IBM PL/I for MVS & VM
Programming Guide
Release 1.1

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Note!

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

Second Edition (June 1995)

This edition applies to Version 1 Release 1.1 of IBM PL/I for MVS & VM (named IBM SAA AD/Cycle PL/I MVS & VM for Release 1.0), 5688-235, and to any subsequent releases until otherwise indicated in new editions or technical newsletters. Make sure you are using the correct edition for the level of the product.

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Programming Interface Information

This book is intended to help the customer write programs using IBM PL/I for MVS & VM. This book documents General-use Programming Interface and Associated Guidance Information provided by IBM PL/I for MVS & VM.

General-use programming interfaces allow the customer to write programs that obtain the services of IBM PL/I for MVS & VM.

Macros for Customer Use

IBM PL/I for MVS & VM provides no macros that allow a customer installation to write programs that use the services of IBM PL/I for MVS & VM.

Warning: Do not use as programming interfaces any IBM PL/I for MVS & VM macros.

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System/390
VM/ESA
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Part 1. Introduction

About this book

This book is for PL/I programmers and system programmers. It helps you understand how to use PL/I for MVS & VM to compile PL/I programs. It also describes the operating system features that you might need to optimize program performance or handle errors.

Run-time Environment for PL/I for MVS & VM

PL/I for MVS & VM uses Language Environment as its run-time environment. It conforms to Language Environment architecture and can share the run-time environment with other Language Environment-conforming languages.

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

Debugging Facility for PL/I for MVS & VM

PL/I for MVS & VM uses the IBM Debug Tool as its debugging facility on MVS and VM. Debug Tool utilizes the common run-time environment, Language Environment, to provide the ILC debugging capability among Language Environment-conforming languages. It also provides debugging capability under CICS. Debug Tool is compatible with INSPECT for C/370 and PL/I debugging facility. It provides equivalent functions that PLITEST as for OS PL/I Debug Tool provides the compatibility support for OS PL/I Version 2 and the same level of toleration that PLITEST used to provide for OS PL/I Version 1.

Using Your Documentation

The publications provided with PL/I for MVS & VM are designed to help you do PL/I programming under MVS or VM. Each publication helps you perform a different task.

Where to Look for More Information

The following tables show you how to use the publications you receive with PL/I for MVS & VM and Language Environment. You'll want to know information about both your compiler and run-time environment. For the complete titles and order numbers of these and other related publications, such as the IBM Debug Tool, see the "Bibliography" on page 500.

PL/I Information

Table 1 (Page 1 of 2). How to Use Publications You Receive with PL/I for MVS & VM

To...	Use...
Understand warranty information	Licensed Programming Specifications
Plan for, install, customize, and maintain PL/I	Installation and Customization under MVS Program Directory under VM

Table 1 (Page 2 of 2). How to Use Publications You Receive with PL/I for MVS & VM

To...	Use...
Understand compiler and run-time changes and adapt programs to PL/I and Language Environment	Compiler and Run-Time Migration Guide
Prepare and test your programs and get details on compiler options	Programming Guide
Get details on PL/I syntax and specifications of language elements	Language Reference Reference Summary
Diagnose compiler problems and report them to IBM	Diagnosis Guide
Get details on compile-time messages	Compile-Time Messages and Codes

Language Environment Information

Table 2. How to Use Publications You Receive with Language Environment for MVS & VM

To...	Use...
Evaluate Language Environment	Fact Sheet Concepts Guide
Understand warranty information	Licensed Program Specifications
Understand the Language Environment program models and concepts	Concepts Guide Programming Guide
Plan for, install, customize, and maintain Language Environment on MVS	Installation and Customization under MVS Program Directory under VM
Migrate applications to Language Environment	Run-Time Migration Guide Your language migration guide
Find syntax for run-time options and callable services	Programming Reference
Develop your Language Environment-conforming applications	Programming Guide and your language programming guide
Find syntax for run-time options and callable services	Programming Reference
Develop interlanguage communication (ILC) applications	Writing Interlanguage Communication Applications
Debug your Language Environment-conforming application and get details on run-time messages	Debugging Guide and Run-Time Messages
Diagnose problems with Language Environment	Debugging Guide and Run-Time Messages
Find information in the Language Environment library quickly	Master Index

What Is New in PL/I for MVS & VM

PL/I for MVS & VM enables you to integrate your PL/I applications into Language Environment for MVS & VM. In addition to PL/I's already impressive features, you gain access to Language Environment's rich set of library routines and enhanced interlanguage communication (ILC) with COBOL for MVS & VM, C/370, and C/C^{++} for MVS/ESA. Differences between OS PL/I and Language Environment's support of PL/I for MVS & VM are described in the *PL/I for MVS & VM Compiler and Run-Time Migration Guide*.

PL/I for MVS & VM Release 1.1 provides the following enhancements:

- Language Environment support of the PL/I multitasking facility
- Language Environment compatibility support for the following OS PL/I features:

  - OS PL/I PLICALLA entry support extended to OS PL/I applications that have been recompiled with PL/I for MVS & VM
  - OS PL/I PLICALLB entry support with some differences in handling storage
- Object and/or load module support for OS PL/I expanded to Version 1 Release 3.0-5.1 with some restrictions
- Support for OS PL/I load modules invoking PLISRTx
- Expanded support and rules for OS PL/I Shared Library
- OS PL/I coexistence with Language Environment
- Enhanced SYSPRINT support
- OS PL/I-Assembler clarifications
- Compatibility for location of heap storage
- Help to relink your object and load modules with Language Environment
- Help to relink your OS PL/I-COBOL ILC load modules with Language Environment
- Help to relink your OS PL/I load modules using PLISRTx with Language Environment
- Help to relink your OS PL/I Shared Library
- Enhanced ILC support for PL/I and C/370

Release 1.0 provided the following functions:

- IBM Language Environment for MVS & VM support including:
  - ILC support with COBOL for MVS & VM and C/370.
    - Object code produced by PL/I for MVS & VM Version 1 Release 1
    - Object code produced by all releases of OS PL/I Version 2 and Version 1 Release 5.1
    - Object code produced by LE/370-conforming compilers (all releases)
    - PL/I load modules can be fetched by COBOL/370 and C/370 load modules
    - Load modules from other LE/370 Version 1 Release 1 and Release 1.1 conforming languages. Some load module support for non-LE/370-conforming languages See the *PL/I for MVS & VM Compiler and Run-Time Migration Guide* for details.
    - Object code from VS COBOL II Version 1 Release 3 and C/370 Version 1 and Version 2 as provided by each respective Language Environment-conforming products)

    Note: PL/I for MVS & VM does not support ILC with FORTRAN or OS/VS COBOL.
  - Support for PL/I and C/370 ILC is enhanced.
    - Pointer data type now supports the null value used by C/370 and programs via the SYSNULL built-in function.
  - Under VM, the source listings for PL/I compilations can now be directed to the printer by modifying an IBM-supplied EXEC.

  - CEESTART is the entry point for all environments (including CICS).
  - Support for FETCH in CICS and VM.
  - Procedure OPTIONS option FETCHABLE can be used to specify the procedure that gets control within a fetched load module.
  - Implicit LE/370 enclave is created if the PL/I load module containing a MAIN procedure is fetched or is dynamically called.
  - CEETDLI is supported in addition to PLITDLI, ASMTDLI, and EXEC DLI.
  - By default, only user-generated output is written to SYSPRINT. All run-time generated messages are written to MSGFILE.
  - Automatic storage can now be above the 16-megabyte line.
  - All PL/I MVS & VM Version 1 Release 1 resident library routines are in a LIBPACK, and packaged with LE/370. The transient routines remain transient and are not packaged as part of the LIBPACK.
  - At link-edit time, you have the option of getting math results that are compatible with LE/370 or with OS PL/I.
- Support for DFP Version 3 system-determined blocksize.
- DATETIME and TIME return milliseconds in all environments, including VM and CICS.
- VM terminal I/O is unblocked and immediate.
- ERROR conditions now get control of all system abends. The PL/I message is issued only if there is no ERROR on-unit or if the ERROR on-unit does not recover from the condition via a GOTO.
- Selected items from OS/2 PL/I are implemented to allow better coexistence with PL/I Package/2.
  - Limited support of OPTIONS(BYVALUE and BYADDR)
  - Limited support of EXTERNAL(environment-name) allowing alternate external name
  - Limited support of OPTIONAL arguments/parameters
  - Support for %PROCESS statement
  - NOT and OR compiler options
- Installation enhancements are provided to ease product installation and migration.

Note: You cannot use INSPECT for C/370 and PL/I or PLITEST with PL/I for MVS & VM

Notation Conventions Used in this Book

This book uses the conventions, diagramming techniques, and notation described in “Conventions Used” on page xviii and “How to Read the Notational Symbols” on page xix to illustrate PL/I and non-PL/I programming syntax.

