM File (CRTDDMF) command. The DDM file is stored as a file object in a library, the same as any other file or object.

When an ILE COBOL program opens a DDM file, a DDM conversation with the target system is established. And, if the program is opening the DDM file to access records in the remote file, an open data path (ODP) to the remote file is also established.

DDM can be used to communicate between systems that are architecturally different. For example, although the architectures of the OS/400 system and System/36 are different, these systems can use DDM to access files in each other's database.

The following sections discuss the behavior that is unique to DDM files, and database files access through DDM files. Other topics about database files are discussed elsewhere in this chapter.

Using DDM Files with Non-OS/400 Systems

If you are using DDM among System/38® or System/36® systems as well as OS/400 systems, you should be aware that the concepts for both types are similar, except in the way they point to the remote file:

- An OS/400 system and a System/38 use a separate DDM file to refer to each remote file to be accessed.

- A System/36 system uses a network resource directory that contains one network resource directory entry for each remote file to be accessed.

DDM Programming Considerations

Generally, DDM file names can be specified in ILE COBOL anywhere a database file can be specified, for both iSeries and non-iSeries target systems. This section summarizes the ILE COBOL programming considerations for DDM files:

- DDM file names can be specified on the Create Bound COBOL Program (CRTBNDCBL), Create COBOL Module (CRTCBLMOD), and Create COBOL Program (CRTCBLPGM) commands:
  - To access remote files containing source statements, on an iSeries system or a non-iSeries system, a DDM file name can be specified on the SRCFILE parameter, and a member name can be specified on the SRCMBR parameter.
  - For OS/400 or System/38 target systems, a remote OS/400 or System/38 source file (and, optionally, member) can be accessed in the same manner as a local source file and member.
  - For non-OS/400 target systems, a remote source file can be accessed if both the PGM and SRCMBR parameter defaults are used on the CRTBNDCBL or CRTCBLPGM command. Or, if a member name is specified, it must be the same as the DDM file name specified on the SRCFILE parameter. The CRTCBLMOD command follows similar rules, except that the PGM and SRCMBR parameters are replaced with the MODULE and SRCMBR parameters.
  - To place the compiler listing in a database file on a target system, a DDM file name can be specified on the PRTFILE parameter of the CRTCBLPGM command.
- DDM file names can be specified as the input and output files for the ILE COBOL SORT and MERGE operation.
- A DDM file can be used in the ILE COBOL COPY statement when the DDS option on that statement is used to copy one or all of the externally described record formats from the remote file referred to by the DDM file into the program being compiled. If this is done when the remote file is not on an OS/400 system or a System/38, the field declares for the record descriptions will not have meaningful names. Instead, all of the field names are declared as F*nnnnn* and the key fields are declared as K*nnnnn*.

  A recommended method for describing remote files, when the target is not an OS/400 system or a System/38, is to have the data description specifications (DDS) on the local system and enter a Create Physical File (CRTPF) command or a Create Logical File (CRTLF) command on the local system. Compile the program using the local file name. Ensure that the remote system's file has the corresponding field types and field lengths. To access the remote file, use the Override with Database File (OVRDBF) command preceding the program, for example:

  ```
  OVRDBF FILE(PGMFIL) TOFILE(DDMFIL) LVLCHK(*NO)
  ```
- DDM file names can be specified on a COPY statement:
  - If you do not specify the library name with the file name, the first file found with that file name in the user's library list is used as the include file.
  - If the target system is not an OS/400 system or a System/38, a DDM file name can be specified as the include file on a COPY statement, but the member name must be the same as the DDM file name.
- If the target system is a System/36, ILE COBOL cannot be used to open a DDM file for output if the associated remote file has logical files built over it. For

System/36 files with logical files, the open operation (open output) will fail because ILE COBOL programming language attempts to clear the file before using it.

- When an ILE COBOL program opens a DDM file on the source system, the following statements can be used to perform I/O operations on the remote file at the target system, for both OS/400 and non-OS/400 targets: CLOSE, DELETE, OPEN, READ, REWRITE, START, and WRITE.

DDM Direct (Relative) File Support

An OS/400 server does not support direct files as one of its file types. (An OS/400 server creates direct files as sequential files.) However, an ILE COBOL program on an OS/400 server can specify that a file be accessed as a direct file by specifying an organization of RELATIVE on the SELECT statement.

Keep the following in mind when working with direct files on the OS/400:

- If a file is created on the local OS/400 server as a direct file by a program or user from a non-OS/400 server, the file can be accessed as a direct file by a ILE COBOL program from a remote non-OS/400 source server.
- If a file is created on the local OS/400 server by a program or user on the same OS/400 server, it cannot be accessed as a direct file by a non-iSeries system because the OS/400 target server cannot determine, in this case, whether the file is a direct or sequential file.
- Any files created by a remote system can be used locally.

Distributed Files

Distributed files allow a database file to be spread across multiple OS/400systems, while retaining the look and capability of a single database. Performance of large queries can be enhanced by splitting database requests across multiple systems. Distributed files behave in much the same way as DATABASE files. However, since files are distributed across multiple systems, the arrival sequence or relative number cannot be relied upon, and additional time is required for the data link to pass the data between the systems whenever the remote system is accessed.

A distributed file is created like other database files, with the Create Physical File (CRTPF) command. This command has two new parameters that relate to a distributed file:

- Node group (NODGRP)
- Partitioning key (PTNKEY).

The first parameter has a value of *NONE for regular files, and the name of a node group for a distributed file. A node group is a new system object type (type *NODGRP) that specifies the names of the relational databases that will contain the records of the file. A node group is created with the Create Node Group (CRTNODGRP) command.

The records of a distributed file are divided amongst the various relational databases based on a partitioning key. The partitioning key is a field, or set of fields, from the distributed file whose value will determine in which relational database each record will be stored.

An existing physical file can be changed into a distributed file by using the Change Physical File (CHGPF) command. The two new parameters, node group and partitioning key, that were added to the CRTPF command were also added to the CHGPF command.

Open Considerations for Data Processing

A distributed file's data can be accessed in a buffered or non-buffered way. This buffering of records is in addition to other buffering, like SEQONLY processing.

The Override with Database File (OVRDBF) command has a new parameter called distributed data (DSTDTA) that has three values:

***BUFFERED**
Data may be kept in a buffer.

***PROTECTED**
Similar to *BUFFERED, but the file is locked to prevent updates by other jobs.

***CURRENT**
Data is not buffered.

The remainder of this section describes the open considerations when distributed data processing is overridden and when it is not overridden.

When Distributed Data Processing is Overridden

The following considerations apply for opening distributed files when distributed data processing *is* overridden:

- If the distributed file open operation will be for input-only processing, and records that are deleted, inserted, or updated while the file is open must be processed immediately by your program, then you must use the OVRDBF (Override with Data Base File) command to override the distributed file processing to non-buffered retrieval (*CURRENT). Non-buffered retrieval does not achieve the same performance as buffered retrieval, but it will guarantee data integrity, and provide for maximum record concurrency while you have the distributed file open.
- If the file open operation will be for update or delete operations, then you may want to use the OVRDBF (Override with Data Base File) command to override the distributed data processing to either protected buffer retrieval (*PROTECTED) or buffered retrieval (*BUFFERED).

  These are the advantages and disadvantages to protected buffer retrieval:
  - Achieves the same performance as buffered retrieval.
  - Guarantees data integrity if your program does not delete, insert, or update records.
  - Will not be allowed if another process has the distributed file open for anything other than input-only processing, which does not also include protected buffer retrieval.

  These are the advantages and disadvantages to buffered retrieval:
  - Achieves the same performance as protected buffer retrieval.
  - Allows for maximum record concurrency while you have the distributed file open.

– Records that are deleted, inserted, or updated in the distributed file after the open might not be seen as they occur. This may cause your program to update or delete the wrong record.

When Distributed Data Processing is NOT Overridden

The following considerations apply for opening distributed files when distributed data processing is *not* overridden:

- The system will process a distributed file that is open for input-only using buffered retrieval (*BUFFERED). Buffered retrieval will achieve the best performance along with maximum record concurrency, however, you might not see all of the changes made to the file as they occur. Refer to "Input/Output Considerations for Distributed Files" for more information.
- The system will process a distributed file that is opened for output-only one record at a time. If your distributed file is opened for output-only, the DSTDTA parameter will have no effect. Also, if SEQONLY(*YES) processing has been requested, it will be changed to SEQONLY(*NO). The SEQONLY(*NO) processing will provide feedback on a record-by-record basis when the records are inserted into the file.
- The system will process a distributed file that has been opened with an option that includes update or delete using non-buffered retrieval (*CURRENT). Non-buffered retrieval ensures that you are updating or deleting the same record that would have been updated or deleted if all of the distributed file data had been contained in a non-distributed database file. Since non-buffered retrieval will be used, the best performance for the distributed file will not be achieved, but the best data integrity and the maximum record concurrency will be guaranteed.

  Note: For arrival sequence distributed files, records will be retrieved in arrival sequence starting with the first node, then the second node, and so on. For duplicate key considerations, refer to "Input/Output Considerations for Distributed Files."
- The system will process a distributed file that is opened with all operations (*INP, *OUT, *UPD, *DLT) using non-buffered retrieval (*CURRENT), since it includes both update and delete options.

Input/Output Considerations for Distributed Files

The following considerations apply to input/output operations for distributed files:

- For input of arrival sequence distributed files and keyed sequence distributed files whose keyed access paths have been ignored at open time, the records will be retrieved as follows:
  1. All records from the first node, as defined by the node group at file creation time, will be retrieved in arrival sequence from the first node.
  2. After all records from the first node have been retrieved, then all records from the second node will be retrieved in arrival sequence from the second node.
  3. After all records from the second node have been retrieved, then all records from the third node will be retrieved in arrival sequence from the third node.
  4. This will continue until the last node defined by the node group at file creation time is reached.
  5. After all records from the last node have been retrieved in arrival sequence, end-of-file is reached.

Thus, distributed files that are processed in arrival sequence will not be processed in arrival sequence across the different nodes of the distributed file.

- For input of keyed sequence distributed files whose keyed access paths have not been ignored at open time, the records are retrieved as follows:
  - The first-changed first-out (FCFO), first-in first-out (FIFO), or last-in first-out (LIFO) order of records with duplicate key values will only be valid for records that come from the same node.
  - All records with duplicate key values from the first node as defined by the node group at file creation time will be retrieved in the specified access path order.
  - After all records with duplicate key values from the first node have been retrieved, then all records with duplicate key values from the second node will be retrieved in the specified access path order.
  - After all records with duplicate key values from the second node have been retrieved, then all records with duplicate key values from the third node will be retrieved in the specified access path order.
  - This will continue until the last node as defined by the node group at the file creation time is reached.
  - After all records with duplicate key values have been retrieved from the last node in the specified access path order, the next non-duplicate key value will be retrieved.

  Therefore, distributed files that have duplicate key values will not be processed in the specified access path order across the different nodes of the distributed file.
- When buffered retrieval (*BUFFERED) or protected buffered retrieval (*PROTECTED) is being used:
  - Records that are inserted or updated in the distributed file after the open might not be seen while retrieving records even if their key values come after the last record returned to your program. This is because each node has its own key position based on the last get-by-key request. “Example of How Records are Retrieved for Insert, Update, and Delete” provides an example of how duplicate key records are retrieved for insert or update.
  - Records that are deleted from the distributed file after the open might still be seen while retrieving records from the file.
  - The only difference between buffered retrieval and protected buffer retrieval is that protected buffer retrieval restricts the deleting, inserting, and updating of records in the distributed file to your job.
- For output to distributed files, the system will process insert requests one record at a time. If your distributed file open request is for output-only and SEQONLY(*YES) processing, it will be changed to SEQONLY(*NO). The single record output processing will provide feedback on a record-by-record basis when the records are inserted into the file.

Example of How Records are Retrieved for Insert, Update, and Delete

Figure 129 on page 489 shows the different record positions for a distributed file after the first get-by-key request in buffered retrieval. This get-by-key request has positioned the distributed file at the first record on each node.

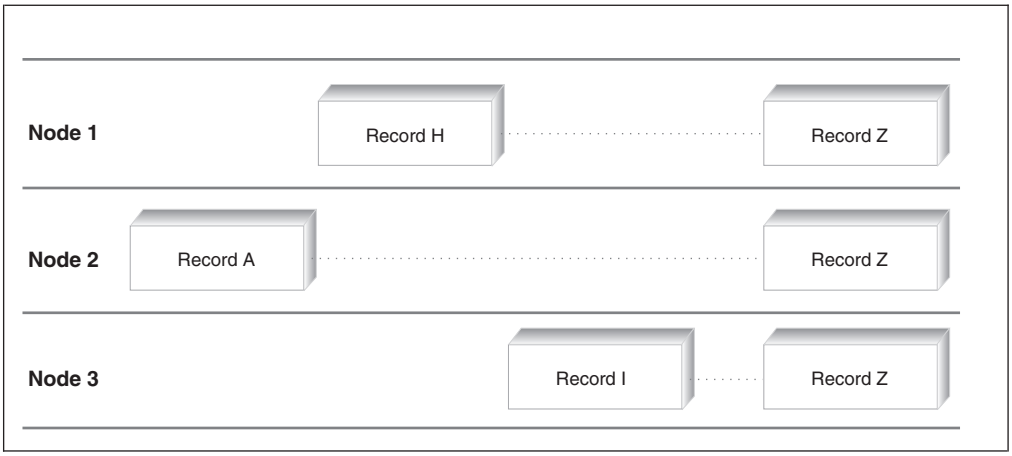


Figure 129. First Duplicate Record Key Positions Across Nodes in a Distributed File

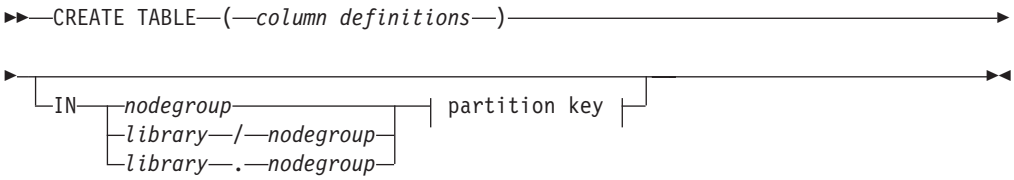
In this example, the first get-by-key request has returned record A to your program. Because of the different record positions on the different nodes, subsequent get-by-key-next requests would not return records that had been inserted or updated on node 1 that preceded either Record H on Node 1 or Record I on Node 3. An inserted or updated record that comes after the last record returned to your program, but before the current key position for a particular node, will not be seen by your program unless the direction in which you are reading records is changed.

Records that have been deleted may also be seen by your program if they have already been positioned to and retrieved from a particular node. For example, if Record A from Node 2 has been returned to your program, Record I from Node 3 will be returned to your program even if it has been deleted prior to issuing the next get-by-key-next request set to retrieve it.

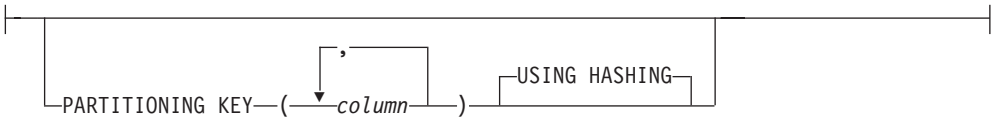
When non-buffered retrieval (*CURRENT) is being used, records that are inserted or updated in the distributed file after the open will be retrieved in the same way as they would have been for a non-distributed database file, except for duplicate key values that span nodes. Records that are inserted or updated in a distributed file after it has been opened for non-buffered retrieval also might not be seen if its key value comes before the last record that has been returned to your program. If you require that the keyed sequence input to your distributed file retrieves the same records that would have been retrieved for a non-distributed database file, except for duplicate key values that span nodes, then you should override the open of your keyed distributed file to non-buffered retrieval.

SQL Statement Additions for Distributed Data Files

New clauses have been added to the SQL CREATE TABLE statement to allow you to create distributed files with SQL. These additions are shown below:



partition key:



For more information about using SQL commands in ILE COBOL programs, refer to ″Including Structured Query Language (SQL) Statements in Your ILE COBOL Program″.

Examples of Processing Distributed Files

In order to create a distributed file, you must do the following on each system on which parts of the distributed file will exist:

1. You need to add a relational database directory entry for the local system, and one relational database directory entry for every other system that is going to contain part of the file
2. You have to create the library that will contain the distributed file.

For the primary system, you need to do the following:

1. Create a node group which contains the names of all of the relational databases involved
2. Define the DDS for the physical file
3. Create the physical file specifying the Node Group (NODGRP) and Partitioning Key (PTNKEY) parameters
4. If you create a logical file over the distributed physical file, a distributed logical file results.

For example, suppose you have two systems, and you want each one to contain part of a distributed file. Assume:

- Your primary system is called OS400SYS1, and your other system is OS400SYS2
- The library where the distributed file will exist is DISTRIBUTE.

To create the relational database directory entries on system OS400SYS1, you would enter the following commands:

```
ADDRDBDIRE RDB(OS400SYS1) RMTLOCNAME(*LOCAL)
           TEXT('local database RDB directory entry')
ADDRDBDIRE RDB(OS400SYS2) RMTLOCNAME(AS400SYS2)
           TEXT('remote database RDB directory entry')
```

To create the library DISTRIBUTE on OS400SYS1, enter the CRTLIB command.

To create the relational database directory entries on system OS400SYS2, you would enter the following commands:

```
ADDRDBDIRE RDB(OS400SYS2) RMTLOCNAME(*LOCAL)
           TEXT('local database RDB directory entry')
ADDRDBDIRE RDB(OS400SYS1) RMTLOCNAME(AS400SYS1)
           TEXT('remote database RDB directory entry')
```

To create the library DISTRIBUTE on OS400SYS2, enter the CRTLIB command.

On your primary system, assume:

- The name of the node group, which names the relational databases that will contain the records for the distributed file, is NODEGROUP

- The name of the distributed physical file is CUSTMAST.

Then, to create the node group on system OS400SYS1, use the following command:

```
CRTNODGRP NODGRP(DISTRIBUTE/NODEGROUP) RDB(OS400SYS1 AS400SYS2)
          TEXT('node group for distributed file')
```

The DDS for the Create Physical File (CRTPF) command (contained in source file QDDSSRC, in library DISTRIBUTE) is:

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A          R CUSTREC
     A            CUSTOMERNO     9S 0       ALIAS(CUSTOMER_NUMBER)
     A            FIRSTNAME     15A         ALIAS(CUSTOMER_FIRST_NAME)
     A            LASTNAME      15A         ALIAS(CUSTOMER_LAST_NAME)
     A            ADDRESS       20A         ALIAS(CUSTOMER_ADDRESS)
     A            ACCOUNTNO      9S 0       ALIAS(CUSTOMER_ACCOUNT_NUMBER)
```

The DDS field CUSTOMERNO is used below as the partitioning key for the distributed file.

```
CRTPF FILE(DISTRIBUTE/CUSTMAST)
      SRCFILE(DISTRIBUTE/QDDSSRC) SRCMBR(CUSTMAST)
      NODGRP(DISTRIBUTE/NODEGROUP)
      PTNKEY(CUSTOMERNO)
```

When the Create Physical File (CRTPF) command completes on the primary system, the file is created on the primary system as well as on all of the other relational databases in the node group. After the file has been created, changes to the node group will no longer affect the distributed file.

Processing Files with Constraints

Data within the fields of a database physical file (SQL TABLE) can be restricted to certain values by adding a constraint relationship. There are four types of constraints:

- Referential
- Unique
- Primary key (a special case of a unique constraint)
- Check.

You can use constraint relationships to define dependencies between files. The relationships that you define are enforced by the system when changes occur to information in the files. When you define constraint relationships, you control the **referential integrity** of the data being processed.

Check constraints are validity checks that can be placed on fields (columns) in the database physical files (SQL tables), thereby increasing the integrity of your data.

When data is inserted or updated in fields with constraints, the data must first meet the validity checks placed on those fields, before the insert or update operation can be completed. If all of the constraints are not met, then the I/O request is not performed, and a message is sent back to the program indicating that a constraint has been violated. When a check constraint has been violated during the running of a COBOL I/O statement, a file status of 9W is set. If a referential constraint is violated, a file status of 9R is set.

Although only physical files can have constraints, the constraint is enforced while performing I/O on a logical file built over a physical file with constraints. Check constraints can be used for one or many fields, and can be used with field-to-field-comparisons or field-to-literal comparisons.

For more detailed information about constraints, refer to the *DB2 Universal Database for AS/400* section of the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site - http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Restrictions

The following restrictions apply when adding constraints to a file or table. The file:
- Must be a database physical file
- Can have a maximum of one member
- Cannot be a program-described file
- Cannot be a source file
- Cannot reside in QTEMP
- Cannot be opened
- Cannot have uncommitted I/O changes.

Referential and check constraints have four states:
- Defined and enabled
- Defined and disabled
- Established and enabled
- Established and disabled.

Defined means the constraint definition has been added to the file, but not all of the pieces of the file are there for enforcement. For example, the file's member does not exist.

Established means the constraint definition has been added to the file, and all of the pieces of the file are there for enforcement.

Enabled means the check constraint will be enforced if the constraint is also established. If the constraint is defined, then the file member structures do not yet exist for enforcement.

Disabled means the constraint definition will not be enforced, regardless of whether the constraint is established or defined.

To define or establish a referential constraint, the parent file and the dependent file must exist. However, if the parent or dependent file has no members, the constraint is defined only (not established).

Adding, Modifying and Removing Constraints

Constraints can be added, modified, or removed using:
- SQL
- CL commands.

Through SQL, a constraint can be added to the column of a table using the CREATE TABLE statement. If the table already exists, then the ALTER TABLE statement can be used to add the constraint. The ALTER TABLE statement can also be used to DROP the constraint.

Using CL commands, the Add PF Constraint (ADDPFCST) command can be used to add or change a constraint, and the Remove PF Constraint (RMVPFCST) command can be used to remove a constraint.

Checking that Constraints Have Been Successfully Added or Removed

From an ILE COBOL program, the Retrieve File Description (QDBRTVFD) API can be used. Externally, from the OS/400 operating system, the Display File Description (DSPFD) command can be used. A query of the system cross-reference file (QADBFCST) will also show if a constraint has been added to a file.

Both the Retrieve File Description (QDBRTVFD) API and the Display File Description (DSPFD) command retrieve the file definition along with all of the constraints that have been added.

Order of Operations

The following is the order of operations for a file on which commitment control has *not* been started:

- BEFORE trigger fired
- Referential constraint processed for *RESTRICT
- Check constraint processed
- I/O operation processed
- AFTER trigger fired
- Referential constraints, other than *RESTRICT, processed.

The following is the order of operations for a file on which commitment control *has* been started:

- BEFORE trigger fired
- Referential constraint processed for *RESTRICT
- I/O operation processed
- AFTER trigger fired
- Referential constraints, other than *RESTRICT, processed
- Check constraint processed.

Handling Null Fields with Check Constraints

If a field is null-capable and used in a check constraint, then depending on the field's value, the constraint may, or may not be, affected:

- If a field (column) value in a record (row) is *not* null, then the field is used in the validation process of the check constraint to return either a status of valid or check pending.
- If the field (column) *is null*, then the field (column) value is *not* used to validate the constraint, unless the check constraint specifically tests for a null value. This means that the affect a null field will have on a check constraint is unknown.

Handling Constraint Violations

Constraints can have a status of **check pending**. A status of check pending means that the data in the record (row) violates a constraint. When a COBOL I/O statement is run, the system will ensure that a record cannot be inserted or updated that would cause a constraint to be violated. Any attempt to do so, will result in file status 9W (check constraint failure) or file status 9R (referential constraint failure). However, adding constraints where data already exists or restoring old data can cause constraint violations, and, thereby, statuses of check pending.

Once an established and enabled check constraint has been violated (has a status of check pending), data cannot be read from the file. For those insert, update, or delete operations that require a read for update, the I/O operation will not be performed. Otherwise, insert, update, and delete operations will be performed. In order to read from the file again after a check constraint has been violated, the check constraint has to be disabled using the Change PF Constraint (CHGPFCST) command.

Once an established and enabled referential constraint has a status of check pending:
- No file I/O is allowed against the dependent file
- Limited file I/O (READ/INSERT) is allowed against the parent file

To figure out what is causing the constraint violation, after the constraint has been disabled, you can use one of the following methods:
- Use the Display CHKPND Constraint (DSPCPCST) command to check which records are causing the violation.
- Use the Work with PF Constraints (WRKPFCST) command to find out which constraint is in check pending.
- Use the Remove PF Constraint (RMVPFCST) command to remove the constraint, followed by the Add PF Constraint (ADDPFCST) command to add the constraint back on. This will list the first 20 records of the constraint that is causing the violation.

Database Features that Support Referential or Check Constraints

The following database features support referential and check constraints:
- Journaling
- Commitment control
- Distributed Data Management (DDM) files
- Distributed (multi-system) files.

Journaling

A file with referential or check constraints can be journaled, but it is not required to be. There are not any special journal entries associated with check constraints.

Commitment Control

When commitment control is active, file I/O functions follow the same rules that apply when commitment control is not active. That is, when performing I/O on a file with constraints, an insert, update, or delete is not allowed where a constraint rule would be violated. Potential violations result in notification messages. If the I/O operation completes successfully, then either a COMMIT or ROLLBACK can be performed.

Distributed Data Management (DDM)

Check constraints are supported for Distributed Data Management (DDM) files. When DDM is being used between a V4R2 and a pre-V4R2 system, then any check constraint information that may exist on the V4R2 system is not passed to the pre-V4R2 system.

When an attempt is made to propagate check constraints between a V4R2 and a pre-V4R2 system for DDM files, the following operations will either not propagate the check constraints or will fail:
- A create file or create table operation will work, but will not propagate check constraints

- An extract file definition operation will work, but will not propagate check constraints
- An ALTER TABLE statement will fail
- A Change Physical File (CHGPF) CL command will fail.

Distributed Files

Check constraints are supported for Distributed (multi-system) files. When distributed files are being used between a V4R2 and a pre-V4R2 system, then any check constraint information that may exist on the V4R2 system is not passed to the pre-V4R2 system.

When an attempt is made to propagate check constraints between a V4R2 and a pre-V4R2 system for distributed files, the following operations will fail:
- Create file or create table operation
- The Add PF Constraint (ADDPFCST) CL command
- ALTER TABLE statement
- Change Physical File (CHGPF) CL command.

Chapter 20. Using Transaction Files

This chapter describes the ILE COBOL language extensions that support workstations and program-to-program communication.

The TRANSACTION file organization allows an ILE COBOL program to communicate interactively with:
- One or more workstations
- One or more programs on a remote system
- One or more devices on a remote system.

The AS/400 system permits you to communicate with a program or device (such as Asynchronous communication types) on a remote system. For a detailed discussion of these devices, see the *ICF Programming* manual

ILE COBOL TRANSACTION files are usually externally described. If these files are program-described, only simple display formatting can be performed. For more information about using program-described display files, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

An ILE COBOL TRANSACTION file usually uses an externally described file that contains file information and a description of the fields in the records. The records in this file can be described in an ILE COBOL program by using the Format 2 COPY statement. Refer to the *WebSphere Development Studio: ILE COBOL Reference* for more information about the Format 2 COPY statement.

Do not send packed or binary data (COMP, COMP-3, or COMP-4) to a display station as output data. Such data can contain display station control characters that can cause unpredictable results.

Defining Transaction Files Using Data Description Specifications

You use data description specifications (DDS) to describe an externally described TRANSACTION file.

In addition to the field descriptions (such as field names and attributes), the data description specifications (DDS) for a display device file do the following:
- Specify the line number and position number entries for each field and constant to format the placement of the record on the display.
- Specify attention functions such as underlining and highlighting fields, reverse image, or a blinking cursor.
- Specify validity checking for data entered at the display workstation.
- Control display management functions such as when fields are to be erased, overlaid, or retained when new data is displayed.
- Associate indicators 01 through 99 with function keys designated as type `CA` or `CF`. If a function key is designated as `CF`, both the modified data record and the response indicator are returned to the program. If a function key is designated as `CA`, the response indicator is returned to the program, but the data record usually contains default values for input-only fields and values written to the format for hidden output/input fields. For more information about type `CF` and

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CA function keys, see refer to the*Database anf File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

- Assign an edit code (EDTCDE keyword) or edit word (EDTWRD keyword) to a field to specify how the field's values are to be displayed.
- Specify subfiles.

Display format data defines or describes a display. A display device record format contains three types of fields:

- *Input Fields:* Input fields pass from the device to the program when the program reads a record. Input fields can be initialized with a default value; if the default value is not changed, the default value passes to the program. Un-initialized input fields are displayed as blanks where the work station user can enter data.
- *Output Fields:* Output fields pass from the program to the device when the program writes a record to a display. The program or the record format in the device file can provide output fields.
- *Output/Input (Both) Fields:* An output/input field is an output field that can be changed to become an input field. Output/input fields pass *from* the program when the program writes a record to a display and pass *to* the program when the program reads a record from the display. Output/input fields are used when the user is to change or update the data that is written to the display from the program.

For a detailed description of a data communications file, see the *ICF Programming* manual. For more information on externally defined display files and a list of the valid data description specifications (DDS) keywords, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Figure 130 shows an example of the DDS for a display device file:

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* CUSTOMER MASTER INQUIRY FILE ** CUSMINQ
     A*
     A                                      REF(CUSMSTP)  1
     A          R CUSPMT                    TEXT('CUSTOMER PROMPT')
     A                                      CA01(15 'END OF PROGRAM')  2
     A                                   1  3'CUSTOMER MASTER INQUIRY'
     A                                   3  3'CUSTOMER NUMBER'
     A            CUST      R        I  3 20
     A  99                                  ERRMSG('CUSTOMER NUMBER NOT FOUND +  3
     A                                      PRESS RESET, THEN ENTER A VALID NU+
     A                                      MBER' 99)
     A                                   5  3'USE CF1 TO END PROGRAM, USE ENTE+
     A                                      R TO RETURN TO PROMPT SCREEN'
     A          R CUSFLDS                   TEXT('CUSTOMER DISPLAY')
     A                                      CA01(15 'END OF PROGRAM')
     A                                      OVERLAY  4
     A                                   8  3'NAME'
     A            NAME      R            8 11
     A                                   9  3'ADDRESS'
     A            ADDR      R            9 11
     A                                  10  3'CITY'  5
     A            CITY      R           10 11
     A                              6   11  3'STATE'
     A            STATE     R           11 11
     A                                  11 21'ZIP CODE'
     A            ZIP       R           11 31
     A                                  12  3'A/R BALANCE'
     A            ARBAL     R           12 17
```

Figure 130. Example of the Data Description Specifications for a Display Device File

This display device file contains two record formats: CUSPMT and CUSFLDS.

1 The attributes for the fields in this file are defined in the CUSMSTP field reference file. For example, EDTCDE(J) is defined in CUSMSTP for the field ARBAL.

2 The F1 key is associated with indicator 15, with which the user ends the program.

3 The ERRMSG keyword identifies the error message that is displayed if indicator 99 is set on in the program that uses this record format.

4 The OVERLAY keyword is used for the record format CUSFLDS so that the CUSPMT record on the display will not be erased when the CUSFLDS record is written to the display.

5 The constants such as 'Name', 'Address', and 'City' describe the fields that are written out by the program.

6 The line and position entries identify where the fields or constants are written on the display.

Processing an Externally Described Transaction File

When an externally described TRANSACTION file is processed, the operating system transforms data from your ILE COBOL program to the format specified for the file and displays the data. When data passes to your ILE COBOL program, the data is transformed to the format used by your ILE COBOL program.

The operating system provides device control information for performing input/output operations for the device. When an input record is requested from the device by your ILE COBOL program, the operating system issues the request,

and then removes device control information from the data before passing the data to the program. In addition, the operating system can pass indicators to your ILE COBOL program indicating which, if any, fields in the record have changed.

When your ILE COBOL program requests an output operation, it passes the output record to the operating system. The operating system provides the necessary device control information to display the record. It also adds any constant information specified for the record format when the record is displayed.

When a record passes to your ILE COBOL program, the fields are arranged in the order in which they are specified in the DDS. The order in which the fields are displayed is based on the display positions (line numbers and positions) assigned to the fields in the DDS. Therefore, the order in which the fields are specified in the DDS and the order in which they appear on the display need not be the same.

Writing Programs That Use Transaction Files

Typically, you use a TRANSACTION file to read one record from or write one record to a display. To use a TRANSACTION file in an ILE COBOL program, you must:

- Name the file through a file control entry in the FILE-CONTROL paragraph of the Environment Division
- Describe the file through a file description entry in the Data Division
- Use extensions to Procedure Division statements that support transaction processing.

Note: Using extended ACCEPT/DISPLAY statements and TRANSACTION files in the same program is not recommended. If extended ACCEPT/DISPLAY statements are used in the same program as TRANSACTION files, then the TRANSACTION file should be closed when the extended ACCEPT/DISPLAY statements are performed. Unpredictable results will occur if an extended ACCEPT/DISPLAY statement is performed when a TRANSACTION file is open. A severe error may be generated or data on the workstation may be overlapped or intermixed.

Naming a Transaction File

To use a TRANSACTION file in an ILE COBOL program, you must name the file through a file control entry in the FILE-CONTROL paragraph. See the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the FILE-CONTROL paragraph.

You name the TRANSACTION file in the FILE-CONTROL paragraph as follows:

```
FILE-CONTROL.
    SELECT transaction-file-name
        ASSIGN TO WORKSTATION-display_file_name
        ORGANIZATION IS TRANSACTION
        ACCESS MODE IS SEQUENTIAL
        CONTROL AREA IS control-area-data-item.
```

You use the SELECT clause to choose a file. This file must be identified by a FD entry in the Data Division.

You use the ASSIGN clause to associate the TRANSACTION file with a display file or ICF file. You must specify a device type of WORKSTATION in the ASSIGN clause to use TRANSACTION files. If you want to use a separate indicator area for

this TRANSACTION file, you need to include the -SI attribute with the ASSIGN clause. See "Using Indicators with Transaction Files" on page 512 for further details of how to use the separate indicator area.

You must specify ORGANIZATION IS TRANSACTION in the file control entry in order to use a TRANSACTION file. This clause tells your ILE COBOL program that it will be interacting with a workstation user or another system.

You access a TRANSACTION file sequentially. You use the ACCESS MODE clause in the file control entry to tell your ILE COBOL program how to access the TRANSACTION file. You specify ACCESS MODE IS SEQUENTIAL to read or write to the TRANSACTION file in sequential order. If you do not specify the ACCESS MODE clause, sequential access is assumed.

If you want feedback on the status of an input-output request that refers to a TRANSACTION file, you define a status key data item in the file control entry using the FILE STATUS clause. When you specify the FILE STATUS clause, the system moves a value into the status key data item after each input-output request that explicitly or implicitly refers to the TRANSACTION file. The value indicates the status of the execution of the I-O statement.

You can obtain specific device-dependent and system dependent information that is used to control input-output operations for TRANSACTION files by identifying a control area data item using the CONTROL-AREA clause. You can define the data item specified by the CONTROL-AREA clause in the LINKAGE SECTION or WORKING-STORAGE SECTION with the following format:

```
01  control-area-data-item.
    05  function-key          PIC X(2).
    05  device-name           PIC X(10).
    05  record-format         PIC X(10).
```

The control area can be 2, 12, or 22 bytes long. Thus, you can specify only the first 05-level element, the first two 05-level elements, or all three 05-level elements, depending of the type of information your are looking for.

The control area data item will allow you to identify:

- The function key that the operator pressed to initiate a transaction
- The name of the program device used
- The name of the DDS record format that was referenced by the last I-O statement.

Describing a Transaction File

To use a TRANSACTION file in an ILE COBOL program, you must describe the file through a file description entry in the Data Division. See *WebSphere Development Studio: ILE COBOL Reference* for a full description of the File Description Entry. Use the Format 6 File Description Entry to describe a TRANSACTION file.

A file description entry in the Data Division that describes a TRANSACTION file looks as follows:

```
FD  CUST-DISPLAY.
01  DISP-REC.
    COPY DDS-ALL-FORMATS OF CUSMINQ.
```

In ILE COBOL, TRANSACTION files are usually externally described. Create a DDS for the TRANSACTION file you want to use. Refer to "Defining Transaction Files Using Data Description Specifications" on page 497 for how to create a DDS. Then create the TRANSACTION file.

Once you have created the DDS for the TRANSACTION file and the TRANSACTION file, use the Format 2 COPY statement to describe the layout of the TRANSACTION file data record. When you compile your ILE COBOL program, the Format 2 COPY will create the Data Division statements to describe the TRANSACTION file. Use the DDS-ALL-FORMATS option of the Format 2 COPY statement to generate one storage area for all formats.

Processing a Transaction File

The following is a list of all of the Procedure Division statements that have extensions specifically for processing TRANSACTION files in an ILE COBOL program. See the *WebSphere Development Studio: ILE COBOL Reference* for a detailed discussion of each of these statements.

- ACCEPT Statement - Format 6
- ACQUIRE Statement
- CLOSE Statement - Format 1
- DROP Statement
- OPEN Statement - Format 3
- READ Statement - Format 4 (Nonsubfile)
- WRITE Statement - Format 4 (Nonsubfile).

Opening a Transaction File

To process a TRANSACTION file in the Procedure Division, you must first open the file. You use the Format 3 OPEN statement to open a TRANSACTION file. A TRANSACTION file must be opened in I-O mode.

```
OPEN I-O file-name.
```

Acquiring Program Devices

You must acquire a program device for the TRANSACTION file. Once acquired, the program device is available for input and output operations. You can acquire a program device implicitly or explicitly.

You implicitly acquire one program device when you open the TRANSACTION file. If the file is an ICF file, the single implicitly acquired program device is determined by the ACQPGMDEV parameter of the CRTICFF command. If the file is a display file, the single implicitly acquired program device is determined by the first entry in the DEV parameter of the CRTDSPF command. Additional program devices must be explicitly acquired.

You explicitly acquire a program device by using the ACQUIRE statement. For an ICF file, the device must have been defined to the file with the ADDICFDEVE or OVRICFDEVE CL command before the file was opened. For display files, there is no such requirement. That is, the device named in the ACQUIRE statement does not have to be specified in the DEV parameter of the CRTDSPF command, CHGDSPF command, or the OVRDSPF command. However, when you create the display file, you must specify the number of devices that may be acquired (the default is one). For a display file, the program device name must match the display device.

```
ACQUIRE program-device-name FOR transaction-file-name.
```

Writing to a Transaction File

Once you have opened the TRANSACTION file and acquired a program device for it, you are now ready to perform input and output operations on it.

The first input/output operation you typically perform on a TRANSACTION file is to write a record to the display. This record is used to prompt the user to enter a response or some data.

You use the Format 4 WRITE statement to write a logical record to the TRANSACTION file. You simply code the WRITE statement as follows:

```
WRITE record-name FORMAT IS format-name.
```

In some situations, you may have multiple data records, each with a different format, that you want active for a TRANSACTION file. In this case, you must use the FORMAT phrase of the Format 4 WRITE statement to specify the format of the output data record you want to write to the TRANSACTION file.

If you have explicitly acquired multiple program devices for the TRANSACTION file, you must use the TERMINAL phrase of the Format 4 WRITE statement to specify the program device to which you want the output record to be sent.

You can control the line number on the display where the WRITE statement will write the output record by specifying the STARTING phrase and ROLLING phrase of the Format 4 WRITE statement. The STARTING phrase specifies the starting line number for the record formats that use the variable record start line keyword. The ROLLING phrase allows you to move lines displayed on the workstation screen. All or some of the lines on the screen can be rolled up or down.

```
WRITE record-name FORMAT IS format-name
                  TERMINAL IS program-device-name
                  STARTING AT LINE start-line-no
                  AFTER ROLLING LINES first-line-no THRU last-line-no
                                DOWN no-of-lines LINES
END-WRITE.
```

Reading from a Transaction File

You use the Format 4 READ statement to read a logical record from the TRANSACTION file. If data is available when the READ statement is executed, it is returned in the record area. The names of the record format and the program device are returned in the I-O-FEEDBACK area and in the CONTROL-AREA area.

Before you use the READ statement, you must have acquired at least one program device for the TRANSACTION file. If a READ statement is performed and there are no acquired program devices, a logic error is reported by setting the file status to 92.

You can use the READ statement in its simplest form as follows:

```
READ record-name RECORD.
```

If you have only acquired one program device, this simple form of the READ statement will always wait for data to be made available. Even if the job receives a controlled cancellation, or a wait time is specified in the WAITRCD parameter for the display file or ICF file, the program will never regain control from the READ statement.

If you have acquired multiple program devices, this simple form of the READ statement will receive data from the first invited program device that has data available. When multiple program devices have been acquired, this simple form of

the READ statement can complete without returning any data if there are no invited devices and a wait time is not specified, a controlled cancellation of the job occurs, or the specified wait time expires.

For a detailed explanation of how the READ operation is performed, refer to the section on the READ statement in the *WebSphere Development Studio: ILE COBOL Reference*.

In those cases where you have acquired multiple program devices, you can explicitly specify the program device from which you read data by identifying it in the TERMINAL phrase of the READ statement.

In those cases where you want to receive the data in a specific format, you can identify this format in the FORMAT phrase of the READ statement. If the data available does not match the requested record format, a file status of 9K is set.

The following are examples of the READ statement with the TERMINAL and FORMAT phrases specified.

```
READ record-name RECORD
     FORMAT IS record-format
END-READ
READ record-name RECORD
     TERMINAL IS program-device-name
END-READ
READ record-name RECORD
     FORMAT IS record-format
     TERMINAL IS program-device-name
END-READ
```

When the READ statement is performed, the following conditions can arise:

1. Data is immediately available and the AT END condition does not exist. The AT END condition occurs when there are no invited program devices and a wait time is not specified.
2. Data is not immediately available.
3. The AT END condition exists.

You can transfer control to various statements of your ILE COBOL program from the READ statement based on the condition that results from performing the READ statement by specifying the NO DATA phrase, AT END phrase, or NOT AT END phrase.

To perform a group of statements when the READ statement completes successfully, specify the NOT AT END phrase of the READ statement.

To perform a group of statements when the data is not immediately available, specify the NO DATA phrase of the READ statement. The NO DATA phrase prevents the READ statement from waiting for data to become available.

To perform a group of statements when the AT END condition exists, specify the AT END phrase of the READ statement.

The following are examples of the READ statement with the NO DATA, NOT AT END, and AT END phrases specified.

```
READ record-name RECORD
     TERMINAL IS program-device-name
     NO DATA imperative-statement-1
END-READ
```

```
READ record-name RECORD
     TERMINAL IS program-device-name
     AT END imperative-statement-2
     NOT AT END imperative-statement-3
END-READ
```

Dropping Program Devices

Once you have finished using a program device that you had previously acquired for a TRANSACTION file, you should drop it. Dropping a program device means that it will no longer be available for input or output operations through the TRANSACTION file. Dropping a program device makes it available to other applications. You can drop a program device implicitly or explicitly.

You implicitly drop all program devices attached to a TRANSACTION file when you close the file.

You explicitly drop a program device by indicating it in the DROP statement. The device, once dropped, can be re-acquired again, if necessary.

```
DROP program-device-name FROM transaction-file-name.
```

Closing a TRANSACTION File

When you have finished using a TRANSACTION file, you must close it. Use the Format 1 CLOSE statement to close the TRANSACTION file. Once you close the file, it cannot be processed again until it is opened again.

```
CLOSE transaction-file-name.
```

Example of a Basic Inquiry Program Using Transaction Files

Figure 131 shows the associated DDS for a basic inquiry program that uses the ILE COBOL TRANSACTION file.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
     A* CUSTOMER MASTER INQUIRY FILE ** CUSMINQ
     A*
     A                                       REF(CUSMSTP)
     A          R CUSPMT                     TEXT('CUSTOMER PROMPT')
     A                                       CA01(15 'END OF PROGRAM')
     A                                     1  3'CUSTOMER MASTER INQUIRY'
     A                                     3  3'CUSTOMER NUMBER'
     A            CUST      R        I  3 20
     A  99                                   ERRMSG('CUSTOMER NUMBER NOT FOUND +
     A                                       PRESS RESET, THEN ENTER A VALID NU+
     A                                       MBER' 99)
     A  98                                   ERRMSG('EOF CONDITION IN READ, +
     A                                       PROGRAM ENDED' 98)
     A                                     5  3'USE F1 TO END PROGRAM, USE ENTE+
     A                                       R TO RETURN TO PROMPT SCREEN'
     A          R CUSFLDS                    TEXT('CUSTOMER DISPLAY')
     A                                       CA01(15 'END OF PROGRAM')
     A                                       OVERLAY
     A                                     8  3'NAME'
     A            NAME      R           8 11
     A                                     9  3'ADDRESS'
     A            ADDR      R           9 11
     A                                    10  3'CITY'
     A            CITY      R          10 11
     A                                    11  3'STATE'
     A            STATE     R          11 11
     A                                    11 21'ZIP CODE'
     A            ZIP       R          11 31
     A                                    12  3'A/R BALANCE'
     A            ARBAL     R          12 17
```

Figure 131. Example of a TRANSACTION Inquiry Program Using a Single Display Device

The data description specifications (DDS) for the display device file (CUSMINQ) to be used by this program describe two record formats: CUSPMT and CUSFLDS.

The CUSPMT record format contains the constant 'Customer Master Inquiry', which identifies the display. It also contains the prompt 'Customer Number' and the input field (CUST) where you enter the customer number. Five underscores appear under the input field CUST on the display where you are to enter the customer number. The error message:

```
Customer number not found
```

is also included in this record format. This message is displayed if indicator 99 is set to **ON** by the program. In addition, this record format defines a function key that you can press to end the program. When you press function key F1, indicator 15 is set to **ON** in the ILE COBOL program. This indicator is then used to end the program.

The CUSFLDS record format contains the following constants:

- Name
- Address
- City
- State
- Zip Code
- Accounts Receivable Balance (A/R Balance).

These constants identify the fields to be written out from the program. This record format also describes the fields that correspond to these constants. All of these

fields are described as output fields (blank in position 38) because they are filled in by the program; you do not enter any data into these fields. To enter another customer number, press Enter in response to this record. Notice that the CUSFLDS record overlays the CUSPMT record. Therefore, when the CUSFLDS record is written to the display, the CUSPMT record remains on the display.

In addition to describing the constants, fields, and attributes for the display, the record formats also define the line numbers and horizontal positions where the constants and fields are to be displayed.

Note: The field attributes are defined in a physical file (CUSMSTP) used for field reference purposes, instead of in the DDS for the display file.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A* THIS IS THE CUSTOMER MASTER FILE ** CUSMSTP
     A
     A
     A                                     UNIQUE
     A          R CUSMST                   TEXT('CUSTOMER MASTER RECORD')
     A            CUST           5         TEXT('CUSTOMER NUMBER')
     A            NAME          25         TEXT('CUSTOMER NAME')
     A            ADDR          20         TEXT('CUSTOMER ADDRESS')
     A            CITY          20         TEXT('CUSTOMER CITY')
     A            STATE          2         TEXT('STATE')
     A            ZIP            5 00      TEXT('ZIP CODE')
     A            SRHCOD         6         TEXT('CUSTOMER NUMBER SEARCH CODE')
     A            CUSTYP         1 00      TEXT('CUSTOMER TYPE 1=GOV 2=SCH +
     A                                     3=BUS 4=PVT 5=OT')
     A            ARBAL          8 02      TEXT('ACCOUNTS REC. BALANCE')
     A            ORDBAL         8 02      TEXT('A/R AMT. IN ORDER FILE')
     A            LSTAMT         8 02      TEXT('LAST AMT. PAID IN A/R')
     A            LSTDAT         6 00      TEXT('LAST DATE PAID IN A/R')
     A            CRDLMT         8 02      TEXT('CUSTOMER CREDIT LIMIT')
     A            SLSYR         10 02      TEXT('CUSTOMER SALES THIS YEAR')
     A            SLSLYR        10 02      TEXT('CUSTOMER SALES LAST YEAR')
                K CUST
```

Figure 132. Data Description Specification for the Record Format CUSMST.