Conventions Used

Some of the programming syntax in this book uses type fonts to denote different elements:

- Items shown in UPPERCASE letters indicate key elements that must be typed exactly as shown.
- Items shown in lowercase letters indicate user-supplied variables for which you must substitute appropriate names or values. The variables begin with a letter and can include hyphens, numbers, or the underscore character (_).
- The term *digit* indicates that a digit (0 through 9) should be substituted.
- The term *do-group* indicates that a do-group should be substituted.
- <u>Underlined</u> items indicate default options.
- `Examples` are shown in monocase type.
- Unless otherwise indicated, separate repeatable items from each other by one or more blanks.

Note: Any symbols shown that are not purely notational, as described in "How to Read the Notational Symbols" on page xix, are part of the programming syntax itself.

For an example of programming syntax that follows these conventions, see "Example of Notation" on page xx.

How to Read the Syntax Notation

Throughout this book, syntax is described using the following structure:

- Read the syntax diagrams from left to right, from top to bottom, following the path of the line. The following table shows the meaning of symbols at the beginning and end of syntax diagram lines.

Symbol	Indicates
►►──	the syntax diagram starts here
──►	the syntax diagram is continued on the next line
►──	the syntax diagram is continued from the previous line
──►◄	the syntax diagram ends here

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

```
►►──STATEMENT──required–item──────────────────────────────────►◄
```

- Optional items appear below the main path.

```
►►──STATEMENT──┬───────────────┬───────────────────────────────►◄
               └─optional–item─┘
```

- Keywords appear in uppercase (for example, STATEMENT). They must be spelled exactly as shown. Variables appear in all lowercase letters and in italics (for example, *item*). They represent user-supplied names or values.
- If punctuation marks, parentheses, arithmetic operators, or other symbols are shown, you must enter them as part of the syntax.

- When you can choose from two or more items, the items appear vertically, in a stack. If you **must** choose one of the items, one item of the stack appears on the main path. The default, if any, appears above the main path and is chosen by the compiler if you do not specify another choice. In some cases, the default is affected by the system in which the program is being run or the environmental parameters specified.

  Because *choice 1* appears on the horizontal bar, one of the items must be included in the statement. If you don't specify either *choice 1* or *choice 2*, the compiler implements the default for you.

  ```
                ┌─default-item─┐
  ►►──STATEMENT─┼─choice 1─────┼──────────────────────────────────────────►◄
                └─choice 2─────┘
  ```

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

  ```
  ►►──STATEMENT──┬─────────────────────┬──────────────────────────────────►◄
                 ├─optional-choice 1─┤
                 └─optional-choice 2─┘
  ```

- An arrow returning to the left above the main line is a *repeat arrow*, and it indicates an item that can be repeated.

  ```
                ┌──────────────────┐
                ▼                  │
  ►►──STATEMENT───repeatable-item──┴──────────────────────────────────────►◄
  ```

  A repeat arrow above a stack indicates that you can make more than one choice from the stacked items, or repeat a single choice.

- If there is a comma as part of the repeat arrow, you must use a comma to separate items in a series.

  ```
                ┌─,────────────────┐
                ▼                  │
  ►►──STATEMENT───repeatable-item──┴──────────────────────────────────────►◄
  ```

  If the comma appears below the repeat arrow line instead of on the line as shown in the previous example, the comma is optional as a separator of items in a series.

- A syntax fragment is delimited in the main syntax diagram by a set of vertical lines. The corresponding meaning of the fragment begins with the name of the fragment followed by the syntax, which starts and ends with a vertical line.

  ```
  ►►──STATEMENT──┤ fragment ├─────────────────────────────────────────────►◄
  ```

  fragment:

  ```
  ├──syntax items──────────────────────────────────────────────────────────┤
  ```

How to Read the Notational Symbols

Some of the programming syntax in this book is presented using notational symbols. This is to maintain consistency with descriptions of the same syntax in other IBM publications, or to allow the syntax to be shown on single lines within a table or heading.

- **Braces**, { }, indicate a choice of entry. Unless an item is underlined, indicating a default, or the items are enclosed in brackets, you must choose at least one of the entries.

- Items separated by a single **vertical bar**, |, are alternative items. You can select only one of the group of items separated by single vertical bars. (Double vertical bars, ||, specify a concatenation operation, not alternative items. See the *PL/I for MVS & VM Language Reference* for more information on double vertical bars.)
- Anything enclosed in **brackets**, [ ], is optional. If the items are vertically stacked within the brackets, you can specify only one item.
- An **ellipsis**, ..., indicates that multiple entries of the type immediately preceding the ellipsis are allowed.

Example of Notation

The following example of PL/I syntax illustrates the notational symbols described In "How to Read the Notational Symbols" on page xix:

```
DCL file-reference FILE STREAM
                   INPUT | {OUTPUT [PRINT]}
                   ENVIRONMENT(option ...);
```

Interpret this example as follows:

- You must spell and enter the first line as shown, except for *file-reference*, for which you must substitute the name of the file you are referencing.
- In the second line, you can specify INPUT or OUTPUT, but not both. If you specify OUTPUT, you can optionally specify PRINT as well. If you do not specify either alternative, INPUT takes effect by default.
- You must enter and spell the last line as shown (including the parentheses and semicolon), except for *option ...*, for which you must substitute one or more options separated from each other by one or more blanks.

Part 2. Compiling your program

Chapter 1. Using Compile-Time Options and Facilities

This chapter describes the options that you can use for the compiler, along with their abbreviations and IBM-supplied defaults. It's important to remember that PL/I requires access to Language Environment run time when you compile your applications.

Most compile-time options have a positive and negative form. The negative form is the positive with `'NO'` added at the beginning (as in TEST and NOTEST). Some options have only a positive form (as in SYSTEM).

Your installation can change the IBM-supplied defaults when this product is installed. Therefore, the defaults listed in this chapter might not be the same as those chosen by your installation. You can override most defaults when you compile your PL/I program.

Compile-Time Option Descriptions

There are three types of compile-time options:

1. Simple pairs of keywords: a positive form that requests a facility, and an alternative negative form that inhibits that facility (for example, NEST and NONEST).
2. Keywords that allow you to provide a value list that qualifies the option (for example, FLAG(W)).
3. A combination of 1 and 2 above (for example, NOCOMPILE(E)).

Table 3 lists all compile-time options with their abbreviated syntax and their IBM-supplied default values. Table 4 on page 7 lists the options by function so that you can, for example, determine the preprocessing options.

The paragraphs following Table 3 and Table 4 describe the options in alphabetical order. In the accompanying syntax diagrams, defaults are not highlighted because that information is provided Table 3. For those options that specify that the compiler is to list information, only a brief description is included; the generated listing is described under “Using the Compiler Listing” on page 33.

Note: Under VM, use only the abbreviated form of the compile-time option if the option name is longer than eight characters.

Table 3 (Page 1 of 2). Compile-Time Options, Abbreviations, and IBM-Supplied Defaults

Compile-time option	Abbreviated name	MVS default	TSO default	VM default
AGGREGATE|NOAGGREGATE	AG|NAG	NAG	NAG	NAG
ATTRIBUTES[(FULL|SHORT)]| NOATTRIBUTES	A[(F|S)]|NA	NA [(FULL)][1]	NA [(FULL)][1]	NA [(FULL)][1]
CMPAT(V1|V2)	CMP(V1|V2)	CMP(V2)	CMP(V2)	CMP(V2)
COMPILE|NOCOMPILE[(W|E|S)]	C|NC[(W|E|S)]	NC(S)	NC(S)	NC(S)
CONTROL('password')	–	–	–	–
DECK|NODECK	D|ND	ND	ND	ND
ESD|NOESD	–	NOESD	NOESD	NOESD
FLAG[(I|W|E|S)]	F[(I|W|E|S)]	F(I)	F(W)	F(W)
GONUMBER|NOGONUMBER	GN|NGN	NGN	NGN	NGN

Table 3 (Page 2 of 2). Compile-Time Options, Abbreviations, and IBM-Supplied Defaults

Compile-time option	Abbreviated name	MVS default	TSO default	VM default
GOSTMT|NOGOSTMT	GS|NGS	NGS	NGS	NGS
GRAPHIC|NOGRAPHIC	GR|NGR	NGR	NGR	NGR
IMPRECISE|NOIMPRECISE	IMP|NIMP	NIMP	NIMP	NIMP
INCLUDE|NOINCLUDE	INC|NINC	NINC	NINC	NINC
INSOURCE|NOINSOURCE	IS|NIS	IS	NIS	NIS
INTERRUPT|NOINTERRUPT	INT|NINT	NINT	NINT	NINT
LANGLVL({OS,SPROG|NOSPROG})	–	LANGLVL (OS,NOSPROG)	LANGLVL (OS,NOSPROG)	LANGLVL (OS,NOSPROG)
LINECOUNT(n)	LC(n)	LC(55)	LC(55)	LC(55)
LIST[(m[,n])]|NOLIST	–	NOLIST	NOLIST	NOLIST
LMESSAGE|SMESSAGE	LMSG|SMSG	LMSG	LMSG	LMSG
MACRO|NOMACRO	M|NM	NM	NM	NM
MAP|NOMAP	–	NOMAP	NOMAP	NOMAP
MARGINI('c')|NOMARGINI	MI('c')|NMI	NMI	NMI	NMI
MARGINS(m,n[,c])	MAR(m,n[,c])	MAR F-format: (2,72) V-format: (10,100)	MAR F-format: (2,72) V-format: (10,100)	MAR F-format: (2,72) V-format: (10,100)
MDECK|NOMDECK	MD|NMD	NMD	NMD	NMD
NAME('name')	N('name')	–	–	–
NOT	–	NOT('¬')	NOT('¬')	NOT('¬')
NEST|NONEST	–	NONEST	NONEST	NONEST
NUMBER|NONUMBER	NUM|NNUM	NNUM	NUM	NUM
OBJECT|NOOBJECT	OBJ|NOBJ	OBJ	OBJ	OBJ
OFFSET|NOOFFSET	OF|NOF	NOF	NOF	NOF
OPTIMIZE(TIME|0|2)|NOOPTIMIZE	OPT(TIME|0|2)|NOPT	NOPT	NOPT	NOPT
OPTIONS|NOOPTIONS	OP|NOP	OP	NOP	NOP
OR	–	OR('|')	OR('|')	OR('|')
SEQUENCE(m,n)|NOSEQUENCE	SEQ(m,n)|NSEQ	SEQ F-format: (73,80) V-format: (1,8)	SEQ F-format: (73,80) V-format: (1,8)	SEQ F-format: (73,80) V-format: (1,8)
SIZE([-]yyyyyyyy|[-]yyyyyK|MAX)	SZ([-]yyyyyyyy| [-]yyyyyK|MAX)	SZ(MAX)	SZ(MAX)	SZ(MAX)
SOURCE|NOSOURCE	S|NS	S	NS	NS
STMT|NOSTMT	–	STMT	NOSTMT	NOSTMT
STORAGE|NOSTORAGE	STG|NSTG	NSTG	NSTG	NSTG
SYNTAX|NOSYNTAX[(W|E|S)]	SYN|NSYN[(W|E|S)]	NSYN(S)	NSYN(S)	NSYN(S)
SYSTEM(CMS|CMSTPL|MVS|TSO| CICS|IMS)	–	MVS	MVS	VM
TERMINAL[(opt-list)]|NOTERMINAL	TERM[(opt-list)]|NTERM	NTERM	TERM	TERM
TEST[([ALL|BLOCK|NONE|PATH| STMT][,SYM|,NOSYM])]|NOTEST	–	NOTEST [(NONE,SYM)][2]	NOTEST [(NONE,SYM)][2]	NOTEST [(NONE,SYM)][2]
XREF[(FULL|SHORT)]|NOXREF	X[(F|S)]|NX	NX [(FULL)][1]	NX [(FULL)][1]	NX [(FULL)][1]

Notes:

1. FULL is the default suboption if the suboption is omitted with ATTRIBUTES or XREF.
2. (NONE,SYM) is the default suboption if the suboption is omitted with TEST.

Table 4 (Page 1 of 2). Compile-Time Options Arranged by Function

Options for use when testing or debugging	**TEST**	specifies which debugging tool capabilities are available for testing programs.
Listing options		
Control listings produced	**AGGREGATE**	lists aggregates and their size.
	ATTRIBUTES	lists attributes of identifiers.
	ESD	lists external symbol dictionary.
	FLAG	suppresses diagnostic messages below a certain severity.
	INSOURCE	lists preprocessor input.
	LIST	lists object code produced by compiler.
	MAP	lists offsets of variables in static control section and DSAs.
	OFFSET	lists statement numbers associated with offsets.
	OPTIONS	lists options used.
	SOURCE	lists source program or preprocessor output.
	STORAGE	lists storage used.
	XREF	lists statements in which each identifier is used.
Improve readability of source listing	**MARGINI**	highlights any source outside margins.
	NEST	indicates do-group and block level by numbering in margin.
Control lines per page	**LINECOUNT**	specifies number of lines per page on listing.
Input options	**GRAPHIC**	specifies that shift codes can be used in source.
	MARGINS	identifies position of PL/I source and a carriage control character.
	NOT	used to specify up to seven alternate symbols for the logical NOT operator.
	OR	used to specify up to seven alternate symbols for the logical OR operator and the string concatenation operator.
	SEQUENCE	specifies the columns used for sequence numbers.
Options to prevent unnecessary processing	**COMPILE**	stops processing after errors are found in syntax checking.
	SYNTAX	stops processing after errors are found in preprocessing.
Options for preprocessing	**INCLUDE**	allows secondary input to be included without using preprocessor.
	MACRO	allows preprocessor to be used.
	MDECK	produces a source deck from preprocessor output.
Option to improve performance	**OPTIMIZE**	improves run-time performance or specifies faster compile time.
Options to use when producing an object module	**CMPAT**	controls level of compatibility with previous releases.
	DECK	produces an object module in punched card format.
	OBJECT	produces object code.
	NAME	specifies the TEXT file will be given a particular external name.
	SYSTEM	specifies the parameter list format that is passed to the main procedure.
Option to control storage	**SIZE**	controls the amount of storage used by the compiler.
Options to improve usability at a terminal	**LMESSAGE/SMESSAGE**	specifies full or concise message format.
	TERMINAL	specifies how much of listing is transmitted to terminal.
Options to specify statement numbering system	**NUMBER & GONUMBER**	numbers statements according to line in which they start.
	STMT & GOSTMT	numbers statements sequentially.
Option to control effect of attention interrupts	**INTERRUPT**	specifies that the ATTENTION condition will be raised after an interrupt is caused.
Option for use on imprecise interrupt machines	**IMPRECISE**	allows imprecise interrupts to be handled correctly.
Option to control compile-time options	**CONTROL**	specifies that any compile-time options previously deleted are available.

Table 4 (Page 2 of 2). Compile-Time Options Arranged by Function

Option to control language level	**LANGLVL**	defines the level of language supported.

AGGREGATE

```
      ┌─NOAGGREGATE─┐
►►────┴─AGGREGATE───┴─────────────────────────────────────────────────────────►◄
```

The AGGREGATE option specifies that the compiler includes an aggregate-length table that gives the lengths of all arrays and major structures in the source program in the compiler listing.

ATTRIBUTES

```
      ┌─NOATTRIBUTES─────────────────────┐
►►────┴─ATTRIBUTES─┬────────────────────┬┴────────────────────────────────────►◄
                   │       ┌─FULL──┐    │
                   └─(─────┴─SHORT─┴──)─┘
```

The ATTRIBUTES option specifies that the compiler includes a table of source-program identifiers and their attributes in the compiler listing. If you include both ATTRIBUTES and XREF, the two tables are combined. However, if the SHORT and FULL suboptions are in conflict, the last option specified is used. For example, if you specify ATTRIBUTES(SHORT) XREF(FULL), FULL applies to the combined listing.

FULL
All identifiers and attributes are included in the compiler listing. FULL is the default.

SHORT
Unreferenced identifiers are omitted, making the listing more manageable.

CMPAT

```
                 ┌─V2─┐
►►──CMPAT──(─────┴─V1─┴──)────────────────────────────────────────────────────►◄
```

The CMPAT option specifies whether object compatibility with OS PL/I Version 1 is maintained for those programs sharing arrays, AREAs, or aggregates.

CMPAT(V1)
If you use CMPAT(V1), you can use arrays, AREAs, and aggregates in exactly the same way that they were used in OS PL/I Version 1 as long as other external procedures sharing them are not compiled with CMPAT(V2).

If any procedures in an application load module (MAIN or FETCHed) are recompiled (and therefore relink-edited), object code compatibility with OS PL/I Version 1 Release 5.1 is provided under the following guidelines:

- If arrays, aggregates, or AREAs are to be shared between OS PL/I Version 1 Release 5.1 object code and PL/I MVS & VM object code, PL/I MVS & VM compilations must use CMPAT(V1).
- If arrays, aggregates, or AREAs are to be shared between PL/I MVS & VM object code only, PL/I MVS & VM compilations must use either CMPAT(V1) or CMPAT(V2), but not both.
- Using CMPAT(V2) is required for larger arrays, aggregates, or AREAs and is recommended even if you do not use larger arrays, aggregates, or AREAs.
- If arrays, aggregates, or AREAs are to be shared between OS PL/I Version 1 Release 5.1 object code only, no precautions need to be taken.

CMPAT(V2)

In general, you should compile PL/I programs with CMPAT(V2).

CMPAT(V2) does not provide object compatibility with OS PL/I Version 1. Therefore, if you are migrating OS PL/I Version 1 applications or OS PL/I Version 2 applications compiled with CMPAT(V1), you must make code changes if:

- You want to use fullword subscripts.
- You have any expressions that rely on precision and scale values returned from the BUILTIN functions HBOUND, LBOUND, DIM, or ALLOCATION.

If you do not have either of the above requirements you do not need to make code changes to use CMPAT(V2) as long as all external procedures sharing the same array or aggregate are also compiled with CMPAT(V2).

If all of your existing object code was produced by OS PL/I Version 2 with the compiler option CMPAT(V2), your object code is fully compatible with object code produced by PL/I MVS & VM, provided you continue to use CMPAT(V2) compiler option. (Other factors can affect object code compatibility. For a list of these factors, see *PL/I for MVS & VM Compiler and Run-Time Migration Guide*.)