The data description specifications (DDS) for the database file that is used by this program describe one record format: CUSMST. Each field in the record format is described, and the CUST field is identified as the key field for the record format.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/INQUIRY         ISERIES1   03/09/15 14:57:34        Page      2
                           S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     INQUIRY.
          000300*    SAMPLE TRANSACTION INQUIRY PROGRAM USING 1 DISPLAY DEVICE
          000400
    3     000500 ENVIRONMENT DIVISION.
    4     000600 CONFIGURATION SECTION.
    5     000700 SOURCE-COMPUTER. IBM-ISERIES.
    6     000800 OBJECT-COMPUTER. IBM-ISERIES.
    7     000900 INPUT-OUTPUT SECTION.
    8     001000 FILE-CONTROL.
    9     001100     SELECT CUST-DISPLAY
   10     001200         ASSIGN TO WORKSTATION-CUSMINQ
   11     001300         ORGANIZATION IS TRANSACTION
   12     001400         CONTROL-AREA IS WS-CONTROL.
   13     001500     SELECT CUST-MASTER
   14     001600         ASSIGN TO DATABASE-CUSMSTP
   15     001700         ORGANIZATION IS INDEXED
   16     001800         ACCESS IS RANDOM
   17     001900             RECORD KEY IS CUST OF CUSMST
   18     002000         FILE STATUS IS CM-STATUS.
          002100
   19     002200 DATA DIVISION.
   20     002300 FILE SECTION.
   21     002400 FD  CUST-DISPLAY.
   22     002500 01  DISP-REC.
          002600     COPY DDS-ALL-FORMATS OF CUSMINQ.
   23    +000001       05  CUSMINQ-RECORD PIC X(80).                                    <-ALL-FMTS
         +000002*  INPUT FORMAT:CUSPMT     FROM FILE CUSMINQ    OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000003*                          CUSTOMER PROMPT                              <-ALL-FMTS
   24    +000004       05  CUSPMT-I      REDEFINES CUSMINQ-RECORD.                     <-ALL-FMTS
   25    +000005           06 CUSPMT-I-INDIC.                                          <-ALL-FMTS
   26    +000006                07 IN15             PIC 1  INDIC 15.                  <-ALL-FMTS
         +000007*                          END OF PROGRAM                               <-ALL-FMTS
   27    +000008                07 IN99             PIC 1  INDIC 99.                  <-ALL-FMTS
         +000009*                          CUSTOMER NUMBER NOT FOUND PRESS RESET, THEN ENT <-ALL-FMTS
   28    +000010                07 IN98             PIC 1  INDIC 98.                  <-ALL-FMTS
         +000011*                          EOF CONDITION IN READ, PROGRAM ENDED         <-ALL-FMTS
   29    +000012           06 CUST                  PIC X(5).                         <-ALL-FMTS
         +000013*                    CUSTOMER NUMBER                                    <-ALL-FMTS
         +000014* OUTPUT FORMAT:CUSPMT     FROM FILE CUSMINQ    OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000015*                          CUSTOMER PROMPT                              <-ALL-FMTS
   30    +000016       05  CUSPMT-O      REDEFINES CUSMINQ-RECORD.                     <-ALL-FMTS
   31    +000017           06 CUSPMT-O-INDIC.                                          <-ALL-FMTS
   32    +000018                07 IN99             PIC 1  INDIC 99.                  <-ALL-FMTS
         +000019*                          CUSTOMER NUMBER NOT FOUND PRESS RESET, THEN ENT <-ALL-FMTS
   33    +000020                07 IN98             PIC 1  INDIC 98.                  <-ALL-FMTS
         +000021*                          EOF CONDITION IN READ, PROGRAM ENDED         <-ALL-FMTS
         +000022*  INPUT FORMAT:CUSFLDS     FROM FILE CUSMINQ    OF LIBRARY CBLGUIDE     <-ALL-FMTS
         +000023*                          CUSTOMER DISPLAY                             <-ALL-FMTS
   34    +000024       05  CUSFLDS-I     REDEFINES CUSMINQ-RECORD.                     <-ALL-FMTS
   35    +000025           06 CUSFLDS-I-INDIC.                                         <-ALL-FMTS
   36    +000026                07 IN15             PIC 1  INDIC 15.                  <-ALL-FMTS
         +000027*                          END OF PROGRAM                               <-ALL-FMTS
```

Figure 133. Source Listing of a TRANSACTION Inquiry Program Using a Single Display Device. (Part 1 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INQUIRY         ISERIES1   03/09/15 14:57:34        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        +000028* OUTPUT FORMAT:CUSFLDS    FROM FILE CUSMINQ    OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000029*                          CUSTOMER DISPLAY                                  <-ALL-FMTS
   37   +000030       05  CUSFLDS-O     REDEFINES CUSMINQ-RECORD.                         <-ALL-FMTS
   38   +000031           06 NAME                 PIC X(25).                               <-ALL-FMTS
        +000032*                 CUSTOMER NAME                                             <-ALL-FMTS
   39   +000033           06 ADDR                 PIC X(20).                               <-ALL-FMTS
        +000034*                 CUSTOMER ADDRESS                                          <-ALL-FMTS
   40   +000035           06 CITY                 PIC X(20).                               <-ALL-FMTS
        +000036*                 CUSTOMER CITY                                             <-ALL-FMTS
   41   +000037           06 STATE                PIC X(2).                                <-ALL-FMTS
        +000038*                 STATE                                                     <-ALL-FMTS
   42   +000039           06 ZIP                  PIC S9(5).                               <-ALL-FMTS
        +000040*                 ZIP CODE                                                  <-ALL-FMTS
   43   +000041           06 ARBAL                PIC S9(6)V9(2).                          <-ALL-FMTS
        +000042*                 ACCOUNTS REC. BALANCE                                     <-ALL-FMTS
         002700
   44    002800 FD  CUST-MASTER.
   45    002900 01  CUST-REC.
         003000     COPY DDS-CUSMST OF CUSMSTP.
        +000001*    I-O FORMAT:CUSMST     FROM FILE CUSMSTP    OF LIBRARY CBLGUIDE          CUSMST
        +000002*                          CUSTOMER MASTER RECORD                            CUSMST
        +000003*          USER SUPPLIED KEY BY RECORD KEY CLAUSE                            CUSMST
   46   +000004       05  CUSMST.                                                          CUSMST
   47   +000005           06 CUST                 PIC X(5).                                CUSMST
        +000006*                 CUSTOMER NUMBER                                           CUSMST
   48   +000007           06 NAME                 PIC X(25).                               CUSMST
        +000008*                 CUSTOMER NAME                                             CUSMST
   49   +000009           06 ADDR                 PIC X(20).                               CUSMST
        +000010*                 CUSTOMER ADDRESS                                          CUSMST
   50   +000011           06 CITY                 PIC X(20).                               CUSMST
        +000012*                 CUSTOMER CITY                                             CUSMST
   51   +000013           06 STATE                PIC X(2).                                CUSMST
        +000014*                 STATE                                                     CUSMST
   52   +000015           06 ZIP                  PIC S9(5)         COMP-3.                CUSMST
        +000016*                 ZIP CODE                                                  CUSMST
   53   +000017           06 SRHCOD               PIC X(6).                                CUSMST
        +000018*                 CUSTOMER NUMBER SEARCH CODE                               CUSMST
   54   +000019           06 CUSTYP               PIC S9(1)         COMP-3.                CUSMST
        +000020*                 CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT                CUSMST
   55   +000021           06 ARBAL                PIC S9(6)V9(2)    COMP-3.                CUSMST
        +000022*                 ACCOUNTS REC. BALANCE                                     CUSMST
   56   +000023           06 ORDBAL               PIC S9(6)V9(2)    COMP-3.                CUSMST
        +000024*                 A/R AMT. IN ORDER FILE                                    CUSMST
   57   +000025           06 LSTAMT               PIC S9(6)V9(2)    COMP-3.                CUSMST
        +000026*                 LAST AMT. PAID IN A/R                                     CUSMST
   58   +000027           06 LSTDAT               PIC S9(6)         COMP-3.                CUSMST
        +000028*                 LAST DATE PAID IN A/R                                     CUSMST
   59   +000029           06 CRDLMT               PIC S9(6)V9(2)    COMP-3.                CUSMST
        +000030*                 CUSTOMER CREDIT LIMIT                                     CUSMST
   60   +000031           06 SLSYR                PIC S9(8)V9(2)    COMP-3.                CUSMST
        +000032*                 CUSTOMER SALES THIS YEAR                                  CUSMST
   61   +000033           06 SLSLYR               PIC S9(8)V9(2)    COMP-3.                CUSMST
        +000034*                 CUSTOMER SALES LAST YEAR                                  CUSMST
         003100
   62    003200 WORKING-STORAGE SECTION.
```

Figure 133. Source Listing of a TRANSACTION Inquiry Program Using a Single Display Device. (Part 2 of 3)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INQUIRY         ISERIES1   03/09/15 14:57:34       Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   63     003300 01  ONE                              PIC 1 VALUE B"1".
   64     003400 01  CM-STATUS                        PIC X(2).
   65     003500 01  WS-CONTROL.
   66     003600     02  WS-IND                       PIC X(2).
   67     003700     02  WS-FORMAT                    PIC X(10).
          003800
   68     003900 PROCEDURE DIVISION.
   69     004000 DECLARATIVES.
          004100 DISPLAY-ERR-SECTION SECTION.
          004200     USE AFTER STANDARD EXCEPTION PROCEDURE ON CUST-DISPLAY.
          004300 DISPLAY-ERR-PARAGRAPH.
   70     004400     MOVE ONE TO IN98 OF CUSPMT-O
   71     004500     WRITE DISP-REC FORMAT IS "CUSPMT"
          004600     END-WRITE
   72     004700     CLOSE CUST-MASTER
          004800           CUST-DISPLAY.
   73     004900     STOP RUN.
          005000 END DECLARATIVES.
          005100
          005200 MAIN-PROGRAM SECTION.
          005300 MAINLINE.
   74     005400     OPEN INPUT CUST-MASTER
          005500          I-O CUST-DISPLAY.
          005600
   75     005700     MOVE ZERO TO IN99 OF CUSPMT-O
   76     005800     WRITE DISP-REC FORMAT IS "CUSPMT"   1
          005900     END-WRITE
   77     006000     READ CUST-DISPLAY RECORD
          006100     END-READ
          006200
   78     006300     PERFORM UNTIL IN15 OF CUSPMT-I IS EQUAL TO ONE
          006400
   79     006500         MOVE CUST OF CUSPMT-I TO CUST OF CUSMST
   80     006600         READ CUST-MASTER RECORD  2
          006700             INVALID KEY  3
   81     006800                 MOVE ONE TO IN99 OF CUSPMT-O
   82     006900                 WRITE DISP-REC FORMAT IS "CUSPMT"
          007000                 END-WRITE
   83     007100                 READ CUST-DISPLAY RECORD
          007200                 END-READ
          007300             NOT INVALID KEY
   84     007400                 MOVE CORRESPONDING CUSMST TO CUSFLDS-O
                *** CORRESPONDING items for statement 84:
                ***     NAME
                ***     ADDR
                ***     CITY
                ***     STATE
                ***     ZIP
                ***     ARBAL
                *** End of CORRESPONDING items for statement 84
   85     007500                 WRITE DISP-REC FORMAT IS "CUSFLDS"
          007600                 END-WRITE
   86     007700                 READ CUST-DISPLAY RECORD
          007800                 END-READ
   87     007900                 IF  IN15 OF CUSPMT-I IS NOT EQUAL TO ONE
   88     008000                     MOVE ZERO TO IN99 OF CUSPMT-O
   89     008100                     WRITE DISP-REC FORMAT IS "CUSPMT"
          008200                     END-WRITE
   90     008300                     READ CUST-DISPLAY RECORD
          008400                     END-READ
          008500                 END-IF
          008600         END-READ
          008700
          008800     END-PERFORM
          008900
   91     009000     CLOSE CUST-MASTER
          009100           CUST-DISPLAY.
   92     009200     GOBACK.
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 133. Source Listing of a TRANSACTION Inquiry Program Using a Single Display Device. (Part 3 of 3)

The complete source listing for this program example is shown here. In particular, note the FILE-CONTROL and FD entries and the data structures generated by the Format 2 COPY statements.

The WRITE operation at **1** writes the CUSPMT format to the display. This record prompts you to enter a customer number. If you enter a customer number and press Enter, the next READ operation then reads the record back into the program.

The READ operation at **2** uses the customer number (CUST) field to retrieve the corresponding CUSMST record from the CUSMSTP file. If no record is found in the CUSMSTP file, the INVALID KEY imperative statements at **3** are performed. Indicator 99 is set on and the message:

```
Customer number not found
```

is displayed when the format is written. The message is conditioned by indicator 99 in the DDS for the file. When you receive this message, the keyboard locks. You must press the Reset key in response to this message to unlock the keyboard. You can then enter another customer number.

If the READ operation retrieves a record from the CUSMSTP file, the WRITE operation writes the CUSFLDS record to the display workstation. This record contains the customer's name, address, and accounts receivable balance.

You then press Enter, and the program branches back to the beginning. You can enter another customer number or end the program. To end the program, press F1, which sets on indicator 15 in the program.

When indicator 15 is on, the program closes all files and processes the GOBACK statement. The program then returns control to the individual who called the ILE COBOL program.

This is the initial display written by the WRITE operation at **1**:

```
Customer Master Inquiry

Customer Number  ________

Use F3 to end program, use enter key to return to prompt screen
```

This display appears if a record is found in the CUSMSTP file for the customer number entered in response to the first display:

```
Customer Master Inquiry

Customer Number   1000

Use F3 to end program, use enter key to return to prompt screen


Name    EXAMPLE WHOLESALERS LTD.
Address ANYWHERE STREET
City    ACITY
State   IL        Zipcode  12345
A/R balance       137.02
```

This display appears if the CUSMSTP file does not contain a record for the customer number entered in response to the first display:

```
Customer Master Inquiry

Customer Number

Use F3 to end program, use enter key to return to prompt screen




Customer number not found, press reset, then enter valid number
```

Using Indicators with Transaction Files

Indicators are Boolean data items that can have the values B"0" or B"1".

When you define a record format for a file using DDS, you can condition the options using indicators; indicators can also be used to reflect particular responses. These indicators are known as OPTION and RESPONSE, respectively.

Option indicators provide options such as spacing, underlining, and allowing or requesting data transfer from your ILE COBOL program to a printer or display device. Response indicators provide response information to your ILE COBOL program from a device, such as function keys pressed by a workstation user, and whether data has been entered.

Indicators can be passed with data records in a record area, or outside the record area in a separate indicator area.

Passing Indicators in a Separate Indicator Area

If you specify the file level keyword INDARA in the DDS, all indicators defined in the record format or formats for that file are passed to and from your ILE COBOL program in a separate indicator area, not in the record area. For information on how to specify the INDARA keyword, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

The file control entry for a file that has INDARA specified in its DDS must have the separate indicator area attribute, SI, as part of the assignment-name. For example, the assignment for a file named DSPFILE is as follows:

```
FILE-CONTROL.
    SELECT DISPFILE
           ASSIGN TO WORKSTATION-DSPFILE-SI
           ORGANIZATION IS TRANSACTION
           ACCESS IS SEQUENTIAL.
```

The advantages of using a separate indicator area are:

- The number and order of indicators used in an I/O statement for any record format in a file need not match the number and order of indicators specified in the DDS for that record format
- The program associates the indicator number in a data description entry with the appropriate indicator.

Passing Indicators in the Record Area

If the keyword INDARA is not used in the DDS of the file, indicators are created in the record area. When indicators are defined in a record format for a file, they are read, rewritten, and written with the data in the record area.

The number and order of indicators defined in the DDS for a record format for a file determines the number and order in which the data description entries for the indicators in the record format must be coded in your ILE COBOL program.

The file control entry for a file that does not have the INDARA keyword specified in the DDS associated with it must *not* have the separate indicator area attribute, SI, as part of the assignment-name.

If you use a Format 2 COPY statement to copy indicators into your ILE COBOLprogram, the indicators are defined in the order in which they are specified in the DDS for the file.

Examples of Using Indicators in ILE COBOL Programs

This section contains examples of ILE COBOL programs that illustrate the use of indicators in either a record area or a separate indicator area.

All of the ILE COBOL programs do the following:

1. Determine the current date.
2. If it is the first day of the month, turn on an option indicator that causes an output field to appear and blink.
3. Allow you to press function keys to terminate the program, or turn on response indicators and call programs to write daily or monthly reports.

Figure 135 on page 515 shows an ILE COBOL program that uses indicators in the record area but does not use the INDICATORS phrase in any I/O statement. Figure 134 on page 514 shows the associated DDS for the file.

Figure 136 on page 518 shows an ILE COBOL program that uses indicators in the record area and the INDICATORS phrase in the I/O statements. The associated DDS for Figure 136 is Figure 134 on page 514.

Figure 138 on page 521 shows an ILE COBOL program that uses indicators in a separate indicator area, defined in the WORKING-STORAGE SECTION by using the Format 2 COPY statement. Figure 137 on page 520 shows the associated DDS for the file.

Figure 139 on page 523 shows an ILE COBOL program that uses indicators in a separate indicator area, defined in a table in the WORKING-STORAGE SECTION. The associated DDS for the file is the same as Figure 137 on page 520.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A* DISPLAY FILE DDS FOR INDICATOR EXAMPLES - INDICATORS IN RECORD AREA
     A* DSPFILEX                                  1
     A      2   R FORMAT1                  3 CF01(99 'END OF PROGRAM')
     A                                       CF05(51 'DAILY REPORT')
     A                                       CF09(52 'MONTHLY REPORT')
     A*
     A                              4     10 10'DEPARTMENT NUMBER:'
     A             DEPTNO          5   I 10 32
     A   5 01                              20 26'PRODUCE MONTHLY REPORTS'
     A                                          DSPATR(BL)
     A*
     A                                 6   24 01'F5 = DAILY REPORT'
     A                                     24 26'F9 = MONTHLY REPORT'
     A                                     24 53'F1 = TERMINATE'
     A          R ERRFMT
     A     98                               6  5'INPUT-OUTPUT ERROR'
```

Figure 134. Example of a Program Using Indicators in the Record Area without Using the INDICATORS Phrase in the I/O Statement—DDS

1 The INDARA keyword is not used; indicators are stored in the record area with the data fields.

2 Record format FORMAT1 is specified.

3 Three indicators are associated with three function keys. Indicator 99 will be set on when you press F1, and so on.

4 One field is defined for input.

5 Indicator 01 is defined to cause the associated constant field to blink if the indicator is on.

6 The function (F) key definitions are documented on the workstation display.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INDIC1          ISERIES1   03/09/15 14:59:29        Page      2
                           S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200   PROGRAM-ID.     INDIC1.
          000300*    SAMPLE PROGRAM WITH INDICATORS IN RECORD AREA.
          000400
    3     000500 ENVIRONMENT DIVISION.
    4     000600   CONFIGURATION SECTION.
    5     000700   SOURCE-COMPUTER. IBM-ISERIES
    6     000800   OBJECT-COMPUTER. IBM-ISERIES
    7     000900   INPUT-OUTPUT SECTION.
    8     001000   FILE-CONTROL.
    9     001100     SELECT DISPFILE
   10     001200       ASSIGN TO WORKSTATION-DSPFILEX  1
   11     001300       ORGANIZATION IS TRANSACTION
   12     001400       ACCESS       IS SEQUENTIAL.
          001500
   13     001600 DATA DIVISION.
   14     001700   FILE SECTION.
   15     001800   FD  DISPFILE.
   16     001900   01  DISP-REC.
          002000       COPY DDS-ALL-FORMATS OF DSPFILEX.  2
   17    +000001       05  DSPFILEX-RECORD PIC X(8).                                    <-ALL-FMTS
         +000002*  INPUT FORMAT:FORMAT1    FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE    <-ALL-FMTS
         +000003*                                                                      <-ALL-FMTS
   18    +000004       05  FORMAT1-I     REDEFINES DSPFILEX-RECORD.                   <-ALL-FMTS
   19    +000005           06 FORMAT1-I-INDIC.                                        <-ALL-FMTS
   20    +000006                07 IN99            PIC 1  INDIC 99.  3               <-ALL-FMTS
         +000007*                          END OF PROGRAM                              <-ALL-FMTS
   21    +000008                07 IN51            PIC 1  INDIC 51.                  <-ALL-FMTS
         +000009*                          DAILY REPORT                                <-ALL-FMTS
   22    +000010                07 IN52            PIC 1  INDIC 52.                  <-ALL-FMTS
         +000011*                          MONTHLY REPORT                              <-ALL-FMTS
   23    +000012           06 DEPTNO              PIC X(5).                           <-ALL-FMTS
         +000013* OUTPUT FORMAT:FORMAT1    FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE    <-ALL-FMTS
         +000014*                                                                      <-ALL-FMTS
   24    +000015       05  FORMAT1-O     REDEFINES DSPFILEX-RECORD.                   <-ALL-FMTS
   25    +000016           06 FORMAT1-O-INDIC.                                        <-ALL-FMTS
   26    +000017                07 IN01            PIC 1  INDIC 01.                  <-ALL-FMTS
         +000018*  INPUT FORMAT:ERRFMT     FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE    <-ALL-FMTS
         +000019*                                                                      <-ALL-FMTS
         +000020*      05  ERRFMT-I      REDEFINES DSPFILEX-RECORD.                   <-ALL-FMTS
         +000021* OUTPUT FORMAT:ERRFMT     FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE    <-ALL-FMTS
         +000022*                                                                      <-ALL-FMTS
   27    +000023       05  ERRFMT-O      REDEFINES DSPFILEX-RECORD.                   <-ALL-FMTS
   28    +000024           06 ERRFMT-O-INDIC.                                         <-ALL-FMTS
   29    +000025                07 IN98            PIC 1  INDIC 98.                  <-ALL-FMTS
          002100
   30     002200 WORKING-STORAGE SECTION.
   31     002300 01  CURRENT-DATE.
   32     002400    05  CURR-YEAR                PIC 9(2).
   33     002500    05  CURR-MONTH               PIC 9(2).
   34     002600    05  CURR-DAY                 PIC 9(2).
   35     002700 01  INDIC-AREA.  4
   36     002800    05  IN01                     PIC 1.
```

Figure 135. Example of a Program Using Indicators in the Record Area without Using the INDICATORS Phrase in the I/O Statement—COBOL Source Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INDIC1          ISERIES1   03/09/15 14:59:29       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   37     002900       88  NEW-MONTH              VALUE B"1".  5
   38     003000    05  IN51                      PIC 1.
   39     003100       88  WANT-DAILY             VALUE B"1".
   40     003200    05  IN52                      PIC 1.
   41     003300       88  WANT-MONTHLY           VALUE B"1".
   42     003400    05  IN98                      PIC 1.
   43     003500       88  IO-ERROR               VALUE B"1".
   44     003600    05  IN99                      PIC 1.
   45     003700       88  NOT-END-OF-JOB         VALUE B"0".
   46     003800       88  END-OF-JOB             VALUE B"1".
          003900
   47     004000 PROCEDURE DIVISION.
   48     004100 DECLARATIVES.
          004200 DISPLAY-ERR-SECTION SECTION.
          004300     USE AFTER STANDARD EXCEPTION PROCEDURE ON DISPFILE.
          004400 DISPLAY-ERR-PARAGRAPH.
   49     004500     SET IO-ERROR TO TRUE
   50     004600     MOVE CORR INDIC-AREA TO ERRFMT-O-INDIC
                 *** CORRESPONDING items for statement 50:
                 ***     IN98
                 *** End of CORRESPONDING items for statement 50
   51     004700     WRITE DISP-REC FORMAT IS "ERRFMT"
          004800     END-WRITE
   52     004900     CLOSE DISPFILE.
   53     005000     STOP RUN.
          005100 END DECLARATIVES.
          005200
          005300 MAIN-PROGRAM SECTION.
          005400 MAINLINE.
   54     005500     OPEN I-O DISPFILE.
   55     005600     ACCEPT CURRENT-DATE FROM DATE.
   56     005700     SET NOT-END-OF-JOB TO TRUE.
   57     005800     PERFORM UNTIL END-OF-JOB
          005900
   58     006000         MOVE ZEROS TO INDIC-AREA  6
   59     006100         IF CURR-DAY = 01 THEN
   60     006200            SET NEW-MONTH TO TRUE  7
          006300         END-IF
   61     006400         MOVE CORR INDIC-AREA TO FORMAT1-O-INDIC  8
                 *** CORRESPONDING items for statement 61:
                 ***     IN01
                 *** End of CORRESPONDING items for statement 61
   62     006500         WRITE DISP-REC FORMAT IS "FORMAT1"  9
          006600         END-WRITE
          006700
   63     006800         MOVE ZEROS TO INDIC-AREA
   64     006900         READ DISPFILE FORMAT IS "FORMAT1"  10
          007000         END-READ
   65     007100         MOVE CORR FORMAT1-I-INDIC TO INDIC-AREA  11
                 *** CORRESPONDING items for statement 65:
                 ***     IN99
                 ***     IN51
                 ***     IN52
                 *** End of CORRESPONDING items for statement 65
   66     007200         IF WANT-DAILY THEN
   67     007300            CALL "DAILY" USING DEPTNO
          007400         ELSE
   68     007500            IF WANT-MONTHLY THEN
   69     007600               CALL "MONTHLY" USING DEPTNO  12
          007700            END-IF
          007800         END-IF
          007900
          008000     END-PERFORM.
   70     008100     CLOSE DISPFILE.
   71     008200     STOP RUN.
                       *****  E N D   O F   S O U R C E  *****
```

Figure 135. Example of a Program Using Indicators in the Record Area without Using the INDICATORS Phrase in the I/O Statement—COBOL Source Program (Part 2 of 2)

1 The separate indicator area attribute, SI, is not coded in the ASSIGN clause. As a result, the indicators form part of the record area.

2 The Format 2 COPY statement defines data fields and indicators in the record area.

3 Because the file indicators form part of the record area, response and

option indicators are defined in the order in which they are used in the DDS, and the indicator numbers are treated as documentation.

4 All indicators used by the program are defined with meaningful names in data description entries in the WORKING-STORAGE SECTION. Indicator numbers are omitted here because they have no effect.

5 For each indicator, a meaningful level-88 condition-name is associated with a value for that indicator.

6 Initialize group level to zeros.

7 IN01 in the WORKING-STORAGE SECTION is set on if it is the first day of the month.

8 Indicators appropriate to the output of FORMAT1 are copied to the record area.

9 FORMAT1 is written to the workstation display with both data and indicator values in the record area.

The INDICATORS phrase is not necessary because there is no separate indicator area and indicator values have been set in the record area through the previous MOVE CORRESPONDING statement.

10 FORMAT1, including both data and indicators, is read from the display.

11 The response indicators for FORMAT1 are copied from the record area to the data description entries in the WORKING-STORAGE SECTION.

12 If F5 has been pressed, a program call is processed.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INDIC1          ISERIES1   03/09/15 15:00:29        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200   PROGRAM-ID.     INDIC2.
          000300*    SAMPLE PROGRAM - FILE WITH INDICATORS IN RECORD AREA
          000400
    3     000500 ENVIRONMENT DIVISION.
    4     000600   CONFIGURATION SECTION.
    5     000700   SOURCE-COMPUTER. IBM-ISERIES
    6     000800   OBJECT-COMPUTER. IBM-ISERIES
    7     000900   INPUT-OUTPUT SECTION.
    8     001000   FILE-CONTROL.
    9     001100     SELECT DISPFILE
   10     001200       ASSIGN TO WORKSTATION-DSPFILEX  1
   11     001300       ORGANIZATION IS TRANSACTION
   12     001400       ACCESS       IS SEQUENTIAL.
          001500
   13     001600 DATA DIVISION.
   14     001700   FILE SECTION.
   15     001800   FD  DISPFILE.
   16     001900   01  DISP-REC.
          002000       COPY DDS-ALL-FORMATS OF DSPFILEX.  2
   17    +000001       05  DSPFILEX-RECORD PIC X(8).                                        <-ALL-FMTS
         +000002*  INPUT FORMAT:FORMAT1    FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE       <-ALL-FMTS
         +000003*                                                                          <-ALL-FMTS
   18    +000004       05  FORMAT1-I     REDEFINES DSPFILEX-RECORD.                       <-ALL-FMTS
   19    +000005           06 FORMAT1-I-INDIC.                                            <-ALL-FMTS
   20    +000006                07 IN99             PIC 1  INDIC 99.  3                  <-ALL-FMTS
         +000007*                           END OF PROGRAM                                 <-ALL-FMTS
   21    +000008                07 IN51             PIC 1  INDIC 51.                     <-ALL-FMTS
         +000009*                           DAILY REPORT                                   <-ALL-FMTS
   22    +000010                07 IN52             PIC 1  INDIC 52.                     <-ALL-FMTS
         +000011*                           MONTHLY REPORT                                 <-ALL-FMTS
   23    +000012           06 DEPTNO               PIC X(5).                            <-ALL-FMTS
         +000013* OUTPUT FORMAT:FORMAT1    FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE       <-ALL-FMTS
         +000014*                                                                          <-ALL-FMTS
   24    +000015       05  FORMAT1-O     REDEFINES DSPFILEX-RECORD.                       <-ALL-FMTS
   25    +000016           06 FORMAT1-O-INDIC.                                            <-ALL-FMTS
   26    +000017                07 IN01             PIC 1  INDIC 01.                     <-ALL-FMTS
         +000018*  INPUT FORMAT:ERRFMT     FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE       <-ALL-FMTS
         +000019*                                                                          <-ALL-FMTS
         +000020*      05  ERRFMT-I      REDEFINES DSPFILEX-RECORD.                       <-ALL-FMTS
         +000021* OUTPUT FORMAT:ERRFMT     FROM FILE DSPFILEX   OF LIBRARY CBLGUIDE       <-ALL-FMTS
         +000022*                                                                          <-ALL-FMTS
   27    +000023       05  ERRFMT-O      REDEFINES DSPFILEX-RECORD.                       <-ALL-FMTS
   28    +000024           06 ERRFMT-O-INDIC.                                             <-ALL-FMTS
   29    +000025                07 IN98             PIC 1  INDIC 98.                     <-ALL-FMTS
          002100
   30     002200 WORKING-STORAGE SECTION.
   31     002300 01  CURRENT-DATE.
   32     002400     05  CURR-YEAR                PIC 9(2).
   33     002500     05  CURR-MONTH               PIC 9(2).
   34     002600     05  CURR-DAY                 PIC 9(2).
          002700
   35     002800 77  IND-OFF                     PIC 1      VALUE B"0".
```

Figure 136. Example of Program Using Indicators in the Record Area and the INDICATORS Phrase in I/O Statements–COBOL Source Program (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/INDIC1         ISERIES1   03/09/15 15:00:29       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   36     002900 77  IND-ON                       PIC 1      VALUE B"1".
          003000
   37     003100 01  RESPONSE-INDICS.
   38     003200     05  END-OF-PROGRAM           PIC 1.  4
   39     003300     05  DAILY-REPORT             PIC 1.
   40     003400     05  MONTHLY-REPORT           PIC 1.
   41     003500 01  OPTION-INDICS.
   42     003600     05  NEW-MONTH                PIC 1.
   43     003700 01  ERROR-INDICS.
   44     003800     05  IO-ERROR                 PIC 1.
          003900
   45     004000 PROCEDURE DIVISION.
   46     004100 DECLARATIVES.
          004200 DISPLAY-ERR-SECTION SECTION.
          004300     USE AFTER STANDARD EXCEPTION PROCEDURE ON DISPFILE.
          004400 DISPLAY-ERR-PARAGRAPH.
   47     004500     MOVE IND-ON TO IO-ERROR
   48     004600     WRITE DISP-REC FORMAT IS "ERRFMT"
          004700                    INDICATORS ARE ERROR-INDICS
          004800     END-WRITE
   49     004900     CLOSE DISPFILE.
   50     005000     STOP RUN.
          005100 END DECLARATIVES.
          005200
          005300 MAIN-PROGRAM SECTION.
          005400 MAINLINE.
   51     005500     OPEN I-O DISPFILE.
   52     005600     ACCEPT CURRENT-DATE FROM DATE.
   53     005700     MOVE IND-OFF TO END-OF-PROGRAM.
   54     005800     PERFORM UNTIL END-OF-PROGRAM = IND-ON
   55     005900         MOVE ZEROS TO OPTION-INDICS
   56     006000         IF CURR-DAY = 01 THEN  5
   57     006100            MOVE IND-ON TO NEW-MONTH
          006200         END-IF
   58     006300         WRITE DISP-REC FORMAT IS "FORMAT1"  6
          006400                        INDICATORS ARE OPTION-INDICS
          006500         END-WRITE
          006600
   59     006700         MOVE ZEROS TO RESPONSE-INDICS
   60     006800         READ DISPFILE FORMAT IS "FORMAT1"  7
          006900                       INDICATORS ARE RESPONSE-INDICS  8
          007000         END-READ
   61     007100         IF DAILY-REPORT = IND-ON THEN
   62     007200            CALL "DAILY" USING DEPTNO  9
          007300         ELSE
   63     007400            IF MONTHLY-REPORT = IND-ON THEN
   64     007500               CALL "MONTHLY" USING DEPTNO
          007600            END-IF
          007700         END-IF
          007800
          007900     END-PERFORM
   65     008000     CLOSE DISPFILE.
   66     008100     STOP RUN.
          008200
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 136. Example of Program Using Indicators in the Record Area and the INDICATORS Phrase in I/O Statements–COBOL Source Program (Part 2 of 2)

1 The separate indicator area attribute, SI, is not coded in the ASSIGN clause.

2 The Format 2 COPY statement defines data fields and indicators in the record area.

3 Because the file does not have a separate indicator area, response and option indicators are defined in the order in which they are used in the DDS, and the indicator numbers are treated as documentation.

4 All indicators used by the program are defined with meaningful names in data description entries in the WORKING-STORAGE SECTION. Indicator numbers are omitted here because they have no effect. Indicators should be defined in the order needed by the display file.

5 IN01 in the WORKING-STORAGE SECTION is set on if it is the first day of the month.

6 FORMAT1 is written to the workstation display:

- The INDICATORS phrase causes the contents of the variable OPTION-INDICS to be copied to the beginning of the record area.
- Data and indicator values are written to the workstation display.

7 FORMAT1, including both data and indicators, is read from the work station display.

8 The INDICATORS phrase causes bytes to be copied from the beginning of the record area to RESPONSE-INDICS.

9 If F5 has been pressed, a program call is processed.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A* DISPLAY FILE FOR INDICATOR EXAMPLES - INDICATORS IN SI AREA
     A* DSPFILE
     A                                      INDARA 1
     A          R FORMAT1                   CF01(99 'END OF PROGRAM')
     A                                      CF05(51 'DAILY REPORT')
     A                                      CF09(52 'MONTHLY REPORT')
     A*
     A                                10 10'DEPARTMENT NUMBER:'
     A            DEPTNO         5   I 10 32
     A     01                         20 26'PRODUCE MONTHLY REPORTS'
     A                                     DSPATR(BL)
     A*
     A                                24 01'F5 = DAILY REPORT'
     A                                24 26'F9 = MONTHLY REPORT'
     A                                24 53'F1 = TERMINATE'
     A          R ERRFMT
     A     98                          6  5'INPUT-OUTPUT ERROR'
```

*Figure 137. Example of a Program Using Indicators in a Separate Indicator Area, Defined in WORKING-STORAGE by Using the COPY Statement ** DDS*

1 The INDARA keyword is specified; indicators are stored in a separate indicator area, not in the record area. Except for this specification, the DDS for this file is the same as that shown in Figure 134 on page 514.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INDIC1          ISERIES1   03/09/15 15:01:36        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     INDIC3.
          000300*    SAMPLE PROGRAM - FILE WITH SEPERATE INDICATORS AREA
          000400
    3     000500 ENVIRONMENT DIVISION.
    4     000600 CONFIGURATION SECTION.
    5     000700 SOURCE-COMPUTER. IBM-ISERIES
    6     000800 OBJECT-COMPUTER. IBM-ISERIES
    7     000900 INPUT-OUTPUT SECTION.
    8     001000 FILE-CONTROL.
    9     001100     SELECT DISPFILE
   10     001200         ASSIGN TO WORKSTATION-DSPFILE-SI  1
   11     001300         ORGANIZATION IS TRANSACTION
   12     001400         ACCESS IS SEQUENTIAL.
          001500
   13     001600 DATA DIVISION.
   14     001700 FILE SECTION.
   15     001800 FD  DISPFILE.
   16     001900 01  DISP-REC.
          002000     COPY DDS-ALL-FORMATS OF DSPFILE.  2
   17    +000001       05  DSPFILE-RECORD PIC X(5).                                    <-ALL-FMTS
         +000002*  INPUT FORMAT:FORMAT1    FROM FILE DSPFILE    OF LIBRARY CBLGUIDE   <-ALL-FMTS
         +000003*                                                                     <-ALL-FMTS
   18    +000004       05  FORMAT1-I     REDEFINES DSPFILE-RECORD.                   <-ALL-FMTS
   19    +000005           06 DEPTNO               PIC X(5).                         <-ALL-FMTS
         +000006* OUTPUT FORMAT:FORMAT1    FROM FILE DSPFILE    OF LIBRARY CBLGUIDE   <-ALL-FMTS
         +000007*                                                                     <-ALL-FMTS
         +000008*      05  FORMAT1-O     REDEFINES DSPFILE-RECORD.                   <-ALL-FMTS
         +000009*  INPUT FORMAT:ERRFMT     FROM FILE DSPFILE    OF LIBRARY CBLGUIDE   <-ALL-FMTS
         +000010*                                                                     <-ALL-FMTS
         +000011*      05  ERRFMT-I      REDEFINES DSPFILE-RECORD.                   <-ALL-FMTS
         +000012* OUTPUT FORMAT:ERRFMT     FROM FILE DSPFILE    OF LIBRARY CBLGUIDE   <-ALL-FMTS
         +000013*                                                                     <-ALL-FMTS
         +000014*      05  ERRFMT-O      REDEFINES DSPFILE-RECORD.                   <-ALL-FMTS
          002100
   20     002200 WORKING-STORAGE SECTION.
   21     002300 01  CURRENT-DATE.
   22     002400    05  CURR-YEAR                 PIC 9(2).
   23     002500    05  CURR-MONTH                PIC 9(2).
   24     002600    05  CURR-DAY                  PIC 9(2).
          002700
   25     002800    77 IND-OFF                    PIC 1 VALUE B"0".
   26     002900    77 IND-ON                     PIC 1 VALUE B"1".
          003000
   27     003100 01  DISPFILE-INDICS.
          003200     COPY DDS-ALL-FORMATS-INDIC OF DSPFILE.  3
   28    +000001       05  DSPFILE-RECORD.                                           <-ALL-FMTS
         +000002*  INPUT FORMAT:FORMAT1    FROM FILE DSPFILE    OF LIBRARY CBLGUIDE   <-ALL-FMTS
         +000003*                                                                     <-ALL-FMTS
   29    +000004           06 FORMAT1-I-INDIC.                                       <-ALL-FMTS
   30    +000005               07 IN51            PIC 1  INDIC 51.  4               <-ALL-FMTS
         +000006*                          DAILY REPORT                             <-ALL-FMTS
   31    +000007               07 IN52            PIC 1  INDIC 52.                  <-ALL-FMTS
```

Figure 138. COBOL Listing Using Indicators in a Separate Indicator Area (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/INDIC1          ISERIES1   03/09/15 15:01:36       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        +000008*                          MONTHLY REPORT                                    <-ALL-FMTS
  32    +000009               07 IN99            PIC 1  INDIC 99.                          <-ALL-FMTS
        +000010*                          END OF PROGRAM                                    <-ALL-FMTS
        +000011* OUTPUT FORMAT:FORMAT1    FROM FILE DSPFILE    OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000012*                                                                            <-ALL-FMTS
  33    +000013           06 FORMAT1-O-INDIC.                                              <-ALL-FMTS
  34    +000014                07 IN01            PIC 1  INDIC 01.                       <-ALL-FMTS
        +000015*  INPUT FORMAT:ERRFMT     FROM FILE DSPFILE    OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000016*                                                                            <-ALL-FMTS
        +000017*          06 ERRFMT-I-INDIC.                                                <-ALL-FMTS
        +000018* OUTPUT FORMAT:ERRFMT     FROM FILE DSPFILE    OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000019*                                                                            <-ALL-FMTS
  35    +000020           06 ERRFMT-O-INDIC.                                               <-ALL-FMTS
  36    +000021                07 IN98            PIC 1  INDIC 98.                       <-ALL-FMTS
         003300
  37     003400 PROCEDURE DIVISION.
  38     003500 DECLARATIVES.
         003600 DISPLAY-ERR-SECTION SECTION.
         003700     USE AFTER STANDARD EXCEPTION PROCEDURE ON DISPFILE.
         003800 DISPLAY-ERR-PARAGRAPH.
  39     003900     MOVE IND-ON TO IN98 IN ERRFMT-O-INDIC
  40     004000     WRITE DISP-REC FORMAT IS "ERRFMT"
         004100                    INDICATORS ARE ERRFMT-O-INDIC
         004200     END-WRITE
  41     004300     CLOSE DISPFILE.
  42     004400     STOP RUN.
         004500 END DECLARATIVES.
         004600
         004700 MAIN-PROGRAM SECTION.
         004800 MAINLINE.
         004900
  43     005000     OPEN I-O DISPFILE.
  44     005100     ACCEPT CURRENT-DATE FROM DATE.
  45     005200     MOVE IND-OFF TO IN99 IN FORMAT1-I-INDIC.
  46     005300     PERFORM UNTIL IN99 IN FORMAT1-I-INDIC = IND-ON
         005400
  47     005500         MOVE ZEROS TO FORMAT1-O-INDIC
  48     005600         IF CURR-DAY = 01 THEN
  49     005700            MOVE IND-ON TO IN01 IN FORMAT1-O-INDIC   5
         005800         END-IF
  50     005900         WRITE DISP-REC FORMAT IS "FORMAT1"
         006000                        INDICATORS ARE FORMAT1-O-INDIC   6
         006100         END-WRITE
         006200
  51     006300         MOVE ZEROS TO FORMAT1-I-INDIC
  52     006400         READ DISPFILE FORMAT IS "FORMAT1"
         006500                       INDICATORS ARE FORMAT1-I-INDIC   7
         006600         END-READ
  53     006700         IF IN51 IN FORMAT1-I-INDIC = IND-ON THEN
  54     006800             CALL "DAILY" USING DEPTNO
         006900         ELSE
  55     007000             IF IN52 IN FORMAT1-I-INDIC = IND-ON THEN
  56     007100                 CALL "MONTHLY" USING DEPTNO   8
         007200             END-IF
         007300         END-IF
         007400
         007500     END-PERFORM
  57     007600     CLOSE DISPFILE.
  58     007700     STOP RUN.
         007800
                         * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 138. COBOL Listing Using Indicators in a Separate Indicator Area (Part 2 of 2)

1 The separate indicator area attribute, SI, is specified in the ASSIGN clause.

2 The Format 2 COPY statement generates data descriptions in the record area for data fields only. The data description entries for the indicators are not generated because a separate indicator area has been specified for the file.

3 The Format 2 COPY statement, with the INDICATOR attribute, INDIC, defines data description entries in the WORKING-STORAGE SECTION for all indicators used in the DDS for the record format for the file.

4 Because the file has a separate indicator area, the indicator numbers used in the data description entries are not treated as documentation.

5 IN01 in the separate indicator area for FORMAT1 is set on if it is the first day of the month.

6 The INDICATORS phrase is required to send indicator values to the workstation display.

7 The INDICATORS phrase is required to receive indicator values from the workstation display. If you have pressed F5, IN51 is set on.