If some or all of your existing object code was produced by OS PL/I Version 2 with the compiler option CMPAT(V1) or by OS PL/I Version 1 Release 5.1, the following considerations apply when mixing with object code produced by PL/I MVS & VM:

- If arrays, aggregates, or AREAs are to be shared between OS PL/I Version 1 Release 5.1 or OS PL/I Version 2 (compiled with CMPAT(V1)) object code and PL/I MVS & VM object code, PL/I MVS & VM compilations must use CMPAT(V1).
- If arrays, aggregates, or AREAs are to be shared between OS PL/I Version 2 (compiled with CMPAT(V2)) object code and PL/I MVS & VM object code, PL/I MVS & VM compilations must use CMPAT(V2).

  Using CMPAT(V2) is required for larger arrays, aggregates, or AREAs and is recommended even if you do not use larger arrays, aggregates, or AREAs.

COMPILE

```
      ┌─NOCOMPILE──┬─────────────────┬┐
      │            │    ┌─S─┐        ││
      │            └─(──┼─W─┼──)─────┘│
      │                 └─E─┘         │
►►────┴─COMPILE───────────────────────┴──────────────────────────────────►◄
```

The COMPILE option specifies that the compiler compiles the source program unless it detects an unrecoverable error during preprocessing or syntax checking. Whether the compiler continues or not depends on the severity of the error detected, as specified by the NOCOMPILE option in the list below. The NOCOMPILE option specifies that processing stops unconditionally after syntax checking.

NOCOMPILE(W)
No compilation if a warning, error, severe error, or unrecoverable error is detected.

NOCOMPILE(E)
No compilation if an error, severe error, or unrecoverable error is detected.

NOCOMPILE(S)
No compilation if a severe error or unrecoverable error is detected.

If the compilation is terminated by the NOCOMPILE option, the cross-reference listing and attribute listing can be produced; the other listings that follow the source program will not be produced.

CONTROL

```
►►──CONTROL──(──'──password──'──)────────────────────────────────────────►◄
```

The CONTROL option specifies that any compile-time options deleted for your installation are available for this compilation. Using the CONTROL option alone does not restore compile-time options you have deleted from your system. You still must specify the appropriate keywords to use the options. The CONTROL option must be specified with a password that is established for each installation. If you use an incorrect password, processing will be terminated. If you use the CONTROL option, it must be specified first in the list of options.

password
is a character string not exceeding eight characters.

Under VM: You cannot use a right or left parenthesis or include lower case characters on a password if you use CONTROL in the PLIOPT command.

DECK

```
      ┌─NODECK─┐
►►────┴─DECK───┴─────────────────────────────────────────────────────────►◄
```

The DECK option specifies that the compiler produces an object module in the form of 80-character records and store it in the SYSPUNCH data set. Columns 73-76 of each record contain a code to identify the object module. This code comprises the first four characters of the first label in the external procedure represented by the object module. Columns 77-80 contain a 4-digit decimal number: the first record is numbered 0001, the second 0002, and so on.

ESD

```
    ┌─NOESD─┐
►►──┴─ESD───┴──────────────────────────────────────────────────────────►◄
```

The ESD option specifies that the external symbol dictionary (ESD) is listed in the compiler listing.

FLAG

```
►►──FLAG──┬──────────────────┬──────────────────────────────────────────►◄
          └─(──┬─I─┬──)──────┘
               ├─W─┤
               ├─E─┤
               └─S─┘
```

The FLAG option specifies the minimum severity of error that requires a message listed in the compiler listing.

FLAG(I)
List all messages.

FLAG(W)
List all except information messages. If you specify FLAG, FLAG(W) is assumed.

FLAG(E)
List all except warning and information messages.

FLAG(S)
List only severe error and unrecoverable error messages.

GONUMBER

```
    ┌─NOGONUMBER─┐
►►──┴─GONUMBER───┴─────────────────────────────────────────────────────►◄
```

The GONUMBER option specifies that the compiler produces additional information that allows line numbers from the source program to be included in run-time messages.

Alternatively, these line numbers can be derived by using the offset address, which is always included in run-time messages, and the table produced by the OFFSET option. (The NUMBER option must also apply.)

The GONUMBER option implies NUMBER, NOSTMT, and NOGOSTMT. If NUMBER applies, GONUMBER is forced by the ALL, STMT, and PATH suboptions of the TEST option. The OFFSET option is separate from these numbering options and must be specified if required.

GOSTMT

```
        ┌─NOGOSTMT─┐
►►──────┴─GOSTMT───┴────────────────────────────────────────────────────────►◄
```

The GOSTMT option specifies that the compiler produces additional information that allows statement numbers from the source program to be included in run-time messages.

These statement numbers can also be derived by using the offset address, which is always included in run-time messages, and the table produced by the OFFSET option. (The STMT option must also apply.)

The GOSTMT option implies STMT, NONUMBER, and NOGONUMBER. If STMT applies, GOSTMT is forced by the ALL, STMT, and PATH suboptions of the TEST option. The OFFSET option is separate from these numbering options and must be specified if required.

GRAPHIC

```
        ┌─NOGRAPHIC─┐
►►──────┴─GRAPHIC───┴───────────────────────────────────────────────────────►◄
```

Using GRAPHIC option specifies that the source program can contain double-byte characters. The hexadecimal codes '0E' and '0F' are treated as the shift-out and shift-in control codes, respectively, wherever they appear in the source program. This includes occurrences in comments and string constants.

The GRAPHIC compile-time option must be specified if the source program uses any of the following:

- DBCS identifiers
- Graphic string constants
- Mixed string constants
- Shift codes anywhere else in the source

For more information see the discussion of the DBCSOS Ordering Product and the SIZE option on page 22.

IMPRECISE

```
        ┌─NOIMPRECISE─┐
►►──────┴─IMPRECISE───┴─────────────────────────────────────────────────────►◄
```

The IMPRECISE option specifies that the compiler includes extra text in the object module to localize imprecise interrupts when executing the program with an IBM System/390 Model 165 or 195. This extra text is generated for ON statements (to ensure that the correct ON-units are entered if interrupts occur), for null statements, and for ENTRY statements. The correct line or statement numbers do not necessarily appear in run-time messages. If you need more accurate identification of the statement in error, insert null statements at suitable points in your program.

INCLUDE

```
      ┌─NOINCLUDE─┐
►►────┴─INCLUDE───┴──────────────────────────────────────────────►◄
```

The INCLUDE option specifies that %INCLUDE statements are handled without using the full preprocessor facilities and incurring more overhead. This method is faster than using the preprocessor for programs that use the %INCLUDE statement but no other PL/I preprocessor statements. The INCLUDE option has no effect if preprocessor statements other than %INCLUDE are used in the program. In these cases, the MACRO option must be used.

If you specify the MACRO option, it overrides the INCLUDE option.

INSOURCE

```
►►────┬─INSOURCE───┬─────────────────────────────────────────────►◄
      └─NOINSOURCE─┘
```

The INSOURCE option specifies that the compiler should include a listing of the source program before the PL/I macro preprocessor translates it. Thus, the INSOURCE listing contains preprocessor statements that do not appear in the SOURCE listing. This option is applicable only when the MACRO option is in effect.

INTERRUPT

```
      ┌─NOINTERRUPT─┐
►►────┴─INTERRUPT───┴────────────────────────────────────────────►◄
```

This option determines the effect of attention interrupts when the compiled PL/I program runs under an interactive system. (If specified on a batch system, INTERRUPT can cause an abend.)

The INTERRUPT option causes the compiled program to respond to attention requests (interrupts). If you have written a program that relies on raising the ATTENTION condition, you must compile it with the INTERRUPT option.

The INTERRUPT option allows attention interrupts to become an integral part of programming. This gives you considerable interactive control of the program.

If you specify the INTERRUPT option, an established ATTENTION ON-unit gets control when an attention interrupt occurs. When the execution of an ATTENTION ON-unit is complete, control returns to the point of interrupt unless directed elsewhere by means of a GOTO statement. If you do not establish an ATTENTION ON-unit, the attention interrupt is ignored.

If you specify NOINTERRUPT, an attention interrupt during a program run does not give control to any ATTENTION ON-units.

If you require the attention interrupt capability purely for testing purposes, you need not use the INTERRUPT option. The TEST option provides this capability. For more information See “TEST” on page 26.

See Chapter 20, “Interrupts and Attention Processing” on page 436 for more information about the INTERRUPT option.

LANGLVL

```
              ┌─OS──────┬───────────────┬──┐
              │         │ ┌─, NOSPROG─┐ │  │
              │         └─┴─, SPROG───┴─┘  │
►►──LANGLVL──(──┼─NOSPROG──┬────────┬────────┼──)───────────────────────────►◄
              │          └─,──OS──┘        │
              └─SPROG──┬────────┬──────────┘
                       └─,──OS──┘
```

The LANGLVL option specifies the level of PL/I language supported, including whether pointers in expressions are to be supported.

OS
specifies the level of PL/I language the compiler is to support. OS is the only level currently supported.

NOSPROG
specifies that the compiler is ***not*** to allow the additional support for pointers allowed under SPROG.

SPROG
specifies that the compiler is to allow extended operations on pointers, including arithmetic, and the use of the POINTERADD, BINARYVALUE, and POINTERVALUE built-in functions.

For more information on pointer operations, see the *PL/I for MVS & VM Language Reference* book.

LINECOUNT

```
►►──LINECOUNT──(──n──)──────────────────────────────────────────────►◄
```

The LINECOUNT option specifies the number of lines included in each page of the compiler listing, including heading lines and blank lines.

n is the number of lines. It must be in the range 1 through 32,767, but only headings are generated if you specify less than 7. When you specify less than 100, the static internal storage map and the object listing are printed in double column format. Otherwise, they are printed in single column format.

LIST

```
      ┌─NOLIST───────────────────────────┐
►►────┴─LIST──┬──────────────────────┬───┴──────────────────────────►◄
              └─(──m──┬───────┬──)───┘
                      └─,──n──┘
```

The LIST option specifies that the compiler includes a listing of the object module (in a syntax similar to assembler language instructions) in the compiler listing. If both *m* and *n* are omitted, the compiler produces a listing of the whole program.

m is the number of the first, or only, source statement for which an object listing is required.

n is the number of the last source statement for which an object listing is required. If *n* is omitted, only statement *m* is listed.

If the option NUMBER applies, *m* and *n* must be specified as line numbers. If the STMT option applies, *m* and *n* must be statement numbers.

If you use LIST in conjunction with MAP, it increases the information generated by MAP. (See “MAP” for more information on the MAP compile-time option.)

Under TSO: Use the LIST(m[,n]) option to direct a listing of particular statements to the terminal in either of the following ways:

- Use the LIST option, with no statement numbers, within the TERMINAL option.
- Use the PRINT(*) operand in the PLI command.

LMESSAGE

```
     ┌─LMESSAGE─┐
►►───┴─SMESSAGE─┴──────────────────────────────────────────────────►◄
```

The LMESSAGE and SMESSAGE options produce messages in a long form (specify LMESSAGE) or in a short form (specify SMESSAGE).

MACRO

```
     ┌─NOMACRO─┐
►►───┴─MACRO───┴───────────────────────────────────────────────────►◄
```

The MACRO option specifies that the source program is to be processed by the preprocessor. MACRO overrides INCLUDE if both are specified.

MAP

```
     ┌─NOMAP─┐
►►───┴─MAP───┴─────────────────────────────────────────────────────►◄
```

The MAP option specifies that the compiler produces tables showing the organization of the static storage for the object module. These tables show how variables are mapped in the static internal control section and in DSAs, thus enabling STATIC INTERNAL and AUTOMATIC variables to be found in PLIDUMP. If LIST (described under “LIST” on page 14) is also specified, the MAP option produces tables showing constants, control blocks and INITIAL variable values. LIST generates a listing of the object code in pseudo-assembler language format.

If you want a complete map, but not a complete list, you can specify a single statement as an argument for LIST to minimize the size of the LIST. For example:

```
%PROCESS MAP LIST(1);
```

MARGINI

```
      ┌─NOMARGINI────────────────┐
►►────┴─MARGINI──(──'──c──'──)───┴──────────────────────────────────────────────►◄
```

The MARGINI option specifies that the compiler includes a specified character in the column preceding the left-hand margin, and also in the column following the right-hand margin of the listings that the compiler produces when you use the INSOURCE and SOURCE options. The compiler shifts any text in the source input that precedes the left-hand margin left one column. It shifts any text that follows the right-hand margin right one column. Thus you can easily detect text outside the source margins.

c is the character to be printed as the margin indicator.

MARGINS

```
►►──MARGINS──(──m──,──n──┬───────┬──)───────────────────────────────────────────►◄
                         └─,──c──┘
```

The MARGINS option specifies which part of each compiler input record contains PL/I statements, and the position of the ANS control character that formats the listing, if the SOURCE and/or INSOURCE options apply. The compiler does not process data that is outside these limits, but it does include it in the source listings.

The PL/I source is extracted from the source input records so that the first data byte of a record immediately follows the last data byte of the previous record. For variable records, you must ensure that when you need a blank you explicitly insert it between margins of the records.

m is the column number of the leftmost character (first data byte) that is processed by the compiler. It must not exceed 100.

n is the column number of the rightmost character (last data byte) that is processed by the compiler. It should be greater than *m*, but not greater than 100.

For variable-length records, *n* is interpreted as the rightmost column, or the last data byte if the record has less than *n* data bytes. Thus, the last character of a variable-length record is usually a nonblank character and is immediately followed (without any intervening blank) by the first data byte (*m*) of the next record. If you do not intend to have continuation, be sure that at least one blank occurs at the beginning (*m*) of the next record.

c is the column number of the ANS printer control character. It must not exceed 100 and should be outside the values specified for *m* and *n*. A value of 0 for *c* indicates that no ANS control character is present. Only the following control characters can be used:

(blank)	Skip one line before printing
0	Skip two lines before printing
–	Skip three lines before printing
+	No skip before printing
1	Start new page

Any other character is an error and is replaced by a blank.

Do not use a value of *c* that is greater than the maximum length of a source record, because this causes the format of the listing to be unpredictable. To avoid this problem, put the carriage control character to the left of the source margins for variable length records.

Specifying MARGINS(,,c) is an alternative to using %PAGE and %SKIP statements (described in the *PL/I for MVS & VM Language Reference*).

The IBM-supplied default for fixed-length records is MARGINS(2,72). For variable-length and undefined-length records, the IBM-supplied default is MARGINS(10,100). This specifies that there is **no** printer control character.

Use the MARGINS option to override the default for the primary input in a program. The secondary input must have either the same margins as the primary input if it is the same type of record, or default margins if it is a different type. (See “Input Record Formats” on page 28.)

MDECK

```
      ┌─NOMDECK─┐
►►────┴─MDECK───┴──────────────────────────────────────────────────────────────►◄
```

The MDECK option specifies that the preprocessor produces a copy of its output on the file defined by the SYSPUNCH DD statement. The MDECK option allows you to retain the output from the preprocessor as a file of 80-column records.

The compiler ignores MDECK if NOMACRO is in effect.

NAME

```
►►──NAME──(──'──name──'──)─────────────────────────────────────────────────────►◄
```

The NAME option specifies that the TEXT file created by the compiler is given the specified external name that you specify. This allows you to create more than one TEXT file while doing batched compilation. It also allows you to produce text files that can be included in a text library. You can also use the NAME option to cause the linkage editor to substitute a new load module for an existing load module with the same name in the library.

name
has from one through eight characters, and begins with an alphabetic character. NAME has no default.

For more uses of the NAME option, see either “Compiling a Program to be Placed in a TXTLIB” on page 77 for compiling under VM, or “NAME Option” on page 69 for compiling under MVS.

NEST

```
     ┌─NONEST─┐
►►───┴─NEST───┴──────────────────────────────────────────────────────────────►◄
```

You can use the NEST option to specify that the listing resulting from the SOURCE option indicates the block level and the do-group level for each statement.

NOT

```
                ┌────────┐
                ▼        │
►►──NOT──(──'───┴─char───┴──'──)──────────────────────────────────────────────►◄
```

The NOT option specifies up to seven alternate symbols, any one of which can be used as the logical NOT operator.

char

is a single SBCS character.

You cannot specify any of the alphabetic characters, digits, and special characters defined in the *PL/I for MVS & VM Language Reference*, except for the logical NOT symbol (¬).

If you specify the NOT option, the standard NOT symbol is no longer recognized unless you specify it as one of the characters in the character string.

For example, NOT('˜') means that the tilde character, X'A1', will be recognized as the logical NOT operator, and the standard NOT symbol, '¬', X'5F', will not be recognized. Similarly, NOT('˜¬') means that either the tilde or the standard NOT symbol will be recognized as the logical NOT operator.

The IBM-supplied default code point for the NOT symbol is X'5F'. The logical NOT sign might appear as a logical NOT symbol (¬) or a caret symbol (^) on your keyboard.

NUMBER

```
►►───┬─NUMBER───┬────────────────────────────────────────────────────────────►◄
     └─NONUMBER─┘
```

The NUMBER option specifies that numbers in the sequence fields in the source input records are used to derive the statement numbers in the listings resulting from the AGGREGATE, ATTRIBUTES, LIST, OFFSET, SOURCE and XREF options.

You can specify the position of the sequence field in the SEQUENCE option. Otherwise the following default positions are assumed:

- First eight columns for undefined-length or variable-length source input records
- Last eight columns for fixed-length source input records

Note: The preprocessor output has fixed-length records regardless of the format of the primary input. The sequence numbers are in columns 73-80 in the source listing.

The compiler calculates the line number from the five right-hand characters of the sequence number (or the number specified, if less than five). These characters are converted to decimal digits if necessary. Each time the compiler finds a line number that is not greater than the preceding line number, it forms a new line number by adding the minimum integral multiple of 100,000 to produce a line number that is greater than the preceding one. The compiler issues a message to warn you of the adjustment, except when you specify the INCLUDE option or the MACRO option.