8 If IN51 has been set on, a program call is processed.

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/INDIC4          ISERIES1   03/09/15 15:02:22        Page      2
                           S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     INDIC4.
          000300*    SAMPLE PROGRAM
          000400*    FILE WITH SEPERATE INDICATORS AREA IN WORKING STORAGE
          000500
    3     000600 ENVIRONMENT DIVISION.
    4     000700 CONFIGURATION SECTION.
    5     000800 SOURCE-COMPUTER. IBM-ISERIES
    6     000900 OBJECT-COMPUTER. IBM-ISERIES
    7     001000 INPUT-OUTPUT SECTION.
    8     001100 FILE-CONTROL.
    9     001200     SELECT DISPFILE
   10     001300         ASSIGN TO WORKSTATION-DSPFILE-SI  1
   11     001400         ORGANIZATION IS TRANSACTION
   12     001500         ACCESS IS SEQUENTIAL.
          001600
   13     001700 DATA DIVISION.
   14     001800 FILE SECTION.
   15     001900 FD  DISPFILE.
   16     002000 01  DISP-REC.
          002100     COPY DDS-ALL-FORMATS OF DSPFILE.  2
   17    +000001       05  DSPFILE-RECORD PIC X(5).                                        <-ALL-FMTS
         +000002*  INPUT FORMAT:FORMAT1    FROM FILE DSPFILE    OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000003*                                                                         <-ALL-FMTS
   18    +000004       05  FORMAT1-I     REDEFINES DSPFILE-RECORD.                       <-ALL-FMTS
   19    +000005           06 DEPTNO               PIC X(5).                             <-ALL-FMTS
         +000006* OUTPUT FORMAT:FORMAT1    FROM FILE DSPFILE    OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000007*                                                                         <-ALL-FMTS
         +000008*      05  FORMAT1-O     REDEFINES DSPFILE-RECORD.                       <-ALL-FMTS
         +000009*  INPUT FORMAT:ERRFMT     FROM FILE DSPFILE    OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000010*                                                                         <-ALL-FMTS
         +000011*      05  ERRFMT-I      REDEFINES DSPFILE-RECORD.                       <-ALL-FMTS
         +000012* OUTPUT FORMAT:ERRFMT     FROM FILE DSPFILE    OF LIBRARY CBLGUIDE      <-ALL-FMTS
         +000013*                                                                         <-ALL-FMTS
         +000014*      05  ERRFMT-O      REDEFINES DSPFILE-RECORD.                       <-ALL-FMTS
          002200
   20     002300 WORKING-STORAGE SECTION.
   21     002400 01  CURRENT-DATE.
   22     002500    05  CURR-YEAR                 PIC 9(2).
   23     002600    05  CURR-MONTH                PIC 9(2).
   24     002700    05  CURR-DAY                  PIC 9(2).
          002800
   25     002900 01  INDIC-AREA.
   26     003000    05 INDIC-TABLE  OCCURS 99      PIC 1    INDICATOR 1.  3
   27     003100      88  IND-OFF                           VALUE B"0".
   28     003200      88  IND-ON                            VALUE B"1".
          003300
   29     003400 01  DISPFILE-INDIC-USAGE.
   30     003500    05  IND-NEW-MONTH              PIC 9(2) VALUE 01.
   31     003600    05  IND-DAILY                  PIC 9(2) VALUE 51.  4
   32     003700    05  IND-MONTHLY                PIC 9(2) VALUE 52.
   33     003800    05  IND-IO-ERROR               PIC 9(2) VALUE 98.
   34     003900    05  IND-EOJ                    PIC 9(2) VALUE 99.
```

Figure 139. Example of a Program Using Indicators in a Separate Indicator Area, Defined in a Table in WORKING-STORAGE (Part 1 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/INDIC4         ISERIES1   03/09/15 15:02:22       Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        004000
   35   004100 PROCEDURE DIVISION.
   36   004200 DECLARATIVES.
        004300 DISPLAY-ERR-SECTION SECTION.
        004400     USE AFTER STANDARD EXCEPTION PROCEDURE ON DISPFILE.
        004500 DISPLAY-ERR-PARAGRAPH.
   37   004600     SET IND-ON (IND-IO-ERROR) TO TRUE
   38   004700     WRITE DISP-REC FORMAT IS "ERRFMT"
        004800                      INDICATORS ARE INDIC-TABLE
        004900     END-WRITE
   39   005000     CLOSE DISPFILE.
   40   005100     STOP RUN.
        005200 END DECLARATIVES.
        005300
        005400 MAIN-PROGRAM SECTION.
        005500 MAINLINE.
   41   005600     OPEN I-O DISPFILE.
   42   005700     ACCEPT CURRENT-DATE FROM DATE.
   43   005800     SET IND-OFF (IND-EOJ) TO TRUE.
   44   005900     PERFORM UNTIL IND-ON (IND-EOJ)
        006000
   45   006100         MOVE ZEROS TO INDIC-AREA
   46   006200         IF CURR-DAY = 01 THEN
   47   006300            SET IND-ON (IND-NEW-MONTH) TO TRUE  5
        006400         END-IF
   48   006500         WRITE DISP-REC FORMAT IS "FORMAT1"
        006600                        INDICATORS ARE INDIC-TABLE  6
        006700         END-WRITE
        006800
   49   006900         READ DISPFILE FORMAT IS "FORMAT1"
        007000                        INDICATORS ARE INDIC-TABLE  7
        007100         END-READ
   50   007200         IF IND-ON (IND-DAILY) THEN
   51   007300             CALL "DAILY" USING DEPTNO  8
        007400         ELSE
   52   007500             IF IND-ON (IND-MONTHLY) THEN
   53   007600                 CALL "MONTHLY" USING DEPTNO
        007700             END-IF
        007800         END-IF
        007900
        008000     END-PERFORM
   54   008100     CLOSE DISPFILE.
   55   008200     STOP RUN.
        008300
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 139. Example of a Program Using Indicators in a Separate Indicator Area, Defined in a Table in WORKING-STORAGE (Part 2 of 2)

1 The separate indicator area attribute, SI, is specified in the ASSIGN clause.

2 The Format 2 COPY statement generates fields in the record area for data fields only.

3 A table of 99 Boolean data items is defined in the WORKING-STORAGE SECTION. The INDICATOR clause for this data description entry causes these data items to be associated with indicators 1 through 99 respectively. The use of such a table may result in improved performance as compared to the use of a group item with multiple subordinate entries for individual indicators.

4 A series of data items is defined in the WORKING-STORAGE SECTION to provide meaningful subscript names with which to refer to the table of indicators. The use of such data items is not required.

5 INDIC-TABLE (01) in the separate indicator area for FORMAT1 is set on if it is the first day of the month.

6 The INDICATOR phrase is required to send indicator values to the workstation display.

7 The INDICATOR phrase is required to receive indicator values from the workstation display. If F5 has been pressed, INDIC-TABLE (51) will be set on.

8 If INDIC-TABLE (51) has been set on, program DAILY is called.

Using Subfile Transaction Files

A **subfile** is a group of records that are read from or written to a display device. The program processes one record at a time, but the operating system and the workstation send and receive blocks of records. If more records are transmitted than can be shown on the display at one time, the workstation operator can page through the block of records without returning control to the program.

Subfiles offer a convenient way of reading and writing large numbers of similar records to and from displays. Subfiles are display files whose records can be accessed sequentially or randomly by relative key value.

For example, suppose you want to display all customers who have spent more than $5000 with your company over the last year. You can do a query of your database and get the names of all these customers, and place them in a special file (the subfile), by performing WRITE SUBFILE operations on the subfile. When you have done this, you can write the entire contents of the subfile to the display by performing a WRITE operation on the subfile control record. Then you can read the customer list as modified by the user using a READ operation on the subfile control record, and subsequently retrieve the individual records from the subfile using READ SUBFILE operations.

Subfiles can be specified in the DDS for a display file to allow you to handle multiple records of the same type on a display. See Figure 140 on page 526 for an example of a subfile display.

Records formats to be included in a subfile are specified in the DDS for the file. The number of records that can be contained in a subfile must also be specified in the DDS. One file can contain more than one subfile; however, only twelve subfiles can be active concurrently for a device.

Defining a Subfile Using Data Description Specifications

The DDS for a subfile consists of two record formats: a subfile record format and a subfile control record format.

The subfile record format contains the field descriptions for the records in the subfile. Specifications of the subfile record format on a READ, WRITE, or REWRITE causes the specified subfile record to be processed, but does not directly affect the displayed data.

Specification of the subfile control record format on a READ or WRITE statement causes the physical read, write, or setup operations of a subfile to take place. Figure 141 on page 528 shows an example of the DDS for a subfile record format and a subfile control record format.

For a description of how the records in a subfile can be displayed and for a description of the keywords that can be specified for a subfile, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

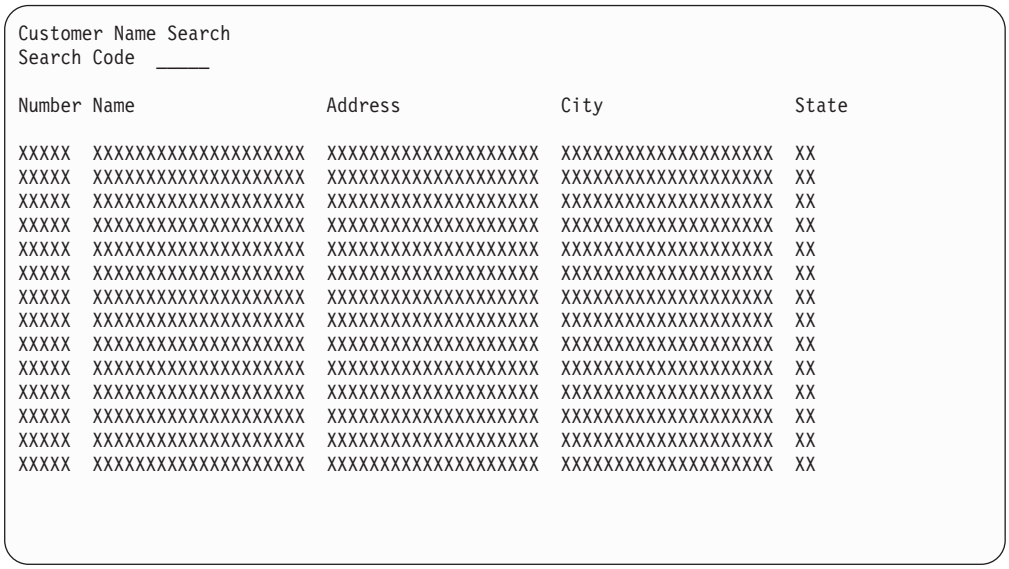

Figure 140. Subfile Display

Using Subfiles for a Display File

To use a subfile for a display file in an ILE COBOL program, you must specify the SUBFILE phrase with the input/output operation. Valid subfile operations are:

- READ SUBFILE file-name RECORD
- WRITE SUBFILE record-name
- REWRITE SUBFILE record-name.

Subfiles can be processed sequentially with the READ SUBFILE NEXT MODIFIED statement, or processed randomly by specifying a relative key value. A relative key is an unsigned number that can be used directly by the system to locate a record in a file.

The TRANSACTION file must be an externally described file. In ILE COBOL, access to the subfile is done with a relative record number, except when READ SUBFILE NEXT MODIFIED is used. If the SUBFILE phrases are used with a TRANSACTION file, the SELECT statement in the Environment Division must state that ACCESS MODE IS DYNAMIC and must specify a RELATIVE KEY.

If more than one display device is acquired by a display file, there is a separate subfile for each individual display device. If a subfile has been created for a particular display device acquired by a TRANSACTION file, all input operations that refer to a record format for the subfile are performed against the subfile belonging to that device. Any operations that reference a record format name that is not designated as a subfile are processed as an input/output operation directly to the display device.

Some typical uses of subfiles are summarized in Table 27.

Table 27. Uses of Subfiles

Use	Meaning
Display Only	The workstation user reviews the display.
Display With Selection	The user requests more information about one of the items on display.

Table 27. Uses of Subfiles (continued)

Use	Meaning
Modification	The user modifies one or more of the records.
Input Only (with no validity checking)	A subfile is used for a data-entry function.
Input Only (with validity checking)	A subfile is used for a data-entry function, and the records are checked as well.
Combination of Tasks	A subfile can be used as a display with modification.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A* THIS IS THE DISPLAY DEVICE FILE FOR PAYUPDT ** PAYUPDTD
     A* ACCOUNTS RECEIVABLE INTERACTIVE PAYMENT UPDATE
     A*
     A
     A          R SUBFILE1                  SFL  1
     A                                      TEXT('SUBFILE FOR CUSTOMER PAYMENT'
     A*
     A            ACPPMT         4A  I  5  4TEXT('ACCEPT PAYMENT')
     A                                  2   VALUES('*YES' '*NO')  3
     A  51                                  DSPATR(RI MDT)
     A N51                                  DSPATR(ND PR)
     A*
     A            CUST           5   B  5 15TEXT('CUSTOMER NUMBER')
     A  52                          4       DSPATR(RI)
     A  53                                  DSPATR(ND)
     A  54                                  DSPATR(PR)
     A*
     A            AMPAID         8 02B  5 24TEXT('AMOUNT PAID')
     A                                      CHECK(FE)  5
     A                                      AUTO(RAB)  6
     A                                      CMP(GT 0)  7
     A  52                                  DSPATR(RI)
     A  53                                  DSPATR(ND)
     A  54                                  DSPATR(PR)
     A*
     A            ECPMSG        31A  O  5 37TEXT('EXCEPTION MESSAGE')
     A  52                                  DSPATR(RI)
     A  53                                  DSPATR(ND)
     A  54                                  DSPATR(BL)
     A*
     A            OVRPMT         8Y 2O  5 70TEXT('OVERPAYMENT')
     A                                      EDTCDE(1)  8
     A  55                                  DSPATR(BL)  9
     A N56                                  DSPATR(ND)
     A*
     A            STSCDE         1A  H      TEXT('STATUS CODE')
     A          R CONTROL1                  TEXT('SUBFILE CONTROL')
     A                                      SFLCTL(SUBFILE1)  10
     A                                      SFLSIZ(17)  11
     A                                      SFLPAG(17)  12
     A  61                                  SFLCLR  13
     A  62                                  SFLDSP  14
     A  62                                  SFLDSPCTL  15
     A                                      OVERLAY
     A                                      LOCK  16
     A*
     A                                      HELP(99 'HELP KEY')  17
     A                                      CA12(98 'END PAYMENT UPDATE')
     A                                      CA11(97 'IGNORE INPUT')
     A*                                      18
     A  99                                  SFLMSG(' F11 - IGNORE INVALID INPUT+
     A                                                   F12 - END PAYMENT +
     A                                      UPDATE')
```

Figure 141. Data Description Specifications for a Subfile Record Format (Part 1 of 2)

```
      A*
      A                                    1  2'CUSTOMER PAYMENT UPDATE PROMPT'
      A                                    1 65'DATE'
      A                                    1 71DATE EDTCDE(Y)
      A  63                                3  2'ACCEPT'
      A  63                                4  2'PAYMENT'
      A                                    3 14'CUSTOMER'
      A                                    3 26'PAYMENT'
      A  64                                3 37'EXCEPTION MESSAGE'
      A*
      A          R MESSAGE1                     TEXT('MESSAGE RECORD')
      A                                         OVERLAY
      A                                         LOCK
      A*
      A  71                               24  2' ACCEPT PAYMENT VALUES: (*NO
*YES)
DSPATR(RI)
```

Figure 141. Data Description Specifications for a Subfile Record Format (Part 2 of 2)

The data description specifications (DDS) for a subfile record format describe the records in the subfile:

1 The SFL keyword identifies the record format as a subfile.

2 The line and position entries define the location of the fields on the display.

3 The VALUES keyword specifies that the user can only specify *YES or *NO as values for the ACPPMT field.

4 The usage entries define whether the named field is to be an output (O), input (I), output/input (B), or hidden (H) field.

5 The entry CHECK(FE) specifies that the user cannot skip to the next input field without pressing one of the field exit keys.

6 The entry AUTO(RAB) specifies that data entered into the field AMPAID is to be automatically right-justified, and the leading characters are to be filled with blanks.

7 The entry CMP(GT 0) specifies that the data entered for the field AMPAID is to be compared to zero to ensure that the value is greater than zero.

8 The EDTCDE keyword specifies the desired editing for output field OVRPMT. EDTCDE(1) indicates that the field OVRPMT is to be printed with commas, decimal point, and no sign. Also, a zero balance will be printed, and leading zeros will be suppressed.

9 The DSPATR keyword is used to specify the display attributes for the named field when the corresponding indicator status is true. The attributes specified are:
- BL (blink)
- RI (reverse image)
- PR (protect)
- MDT (set modified data tag)
- ND (nondisplay).

The subfile control record format defines the attributes of the subfile, the search input field, constants, and command keys. The keywords used indicate the following:

10 SFLCTL identifies this record as a subfile control record and names the associated subfile record (SUBFILE1).

11 SFLSIZ indicates the total number of records to be included in the subfile (17).

12 SFLPAG indicates the total number of records in a page (17).

13 SFLCLR indicates when the subfile should be cleared (when indicator 61 is on).

14 SFLDSP indicates when to display the subfile (when indicator 62 is on).

15 SFLDSPCTL indicates when to display the subfile control record (when indicator 62 is on).

16 The LOCK keyword prevents the workstation user from using the keyboard when the CONTROL1 record format is initially displayed.

17 HELP allows the user to press the Help key and sets indicator 99 on.

18 SFLMSG identifies the constant as a message that is displayed if indicator 99 is on.

In addition to the control information, the subfile control record format defines the constants to be used as column headings for the subfile record format. Refer to Figure 141 on page 528 for an example of the subfile control record format.

Accessing Single Device Files and Multiple Device Files

A **single device file** is a device file created with only one program device defined for it. Printer files, diskette files and tape files are single device files. Display files and Intersystem Communication Function (ICF) files created with a maximum number of one program device are also single device files.

A **multiple device file** is either a display file or an Intersystem Communications Function (ICF) file. A multiple device file can acquire more than one program device. For an example of the use of multiple device files, see Figure 145 on page 534.

A display file can have multiple program devices when the MAXDEV parameter of the CRTDSPF command is greater than 1. If you specify *NONE for the DEV parameter of this command, you must supply the name of a display device *before* you use any fields that are related to the file.

For more information about how to create and use a display file, refer to the *Database and File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

ICF files can have multiple program devices when the MAXPGMDEV parameter of the CRTICFF command is greater than 1. For more information about how to create and use ICF files, see the *ICF Programming*.

ILE COBOL determines at run time whether a file is a single device file or a multiple device file, based on whether the file is *capable* of having multiple devices. The actual number of devices acquired does not affect whether a file is considered a single or multiple device file. Whether a file is a single or a multiple device file is *not* determined at compilation time; this determination is based on the current description of the display or ICF file.

For multiple device files, if a particular program device is to be used in an I/O statement, that device is specified by the TERMINAL phrase. The TERMINAL phrase can also be specified for a single device file.

The following pages contain an example illustrating the use of multiple device files. The program uses a display file, and is intended to be run in batch mode. The program acquires terminals and invites those terminals using a sign-on display. After the terminals are invited, they are polled. If nobody signs on before the wait time expires, the program ends. If you enter a valid password, you are allowed to update an employee file by calling another ILE COBOL program. Once the update is complete, the device is invited again and the terminals are polled again.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A*            THIS IS THE MULTIPLE DEVICE DISPLAY FILE
     A*
     A*                  DDS FOR THE MIXED FILE MULT
     A*
     A
     A          R SIGNON                    INVITE 1
     A                                 O  5 20'                    '
     A                                      DSPATR(RI)
     A                                 O  6 20'  '
     A                                      DSPATR(RI)
     A                                 O  6 38'  '
     A                                      DSPATR(RI)
     A                                 O  7 20'  '
     A                                      DSPATR(RI)
     A                                 O  7 27'M D F'
     A                                      DSPATR(HI BL)
     A                                 O  7 38'  '
     A                                      DSPATR(RI)
     A                                 O  9 20'                    '
     A                                      DSPATR(RI)
     A                                 O 20 20'PLEASE LOGON'
     A                                      DSPATR(HI)
     A            PASSWORD      10A  I 20 43DSPATR(PC ND)
     A            WRONG         20A  O 21 43
     A
     A          R UPDATE
     A                                 O  3  5'UPDATE OF PERSONNEL FILE'
     A                                       DSPATR(BL)
     A                                 O  7  5'TYPE IN EMPLOYEE NUMBER TO BE +
     A                                        UPDATED'
     A            NUM            7A  I  7 44DSPATR(RI PC)
     A
     A          R EMPLOYEE
     A                                 O  3  5'EMPLOYEE NUMBER'
     A            NUM            7A  B  3 25DSPATR(PC)
     A                                 O  5  5'EMPLOYEE NAME'
     A            NAME          30A  B  5 25DSPATR(PC)
     A                                 O  7  5'EMPLOYEE ADDRESS'
     A                                 O  9  5'STREET'
     A            STREET        30A  B  9 25DSPATR(PC)
     A                                 O 11  5'APARTMENT NUMBER'
     A            APTNO          5A  B 11 25DSPATR(PC)
     A                                 O 13  5'CITY'
     A            CITY          20A  B 13 25DSPATR(PC)
     A                                 O 15  5'PROVINCE'
     A            PROV          20A  B 15 25DSPATR(PC)
     A
     A          R RECOVERY
     A                                 O  3  5'THE EMPLOYEE NUMBER YOU HAVE GIVEN
     A                                        IS INVALID'
     A                                 O  6  5'TYPE Y TO RETRY'
     A                                 O  8  5'TYPE N TO EXIT'
     A            ANSWER         1X  I 10  5DSPATR(RI PC)
     A                                       VALUES('Y' 'N')
```

*Figure 142. Example of the Use of Multiple Device Files ** Display File*

1 The format SIGNON has the keyword INVITE associated with it. This means that, if format SIGNON is used in a WRITE statement, the device to which it is writing will be invited.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A** DDS FOR THE PHYSICAL FILE PASSWORD
     A*
     A*
     A                                     UNIQUE
     A          R PASSWORDS
     A            PASSKEY       10
     A            PASSWORD      10
     A          K PASSKEY
     A
```

*Figure 143. Example of the Use of Multiple Device Files ** Physical File PASSWORD*

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A*  DDS FOR THE PHYSICAL FILE TERM
     A*  WHICH CONTAINS THE LIST OF TERMINALS
     A*
     A
     A          R TERM
     A            TERM          10
```

*Figure 144. Example of the Use of Multiple Device Files ** Physical File TERM*

```
5722WDS V5R3M0 030905 LN  IBM ILE COBOL               CBLGUIDE/SAMPMDF         ISERIES1   00208/15 15:04:02        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     SAMPMDF.
          000300
          000400*************************************************************
          000500*  THE FOLLOWING PROGRAM DEMONSTRATES SOME OF THE FUNCTIONS  *
          000600*  AVAILABLE WITH MULTIPLE DEVICE FILE SUPPORT.              *
          000700*************************************************************
          000800
    3     000900 ENVIRONMENT DIVISION.
    4     001000 CONFIGURATION SECTION.
    5     001100 SOURCE-COMPUTER. IBM-ISERIES
    6     001200 OBJECT-COMPUTER. IBM-ISERIES
    7     001300 SPECIAL-NAMES.  ATTRIBUTE-DATA IS ATTR.  1
    9     001400 INPUT-OUTPUT SECTION.
   10     001500 FILE-CONTROL.
   11     001600     SELECT MULTIPLE-FILE
   12     001700            ASSIGN TO WORKSTATION-MULT
   13     001800            ORGANIZATION IS TRANSACTION  2
   14     001900            ACCESS MODE IS SEQUENTIAL
   15     002000            FILE STATUS IS MULTIPLE-FS1, MULTIPLE-FS2  3
   16     002100            CONTROL-AREA IS MULTIPLE-CONTROL-AREA.  4
          002200
   17     002300     SELECT TERMINAL-FILE
   18     002400            ASSIGN TO DATABASE-TERM
   19     002500            ORGANIZATION IS SEQUENTIAL
   20     002600            ACCESS IS SEQUENTIAL
   21     002700            FILE STATUS IS TERMINAL-FS1.
          002800
   22     002900     SELECT PASSWORD-FILE
   23     003000            ASSIGN TO DATABASE-PASSWORD
   24     003100            ORGANIZATION IS INDEXED
   25     003200            RECORD KEY IS EXTERNALLY-DESCRIBED-KEY
   26     003300            ACCESS MODE IS RANDOM
   27     003400            FILE STATUS IS PASSWORD-FS1.
          003500
   28     003600     SELECT PRINTER-FILE
   29     003700            ASSIGN TO PRINTER-QPRINT.
          003800
   30     003900 DATA DIVISION.
   31     004000 FILE SECTION.
   32     004100 FD  MULTIPLE-FILE.
   33     004200 01  MULTIPLE-REC.
          004200                COPY DDS-SIGNON OF MULT.  5
   34    +000001       05  MULT-RECORD PIC X(20).                                  SIGNON
         +000002*  INPUT FORMAT:SIGNON     FROM FILE MULT       OF LIBRARY CBLGUIDE  SIGNON
         +000003*                                                                  SIGNON
   35    +000004       05  SIGNON-I      REDEFINES MULT-RECORD.                   SIGNON
   36    +000005           06 PASSWORD              PIC X(10).  6                 SIGNON
         +000006* OUTPUT FORMAT:SIGNON     FROM FILE MULT       OF LIBRARY CBLGUIDE  SIGNON
         +000007*                                                                  SIGNON
   37    +000008       05  SIGNON-O      REDEFINES MULT-RECORD.                   SIGNON
   38    +000009           06 WRONG                 PIC X(20).                    SIGNON
          004300
```

Figure 145. ILE COBOL Source Listing for Multiple Device File Support (Part 1 of 5)

```
5722WDS V5R3M0 030905 LN  IBM ILE COBOL             CBLGUIDE/SAMPMDF         ISERIES1   00208/15 15:04:02        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   39     004400 FD  TERMINAL-FILE.
   40     004500 01  TERMINAL-REC.
          004500                  COPY DDS-ALL-FORMATS OF TERM.
   41    +000001       05  TERM-RECORD PIC X(10).                                          <-ALL-FMTS
         +000002*    I-O FORMAT:TERM       FROM FILE TERM       OF LIBRARY CBLGUIDE       <-ALL-FMTS
         +000003*                                                                         <-ALL-FMTS
   42    +000004       05  TERM          REDEFINES TERM-RECORD.                          <-ALL-FMTS
   43    +000005           06 TERM                 PIC X(10).                           <-ALL-FMTS
          004600
   44     004700 FD  PASSWORD-FILE.
   45     004800 01  PASSWORD-REC.
          004800                  COPY DDS-ALL-FORMATS OF PASSWORD.
   46    +000001       05  PASSWORD-RECORD PIC X(20).                                      <-ALL-FMTS
         +000002*    I-O FORMAT:PASSWORDS  FROM FILE PASSWORD   OF LIBRARY CBLGUIDE       <-ALL-FMTS
         +000003*                                                                         <-ALL-FMTS
         +000004*THE KEY DEFINITIONS FOR RECORD FORMAT  PASSWORDS                        <-ALL-FMTS
         +000005*  NUMBER              NAME               RETRIEVAL       ALTSEQ       <-ALL-FMTS
         +000006*   0001   PASSKEY                        ASCENDING         NO          <-ALL-FMTS
   47    +000007       05  PASSWORDS     REDEFINES PASSWORD-RECORD.                      <-ALL-FMTS
   48    +000008           06 PASSKEY              PIC X(10).                           <-ALL-FMTS
   49    +000009           06 PASSWORD             PIC X(10).                           <-ALL-FMTS
          004900
   50     005000 FD  PRINTER-FILE.
   51     005100 01  PRINTER-REC.
   52     005200    05 PRINTER-RECORD        PIC X(132).
          005300
   53     005400 WORKING-STORAGE SECTION.
          005500
          005600*****************************************************************
          005700*       DECLARE THE FILE STATUS FOR EACH FILE                   *
          005800*****************************************************************
          005900
   54     006000 01  MULTIPLE-FS1           PIC X(2)    VALUE SPACES.
   55     006100 01  MULTIPLE-FS2.  7
   56     006200    05  MULTIPLE-MAJOR       PIC X(2)    VALUE SPACES.
   57     006300    05  MULTIPLE-MINOR       PIC X(2)    VALUE SPACES.
   58     006400 01  TERMINAL-FS1           PIC X(2)    VALUE SPACES.
   59     006500 01  PASSWORD-FS1           PIC X(2)    VALUE SPACES.
          006600
          006700*****************************************************************
          006800*       DECLARE STRUCTURE FOR HOLDING FILE ATTRIBUTES           *
          006900*****************************************************************
          007000
   60     007100 01  STATION-ATTR.
   61     007200    05 STATION-TYPE          PIC X(1).  8
   62     007300    05 STATION-SIZE          PIC X(1).
   63     007400    05 STATION-LOC           PIC X(1).
   64     007500    05 FILLER                PIC X(1).
   65     007600    05 STATION-ACQUIRE       PIC X(1).
   66     007700    05 STATION-INVITE        PIC X(1).
   67     007800    05 STATION-DATA          PIC X(1).
   68     007900    05 STATION-STATUS        PIC X(1).
   69     008000    05 STATION-DISPLAY       PIC X(1).
   70     008100    05 STATION-KEYBOARD      PIC X(1).
   71     008200    05 STATION-SIGNON        PIC X(1).
```

Figure 145. ILE COBOL Source Listing for Multiple Device File Support (Part 2 of 5)

```
5722WDS V5R3M0 030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPMDF         ISERIES1   00208/15 15:04:02        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   72     008300    05 FILLER               PIC X(5).
          008400
          008500*************************************************************
          008600*       DECLARE THE CONTROL AREA FOR MULTIPLE-FILE           *
          008700*************************************************************
          008800
   73     008900 01  MULTIPLE-CONTROL-AREA.
   74     009000    05 MULTIPLE-KEY-FEEDBACK PIC X(2)    VALUE SPACES.
   75     009100    05 MULTIPLE-DEVICE-NAME  PIC X(10)   VALUE SPACES.
   76     009200    05 MULTIPLE-FORMAT-NAME  PIC X(10)   VALUE SPACES.
          009300
          009400*************************************************************
          009500*               DECLARE ERROR REPORT VARIABLES              *
          009600*************************************************************
          009700
   77     009800 01  HEADER-LINE.
   78     009900    05 FILLER                PIC X(60)   VALUE SPACES.
   79     010000    05 FILLER                PIC X(72)
          010100                             VALUE "MDF ERROR REPORT".
   80     010200 01  DETAIL-LINE.
   81     010300    05 FILLER                PIC X(15)   VALUE SPACES.
   82     010400    05 DESCRIPTION           PIC X(25)   VALUE SPACES.
   83     010500    05 DETAIL-VALUE          PIC X(92)   VALUE SPACES.
          010600
          010700*************************************************************
          010800*        DECLARE COUNTERS, FLAGS AND STORAGE VARIABLES       *
          010900*************************************************************
          011000
   84     011100 01  CURRENT-TERMINAL        PIC X(10)   VALUE SPACES.
   85     011200 01  TERMINAL-ARRAY.
   86     011300    05 LIST-OF-TERMINALS OCCURS 250 TIMES.
   87     011400      07 DEVICE-NAME         PIC X(10).
   88     011500 01  COUNTER                 PIC 9(3)    VALUE IS 1.
   89     011600 01  NO-OF-TERMINALS         PIC 9(3)    VALUE IS 1.
   90     011700 01  TERMINAL-LIST-FLAG      PIC 1.
   91     011800    88 END-OF-TERMINAL-LIST              VALUE IS B"1".
   92     011900    88 NOT-END-OF-TERMINAL-LIST          VALUE IS B"0".
   93     012000 01  NO-DATA-FLAG            PIC 1.
   94     012100    88 NO-DATA-AVAILABLE                 VALUE IS B"1".
   95     012200    88 DATA-AVAILABLE                    VALUE IS B"0".
          012300
   96     012400 PROCEDURE DIVISION.
          012500
   97     012600 DECLARATIVES.
          012700
          012800 MULTIPLE-SECTION SECTION.
          012900     USE AFTER STANDARD EXCEPTION PROCEDURE ON MULTIPLE-FILE.
          013000
          013100 MULTIPLE-PARAGRAPH.
   98     013200     WRITE PRINTER-REC FROM HEADER-LINE AFTER ADVANCING PAGE.
   99     013300     MOVE "FILE NAME IS:" TO DESCRIPTION OF DETAIL-LINE.
  100     013400     MOVE "MULTIPLE FILE" TO DETAIL-VALUE OF DETAIL-LINE.
  101     013500     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 5 LINES.
  102     013600     MOVE "FILE STATUS IS:" TO DESCRIPTION OF DETAIL-LINE.
  103     013700     MOVE MULTIPLE-FS1 TO DETAIL-VALUE OF DETAIL-LINE.
```

Figure 145. ILE COBOL Source Listing for Multiple Device File Support (Part 3 of 5)

```
5722WDS V5R3M0 030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPMDF        ISERIES1   00208/15 15:04:02        Page      5
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  104     013800     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
  105     013900     MOVE "EXTENDED STATUS IS:" TO DESCRIPTION OF DETAIL-LINE.  9
  106     014000     MOVE MULTIPLE-FS2 TO DETAIL-VALUE OF DETAIL-LINE.
  107     014100     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
  108     014200     ACCEPT STATION-ATTR FROM ATTR.  10
  109     014300     MOVE "FILE ATTRIBUTES ARE:" TO DESCRIPTION OF DETAIL-LINE.
  110     014400     MOVE STATION-ATTR TO DETAIL-VALUE OF DETAIL-LINE.
  111     014500     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
  112     014600     STOP RUN.
          014700
          014800 TERMINAL-SECTION SECTION.
          014900     USE AFTER STANDARD EXCEPTION PROCEDURE ON TERMINAL-FILE.
          015000 TERMINAL-PARAGRAPH.
  113     015100     WRITE PRINTER-REC FROM HEADER-LINE AFTER ADVANCING PAGE.
  114     015200     MOVE "FILE NAME IS:" TO DESCRIPTION OF DETAIL-LINE.
  115     015300     MOVE "TERMINAL FILE" TO DETAIL-VALUE OF DETAIL-LINE.
  116     015400     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 5 LINES.
  117     015500     MOVE "FILE STATUS IS:" TO DESCRIPTION OF DETAIL-LINE.
  118     015600     MOVE TERMINAL-FS1 TO DETAIL-VALUE OF DETAIL-LINE.
  119     015700     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
  120     015800     STOP RUN.
          015900
          016000 PASSWORD-SECTION SECTION.
          016100     USE AFTER STANDARD EXCEPTION PROCEDURE ON PASSWORD-FILE.
          016200 PASSWORD-PARAGRAPH.
  121     016300     WRITE PRINTER-REC FROM HEADER-LINE AFTER ADVANCING PAGE.
  122     016400     MOVE "FILE NAME IS:" TO DESCRIPTION OF DETAIL-LINE.
  123     016500     MOVE "PASSWORD FILE" TO DETAIL-VALUE OF DETAIL-LINE.
  124     016600     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 5 LINES.
  125     016700     MOVE "FILE STATUS IS:" TO DESCRIPTION OF DETAIL-LINE.
  126     016800     MOVE PASSWORD-FS1 TO DETAIL-VALUE OF DETAIL-LINE.
  127     016900     WRITE PRINTER-REC FROM DETAIL-LINE AFTER ADVANCING 2 LINES.
  128     017000     STOP RUN.
          017100
          017200 END DECLARATIVES.
          017300
          017400*****************************************************************
          017500*        MAIN PROGRAM LOGIC BEGINS HERE                         *
          017600*****************************************************************
          017700
          017800 MAIN-PROGRAM SECTION.
          017900 MAINLINE.
  129     018000     OPEN I-O    MULTIPLE-FILE  11
          018100          INPUT  TERMINAL-FILE
          018200          I-O    PASSWORD-FILE
          018300          OUTPUT PRINTER-FILE.
          018400
  130     018500       MOVE 1 TO COUNTER.
  131     018600       SET NOT-END-OF-TERMINAL-LIST TO TRUE.
          018700******
          018800*      Fill Terminal List
          018900******
  132     019000       PERFORM UNTIL END-OF-TERMINAL-LIST
  133     019100          READ TERMINAL-FILE RECORD
          019200             INTO LIST-OF-TERMINALS(COUNTER)
```

Figure 145. ILE COBOL Source Listing for Multiple Device File Support (Part 4 of 5)

```
5722WDS V5R3M0 030905 LN  IBM ILE COBOL                CBLGUIDE/SAMPMDF         ISERIES1   00208/15 15:04:02        Page      6
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         019300             AT END
  134    019400                SET END-OF-TERMINAL-LIST TO TRUE
  135    019500                SUBTRACT 1 FROM COUNTER
  136    019600                MOVE COUNTER TO NO-OF-TERMINALS
         019700          END-READ
  137    019800          ADD 1 TO COUNTER
         019900       END-PERFORM.
         020000******
         020100*      Acquire and invite terminals
         020200******
  138    020300       PERFORM VARYING COUNTER FROM 1 BY 1
         020400               UNTIL COUNTER GREATER THAN NO-OF-TERMINALS
  139    020500          ACQUIRE LIST-OF-TERMINALS(COUNTER) FOR MULTIPLE-FILE  12
  140    020600          WRITE MULTIPLE-REC  13
         020700             FORMAT IS "SIGNON"
         020800             TERMINAL IS LIST-OF-TERMINALS(COUNTER)
         020900          END-WRITE
         021000       END-PERFORM.
         021100
  141    021200       MOVE 1 TO COUNTER.
  142    021300       SET DATA-AVAILABLE TO TRUE.
         021400******
         021500*      Poll terminals
         021600******
  143    021700       PERFORM UNTIL NO-DATA-AVAILABLE
  144    021800          READ MULTIPLE-FILE RECORD  14
  145    021900          IF MULTIPLE-FS2 EQUAL "310" THEN
  146    022000             SET NO-DATA-AVAILABLE TO TRUE  15
         022100          END-IF
  147    022200          IF DATA-AVAILABLE THEN
  148    022300             MOVE MULTIPLE-DEVICE-NAME TO CURRENT-TERMINAL
         022400******
         022500*            Validate Password  16
         022600******
  149    022700             MOVE CURRENT-TERMINAL TO PASSKEY OF PASSWORD-REC
  150    022800             READ PASSWORD-FILE RECORD
  151    022900             IF PASSWORD OF SIGNON-I EQUAL
         023000                PASSWORD OF PASSWORD-REC THEN
  152    023100                   CALL "UPDT" USING CURRENT-TERMINAL
  153    023200                   MOVE SPACES TO WRONG OF SIGNON-O
         023300             ELSE
  154    023400                   MOVE "INVALID PASSWORD" TO WRONG OF SIGNON-O
         023500             END-IF
  155    023600             WRITE MULTIPLE-REC
         023700                FORMAT IS "SIGNON"
         023800                TERMINAL IS CURRENT-TERMINAL
         023900             END-WRITE
         024000          END-IF
         024100       END-PERFORM.
         024200******
         024300*      Drop terminals
         024400******
  156    024500       PERFORM VARYING COUNTER FROM 1 BY 1
         024600               UNTIL COUNTER GREATER THAN NO-OF-TERMINALS
  157    024700          DROP LIST-OF-TERMINALS(COUNTER) FROM MULTIPLE-FILE  17
         024800       END-PERFORM.
         024900
  158    025000       CLOSE   MULTIPLE-FILE
         025100               TERMINAL-FILE
         025200               PASSWORD-FILE
         025300               PRINTER-FILE.
  159    025400       STOP RUN.
         025500
                        * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 145. ILE COBOL Source Listing for Multiple Device File Support (Part 5 of 5)

1 ATTR is the mnemonic-name associated with the function-name ATTRIBUTE-DATA. ATTR is used in the ACCEPT statement to obtain attribute data for the TRANSACTION file MULTIPLE-FILE. See item **10** .

2 File MULT must have been created using the CRTDSPF command, where the DEV parameter has a value of *NONE and the MAXDEV parameter has a value greater than 1. The WAITRCD parameter specifies the wait time for READ operations on the file. The WAITRCD parameter must have a value greater than 0.

3 MULTIPLE-FS2 is the extended file status for the TRANSACTION file MULTIPLE-FILE. This variable has been declared in the WORKING-STORAGE section of the program. See item 7 .

4 MULTIPLE-CONTROL-AREA is the control area for the TRANSACTION file MULTIPLE-FILE. This variable is used to determine which program device was used to sign on. See item 15 .

5 The data description for MULTIPLE-REC has been defined using the COPY DDS statement.

Note: Only the fields that are copied are named fields. Refer to the DDS of this example for comments regarding the DDS used.

6 Format SIGNON is the format with the INVITE keyword. This is the format that will be used to invite devices via the WRITE statement.

7 This is the declaration for the extended file-status MULTIPLE-FS2. It is a 4-byte field that is subdivided into a major return code (first 2 bytes) and a minor return code (last 2 bytes).

8 STATION-ATTR is where the ACCEPT statement stores the attribute data for the TRANSACTION file MULTIPLE-FILE. See item 10 .

9 In this statement, the extended file status MULTIPLE-FS2 is being written.

10 This statement accepts attribute data for the TRANSACTION file MULTIPLE-FILE. Since the FOR phrase is not specified with the ACCEPT statement, the last program device is used.

11 This statement opens the TRANSACTION file MULTIPLE-FILE. Because the ACQPGMDEV parameter of the CRTDSPF command has the value *NONE, no program devices are implicitly acquired when this file is opened.

12 This statement acquires the program device contained in the variable LIST-OF-TERMINALS (COUNTER), for the TRANSACTION file MULTIPLE-FILE.

13 This WRITE statement is inviting the program device specified in the TERMINAL phrase. The format SIGNON has the DDS keyword INVITE associated with it. Refer to item 14 .

14 This READ statement will read from any invited program device. See item 13 . If the wait time expires before anyone inputs to the invited devices, the extended file status will be set to “0310” and processing will continue. See item 15 .

15 In this statement, the extended file status for MULTIPLE-FILE is being checked to see if the wait time expired.

16 The program device name stored in the control area is used to determine which program device was used to sign on. See item 4 .

17 This DROP statement detaches the program device contained in the variable LIST-OF-TERMINALS from the TRANSACTION file MULTIPLE-FILE.

Writing Programs That Use Subfile Transaction Files

Typically, you use a subfile TRANSACTION file to read a group of records from or write a group of record to a display device. To use a subfile TRANSACTION file in an ILE COBOL program, you must:

- Name the file through a file control entry in the FILE-CONTROL paragraph of the Environment Division
- Describe the file through a file description entry in the Data Division
- Use extensions to Procedure Division statements that support transaction processing.

Naming a Subfile Transaction File

To use a subfile TRANSACTION file in your ILE COBOL program, you must name the file through a file control entry in the FILE-CONTROL paragraph. See the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the FILE-CONTROL paragraph.

You name the TRANSACTION file in the FILE-CONTROL paragraph as follows:

```
FILE-CONTROL.
    SELECT transaction-file-name
        ASSIGN TO WORKSTATION-display_file_name
        ORGANIZATION IS TRANSACTION
        ACCESS MODE IS DYNAMIC
               RELATIVE KEY IS relative-key-data-item
        CONTROL AREA IS control-area-data-item.
```

You use the SELECT clause to choose a file. This file must be identified by a FD entry in the Data Division.

You use the ASSIGN clause to associate the TRANSACTION file with a display file. You must specify a device type of WORKSTATION in the ASSIGN clause to use TRANSACTION files. If you want to use a separate indicator area for this TRANSACTION file, you need to include the -SI attribute with the ASSIGN clause. See "Using Indicators with Transaction Files" on page 512 for further details of how to use the separate indicator area.

You must specify ORGANIZATION IS TRANSACTION in the file control entry in order to use a TRANSACTION file. This clause tells your ILE COBOL program that it will be interacting with a workstation user or another system.

You access a subfile TRANSACTION file dynamically. Dynamic access allows you to read or write records to the file sequentially or randomly, depending on the form of the specific input-output request. Subfiles are the only TRANSACTION files that can be accessed randomly. You use the ACCESS MODE clause in the file control entry to tell your ILE COBOL program how to access the TRANSACTION file. You must specify ACCESS MODE IS DYNAMIC to read or write to the subfile TRANSACTION file.

When using subfiles, you must provide a relative key. Use the RELATIVE KEY clause to identify the relative key data item. The relative key data item specifies the relative record number for a specific record in a subfile.

If you want feedback on the status of an input/output request that refers to a TRANSACTION file, you define a status key data item in the file control entry using the FILE STATUS clause. When you specify the FILE STATUS clause, the system moves a value into the status key data item after each input-output request that explicitly or implicitly refers to the TRANSACTION file. The value indicates the status of the execution of the I-O statement.

You can obtain specific device-dependent and system dependent information that is used to control input-output operations for TRANSACTION files by identifying

a control area data item using the CONTROL-AREA clause. You can define the data item specified by the CONTROL-AREA clause in the LINKAGE SECTION or WORKING-STORAGE SECTION with the following format:

```
01  control-area-data-item.
    05  function-key          PIC X(2).
    05  device-name           PIC X(10).
    05  record-format         PIC X(10).
```

The control area can be 2, 12, or 22 bytes long. Thus, you can specify only the first 05-level element, the first two 05-level elements, or all three 05-level elements, depending of the type of information you are looking for.

The control area data item will allow you to identify:

- The function key that the operator pressed to initiate a transaction
- The name of the program device used
- The name of the DDS record format that was referenced by the last I-O statement.

Describing a Subfile Transaction File

To use a TRANSACTION file in your ILE COBOL program, you must describe the file through a file description entry in the Data Division. See the *WebSphere Development Studio: ILE COBOL Reference* for a full description of the File Description Entry. Use the Format 6 File Description Entry to describe a TRANSACTION file.

A file description entry in the Data Division that describes a TRANSACTION file looks as follows:

```
FD  CUST-DISPLAY.
01  DISP-REC.
    COPY DDS-ALL-FORMATS OF CUSMINQ.
```

In ILE COBOL, TRANSACTION files are usually externally described. Create a DDS for the TRANSACTION file you want to use. Refer to “Defining Transaction Files Using Data Description Specifications” on page 497 for how to create a DDS. Then create the TRANSACTION file.

Once you have created the DDS for the TRANSACTION file and the TRANSACTION file, use the Format 2 COPY statement to describe the layout of the TRANSACTION file data record. When you compile your ILE COBOL program, the Format 2 COPY will create the Data Division statements to describe the TRANSACTION file. Use the DDS-ALL-FORMATS option of the Format 2 COPY statement to generate one storage area for all formats.

Processing a Subfile Transaction File

The following is a list of all of the Procedure Division statements that have extensions specifically for processing TRANSACTION files in an ILE COBOL program. See the *WebSphere Development Studio: ILE COBOL Reference* for a detailed discussion of each of these statements.

- ACCEPT Statement - Format 6
- ACQUIRE Statement
- CLOSE Statement - Format 1
- DROP Statement
- OPEN Statement - Format 3
- READ Statement - Format 5 (Subfile)
- REWRITE Statement - Format 2 (Subfile)

- WRITE Statement - Format 5 (Subfile).

Opening a Subfile Transaction File

To process a TRANSACTION file in the Procedure Division, you must first open the file. You use the Format 3 OPEN statement to open a TRANSACTION file. A TRANSACTION file must be opened in I-O mode.

```
OPEN I-O file-name.
```

Acquiring Program Devices

You must acquire a program device for the TRANSACTION file. Once acquired, the program device is available for input and output operations. You can acquire a program device implicitly or explicitly.

You implicitly acquire one program device when you open the TRANSACTION file. If the file is a display file, the single implicitly acquired program device is determined by the first entry in the DEV parameter of the CRTDSPF command. Additional program devices must be explicitly acquired.

You explicitly acquire a program device by using the ACQUIRE statement. For display files, the device named in the ACQUIRE statement does not have to be specified in the DEV parameter of the CRTDSPF command, CHGDSPF command, or the OVRDSPF command. However, when you create the display file, you must specify the number of devices that may be acquired (the default is one). For a display file, the program device name must match the display device.

```
ACQUIRE program-device-name FOR transaction-file-name.
```

Writing to a Subfile Transaction File

Once you have opened the TRANSACTION file and acquired a program device for it, you are now ready to perform input and output operations on it.

The first input/output operation you typically perform on a TRANSACTION file is to write a record to the display. This record is used to prompt the user to enter a response or some data.

You use the Format 5 WRITE statement to write a logical record to the subfile TRANSACTION file. You simply code the WRITE statement as follows:

```
WRITE SUBFILE record-name FORMAT IS format-name.
```

In some situations, you may have multiple data records, each with a different format, that you want active for a TRANSACTION file. In this case, you must use the FORMAT phrase of the Format 5 WRITE statement to specify the format of the output data record you want to write to the TRANSACTION file.

If you have explicitly acquired multiple program devices for the TRANSACTION file, you must use the TERMINAL phrase of the Format 5 WRITE statement to specify the program device's subfile to which you want the output record to be sent.

```
WRITE SUBFILE record-name
      FORMAT IS format-name
      TERMINAL IS program-device-name
END-WRITE.
```

Before or after filling the subfile TRANSACTION file with records using the Format 5 WRITE statement, you can write the subfile control record to the program device using the Format 4 WRITE statement. Refer to "Writing to a Transaction File" on page 503 for a description of how to use the Format 4 WRITE statement to write to a TRANSACTION file. Writing the subfile control record

could cause the display of either the subfile control record, the subfile records, or both the subfile control record and subfile records.

Reading from a Subfile Transaction File

You use the Format 4 READ statement to read a subfile control record. Refer to "Reading from a Transaction File" on page 503 for a description of how to use the Format 4 READ statement to read to a TRANSACTION file. Reading the subfile control record physically transfers records from the program device so that they can be made available to the subfile.

Once the records are available to the subfile, you use the Format 5 READ statement to read a specified record from the subfile TRANSACTION file. The Format 5 READ statement can only be used to read a format that is a subfile record; it cannot be used for communications devices.

Before you use the READ statement, you must have acquired at least one program device for the TRANSACTION file. If a READ statement is performed and there are no acquired program devices, a logic error is reported by setting the file status to 92.

You can read a subfile sequentially or randomly.

To read a subfile sequentially, you must specify the NEXT MODIFIED phrase in the Format 5 READ statement. When the NEXT MODIFIED phrase is specified, the record made available is the first record in the subfile that has been modified. For information about how a subfile record is marked as being modified, refer to the *Database anf File Systems* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

If there are no next modified subfile records available, the AT END condition exists, the file status is set to 12, and the value of the RELATIVE KEY data item is set to the key of the last record in the subfile.

When reading a subfile sequentially, you should also specify the AT END phrase in the Format 5 READ statement. The AT END phrase allows you to specify an imperative statement to be executed when the AT END condition arises.

```
READ SUBFILE subfile-name NEXT MODIFIED RECORD
     AT END imperative-statement
END-READ
```

To read a subfile randomly, you must specify, in the RELATIVE KEY data item, the relative record number of the subfile record you want to read and you must not specify the NEXT MODIFIED phrase in the Format 5 READ statement. When the NEXT MODIFIED phrase is not specified, the record made available is the record in the subfile with a relative key record number that corresponds to the value of the RELATIVE KEY data item. If the RELATIVE KEY data item, at the time that the READ statement is performed, contains a value that does not correspond to a relative record number for the subfile, the INVALID KEY condition exists.

When reading a subfile randomly, you should also specify the INVALID KEY phrase in the Format 5 READ statement. The INVALID KEY phrase allows you to specify an imperative statement to be executed when the INVALID KEY condition arises.

```
READ SUBFILE subfile-name RECORD
     INVALID KEY imperative-statement
END-READ
```

For a detailed explanation of how the READ operation is performed, refer to the section on the READ statement in the *WebSphere Development Studio: ILE COBOL Reference*.

In those cases where you have acquired multiple program devices, you can explicitly specify the program device from which you read data by identifying it in the TERMINAL phrase of the READ statement.

In those cases where you want to receive the data in a specific format, you can identify this format in the FORMAT phrase of the READ statement. If the data available does not match the requested record format, a file status of 9K is set.

The following are examples of the READ statement with the TERMINAL and FORMAT phrases specified.

```
READ SUBFILE subfile-name RECORD
     FORMAT IS record-format
END-READ
READ SUBFILE subfile-name RECORD
     TERMINAL IS program-device-name
END-READ
READ SUBFILE subfile-name RECORD
     FORMAT IS record-format
     TERMINAL IS program-device-name
END-READ
```

Replacing (Rewriting) a Subfile Record

Once you have read and modified a subfile record, you can replace it in the subfile using the REWRITE statement.

```
REWRITE SUBFILE record-name
        FORMAT IS record-format
        TERMINAL IS program-device-name
END-REWRITE
```

The record replaced in the subfile is the record in the subfile accessed by the previous successful READ operation.

Dropping Program Devices

Once you have finished using a program device that you had previously acquired for a TRANSACTION file, you should drop it. Dropping a program device means that it will no longer be available for input or output operations through the TRANSACTION file. Dropping a program device makes it available to other applications. You can drop a program device implicitly or explicitly.

You implicitly drop all program devices attached to a TRANSACTION file when you close the file.

You explicitly drop a program device by indicating it in the DROP statement. The device, once dropped, can be re-acquired again, if necessary.

```
DROP program-device-name FROM transaction-file-name.
```

Closing a Subfile Transaction File

When you have finished using a subfile TRANSACTION file, you must close it. Use the Format 1 CLOSE statement to close the TRANSACTION file. Once you close the file, it cannot be processed again until it is opened again.

```
CLOSE transaction-file-name.
```

Example of Using WRITE SUBFILE in an Order Inquiry Program

Figure 149 on page 549 shows an example of an order inquiry program, ORDINQ, that uses subfiles. The associated DDS is also shown, except for the DDS for the customer master file, CUSMSTP. Refer to Figure 132 on page 507 for the DDS for CUSMSTP.

ORDINQ displays all the detail order records for the requested order number. The program prompts you to enter the order number that is to be reviewed. The order number is checked against the order header file, ORDHDRP. If the order number exists, the customer number accessed from the order header file is checked against the customer master file, CUSMSTP. All detail order records in ORDDTLP for the requested order are read and written to the subfile. A write for the subfile control record format is processed, and the detail order records in the subfile are displayed for you to review. You end the program by pressing F12.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A** PHYSICAL ORDDTLP     ORDER DETAIL FILE
     A
     A                                      UNIQUE
     A*
     A          R ORDDTL                    TEXT('ORDER DETAIL RECORD')
     A*
     A            CUST           5          CHECK(MF)
     A                                      COLHDG('CUSTOMER' 'NUMBER')
     A*
     A            ORDERN         5  0       COLHDG('ORDER' 'NUMBER')
     A*
     A            LINNUM         3  0
     A                                      COLHDG('LINE' 'NO')
     A                                      TEXT('LINE NUMBER OF LINE IN ORDER'
     A                                      )
     A*
     A            ITEM           5  0       CHECK(M10)
     A                                      COLHDG('ITEM' 'NUMBER')
     A            QTYORD         3  0
     A                                      COLHDG('QUANTITY' 'ORDERED')
     A                                      TEXT('QUANTITY ORDERED')
     A*
     A            DESCRP        30          COLHDG('ITEM' 'DESCRIPTION')
     A*
     A            PRICE          6  2       CMP(GT 0)
     A                                      COLHDG('PRICE')
     A                                      TEXT('SELLING PRICE')
     A                                      EDTCDE(J)
     A            EXTENS         8  2       COLHDG('EXTENSION')
     A                                      TEXT('EXTENSION AMOUNT OF QTYORD X
     A                                      PRICE')
     A*
     A            WHSLOC         3          CHECK(MF)
     A                                      COLHDG('BIN' 'NO.')
     A*
     A            ORDDAT         6  0       TEXT('DATE ORDER WAS ENTERED')
     A*
     A            CUSTYP         1  0       RANGE(1 5)
     A                                      COLHDG('CUST' 'TYPE')
     A                                      TEXT('CUSTOMER TYPE 1=GOV 2=SCH   +
     A                                      3=BUS 4=PVT 5=OT')
     A*
     A            STATE          2          CHECK(MF)
     A                                      COLHDG('STATE')
     A*
     A            ACTMTH         2  0       COLHDG('ACCT' 'MTH')
     A                                      TEXT('ACCOUNTING MONTH OF SALE')
     A*
     A            ACTYR          2  0       COLHDG('ACCT' 'YEAR')
     A                                      TEXT('ACCOUNTING YEAR OF SALE')
     A
     A          K ORDERN
     A          K LINNUM
```

Figure 146. Data Description Specifications for an Order Inquiry Program - Order Detail File

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A*   ORDINQD            EXISTING ORDER REVIEW DISPLAY FILE
     A
     A*
     A          R SUB1                        SFL
     A            ITEM           5  0  10  2TEXT('ITEM NUMBER')
     A            QTYORD         3  0  10  9TEXT('QUANTITY ORDERED')
     A            DESCRP        30     10 14TEXT('ITEM DESCRIPTION')
     A            PRICE          6  2  10 46TEXT('SELLING PRICE')
     A            EXTENS         8  2  10 56EDTCDE(J)
     A                                      TEXT('EXTENSION AMOUNT OF QTYORD +
     A                                      X PRICE')
     A
     A          R SUBCTL1                     SFLCTL(SUB1)
     A  58                                    SFLCLR
     A  57                                    SFLDSP
     A N58                                    SFLDSPCTL
     A                                        SFLSIZ(57)
     A                                        SFLPAG(14)
     A  57                                    SFLEND
     A                                        OVERLAY
     A                                        LOCK
     A N45
     AON47                                    ROLLUP(97 'CONTINUE DISPLAY')
     A                                        CA12(98 'END OF PROGRAM')
     A                                        SETOFF(57 'DISPLAY SUBFILE')
     A                                        SETOFF(58 'OFF = DISPLAY SUBCTL1 O+
     A                                        N = CLEAR SUBFILE')
     A                                   1  2'EXISTING ORDER INQUIRY'
     A                                   3  2'ORDER'
     A            ORDERN         5Y 0B  3  8TEXT('ORDER NUMBER')
     A  61                                    ERRMSG('ORDER NUMBER NOT FOUND' 61)
     A  47                                    ERRMSG('NO LINE FOR THIS ORDER' 47)
     A  62                                    ERRMSG('NO CUSTOMER RECORD' 62)
     A                                   4  2'DATE'
     A            ORDDAT         6  0   4  7TEXT('DATE ORDER WAS ENTERED')
     A                                   5  2'CUST #'
     A            CUST           5      5  9TEXT('CUSTOMER NUMBER')
     A            NAME          25      3 16TEXT('CUSTOMER NAME')
     A            ADDR          20      4 16TEXT('CUSTOMER ADDRESS')
     A            CITY          20      5 16TEXT('CUSTOMER CITY')
     A            STATE          2      6 16TEXT('CUSTOMER STATE')
     A            ZIP            5  0   6 31TEXT('ZIP CODE')
     A                                   1 44'TOTAL'
     A            ORDAMT         8  2   1 51TEXT('TOTAL AMOUNT OF ORDER')
     A                                   2 44'STATUS'
     A            STSORD        12      2 51
     A                                   3 44'OPEN'
     A            STSOPN        12      3 51
     A                                   4 44'CUSTOMER ORDER'
     A            CUSORD        15      4 59TEXT('CUSTOMER PURCHASE ORDER +
     A                                      NUMBER')
     A                                   5 44'SHIP VIA'
     A            SHPVIA        15      5 59TEXT('SHIPPING INSTRUCTIONS')
     A                                   6 44'PRINTED DATE'
     A            PRTDAT         6  0   6 57TEXT('DATE ORDER WAS PRINTED')
     A                                   7 29'INVOICE'
```

Figure 147. Data Description Specifications for an Order Inquiry Program - Order Review File (Part 1 of 2)

```
     A            INVNUM         5  0   7 38TEXT('INVOICE NUMBER')
     A                                   7 64'MTH'
     A            ACTMTH         2  0   7 68TEXT('ACCOUNTING MONTH OF SALE')
     A                                   7 72'YEAR'
     A            ACTYR          2  0   7 77TEXT('ACCOUNTING YEAR OF SALE')
     A                                   8  2'ITEM'
     A                                   8  8'QTY'
     A                                   8 14'ITEM DESCRIPTION'
     A                                   8 46'PRICE'
     A                                   8 55'EXTENSION'
```

Figure 147. Data Description Specifications for an Order Inquiry Program - Order Review File (Part 2 of 2)

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A* THIS IS THE ORDER HEADER FILE ** ORDHDRP
     A
     A
     A                                     UNIQUE
     A          R ORDHDR                   TEXT('ORDER HEADER RECORD')
     A            CUST           5         TEXT('CUSTOMER NUMBER')
     A            ORDERN         5 00      TEXT('ORDER NUMBER')
     A            ORDDAT         6 00      TEXT('DATE ORDER ENTERED')
     A            CUSORD        15         TEXT('CUSTOMER PURCHASE ORDER +
     A                                     NUMBER')
     A            SHPVIA        15         TEXT('SHIPPING INSTRUCTIONS')
     A            ORDSTS         1 00      TEXT('ORDER SATAUS 1PCS 2CNT  + 3CHK 4RDY 5PRT 6PCK')
     A            OPRNAM        10         TEXT('OPERATOR WHO ENTERED ORD')
     A            ORDAMT         8 02      TEXT('DOLLAR AMOUNT OF ORDER')
     A            CUSTYP         1 00      TEXT('CUSTOMER TYPE 1=GOV 2=SCH +
     A                                     3=BUS 4=PVT 5=OT')
     A            INVNUM         5 00      TEXT('INVOICE NUMBER')
     A            PRTDAT         6 00      TEXT('DATE ORDER WAS PRINTED')
     A            OPNSTS         1 00      TEXT('ORDER OPEN STATUS 1=OPEN + 2= CLOSE 3=CANCEL')
     A            TOTLIN         3 00      TEXT('TOTAL LINE ITEMS IN ORDER')
     A            ACTMTH         2 00      TEXT('ACCOUNTING MONTH OF SALE')
     A            ACTYR          2 00      TEXT('ACCOUNTING YEAR OF SALE')
     A            STATE          2         TEXT('STATE')
     A            AMPAID         8 02      TEXT('AMOUNT PAID')
                K ORDERN
```

Figure 148. Data Description Specifications for an Order Inquiry Program - Order Header File

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page      2
                           S o u r c e
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     ORDINQ.
          000300*    SAMPLE ORDER INQUIRY PROGRAM
          000400
    3     000500 ENVIRONMENT DIVISION.
    4     000600 CONFIGURATION SECTION.
    5     000700 SOURCE-COMPUTER. IBM-ISERIES
    6     000800 OBJECT-COMPUTER. IBM-ISERIES
    7     000900 INPUT-OUTPUT SECTION.
    8     001000 FILE-CONTROL.
    9     001100     SELECT ORDER-HEADER-FILE
   10     001200         ASSIGN TO DATABASE-ORDHDRP
   11     001300         ORGANIZATION IS INDEXED
   12     001400         ACCESS MODE IS RANDOM
   13     001500         RECORD KEY IS ORDERN OF ORDER-HEADER-RECORD.
   14     001600     SELECT ORDER-DETAIL-FILE
   15     001700         ASSIGN TO DATABASE-ORDDTLP
   16     001800         ORGANIZATION IS INDEXED
   17     001900         ACCESS IS DYNAMIC
   18     002000         RECORD KEY IS ORDER-DETAIL-RECORD-KEY.
   19     002100     SELECT CUSTOMER-MASTER-FILE
   20     002200         ASSIGN TO DATABASE-CUSMSTP
   21     002300         ORGANIZATION IS INDEXED
   22     002400         ACCESS IS RANDOM
   23     002500         RECORD KEY IS CUST OF CUSTOMER-MASTER-RECORD.
   24     002600     SELECT EXISTING-ORDER-DISPLAY-FILE
   25     002700         ASSIGN TO WORKSTATION-ORDINQD
   26     002800         ORGANIZATION IS TRANSACTION
   27     002900         ACCESS IS DYNAMIC
   28     003000         RELATIVE KEY IS SUBFILE-RECORD-NUMBER
   29     003100         FILE STATUS IS STATUS-CODE-ONE.
          003200
   30     003300 DATA DIVISION.
   31     003400 FILE SECTION.
   32     003500 FD  ORDER-HEADER-FILE.
   33     003600 01  ORDER-HEADER-RECORD.
          003700     COPY DDS-ORDHDR OF ORDHDRP.
         +000001*    I-O FORMAT:ORDHDR     FROM FILE ORDHDRP    OF LIBRARY CBLGUIDE          ORDHDR
         +000002*                          ORDER HEADER RECORD                               ORDHDR
         +000003*          USER SUPPLIED KEY BY RECORD KEY CLAUSE                            ORDHDR
   34    +000004       05  ORDHDR.                                                          ORDHDR
   35    +000005           06 CUST                 PIC X(5).                               ORDHDR
         +000006*                 CUSTOMER NUMBER                                          ORDHDR
   36    +000007           06 ORDERN                PIC S9(5)         COMP-3.               ORDHDR
         +000008*                 ORDER NUMBER                                             ORDHDR
   37    +000009           06 ORDDAT                PIC S9(6)         COMP-3.               ORDHDR
         +000010*                 DATE ORDER ENTERED                                       ORDHDR
   38    +000011           06 CUSORD                PIC X(15).                              ORDHDR
         +000012*                 CUSTOMER PURCHASE ORDER NUMBER                           ORDHDR
   39    +000013           06 SHPVIA                PIC X(15).                              ORDHDR
         +000014*                 SHIPPING INSTRUCTIONS                                    ORDHDR
   40    +000015           06 ORDSTS                PIC S9(1)         COMP-3.               ORDHDR
         +000016*                 ORDER SATAUS 1PCS 2CNT  3CHK 4RDY 5PRT 6PCK              ORDHDR
```

Figure 149. Example of an Order Inquiry Program (Part 1 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
   41    +000017           06 OPRNAM                PIC X(10).                                ORDHDR
         +000018*                 OPERATOR WHO ENTERED ORD                                    ORDHDR
   42    +000019           06 ORDAMT                PIC S9(6)V9(2)    COMP-3.                 ORDHDR
         +000020*                 DOLLAR AMOUNT OF ORDER                                      ORDHDR
   43    +000021           06 CUSTYP                PIC S9(1)         COMP-3.                 ORDHDR
         +000022*                 CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT                  ORDHDR
   44    +000023           06 INVNUM                PIC S9(5)         COMP-3.                 ORDHDR
         +000024*                 INVOICE NUMBER                                              ORDHDR
   45    +000025           06 PRTDAT                PIC S9(6)         COMP-3.                 ORDHDR
         +000026*                 DATE ORDER WAS PRINTED                                      ORDHDR
   46    +000027           06 OPNSTS                PIC S9(1)         COMP-3.                 ORDHDR
         +000028*                 ORDER OPEN STATUS 1=OPEN 2= CLOSE 3=CANCEL                  ORDHDR
   47    +000029           06 TOTLIN                PIC S9(3)         COMP-3.                 ORDHDR
         +000030*                 TOTAL LINE ITEMS IN ORDER                                   ORDHDR
   48    +000031           06 ACTMTH                PIC S9(2)         COMP-3.                 ORDHDR
         +000032*                 ACCOUNTING MONTH OF SALE                                    ORDHDR
   49    +000033           06 ACTYR                 PIC S9(2)         COMP-3.                 ORDHDR
         +000034*                 ACCOUNTING YEAR OF SALE                                     ORDHDR
   50    +000035           06 STATE                 PIC X(2).                                 ORDHDR
         +000036*                 STATE                                                       ORDHDR
   51    +000037           06 AMPAID                PIC S9(6)V9(2)    COMP-3.                 ORDHDR
         +000038*                 AMOUNT PAID                                                 ORDHDR
          003800
   52     003900 FD  ORDER-DETAIL-FILE.
   53     004000 01  ORDER-DETAIL-RECORD.
          004100     COPY DDS-ORDDTL OF ORDDTLP.
         +000001*    I-O FORMAT:ORDDTL     FROM FILE ORDDTLP    OF LIBRARY CBLGUIDE          ORDDTL
         +000002*                          ORDER DETAIL RECORD                               ORDDTL
         +000003*          USER SUPPLIED KEY BY RECORD KEY CLAUSE                            ORDDTL
   54    +000004       05  ORDDTL.                                                           ORDDTL
   55    +000005           06 CUST                  PIC X(5).                                 ORDDTL
         +000006*                 CUSTOMER NUMBER                                             ORDDTL
   56    +000007           06 ORDERN                PIC S9(5)         COMP-3.                 ORDDTL
         +000008*                 ORDER NUMBER                                                ORDDTL
   57    +000009           06 LINNUM                PIC S9(3)         COMP-3.                 ORDDTL
         +000010*                 LINE NUMBER OF LINE IN ORDER                                ORDDTL
   58    +000011           06 ITEM                  PIC S9(5)         COMP-3.                 ORDDTL
         +000012*                 ITEM NUMBER                                                 ORDDTL
   59    +000013           06 QTYORD                PIC S9(3)         COMP-3.                 ORDDTL
         +000014*                 QUANTITY ORDERED                                            ORDDTL
   60    +000015           06 DESCRP                PIC X(30).                                ORDDTL
         +000016*                 ITEM DESCRIPTION                                            ORDDTL
   61    +000017           06 PRICE                 PIC S9(4)V9(2)    COMP-3.                 ORDDTL
         +000018*                 SELLING PRICE                                               ORDDTL
   62    +000019           06 EXTENS                PIC S9(6)V9(2)    COMP-3.                 ORDDTL
         +000020*                 EXTENSION AMOUNT OF QTYORD X PRICE                          ORDDTL
   63    +000021           06 WHSLOC                PIC X(3).                                 ORDDTL
         +000022*                 BIN NO.                                                     ORDDTL
   64    +000023           06 ORDDAT                PIC S9(6)         COMP-3.                 ORDDTL
         +000024*                 DATE ORDER WAS ENTERED                                      ORDDTL
   65    +000025           06 CUSTYP                PIC S9(1)         COMP-3.                 ORDDTL
         +000026*                 CUSTOMER TYPE 1=GOV 2=SCH   3=BUS 4=PVT 5=OT              ORDDTL
   66    +000027           06 STATE                 PIC X(2).                                 ORDDTL
         +000028*                 STATE                                                       ORDDTL
   67    +000029           06 ACTMTH                PIC S9(2)         COMP-3.                 ORDDTL
```

Figure 149. Example of an Order Inquiry Program (Part 2 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
       +000030*                ACCOUNTING MONTH OF SALE                                    ORDDTL
   68  +000031           06 ACTYR                PIC S9(2)         COMP-3.                ORDDTL
       +000032*                ACCOUNTING YEAR OF SALE                                     ORDDTL
   69   004200 66  ORDER-DETAIL-RECORD-KEY RENAMES ORDERN THRU LINNUM.
        004300
   70   004400 FD  CUSTOMER-MASTER-FILE.
   71   004500 01  CUSTOMER-MASTER-RECORD.
        004600     COPY DDS-CUSMST OF CUSMSTP.
       +000001*    I-O FORMAT:CUSMST     FROM FILE CUSMSTP    OF LIBRARY CBLGUIDE          CUSMST
       +000002*                          CUSTOMER MASTER RECORD                             CUSMST
       +000003*          USER SUPPLIED KEY BY RECORD KEY CLAUSE                             CUSMST
   72  +000004       05  CUSMST.                                                           CUSMST
   73  +000005           06 CUST                 PIC X(5).                                CUSMST
       +000006*                CUSTOMER NUMBER                                            CUSMST
   74  +000007           06 NAME                 PIC X(25).                               CUSMST
       +000008*                CUSTOMER NAME                                              CUSMST
   75  +000009           06 ADDR                 PIC X(20).                               CUSMST
       +000010*                CUSTOMER ADDRESS                                           CUSMST
   76  +000011           06 CITY                 PIC X(20).                               CUSMST
       +000012*                CUSTOMER CITY                                              CUSMST
   77  +000013           06 STATE                PIC X(2).                                CUSMST
       +000014*                STATE                                                      CUSMST
   78  +000015           06 ZIP                  PIC S9(5)         COMP-3.                CUSMST
       +000016*                ZIP CODE                                                   CUSMST
   79  +000017           06 SRHCOD               PIC X(6).                                CUSMST
       +000018*                CUSTOMER NUMBER SEARCH CODE                                CUSMST
   80  +000019           06 CUSTYP               PIC S9(1)         COMP-3.                CUSMST
       +000020*                CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT                 CUSMST
   81  +000021           06 ARBAL                PIC S9(6)V9(2)    COMP-3.                CUSMST
       +000022*                ACCOUNTS REC. BALANCE                                      CUSMST
   82  +000023           06 ORDBAL               PIC S9(6)V9(2)    COMP-3.                CUSMST
       +000024*                A/R AMT. IN ORDER FILE                                     CUSMST
   83  +000025           06 LSTAMT               PIC S9(6)V9(2)    COMP-3.                CUSMST
       +000026*                LAST AMT. PAID IN A/R                                      CUSMST
   84  +000027           06 LSTDAT               PIC S9(6)         COMP-3.                CUSMST
       +000028*                LAST DATE PAID IN A/R                                      CUSMST
   85  +000029           06 CRDLMT               PIC S9(6)V9(2)    COMP-3.                CUSMST
       +000030*                CUSTOMER CREDIT LIMIT                                      CUSMST
   86  +000031           06 SLSYR                PIC S9(8)V9(2)    COMP-3.                CUSMST
       +000032*                CUSTOMER SALES THIS YEAR                                   CUSMST
   87  +000033           06 SLSLYR               PIC S9(8)V9(2)    COMP-3.                CUSMST
       +000034*                CUSTOMER SALES LAST YEAR                                   CUSMST
        004700
   88   004800 FD  EXISTING-ORDER-DISPLAY-FILE.
   89   004900 01  EXISTING-ORDER-DISPLAY-RECORD.
        005000     COPY DDS-ALL-FORMATS OF ORDINQD.
   90  +000001       05  ORDINQD-RECORD PIC X(171).                                        <-ALL-FMTS
       +000002*    I-O FORMAT:SUB1       FROM FILE ORDINQD    OF LIBRARY CBLGUIDE          <-ALL-FMTS
       +000003*                                                                           <-ALL-FMTS
   91  +000004       05  SUB1          REDEFINES ORDINQD-RECORD.                         <-ALL-FMTS
   92  +000005           06 ITEM                 PIC S9(5).                               <-ALL-FMTS
       +000006*                ITEM NUMBER                                                <-ALL-FMTS
   93  +000007           06 QTYORD               PIC S9(3).                               <-ALL-FMTS
       +000008*                QUANTITY ORDERED                                           <-ALL-FMTS
   94  +000009           06 DESCRP               PIC X(30).                               <-ALL-FMTS
```

Figure 149. Example of an Order Inquiry Program (Part 3 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page      5
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        +000010*                ITEM DESCRIPTION                                          <-ALL-FMTS
  95    +000011           06 PRICE                PIC S9(4)V9(2).                        <-ALL-FMTS
        +000012*                SELLING PRICE                                             <-ALL-FMTS
  96    +000013           06 EXTENS               PIC S9(6)V9(2).                        <-ALL-FMTS
        +000014*                EXTENSION AMOUNT OF QTYORD X PRICE                        <-ALL-FMTS
        +000015*  INPUT FORMAT:SUBCTL1    FROM FILE ORDINQD    OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000016*                                                                          <-ALL-FMTS
  97    +000017       05  SUBCTL1-I     REDEFINES ORDINQD-RECORD.                       <-ALL-FMTS
  98    +000018           06 SUBCTL1-I-INDIC.                                            <-ALL-FMTS
  99    +000019                07 IN97            PIC 1  INDIC 97.                      <-ALL-FMTS
        +000020*                        CONTINUE DISPLAY                                  <-ALL-FMTS
 100    +000021                07 IN98            PIC 1  INDIC 98.                      <-ALL-FMTS
        +000022*                        END OF PROGRAM                                    <-ALL-FMTS
 101    +000023                07 IN57            PIC 1  INDIC 57.                      <-ALL-FMTS
        +000024*                        DISPLAY SUBFILE                                   <-ALL-FMTS
 102    +000025                07 IN58            PIC 1  INDIC 58.                      <-ALL-FMTS
        +000026*                        OFF = DISPLAY SUBCTL1 ON = CLEAR SUBFILE          <-ALL-FMTS
 103    +000027                07 IN61            PIC 1  INDIC 61.                      <-ALL-FMTS
        +000028*                        ORDER NUMBER NOT FOUND                            <-ALL-FMTS
 104    +000029                07 IN47            PIC 1  INDIC 47.                      <-ALL-FMTS
        +000030*                        NO LINE FOR THIS ORDER                            <-ALL-FMTS
 105    +000031                07 IN62            PIC 1  INDIC 62.                      <-ALL-FMTS
        +000032*                        NO CUSTOMER RECORD                                <-ALL-FMTS
 106    +000033           06 ORDERN               PIC S9(5).                             <-ALL-FMTS
        +000034*                ORDER NUMBER                                              <-ALL-FMTS
        +000035* OUTPUT FORMAT:SUBCTL1    FROM FILE ORDINQD    OF LIBRARY CBLGUIDE          <-ALL-FMTS
        +000036*                                                                          <-ALL-FMTS
 107    +000037       05  SUBCTL1-O     REDEFINES ORDINQD-RECORD.                       <-ALL-FMTS
 108    +000038           06 SUBCTL1-O-INDIC.                                            <-ALL-FMTS
 109    +000039                07 IN58            PIC 1  INDIC 58.                      <-ALL-FMTS
        +000040*                        OFF = DISPLAY SUBCTL1 ON = CLEAR SUBFILE          <-ALL-FMTS
 110    +000041                07 IN57            PIC 1  INDIC 57.                      <-ALL-FMTS
        +000042*                        DISPLAY SUBFILE                                   <-ALL-FMTS
 111    +000043                07 IN45            PIC 1  INDIC 45.                      <-ALL-FMTS
 112    +000044                07 IN47            PIC 1  INDIC 47.                      <-ALL-FMTS
        +000045*                        NO LINE FOR THIS ORDER                            <-ALL-FMTS
 113    +000046                07 IN61            PIC 1  INDIC 61.                      <-ALL-FMTS
        +000047*                        ORDER NUMBER NOT FOUND                            <-ALL-FMTS
 114    +000048                07 IN62            PIC 1  INDIC 62.                      <-ALL-FMTS
        +000049*                        NO CUSTOMER RECORD                                <-ALL-FMTS
 115    +000050           06 ORDERN               PIC S9(5).                             <-ALL-FMTS
        +000051*                ORDER NUMBER                                              <-ALL-FMTS
 116    +000052           06 ORDDAT               PIC S9(6).                             <-ALL-FMTS
        +000053*                DATE ORDER WAS ENTERED                                    <-ALL-FMTS
 117    +000054           06 CUST                 PIC X(5).                              <-ALL-FMTS
        +000055*                CUSTOMER NUMBER                                           <-ALL-FMTS
 118    +000056           06 NAME                 PIC X(25).                             <-ALL-FMTS
        +000057*                CUSTOMER NAME                                             <-ALL-FMTS
 119    +000058           06 ADDR                 PIC X(20).                             <-ALL-FMTS
        +000059*                CUSTOMER ADDRESS                                          <-ALL-FMTS
 120    +000060           06 CITY                 PIC X(20).                             <-ALL-FMTS
        +000061*                CUSTOMER CITY                                             <-ALL-FMTS
 121    +000062           06 STATE                PIC X(2).                              <-ALL-FMTS
        +000063*                CUSTOMER STATE                                            <-ALL-FMTS
 122    +000064           06 ZIP                  PIC S9(5).                             <-ALL-FMTS
```

Figure 149. Example of an Order Inquiry Program (Part 4 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page      6
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        +000065*                ZIP CODE                                                    <-ALL-FMTS
  123   +000066          06 ORDAMT               PIC S9(6)V9(2).                          <-ALL-FMTS
        +000067*                TOTAL AMOUNT OF ORDER                                       <-ALL-FMTS
  124   +000068          06 STSORD               PIC X(12).                               <-ALL-FMTS
  125   +000069          06 STSOPN               PIC X(12).                               <-ALL-FMTS
  126   +000070          06 CUSORD               PIC X(15).                               <-ALL-FMTS
        +000071*                CUSTOMER PURCHASE ORDER NUMBER                              <-ALL-FMTS
  127   +000072          06 SHPVIA               PIC X(15).                               <-ALL-FMTS
        +000073*                SHIPPING INSTRUCTIONS                                       <-ALL-FMTS
  128   +000074          06 PRTDAT               PIC S9(6).                               <-ALL-FMTS
        +000075*                DATE ORDER WAS PRINTED                                      <-ALL-FMTS
  129   +000076          06 INVNUM               PIC S9(5).                               <-ALL-FMTS
        +000077*                INVOICE NUMBER                                              <-ALL-FMTS
  130   +000078          06 ACTMTH               PIC S9(2).                               <-ALL-FMTS
        +000079*                ACCOUNTING MONTH OF SALE                                    <-ALL-FMTS
  131   +000080          06 ACTYR                PIC S9(2).                               <-ALL-FMTS
        +000081*                ACCOUNTING YEAR OF SALE                                     <-ALL-FMTS
         005100
  132    005200 WORKING-STORAGE SECTION.
  133    005300 01  EXISTING-ORDER-DISPLAY-KEY.
  134    005400    05  SUBFILE-RECORD-NUMBER              PIC 9(2)
         005500                                        VALUE ZERO.
         005600
  135    005700 01  ORDER-STATUS-COMMENT-VALUES.
  136    005800    05  FILLER                           PIC X(12)
         005900                                        VALUE "1-IN PROCESS".
  137    006000    05  FILLER                           PIC X(12)
         006100                                        VALUE "2-CONTINUED ".
  138    006200    05  FILLER                           PIC X(12)
         006300                                        VALUE "3-CREDIT CHK".
  139    006400    05  FILLER                           PIC X(12)
         006500                                        VALUE "4-READY PRT ".
  140    006600    05  FILLER                           PIC X(12)
         006700                                        VALUE "5-PRINTED   ".
  141    006800    05  FILLER                           PIC X(12)
         006900                                        VALUE "6-PICKED    ".
  142    007000    05  FILLER                           PIC X(12)
         007100                                        VALUE "7-INVOICED  ".
  143    007200    05  FILLER                           PIC X(12)
         007300                                        VALUE "8-INVALID   ".
  144    007400    05  FILLER                           PIC X(12)
         007500                                        VALUE "9-CANCELED  ".
         007600
  145    007700 01  ORDER-STATUS-COMMENT-TABLE
         007800         REDEFINES ORDER-STATUS-COMMENT-VALUES.
  146    007900    05  ORDER-STATUS OCCURS 9 TIMES.
  147    008000       10 ORDER-STATUS-COMMENT           PIC X(12).
         008100
  148    008200 01  OPEN-STATUS-COMMENT-VALUES.
  149    008300    05  FILLER                           PIC X(12)
         008400                                        VALUE "1-OPEN      ".
  150    008500    05  FILLER                           PIC X(12)
         008600                                        VALUE "2-CLOSED    ".
  151    008700    05  FILLER                           PIC X(12)
         008800                                        VALUE "3-CANCELED  ".
```

Figure 149. Example of an Order Inquiry Program (Part 5 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50       Page      7
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        008900
  152     009000 01  OPEN-STATUS-COMMENT-TABLE
          009100         REDEFINES OPEN-STATUS-COMMENT-VALUES.
  153     009200    05  OPEN-STATUS OCCURS 3 TIMES.
  154     009300       10  OPEN-STATUS-COMMENT              PIC X(12).
          009400
  155     009500 01  ERRHDL-PARAMETERS.
  156     009600    05  STATUS-CODE-ONE                     PIC X(2).
  157     009700       88  SUBFILE-IS-FULL               VALUE "0M".
          009800
  158     009900 01  ERRPGM-PARAMETERS.
  159     010000    05  DISPLAY-PARAMETER                   PIC X(8)
          010100                                         VALUE "ORD220D ".
  160     010200    05  DUMMY-ONE                           PIC X(6)
          010300                                         VALUE SPACES.
  161     010400    05  DUMMY-TWO                           PIC X(8)
          010500                                         VALUE SPACES.
  162     010600    05  STATUS-CODE-TWO.
  163     010700       10  PRIMARY                         PIC X(1).
  164     010800       10  SECONDARY                       PIC X(1).
  165     010900       10  FILLER                          PIC X(5)
          011000                                         VALUE SPACES.
          011100
  166     011200 01  SWITCH-AREA.
  167     011300    05  SW01                                PIC 1.
  168     011400       88  NO-MORE-DETAIL-LINE-ITEMS      VALUE B"1".
  169     011500       88  MORE-DETAIL-LINE-ITEMS-EXIST   VALUE B"0".
  170     011600    05  SW02                                PIC 1.
  171     011700       88  WRITE-DISPLAY                  VALUE B"1".
  172     011800       88  READ-DISPLAY                   VALUE B"0".
  173     011900    05  SW03                                PIC 1.
  174     012000       88  SUBCTL1-FORMAT                 VALUE B"1".
  175     012100       88  NOT-SUBCTL1-FORMAT             VALUE B"0".
  176     012200    05  SW04                                PIC 1.
  177     012300       88  SUB1-FORMAT                    VALUE B"1".
  178     012400       88  NOT-SUB1-FORMAT                VALUE B"0".
          012500
  179     012600 01  INDICATOR-AREA.
  180     012700    05  IN98                                PIC 1 INDIC 98.
  181     012800       88  END-OF-EXISTING-ORDER-INQUIRY  VALUE B"1".
  182     012900    05  IN97                                PIC 1 INDIC 97.
  183     013000       88  CONTINUE-DETAIL-LINES-DISPLAY  VALUE B"1".
  184     013100    05  IN62                                PIC 1 INDIC 62.
  185     013200       88  CUSTOMER-NOT-FOUND             VALUE B"1".
  186     013300       88  CUSTOMER-EXIST                 VALUE B"0".
  187     013400    05  IN61                                PIC 1 INDIC 61.
  188     013500       88  ORDER-NOT-FOUND                VALUE B"1".
  189     013600       88  ORDER-EXIST                    VALUE B"0".
  190     013700    05  IN58                                PIC 1 INDIC 58.
  191     013800       88  CLEAR-SUBFILE                  VALUE B"1".
  192     013900       88  DISPLAY-SUBFILE-CONTROL        VALUE B"0".
  193     014000    05  IN57                                PIC 1 INDIC 57.
  194     014100       88  DISPLAY-SUBFILE                VALUE B"1".
  195     014200    05  IN47                                PIC 1 INDIC 47.
  196     014300       88  NO-DETAIL-LINES-FOR-ORDER      VALUE B"1".
```

Figure 149. Example of an Order Inquiry Program (Part 6 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page      8
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  197     014400       88  DETAIL-LINES-FOR-ORDER-EXIST   VALUE B"0".
  198     014500    05  IN45                                 PIC 1 INDIC 45.
  199     014600       88  END-OF-ORDER                    VALUE B"1".
          014700
  200     014800 PROCEDURE DIVISION.
          014900
  201     015000 DECLARATIVES.
          015100 TRANSACTION-ERROR SECTION.
          015200     USE AFTER STANDARD ERROR PROCEDURE
          015300         EXISTING-ORDER-DISPLAY-FILE.
          015400 WORK-STATION-ERROR-HANDLER.
  202     015500     IF NOT (SUBFILE-IS-FULL) THEN
  203     015600         DISPLAY "WORK-STATION ERROR"   STATUS-CODE-ONE
          015700     END-IF.
          015800 END DECLARATIVES.
          015900
          016000 MAIN-PROGRAM SECTION.
          016100 MAINLINE.
  204     016200     OPEN INPUT  ORDER-HEADER-FILE
          016300                 ORDER-DETAIL-FILE
          016400                 CUSTOMER-MASTER-FILE
          016500          I-O    EXISTING-ORDER-DISPLAY-FILE.
  205     016600     MOVE SPACES TO   CUST   OF SUBCTL1-O
          016700                      NAME   OF SUBCTL1-O
          016800                      ADDR   OF SUBCTL1-O
          016900                      CITY   OF SUBCTL1-O
          017000                      STATE  OF SUBCTL1-O
          017100                      STSORD OF SUBCTL1-O
          017200                      STSOPN OF SUBCTL1-O
          017300                      CUSORD OF SUBCTL1-O.
  206     017400     MOVE ZEROS TO    ORDERN OF SUBCTL1-O
          017500                      ORDDAT OF SUBCTL1-O
          017600                      ZIP    OF SUBCTL1-O
          017700                      ORDAMT OF SUBCTL1-O
          017800                      PRTDAT OF SUBCTL1-O
          017900                      INVNUM OF SUBCTL1-O
          018000                      ACTMTH OF SUBCTL1-O
          018100                      ACTYR  OF SUBCTL1-O.
  207     018200     MOVE B"0" TO INDICATOR-AREA.
  208     018300     SET READ-DISPLAY
          018400         NOT-SUBCTL1-FORMAT
          018500         NOT-SUB1-FORMAT TO TRUE.
  209     018600     MOVE CORR INDICATOR-AREA TO SUBCTL1-O-INDIC.
                *** CORRESPONDING items for statement 209:
                ***     IN62
                ***     IN61
                ***     IN58
                ***     IN57
                ***     IN47
                ***     IN45
                *** End of CORRESPONDING items for statement 209
  210     018700     WRITE EXISTING-ORDER-DISPLAY-RECORD FORMAT IS "SUBCTL1"
          018800     END-WRITE
  211     018900     READ EXISTING-ORDER-DISPLAY-FILE RECORD.
  212     019000     MOVE CORR SUBCTL1-I-INDIC TO INDICATOR-AREA.
```

Figure 149. Example of an Order Inquiry Program (Part 7 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50       Page      9
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
               *** CORRESPONDING items for statement 212:
               ***     IN97
               ***     IN98
               ***     IN57
               ***     IN58
               ***     IN61
               ***     IN47
               ***     IN62
               *** End of CORRESPONDING items for statement 212
         019100
  213    019200     PERFORM EXISTING-ORDER-INQUIRY
         019300         UNTIL END-OF-EXISTING-ORDER-INQUIRY.
         019400
  214    019500      CLOSE     ORDER-HEADER-FILE
         019600                ORDER-DETAIL-FILE
         019700                CUSTOMER-MASTER-FILE
         019800                EXISTING-ORDER-DISPLAY-FILE.
  215    019900      STOP RUN.
         020000
         020100 EXISTING-ORDER-INQUIRY.
  216    020200     IF CONTINUE-DETAIL-LINES-DISPLAY THEN
  217    020300         PERFORM READ-NEXT-ORDER-DETAIL-RECORD
  218    020400         IF MORE-DETAIL-LINE-ITEMS-EXIST THEN
  219    020500             IF ORDERN OF ORDER-DETAIL-RECORD IS NOT EQUAL TO
         020600                ORDERN OF ORDER-HEADER-RECORD THEN
  220    020700                    SET DISPLAY-SUBFILE TO TRUE
  221    020800                    SET NO-DETAIL-LINES-FOR-ORDER TO TRUE
         020900             ELSE
  222    021000                 PERFORM SUBFILE-SET-UP
         021100             END-IF
         021200         ELSE
  223    021300             SET DISPLAY-SUBFILE TO TRUE
  224    021400             SET NO-DETAIL-LINES-FOR-ORDER TO TRUE
         021500         END-IF
         021600     ELSE
  225    021700         PERFORM ORDER-NUMBER-VALIDATION
         021800     END-IF
  226    021900     MOVE CORR INDICATOR-AREA TO SUBCTL1-O-INDIC.
               *** CORRESPONDING items for statement 226:
               ***     IN62
               ***     IN61
               ***     IN58
               ***     IN57
               ***     IN47
               ***     IN45
               *** End of CORRESPONDING items for statement 226
  227    022000     SET WRITE-DISPLAY TO TRUE.
  228    022100     SET SUBCTL1-FORMAT TO TRUE.
  229    022200     WRITE EXISTING-ORDER-DISPLAY-RECORD FORMAT IS "SUBCTL1".
  230    022300     READ EXISTING-ORDER-DISPLAY-FILE RECORD.
  231    022400     MOVE CORR SUBCTL1-I-INDIC TO INDICATOR-AREA.
               *** CORRESPONDING items for statement 231:
               ***     IN97
               ***     IN98
               ***     IN57
```

Figure 149. Example of an Order Inquiry Program (Part 8 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50       Page     10
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
               ***     IN58
               ***     IN61
               ***     IN47
               ***     IN62
               *** End of CORRESPONDING items for statement 231
         022500
         022600 ORDER-NUMBER-VALIDATION.
  232    022700     PERFORM READ-ORDER-HEADER-FILE.
  233    022800     IF ORDER-EXIST THEN
  234    022900         PERFORM READ-CUSTOMER-MASTER-FILE
  235    023000         IF CUSTOMER-EXIST THEN
  236    023100             PERFORM READ-FIRST-ORDER-DETAIL-RECORD
  237    023200             IF DETAIL-LINES-FOR-ORDER-EXIST THEN
  238    023300                 PERFORM SUBFILE-SET-UP
         023400             END-IF
         023500         END-IF
         023600     END-IF.
         023700
         023800 READ-ORDER-HEADER-FILE.
  239    023900     MOVE ORDERN OF SUBCTL1-I OF EXISTING-ORDER-DISPLAY-RECORD
         024000         TO ORDERN OF ORDER-HEADER-RECORD.
  240    024100     READ ORDER-HEADER-FILE
  241    024200         INVALID KEY SET ORDER-NOT-FOUND TO TRUE
         024300     END-READ.
         024400
         024500 READ-CUSTOMER-MASTER-FILE.
  242    024600     MOVE CUST OF ORDER-HEADER-RECORD
         024700         TO CUST OF CUSTOMER-MASTER-RECORD.
  243    024800     READ CUSTOMER-MASTER-FILE
  244    024900         INVALID KEY SET CUSTOMER-NOT-FOUND TO TRUE
         025000     END-READ.
         025100
         025200 READ-FIRST-ORDER-DETAIL-RECORD.
  245    025300     MOVE ORDERN OF ORDER-HEADER-RECORD
         025400         TO ORDERN OF ORDER-DETAIL-RECORD.
  246    025500     MOVE 1 TO LINNUM OF ORDER-DETAIL-RECORD.
  247    025600     READ ORDER-DETAIL-FILE
  248    025700         INVALID KEY SET NO-DETAIL-LINES-FOR-ORDER TO TRUE
         025800     END-READ.
         025900
         026000 SUBFILE-SET-UP.
  249    026100     SET CLEAR-SUBFILE TO TRUE.
  250    026200     MOVE CORR INDICATOR-AREA TO SUBCTL1-O-INDIC.
               *** CORRESPONDING items for statement 250:
               ***     IN62
               ***     IN61
               ***     IN58
               ***     IN57
               ***     IN47
               ***     IN45
               *** End of CORRESPONDING items for statement 250
  251    026300     SET WRITE-DISPLAY TO TRUE.
  252    026400     SET SUBCTL1-FORMAT TO TRUE.
  253    026500     WRITE EXISTING-ORDER-DISPLAY-RECORD FORMAT IS "SUBCTL1"
         026600     END-WRITE
```

Figure 149. Example of an Order Inquiry Program (Part 9 of 10)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/ORDINQ          ISERIES1   03/09/15 15:06:50        Page     11
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  254     026700     SET DISPLAY-SUBFILE-CONTROL TO TRUE.
  255     026800     PERFORM BUILD-DISPLAY-SUBFILE
          026900         UNTIL NO-MORE-DETAIL-LINE-ITEMS OR SUBFILE-IS-FULL.
  256     027000     MOVE CORR ORDHDR OF ORDER-HEADER-RECORD
          027100         TO SUBCTL1-O OF EXISTING-ORDER-DISPLAY-RECORD.
                *** CORRESPONDING items for statement 256:
                ***     CUST
                ***     ORDERN
                ***     ORDDAT
                ***     CUSORD
                ***     SHPVIA
                ***     ORDAMT
                ***     INVNUM
                ***     PRTDAT
                ***     ACTMTH
                ***     ACTYR
                ***     STATE
                *** End of CORRESPONDING items for statement 256
  257     027200     MOVE CORR CUSMST OF CUSTOMER-MASTER-RECORD
          027300         TO SUBCTL1-O OF EXISTING-ORDER-DISPLAY-RECORD.
                *** CORRESPONDING items for statement 257:
                ***     CUST
                ***     NAME
                ***     ADDR
                ***     CITY
                ***     STATE
                ***     ZIP
                *** End of CORRESPONDING items for statement 257
  258     027400     MOVE ORDER-STATUS(ORDSTS) TO STSORD.
  259     027500     MOVE OPEN-STATUS(OPNSTS) TO STSOPN.
  260     027600     SET MORE-DETAIL-LINE-ITEMS-EXIST TO TRUE.
  261     027700     MOVE ZEROS TO SUBFILE-RECORD-NUMBER.
          027800
          027900 BUILD-DISPLAY-SUBFILE.
  262     028000     MOVE CORR ORDDTL OF ORDER-DETAIL-RECORD
          028100         TO SUB1 OF EXISTING-ORDER-DISPLAY-RECORD.
                *** CORRESPONDING items for statement 262:
                ***     ITEM
                ***     QTYORD
                ***     DESCRP
                ***     PRICE
                ***     EXTENS
                *** End of CORRESPONDING items for statement 262
  263     028200     SET WRITE-DISPLAY TO TRUE.
  264     028300     SET SUB1-FORMAT TO TRUE.
  265     028400     ADD 1 TO SUBFILE-RECORD-NUMBER.
  266     028500     WRITE SUBFILE EXISTING-ORDER-DISPLAY-RECORD FORMAT IS "SUB1"
          028600     END-WRITE
  267     028700     IF SUBFILE-IS-FULL THEN
  268     028800         SET DISPLAY-SUBFILE TO TRUE
          028900     ELSE
  269     029000         PERFORM READ-NEXT-ORDER-DETAIL-RECORD
  270     029100         IF MORE-DETAIL-LINE-ITEMS-EXIST THEN
  271     029200             IF ORDERN OF ORDER-DETAIL-RECORD IS NOT EQUAL TO
          029300                ORDERN OF ORDER-HEADER-RECORD THEN
  272     029400                   SET DISPLAY-SUBFILE TO TRUE
  273     029500                   SET NO-MORE-DETAIL-LINE-ITEMS TO TRUE
          029600             END-IF
          029700         END-IF
          029800     END-IF.
          029900
          030000 READ-NEXT-ORDER-DETAIL-RECORD.
  274     030100     READ ORDER-DETAIL-FILE NEXT RECORD
  275     030200         AT END SET DISPLAY-SUBFILE TO TRUE
  276     030300                SET NO-MORE-DETAIL-LINE-ITEMS TO TRUE
          030400     END-READ.
                      * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 149. Example of an Order Inquiry Program (Part 10 of 10)

This is the initial order-entry prompt display written to the workstation:

```
Existing Order Entry                    Total  000000000
                                        Status
Order 12400                             Open
Date 000000                             Customer order
Cust #                                  Ship via
                            00000       Printed date 000000
                          Invoice 00000                     Mth 00  Year 00
Item  Qty   Item Description              Price   Extension
```

This display appears if there are detail order records forthe customer whose order number was entered in the first display:

```
Existing Order Entry                    Total  007426656
                                        Status 7-INVOICED
Order 17924   ABC HARDWARE LTD.         Open   2-CLOSED
Date 110896   123 ANYWHERE AVE.         Customer order TESTCS179330001I
Cust # 11200  TORONTO                   Ship via       TRUCKCO
              ONT           M4K 0A0     Printed date 110896
                          Invoice 17924                     Mth 12  Year 88
Item  Qty   Item Description              Price   Extension
33001  003  TORQUE WRENCH 75LB 14 INCH    009115       273.45
33100  001  TORQUE WRENCH W/GAUGE 200 LB  015777       650.95
44529  004  WOOD CHISEL - 3 1/4           006840        56.87
44958  002  POWER DRILL 1/2 REV           008200       797.50
46102  001  WROUGHT IRON RAILING 4FTX6FT  007930       237.75
46201  001  WROUGHT IRON HAND RAIL 6FT    007178        77.35
47902  002  ESCUTCHEON BRASS 15X4 INCHES  044488       213.00
```

This display appears if the ORDHDRP file does not contain arecord for the order number entered on the first display:

```
Existing Order Entry                    Total  000000000
                                        Status
Order 12400                             Open
Date 000000                             Customer order
Cust #                                  Ship via
                            00000       Printed date 000000
                          Invoice 00000                     Mth 00  Year 00
Item  Qty   Item Description              Price   Extension









Order number not found
```

Example of Using READ SUBFILE...NEXT MODIFIED and REWRITE SUBFILE in a Payment Update Program

Figure 152 on page 563 shows an example of a payment update program, PAYUPDT. For the related DDS, see Figure 150 on page 560 and Figure 151 on page 561. For the related display-screen examples, see page “Customer Payment Display” on page 575. For the DDS for the customer master file, CUSMSTP, refer to Figure 132 on page 507.