If there is more than one statement on a line, the compiler uses a suffix to identify the actual statement in the messages. For example, the second statement beginning on the line numbered 40 is identified by the number 40.2. The maximum value for this suffix is 31. Thus the thirty-first and subsequent statements on a line have the same number.

If the sequence field consists only of blanks, the compiler forms the new line number by adding 10 to the preceding one. The maximum line number allowed by the compiler is 134,000,000. Numbers that would normally exceed this are set to this maximum value. Only eight digits print in the source listing; line numbers of 100,000,000 or over print without the leading *1* digit.

If you specify NONUMBER, STMT and NOGONUMBER are implied. NUMBER is implied by NOSTMT or GONUMBER.

OBJECT

```
     ┌─OBJECT───┐
►►───┴─NOOBJECT─┴──────────────────────────────────────────────────►◄
```

The OBJECT option specifies that the compiler creates an object module and stores it in a TEXT file (VM) or in a data set defined by the DD statement with the name SYSLIN (MVS).

OFFSET

```
     ┌─NOOFFSET─┐
►►───┴─OFFSET───┴──────────────────────────────────────────────────►◄
```

The OFFSET option specifies that the compiler prints a table of statement or line numbers for each procedure with their offset addresses relative to the primary entry point of the procedure. You can use this table to identify a statement from a run-time error message if the GONUMBER or GOSTMT option is not in effect.

If GOSTMT applies, the run-time library includes statement numbers, as well as offset addresses, in run-time messages. If GONUMBER applies, the run-time library includes line numbers, as well as offset addresses, in run-time messages.

For more information on determining line numbers from the offsets given in error messages, see “Statement Offset Addresses” on page 40.

OPTIMIZE

```
►►──┬─NOOPTIMIZE────────────────┬──────────────────────────────────────►◄
    └─OPTIMIZE──(──┬─TIME─┬──)──┘
                   ├─0────┤
                   └─2────┘
```

The OPTIMIZE option specifies the type of optimization required:

OPTIMIZE(TIME)
specifies that the compiler optimizes the machine instructions generated to produce a more efficient object program. This type of optimization can also reduce the amount of main storage required for the object module. The use of OPTIMIZE(TIME) could result in a substantial increase in compile time over NOOPTIMIZE. During optimization the compiler can move code to increase run-time efficiency. As a result, statement numbers in the program listing cannot correspond to the statement numbers used in run-time messages.

OPTIMIZE(0)
is the equivalent of NOOPTIMIZE.

OPTIMIZE(2)
is the equivalent of OPTIMIZE(TIME).

NOOPTIMIZE
specifies fast compilation speed, but inhibits optimization.

For a full discussion of optimization, see Chapter 14, “Efficient Programming” on page 305.

OPTIONS

```
►►──┬─OPTIONS───┬──────────────────────────────────────────────────────►◄
    └─NOOPTIONS─┘
```

The OPTIONS option specifies that the compiler includes a list showing the compile-time options to be used during this compilation in the compiler listing. This list includes all options applied by default, those specified in the PARM parameter of an EXEC statement or in the invoking command (PLI or PLIOPT), and those specified in a %PROCESS statement.

Under TSO: If the PRINT(*) operand of the PL/I command applies, the list of options prints at the terminal. This can show the negative forms of the options that cause listings to be produced, even where the positive forms apply. The positive form is shown within the TERMINAL option. This is because the PRINT(*) operand is implemented by generating a TERMINAL option containing a list of options corresponding to those listings that are printed at the terminal. Specifying the TERMINAL option after the PRINT(*) operand overrides the TERMINAL option generated by the PRINT(*) operand.

OR

```
               ┌──────┐
►►──OR──(──'───▼─char─┴──'──)──────────────────────────────►◄
```

The OR option specifies up to seven alternate symbols, any one of which is interpreted as the logical OR operator (|). These symbols are also used as the concatenation operator, which is defined as two consecutive logical OR symbols.

char
is a single SBCS character.

You cannot specify any of the alphabetic characters, digits, and special characters defined in the *PL/I for MVS & VM Language Reference*, except for the logical OR symbol (|).

If you specify the OR option, the standard OR symbol is no longer recognized unless you specify it as one of the characters in the character string.

For example, OR('\') means that the backslash character, X'E0', will be recognized as the logical OR operator, and two consecutive backslashes will be recognized as the concatenation operator. The standard OR symbol, '|', X'4F', will not be recognized as either operator. Similarly, OR('\|') means that either the backslash or the standard OR symbol will be recognized as the logical OR operator, and either symbol or both symbols Can be used to form the concatenation operator.

The IBM-supplied default code point for the OR symbol (|) is X'4F'.

SEQUENCE

```
     ┌─SEQUENCE──(──m──,──n──)─┐
►►───┴─NOSEQUENCE──────────────┴──────────────────────────►◄
```

The SEQUENCE option defines the section of the input record from which the compiler takes the sequence numbers. These numbers are included in the source listings produced by the INSOURCE and SOURCE option.

The compiler uses sequence numbers to calculate statement numbers if the NUMBER option is in effect. The compiler does not sort the input lines or records into the specified sequence.

m specifies the column number of the left-hand margin.

n specifies the column number of the right-hand margin.

The extent specified should not overlap with the source program (as specified in the MARGINS option).

The IBM-supplied default for fixed-length records is SEQUENCE (73,80); for variable-length and undefined-length records. The default is SEQUENCE (1,8).

If the SEQUENCE option is used, an external procedure cannot contain more than 32,767 lines. To Compile an external procedure containing more than 32,767 lines, you must specify the NOSEQUENCE option. Because NUMBER and GONUMBER imply SEQUENCE, you should not specify the SEQUENCE or NOSEQUENCE options.

You can use the SEQUENCE option to override the default margin positions that are set up during compiler installation by the FSEQUENCE and VSEQUENCE options (see “Input Record Formats” on page 28).

The FSEQUENCE default applies to F-format records and the VSEQUENCE default applies to V-format or U-format records. Only one of these defaults is overridden by the SEQUENCE option. If the first input record to the compiler is F-format, the FSEQUENCE default is overridden. If the first input record is a V-format or a U-format record, the VSEQUENCE default is overridden. The compiler assumes default values if it encounters a record with a different type of format. The compiler includes numbers that it finds in the sequence field in the source listings produced by the FORMAT, INSOURCE, and SOURCE options.

Under VM: Note: The preprocessor output has F-format records regardless of the format of the primary input. The sequence numbers are in columns 73-80 in the source listing.

SIZE

```
               ┌─MAX─────────────────┐
►►──SIZE──(────┼────┬───┬──yyyyyyyy──┼───)──────────────────────────────────►◄
               │    └─-─┘            │
               └────┬───┬──yyyyyK────┘
                    └─-─┘
```

You can use this option to limit the amount of main storage the compiler uses. This is of value, for example, when dynamically invoking the compiler, to ensure that space is left for other purposes. There are five forms of the SIZE option:

SIZE(yyyyyyyy)
specifies that yyyyyyyy bytes of main storage are requested. Leading zeros are not required.

SIZE(yyyyyK)
specifies that yyyyyK bytes of main storage are requested (1K=1024). Leading zeros are not required.

SIZE(MAX)
specifies that the compiler obtains as much main storage as it can.

SIZE(-yyyyyy)
specifies that the compiler obtains as much main storage as it can, and then releases yyyyyy bytes to the operating system. Leading zeros are not required.

SIZE(-yyyK)
specifies that the compiler obtains as much main storage as it can, and then releases yyyK bytes to the operating system (1K=1024). Leading zeros are not required.

The IBM-supplied default, SIZE(MAX), allows the compiler to use as much main storage in the region as it can.

The negative forms of SIZE can be useful when a certain amount of space must be left free and the maximum size is unknown, or can vary because the job is run in regions of different sizes.

Under MVS: If you use the DBCSOS Ordering Product under MVS (a utility to sort DBCS characters), you must reserve storage for the operating system to load it. Specify SIZE(-n) to reserve sufficient storage, where *n* is at least 128K. See “ATTRIBUTE and Cross-Reference Table” on page 36.

Note: Specifying both a region size that gives the job or job step all the available storage below the line and the compile-time option SIZE(MAX) can cause storage problems.

Under TSO: 10K to 30K bytes of storage must be reserved for the operating system to load TSO routines. The exact amount of storage required depends on which routines are in the link pack area. Specify SIZE(-n) to reserve sufficient storage space, where *n* is at least 10K bytes. For TSO edit mode, *n* must be at least 30K bytes.

Under VM: You should always use SIZE(MAX) in VM unless it is essential to limit the space used. If you set a limit in the SIZE option, the value used exceeds that which is specified. That is because storage is handled by a VM/compiler interface routine and not directly by the compiler.

SMESSAGE

The LMESSAGE and SMESSAGE options produce messages in a long form (specify LMESSAGE) or in a short form (specify SMESSAGE). See “LMESSAGE” on page 15 for the syntax.

SOURCE

```
►►──┬─SOURCE───┬─────────────────────────────────────────────────────►◄
    └─NOSOURCE─┘
```

The SOURCE option specifies that the compiler includes a listing of the source program in the compiler listing. The source program listed is either the original source input or, if the MACRO option applies, the output from the preprocessor.

STMT

```
►►──┬─STMT───┬───────────────────────────────────────────────────────►◄
    └─NOSTMT─┘
```

The STMT option specifies that statements in the source program are counted, and this statement number is used to identify statements in the compiler listings resulting from the AGGREGATE, ATTRIBUTES, LIST, OFFSET, SOURCE, and XREF options. STMT is implied by NONUMBER or GOSTMT. If NOSTMT is specified, NUMBER and NOGOSTMT are implied.

STORAGE

```
    ┌─NOSTORAGE─┐
►►──┴─STORAGE───┴────────────────────────────────────────────────────►◄
```

The STORAGE option specifies that the compiler includes a table giving the main storage requirements for the object module in the compiler listing.

SYNTAX

```
       ┌─NOSYNTAX─────┬────────────────┬─┐
       │              │      ┌─S─┐     │ │
       │              └─(────┼─W─┼──)──┘ │
       │                     └─E─┘       │
►►─────┴─SYNTAX──────────────────────────┴────────────────────────►◄
```

The SYNTAX option specifies that the compiler continues into syntax checking after preprocessing when you specify the MACRO option, unless an unrecoverable error has occurred. Whether the compiler continues with the compilation depends on the severity of the error, as specified by the NOSYNTAX option.

NOSYNTAX
Processing stops unconditionally after preprocessing.

NOSYNTAX(W)
No syntax checking if a warning, error, severe error, or unrecoverable error is detected.

NOSYNTAX(E)
No syntax checking if the compiler detects an error, severe error, or unrecoverable error.

NOSYNTAX(S)
No syntax checking if the compiler detects a severe error or unrecoverable error.

If the SOURCE option applies, the compiler generates a source listing even if it does not perform syntax checking.

If the NOSYNTAX option terminates the compilation, the compiler does not produce the cross-reference listing, attribute listing, and other listings that follow the source program.

You can use this option to prevent wasted runs when debugging a PL/I program that uses the preprocessor.

SYSTEM

```
►►──SYSTEM──(──┬─CMS────┬──)──────────────────────────────────────►◄
               ├─CMSTPL─┤
               ├─MVS────┤
               ├─TSO────┤
               ├─CICS───┤
               └─IMS────┘
```

The SYSTEM option specifies the format used to pass parameters to the MAIN PL/I procedure, and generally indicates the host system under which the program runs. MVS, CMS, CMSTPL, CICS, IMS, and TSO are the subparameters recognized. This option allows a program compiled under one system to run under another. For example, a program compiled under VM can run under MVS, and parameters are passed according to MVS conventions.

Table 5 on page 25 shows the type of parameter list you can expect, and how the program runs under the specified host system. It also shows the implied settings of NOEXECOPS.

Table 5. SYSTEM Option Table

SYSTEM option	Type of parameter list	Program runs as	NOEXECOPS implied	For more information
SYSTEM(MVS)	Single varying character string or no parameters.	MVS application program	NO	See *Language Environment for MVS & VM Programming Guide*.
	Otherwise, arbitrary parameter list.		YES	
SYSTEM(CMS)	Single varying character string or no parameters.	VM application program	NO	See *Language Environment for MVS & VM Programming Guide*.
	Otherwise, arbitrary parameter list.		YES	
SYSTEM(CMSTPL)	Single varying character string or no parameters.	VM application program	NO	See *Language Environment for MVS & VM Programming Guide*.
SYSTEM(CICS)	Pointer(s)	CICS transaction	YES	See *Language Environment for MVS & VM Programming Guide*.
SYSTEM(IMS)	Pointer(s)	IMS application program	YES	See *Language Environment for MVS & VM Programming Guide*.
SYSTEM(TSO)	Pointer to CCPL	TSO command processor	YES	See *Language Environment for MVS & VM Programming Guide*.

TERMINAL

```
►►──┬─TERMINAL──┬──────────────────┬─┬─────────────────────────────►◄
    │           └─(───opt-list───)─┘ │
    └─NOTERMINAL─────────────────────┘
```

The TERMINAL option is applicable only in a conversational environment. It specifies that a subset of, or all of, the compiler listing produced during compilation prints at the terminal. If you specify TERMINAL without an argument, the compiler prints diagnostic and information messages at the terminal. You can add an argument, which takes the form of an option list, to specify other parts of the compiler listing that the compiler prints at the terminal.

The listing at the terminal is independent of that written on SYSPRINT for TSO, or the LISTING file for VM. However, if you associate SYSPRINT in TSO, or LISTING in VM, with the terminal, only one copy of each option requested is printed.

opt-list

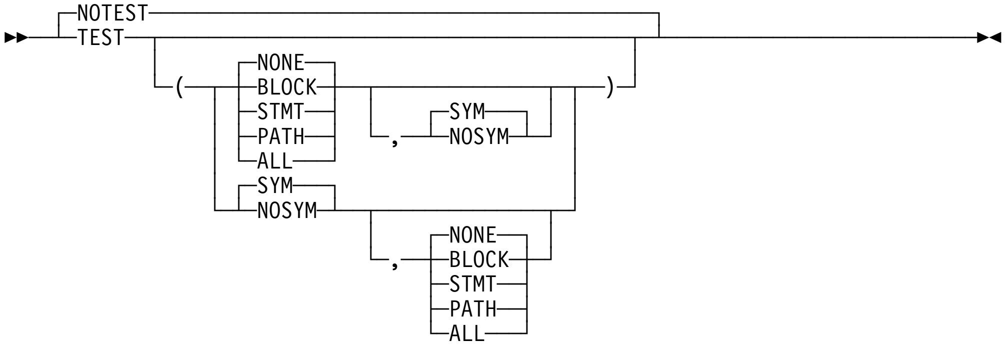
You can specify the following option keywords, their negative forms, or their abbreviated forms, in the option list:

AGGREGATE
ATTRIBUTES
ESD
INSOURCE
LIST
MAP

OFFSET
OPTIONS
SOURCE
STORAGE
XREF

The other options that relate to the listing (FLAG, GONUMBER, GOSTMT, LINECOUNT, LMESSAGE/SMESSAGE, MARGINI, NEST, NUMBER, and the SHORT and FULL suboptions of ATTRIBUTES and XREF) are the same as for the SYSPRINT listing.

TEST



The TEST option specifies the level of testing capability that the compiler generates as part of the object code. It allows you to control the location of test hooks and to control whether or not the symbol table will be generated.

The TEST option can imply GONUMBER or GOSTMT, depending on whether NUMBER or STMT is in effect.

Because the TEST option can increase the size of the object code and can affect performance, you might want to limit the number and placement of hooks.

BLOCK
tells the compiler to insert hooks at block boundaries (block entry and block exit).

STMT
Specifies that the compiler inserts hooks at statement boundaries and block boundaries. STMT causes a statement table to be generated.

PATH
tells the compiler to insert hooks:

- Before the first statement enclosed by an iterative DO statement
- Before the first statement of the true part of an IF statement
- Before the first statement of the false part of an IF statement
- Before the first statement of a true WHEN or OTHERWISE statement of a SELECT group
- Before the statement following a user label
- At CALLs or function references—both before and after control is passed to the routine
- At block boundaries.

When PATH is specified, the compiler generates a statement table.

ALL
tells the compiler to insert hooks at all possible locations and to generate a statement table.

NONE
tells the compiler not to put hooks into the program.

SYM
tells the compiler to create a symbol table that will allow you to examine variables by name.

NOSYM
tells the compiler not to generate a symbol table.

NOTEST
suppresses the generation of all testing information.

Any TEST option other than NOTEST and TEST(NONE,NOSYM) will automatically provide the attention interrupt capability for program testing.

If the program has an ATTENTION ON-unit that you want invoked, you must compile the program with either of the following:

- The INTERRUPT option
- A TEST option other than NOTEST or TEST(NONE,NOSYM).

XREF

```
     ┌─NOXREF──────────────────┐
►►───┴─XREF──┬─────────────────┬┴───────────────────────────────────────►◄
             │      ┌─FULL──┐  │
             └─(────┴─SHORT─┴──)─┘
```

The XREF option specifies that the compiler includes a cross-reference table of names used in the program together with the numbers of the statements in which they are declared or referenced in the compiler listing. (The only exception is that label references on END statements are not included. For example, assume that statement number 20 in the procedure PROC1 is END PROC1;. In this situation, statement number 20 does not appear in the cross reference listing for PROC1.)

FULL
is the default suboption. All identifiers and attributes are included in the compiler listing.

SHORT
Unreferenced identifiers are omitted from the compiler listing.

For a description of the format and content of the cross-reference table, see “Cross-Reference Table” on page 37.

For more information about sorting identifiers and storage requirements with DBCS Ordering Support Product, see “ATTRIBUTE and Cross-Reference Table” on page 36.

If the suboption SHORT is specified, unreferenced identifiers are omitted.

The default suboption FULL means that FULL applies if you specify the option with no suboption.

If you specify both the XREF and ATTRIBUTES options, the two listings are combined. If there is a conflict between SHORT and FULL, the usage is determined by the last option specified. For example, ATTRIBUTES(SHORT) XREF(FULL) results in the FULL option for the combined listing.