In this example, payments from customers are registered. The clerk is prompted to enter one or more customer numbers and the amount of money to be credited to each customer's account. The program checks the customer number and unconditionally accepts any payment for an existing customer who has invoices outstanding. If an overpayment will result from the amount of the payment from a customer, the clerk is given the option of accepting or rejecting the payment. If no customer record exists for a customer number, an error message is issued. Payments can be entered until the clerk ends the program by pressing F12.

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A** THIS IS THE ORDER HEADER LOGICAL FILE ** ORDHDRL
     A
     A
     A                                      UNIQUE
     A          R ORDHDR                    PFILE(ORDHDRP)
     A*
     A            CUST
     A            INVNUM
     A            ORDERN
     A            ORDDAT
     A            CUSORD
     A            SHPVIA
     A            ORDSTS
     A            OPRNAM
     A            ORDAMT
     A            CUSTYP
     A            PRTDAT
     A            OPNSTS
     A            TOTLIN
     A            ACTMTH
     A            ACTYR
     A            STATE
     A            AMPAID
     A          K CUST
     A          K INVNUM
```

Figure 150. Example of a Data Description Specification for a Payment Update Program - Logical Order File

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....
     A* THIS IS THE DISPLAY DEVICE FILE FOR PAYUPDT ** PAYUPDTD
     A* ACCOUNTS RECEIVABLE INTERACTIVE PAYMENT UPDATE
     A*
     A
     A          R SUBFILE1                  SFL
     A                                      TEXT('SUBFILE FOR CUSTOMER PAYMENT'
     A*
     A            ACPPMT         4A  I  5  4TEXT('ACCEPT PAYMENT')
     A                                      VALUES('*YES' '*NO')
     A  51                                  DSPATR(RI MDT)
     A N51                                  DSPATR(ND PR)
     A*
     A            CUST           5   B  5 15TEXT('CUSTOMER NUMBER')
     A  52                                  DSPATR(RI)
     A  53                                  DSPATR(ND)
     A  54                                  DSPATR(PR)
     A*
     A            AMPAID         8 02B  5 24TEXT('AMOUNT PAID')
     A                                      CHECK(FE)
     A                                      AUTO(RAB)
     A                                      CMP(GT 0)
     A  52                                  DSPATR(RI)
     A  53                                  DSPATR(ND)
     A  54                                  DSPATR(PR)
     A*
     A            ECPMSG        31A  O  5 37TEXT('EXCEPTION MESSAGE')
     A  52                                  DSPATR(RI)
     A  53                                  DSPATR(ND)
     A  54                                  DSPATR(BL)
     A*
     A            OVRPMT         8Y 2O  5 70TEXT('OVERPAYMENT')
     A                                      EDTCDE(1)
     A  55                                  DSPATR(BL)
     A N56                                  DSPATR(ND)
     A*
```

Figure 151. Example of a Data Description Specification for a Payment Update Program - Display Device File (Part 1 of 2)

```
     A            STSCDE         1A  H      TEXT('STATUS CODE')
     A          R CONTROL1                  TEXT('SUBFILE CONTROL')
     A                                      SFLCTL(SUBFILE1)
     A                                      SFLSIZ(17)
     A                                      SFLPAG(17)
     A  61                                  SFLCLR
     A  62                                  SFLDSP
     A  62                                  SFLDSPCTL
     A                                      OVERLAY
     A                                      LOCK
     A*
     A                                      HELP(99 'HELP KEY')
     A                                            CA12(98 'END PAYMENT UPDATE')
     A                                      CA11(97 'IGNORE INPUT')
     A*
     A  99                                  SFLMSG(' F11 - IGNORE INVALID INPUT+
     A                                                    F12 - END PAYMENT +
     A                                      UPDATE')
     A*
     A                                   1  2'CUSTOMER PAYMENT UPDATE PROMPT'
     A                                   1 65'DATE'
     A                                   1 71DATE EDTCDE(Y)
     A  63                               3  2'ACCEPT'
     A  63                               4  2'PAYMENT'
     A                                   3 14'CUSTOMER'
     A                                   3 26'PAYMENT'
     A  64                               3 37'EXCEPTION MESSAGE'
     A*
     A          R MESSAGE1                  TEXT('MESSAGE RECORD')
     A                                      OVERLAY
     A                                      LOCK
     A*
     A  71                              24  2' ACCEPT PAYMENT VALUES: (*NO *YES)
                                            DSPATR(RI)
```

Figure 151. Example of a Data Description Specification for a Payment Update Program - Display Device File (Part 2 of 2)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         000100 PROCESS APOST
    1    000200 IDENTIFICATION DIVISION.
    2    000300 PROGRAM-ID.  PAYUPDT.
         000400
    3    000500 ENVIRONMENT DIVISION.
    4    000600 CONFIGURATION SECTION.
    5    000700 SOURCE-COMPUTER. IBM-ISERIES
    6    000800 OBJECT-COMPUTER. IBM-ISERIES
    7    000900 INPUT-OUTPUT SECTION.
    8    001000 FILE-CONTROL.
    9    001100     SELECT CUSTOMER-INVOICE-FILE
   10    001200         ASSIGN TO DATABASE-ORDHDRL
   11    001300         ORGANIZATION IS INDEXED
   12    001400         ACCESS MODE IS SEQUENTIAL
   13    001500         RECORD KEY IS COMP-KEY
   14    001600         FILE STATUS IS STATUS-CODE-ONE.
   15    001700     SELECT CUSTOMER-MASTER-FILE
   16    001800         ASSIGN TO DATABASE-CUSMSTP
   17    001900         ORGANIZATION IS INDEXED
   18    002000         ACCESS IS RANDOM
   19    002100         RECORD KEY IS CUST OF CUSTOMER-MASTER-RECORD.
   20    002200     SELECT PAYMENT-UPDATE-DISPLAY-FILE
   21    002300         ASSIGN TO WORKSTATION-PAYUPDTD
   22    002400         ORGANIZATION IS TRANSACTION
   23    002500         ACCESS IS DYNAMIC
   24    002600         RELATIVE KEY IS REL-NUMBER
   25    002700         FILE STATUS IS STATUS-CODE-ONE
   26    002800         CONTROL-AREA IS WS-CONTROL.
         002900
   27    003000 DATA DIVISION.
   28    003100 FILE SECTION.
   29    003200 FD  CUSTOMER-INVOICE-FILE.
   30    003300 01  CUSTOMER-INVOICE-RECORD.
         003400     COPY DDS-ORDHDR OF ORDHDRL.
        +000001*    I-O FORMAT:ORDHDR     FROM FILE ORDHDRL    OF LIBRARY CBLGUIDE          ORDHDR
        +000002*                                                                            ORDHDR
        +000003*          USER SUPPLIED KEY BY RECORD KEY CLAUSE                            ORDHDR
   31   +000004       05  ORDHDR.                                                          ORDHDR
   32   +000005           06 CUST                 PIC X(5).                              ORDHDR
        +000006*                 CUSTOMER NUMBER                                          ORDHDR
   33   +000007           06 INVNUM               PIC S9(5)         COMP-3.              ORDHDR
        +000008*                 INVOICE NUMBER                                           ORDHDR
   34   +000009           06 ORDERN               PIC S9(5)         COMP-3.              ORDHDR
        +000010*                 ORDER NUMBER                                             ORDHDR
   35   +000011           06 ORDDAT               PIC S9(6)         COMP-3.              ORDHDR
        +000012*                 DATE ORDER ENTERED                                       ORDHDR
   36   +000013           06 CUSORD               PIC X(15).                             ORDHDR
        +000014*                 CUSTOMER PURCHASE ORDER NUMBER                           ORDHDR
   37   +000015           06 SHPVIA               PIC X(15).                             ORDHDR
        +000016*                 SHIPPING INSTRUCTIONS                                    ORDHDR
   38   +000017           06 ORDSTS               PIC S9(1)         COMP-3.              ORDHDR
        +000018*                 ORDER SATAUS 1PCS 2CNT  3CHK 4RDY 5PRT 6PCK              ORDHDR
   39   +000019           06 OPRNAM               PIC X(10).                             ORDHDR
```

Figure 152. Source Listing of a Payment Update Program Example (Part 1 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      3
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        +000020*                OPERATOR WHO ENTERED ORD                                    ORDHDR
   40   +000021           06 ORDAMT                PIC S9(6)V9(2)    COMP-3.               ORDHDR
        +000022*                DOLLAR AMOUNT OF ORDER                                      ORDHDR
   41   +000023           06 CUSTYP                PIC S9(1)         COMP-3.               ORDHDR
        +000024*                CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT                  ORDHDR
   42   +000025           06 PRTDAT                PIC S9(6)         COMP-3.               ORDHDR
        +000026*                DATE ORDER WAS PRINTED                                      ORDHDR
   43   +000027           06 OPNSTS                PIC S9(1)         COMP-3.               ORDHDR
        +000028*                ORDER OPEN STATUS 1=OPEN 2= CLOSE 3=CANCEL                  ORDHDR
   44   +000029           06 TOTLIN                PIC S9(3)         COMP-3.               ORDHDR
        +000030*                TOTAL LINE ITEMS IN ORDER                                   ORDHDR
   45   +000031           06 ACTMTH                PIC S9(2)         COMP-3.               ORDHDR
        +000032*                ACCOUNTING MONTH OF SALE                                    ORDHDR
   46   +000033           06 ACTYR                 PIC S9(2)         COMP-3.               ORDHDR
        +000034*                ACCOUNTING YEAR OF SALE                                     ORDHDR
   47   +000035           06 STATE                 PIC X(2).                               ORDHDR
        +000036*                STATE                                                       ORDHDR
   48   +000037           06 AMPAID                PIC S9(6)V9(2)    COMP-3.               ORDHDR
        +000038*                AMOUNT PAID                                                 ORDHDR
   49    003500 66  COMP-KEY RENAMES CUST THRU INVNUM.
         003600
   50    003700 FD  CUSTOMER-MASTER-FILE.
   51    003800 01  CUSTOMER-MASTER-RECORD.
         003900     COPY DDS-CUSMST OF CUSMSTP.
        +000001*    I-O FORMAT:CUSMST     FROM FILE CUSMSTP    OF LIBRARY CBLGUIDE          CUSMST
        +000002*                          CUSTOMER MASTER RECORD                            CUSMST
        +000003*         USER SUPPLIED KEY BY RECORD KEY CLAUSE                             CUSMST
   52   +000004       05  CUSMST.                                                          CUSMST
   53   +000005           06 CUST                  PIC X(5).                               CUSMST
        +000006*                CUSTOMER NUMBER                                             CUSMST
   54   +000007           06 NAME                  PIC X(25).                              CUSMST
        +000008*                CUSTOMER NAME                                               CUSMST
   55   +000009           06 ADDR                  PIC X(20).                              CUSMST
        +000010*                CUSTOMER ADDRESS                                            CUSMST
   56   +000011           06 CITY                  PIC X(20).                              CUSMST
        +000012*                CUSTOMER CITY                                               CUSMST
   57   +000013           06 STATE                 PIC X(2).                               CUSMST
        +000014*                STATE                                                       CUSMST
   58   +000015           06 ZIP                   PIC S9(5)         COMP-3.               CUSMST
        +000016*                ZIP CODE                                                    CUSMST
   59   +000017           06 SRHCOD                PIC X(6).                               CUSMST
        +000018*                CUSTOMER NUMBER SEARCH CODE                                 CUSMST
   60   +000019           06 CUSTYP                PIC S9(1)         COMP-3.               CUSMST
        +000020*                CUSTOMER TYPE 1=GOV 2=SCH 3=BUS 4=PVT 5=OT                  CUSMST
   61   +000021           06 ARBAL                 PIC S9(6)V9(2)    COMP-3.               CUSMST
        +000022*                ACCOUNTS REC. BALANCE                                       CUSMST
   62   +000023           06 ORDBAL                PIC S9(6)V9(2)    COMP-3.               CUSMST
        +000024*                A/R AMT. IN ORDER FILE                                      CUSMST
   63   +000025           06 LSTAMT                PIC S9(6)V9(2)    COMP-3.               CUSMST
        +000026*                LAST AMT. PAID IN A/R                                       CUSMST
   64   +000027           06 LSTDAT                PIC S9(6)         COMP-3.               CUSMST
        +000028*                LAST DATE PAID IN A/R                                       CUSMST
   65   +000029           06 CRDLMT                PIC S9(6)V9(2)    COMP-3.               CUSMST
        +000030*                CUSTOMER CREDIT LIMIT                                       CUSMST
   66   +000031           06 SLSYR                 PIC S9(8)V9(2)    COMP-3.               CUSMST
```

Figure 152. Source Listing of a Payment Update Program Example (Part 2 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      4
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
       +000032*                CUSTOMER SALES THIS YEAR                                     CUSMST
  67   +000033           06 SLSLYR               PIC S9(8)V9(2)    COMP-3.                 CUSMST
       +000034*                CUSTOMER SALES LAST YEAR                                     CUSMST
        004000
  68    004100 FD  PAYMENT-UPDATE-DISPLAY-FILE.
  69    004200 01  PAYMENT-UPDATE-DISPLAY-RECORD.
        004300     COPY DDS-ALL-FORMATS OF PAYUPDTD.
  70   +000001       05  PAYUPDTD-RECORD PIC X(59).                                         <-ALL-FMTS
       +000002*  INPUT FORMAT:SUBFILE1   FROM FILE PAYUPDTD   OF LIBRARY CBLGUIDE          <-ALL-FMTS
       +000003*                         SUBFILE FOR CUSTOMER PAYMENT                       <-ALL-FMTS
  71   +000004       05  SUBFILE1-I    REDEFINES PAYUPDTD-RECORD.                          <-ALL-FMTS
  72   +000005           06 ACPPMT               PIC X(4).                                <-ALL-FMTS
       +000006*                ACCEPT PAYMENT                                             <-ALL-FMTS
  73   +000007           06 CUST                 PIC X(5).                                <-ALL-FMTS
       +000008*                CUSTOMER NUMBER                                            <-ALL-FMTS
  74   +000009           06 AMPAID               PIC S9(6)V9(2).                          <-ALL-FMTS
       +000010*                AMOUNT PAID                                                <-ALL-FMTS
  75   +000011           06 ECPMSG               PIC X(31).                               <-ALL-FMTS
       +000012*                EXCEPTION MESSAGE                                          <-ALL-FMTS
  76   +000013           06 OVRPMT               PIC S9(6)V9(2).                          <-ALL-FMTS
       +000014*                OVERPAYMENT                                                <-ALL-FMTS
  77   +000015           06 STSCDE               PIC X(1).                                <-ALL-FMTS
       +000016*                STATUS CODE                                                <-ALL-FMTS
       +000017* OUTPUT FORMAT:SUBFILE1   FROM FILE PAYUPDTD   OF LIBRARY CBLGUIDE          <-ALL-FMTS
       +000018*                         SUBFILE FOR CUSTOMER PAYMENT                       <-ALL-FMTS
  78   +000019       05  SUBFILE1-O    REDEFINES PAYUPDTD-RECORD.                          <-ALL-FMTS
  79   +000020           06 SUBFILE1-O-INDIC.                                              <-ALL-FMTS
  80   +000021                07 IN51            PIC 1  INDIC 51.                         <-ALL-FMTS
  81   +000022                07 IN52            PIC 1  INDIC 52.                         <-ALL-FMTS
  82   +000023                07 IN53            PIC 1  INDIC 53.                         <-ALL-FMTS
  83   +000024                07 IN54            PIC 1  INDIC 54.                         <-ALL-FMTS
  84   +000025                07 IN55            PIC 1  INDIC 55.                         <-ALL-FMTS
  85   +000026                07 IN56            PIC 1  INDIC 56.                         <-ALL-FMTS
  86   +000027           06 CUST                 PIC X(5).                                <-ALL-FMTS
       +000028*                CUSTOMER NUMBER                                            <-ALL-FMTS
  87   +000029           06 AMPAID               PIC S9(6)V9(2).                          <-ALL-FMTS
       +000030*                AMOUNT PAID                                                <-ALL-FMTS
  88   +000031           06 ECPMSG               PIC X(31).                               <-ALL-FMTS
       +000032*                EXCEPTION MESSAGE                                          <-ALL-FMTS
  89   +000033           06 OVRPMT               PIC S9(6)V9(2).                          <-ALL-FMTS
       +000034*                OVERPAYMENT                                                <-ALL-FMTS
  90   +000035           06 STSCDE               PIC X(1).                                <-ALL-FMTS
       +000036*                STATUS CODE                                                <-ALL-FMTS
       +000037*  INPUT FORMAT:CONTROL1   FROM FILE PAYUPDTD   OF LIBRARY CBLGUIDE          <-ALL-FMTS
       +000038*                         SUBFILE CONTROL                                    <-ALL-FMTS
  91   +000039       05  CONTROL1-I    REDEFINES PAYUPDTD-RECORD.                          <-ALL-FMTS
  92   +000040           06 CONTROL1-I-INDIC.                                              <-ALL-FMTS
  93   +000041                07 IN99            PIC 1  INDIC 99.                         <-ALL-FMTS
       +000042*                        HELP KEY                                           <-ALL-FMTS
  94   +000043                07 IN98            PIC 1  INDIC 98.                         <-ALL-FMTS
       +000044*                        END PAYMENT UPDATE                                 <-ALL-FMTS
  95   +000045                07 IN97            PIC 1  INDIC 97.                         <-ALL-FMTS
       +000046*                        IGNORE INPUT                                       <-ALL-FMTS
       +000047* OUTPUT FORMAT:CONTROL1   FROM FILE PAYUPDTD   OF LIBRARY CBLGUIDE          <-ALL-FMTS
       +000048*                         SUBFILE CONTROL                                    <-ALL-FMTS
```

Figure 152. Source Listing of a Payment Update Program Example (Part 3 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      5
STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  96    +000049       05  CONTROL1-O    REDEFINES PAYUPDTD-RECORD.                          <-ALL-FMTS
  97    +000050           06 CONTROL1-O-INDIC.                                             <-ALL-FMTS
  98    +000051                07 IN61             PIC 1  INDIC 61.                       <-ALL-FMTS
  99    +000052                07 IN62             PIC 1  INDIC 62.                       <-ALL-FMTS
 100    +000053                07 IN99             PIC 1  INDIC 99.                       <-ALL-FMTS
        +000054*                          HELP KEY                                        <-ALL-FMTS
 101    +000055                07 IN63             PIC 1  INDIC 63.                       <-ALL-FMTS
 102    +000056                07 IN64             PIC 1  INDIC 64.                       <-ALL-FMTS
        +000057*  INPUT FORMAT:MESSAGE1   FROM FILE PAYUPDTD   OF LIBRARY CBLGUIDE         <-ALL-FMTS
        +000058*                          MESSAGE RECORD                                  <-ALL-FMTS
        +000059*      05  MESSAGE1-I    REDEFINES PAYUPDTD-RECORD.                       <-ALL-FMTS
        +000060* OUTPUT FORMAT:MESSAGE1   FROM FILE PAYUPDTD   OF LIBRARY CBLGUIDE         <-ALL-FMTS
        +000061*                          MESSAGE RECORD                                  <-ALL-FMTS
 103    +000062       05  MESSAGE1-O    REDEFINES PAYUPDTD-RECORD.                       <-ALL-FMTS
 104    +000063           06 MESSAGE1-O-INDIC.                                          <-ALL-FMTS
 105    +000064                07 IN71             PIC 1  INDIC 71.                       <-ALL-FMTS
         004400
 106     004500 WORKING-STORAGE SECTION.
         004600
 107     004700 01  REL-NUMBER                  PIC 9(05)
         004800                                   VALUE ZEROS.
         004900
 108     005000 01  WS-CONTROL.
 109     005100     05  WS-IND                  PIC X(02).
 110     005200     05  WS-FORMAT               PIC X(10).
 111     005300 01  SYSTEM-DATE.
 112     005400     05  SYSTEM-YEAR             PIC 99.
 113     005500     05  SYSTEM-MONTH            PIC 99.
 114     005600     05  SYSTEM-DAY              PIC 99.
 115     005700 01  PROGRAM-DATE.
 116     005800     05  PROGRAM-MONTH           PIC 99.
 117     005900     05  PROGRAM-DAY             PIC 99.
 118     006000     05  PROGRAM-YEAR            PIC 99.
 119     006100 01  FILE-DATE REDEFINES PROGRAM-DATE
         006200                                  PIC S9(6).
 120     006300 01  EXCEPTION-STATUS.
 121     006400     05  STATUS-CODE-ONE         PIC XX.
 122     006500         88  SUBFILE-IS-FULL     VALUE '0M'.
 123     006600 01  EXCEPTION-MESSAGES.
 124     006700     05  MESSAGE-ONE             PIC X(31)
         006800         VALUE 'CUSTOMER DOES NOT EXIST        '.
 125     006900     05  MESSAGE-TWO             PIC X(31)
         007000         VALUE 'NO INVOICES EXIST FOR CUSTOMER '.
 126     007100     05  MESSAGE-THREE           PIC X(31)
         007200         VALUE 'CUSTOMER HAS AN OVER PAYMENT OF'.
 127     007300 01  PROGRAM-VARIABLES.
 128     007400     05  AMOUNT-OWED             PIC S9(6)V99.
 129     007500     05  AMOUNT-PAID             PIC S9(6)V99.
 130     007600     05  INVOICE-BALANCE         PIC S9(6)V99.
 131     007700 01  ERRPGM-PARAMETERS.
 132     007800     05  DISPLAY-PARAMETER       PIC X(8)
         007900                                   VALUE 'PAYUPDTD'.
 133     008000     05  DUMMY-ONE               PIC X(6)
         008100                                   VALUE SPACES.
 134     008200     05  DUMMY-TWO               PIC X(6)
```

Figure 152. Source Listing of a Payment Update Program Example (Part 4 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      6
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         008300                                  VALUE SPACES.
  135    008400    05  STATUS-CODE-TWO.
  136    008500       10  PRIMARY                PIC X(1).
  137    008600       10  SECONDARY              PIC X(1).
  138    008700       10  FILLER                 PIC X(5)
         008800                                    VALUE SPACES.
  139    008900    05  DUMMY-THREE               PIC X(10)
         009000                                    VALUE SPACES.
         009100
  140    009200 01  SWITCH-AREA.
  141    009300    05  SW01                      PIC 1.
  142    009400       88  WRITE-DISPLAY               VALUE B'1'.
  143    009500       88  READ-DISPLAY                VALUE B'0'.
  144    009600    05  SW02                      PIC 1.
  145    009700       88  SUBFILE1-FORMAT             VALUE B'1'.
  146    009800       88  NOT-SUBFILE1-FORMAT         VALUE B'0'.
  147    009900    05  SW03                      PIC 1.
  148    010000       88  CONTROL1-FORMAT             VALUE B'1'.
  149    010100       88  NOT-CONTROL1-FORMAT         VALUE B'0'.
  150    010200    05  SW04                      PIC 1.
  151    010300       88  NO-MORE-TRANSACTIONS-EXIST   VALUE B'1'.
  152    010400       88  TRANSACTIONS-EXIST           VALUE B'0'.
  153    010500    05  SW05                      PIC 1.
  154    010600       88  CUSTOMER-NOT-FOUND           VALUE B'1'.
  155    010700       88  CUSTOMER-EXIST               VALUE B'0'.
  156    010800    05  SW06                      PIC 1.
  157    010900       88  NO-MORE-INVOICES-EXIST       VALUE B'1'.
  158    011000       88  CUSTOMER-INVOICE-EXIST       VALUE B'0'.
  159    011100    05  SW07                      PIC 1.
  160    011200       88  NO-MORE-PAYMENT-EXIST        VALUE B'1'.
  161    011300       88  PAYMENT-EXIST                VALUE B'0'.
  162    011400    05  SW08                      PIC 1.
  163    011500       88  INPUT-ERRORS-EXIST           VALUE B'1'.
  164    011600       88  NO-INPUT-ERRORS-EXIST        VALUE B'0'.
  165    011700    05  SW09                      PIC 1.
  166    011800       88  OVER-PAYMENT-DISPLAYED-ONCE  VALUE B'1'.
  167    011900       88  OVER-PAYMENT-NOT-DISPLAYED   VALUE B'0'.
         012000
  168    012100 01  INDICATOR-AREA.
  169    012200    05  IN99                      PIC 1 INDIC 99.
  170    012300       88 HELP-IS-NEEDED              VALUE B'1'.
  171    012400       88 HELP-IS-NOT-NEEDED          VALUE B'0'.
  172    012500    05  IN98                      PIC 1 INDIC 98.
  173    012600       88 END-OF-PAYMENT-UPDATE       VALUE B'1'.
  174    012700    05  IN97                      PIC 1 INDIC 97.
  175    012800       88 IGNORE-INPUT                VALUE B'1'.
  176    012900    05  IN51                      PIC 1 INDIC 51.
  177    013000       88 DISPLAY-ACCEPT-PAYMENT      VALUE B'1'.
  178    013100       88 DO-NOT-DISPLAY-ACCEPT-PAYMENT  VALUE B'0'.
  179    013200    05  IN52                      PIC 1 INDIC 52.
  180    013300       88 REVERSE-FIELD-IMAGE         VALUE B'1'.
  181    013400       88 DO-NOT-REVERSE-FIELD-IMAGE  VALUE B'0'.
  182    013500    05  IN53                      PIC 1 INDIC 53.
  183    013600       88 DO-NOT-DISPLAY-FIELD        VALUE B'1'.
  184    013700       88 DISPLAY-FIELD               VALUE B'0'.
```

Figure 152. Source Listing of a Payment Update Program Example (Part 5 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      7
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  185     013800    05  IN54                      PIC 1 INDIC 54.
  186     013900       88 PROTECT-INPUT-FIELD            VALUE B'1'.
  187     014000       88 DO-NOT-PROTECT-INPUT-FIELD     VALUE B'0'.
  188     014100    05  IN55                      PIC 1 INDIC 55.
  189     014200       88 MAKE-FIELD-BLINK               VALUE B'1'.
  190     014300       88 DO-NOT-MAKE-FIELD-BLINK        VALUE B'0'.
  191     014400    05  IN56                      PIC 1 INDIC 56.
  192     014500       88 DISPLAY-OVER-PAYMENT           VALUE B'1'.
  193     014600       88 DO-NOT-DISPLAY-OVER-PAYMENT    VALUE B'0'.
  194     014700    05  IN61                      PIC 1 INDIC 61.
  195     014800       88 CLEAR-SUBFILE                  VALUE B'1'.
  196     014900       88 DO-NOT-CLEAR-SUBFILE           VALUE B'0'.
  197     015000    05  IN62                      PIC 1 INDIC 62.
  198     015100       88 DISPLAY-SCREEN                 VALUE B'1'.
  199     015200       88 DO-NOT-DISPLAY-SCREEN          VALUE B'0'.
  200     015300    05  IN63                      PIC 1 INDIC 63.
  201     015400       88 DISPLAY-ACCEPT-HEADING         VALUE B'1'.
  202     015500       88 DO-NOT-DISPLAY-ACCEPT-HEADING  VALUE B'0'.
  203     015600    05  IN64                      PIC 1 INDIC 64.
  204     015700       88 DISPLAY-EXCEPTION              VALUE B'1'.
  205     015800       88 DO-NOT-DISPLAY-EXCEPTION       VALUE B'0'.
  206     015900    05  IN71                      PIC 1 INDIC 71.
  207     016000       88 DISPLAY-ACCEPT-MESSAGE         VALUE B'1'.
  208     016100       88 DO-NOT-DISPLAY-ACCEPT-MESSAGE  VALUE B'0'.
          016200
  209     016300 PROCEDURE DIVISION.
          016400
  210     016500 DECLARATIVES.
          016600
          016700 TRANSACTION-ERROR SECTION.
          016800     USE AFTER STANDARD ERROR PROCEDURE
          016900         PAYMENT-UPDATE-DISPLAY-FILE.
          017000 WORK-STATION-ERROR-HANDLER.
  211     017100     IF NOT (SUBFILE-IS-FULL) THEN
  212     017200       DISPLAY 'ERROR IN PAYMENT-UPDATE' STATUS-CODE-ONE
          017300     END-IF.
          017400 END DECLARATIVES.
          017500
          017600 MAIN-PROGRAM SECTION.
          017700 MAINLINE.
  213     017800     OPEN I-O      CUSTOMER-INVOICE-FILE
          017900                   CUSTOMER-MASTER-FILE
          018000                   PAYMENT-UPDATE-DISPLAY-FILE.
          018100
  214     018200     MOVE ALL B'0' TO INDICATOR-AREA
          018300                      SWITCH-AREA.
  215     018400     ACCEPT SYSTEM-DATE FROM DATE
          018500     END-ACCEPT.
  216     018600     MOVE SYSTEM-YEAR  TO PROGRAM-YEAR.
  217     018700     MOVE SYSTEM-MONTH TO PROGRAM-MONTH.
  218     018800     MOVE SYSTEM-DATE  TO PROGRAM-DAY.
  219     018900     SET WRITE-DISPLAY
          019000         CONTROL1-FORMAT
          019100         DO-NOT-DISPLAY-OVER-PAYMENT
          019200         DO-NOT-PROTECT-INPUT-FIELD
```

Figure 152. Source Listing of a Payment Update Program Example (Part 6 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page      8
STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         019300         DO-NOT-REVERSE-FIELD-IMAGE
         019400         DO-NOT-MAKE-FIELD-BLINK
         019500         CLEAR-SUBFILE TO TRUE.
 220     019600     MOVE CORR INDICATOR-AREA TO CONTROL1-O-INDIC.
               *** CORRESPONDING items for statement 220:
               ***     IN99
               ***     IN61
               ***     IN62
               ***     IN63
               ***     IN64
               *** End of CORRESPONDING items for statement 220
 221     019700     WRITE PAYMENT-UPDATE-DISPLAY-RECORD
         019800         FORMAT IS 'CONTROL1'
         019900     END-WRITE.
 222     020000     SET DO-NOT-CLEAR-SUBFILE TO TRUE.
 223     020100     PERFORM INITIALIZE-SUBFILE-RECORD 17 TIMES.
 224     020200     SET DISPLAY-SCREEN TO TRUE.
 225     020300     MOVE CORR INDICATOR-AREA TO CONTROL1-O-INDIC.
               *** CORRESPONDING items for statement 225:
               ***     IN99
               ***     IN61
               ***     IN62
               ***     IN63
               ***     IN64
               *** End of CORRESPONDING items for statement 225
 226     020400     WRITE PAYMENT-UPDATE-DISPLAY-RECORD
         020500         FORMAT IS 'CONTROL1'
         020600     END-WRITE.
 227     020700     READ PAYMENT-UPDATE-DISPLAY-FILE RECORD
         020800         FORMAT IS 'CONTROL1'
         020900     END-READ.
 228     021000     MOVE CORR CONTROL1-I-INDIC TO INDICATOR-AREA.
               *** CORRESPONDING items for statement 228:
               ***     IN99
               ***     IN98
               ***     IN97
               *** End of CORRESPONDING items for statement 228
         021100
 229     021200     PERFORM PROCESS-TRANSACTION-FILE
         021300       UNTIL END-OF-PAYMENT-UPDATE.
         021400
 230     021500     CLOSE CUSTOMER-INVOICE-FILE
         021600           CUSTOMER-MASTER-FILE
         021700           PAYMENT-UPDATE-DISPLAY-FILE.
 231     021800     STOP RUN.
         021900
         022000 PROCESS-TRANSACTION-FILE.
 232     022100     IF HELP-IS-NOT-NEEDED THEN
 233     022200        IF  IGNORE-INPUT THEN
 234     022300            SET WRITE-DISPLAY
         022400                CONTROL1-FORMAT
         022500                CLEAR-SUBFILE
         022600                DISPLAY-FIELD
         022700                DO-NOT-DISPLAY-OVER-PAYMENT
         022800                DO-NOT-PROTECT-INPUT-FIELD
```

Figure 152. Source Listing of a Payment Update Program Example (Part 7 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37       Page      9
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         022900                DO-NOT-REVERSE-FIELD-IMAGE
         023000                DO-NOT-DISPLAY-ACCEPT-PAYMENT
         023100                DO-NOT-DISPLAY-ACCEPT-HEADING
         023200                DO-NOT-DISPLAY-ACCEPT-MESSAGE
         023300                DO-NOT-MAKE-FIELD-BLINK TO TRUE
  235    023400            MOVE CORR INDICATOR-AREA TO CONTROL1-O-INDIC
               *** CORRESPONDING items for statement 235:
               ***     IN99
               ***     IN61
               ***     IN62
               ***     IN63
               ***     IN64
               *** End of CORRESPONDING items for statement 235
  236    023500             WRITE PAYMENT-UPDATE-DISPLAY-RECORD
         023600                 FORMAT IS 'CONTROL1'
         023700             END-WRITE
  237    023800             SET DO-NOT-CLEAR-SUBFILE TO TRUE
  238    023900             MOVE 0 TO REL-NUMBER
  239    024000             PERFORM INITIALIZE-SUBFILE-RECORD 17 TIMES
         024100          ELSE
  240    024200             SET TRANSACTIONS-EXIST
         024300                 DO-NOT-DISPLAY-ACCEPT-HEADING
         024400                 DO-NOT-DISPLAY-ACCEPT-MESSAGE
         024500                 DO-NOT-DISPLAY-EXCEPTION TO TRUE
  241    024600             PERFORM READ-MODIFIED-SUBFILE-RECORD
  242    024700             PERFORM TRANSACTION-VALIDATION
         024800                 UNTIL NO-MORE-TRANSACTIONS-EXIST
  243    024900             SET NO-INPUT-ERRORS-EXIST TO TRUE
  244    025000             PERFORM TEST-FOR-RECORD-INPUT-ERRORS
         025100                 VARYING REL-NUMBER
         025200                 FROM    1
         025300                 BY      1
         025400                 UNTIL   REL-NUMBER IS GREATER THAN 17
         025500                 OR      INPUT-ERRORS-EXIST
  245    025600             IF  NO-INPUT-ERRORS-EXIST THEN
  246    025700                 IF  OVER-PAYMENT-DISPLAYED-ONCE THEN
  247    025800                     SET WRITE-DISPLAY
         025900                         CONTROL1-FORMAT
         026000                         DO-NOT-DISPLAY-OVER-PAYMENT
         026100                         DO-NOT-PROTECT-INPUT-FIELD
         026200                         DO-NOT-REVERSE-FIELD-IMAGE
         026300                         DO-NOT-MAKE-FIELD-BLINK
         026400                         DO-NOT-DISPLAY-ACCEPT-PAYMENT
         026500                         DO-NOT-DISPLAY-ACCEPT-HEADING
         026600                         DO-NOT-DISPLAY-ACCEPT-MESSAGE
         026700                         DO-NOT-DISPLAY-EXCEPTION
         026800                         CLEAR-SUBFILE
         026900                         DISPLAY-FIELD
         027000                           TO TRUE
  248    027100                     MOVE CORR INDICATOR-AREA TO CONTROL1-O-INDIC
               *** CORRESPONDING items for statement 248:
               ***     IN99
               ***     IN61
               ***     IN62
               ***     IN63
```

Figure 152. Source Listing of a Payment Update Program Example (Part 8 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page     10
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
               ***     IN64
               *** End of CORRESPONDING items for statement 248
  249     027200                    WRITE PAYMENT-UPDATE-DISPLAY-RECORD
          027300                        FORMAT IS 'CONTROL1'
          027400                    END-WRITE
  250     027500                    SET DO-NOT-CLEAR-SUBFILE TO TRUE
  251     027600                    MOVE 0 TO REL-NUMBER
  252     027700                    PERFORM INITIALIZE-SUBFILE-RECORD 17 TIMES
          027800                ELSE
  253     027900                    SET OVER-PAYMENT-DISPLAYED-ONCE TO TRUE
          028000                END-IF
          028100            END-IF
          028200         END-IF
          028300     END-IF.
  254     028400     SET WRITE-DISPLAY, DISPLAY-SCREEN TO TRUE.
  255     028500     MOVE CORR INDICATOR-AREA TO MESSAGE1-O-INDIC.
               *** CORRESPONDING items for statement 255:
               ***     IN71
               *** End of CORRESPONDING items for statement 255
  256     028600     WRITE PAYMENT-UPDATE-DISPLAY-RECORD
          028700         FORMAT IS 'MESSAGE1'
          028800     END-WRITE.
  257     028900     SET WRITE-DISPLAY, CONTROL1-FORMAT TO TRUE.
  258     029000     MOVE CORR INDICATOR-AREA TO CONTROL1-O-INDIC.
               *** CORRESPONDING items for statement 258:
               ***     IN99
               ***     IN61
               ***     IN62
               ***     IN63
               ***     IN64
               *** End of CORRESPONDING items for statement 258
  259     029100     WRITE PAYMENT-UPDATE-DISPLAY-RECORD
          029200         FORMAT IS 'CONTROL1'
          029300     END-WRITE.
  260     029400     READ PAYMENT-UPDATE-DISPLAY-FILE RECORD
          029500         FORMAT IS 'CONTROL1'
          029600     END-READ.
  261     029700     MOVE CORR CONTROL1-I-INDIC TO INDICATOR-AREA.
               *** CORRESPONDING items for statement 261:
               ***     IN99
               ***     IN98
               ***     IN97
               *** End of CORRESPONDING items for statement 261
          029800
          029900 READ-MODIFIED-SUBFILE-RECORD.
  262     030000     READ SUBFILE PAYMENT-UPDATE-DISPLAY-FILE
          030100         NEXT MODIFIED RECORD FORMAT IS 'SUBFILE1'
  263     030200         AT END SET NO-MORE-TRANSACTIONS-EXIST TO TRUE
          030300     END-READ.
          030400
          030500 TEST-FOR-RECORD-INPUT-ERRORS.
  264     030600     READ SUBFILE PAYMENT-UPDATE-DISPLAY-FILE RECORD
          030700         FORMAT IS 'SUBFILE1'
          030800     END-READ.
  265     030900     IF  STSCDE OF SUBFILE1-I IS EQUAL TO '1' THEN
```

Figure 152. Source Listing of a Payment Update Program Example (Part 9 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page     11
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
  266     031000         SET INPUT-ERRORS-EXIST TO TRUE
          031100     END-IF.
          031200
          031300 TRANSACTION-VALIDATION.
  267     031400     MOVE CUST OF SUBFILE1-I OF PAYMENT-UPDATE-DISPLAY-RECORD
          031500         TO CUST OF CUSTOMER-MASTER-RECORD.
  268     031600     SET CUSTOMER-EXIST TO TRUE.
  269     031700     READ CUSTOMER-MASTER-FILE
  270     031800         INVALID KEY SET CUSTOMER-NOT-FOUND TO TRUE
          031900     END-READ.
  271     032000     IF  CUSTOMER-EXIST THEN
  272     032100         MOVE CUST OF CUSMST TO CUST OF ORDHDR
  273     032200         MOVE ZEROES TO INVNUM
  274     032300         SET CUSTOMER-INVOICE-EXIST TO TRUE
  275     032400         PERFORM START-ON-CUSTOMER-INVOICE-FILE
  276     032500         IF  CUSTOMER-INVOICE-EXIST THEN
  277     032600             PERFORM READ-CUSTOMER-INVOICE-RECORD
  278     032700             IF CUSTOMER-INVOICE-EXIST THEN
  279     032800                 PERFORM CUSTOMER-MASTER-FILE-UPDATE
  280     032900                 MOVE AMPAID OF SUBFILE1-I TO AMOUNT-PAID
  281     033000                 SET PAYMENT-EXIST TO TRUE
  282     033100                 PERFORM PAYMENT-UPDATE
          033200                     UNTIL NO-MORE-INVOICES-EXIST
          033300                     OR NO-MORE-PAYMENT-EXIST
  283     033400                 IF  ARBAL OF CUSTOMER-MASTER-RECORD IS NEGATIVE
  284     033500                     SET MAKE-FIELD-BLINK
          033600                         DISPLAY-FIELD
          033700                         DO-NOT-REVERSE-FIELD-IMAGE
          033800                         OVER-PAYMENT-NOT-DISPLAYED
          033900                         DISPLAY-OVER-PAYMENT
          034000                         DISPLAY-EXCEPTION
          034100                         DO-NOT-DISPLAY-ACCEPT-PAYMENT
          034200                         PROTECT-INPUT-FIELD TO TRUE
  285     034300                     MOVE ARBAL TO OVRPMT OF SUBFILE1-O
  286     034400                     MOVE MESSAGE-THREE TO ECPMSG OF SUBFILE1-O
  287     034500                     MOVE '0' TO STSCDE OF SUBFILE1-O
  288     034600                     PERFORM REWRITE-DISPLAY-SUBFILE-RECORD
          034700                 ELSE
  289     034800                     SET DO-NOT-DISPLAY-FIELD
          034900                         DO-NOT-DISPLAY-OVER-PAYMENT
          035000                         DO-NOT-REVERSE-FIELD-IMAGE
          035100                         DO-NOT-MAKE-FIELD-BLINK
          035200                         DO-NOT-DISPLAY-ACCEPT-PAYMENT
          035300                         PROTECT-INPUT-FIELD TO TRUE
  290     035400                     MOVE SPACES TO ECPMSG OF SUBFILE1-O
  291     035500                     MOVE ZEROES TO OVRPMT OF SUBFILE1-O
  292     035600                     MOVE '0' TO STSCDE OF SUBFILE1-O
  293     035700                     PERFORM REWRITE-DISPLAY-SUBFILE-RECORD
          035800                 END-IF
          035900             ELSE
  294     036000                 PERFORM NO-CUSTOMER-INVOICE-ROUTINE
          036100             END-IF
          036200         ELSE
  295     036300             PERFORM NO-CUSTOMER-INVOICE-ROUTINE
          036400         END-IF
```

Figure 152. Source Listing of a Payment Update Program Example (Part 10 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37       Page     12
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
         036500     ELSE
  296    036600         SET REVERSE-FIELD-IMAGE
         036700             DO-NOT-PROTECT-INPUT-FIELD
         036800             DISPLAY-FIELD
         036900             DO-NOT-DISPLAY-OVER-PAYMENT
         037000             DO-NOT-MAKE-FIELD-BLINK
         037100             DISPLAY-EXCEPTION
         037200             DO-NOT-DISPLAY-ACCEPT-PAYMENT
         037300             DO-NOT-PROTECT-INPUT-FIELD TO TRUE
  297    037400         MOVE ZEROES TO OVRPMT OF SUBFILE1-O
  298    037500         MOVE MESSAGE-ONE TO ECPMSG OF SUBFILE1-O
  299    037600         MOVE '1' TO STSCDE OF SUBFILE1-O
  300    037700         PERFORM REWRITE-DISPLAY-SUBFILE-RECORD
         037800     END-IF.
  301    037900     PERFORM READ-MODIFIED-SUBFILE-RECORD.
         038000
         038100 START-ON-CUSTOMER-INVOICE-FILE.
  302    038200     START CUSTOMER-INVOICE-FILE
         038300         KEY IS GREATER THAN COMP-KEY
  303    038400         INVALID KEY SET NO-MORE-INVOICES-EXIST TO TRUE
         038500     END-START.
         038600
         038700 READ-CUSTOMER-INVOICE-RECORD.
  304    038800     READ CUSTOMER-INVOICE-FILE NEXT RECORD
  305    038900         AT END SET NO-MORE-INVOICES-EXIST TO TRUE
         039000     END-READ.
  306    039100     IF  CUST OF CUSTOMER-MASTER-RECORD
         039200         IS NOT EQUAL TO CUST OF CUSTOMER-INVOICE-RECORD THEN
  307    039300         SET NO-MORE-INVOICES-EXIST TO TRUE
         039400     END-IF.
         039500
         039600 CUSTOMER-MASTER-FILE-UPDATE.
  308    039700     MOVE FILE-DATE TO LSTDAT OF CUSTOMER-MASTER-RECORD.
  309    039800     MOVE AMPAID OF SUBFILE1-I
         039900         TO LSTAMT OF CUSTOMER-MASTER-RECORD.
  310    040000     SUBTRACT AMPAID OF SUBFILE1-I
         040100         FROM ARBAL OF CUSTOMER-MASTER-RECORD.
  311    040200     REWRITE CUSTOMER-MASTER-RECORD
         040300         INVALID KEY
  312    040400             DISPLAY 'ERROR IN REWRITE OF CUSTOMER MASTER'
         040500     END-REWRITE.
         040600
         040700  REWRITE-DISPLAY-SUBFILE-RECORD.
  313    040800     MOVE AMPAID OF SUBFILE1-I TO AMPAID OF SUBFILE1-O.
  314    040900     MOVE CUST OF SUBFILE1-I TO CUST OF SUBFILE1-O.
  315    041000     SET WRITE-DISPLAY TO TRUE.
  316    041100     SET SUBFILE1-FORMAT TO TRUE.
  317    041200     MOVE CORR INDICATOR-AREA TO SUBFILE1-O-INDIC.
               *** CORRESPONDING items for statement 317:
               ***     IN51
               ***     IN52
               ***     IN53
               ***     IN54
               ***     IN55
               ***     IN56
```

Figure 152. Source Listing of a Payment Update Program Example (Part 11 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL                CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37        Page     13
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
             *** End of CORRESPONDING items for statement 317
  318     041300     REWRITE SUBFILE PAYMENT-UPDATE-DISPLAY-RECORD
          041400         FORMAT IS 'SUBFILE1'
          041500     END-REWRITE.
          041600
          041700 NO-CUSTOMER-INVOICE-ROUTINE.
  319     041800     IF  STSCDE OF SUBFILE1-I IS EQUAL TO '1' THEN
  320     041900        IF  ACPPMT OF SUBFILE1-I IS EQUAL TO '*NO' THEN
  321     042000           SET DO-NOT-DISPLAY-FIELD
          042100               DO-NOT-DISPLAY-OVER-PAYMENT
          042200               DO-NOT-REVERSE-FIELD-IMAGE
          042300               DO-NOT-MAKE-FIELD-BLINK
          042400               DO-NOT-DISPLAY-ACCEPT-PAYMENT
          042500               PROTECT-INPUT-FIELD
          042600                 TO TRUE
  322     042700            MOVE SPACES TO ECPMSG OF SUBFILE1-O
  323     042800            MOVE ZEROES TO OVRPMT OF SUBFILE1-O
  324     042900            MOVE '0' TO STSCDE OF SUBFILE1-O
  325     043000            PERFORM REWRITE-DISPLAY-SUBFILE-RECORD
          043100        ELSE
  326     043200            PERFORM CUSTOMER-MASTER-FILE-UPDATE
  327     043300            SET MAKE-FIELD-BLINK
          043400                DISPLAY-FIELD
          043500                DO-NOT-REVERSE-FIELD-IMAGE
          043600                OVER-PAYMENT-NOT-DISPLAYED
          043700                DISPLAY-OVER-PAYMENT
          043800                DISPLAY-EXCEPTION
          043900                DO-NOT-DISPLAY-ACCEPT-PAYMENT
          044000                PROTECT-INPUT-FIELD
          044100                  TO TRUE
  328     044200            MOVE ARBAL TO OVRPMT OF SUBFILE1-O
  329     044300            MOVE MESSAGE-THREE TO ECPMSG OF SUBFILE1-O
  330     044400            MOVE '0' TO STSCDE OF SUBFILE1-O
  331     044500            PERFORM REWRITE-DISPLAY-SUBFILE-RECORD
          044600         END-IF
          044700     ELSE
  332     044800         SET REVERSE-FIELD-IMAGE
          044900             DISPLAY-FIELD
          045000             DO-NOT-PROTECT-INPUT-FIELD
          045100             DO-NOT-DISPLAY-OVER-PAYMENT
          045200             DISPLAY-EXCEPTION
          045300             DISPLAY-ACCEPT-PAYMENT
          045400             DISPLAY-ACCEPT-HEADING
          045500             DISPLAY-ACCEPT-MESSAGE
          045600             DO-NOT-MAKE-FIELD-BLINK
          045700               TO TRUE
  333     045800         MOVE ZEROS TO OVRPMT OF SUBFILE1-O
  334     045900         MOVE MESSAGE-TWO TO ECPMSG OF SUBFILE1-O
  335     046000         MOVE '1' TO STSCDE OF SUBFILE1-O
  336     046100         PERFORM REWRITE-DISPLAY-SUBFILE-RECORD
          046200     END-IF.
          046300
          046400 PAYMENT-UPDATE.
  337     046500     SUBTRACT AMPAID OF CUSTOMER-INVOICE-RECORD
          046600         FROM ORDAMT OF CUSTOMER-INVOICE-RECORD
```

Figure 152. Source Listing of a Payment Update Program Example (Part 12 of 13)

```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL               CBLGUIDE/PAYUPDT         ISERIES1   03/09/15 15:08:37       Page     14
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
        046700         GIVING AMOUNT-OWED.
  338   046800     SUBTRACT AMOUNT-PAID
        046900         FROM AMOUNT-OWED
        047000         GIVING INVOICE-BALANCE.
  339   047100     IF  INVOICE-BALANCE IS LESS THAN 0.01 THEN
  340   047200         MOVE 2 TO OPNSTS OF CUSTOMER-INVOICE-RECORD
  341   047300         MOVE ORDAMT OF CUSTOMER-INVOICE-RECORD
        047400           TO AMPAID OF CUSTOMER-INVOICE-RECORD
  342   047500         SUBTRACT AMOUNT-OWED
        047600             FROM AMOUNT-PAID
        047700     ELSE
  343   047800         ADD AMOUNT-PAID TO AMPAID OF CUSTOMER-INVOICE-RECORD
  344   047900         SET NO-MORE-PAYMENT-EXIST TO TRUE
        048000     END-IF.
  345   048100     REWRITE CUSTOMER-INVOICE-RECORD
        048200         INVALID KEY
  346   048300             DISPLAY 'ERROR IN REWRITE OF CUSTOMER INVOICE'
        048400     END-REWRITE.
  347   048500     IF  PAYMENT-EXIST THEN
  348   048600         PERFORM READ-CUSTOMER-INVOICE-RECORD
        048700     END-IF.
        048800
        048900 INITIALIZE-SUBFILE-RECORD.
  349   049000     MOVE SPACES TO CUST OF SUBFILE1-O.
  350   049100     MOVE SPACES TO ECPMSG OF SUBFILE1-O.
  351   049200     MOVE '0' TO STSCDE OF SUBFILE1-O.
  352   049300     MOVE ZEROS TO AMPAID OF SUBFILE1-O.
  353   049400     MOVE ZEROS TO OVRPMT OF SUBFILE1-O.
  354   049500     ADD 1 TO REL-NUMBER.
  355   049600     MOVE CORR INDICATOR-AREA TO SUBFILE1-O-INDIC.
              *** CORRESPONDING items for statement 355:
              ***     IN51
              ***     IN52
              ***     IN53
              ***     IN54
              ***     IN55
              ***     IN56
              *** End of CORRESPONDING items for statement 355
  356   049700     WRITE SUBFILE PAYMENT-UPDATE-DISPLAY-RECORD
        049800         FORMAT IS 'SUBFILE1'
        049900     END-WRITE.
                       * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 152. Source Listing of a Payment Update Program Example (Part 13 of 13)

This is the initial display that is written to the work station to prompt you to enter the customer number and payment:

```
Customer Payment Update Prompt                                  Date  11/08/96

            Customer    Payment


            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________

            ______   _________
            ______   _________
            ______   _________
            ______   _________
            ______   _________
```

Enter the customer numbers and payments:

```
Customer Payment Update Prompt                                  Date  11/08/96

            Customer    Payment


             34500      2000
             40500     30000
             36000      2500
             12500       200
             22799      4500
             41900      7500
             10001      5000
             49500      2500
             13300      3500
             56900      4000
```

Payments that would result in overpayments or that have incorrect customer numbers are left on the display and appropriate messages are added:

```
Customer Payment Update Prompt                                  Date  11/08/96
Accept      Customer    Payment    Exception Message
Payment

_____        40500       30000     NO INVOICES EXIST FOR CUSTOMER

_____        12500         200     NO INVOICES EXIST FOR CUSTOMER

_____        41900        7500     NO INVOICES EXIST FOR CUSTOMER
             10001        5000     CUSTOMER DOES NOT EXIST

_____        13300        3500     NO INVOICES EXIST FOR CUSTOMER









Accept payment values: (*NO *YES)
```

Indicate which payments to accept:

```
Customer Payment Update Prompt                                  Date  11/08/96

Accept      Customer    Payment    Exception Message
Payment

  *NO        40500       30000     NO INVOICES EXIST FOR CUSTOMER

  *YES       12500         200     NO INVOICES EXIST FOR CUSTOMER

  *NO        41900        7500     NO INVOICES EXIST FOR CUSTOMER
             10001        5000     CUSTOMER DOES NOT EXIST

  *NO        13300        3500     NO INVOICES EXIST FOR CUSTOMER









Accept payment values: (*NO *YES)
```

The accepted payments are processed, and overpaymentinformation is displayed:

```
Customer Payment Update Prompt                                  Date  11/08/96
Accept      Customer    Payment    Exception Message
Payment

            12500         200      CUSTOMER HAS AN OVERPAYMENT OF         58.50

            10001        5000      CUSTOMER DOES NOT EXIST
```

Part 4. Appendixes

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Appendix A. Level of Language Support

COBOL Standard

Standard COBOL (as defined in the "About This Guide" on page ix) consists of eleven functional processing modules, seven of which are required and five of which are optional.

The seven required modules are: Nucleus, Sequential I-O, Relative I-O, Indexed I-O, Inter-Program Communication, Sort-Merge, and Source Text Manipulation. The five optional modules are: Intrinsic Function, Report Writer, Communication, Debug, Segmentation.

Language elements within the modules may be classified as level 1 elements and level 2 elements. Elements within nine of the modules are divided into level 1 elements and level 2 elements. Three of the modules (SORT-MERGE, REPORT WRITER, and INTRINSIC FUNCTION) contain only level 1 elements. For instance, Nucleus level 1 elements perform basic internal operations. Nucleus level 2 elements provide for more extensive and sophisticated internal processing.

The three subsets of Standard COBOL are the high subset, the intermediate subset, and the minimum subset. Each subset is composed of a level of the seven required modules: Nucleus, Sequential I-O, Relative I-O, Indexed I-O, Inter-Program Communication, Sort-Merge, and Source Text Manipulation. The five optional modules (Intrinsic Function, Report Writer, Communication, Debug and Segmentation) are not required in the three subsets of Standard COBOL.

- The high subset is composed of all language elements of the highest level of all required modules. That is:
  - Level 2 elements from Nucleus, Sequential I-O, Relative I-O, Indexed I-O, Inter-Program Communication, and Source Text Manipulation
  - Level 1 elements from Sort-Merge.
- The intermediate subset is composed of all language elements of level 1 of all required modules. That is:
  - Level 1 elements from Nucleus, Sequential I-O, Relative I-O, Indexed I-O, Inter-Program Communication, Sort-Merge, and Source Text Manipulation.
- The minimum subset is composed of all language elements of level 1 of the Nucleus, Sequential I-O, and Inter-Program Communication modules.

The five optional modules are not an integral part of any of the subsets. However, none, all, or any combination of the optional modules may be associated with any of the subsets.

ILE COBOL Level of Language Support

The ILE COBOL compiler supports:

- Level 2 of the Sequential I-O and Source-Text Manipulation
- Level 1 of the Nucleus, Relative I-O, Indexed I-O, Inter-Program Communication, and Sort-Merge modules.

The Report Writer, Communication, Debug, and Segmentation modules of Standard COBOL are not supported by the ILE COBOL compiler.

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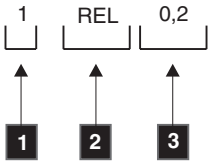
The Intrinsic Function module of ANSI X3.23a-1989 is partially supported by the ILE COBOL compiler.

The level of support provided by the ILE COBOL compiler is represented in Table 28. The table:

- Shows the level of ILE COBOL compiler support for each functional processing module of Standard COBOL
- Describes each module.

The following is an explanation of the notation used within the table:



1 The level of this module supported by the ILE COBOL compiler. In this example, support is provided for Level 1 of the Relative I-O module.

2 A 3-character code that identifies the module. In this example, the Relative I-O module is referred.

3 The **range** of levels of support **defined** by Standard COBOL. A level of 0 means a **minimum** standard of COBOL does not need to support this module to conform to the standard.

Table 28. Level of ILE COBOL Compiler Support

ILE COBOL Level of Language Supported	**Module Description**
Nucleus 1 NUC 1,2	Contains the language elements necessary for internal processing of data within the four basic divisions of a program and the capability for defining and accessing tables.
Sequential I-O 2 SEQ 1,2	Provides access to file records by the established sequence in which they were written to the file.
Relative I-O 1 REL 0,2	Provides access to records in either a random or sequential manner. Each record is uniquely identified by an integer that represents the record's logical position in the file.
Indexed I-O 1 INX 0,2	Provides access to records in either random or sequential manner. Each record in an indexed file is uniquely identified by a record key.
Inter-program Communication 1 IPC 1,2	Allows a COBOL program to communicate with other programs through transfers of control and access to common data items.
Sort-Merge 1 SRT 0,1	Orders one or more files of records, or combines two or more identically ordered files according to user-specified keys.
Source-Text Manipulation 2 STM 0,2	Allows insertion of predefined COBOL text into a program at compile time.
Report Writer 0 RPW 0,1	Provides semiautomatic production of printed reports.

Table 28. Level of ILE COBOL Compiler Support (continued)

ILE COBOL Level of Language Supported	Module Description
Communications 0 COM 0,2	Provides the ability to access, process, and create messages or portions of messages; also allows communication through a Message Control System with local and remote communication devices.
Debug 0 DEB 0,2	Allows you to specify statements and procedures for debugging.
Intrinsic Function 0 ITR 0,1	Provides the capability to reference a data item whose value is derived automatically at the time of reference during the execution of the object program.
Segmentation 0 SEG 0,2	Provides the overlaying at object time of Procedure Division sections.

System Application Architecture® (SAA®) Common Programming Interface (CPI) Support

Source file QCBLLESRC in product library QSYSINC contains members that hold specifications for multiple SAA® Common Programming Interfaces. These specifications describe parameter interfaces. This file is IBM-owned and should not be changed.

If you want to customize any of the specifications, you must copy any members that you want to change to a source file in one of your libraries. You can use the Copy File (CPYF) command to do this. For more information about the CPYF command, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

If you copy these specifications to your library, you must refresh your copies when a new product release is installed, or when any changes are made using a Program Temporary Fix (PTF). IBM provides maintenance for these specifications only in the libraries in which they are distributed.

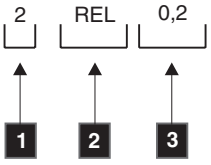
Appendix B. The Federal Information Processing Standard (FIPS) Flagger

The FIPS flagger can be specified to monitor a FIPS COBOL subset, any of the optional modules, all of the obsolete language elements, or a combination of a FIPS COBOL subset, optional modules and all obsolete elements.

The monitoring is an analysis that compares the syntax used in the source program with the syntax included in the user-selected FIPS subset and optional modules. Any syntax used in the source program that does not conform to the selected FIPS COBOL subset and optional modules is identified. Any syntax for an obsolete language element used in the source program will also be identified (depending on the compiler option chosen). See page "FLAGSTD Parameter" on page 39 for more information on the parameters for FIPS flagging.

FIPS 21-4 COBOL specifications are the language specifications contained in Standard COBOL (as described in "About This Guide" on page ix). FIPS COBOL is subdivided into three subsets and four optional modules. The three subsets are identified as Minimum, Intermediate and High. The four optional modules are Report Writer, Communication, Debug, and Segmentation. These four optional modules are not an integral part of any of the subsets; however, none, all, or any combination of the optional modules may be associated with any of the subsets. Any program written to conform to the FIPS 21-4 COBOL standard must conform to one of the subsets of FIPS 21-4 COBOL. Table 29 shows the ANSI Standard COBOL processing modules included in each of the subsets of FIPS 21-4 COBOL.

The following is an explanation of the notation used within the table:



1. The level of this module supported by the FIPS 21-4 COBOL Standard. In this example, support is provided for Level 2 of the Relative I-O module.
2. A 3-character code that identifies the module. In this example, the Relative I-O module is referred.
3. The **range** of levels of support **defined** by Standard COBOL. A level of 0 means a **minimum** standard of COBOL does not need to support this module to conform to the standard.

Table 29. Standard COBOL and FIPS 21-4 COBOL

ANSI Module Name	High FIPS	Intermediate FIPS	Minimum FIPS
Nucleus	2 NUC 1,2	1 NUC 1,2	1 NUC 1,2
Sequential I-O	2 SEQ 1,2	1 SEQ 1,2	1 SEQ 1,2
Relative I-O	2 REL 0,2	1 REL 0,2	0 REL 0,2
Indexed I-O	2 INX 0,2	1 INX 0,2	0 INX 0,2
Source-Text Manipulation	2 STM 0,2	1 STM 0,2	0 STM 0,2

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Table 29. Standard COBOL and FIPS 21-4 COBOL (continued)

ANSI Module Name	High FIPS	Intermediate FIPS	Minimum FIPS
Sort-Merge	1 SRT 0,1	1 SRT 0,1	0 SRT 0,1
Intrinsic Function	1 ITR 0,1	0 ITR 0,1	0 ITR 0,1
Inter-Program Communication	2 IPC 1,2	1 IPC 1,2	1 IPC 1,2
Report Writer	0, or 1 RPW 0,1	0, or 1 RPW 0,1	0, or 1 RPW 0,1
Segmentation	0,1 or 2 SEG 0,2	0,1 or 2 SEG 0,2	0,1 or 2 SEG 0,2
Debug	0,1 or 2 DEB 0,2	0,1 or 2 DEB 0,2	0,1 or 2 DEB 0,2
Communications	0,1 or 2 COM 0,2	0,1 or 2 COM 0,2	0,1 or 2 COM 0,2

Elements that are specified in the ILE COBOL source program and that are not included in FIPS 21-4 COBOL are flagged as described in Appendix A, "Level of Language Support," on page 581.

Appendix C. ILE COBOL Messages

This appendix provides a general description of messages that IBM supplies with the ILE COBOL licensed program.

COBOL Message Descriptions

The messages for the ILE COBOL licensed program begin with prefixes LNC, LNM, LNP, LNR, or LNT.

- The LNC messages are issued by the COBOL syntax checker when SEU is used to enter your ILE COBOL source code. The LNC messages are also compiler-generated messages.
- The LNM messages are used as headings during a run time ILE COBOL formatted dump.
- The LNP messages are used in the ILE COBOL CL commands and menus.
- The LNR messages provide you with additional information about system operation during run time.
- The LNT messages are used as headings for various parts of the ILE COBOL compiler listing.

Message numbers are assigned as follows:

Error Message	Description
LNR7000 through LNR7199	Escape messages
LNR7200 through LNR7999	Run-time messages
LNR8000 through LNR8200	Escape messages
LNC0000 through LNC0999	Messages with severity less than 30
LNC1000 through LNC2999	Messages with severity greater than or equal to 30
LNC8000 through LNC8799	FIPS Flagger messages
LNC9001 through LNC9099	Compiler messages

Severity Levels

The ILE COBOL licensed program provides the following message severity levels:

Severity	Meaning
00	Informational: This level is used to convey information to the user. No error has occurred. Informational messages are listed only when the FLAG (00) option is specified.
10	Warning: This level indicates that an error was detected but is not serious enough to interfere with the running of the program.
20	Error: This level indicates that an error was made, but the compiler is taking a recovery that might yield the desired code.
30	Severe Error: This level indicates that a serious error was detected. Compilation is completed, but the module object is not created and running of the program cannot be attempted.
40	Unrecoverable: This level usually indicates a user error that forces termination of processing.

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50 Unrecoverable: This level usually indicates a compiler error that forces termination of processing.

99 Action: Some manual action is required, such as entering a reply, changing printer forms, or replacing diskettes.

Note: 00, 10, and 20 messages are suppressed when the FLAG(30) option of the PROCESS statement is used or the CRTCBLMOD/CRTBNDCBL command specifies FLAG(30) and is not overridden by the PROCESS statement. See "Using the PROCESS Statement to Specify Compiler Options" on page 49 for further information.

The compiler always attempts to provide full diagnostics of all source text in the program, even when errors have been detected. If the compiler cannot continue on a given statement, the message states that the compiler cannot continue and that it will ignore the rest of the statement. When this error occurs, the programmer should examine the entire statement.

The OS/400 message facility is used to produce all messages. The ILE COBOL compiler messages reside in the message file, QLNCMSG, and the run-time messages reside in the message file, QLNRMSG.

Substitution variables and valid reply values are determined by the program sending the message, *not* by the message description stored in the message file. However, certain elements of a message description can be changed: for example, the text, severity level, default response, or dump list. To effect such changes, you need to define another message description using an Add Message Description (ADDMSGD) command, place the modified description in a user-created message file, and specify that file in the Override Message File (OVRMSGF) command. Using the OVRMSGF command allows the compiler to retrieve messages from the specified file. For additional information, see the ADDMSGD and OVRMSGF commands in the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Note: If an IBM-supplied message must be changed and replaced in its message file, call your service representative.

CAUTION

Overriding an IBM-supplied message with a user-created message can produce results you do not anticipate. If reply values are not retained, the program might not respond to any replies. Changing default replies on *NOTIFY type messages could affect the ability of the program to run in unattended mode. Changing the severity could cancel a job not previously canceled. Be cautious when overriding IBM-supplied messages with user-created messages.

Compilation Messages

LNC messages are printed in the program listing when errors are found during program compilation. The LNC messages include the message issued when Federal Information Processing Standard (FIPS) flagging is requested; for more information on the FIPS messages, refer to page "The FIPS Flagger" on page 585 in this appendix.

Program Listings

In the compiler output, the ILE COBOL messages listing follows the source listing. The ILE COBOL messages listing gives the message identifier, severity, text, usually the location of the error, and the messages summary.

When the *IMBEDERR value is specified with the OPTION parameter of the CRTCBLMOD or CRTBNDCBL commands, first level message text is also provided in the source listing immediately following the line on which the error was detected.

For more information about Program Listings, see "Source Listing" on page 63.

Interactive Messages

In an interactive environment, messages are displayed on the workstation display. They can appear on the current display as a result of the running of the program or in response to your keyed input to prompts, menus, command entry displays, or WebSphere Development Studio tools. The messages can also appear on request, as a result of a display command or an option on a menu.

The messages for the ILE COBOL licensed program begin with an LNC or LNR prefix.

The LNC messages are issued by the ILE COBOL syntax checker when the Source Entry Utility (SEU) is used to enter your ILE COBOL source code. For example, you see the following display after incorrectly entering the program name in the PROGRAM-ID paragraph.

```
Columns . . . :    1  71           Edit           XMPLIB/QCBLLESRC
SEU==> ____________________________________________________________     TESTPR
FMT CB .....-A+++B++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
       *************** Beginning of data ************************************
0000.10        IDENTIFICATION DIVISION.
0000.20        PROGRAM-ID. #TESTPR.
0000.70        ENVIRONMENT DIVISION.
0000.90        SOURCE-COMPUTER. IBM-ISERIES.
       ****************** End of data ***************************************
F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F10=Cursor
F16=Repeat find       F17=Repeat change          F24=More keys
# not in COBOL character set. Line rejected.
```

Figure 153. Example of a ILE COBOL Syntax Checker Message

The LNC messages are also issued during program compilation. See "Compilation Messages" on page 588 for a description.

LNR messages provide you with additional information about system operation during run time. For example, you might see the following display if you have a runtime error:

```
                  Display Program Messages
Job 008529/TESTLIB/QPADEV0003 started on 94/04/08 at 15:32:58 in subsystem Q
Message 'MCH1202' in program object 'SAMPDUMP' in library 'TESTLIB' (C D F G


Type reply, press Enter.
  Reply . . .   _____________________________________________________________
_____________________________________________________________________________

F3=Exit   F12=Cancel
```

Figure 154. Run-Time Error Message

If you move the cursor to the line on which message number MCH1202 is indicated and press either the HELP key or F1, the LNR message information is displayed as shown:

```
                       Additional Message Information
 Message ID . . . . . :   LNR7200       Severity . . . . . :   50
 Message type . . . . :   Inquiry
 Date sent  . . . . . :   96/11/08      Time sent  . . . . . :   15:33:31
 Message . . . . :   Message 'MCH1202' in program object 'SAMPDUMP' in library
   'TESTLIB' (C D F G).
 Cause . . . . . :   Message 'MCH1202' was detected in COBOL statement 42 of
   COBOL program 'SAMPDUMP' in program object 'SAMPDUMP' in library 'TESTLIB'.
 Recovery  . . . :   Enter a G to continue the program at the next MI
   instruction, or a C if no dump is wanted, a D if a dump of the COBOL
   identifiers is wanted, or an F to dump both the COBOL identifiers and the
   file information. The message text for 'MCH1202' follows: 'Decimal data
   error.'
 Possible choices for replying to message . . . . . :
   C -- No formatted dump is given
   D -- A dump of the COBOL identifiers is given
                                                                        More...
 Press Enter to continue.
 F3=Exit   F6=Print   F10=Display messages in job log
 F11=Display message details   F12=Cancel   F21=Select assistance level
```

```
                       Additional Message Information
 Message ID . . . . . :   LNR7200       Severity . . . . . :   50
 Message type . . . . :   Inquiry
   F -- A dump of the COBOL identifiers and file information
   G -- To continue the program at the next MI instruction.

                                                                      Bottom
 Press Enter to continue.

 F3=Exit   F6=Print   F10=Display messages in job log
 F11=Display message details   F12=Cancel   F21=Select assistance level
```

Figure 155. Runtime Error Message—Second-Level Text

"Responding to Messages" explains how to display second-level message text and how to reply to messages.

LNM messages 0001 to 0050 are used as headings for information printed during a ILE COBOL formatted dump.

Responding to Messages

In an interactive environment, a message is indicated by one or several of these conditions:

- A brief message (called first-level text) on the message line
- Reverse image highlighting of the input field in error

- A locked keyboard
- The sound of an alarm (if the alarm option is installed).

The following paragraphs briefly describe some methods of responding to error messages; more information is available in the WebSphere Development Studio publications.

If the necessary correction is obvious from the initial display, you can press the Error Reset key (if the keyboard is locked), enter the correct information, and continue your work.

If the message requires that you choose a reply (such as **C** to cancel, **D** to dump COBOL identifiers, **F** to dump COBOL identifiers and file information, or **G** to resume processing at the next COBOL statement), the reply options are shown in parentheses in the first-level message text. For an example, see Figure 154 on page 590.

If the information on the initial information display does not provide sufficient data for you to handle the error, you can press the HELP key (after positioning the cursor to the message line, if required) to get a second-level display with additional information about how to correct this error. To return to the initial display, press the Enter key; then press the Error Reset key (if the keyboard is locked), and make your correction or response.

If the error occurs when you are compiling or running a program, you might need to modify your ILE COBOL source statements or control language (CL) commands. Refer to the *ADTS for AS/400: Source Entry Utility* for information on how to change the statements.

Appendix D. Supporting International Languages with Double-Byte Character Sets

This appendix describes only those enhancements made to the COBOL programming language for writing programs that process double-byte characters.

Specifically, this appendix describes where you can use Double-Byte Character Set (DBCS) characters in each portion of a COBOL program, and considerations for working with DBCS data in the ILE COBOL language.

There are two ways to specify DBCS characters:
- Bracketed-DBCS
- DBCS-graphic data.

In general, COBOL handles bracketed-DBCS characters in the same way it handles alphanumeric characters. **Bracketed-DBCS** is a character string in which each character is represented by two bytes. The character string starts with a shift-out (SO) character, and ends with a shift-in (SI) character. It is up to you to know (or have the COBOL program check) which data items contain DBCS characters, and to make sure the program receives and processes this information correctly.

You can use DDS descriptions that define DBCS-graphic data fields with your ILE COBOL programs. **DBCS-graphic** pertains to a character string where each character is represented by two bytes. The character string does not contain shift-out or shift-in characters. For information on handling graphic data items specified in externally-described files in your ILE COBOL programs, refer to "DBCS-Graphic Fields" on page 427.

Using DBCS Characters in Literals

A mixed literal consists of Double-Byte Character Set (DBCS) and Single-Byte Character Set (SBCS) characters.

The GRAPHIC option of the PROCESS statement is available for processing DBCS characters in mixed literals. When the GRAPHIC option is specified, mixed literals will be handled with the assumption the hex 0E and hex 0F are shift-in and shift-out characters respectively, and they enclose the DBCS characters in the mixed literal. When NOGRAPHIC is specified or implied, the ILE COBOL compiler will treat nonnumeric literals containing hex 0E and hex 0F as if they only contains SBCS characters. Hex 0E and hex 0F are not treated as shift-in and shift-out characters, they are considered to be part of the SBCS character string.

A DBCS literal consists only of Double-Byte Character Set characters and is always treated as a DBCS character string.

Note: The GRAPHIC option on the PROCESS statement is not to be confused with the *PICXGRAPHIC or *PICGGRAPHIC values in the CVTOPT parameter of the CRTCBLMOD or CRTBNDCBL command and the CVTPICXGRAPHIC and CVTPICGGRAPHIC options on the PROCESS statement, which are used to specify double-byte graphic data from a DDS description. For more information on specifying graphic data, refer to "DBCS-Graphic Fields" on page 427.

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How to Specify Literals Containing DBCS Characters

When you specify any literal that contains DBCS characters, follow the same rules that apply in specifying alphanumeric literals, as well as the following rules specific to mixed and DBCS literals:

- Mixed literals can take many different forms. The following are only two possible examples:

  "SINGLE0$_E$K1K2K30$_F$BYTES"

  "0$_E$K1K20$_F$"
- DBCS literals start with

  G"O$_E$ or N"0$_E$

  followed by one or more Double-Byte characters and ended with

  0$_F$"

  An example of this is as follows:

  G"0$_E$KIK20$_F$"
  N"0$_E$ 0$_F$"
- Mixed literals have an implicit USAGE DISPLAY. DBCS literals have an implicit USAGE DISPLAY-1.
- EBCDIC characters can appear before or after any DBCS string in the mixed literal.
- All DBCS strings appear between shift-out and shift-in characters. A **shift-out** character is a control character (hex 0E) that indicates the start of a string of double-byte characters. A shift-out character occupies 1 byte. A **shift-in** character is a control character (hex 0F) that indicates the end of a string of double-byte characters. A shift-in character occupies 1 byte.
- Double all SBCS quotation marks that occur within the mixed literal. DBCS quotation marks within G″ literals do not require doubling but DBCS quotation marks within N″ literals must be doubled. For example:

  "Mixed ""0$_E$K1K2K30$_F$"" literal"
  G"0$_E$K1K2K3"K4"K5K60$_F$"
  N"0$_E$K1K2K3""K4""K5K60$_F$"
- You can use null DBCS strings (shift-out and shift-in characters without any DBCS characters) in a mixed literal *only* when the literal contains at least one SBCS character.

The shift-out and shift-in characters cannot be nested.

The shift control characters are part of a mixed literal (not a pure DBCS literal), and take part in all operations.

Other Considerations

Quotation Marks: Although the preceding discussion uses the term *a quotation mark* to describe the character that identifies a literal, the character actually used can vary depending upon the option specified on the CRTCBLMOD or CRTBNDCBL commands, or on the PROCESS statement. If you specify the APOST option, an apostrophe (') is used. Otherwise, a quotation mark (") is used. In this appendix, *a quotation mark* refers to both an apostrophe and a quotation mark. The character that you choose does not affect the rules for specifying a literal.

Shift Characters: The shift-out and shift-in characters separate EBCDIC characters from DBCS characters. They are part of the mixed literal. Therefore, the shift code

characters participate in all operations when they appear in mixed literals. Shift code characters do not participate in any operations when they appear in DBCS literals.

How the COBOL Compiler Checks DBCS Characters

When the COBOL compiler finds a DBCS string, it checks the DBCS string by scanning it one DBCS character at a time.

The following conditions cause the COBOL compiler to diagnose a literal containing DBCS characters as *not valid:*

- The syntax for the literal is incorrect.
- The mixed literal is longer than one line and does *not* follow the rules for continuing nonnumeric literals. (See "How to Continue Mixed Literals on a New Line" for more information.)
- The DBCS literal is longer than one line.

For each DBCS, mixed, or SBCS literal that is not valid, the compiler generates an error message and accepts or ignores the literal.

How to Continue Mixed Literals on a New Line

To continue a mixed literal onto another line of source code, do *all* of the following:

- Place a shift-in character in either column 71 or column 72 of the line to be continued. (If you put the shift-in character in column 71, the blank in column 72 is ignored.)
- Place a hyphen (-) in column 7 (the continuation area) of the new line.
- Place a quotation mark, then a shift-out character, and then the rest of the literal in Area B of the new line.

For example:

```
-A 1 B
   ⋮
 01  DBCS1             PIC X(12)                VALUE "0EK1K2K30F
-    "0EK4K50F".
   ⋮
```

The value of DBCS1 is "0_EK1K2K3K4K50$_F$".

The shift-in character, quotation mark, and shift-out character used to continue a line are not counted in the length of the mixed literal. The first shift-out and final shift-in characters are counted.

Syntax-Checker Considerations

When the syntax-checker is working with a line containing a literal, it has no way of knowing whether or not the user intends to specify the GRAPHIC option when the program is compiled. It, therefore, assumes that the default option, NOGRAPHIC, is in effect. This means that certain mixed literals that are valid if compiled with the GRAPHIC option will cause syntax errors to be flagged. For example:

"ABC0_EK1K"0_FDEF"

is valid when the GRAPHIC option is specified, since the double quotation mark appearing between the shift-out and shift-in characters is treated as one element of

a DBCS character. The syntax-checker, however, will mistake this double quotation mark as the termination character for the literal, and the remaining characters (starting with the shift-in character) will be flagged as an error. This may be avoided by replacing the mixed literal with a combination of SBCS nonnumeric literals and pure DBCS literals.

Where You Can Use DBCS Characters in a COBOL Program

In general, you can use mixed literals wherever nonnumeric literals are allowed. Literals for the following, however, cannot include double-byte characters:

- ALPHABET-name clause
- CURRENCY SIGN clause
- ASSIGN clause
- CLASS-name clause
- CALL statement
- CANCEL statement.

You can use DBCS literals whenever nonnumeric literals are allowed except as a literal in the following:

- ALPHABET clause
- ASSIGN clause
- CLASS clause
- CURRENCY SIGN clause
- LINKAGE clause
- CALL statement program-id
- CANCEL statement
- END PROGRAM statement
- PADDING CHARACTER clause
- PROGRAM-ID paragraph
- ACQUIRE statement
- DROP statement
- As the text-name in a COPY statement
- As the library-name in a COPY statement.

Note: You can use DBCS characters for COBOL words or names. See the *WebSphere Development Studio: ILE COBOL Reference* for information on rules for formatting COBOL system-names, reserved words, and user-defined words such as data names and file names.

How to Write Comments

You can write comments containing DBCS characters in a COBOL program by putting an asterisk (*) or slash (/) in column seven of the program line. Either symbol causes the compiler to treat any information following column seven as documentation. The slash also causes a page eject. Because the COBOL compiler does not check the contents of comment lines, DBCS characters in comments are not detected. DBCS characters that are not valid can cause the compiler listing to print improperly.

Identification Division

You can put comment entries that contain DBCS characters in any portion of the Identification Division except the PROGRAM-ID paragraph. The program name specified in the PROGRAM-ID paragraph must be alphanumeric.

Environment Division

Configuration Section

You can use DBCS characters in comment entries only in the Configuration Section paragraph. All function-names, mnemonic-names, condition-names, and alphabet-names must be specified with alphanumeric characters. For the SOURCE-COMPUTER and the OBJECT-COMPUTER entry, use the alphanumeric computer name:

```
IBM-ISERIES
```

You cannot use mixed literals in the Configuration Section. Instead, use alphanumeric literals to define an alphabet-name and the literal in the CURRENCY SIGN clause of the SPECIAL-NAMES paragraph. There is no DBCS alphabet or class. Use the EBCDIC character set instead.

Input-Output Section

Specify all data names, file names, and assignment names using alphanumeric characters. You can use DBCS characters in comments.

For indexed files, the data name in the RECORD KEY clause can refer to a DBCS data item within a record.

You cannot use DBCS mixed data as the RELATIVE KEY in relative files.

File Control Paragraph

ASSIGN Clause

You cannot use literals containing DBCS characters in the ASSIGN clause to specify an external medium such as a printer or a database.

Data Division

File Section

For the FD (File Description) Entry, you can use DBCS data items or literals in the VALUE OF clause. The DATA RECORDS clause can refer to data items only. Because the ILE COBOL compiler treats both the VALUE OF clause and the DATA RECORDS clause in the File Section as documentation, neither clause has any effect when you run the program. However, the COBOL compiler checks all literals in the VALUE OF clause to make sure they are valid.

For magnetic tapes, the system can only read DBCS characters from or write DBCS characters to the tape in the EBCDIC format. The system cannot perform tape functions involving a tape in the ASCII format. Define the alphabet-name in the CODE-SET clause as NATIVE or EBCDIC.

Working-Storage Section

REDEFINES Clause

The existing rules for redefining data also apply to data that contains DBCS characters. When you determine the length of a redefining or redefined data item, remember that each DBCS character is twice as long as an alphanumeric character.

Also, ensure that redefined data items contain the shift control characters when and where necessary.

OCCURS Clause

Use this clause to define tables for storing DBCS data. If you specify the ASCENDING/DESCENDING KEY phrase, COBOL assumes the contents of the table are in the EBCDIC program collating sequence. The shift control characters in mixed data take part in the collating sequence.

For more information about handling tables that contain DBCS characters, see "Table Handling—SEARCH Statement" on page 604.

JUSTIFIED RIGHT Clause

Use the JUSTIFIED RIGHT clause to align DBCS data at the rightmost position of an elementary receiving field. If the receiving field is shorter than the sending field, COBOL truncates the rightmost characters. If the receiving field is longer than the sending field, COBOL pads (fills) the unused space on the left of the receiving field with blanks.

The JUSTIFIED clause does not affect the initial setting in the VALUE clause.

VALUE Clause

You can use mixed literals to specify an initial value for a data item that is not numeric, or to define values for level-88 condition-name entries. DBCS literals should be used to specify initial values for DBCS or DBCS-edited data items.

Any shift control characters in the literal are considered part of the literal's picture string, except when used to continue a new line. When you continue a mixed literal, the compiler does *not* include the shift-in character in column 71 or 72, or the initial quotation mark (") and shift-out character on the continued line as part of the mixed literal. Make certain, however, that the mixed literal does not exceed the size of the data item specified in the PICTURE clause, otherwise truncation occurs.

DBCS literals can be used to initialize DBCS data items.

When you use literals that contain DBCS characters in the VALUE clause for level-88 condition-name entries, COBOL treats the DBCS characters as alphanumeric. Therefore, follow the rules for specifying alphanumeric data, including allowing a THROUGH option. This option uses the normal EBCDIC collating sequence, but remember that shift control characters in DBCS data take part in the collating sequence.

PICTURE Clause

Use the PICTURE symbol X to define mixed data items and either G or N for DBCS data items. You would define a DBCS data item containing *n* DBCS characters as

```
PICTURE G(n) or PICTURE N(n)
```

A mixed data item containing *m* SBCS characters, and one string of *n* DBCS characters would be defined as

```
PICTURE X(m+2n+2)
```

You can use all edited alphanumeric PICTURE symbols for mixed data items. The editing symbols have the same effect on the DBCS data in these items as they do on alphanumeric data items. Check that you have obtained the desired results. Pure DBCS data items can only use the B-editing symbol.

RENAMES Clause

Use this clause to specify alternative groupings of elementary data items. The existing rules for renaming alphanumeric data items also apply to DBCS data items.

Procedure Division

Intrinsic Functions

You can use DBCS data items, DBCS literals, and mixed literals as arguments to some intrinsic functions.

Intrinsic functions may also return a DBCS data item if one of the arguments of the intrinsic function is a DBCS data item or a DBCS literal.

For more information on the intrinsic functions that support DBCS items see the chapter on Intrinsic Functions in the *WebSphere Development Studio: ILE COBOL Reference*.

Conditional Expressions

Because condition-names (level-88 entries) can refer to data items that contain DBCS characters, you can use the condition-name condition to test this data. (See "VALUE Clause" on page 598.) Follow the rules listed in the *WebSphere Development Studio: ILE COBOL Reference* for using conditional variables and condition-names.

You can use DBCS data items or mixed literals as the operands in a relation condition. Because COBOL treats mixed data as alphanumeric, all comparisons occur according to the rules for alphanumeric operands. DBCS data items can only be compared to other DBCS data items. Keep the following in mind:

- The system does not recognize the mixed content
- The system uses the shift codes in comparisons of mixed data
- The system compares the data using either the EBCDIC collating sequence, or a user-defined sequence
- In a comparison of DBCS items with similar items of unequal size, the smaller item is padded on the right with spaces.

See "SPECIAL-NAMES" paragraph in the *WebSphere Development Studio: ILE COBOL Reference* for more information.

You can use class conditions and switch status conditions as described in the *WebSphere Development Studio: ILE COBOL Reference*.

Input/Output Statements

ACCEPT Statement

The input data received from a device by using a Format 1 ACCEPT statement can include DBCS. All DBCS data must be identified by the proper syntax. The input

data, excluding shift control characters, replaces the existing contents of a DBCS data item. The shift control characters are included in the contents of the mixed data items. COBOL does not perform special editing or error checking on the data.

If you use the Format 3 ACCEPT statement to get OPEN-FEEDBACK information about a file, that information includes a field showing whether the file has DBCS or mixed data.

Information received from the local data area by a Format 4 ACCEPT statement can include DBCS or mixed character strings. Information received replaces the existing contents. COBOL does not perform any editing or checking for errors. This also applies to information received from the PIP data area by a Format 5 ACCEPT statement, and from a user defined data area by a Format 9 ACCEPT statement.

Using the Format 6 ACCEPT statement, you can get the attributes of a workstation display and its keyboard. For display stations that can display DBCS characters, the system sets the appropriate value in the ATTRIBUTE-DATA data item. You cannot use DBCS characters to name a device.

If you use an extended (Format 7) ACCEPT statement for field-level workstation input, you must ensure that DBCS data is not split across lines. COBOL does not perform any checking for errors or editing, except for the removal of shift in and shift out characters when necessary.

DISPLAY Statement

You can specify DBCS or mixed data items or literals in the DISPLAY statement. You can mix the types of data. DBCS and mixed data, from either data items or literals, is sent as it appears to the program device or local data area or user-defined data area that is the target named on the DISPLAY statement.

Because COBOL does not know the characteristics of the device on which data is being displayed, you must make sure that the DBCS and mixed data is correct.

Note: ALL is a valid option for mixed literals.

If you use a Format 3 DISPLAY statement or a Format 4 DISPLAY statement for field-level workstation output, you must ensure that DBCS data is not split across lines.

READ Statement

You can use DBCS data items as the RECORD KEY for an indexed file. See “Input-Output Section” on page 597 for more information.

INTO Phrase: You can read a record into a DBCS data item using the INTO phrase. This phrase causes a MOVE statement (without the CORRESPONDING option) to be performed. The compiler moves DBCS data in the same manner that it moves alphanumeric data. It does not make sure that this data is valid.

REWRITE Statement

Use the FROM phrase of this statement to transfer DBCS data from a DBCS data item to an existing record. The FROM phrase causes both types of data to be moved in the same manner as the INTO phrase with the READ statement. (See “READ Statement.”)

START Statement

If you use DBCS characters in the key of an indexed file, specify a corresponding data item in the KEY phrase of the START statement.

One of the following must be true:

- The data item must be the same as the data item specified in the RECORD KEY clause of the FILE-CONTROL paragraph.
- The data item has the same first character as the record key and is not longer than the record key.

You can specify valid operators (such as EQUAL, GREATER THAN, NOT LESS THAN) in the KEY phrase. The system can follow either the EBCDIC or a user-defined collating sequence.

WRITE Statement

Use the FROM phrase of this statement to write DBCS data to a record. This phrase moves the data in the same manner as the REWRITE statement. (See "REWRITE Statement" on page 600.)

You must include the shift control characters when you write the data into a device file.

Data Manipulation Statements

Arithmetic Statements

Because COBOL treats DBCS characters in the same manner that it treats SBCS characters, do not use DBCS characters in numeric operations, nor manipulate them with arithmetic statements.

INSPECT Statement

You can use any DBCS data item as an operand for the INSPECT statement. The system tallies and replaces on each half of a DBCS character, including the shift control characters in these operations. Therefore, the data may not be matched properly.

You can only use DBCS character operands with other DBCS character literals or data items. Mixed operands are treated as alphanumeric. If you use the REPLACING phrase, you might cause parts of an inspected mixed data item to be replaced by alphanumeric data, or parts of an inspected alphanumeric data item to be replaced by mixed data.

You cannot replace a character string with a string of a different length. Consider this when replacing SBCS characters with DBCS characters in a mixed data item, or replacing DBCS characters with SBCS characters in a mixed data item.

If you want to control the use of the INSPECT statement with mixed items containing DBCS characters, define data items containing shift control characters. Use the shift-out and shift-in characters as BEFORE/AFTER operands in the INSPECT statement.

The following example shows how you can use the INSPECT statement to replace one DBCS character with another in a mixed data item.

```
01  SUBJECT-ITEM                PICTURE X(50).
01  DBCS-CHARACTERS             VALUE "0EK1K20F".
    05  SHIFT-OUT               PICTURE X.
    05  DBCS-CHARACTER-1        PICTURE XX.
    05  DBCS-CHARACTER-2        PICTURE XX.
    05  SHIFT-IN                PICTURE X.
```

The INSPECT statement would be coded as follows:

```
INSPECT SUBJECT-ITEM
    REPLACING ALL DBCS-CHARACTER-1
              BY  DBCS-CHARACTER-2
    AFTER INITIAL SHIFT-OUT.
```

Note: Using the AFTER INITIAL SHIFT-OUT phrase helps you to avoid the risk of accidentally replacing two consecutive alphanumeric characters that have the same EBCDIC values as DBCS-CHARACTER-1 (in cases where SUBJECT-ITEM contains mixed data).

You can also use the INSPECT statement to determine if a data item contains DBCS characters, so that appropriate processing can occur. For example:

```
01  SUBJECT-FIELD          PICTURE X(50).
01  TALLY-FIELD            PICTURE 9(3) COMP.
01  SHIFTS                 VALUE "0E0F".
    05  SHIFT-OUT          PICTURE X.
    05  SHIFT-IN           PICTURE X.
```

In the Procedure Division you might enter the following:

```
MOVE ZERO TO TALLY-FIELD.
INSPECT SUBJECT-FIELD TALLYING TALLY-FIELD
                               FOR ALL  SHIFT-OUT.
IF TALLY-FIELD IS GREATER THAN ZERO THEN
    PERFORM DBCS-PROCESSING
ELSE
    PERFORM A-N-K-PROCESSING.
```

MOVE Statement

All DBCS characters are moved as alphanumeric character strings. The system does not convert the data or examine it.

You can move mixed literals to group items and alphanumeric items. You can only move DBCS data items or DBCS literals to DBCS data items.

If the length of the receiving field is different from that of the sending field, COBOL does one of the following:

- Truncates characters from the sending item if it is longer than the receiving item. This operation can reduce data integrity.
- Pads the sending item with blanks if it is shorter than the receiving item.

To understand more about the effect of editing symbols in the PICTURE clause of the receiving data item, see the *WebSphere Development Studio: ILE COBOL Reference*.

SET Statement (Condition-Name Format)

When you set the condition name to TRUE on this statement, COBOL moves the literal from the VALUE clause to the associated data item. You can move a literal with DBCS characters.

STRING Statement

You can use the STRING statement to construct a data item that contains DBCS subfields. All data in the source data items or literals, including shift control characters, is moved to the receiving data item, one-half of a DBCS character at a time.

UNSTRING Statement

The UNSTRING statement treats DBCS data and mixed data the same as alphanumeric data. The UNSTRING operation is performed on one-half of a DBCS character at a time.

Data items can contain both alphanumeric and DBCS characters within the same field.

Use the DELIMITED BY phrase to locate double-byte and alphanumeric subfields within a data field. Identify the data items containing shift control characters, and use those data items as identifiers on the DELIMITED BY phrase. See the following examples for more information on how to do this. Use the POINTER variable to continue scanning through subfields of the sending field.

After the system performs the UNSTRING operation, you can check the delimiters stored by the DELIMITER IN phrases against the shift control character values to see which subfields contain DBCS and which contain alphanumeric characters.

The following example shows how you might set up fields to prepare for the unstring operation on a character string that contain mixed data:

```
01  SUBJECT-FIELD      PICTURE X(40)
01  FILLER.
    05  UNSTRING-TABLE OCCURS 4 TIMES.
        10  RECEIVER   PICTURE X(40).
        10  DELIMTR    PICTURE X.
        10  COUNTS     PICTURE 99 COMP.
01  SHIFTS             VALUE "0E0F".
    05  SHIFT-OUT      PICTURE X.
    05  SHIFT-IN       PICTURE X.
```

Code the UNSTRING statement as follows:

```
UNSTRING SUBJECT-FIELD  DELIMITED BY SHIFT-OUT
                                     OR SHIFT-IN
INTO RECEIVER (1) DELIMITER IN DELIMTR (1)
                  COUNT     IN COUNTS (1)
INTO RECEIVER (2) DELIMITER IN DELIMTR (2)
                  COUNT     IN COUNTS (2)
INTO RECEIVER (3) DELIMITER IN DELIMTR (3)
                  COUNT     IN COUNTS (3)
INTO RECEIVER (4) DELIMITER IN DELIMTR (4)
                  COUNT     IN COUNTS (4)
ON OVERFLOW PERFORM UNSTRING-OVERFLOW-MESSAGE.
```

This UNSTRING statement divides a character string into its alphanumeric and DBCS parts. Assuming that the data in the character string is valid, a delimiter value of shift-out indicates that the corresponding receiving field contains alphanumeric data, while a value of shift-in indicates that corresponding receiving field has DBCS data. You can check the COUNT data items to determine whether each receiving field received any characters. The following figure is an example that shows the results of the UNSTRING operation just described:

```
SUBJECT-FIELD = ABC0EK1K2K30FD0EK4K5K60F
RECEIVER (1) = ABC       DELIMTR (1) = 0E   COUNTS (1) = 3
RECEIVER (2) = K1K2K3    DELIMTR (2) = 0F   COUNTS (2) = 6
RECEIVER (3) = D         DELIMTR (3) = 0E   COUNTS (3) = 1
RECEIVER (4) = K4K5K6    DELIMTR (4) = 0F   COUNTS (4) = 6
SUBJECT-FIELD = 0EK1K2K30FABC0EK40F
RECEIVER (1) = (blanks)  DELIMTR (1) = 0E   COUNTS (1) = 0
RECEIVER (2) = K1K2K3    DELIMTR (2) = 0F   COUNTS (2) = 6
RECEIVER (3) = ABC       DELIMTR (3) = 0E   COUNTS (3) = 3
RECEIVER (4) = K4        DELIMTR (4) = 0F   COUNTS (4) = 2
```

Procedure Branching Statements

You can use a mixed literal as the operand for the STOP statement. When you do, the system displays the literal as you entered it at your workstation for interactive jobs. For batch jobs, the system displays underscores where the literal would normally appear on the system operator's message queue. The system does not edit or check the contents of the literal.

Table Handling—SEARCH Statement

You can perform a Format 1 SEARCH statement (sequential search of a table) on a table that contains DBCS data half a DBCS character at a time.

You can also perform a Format 2 SEARCH statement (SEARCH ALL) against a DBCS table as well. Order the table according to the chosen collating sequence.

Note: The shift control characters in DBCS data participate in the comparison.

SORT/MERGE

You can use DBCS data items as keys in a SORT or MERGE statement. The sort operation orders data according to the collating sequence specified in the SORT, MERGE, or SPECIAL NAMES paragraph. The system orders any shift control characters contained in DBCS and mixed keys.

Use the RELEASE statement to transfer records containing DBCS characters from an input/output area to the initial phase of a sort operation. The system performs the FROM phrase with the RELEASE statement in the same way it performs the FROM phrase with the WRITE statement. (See "WRITE Statement" on page 601.)

You can also use the RETURN statement to transfer records containing DBCS characters from the final phase of a sort or merge operation to an input/output area. The system performs the INTO phrase with the RETURN statement in the same manner that it performs the INTO phrase with the READ statement. (See "READ Statement" on page 600.)

Compiler-Directing Statements

COPY Statement

You can use the COPY statement to copy source text that contains DBCS characters into a COBOL program. When you do, make sure that you specify the name of the copy book using alphanumeric data, and that you specify these names according to the rules stated in the *WebSphere Development Studio: ILE COBOL Reference*.

Use the Format 2 COPY statement to copy fields defined in the data description specifications (DDS). DBCS (value in column 35 of the DDS form is G) and mixed

data items (the value in column 35 of the DDS form is O) are copied into a COBOL program in the PICTURE X(*n*) format. If *PICGGRAPHIC is selected, DBCS data items (format G) are copied in the PICTURE G(*n*) format. The compiler listing does not indicate that these fields contain DBCS characters, unless a field is a key field. In those cases, the system prints an O in the comment table for keys.

DBCS-graphic data items are copied into a COBOL program in the PICTURE X(*n*) format. The compiler listing indicates that these fields contain graphic data. See "DBCS-Graphic Fields" on page 427 for a description of the DBCS-graphic data type.

You can put DBCS characters in text comments that are copied from DDS if the associated DDS field has comments.

If you specify the REPLACING phrase of the COPY statement, consider the following:

- Pseudo-text can contain any combination of DBCS and alphanumeric characters
- You can use literals with DBCS content
- Identifiers can refer to data items that contain DBCS characters.

REPLACE Statement

The REPLACE statement resembles the REPLACING phrase of the COPY statement, except that it acts on the entire source program, not just the text in COPY libraries.

If you specify the REPLACE statement, consider the following:

- Pseudo-text can contain any combination of DBCS and alphanumeric characters
- You can use literals with DBCS content
- Identifiers can refer to data items that contain DBCS characters.

TITLE Statement

You can use DBCS literals as the literal in the TITLE statement.

Communications between Programs

You can specify entries for alphanumeric data items that contain DBCS or mixed characters, in the Linkage Section of the Data Division. If DBCS data items or DBCS literals are being passed to a program you can also define the receiving linkage section items as DBCS data items.

You can pass DBCS characters from one program to another program by specifying those data items in the USING phrase. USING BY CONTENT and USING BY VALUE, allows mixed and DBCS literals to be passed.

You cannot use DBCS characters in the CALL statement for the program-name of the called program. You cannot use DBCS characters in the CANCEL statement because they specify program-names.

FIPS Flagger

Enhancements to the COBOL language that let you use DBCS characters are flagged (identified) by the FIPS (Federal Information Processing Standard) flagger provided by the compiler as IBM extensions.

COBOL Program Listings

DBCS characters can appear in listings that originate from DBCS-capable source files, and that are produced on DBCS-capable systems.

DBCS characters that appear in a program listing originate from the source file, from source text generated by the COPY statement, or from COBOL compiler messages.

A listing containing DBCS characters should be output to a printer file that is capable of processing DBCS data. Listings containing DBCS characters are handled correctly if one of the following conditions is true:

- The source file is defined as capable of containing DBCS data using the IGCDTA parameter of the CRTSRCPF command. In this case, the program overrides the existing value of the attribute for the output printer file.
- The user has specified the required attribute for the output printer, using the IGCDTA parameter of the OVRPRTF command, before compiling the program.

Note: The IGCDTA parameter is only available on DBCS systems, and it cannot be defined or displayed on non-DBCS systems. You can, however, create objects with DBCS attributes on a non-DBCS system by copying them from a DBCS system. You should check for possible incompatibilities if you do this.

The compiler may use characters from your source program as substitution parameters in compiler and syntax checker messages. The system does not check or edit the substitution parameters. If you do not specify DBCS characters properly, the system may print or display parts of messages incorrectly.

Intrinsic Functions with Collating Sequence Sensitivity

The intrinsic functions CHAR and ORD are dependent on the ordinal positions of characters. These intrinsic functions are not supported for the DBCS data type (for example, supported for single-byte characters, alphabetic or numeric). The results of these functions are all based on the collating sequence in effect. The current code page does not affect the result of these intrinsic functions.

Appendix E. Example of a COBOL Formatted Dump

Figure 156 on page 608 shows an example of a COBOL formatted dump. A dump is usually available if something goes wrong when you try to run your program.

Defining a data item in the Data Division as a user-defined data type does not change how the data is represented in a dump. Data items defined using the TYPE clause behave exactly as if they had been defined without using the TYPE clause.

You can request two types of dumps, a data dump and an extended dump. The example in Figure 156 on page 608 is an extended dump.

The **data dump** contains the following information. The labels identify where on the formatted dump you will find the information.

A The name of each variable

B The data type

C The default value

D The hexadecimal value

Note: Only the first 250 characters will be shown in the dump.

The **extended dump** also contains the following additional information. The labels identify where on the formatted dump you will find the information.

E The name of each file

F The system name of each file

G External/internal flag

H Last I/O operation attempted

I Last file status

J Last extended status

K Open/close status

L Blocking information

M Blocking factor

N I/O feedback area information

O Open feedback area information

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```
5722WDS V5R3M0  030905 LN  IBM ILE COBOL          CBLGUIDE/SAMPDUMP    ISERIES1   03/09/15 15:10:06        Page      2
                                Source
 STMT PL SEQNBR -A 1 B..+....2....+....3....+....4....+....5....+....6....+....7..IDENTFCN  S COPYNAME   CHG DATE
    1     000100 IDENTIFICATION DIVISION.
    2     000200 PROGRAM-ID.     SAMPDUMP.
          000300
    3     000400 ENVIRONMENT DIVISION.
    4     000500 CONFIGURATION SECTION.
    5     000600 SOURCE-COMPUTER. IBM-ISERIES.
    6     000700 OBJECT-COMPUTER. IBM-ISERIES.
    7     000800 INPUT-OUTPUT SECTION.
    8     000900 FILE-CONTROL.
    9     001000     SELECT FILE-1 ASSIGN TO DISK-DBSRC.
   11     001100 DATA DIVISION.
   12     001200 FILE SECTION.
   13     001300 FD  FILE-1.
   14     001400 01  RECORD-1.
   15     001500   05 R-TYPE             PIC X(1).
   16     001600   05 R-AREA-CODE        PIC 9(2).
   17     001700     88 R-NORTH-EAST VALUES 15 THROUGH 30.
   18     001800   05 R-SALES-CAT-1      PIC S9(5)V9(2) COMP-3.
   19     001900   05 R-SALES-CAT-2      PIC S9(5)V9(2) COMP-3.
   20     002000   05 FILLER             PIC X(1).
          002100
   21     002200 WORKING-STORAGE SECTION.
   22     002300 01  W-SALES-VALUES.
   23     002400     05 W-CAT-1          PIC S9(8)V9(2).
   24     002500     05 W-CAT-2          PIC S9(8)V9(2).
   25     002600     05 W-TOTAL          PIC S9(8)V9(2).
          002700
   26     002800 01  W-EDIT-VALUES.
   27     002900     05 FILLER           PIC X(8) VALUE "TOTALS: ".
   28     003000     05 W-EDIT-1         PIC Z(7)9.9(2)-.
   29     003100     05 FILLER           PIC X(3) VALUE SPACES.
   30     003200     05 W-EDIT-2         PIC Z(7)9.9(2)-.
   31     003300     05 FILLER           PIC X(3) VALUE SPACES.
   32     003400     05 W-EDIT-TOTAL     PIC Z(7)9.9(2)-.
          003500
   33     003600 01  END-FLAG            PIC X(1) VALUE SPACE.
   34     003700     88 END-OF-INPUT VALUE "Y".
          003800
   35     003900 PROCEDURE DIVISION.
          004000 MAIN-PROGRAM SECTION.
          004100 MAINLINE.
          004200*****************************************************************
          004300* OPEN THE INPUT FILE AND CLEAR TOTALS.                         *
          004400*****************************************************************
   36     004500     OPEN INPUT FILE-1.
   37     004600     MOVE ZEROS TO W-SALES-VALUES.
          004700
          004800*****************************************************************
          004900* READ THE INPUT FILE PROCESSING ONLY THOSE RECORDS FOR THE    *
          005000* NORTH EAST AREA. WHEN END-OF-INPUT REACHED, SET THE FLAG     *
          005100*****************************************************************
   38     005200     PERFORM UNTIL END-OF-INPUT
   39     005300         READ FILE-1
   40     005400             AT END SET END-OF-INPUT TO TRUE
          005500         END-READ
   41     005600         IF R-NORTH-EAST AND NOT END-OF-INPUT THEN
   42     005700             ADD R-SALES-CAT-1 TO W-CAT-1, W-TOTAL
   43     005800             ADD R-SALES-CAT-2 TO W-CAT-2, W-TOTAL
          005900         END-IF
          006000     END-PERFORM.
          006100
          006200*****************************************************************
          006300* DISPLAY THE RESULTS AND END THE PROGRAM.                      *
          006400*****************************************************************
   44     006500     MOVE W-CAT-1 TO W-EDIT-1.
   45     006600     MOVE W-CAT-2 TO W-EDIT-2.
   46     006700     MOVE W-TOTAL TO W-EDIT-TOTAL.
   47     006800     DISPLAY W-EDIT-VALUES.
   48     006900     STOP RUN.
                       * * * * *  E N D  O F  S O U R C E  * * * * *
```

Figure 156. COBOL Program Used to Generate a COBOL Formatted Dump

```
LNR7200 exception in module 'SAMPDUMP  ', program 'SAMPDUMP  ' in library 'TESTLIB   ' at statement number 42.

Formatted data dump for module 'SAMPDUMP  ', program 'SAMPDUMP  ' in library 'TESTLIB   '.
NAME     ATTRIBUTE                      VALUE
DB-FORMAT-NAME  A
         CHAR(10)  B                    "DBSRC     "  C
                                "C4C2E2D9C34040404040"X  D
END-FLAG
         CHAR(1)                        " "
                                        "40"X
R-AREA-CODE   OF RECORD-1 OF FILE-1
         ZONED(2 0)                      0.
                                        "0000"X
R-SALES-CAT-1   OF RECORD-1 OF FILE-1
         PACKED(7 2)                    00000.00
                                        "00000000"X
R-SALES-CAT-2   OF RECORD-1 OF FILE-1
         PACKED(7 2)                    0000Ô.7²
                                        "0000B7A0"X
RETURN-CODE
         BIN(2)                         0000.
                                        "0000"X
W-CAT-1   OF W-SALES-VALUES
         ZONED(10 2)                    00311111.08
                                        "F0F0F3F1F1F1F1F1F0F8"X
W-CAT-2   OF W-SALES-VALUES
         ZONED(10 2)                    00622222.16
                                        "F0F0F6F2F2F2F2F2F1F6"X
W-EDIT-TOTAL   OF W-EDIT-VALUES
         CHAR(12)                       "            "
                                        "40404040404040404040404040"X
W-EDIT-1   OF W-EDIT-VALUES
         CHAR(12)                       "            "
                                        "40404040404040404040404040"X
W-EDIT-2   OF W-EDIT-VALUES
         CHAR(12)                       "            "
                                        "40404040404040404040404040"X
W-TOTAL   OF W-SALES-VALUES
         ZONED(10 2)                    00933333.24
                                        "F0F0F9F3F3F3F3F3F2F4"X
 E          F
Current active file: FILE-1 (DISK-DBSRC).
Information pertaining to file FILE-1 (DISK-DBSRC).
  File is internal.  G
  Last I-O operation attempted for file: READ.  H
  Last file status: '00'.  I
  Last extended file status: '    '.  J
  File is open.  K
  Blocking is in effect.  L
    Blocking factor: 17.  M
  I-O Feedback Area.  N
    Number of successful PUT operations: 0.
```

Figure 157. Example of a COBOL Formatted Dump (Part 1 of 2)

```
   Number of successful GET operations: 1.
   Number of successful PUTGET operations: 0.
   Number of other successful operations: 0.
   Current data management operation: 1.
   Record format: 'DBSRC     '.
   Device class and type: '  '.
   Program device name: '          '.
   Length of last record: 228.
   Number of records for blocked PUT or GET: 17.
   Length of all data returned: 0.
   Number of blocks successfully read or written: 0.
   Offset: '090'. Value: '00000000000000000001000004800004'.
   Offset: '0A0'. Value: '00000000000000000001000000110000'.
   Offset: '0B0'. Value: '0000'.
Open Feedback Area. 0
   Actual file name: 'DBSRC     '.
   Actual library name: 'TESTLIB   '.
   Member name: 'SALES     '.
   File type: 21.
   Open file count: 1.
   Max record length: 0.
   CCSID: 65535.
   Offset: '000'. Value: 'C4C2C4C2E2D9C34040404040D9D4C9E2'.
   Offset: '010'. Value: 'E3D9E8404040000000000000000000000'.
   Offset: '020'. Value: '00000000000000000000000000E40000'.
   Offset: '030'. Value: 'E2C1D3C5E24040404040FFFFFFE00000'.
   Offset: '040'. Value: '00000015000000000000000000011C1'.
   Offset: '050'. Value: 'D900D5A5000000000000500000000000'.
   Offset: '060'. Value: '00000000000000000000011000000EF00'.
   Offset: '070'. Value: '0003E0000000000000000000000000001'.
   Offset: '080'. Value: '00000001020073000FFFF0000000000'.
   Offset: '090'. Value: '00010001C4C1E3C1C2C1E2C540400000'.
   Offset: '0A0'. Value: '00000000000000000302000E00450045'.
   Offset: '0B0'. Value: '0045004500450045006F004500450045'.
   Offset: '0C0'. Value: '00450BFD068E0045000D001100000001'.
   Offset: '0D0'. Value: '00000000000000000000000000000000'.
   Offset: '0E0'. Value: '00000000000000000000000000000000'.
   Offset: '0F0'. Value: '00000000000000000000000000000000'.
   Offset: '100'. Value: '00000000000000000000000000000000'.
   Offset: '110'. Value: '000000000000'.
```

Figure 157. Example of a COBOL Formatted Dump (Part 2 of 2)

Appendix F. XML reference material

This appendix describes the XML exception codes that the XML parser returns in special register XML-CODE. It also documents which well-formedness constraints from the XML specification that the parser checks. Note that the XML parser was ported from IBM's Enterprise COBOL and some of the error codes may not be applicable on the iSeries server, but they are included in the table for completeness.

RELATED REFERENCES
"XML exceptions that allow continuation"
"XML exceptions that do not allow continuation" on page 615
"XML conformance" on page 619
XML specification (www.w3c.org/XML/)

XML exceptions that allow continuation

The following table provides the exception codes that are associated with XML event EXCEPTION and that the XML parser returns in special register XML-CODE when the parser can continue processing the XML data. That is, the code is within one of the following ranges:

- 1-99
- 100,001-165,535
- 200,001-265,535

The table describes the exception and the actions that the parser takes when you request it to continue after the exception. In these descriptions, the term "XML text" means either XML-TEXT or XML-NTEXT, depending on whether the XML document that you are parsing is in an alphanumeric or national data item, respectively.

Table 30. **XML exceptions that allow continuation**

Code	Description	Parser action on continuation
1	The parser found an invalid character while scanning white space outside element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
2	The parser found an invalid start of a processing instruction, element, comment, or document type declaration outside element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
3	The parser found a duplicate attribute name.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.

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Table 30. **XML exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
4	The parser found the markup character '<' in an attribute value.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
5	The start and end tag names of an element did not match.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
6	The parser found an invalid character in element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
7	The parser found an invalid start of an element, comment, processing instruction, or CDATA section in element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
8	The parser found in element content the CDATA closing character sequence ']]>' without the matching opening character sequence '<![CDATA['.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
9	The parser found an invalid character in a comment.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
10	The parser found in a comment the character sequence '—' (two hyphens) not followed by '>'.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
11	The parser found an invalid character in a processing instruction data segment.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
12	A processing instruction target name was 'xml' in lowercase, uppercase or mixed case.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.

Table 30. **XML exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
13	The parser found an invalid digit in a hexadecimal character reference (of the form &#xdddd;).	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.
14	The parser found an invalid digit in a decimal character reference (of the form &#dddd;).	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.
15	The encoding declaration value in the XML declaration did not begin with lowercase or uppercase A through Z.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.
16	A character reference did not refer to a legal XML character.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.
17	The parser found an invalid character in an entity reference name.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.
18	The parser found an invalid character in an attribute value.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the `END-OF-DOCUMENT` event.
50	The document was encoded in EBCDIC, and the CCSID of the COBOL source member is a supported EBCDIC CCSID, but the document encoding declaration did not specify a recognizable encoding.	The parser uses the encoding specified by the CCSID of the COBOL source member.
51	The document was encoded in EBCDIC, and the document encoding declaration specified a supported EBCDIC encoding, but the parser does not support the CCSID of the COBOL source member.	The parser uses the encoding specified by the document encoding declaration.
52	The document was encoded in EBCDIC, and the CCSID of the COBOL source member is a supported EBCDIC CCSID, but the document encoding declaration specified an ASCII encoding.	The parser uses the encoding specified by the CCSID of the COBOL source member

Table 30. **XML exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
53	The document was encoded in EBCDIC, and the CCSID of the COBOL source member is a supported EBCDIC CCSID, but the document encoding declaration specified a supported Unicode encoding.	The parser uses the encoding specified by the CCSID of the COBOL source member.
54	The document was encoded in EBCDIC, and the CCSID of the COBOL source member is a supported EBCDIC CCSID, but the document encoding declaration specified a Unicode encoding that the parser does not support.	The parser uses the encoding specified by the CCSID of the COBOL source member.
55	The document was encoded in EBCDIC, and the CCSID of the COBOL source member is a supported EBCDIC CCSID, but the document encoding declaration specified an encoding that the parser does not support.	The parser uses the encoding specified by the CCSID of the COBOL source member.
56	The document was encoded in ASCII, and the CCSID of the COBOL source member is a supported ASCII CCSID, but the document encoding declaration did not specify a recognizable encoding.	The parser uses the encoding specified by the CCSID of the COBOL source member.
57	The document was encoded in ASCII, and the document encoding declaration specified a supported ASCII encoding, but the parser does not support the CCSID specified by the CCSID of the COBOL source member.	The parser uses the encoding specified by the document encoding declaration.
58	The document was encoded in ASCII, and the CCSID of the COBOL source member is a supported ASCII CCSID, but the document encoding declaration specified a supported EBCDIC encoding.	The parser uses the encoding specified by the CCSID of the COBOL source member.
59	The document was encoded in ASCII, and the CCSID of the COBOL source member is a supported ASCII CCSID, but the document encoding declaration specified a supported Unicode encoding.	The parser uses the encoding specified by the CCSID of the COBOL source member.
60	The document was encoded in ASCII, and the CCSID of the COBOL source member is a supported ASCII CCSID, but the document encoding declaration specified a Unicode encoding that the parser does not support.	The parser uses the encoding specified by the CCSID of the COBOL source member.

Table 30. **XML exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
61	The document was encoded in ASCII, and the CCSID of the COBOL source member is a supported ASCII CCSID, but the document encoding declaration specified an encoding that the parser does not support.	The parser uses the encoding specified by the CCSID of the COBOL source member.
100,001 - 165,535	The document was encoded in EBCDIC, and the encodings specified by the CCSID of the COBOL source member and the document encoding declaration are both supported EBCDIC CCSIDs, but are not the same. `XML-CODE` contains the CCSID for the encoding declaration plus 100,000.	If you set `XML-CODE` to zero before returning from the `EXCEPTION` event, the parser uses the encoding specified by the CCSID of the COBOL source member. If you set `XML-CODE` to the CCSID for the document encoding declaration (by subtracting 100,000), the parser uses this encoding.
200,001 - 265,535	The document was encoded in ASCII, and the encodings specified by the CCSID of the COBOL source member and the document encoding declaration are both supported ASCII CCSIDs, but are not the same. `XML-CODE` contains the CCSID for the encoding declaration plus 200,000.	If you set `XML-CODE` to zero before returning from the `EXCEPTION` event, the parser uses the encoding specified by the CCSID of the COBOL source member. If you set `XML-CODE` to the CCSID for the document encoding declaration (by subtracting 200,000), the parser uses this encoding.

RELATED TASKS

"Handling errors in XML documents" on page 282

XML exceptions that do not allow continuation

With these XML exceptions, no further events are returned from the parser, even if you set `XML-CODE` to zero and return control to the parser after processing the exception. Control is passed to the statement that you specify on your `NOT ON EXCEPTION` phrase or to the end of the parse statement if you have not coded a `NOT ON EXCEPTION` phrase.

Table 31. **XML exceptions that do not allow continuation**

Code	Description
100	The parser reached the end of the document while scanning the start of the XML declaration.
101	The parser reached the end of the document while looking for the end of the XML declaration.
102	The parser reached the end of the document while looking for the root element.
103	The parser reached the end of the document while looking for the version information in the XML declaration.
104	The parser reached the end of the document while looking for the version information value in the XML declaration.
106	The parser reached the end of the document while looking for the encoding declaration value in the XML declaration.
108	The parser reached the end of the document while looking for the standalone declaration value in the XML declaration.

Table 31. **XML exceptions that do not allow continuation** *(continued)*

Code	Description
109	The parser reached the end of the document while scanning an attribute name.
110	The parser reached the end of the document while scanning an attribute value.
111	The parser reached the end of the document while scanning a character reference or entity reference in an attribute value.
112	The parser reached the end of the document while scanning an empty element tag.
113	The parser reached the end of the document while scanning the root element name.
114	The parser reached the end of the document while scanning an element name.
115	The parser reached the end of the document while scanning character data in element content.
116	The parser reached the end of the document while scanning a processing instruction in element content.
117	The parser reached the end of the document while scanning a comment or CDATA section in element content.
118	The parser reached the end of the document while scanning a comment in element content.
119	The parser reached the end of the document while scanning a CDATA section in element content.
120	The parser reached the end of the document while scanning a character reference or entity reference in element content.
121	The parser reached the end of the document while scanning after the close of the root element.
122	The parser found a possible invalid start of a document type declaration.
123	The parser found a second document type declaration.
124	The first character of the root element name was not a letter, '_', or ':'.
125	The first character of the first attribute name of an element was not a letter, '_', or ':'.
126	The parser found an invalid character either in or following an element name.
127	The parser found a character other than '=' following an attribute name.
128	The parser found an invalid attribute value delimiter.
130	The first character of an attribute name was not a letter, '_', or ':'.
131	The parser found an invalid character either in or following an attribute name.
132	An empty element tag was not terminated by a '>' following the '/'.
133	The first character of an element end tag name was not a letter, '_', or ':'.
134	An element end tag name was not terminated by a '>'.
135	The first character of an element name was not a letter, '_', or ':'.
136	The parser found an invalid start of a comment or CDATA section in element content.
137	The parser found an invalid start of a comment.

Table 31. **XML exceptions that do not allow continuation** *(continued)*

Code	Description
138	The first character of a processing instruction target name was not a letter, '_', or ':'.
139	The parser found an invalid character in or following a processing instruction target name.
140	A processing instruction was not terminated by the closing character sequence '?>'.
141	The parser found an invalid character following '&' in a character reference or entity reference.
142	The version information was not present in the XML declaration.
143	'version' in the XML declaration was not followed by '='.
144	The version declaration value in the XML declaration is either missing or improperly delimited.
145	The version information value in the XML declaration specified a bad character, or the start and end delimiters did not match.
146	The parser found an invalid character following the version information value closing delimiter in the XML declaration.
147	The parser found an invalid attribute instead of the optional encoding declaration in the XML declaration.
148	'encoding' in the XML declaration was not followed by '='.
149	The encoding declaration value in the XML declaration is either missing or improperly delimited.
150	The encoding declaration value in the XML declaration specified a bad character, or the start and end delimiters did not match.
151	The parser found an invalid character following the encoding declaration value closing delimiter in the XML declaration.
152	The parser found an invalid attribute instead of the optional standalone declaration in the XML declaration.
153	'standalone' in the XML declaration was not followed by a '='.
154	The standalone declaration value in the XML declaration is either missing or improperly delimited.
155	The standalone declaration value was neither 'yes' nor 'no' only.
156	The standalone declaration value in the XML declaration specified a bad character, or the start and end delimiters did not match.
157	The parser found an invalid character following the standalone declaration value closing delimiter in the XML declaration.
158	The XML declaration was not terminated by the proper character sequence '?>', or contained an invalid attribute.
159	The parser found the start of a document type declaration after the end of the root element.
160	The parser found the start of an element after the end of the root element.
300	The document was encoded in EBCDIC, but the CCSID of the COBOL source member is a supported ASCII CCSID.
301	The document was encoded in EBCDIC, but the CCSID of the COBOL source member is Unicode.
302	The document was encoded in EBCDIC, but the CCSID of the COBOL source member is an unsupported CCSID.

Table 31. **XML exceptions that do not allow continuation** *(continued)*

Code	Description
303	The document was encoded in EBCDIC, but CCSID of the COBOL source member is unsupported and the document encoding declaration was either empty or contained an unsupported alphabetic encoding alias.
304	The document was encoded in EBCDIC, but the CCSID of the COBOL source member is unsupported and the document did not contain an encoding declaration.
305	The document was encoded in EBCDIC, but the CCSID of the COBOL source member is unsupported and the document encoding declaration did not specify a supported EBCDIC encoding.
306	The document was encoded in ASCII, but the CCSID of the COBOL source member is a supported EBCDIC CCSID.
307	The document was encoded in ASCII, but the CCSID of the COBOL source member is Unicode.
308	The document was encoded in ASCII, but the CCSID of the COBOL source member is unsupported and the document did not contain an encoding declaration.
309	The CCSID of the COBOL source member is a supported ASCII CCSID, but the document was encoded in Unicode.
310	The CCSID of the COBOL source member specified a supported EBCDIC CCSID, but the document was encoded in Unicode.
311	The CCSID of the COBOL source member specified an unsupported CCSID and the document was encoded in Unicode.
312	The document was encoded in ASCII, but the CCSID of the COBOL source member is unsupported and the document encoding declaration was either empty or contained an unsupported alphabetic encoding alias.
313	The document was encoded in ASCII, but the CCSID of the COBOL source member is unsupported and the document did not contain an encoding declaration.
314	The document was encoded in ASCII, but the CCSID of the COBOL source member is unsupported and the document encoding declaration did not specify a supported ASCII encoding.
315	The document was encoded in UTF-16 Little Endian, which the parser does not support on this platform.
316	The document was encoded in UCS4, which the parser does not support.
317	The parser cannot determine the document encoding. The document may be damaged.
318	The document was encoded in UTF-8, which the parser does not support.
319	The document was encoded in UTF-16 Big Endian, which the parser does not support on this platform.
500-999	Internal error. Please report the error to your service representative.

RELATED TASKS

"Handling errors in XML documents" on page 282

XML conformance

The XML parser included in ILE COBOL is not a conforming XML processor according to the definition in the XML specification. It does not validate the XML documents that you parse. While it does check for many well-formedness errors, it does not perform all of the actions required of a nonvalidating XML processor.

In particular, it does not process the internal document type definition (DTD internal subset). Thus it does not supply default attribute values, does not normalize attribute values, and does not include the replacement text of internal entities except for the predefined entities. Instead, it passes the entire document type declaration as the contents of `XML-TEXT` or `XML-NTEXT` for the `DOCUMENT-TYPE-DESCRIPTOR` XML event, which allows the application to perform these actions if required.

The parser optionally allows programs to continue processing an XML document after some errors. The purpose of this is to facilitate debugging of XML documents and processing programs.

Recapitulating the definition in the XML specification, a textual object is a well-formed XML document if:

- Taken as a whole, it conforms to the grammar for XML documents.
- It meets all the explicit well-formedness constraints given in the XML specification.
- Each parsed entity (piece of text) that is referenced directly or indirectly within the document is well formed.

The COBOL XML parser does check that documents conform to the XML grammar, except for any document type declaration. The declaration is supplied in its entirety, unchecked, to your application.

The following material is an annotation from the XML specification. The W3C is not responsible for any content not found at the original URL (www.w3.org/TR/REC-xml). All the annotations are non-normative and are shown in *italic*.

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The XML specification also contains twelve explicit well-formedness constraints. The constraints that the COBOL XML parser checks partly or completely are shown in **bold** type:

1. Parameter Entities (PEs) in Internal Subset:
   "In the internal DTD subset, parameter-entity references can occur only where markup declarations can occur, not within markup declarations. (This does not apply to references that occur in external parameter entities or to the external subset.)"

   The parser does not process the internal DTD subset, so it does not enforce this constraint.
2. External Subset:
   "The external subset, if any, must match the production for extSubset."

   The parser does not process the external subset, so it does not enforce this constraint.

3. Parameter Entity Between Declarations:
   "The replacement text of a parameter entity reference in a DeclSep must match the production extSubsetDecl."

   The parser does not process the internal DTD subset, so it does not enforce this constraint.

4. **Element Type Match:**
   "The Name in an element's end-tag must match the element type in the start-tag."

   The parser enforces this constraint.

5. **Unique Attribute Specification:**
   "No attribute name may appear more than once in the same start-tag or empty-element tag."

   The parser partly supports this constraint by checking up to 10 attribute names in a given element for uniqueness. The application can check any attribute names beyond this limit.

6. No External Entity References:
   "Attribute values cannot contain direct or indirect entity references to external entities."

   The parser does not enforce this constraint.

7. No '<' in Attribute Values:
   "The replacement text of any entity referred to directly or indirectly in an attribute value must not contain a '<'."

   T*he parser does not enforce this constraint.*

8. **Legal Character:**
   "Characters referred to using character references must match the production for Char."

   The parser enforces this constraint.

9. Entity Declared:
   "In a document without any DTD, a document with only an internal DTD subset which contains no parameter entity references, or a document with standalone='yes', for an entity reference that does not occur within the external subset or a parameter entity, the Name given in the entity reference must match that in an entity declaration that does not occur within the external subset or a parameter entity, except that well-formed documents need not declare any of the following entities: amp, lt, gt, apos, quot. The declaration of a general entity must precede any reference to it which appears in a default value in an attribute-list declaration.

   Note that if entities are declared in the external subset or in external parameter entities, a non-validating processor is not obligated to read and process their declarations; for such documents, the rule that an entity must be declared is a well-formedness constraint only if standalone='yes'."

   The parser does not enforce this constraint.

10. Parsed Entity:
    "An entity reference must not contain the name of an unparsed entity. Unparsed entities may be referred to only in attribute values declared to be of type ENTITY or ENTITIES."

    The parser does not enforce this constraint.

11. No Recursion:
    "A parsed entity must not contain a recursive reference to itself, either directly or indirectly."

    The parser does not enforce this constraint.

12. In DTD:
    "Parameter-entity references may only appear in the DTD."
    The parser does not enforce this constraint, because the error cannot occur.

The preceding material is an annotation from the XML specification. The W3C is not responsible for any content not found at the original URL (www.w3.org/TR/REC-xml); all these annotations are non-normative. This document has been reviewed by W3C Members and other interested parties and has been endorsed by the Director as a W3C Recommendation. It is a stable document and may be used as reference material or cited as a normative reference from another document. The normative version of the specification is the English version found at the W3C site; any translated document may contain errors from the translation.

RELATED CONCEPTS
"XML parser in COBOL" on page 265

RELATED REFERENCES
XML specification (www.w3c.org/XML/)
2.8 Prolog and document type declaration (*XML specification* at www.w3.org/TR/REC-xml#sec-prolog-dtd)

Appendix G. Migration and Compatibility Considerations between OPM COBOL/400 and ILE COBOL

This appendix describes the differences between ILE COBOL and OPM COBOL/400.

If you are moving your existing OPM COBOL/400 programs and applications to ILE COBOL, you must be aware of the following differences between the OPM COBOL/400 compiler and the ILE COBOL compiler. In some cases, changes to your programs may be required.

Migration Strategy

When migrating your existing OPM COBOL/400 programs and applications to ILE COBOL, the following migration strategy is recommended:

- Migrate an entire application (or COBOL run unit) at one time to a pure ILE environment instead of migrating one program at a time.
- Map a COBOL run unit to an ILE activation group. For example, for a COBOL run unit that contains a number of COBOL programs, you can do one of the following to preserve the COBOL run unit semantics:
  - Create all of the COBOL programs using the CRTBNDCBL command. In this case, all of the programs will run in the QILE activation group.
  - Create all of the COBOL programs using the CRTCBLMOD command followed by CRTPGM with ACTGRP(anyname). In this case, all of the programs will run in the activation group named "anyname".
  - Create the first COBOL program with ACTGRP(*NEW) using the CRTPGM command and create the rest of the programs in the application with ACTGRP(*CALLER). In this case, all of the programs will run in the *NEW activation group of the first COBOL program.
- Ensure that the caller of programs created with the ACTGRP(*CALLER) option on the CRTPGM command are not OPM programs.

  Note: Mixing OPM COBOL/400 and ILE COBOL programs in the same run unit is *not* recommended.
- Pay special attention to system functions that allow different scoping options. For example, default scoping of the following system functions is changed to *ACTGRPDFN (the activation group level) when used in an ILE activation group whereas they have other defaults, such as *CALLLVL (the call level), when used in OPM programs.
  - For OPNDBF and OPNQRYF, you may need to change OPNSCOPE depending on the application. For example, if the application is running in different activation groups and need to share files, you will need to change the scope to *JOB.
  - Overrides.
  - Commitment Control.
- RCLRSRC has no effect on ILE activation groups. Instead, use RCLACTGRP to clean up ILE activation groups.

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Compatibility Considerations

This section describes compatibility considerations between ILE COBOL and OPM COBOL/400.

General Considerations

Area Checking

In ILE COBOL, area checking is only active for the first token on a line. Subsequent tokens are not checked to see if they are in the correct area.

The OPM COBOL/400 compiler checks all tokens.

Attributes Field in the Data Division Map Section of the Compiler Listing

In ILE COBOL, syntax checked only attributes (for example, SAME SORT AREA, SAME SORT-MERGE AREA, SAME AREA, LABEL information) are not reported in the Data Division Map section of the compiler listing.

In ILE COBOL, condition names are not listed in Data Division Map section of the compiler listing.

OPM COBOL/400 lists condition names but does not specify any attribute information.

MIXED, COMMUNICATIONS, and BSC files

MIXED, COMMUNICATIONS, and BSC files are not supported in ILE COBOL. These file types are valid in the System/38™ environment and are not supported by the ILE COBOL compiler at compile time (for COPY DDS) or at run time.

Reserved Words

ILE COBOL supports a number of reserved words that are not currently supported by OPM COBOL/400. For example, SORT-RETURN and RETURN-CODE are special registers. An occurrence of SORT-RETURN or RETURN-CODE in an OPM COBOL/400 program would generate a severity 10 message which indicates that these are reserved words in other implementations of COBOL.

ILE COBOL recognizes these words as reserved words and, in similar situations, ILE COBOL issues a severity 30 message indicating that a reserved word was found where a user-defined word would be required.

Source files for SAA CPI Data Structures

In ILE COBOL, the source files for SAA CPI data structures are found in file QCBLLESRC of library QSYSINC.

In OPM COBOL/400, the source files for SAA CPI data structures are found in file QILBINC of libraries QLBL and QLBLP.

CL Commands

CRTCBLPGM Command Replaced By CRTCBLMOD and CRTBNDCBL Commands

The OPM COBOL/400 compiler is invoked by the CRTCBLPGM CL command. The CRTCBLPGM CL command creates a *PGM object.

The ILE COBOL compiler is invoked by the CRTCBLMOD or CRTBNDCBL CL commands. The CRTCBLMOD CL command creates a *MODULE object and the CRTBNDCBL CL command creates a *PGM object.

The following CRTCBLPGM parameters and options (and their associated PROCESS statement options) are not found on the CRTCBLMOD and CRTBNDCBL commands:

- GENOPT parameter (all remaining GENOPT details have been moved to OPTION details)
- PRTFILE parameter
- SAAFLAG parameter
- DUMP parameter
- ITDUMP parameter
- NOSRCDBG/SRCDBG option in the OPTION parameter
- NOLSTDBG/LSTDBG option in the OPTION parameter
- PRINT/NOPRINT option in the OPTION parameter
- LIST/NOLIST option in the GENOPT parameter
- NOPATCH/PATCH option in the GENOPT parameter
- NODUMP/DUMP option in the GENOPT parameter
- NOATR/ATR option in the GENOPT parameter
- NOOPTIMIZE/OPTIMIZE option in the GENOPT parameter
- STDERR/NOSTDERR option in the GENOPT parameter
- NOEXTACCDSP/EXTACCDSP option in the GENOPT parameter
- FS21DUPKY/NOFS21DUPKY option in the GENOPT parameter.

The following parameters and options have changed:

- For the SRCFILE parameter, the default source file name is QCBLLESRC
- For the CVTOPT parameter, the GRAPHIC/NOGRAPHIC keyword in CRTCBLPGM is changed to PICXGRAPHIC/NOPICXGRAPHIC in CRTCBLMOD and CRTBNDCBL
- For the MSGLMT parameter, the default maximum severity level is 30
- For the GENLVL parameter, the default severity level is 30
- For the FLAGSTD parameter, the NOSEG/SEG1/SEG2 and NODEB/DEB1/DEB2 options in CRTCBLPGM no longer exist in CRTCBLMOD or CRTBNDCBL
- For the OPTION parameter, the default for the NOUNREF/UNREF option is changed to NOUNREF
- For the OPTION parameter, the default for the NOSECLVL/SECLVL option is changed to NOSECLVL.

The following parameters and options are new in the CRTCBLMOD and CRTBNDCBL commands:

- MODULE parameter for CRTCBLMOD only
- PGM parameter for CRTBNDCBL only
- OUTPUT parameter
- DBGVIEW parameter
- OPTIMIZE parameter
- LINKLIT parameter
- SIMPLEPGM parameter for CRTBNDCBL only
- MONOPRC/NOMONOPRC option in the OPTION parameter
- NOSTDTRUNC/STDTRUNC option in the OPTION parameter
- NOIMBEDERR/IMBEDERR option in the OPTION parameter
- NOCHGPOSSGN/CHGPOSSGN option in the OPTION parameter
- NOEVENTF/EVENTF option in the OPTION parameter
- MONOPIC/NOMONOPIC option in the OPTION parameter
- NOPICGGRAPHIC/PICGGRAPHIC option in the CVTOPT parameter

- NOPICNGRAPHIC/PICNGRAPHIC option in the CVTOPT parameter
- NOFLOAT/FLOAT option in the CVTOPT parameter
- NODATE/DATE option in the CVTOPT parameter
- NOTIME/TIME option in the CVTOPT parameter
- NOTIMESTAMP/TIMESTAMP option in the CVTOPT parameter
- NOCVTTODATE/CVTTODATE option in the CVTOPT parameter
- ENBPFRCOL parameter
- PRFDTA parameter
- CCSID parameter
- ARITHMETIC parameter
- NTLPADCHAR parameter
- LICOPT parameter
- BNDDIR parameter for CRTBNDCBL only
- ACTGRP parameter for CRTBNDCBL only.

All of the deletions, changes, and additions to parameters and options are also reflected in associated changes to the PROCESS statement options.

The NOGRAPHIC PROCESS statement option has been added to ILE COBOL as the default value for the GRAPHIC option on the PROCESS statement.

The following OPM COBOL/400 PROCESS statement options are not found in ILE COBOL:
- FS9MTO0M/NOFS9MTO0M
- FS9ATO0A/NOFS9ATO0A.

Coded Character Set Identifiers (CCSID)
In ILE COBOL, CCSID normalization of the source members in a compilation is to the CCSID of the primary source file. In OPM COBOL/400, it is to the CCSID of the compile time job.

Default Source Member Type
In ILE COBOL, the default source member type is CBLLE. In OPM COBOL/400, the default source member type is CBL.

Error Messages
In ILE COBOL, compile time error messages are prefixed with LNC. Also, some of the message numbers are not always the same as in OPM COBOL/400.

GENLVL Parameter
ILE COBOL will *not* generate code when an error with a severity level *greater than or equal to* the severity specified for GENLVL occurs.

OPM COBOL/400 will *not* generate code when an error with a severity level *greater than* the severity specified for GENLVL occurs.

SAA Flagging
SAA Flagging is not supported in ILE COBOL.

STRCBLDBG and ENDCBLDBG CL Commands
The STRCBLDBG and ENDCBLDBG commands are not support in ILE COBOL.

Compiler-Directing Statements

COPY Statement

Comment after Variable Length Field: In OPM COBOL/400, a DDS source with data type G and VARLEN will produce the following:

```
06    FILLER      PIC X(10)
      (Variable length field)
```

ILE COBOL adds a comment after the variable length field comment, which is more accurate:

```
06    FILLER      PIC X(10)
      (Variable length field)
      (Graphic field)
```

Default Source File Name: In ILE COBOL, if a source file member is being
compiled, the default source file name is QCBLLESRC. If a stream file is being
compiled, the stream file must be specified. In ILE COBOL, if a source file member
is being compiled, a COPY statement without the source qualifier will use
QCBLLESRC. If the default file name is used and the source member is not found
in file QCBLLESRC then file QLBLSRC will also be checked. If a stream file is
being compiled, the compiler follows a different search order to resolve copy
books. See the *ILE COBOL Reference* for details.

In OPM COBOL/400 the default source file name is QLBLSRC.

PROCESS Statement

***CBL/*CONTROL Statement:** If *CONTROL is encountered on the PROCESS statement, then it is not handled as a directive but as an invalid PROCESS option. The *CBL/*CONTROL directive should be the only statement on a given line.

INTERMEDIATE and MINIMUM Options (FIPS Flagging): In ILE COBOL, if FIPS flagging is not requested on the CRTCBLMOD or CRTBNDCBL commands, and there is a COPY statement within the PROCESS statement, no FIPS flagging will be performed against the copy member when INTERMEDIATE or MINIMUM is specified after the COPY statement. However, if INTERMEDIATE or MINIMUM is specified before the COPY statement, then FIPS flagging will be performed against the copy member.

In OPM COBOL/400, regardless of whether or not INTERMEDIATE or MINIMUM is specified before or after the COPY STATEMENT, FIPS flagging is performed against the copy member.

NOSOURCE Option: In OPM COBOL/400, when the NOSOURCE option is specified on the PROCESS statement, the Options in Effect values are printed on the compiler listing.

In ILE COBOL, when the NOSOURCE option is specified on the PROCESS statement, the Options in Effect values are not printed on the compiler listing.

USE FOR DEBUGGING

OPM COBOL/400 accepts USE FOR DEBUGGING when WITH DEBUGGING MODE is specified.

ILE COBOL does not support USE FOR DEBUGGING. Text is treated as comments until the start of the next section or the end of the DECLARATIVES. A severity 0 error message and a severity 20 error message are issued.

Environment Division

Order of DATA DIVISION and ENVIRONMENT DIVISION

OPM COBOL/400 is fairly relaxed about intermixing the order of the DATA DIVISION and ENVIRONMENT DIVISION. OPM COBOL/400 issues severity 10 and severity 20 messages when it encounters clauses, phrases, sections and divisions that are not in the proper order.

ILE COBOL does not allow the order of the DATA DIVISION and ENVIRONMENT division to be intermixed. ILE COBOL issues severity 30 messages when it encounters clauses, phrases, sections and division that are not in the proper order.

FILE-CONTROL and I-O-CONTROL Paragraphs

If a duplicate clause occurs in a FILE-CONTROL entry or I-O-CONTROL entry, and only one such clause is allowed, OPM COBOL/400 uses the last such clause specified.

In the same situation, ILE COBOL uses the first such clause specified.

SELECT Clause

The OPM COBOL/400 compiler accepts multiple SELECT clauses that refer to a given file name, if the attributes specified are consistent. In some cases no error messages are issued. In others, severity 10, or severity 20 messages are issued. In the case where attributes specified are inconsistent, severity 30 messages are issued.

The ILE COBOL compiler issues severity 30 messages in all cases of multiple SELECT clauses that refer to a given file name.

Data Division

Order of DATA DIVISION and ENVIRONMENT DIVISION

See “Order of DATA DIVISION and ENVIRONMENT DIVISION” in section “Environment Division.”

FD or SD Entries

If a duplicate clause occurs in a FD entry or SD entry, and only one such clause is allowed, OPM COBOL/400 uses the last such clause specified.

In the same situation, ILE COBOL uses the first such clause specified.

WORKING-STORAGE SECTION

In ILE COBOL, the storage allocation of independent Working-Storage items does not reflect the order in which these items are declared in the Working-Storage section, as was the case in OPM COBOL/400.

The potential impact of this change in the way storage is allocated, is on those programs that use a circumvention scheme to alleviate the 32K maximum table size limitation of OPM COBOL/400. If your program uses a circumvention scheme to increase table size where multiple independent Working-Storage items are consecutively declared and range checking is turned off, then this scheme will no

longer work. If a program that uses such a scheme is run using ILE COBOL, the program will produce unpredictable results.

For ILE COBOL, the maximum table size is now 16 711 568 bytes and thus the problem that triggered this circumvention scheme no longer exists. However, any programs that use this circumvention scheme will have to be recoded.

LIKE Clause

When a REDEFINES clause is found after a LIKE clause, the OPM COBOL/400 compiler issues a severity 20 message indicating that the REDEFINES clause has been ignored because it occurs after a LIKE clause.

In the same situation, the ILE COBOL compiler issues a severity 10 message when the REDEFINES clause is encountered and accepts the REDEFINES clause, but it also issues a severity 30 message indicating the LIKE clause is not compatible with the REDEFINES clause.

This scenario may occur in the case of other incompatible clauses such as LIKE and USAGE, or LIKE and PICTURE.

LINAGE Clause

OPM COBOL/400 flags a signed LINAGE integer with message LBL1350, but issues no message for signed FOOTING, TOP, and BOTTOM.

ILE COBOL issues message LNC1350 in all 4 cases.

PICTURE Clause

The PICTURE string .$$ is not accepted by the ILE COBOL compiler. Similarly, the PICTURE strings +.$$ and -.$$ are not accepted either.

When CR or DB appear on character positions 30 and 31 of a character string, they are not accepted as valid by the ILE COBOL compiler. The entire PICTURE string must be contained within the 30 characters.

REDEFINES Clause

OPM COBOL/400 initializes redefined items.

ILE COBOL does not initialize redefined items. The initial value is determined by the default value of the original data item.

VALUE Clause

In ILE COBOL, a numeric literal specified in the VALUE clause will be truncated if its value is longer than the PICTURE string defining it. In OPM COBOL/400, a value of 0 will be assumed.

Procedure Division

General Considerations

Binary Data Items: In OPM COBOL/400, when you have data in binary data items, where the value in the item exceeds the value described by the picture clause, you will get unpredictable results. In general, when this item is used, it may or may not be truncated to the actual number of digits described by the picture clause. It usually depends on whether a PACKED intermediate is used to copy the value.

In ILE COBOL, you will also get unpredictable results, but they will be different from those generated by OPM COBOL/400.

8-Byte Binary Data Alignment: In OPM COBOL/400, 8-byte binary items are aligned with 4-byte boundaries if the *SYNC option is specified on the GENOPT parameter of the CRTCBLPGM command.

In ILE COBOL, 8-byte binary items are aligned with 8-byte boundaries if the *SYNC option is specified on the OPTION parameter of the CRTCBLMOD or CRTBNDCBL commands.

Duplicate Paragraph Names: When duplicate paragraph names are found in a COBOL program, the OPM COBOL/400 compiler generates a severity 20 message.

In the same situation, the ILE COBOL compiler generates a severity 30 message.

Number of Subscript: When an incorrect number of subscript are specified for an item (too many, two few, none for an item which requires them, or specified for an item which does not require them), a severity 30 message is generated in ILE COBOL.

In the same situation, OPM COBOL/400 generates a severity 20 message.

Segmentation: Segmentation is not supported in ILE COBOL. Consequently, syntax checking of segment numbers is not performed.

Common Phrases

(NOT) ON EXCEPTION Phrase: The (NOT) ON EXCEPTION PHRASE has been added to the DISPLAY statement. The addition of these phrases could require you to add the END-DISPLAY scope delimiter to prevent compile time errors.

For example:

```
ACCEPT B AT LINE 3 COLUMN 1
  ON EXCEPTION
      DISPLAY "IN ON EXCEPTION"
  NOT ON EXCEPTION
      MOVE A TO B
END-ACCEPT.
```

Both the ON EXCEPTION and NOT ON EXCEPTION phrases were meant for the ACCEPT statement; however, without an END-DISPLAY as shown below the NOT ON EXCEPTION would be considered part of the DISPLAY statement.

```
 ACCEPT B AT LINE 3 COLUMN 1
   ON EXCEPTION
      DISPLAY "IN ON EXCEPTION"
      END-DISPLAY
   NOT ON EXCEPTION
      MOVE A TO B
END-ACCEPT.
```

INVALID KEY Phrase: In ILE COBOL, the INVALID KEY phrase is not allowed for sequential access of relative files since the meaning of the invalid key would be indeterminate under these circumstances. The ILE COBOL compiler issues a severity 30 error message in this situation.

The OPM COBOL/400 compiler does not issue any error messages in this situation.

ON SIZE ERROR Phrase: For arithmetic operations and conditional expressions in ILE COBOL, when ON SIZE ERROR is not specified and a size error occurs, the results are unpredictable. The results may be different than those that existed in OPM COBOL/400.

For arithmetic operations and conditional expressions in ILE COBOL, when ON SIZE ERROR is not specified and a divide by zero occurs, the results are unpredictable. The results may be different than those that existed in OPM COBOL/400.

DECLARATIVE Procedures

Declarative Implemented as an ILE Procedure: In ILE COBOL, each DECLARATIVE procedure is an ILE procedure. Thus, each DECLARATIVE procedure run in its own invocation separate from other declaratives and separate from the non-declarative part of the ILE COBOL program. As a result, using invocation sensitive system facilities such as sending and receiving messages, RCLRSC CL command, and overrides will be different in ILE COBOL than in OPM COBOL/400.

Invoking a Declarative from Another Declarative: In ILE COBOL, a declarative may be invoked from another declarative due to an I-O error provided that the former declarative is not already invoked for any reason.

OPM COBOL/400 prevents a declarative from being invoked from another declarative due to an I-O error.

Expressions

Class Condition Expressions: In ILE COBOL, the identifier in a class condition expression cannot be a group item containing one or more signed, numeric elementary items.

Abbreviated Conditional Expressions: For ILE COBOL, the use of parentheses in abbreviated combined relational conditions is not valid. OPM COBOL/400 does not enforce this rule.

Comparing Figurative Constants with Figurative Constants: In OPM COBOL/400, when a figurative constant is compared with another figurative constant, a severity 20 error message is issued and the statement is accepted.

In ILE COBOL, when a figurative constant is compared with another figurative constant, a severity 30 error message is issued and the statement is rejected.

Comparison of Zoned and Non-numeric Items: When comparing zoned items to a non-numeric item, OPM COBOL/400 issues a severity 20 message. ILE COBOL does not issue such a message.

NOT in a Relational Expression: The expression ″ A NOT NOT = B ″ is accepted by OPM COBOL/400 but a severity 20 message is generated.

In the same situation, ILE COBOL generates a severity 30 message.

NOT LESS THAN OR EQUAL TO: ILE COBOL allows some forms of conditional expression that are not permitted by OPM COBOL/400. In particular, these include NOT LESS THAN OR EQUAL and NOT GREATER THAN OR EQUAL.

Special Registers

DEBUG-ITEM Special Register: ILE COBOL no longer supports the DEBUG-ITEM special register. When encountered, it is syntax-checked only.

LINAGE-COUNTER Special Register: In OPM COBOL/400, when an integer occurs in the LINAGE clause, the LINAGE-COUNTER is defined as a 2-byte, 5-digit binary item.

In ILE COBOL, when an integer occurs in the LINAGE clause, the LINAGE-COUNTER is defined as a 4-byte, 9-digit binary item.

WHEN-COMPILED Special Register: In OPM COBOL/400, the WHEN-COMPILED special register can be used with just the MOVE statement.

In ILE COBOL, the WHEN-COMPILED special register can be used with any statement.

Extended ACCEPT and DISPLAY Statements

Compile Time Considerations: OPM COBOL/400 requires a value of EXTACCDSP in the GENOPT parameter of the CRTCBLPGM command in order to enable the extended ACCEPT and DISPLAY statements. The EXTACCDSP option does not exist in the CRTCBLMOD/CRTBNDCBL commands for ILE COBOL. In ILE COBOL, extended ACCEPT and DISPLAY statements are always enabled. Since the EXTACCDSP option no longer exists on the PROCESS statement for ILE COBOL, any OPM COBOL/400 program that specifies this option on its PROCESS statement may behave differently when it is compiled using the ILE COBOL compiler. The ILE COBOL compiler determines whether an ACCEPT or DISPLAY statement is extended by looking for CONSOLE IS CRT in the SPECIAL NAMES paragraph or by looking for phrases found in the Format 7 ACCEPT statement or the Format 3 DISPLAY statement.

In ILE COBOL, the following are COBOL reserved words at all times:
- AUTO
- BEEP
- BELL
- FULL
- BLINK
- COL
- COLUMN
- PROMPT
- UPDATE
- NO-ECHO
- REQUIRED
- AUTO-SKIP
- HIGHLIGHT
- UNDERLINE
- ZERO-FILL
- EMPTY-CHECK
- LEFT-JUSTIFY
- LENGTH-CHECK
- REVERSE-VIDEO
- RIGHT-JUSTIFY
- TRAILING-SIGN.

In OPM COBOL/400, only fixed tables are supported by the DISPLAY statement. In ILE COBOL, any table is supported by both the ACCEPT and DISPLAY statements.

Reference modified data is supported in the extended ACCEPT and DISPLAY statements for ILE COBOL. It is not supported in OPM COBOL/400.

In OPM COBOL/400 you have to use the *NOUNDSPCHR option to be able to use the extended character set in addition to the basic DBCS character set. In ILE COBOL, you can use either the *NOUNDSPCHR or *UNDSPCHR and still manage DBCS characters properly.

The OPM COBOL/400 compiler issues a severity 30 error message when it encounters a data item whose length is longer than the screen's capacity. The ILE COBOL compiler does not issue such an error.

In ILE COBOL, a severity 30 error message is issued when an identifier or integer on the COLUMN phrase exceeds 8 digits. OPM COBOL/400 does not issue an error.

For syntax checked only phrases in the extended DISPLAY statement, the ILE COBOL compiler performs complete syntax checking of the PROMPT, BACKGROUND-COLOR, and FOREGROUND-COLOR phrases. If any of these phrases are coded incorrectly, the ILE COBOL compiler issues severity 30 error messages. The OPM COBOL/400 compiler does not perform complete syntax checking on the PROMPT, BACKGROUND-COLOR, and FOREGROUND-COLOR phrases and does not issue any compile time error messages.

Run Time Considerations: In OPM COBOL/400, the PRINT key is disabled during the extend ACCEPT operation. In ILE COBOL, the PRINT KEY will be enabled at all times, unconditionally.

In OPM COBOL/400, the SIZE phrase is supported in the DISPLAY statement only. In ILE COBOL, the SIZE phrase is supported in both the ACCEPT and DISPLAY statements. When the specified size is greater than the size implied by the PICTURE clause data length, then OPM COBOL/400 pads blanks to the left when alphanumeric data is justified. ILE COBOL always pads blanks to the right.

In OPM COBOL/400, error message LBE7208 is issued when the data item cannot fit within the screen. In ILE COBOL, alphanumeric data that does not fit within the screen is truncated and numeric data that does not fit within the screen is not displayed. No runtime errors are issued.

When the HELP and CLEAR keys are used to complete the ACCEPT operation on a workstation attached to a 3174 or 3274 remote controller, a runtime error will be issued by ILE COBOL. OPM COBOL/400 will successfully complete this ACCEPT operation without issuing a runtime error.

OPM COBOL/400 always updates all the fields which are handled by the ACCEPT statement. ILE COBOL updates only the fields that the user has changed before pressing the ENTER key for one ACCEPT statement. As a result, the two compilers behave differently in three situations:

- When the SECURE phrase is specified on the ACCEPT statement and no value is entered
- When the ACCUPDNE option is in effect and data that is not numeric edited is handled by the ACCEPT statement

- When the field is predisplayed with alphanumeric data and the RIGHT-JUSTIFIED phrase is specified on the ACCEPT statement.

CALL Statement

Lower Case Characters in CALL/CANCEL Literal or Identifier: OPM COBOL/400 allows the CALL/CANCEL literal or identifier to contain lower case characters; however, a program object name that is not a quoted system name (extended name) does not allow lower case characters,. This means the resulting the CALL/CANCEL operation will fail.

ILE COBOL supports two new values on the OPTION parameter of the CRTCBLMOD and CRTBNDCBL commands: *MONOPRC and *NOMONOPRC. The default value, *MONOPRC, causes any lower case letters in the CALL/CANCEL literal or identifier to be converted to upper case. The *NOMONOPRC value specifies that the CALL/CANCEL literal or identifier is not to be converted to upper case.

Passing a File-Name on the USING Phrase: Both OPM COBOL/400 and ILE COBOL allow a file-name to be passed on the USING phrase of the CALL statement; however, OPM COBOL/400 passes a pointer to a FIB (file information block), whereas ILE COBOL passes a pointer to a NULL pointer.

Recursive Calls: ILE COBOL allows recursive programs to be called recursively.
ILE COBOL generates a runtime error message when recursion is detected in a non
recursive program..

OPM COBOL/400 does not prevent recursion. However, if recursion is attempted with OPM COBOL/400 the results may be unpredictable.

CANCEL Statement

In ILE COBOL, the CANCEL statement will only cancel ILE COBOL programs within the same activation group. In ILE COBOL, a list of called program objects is maintained at the activation group (run unit) level. If the program to cancel does not appear in this list, the cancel is ignored.

In OPM COBOL/400, the CANCEL statement will issue an error message if the program to cancel does not exist in the library list.

COMPUTE Statement

In some cases, the result of exponentiation in ILE COBOL may be slightly different than the results of exponentiation in OPM COBOL/400.

When a COMPUTE statement of an exponentiation expression with a negative value for the mantissa and a negative fractional value for the exponent is performed, OPM COBOL/400 yields undefined results. In the same situation, ILE COBOL generates a CEE2020 exception.

DELETE Statement

In OPM COBOL/400, file status is set to 90 when a record format that is not valid for a file is use on the DELETE statement.

In ILE COBOL, file status is set to 9K when a record format that is not valid for a file is use on the DELETE statement.

EVALUATE Statement

In OPM COBOL/400, when the WHEN phrase is specified with ZERO THRU *alphabetic-identifier*, the statement is allowed and no diagnostic message is issued.

In the same situation, ILE COBOL issues a severity 30 error message.

Note: ILE COBOL has relaxed this rule in the case of *alphanumeric-identifier* THRU *alphabetic-identifier* since the alphanumeric-identifier can contain only alphabetic characters.

IF Statement

OPM COBOL/400 has a limit of 30 for the nesting depth of IF statements.

ILE COBOL has no practical limit to the nesting depth of IF statements.

In OPM COBOL/400, when the NEXT SENTENCE phrase is used in the same IF statement as the END-IF phrase, control passes to the statement following the END-IF phrase.

In the same situation in ILE COBOL, control passes to the statement following the next separator period, that is, to the first statement of the next sentence.

Note: The OPM *COBOL/400 Reference* manual states that the expected behaviour is the same as what actually occurs for ILE COBOL.

INSPECT Statement

ILE COBOL supports reference modification in the INSPECT statement.

OPM COBOL/400 does not include this support.

MOVE Statement

Alphanumeric Literals and Index Names: When an alphanumeric literal is moved to an index name, OPM COBOL/400 issues a severity 20 error message. In the same situation, ILE COBOL issues a severity 30 error message.

Alphanumeric Values and Numeric-Edited Literals: When an alphanumeric value containing only numeric characters is moved to a numeric-edited literal (for example, `MOVE "12.34" TO NUMEDIT`), OPM COBOL/400 defaults the literal to 0. In the same situation, ILE COBOL issues a severity 30 error message.

Boolean Values: OPM COBOL/400 allows a Boolean value to be moved to a reference-modified alphabetic identifier. ILE COBOL does not allow this and issues a severity 30 error message.

CORRESPONDING Phrase: The MOVE, ADD, and SUBTRACT CORRESPONDING statements in ILE COBOL use a difference algorithm from OPM COBOL/400 to determine which items correspond. ILE COBOL could generate a severity 30 error message where in OPM COBOL/400, no message would be issued.

```
01 A.
   05  B.
     10  C PIC X(5).
   05  C PIC X(5).
01 D.
```

```
        05  B.
          10  C PIC X(5).
        05  C PIC X(5).
MOVE CORRESPONDING A TO D.
```

OPM COBOL/400 issues no message; ILE COBOL will issue message LNC1463.

Overlapping Source and Target Strings: If source and target strings are overlapping for a MOVE statement, the result is unpredictable. The move may not behave as it did for OPM COBOL/400 in the same situation.

OPEN Statement

Dynamic File Creation: There are two compatibility issues regarding dynamic file creation:

- The OPM COBOL/400 compiler supported the dynamic creation of indexed files.

  The ILE COBOL compiler does *not* provide this support.
- A file will be dynamically created only if it is assigned to a COBOL device type of DISK.

  OPM COBOL/400 creates files (database files) that are assigned to COBOL device types other than DISK if there is an override to a database file (OVRDBF).

Opening FORMATFILEs: In ILE COBOL, FORMATFILEs can only be opened for OUTPUT. The WRITE statement can be used to write output records to the FORMATFILE.

In OPM COBOL/400, FORMATFILEs can be opened for INPUT, I-O, and OUTPUT.

OPEN OUTPUT or OPEN I-O for OPTIONAL Files: In ILE COBOL, OPEN OUTPUT or OPEN I-O for OPTIONAL files will not create the file, if it does not exist, when the file's organization is INDEXED.

In OPM COBOL/400, the file is created.

PERFORM Statement

In ILE COBOL, within the VARYING...AFTER phrase of the PERFORM statement, *identifier-2* is augmented before *identifier-5* is set. In OPM COBOL/400, *identifier-5* is set before *identifier-2* is augmented.

The results of the Format 4 PERFORM statement with the AFTER phrase is different in ILE COBOL compared to OPM COBOL/400. Consider the following example:

```
PERFORM PARAGRAPH-NAME-1
        VARYING X FROM 1 BY 1 UNTIL X > 3
                AFTER Y FROM X BY 1 UNTIL Y > 3.
```

In OPM COBOL/400, *PARAGRAPH-NAME-1* is performed with (X,Y) values of (1,1), (1,2), (1,3), (2,1), (2,2), (2,3), (3,2), (3,3).

In ILE COBOL, *PARAGRAPH-NAME-1* is performed with (X,Y) values of (1,1), (1,2), (1,3), (2,2), (2,3), (3,3).

READ Statement

AT END Not Allowed for Random Reads of Relative Files: In ILE COBOL, the AT END phrase is not allowed for random reads of relative files since the meaning

of the random read would be indeterminate under these circumstances. The ILE COBOL compiler issues a severity 30 error message in this situation.

The OPM COBOL/400 compiler does not issue any error messages in this situation.

Error Messages: For ILE COBOL, error message LNC1408, not LNC0651, is issued for the FORMAT phrase when a READ statement is to be performed on a FORMATFILE.

Error message LNC1408 is issued when the device to be read is something other than DATABASE. Error message LNC0651 is issued when the device is DATABASE, but ORGANIZATION is not indexed.

REWRITE Statement

In OPM COBOL/400, file status is set to 90 when a record format that is not valid for a file is used on the REWRITE statement.

In ILE COBOL, file status is set to 9K when a record format that is not valid for a file is used on the REWRITE statement.

SET Statement

When setting a condition-name to TRUE and the associated condition variable is an edited item, OPM COBOL/400 edits the value of the condition-name when it is moved to the condition variable.

ILE COBOL does not perform any editing when the value of the condition-name is moved to the condition variable.

SORT/MERGE Statements

GIVING Phrase and the SAME AREA/SAME RECORD AREA Clauses: In ILE COBOL, file-names associated with the GIVING phrase may not be specified in the same SAME AREA or SAME RECORD AREA clauses. The ILE COBOL compiler issues a severity 30 error message if this situation is encountered.

The OPM COBOL/400 compiler does not issue any messages in this situation.

STOP RUN Statement

When STOP RUN is issued in an ILE activation group, it will cause an implicit COMMIT to take place, which is not the case in OPM COBOL/400.

Note: A STOP RUN issued in the job default activation group (*DFTACTGRP) will not cause an implicit COMMIT.

STRING/UNSTRING Statements

In OPM COBOL/400, the PROGRAM COLLATING SEQUENCE is used to determine the truth value of the implicit relational conditions in STRING/UNSTRING operations.

In ILE COBOL, the PROGRAM COLLATING SEQUENCE is ignored when determining the truth value of the implicit relational conditions in STRING/UNSTRING operations.

Application Programming Interfaces (APIs)

ILE COBOL Bindable APIs

ILE COBOL uses new bindable APIs instead of the OPM runtime routines:

- QlnRtvCobolErrorHandler ILE bindable API replaces QLRRTVCE
- QlnSetCobolErrorHandler ILE bindable API replaces QLRSETCE
- QlnDumpCobol ILE bindable API replaces QLREXHAN to produce a formatted dump
- QLRCHGCM is not supported in ILE COBOL. Use named ILE activation groups to obtain multiple run units.

Calling OPM COBOL/400 APIs

OPM COBOL/400 APIs can be called from ILE COBOL but they will only affect OPM COBOL/400 run units.

To affect ILE COBOL run units, use the corresponding ILE APIs or the ACTGRP parameter of the CRTPGM command.

Run Time

Preserving the OPM-compatible Run Unit Semantics

You can closely preserve OPM-compatible run unit semantics in:

- An application that consists of only ILE COBOL programs, or
- An application that mixes OPM COBOL/400 programs and ILE COBOL programs.

Preserving OPM-compatible Run Unit Semantics in an ILE COBOL Application: To preserve the OPM-compatible run unit semantics in an ILE COBOL application, the following conditions must be met:

- All run unit participants (ILE COBOL or other ILE programs/procedures) must run in a single ILE activation group.

  Note: By using a named ILE activation group for all participating programs, you need not specify a particular ILE COBOL program to be the main program before execution. On the other hand, if a particular ILE COBOL program is known to be main program before execution, you can specify *NEW attribute for the ACTGRP option when creating a *PGM object using the ILE COBOL program as the UEP. All other participating programs should specify the *CALLER attribute for the ACTGRP option.
- The oldest invocation of the ILE activation group must be that of ILE COBOL. This is the main program of the run unit.

If these conditions are not met, an implicit or explicit STOP RUN in an ILE activation group may not end the activation group. With the activation group still active, the various ILE COBOL programs will be in their last used state.

Note: The above condition dictates that an ILE COBOL program running in the *DFTACTGRP is generally run in a run unit that is not OPM-compatible. ILE COBOL programs running in the *DFTACTGRP will not have their static storage physically reclaimed until the job ends. An ILE COBOL program, with *CALLER specified for the ACTGRP parameter of the CRTPGM command, will run in the *DFTACTGRP if it is called by an OPM program.

Preserving OPM-compatible Run Unit Semantics in a Mixed OPM COBOL/400 and ILE COBOL Application: In order to mix OPM COBOL/400 programs with ILE COBOL programs and still preserve the OPM-compatible run unit semantics as closely as possible, the following conditions need to be met:

- OPM COBOL/400 program's invocation (not ILE COBOL's) must be the first COBOL invocation
- STOP RUN is issued by an OPM COBOL/400 program
- All participating programs in the (OPM COBOL/400) run unit must run in the *DFTACTGRP activation group.

If the above conditions are not met, the OPM-compatible run unit semantics is not preserved for OPM/ILE mixed application. For example, if an ILE COBOL program is running in the *DFTACTGRP and it issues a STOP RUN, both the OPM COBOL/400 and ILE COBOL programs will be left in their last used state.

In ILE COBOL, the flow of control operations, CALL, CANCEL, EXIT PROGRAM, STOP RUN, and GOBACK, will cause the run unit to behave differently unless an OPM-compatible run unit is used.

Error Messages

In ILE COBOL, runtime error messages are prefixed with LNR. Also, some of the message numbers are not always the same as in OPM COBOL/400.

In ILE COBOL, when the run unit terminates abnormally, the message CEE9901 is returned to the caller. In OPM COBOL/400, the message LBE9001 is returned to the caller under the same circumstances.

Due to differences between ILE exception handling and OPM exception handling, you may receive more exceptions in an ILE COBOL statement compared to an OPM COBOL/400 statement.

File Status 9A changed to 0A

In OPM COBOL/400, file status is set to 9A when a job is ended in a controlled manner.

In ILE COBOL, file status is set to 0A when a job is ended in a controlled manner.

File Status 9M changed to 0M

In OPM COBOL/400, file status is set to 9M when the last record is written to a subfile.

In ILE COBOL, file status is set to 0M when the last record is written to a subfile.

Appendix H. Glossary of Abbreviations

Abbreviation	Meaning	Explanation
AG	Activation Group	A partitioning of resources within a job. An activation group consists of system resources (storage for program or procedure variables, commitment definitions, and open files) allocated to one or more programs.
API	Application Programming Interface	A functional interface supplied by the operating system or by a separately orderable licensed program that allows an application program written in a high-level language to use specific data or functions of the operating system or licensed program.
ANSI	American National Standards Institute	An organization consisting of producers, consumers, and general interest groups, that establishes the procedures by which accredited organizations create and maintain voluntary industry standards in the United States.
ASCII	American National Standard Code for Information Interchange	The code developed by American National Standards Institute for information exchange among data processing systems, data communications systems, and associated equipment. The ASCII character set consists of 8-bit characters, consisting of 7-bit control characters and symbolic characters, plus one parity-check bit.
CICS®®	Customer Information Control Service	An IBM licensed program that enables transactions entered at remote work stations to be processed concurrently by user-written application programs. The licensed program includes functions for building, using, and maintaining databases, and for communicating with CICS on other operating systems.
CL	Control Language	The set of all commands with which a user requests system functions.
DBCS	Double-Byte Character Set	A set of characters in which each character is represented by 2 bytes. Languages such as Japanese, Chinese, and Korean, which contain more symbols than can be represented by 256 code points, require double-byte character sets. Because each character requires 2 bytes, the typing, displaying, and printing of DBCS characters requires hardware and programs that support DBCS. Four double-byte character sets are supported by the system: Japanese, Korean, Simplified Chinese, and Traditional Chinese. Contrast with single-byte character set.
DDM	Distributed Data Management	A function of the operating system that allows an application program or user on one system to use data files stored on remote systems. The systems must be connected by a communications network, and the remote systems must also be using DDM.
DDS	Data Description Specifications	A description of the user's database or device files that is entered into the system in a fixed form. The description is then used to create files.
EBCDIC	Extended Binary-Coded Decimal Interchange Code.	A coded character set consisting of 256 eight-bit characters.

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Abbreviation	Meaning	Explanation
EPM	Extended Program Model	The set of functions for compiling source code and creating programs on the iSeries system in high-level languages that define procedure calls.
FIPS	Federal Information Processing Standard	An official standard to improve the utilization and management of computers and data processing in business.
HLL	high-level language	A programming language whose concepts and structures are convenient for human reasoning; for example, C, COBOL, and RPG. High-level languages are independent of the structures of computers and operating structures.
ICF	Intersystem Communications Function	A function of the operating system that allows a program to communicate interactively with another program or system.
ILE	Integrated Language Environment	A set of constructs and interfaces that provides a common runtime environment and runtime bindable application programming interfaces (APIs) for all ILE-conforming high-level languages.
I/O	Input/Output	Data provided to the computer or data resulting from computer processing.
LVLCHK	Level Checking	A function that compares the record format-level identifiers of a file to be opened with the file description that is part of a compiled program to determine if the record format for the file changed since the program was compiled.
ODP	open data path	A control block created when a file is opened. An ODP contains information about the merged file attributes and information returned by input and output operations. The ODP only exists while the file is open.
ODT	Object Definition Table	A table built at compile time by the system to keep track of objects declared in the program. The program objects in the table include variables, constants, labels, operand lists and exception descriptions. The table resides in the compiled program object.
OPM	original program model	The set of functions for compiling source code and creating high-level language programs on the iSeries system before the Integrated Language Environment (ILE) model was introduced.
OS/400	Operating System/400	The iSeries operating system.
PEP	program entry procedure	A procedure provided by the compiler that is the entry point for an ILE program on a dynamic program call. Contrast with *user entry procedure*.
SDA	Screen Design Aid	A function of the Application Development ToolSet for iSeries licensed program that helps the user design, create, and maintain displays and menus.
SEU	Source Entry Utility	A function of the Application Development ToolSet for iSeries licensed program that is used to create and change source members.
SQL/400	Structured Query Language/400	An IBM licensed program supporting the relational database that is used to put information into a database and to get and organize selected information from a database.

Abbreviation	Meaning	Explanation
UEP	user entry procedure	The entry procedure, written by an application programmer, that is the target of the dynamic program call. This procedure is called by the program entry procedure (PEP). Contrast with *program entry procedure*.
UPSI	User Program Status Indicator switch	An external program switch that performs the functions of a hardware switch. Eight switches are provided: UPSI 0 - 7.

Note: The abbreviations for OS/400 commands do not appear here. For OS/400 commands and their usage, refer to the *CL and APIs* section of the *Programming* category in the **iSeries 400 Information Center** at this Web site -http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm.

Appendix I. ILE COBOL Documentation

The appendix describes the online information and hardcopy books available with ILE COBOL. For more information about ordering books, contact your IBM Representative.

Online Information

You can access the online information in several ways:

- Pressing F1 from a Create Bound COBOL Program (CRTBNDCBL) or Create COBOL Module (CRTCBLMOD) display
- Pressing F1 from within the Compiler Options or Program Verifier dialog boxes, or pressing F1 from within the Editor of CoOperative Development Environment/400
- Going to the iSeries Infocenter:
  http://publib.boulder.ibm.com/pubs/html/as400/infocenter.htm

  Select your geography, then the language and the latest release. In the left pane, select **iSeries supplemental manuals**. Then click **Complete list of manuals**. From the list of online books displayed, you can access the *WebSphere Development Studio: ILE COBOL Programmer's Guide* and the *WebSphere Development Studio: ILE COBOL Reference*.

Hardcopy Information

The following hardcopy books are available for the ILE COBOL product:

- *WebSphere Development Studio: ILE COBOL Programmer's Guide*, SC09-2540-03
- *WebSphere Development Studio: ILE COBOL Reference*, SC09-2539-03
- *ILE Concepts*, SC41-5606-06.

Note: Additional copies of any of the publications can be ordered for a fee.

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Programming Interface Information

This publication is intended to help you write Integrated Language Environment® ILE COBOL programs. It contains information necessary for you to use the ILE COBOL compiler.

This manual does not document programming interfaces for use in writing programs that request or receive the services of the ILE COBOL compiler.

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IBM acknowledges the use of the following research product in the ILE COBOL compiler:

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Bibliography

For additional information about topics related to ILE COBOL programming on the iSeries system, refer to the following IBM iSeries publications:

- *WebSphere Development Studio: Application Development Manager User's Guide*, SC09-2133-02, describes creating and managing projects defined for the Application Development Manager feature as well as using the program to develop applications.
- *ADTS/400: Programming Development Manager*, SC09-1771-00, provides information about using the Application Development ToolSet programming development manager (PDM) to work with lists of libraries, objects, members, and user-defined options to easily do such operations as copy, delete, and rename. Contains activities and reference material to help the user learn PDM. The most commonly used operations and function keys are explained in detail using examples.
- *ADTS for AS/400: Source Entry Utility*, SC09-2605-00, provides information about using the Application Development ToolSet source entry utility (SEU) to create and edit source members. The manual explains how to start and end an SEU session and how to use the many features of this full-screen text editor. The manual contains examples to help both new and experienced users accomplish various editing tasks, from the simplest line commands to using pre-defined prompts for high-level languages and data formats.
- *Application Display Programming*, SC41-5715-00, provides information about:
  - Using DDS to create and maintain displays for applications
  - Creating and working with display files on the system
  - Creating online help information
  - Using UIM to define panels and dialogs for an application
  - Using panel groups, records, or documents
- *Backup and Recovery*, SC41-5304-06, provides information about setting up and managing the following:
  - Journaling, access path protection, and commitment control
  - User auxiliary storage pools (ASPs)
  - Disk protection (device parity, mirrored, and checksum)

  Provides performance information about backup media and save/restore operations. Also includes advanced backup and recovery topics, such as using save-while-active support, saving and restoring to a different release, and programming tips and techniques.
- *CICS for iSeries Application Programming Guide*, SC41-5454-01, provides information on application programming for CICS® for iSeries. It includes guidance and reference information on the CICS application programming interface and system programming interface commands, and gives general information about developing new applications and migrating existing applications from other CICS platforms.
- *CL Programming*, SC41-5721-05 provides a wide-ranging discussion of iSeries programming topics including a general discussion on objects and libraries, CL programming, controlling flow and communicating between programs, working with objects in CL programs, and creating CL programs. Other topics include predefined and impromptu messages and message handling, defining and creating user-defined commands and menus, application testing, including debug mode, breakpoints, traces, and display functions.
- *Communications Management*, SC41-5406-02, provides information about work management in a communications environment, communications status, tracing and diagnosing communications problems, error handling and recovery, performance, and specific line speed and subsystem storage information.
- *Experience RPG IV Tutorial*, GK2T-9882-00, is an interactive self-study program explaining the differences between RPG III and RPG IV and how to work within the new ILE environment. An accompanying workbook provides additional exercises and doubles as a reference upon completion of the tutorial. ILE RPG compiler code examples are shipped with the tutorial and run directly on the iSeries.
- *GDDM Programming Guide*, SC41-0536-00, provides information about using OS/400

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graphical data display manager (GDDM) to write graphics application programs. Includes many example programs and information to help users understand how the product fits into data processing systems.

- *GDDM Reference*, SC41-3718-00, provides information about using OS/400 graphical data display manager (GDDM) to write graphics application programs. This manual provides detailed descriptions of all graphics routines available in GDDM. Also provides information about high-level language interfaces to GDDM.
- *ICF Programming*, SC41-5442-00, provides information needed to write application programs that use iSeries communications and the OS/400 intersystem communications function (OS/400-ICF). Also contains information on data description specifications (DDS) keywords, system-supplied formats, return codes, file transfer support, and program examples.
- *IDDU Use*, SC41-5704-00, describes how to use the iSeries interactive data definition utility (IDDU) to describe data dictionaries, files, and records to the system. Includes:
  - An introduction to computer file and data definition concepts
  - An introduction to the use of IDDU to describe the data used in queries and documents
  - Representative tasks related to creating, maintaining, and using data dictionaries, files, record formats, and fields
  - Advanced information about using IDDU to work with files created on other systems and information about error recovery and problem prevention.
- *WebSphere Development Studio: ILE C/C++ Programmer's Guide*, SC09-2712-03, provides information on how to develop applications using the ILE C compiler language. It includes information about creating, running and debugging programs. It also includes programming considerations for interlanguage program and procedure calls, locales, handling exceptions, database, externally described and device files. Some performance tips are also described. An appendix includes information on migrating source code from EPM C/400 or System C/400 to the ILE C compiler.
- *ILE C for AS/400 Language Reference*, SC09-2711-01, provides information on Machine Interface instructions available in the ILE C compiler, that provide system-level programming capabilities.
- *WebSphere Development Studio: ILE COBOL Reference*, SC09-2539-03, provides a description of the ILE COBOL programming language. It provides information on the structure of the ILE COBOL programming language and the structure of an ILE COBOL source program. It also provides a description of all Identification Division paragraphs, Environment Division clauses, Data Division clauses, Procedure Division statements, and Compiler-Directing statements.
- *ILE Concepts*, SC41-5606-06, explains concepts and terminology pertaining to the Integrated Language Environment (ILE) architecture of the iSeries licensed program. Topics covered include creating modules, binding, running programs, debugging programs, and handling exceptions.
- *WebSphere Development Studio: ILE RPG Programmer's Guide*, SC09-2507-04, provides information about the ILE RPG compiler programming language, which is an implementation of the RPG IV language in the Integrated Language Environment (ILE) on the iSeries. It includes information on creating and running programs, with considerations for procedure calls and interlanguage programming. The guide also covers debugging and exception handling and explains how to use iSeries files and devices in RPG programs. Appendixes include information on migration to RPG IV and sample compiler listings. It is intended for people with a basic understanding of data processing concepts and of the RPG language.
- *WebSphere Development Studio: ILE RPG Reference*, SC09-2508-04, provides information about the ILE RPG compiler programming language. This manual describes, position by position and keyword by keyword, the valid entries for all RPG IV specifications, and provides a detailed description of all the operation codes and built-in functions. This manual also contains information on the RPG logic cycle, arrays and tables, editing functions, and indicators.
- *WebSphere Development Studio: ILE RPG Reference Summary*, SX09-1315-03, provides information about the RPG III and RPG IV programming language. This manual contains tables and lists for all specifications and operations in both languages. A key is provided

to map RPG III specifications and operations to RPG IV specifications and operations.

- *Local Device Configuration*, SC41-5121-00, provides information about configuring local devices on the iSeries server. This includes information on how to configure the following:
  - Local work station controllers (including twinaxial controllers)
  - Tape controllers
  - Locally attached devices (including twinaxial devices)
- *Printer Device Programming*, SC41-5713-05, provides information to help you understand and control printing. Provides specific information on printing elements and concepts of the iSeries server, printer file and print spooling support for printing operations, and printer connectivity. Includes considerations for using personal computers, other printing functions such as Business Graphics Utility (BGU), advanced function printing (AFP™), and examples of working with the iSeries printing elements such as how to move spooled output files from one output queue to a different output queue. Also includes an appendix of control language (CL) commands used to manage printing workload. Fonts available for use with the iSeries are also provided. Font substitution tables provide a cross-reference of substituted fonts if attached printers do not support application-specified fonts.
- *iSeries Security Reference*, SC41-5302-06, tells how system security support can be used to protect the system and the data from being used by people who do not have the proper authorization, protect the data from intentional or unintentional damage or destruction, keep security information up-to-date, and set up security on the system.
- *Software Installation*, SC41-5120-06, provides step-by-step procedures for initial installation, installing licensed programs, program temporary fixes (PTFs), and secondary languages from IBM. This manual is also for users who already have an iSeries server with an installed release and want to install a new release.
- *Tape and Diskette Device Programming*, SC41-5716-02, provides information to help users develop and support programs that use tape and diskette drives for I/O. Includes information on device files and descriptions for tape and diskette devices.

For information about Systems Application Architecture (SAA) Common Programming Interface (CPI) COBOL, refer to the following publication:

- *Systems Application Architecture Common Programming Interface COBOL Reference*, SC26-4354.

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