Input Record Formats

The compiler accepts both F-format and V-format records; the primary and secondary input data sets can have different formats.

The compiler determines the positions, within each record, of the PL/I source code and the sequence numbers from the following options:

Option	Specifying	IBM-supplied default
FMARGINS	Positions of source and sequence	FMARGINS(2,72)
FSEQUENCE	Numbers for F-format records	FSEQUENCE(73,80)
VMARGINS	Positions of source text and sequence	VMARGINS(10,100)
VSEQUENCE	Numbers for V-format records	VSEQUENCE(1,8)
MARGINS	Overriding values for above options	—
SEQUENCE	Overriding values for above options	—

You can set the values of FMARGINS, FSEQUENCE, VMARGINS and VSEQUENCE only when you install the compiler. If you do not set values at this time, the IBM-supplied default values apply. You can specify MARGINS and SEQUENCE when you invoke the compiler. When specified, they override either FMARGINS and FSEQUENCE or VMARGINS and VSEQUENCE, depending on whether the first input data set read by the syntax-checking stage of the compiler is F-format. The overriding values also apply if the compiler reads records of the same format as secondary input. If the records of the other format are read as the compiler installation values, the values for that format apply.

Specifying Options in the %PROCESS or *PROCESS statements

The compiler uses the %PROCESS statement to identify the start of each external procedure and to allow compile-time options to be specified for each compilation. The options you specify in adjacent %PROCESS statements apply to the compilation of the source statements to the end of input, or the next %PROCESS statement.

To specify options in the %PROCESS statement, code as follows:

```
%PROCESS options;
```

where *options* is a list of compile-time options. You must end the list of options with a semicolon, and the options list should not extend beyond the default right-hand source margin. The asterisk must appear in the first data byte of the record. If the records are F format, the asterisk must be in column 1. If the records are V or U format, the asterisk must be as far left as possible, that is column 1 if possible, or immediately following the sequence numbers if these are on the extreme left. The keyword %PROCESS can follow in the next byte (column) or after any number of blanks. You must separate option keywords by a comma or at least one blank.

The number of characters is limited only by the length of the record. If you do not wish to specify any options, code:

```
%PROCESS;
```

If you find it necessary to continue the %PROCESS statement onto the next record, terminate the first part of the list after any delimiter, and continue on the next record. You can split option keywords or keyword arguments when continuing onto the next record, provided that the keyword or argument string terminates in the right-hand source margin, and the remainder of the string starts in the same column as the asterisk. You can continue a %PROCESS statement on several lines, or start a new %PROCESS statement. An example of multiple adjacent %PROCESS statements is as follows:

```
%PROCESS INT F(I) AG A(F) ESD MAP OP STG NEST X(F) SOURCE ;
%PROCESS LIST TEST ;
```

For information about using the %PROCESS statement with batched compilation, see “Compiling Multiple Procedures in a Single Job Step” on page 69.

Compile-time options, their abbreviated syntax, and their IBM-supplied defaults are shown in Table 3 on page 5 and Table 4 on page 7. Your site might have changed the IBM-supplied defaults or deleted options. Be sure to check for any changes before using compile-time option defaults. You can reinstate deleted compile-time options for a compilation by using the CONTROL compile-time option.

Using the Preprocessor

The preprocessing facilities of the compiler are described in the *PL/I for MVS & VM Language Reference*. You can include statements in your PL/I program that, when executed by the preprocessor stage of the compiler, modify the source program or cause additional source statements to be included from a library. The following discussion provides some illustrations of the use of the preprocessor and explains how to establish and use source statement libraries.

Invoking the Preprocessor

If you specify the compile-time option MACRO, the preprocessor stage of the compiler is executed. The compiler and the preprocessor use the data set defined by the DD statement with the name SYSUT1 during processing. They also use this data set to store the preprocessed source program until compilation begins. The IBM-supplied cataloged procedures for compilation include a DD statement with the name SYSUT1.

The format of the preprocessor output is given in Table 6.

Table 6. Format of the Preprocessor Output

Column 1	Printer control character, if any, transferred from the position specified in the MARGINS option.
Columns 2-72	Source program. If the original source program used more than 71 columns, additional lines are included for any lines that need continuation. If the original source program used fewer than 71 columns, extra blanks are added on the right.
Columns 73-80	Sequence number, right-aligned. If either SEQUENCE or NUMBER applies, this is taken from the sequence number field. Otherwise, it is a preprocessor generated number, in the range 1 through 99999. This sequence number will be used in the listing produced by the INSOURCE and SOURCE options, and in any preprocessor diagnostic messages.
Column 81	blank
Columns 82, 83	Two-digit number giving the maximum depth of replacement by the preprocessor for this line. If no replacement occurs, the columns are blank.
Column 84	*E* signifying that an error occurred while replacement was being attempted. If no error occurred, the column is blank.

Three other compile-time options, MDECK, INSOURCE, and SYNTAX, are meaningful only when you also specify the MACRO option. For more information about these options, see MDECK on page 17, INSOURCE on page 13, and SYNTAX on page 24.

A simple example of the use of the preprocessor to produce a source deck is shown in Figure 1. According to the value assigned to the preprocessor variable USE, the source statements will represent either a subroutine (CITYSUB) or a function (CITYFUN). The DSNAME used for SYSPUNCH specifies a source program library on which the preprocessor output will be placed. Normally compilation would continue and the preprocessor output would be compiled.

```
//OPT4#8  JOB
//STEP2 EXEC  IEL1C,PARM.PLI='MACRO,MDECK,NOCOMPILE,NOSYNTAX'
//PLI.SYSPUNCH DD  DSNAME=HPU8.NEWLIB(FUN),DISP=(NEW,CATLG),UNIT=SYSDA,
//          SPACE=(TRK,(1,1,1)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=400)
//PLI.SYSIN  DD *
 /* GIVEN ZIP CODE, FINDS CITY                                      */
 %DCL USE CHAR;
 %USE = 'FUN'                  /* FOR SUBROUTINE, %USE = 'SUB' */ ;
 %IF USE = 'FUN' %THEN %DO;
 CITYFUN: PROC(ZIPIN) RETURNS(CHAR(16)) REORDER; /* FUNCTION        */
                       %END;
                 %ELSE %DO;
 CITYSUB: PROC(ZIPIN, CITYOUT) REORDER;     /* SUBROUTINE           */
   DCL CITYOUT CHAR(16);          /* CITY NAME                      */
                       %END;
   DCL (LBOUND, HBOUND) BUILTIN;
   DCL ZIPIN PIC '99999';        /* ZIP CODE                        */
   DCL 1 ZIP_CITY(7) STATIC,     /* ZIP CODE - CITY NAME TABLE      */
         2 ZIP PIC '99999' INIT(
                     95141, 95014, 95030,
                     95051, 95070, 95008,
                     0),           /* WILL NOT LOOK AT LAST ONE      */
         2 CITY CHAR(16) INIT(
                     'SAN JOSE', 'CUPERTINO', 'LOS GATOS',
                     'SANTA CLARA', 'SARATOGA', 'CAMPBELL',
                     'UNKNOWN CITY');  /* WILL NOT LOOK AT LAST ONE  */
   DCL I FIXED BIN(31);
   DO I = LBOUND(ZIP,1) TO             /* SEARCH FOR ZIP IN TABLE    */
          HBOUND(ZIP,1)-1              /* DON'T LOOK AT LAST ELEMENT */
          WHILE(ZIPIN ¬= ZIP(I));
   END;
 %IF USE = 'FUN' %THEN %DO;
   RETURN(CITY(I));                    /* RETURN CITY NAME          */
                       %END;
                 %ELSE %DO;
   CITYOUT=CITY(I);                    /* RETURN CITY NAME          */
                       %END;
 END;
```

Figure 1. Using the preprocessor to Produce a Source Deck That Is Placed on a Source Program Library

Using the %INCLUDE Statement

The *PL/I for MVS & VM Language Reference* describes how to use the %INCLUDE statement to incorporate source text from a library into a PL/I program. (A *library* is an MVS partitioned data set or a VM MACLIB that can be used to store other data sets called members.) Source text that you might want to insert into a PL/I program using a %INCLUDE statement must exist as a member within a library. “Source Statement Library (SYSLIB)” on page 67 further describes the process of defining a source statement library to the compiler.

The statement:

```
%INCLUDE DD1 (INVERT);
```

specifies that the source statements in member INVERT of the library defined by the DD statement with the name DD1 are to be inserted consecutively into the source program. The compilation job step must include appropriate DD statements.

If you omit the ddname, the ddname SYSLIB is assumed. In such a case, you must include a DD statement with the name SYSLIB. (The IBM-supplied cataloged procedures do not include a DD statement with this name in the compilation procedure step.)

A %PROCESS statement in source text included by a %INCLUDE statement results in an error in the compilation.

Figure 2 shows the use of a %INCLUDE statement to include the source statements for FUN in the procedure TEST. The library HPU8.NEWLIB is defined in the DD statement with the qualified name PLI.SYSLIB, which is added to the statements of the cataloged procedure IEL1CLG for this job. Since the source statement library is defined by a DD statement with the name SYSLIB, the %INCLUDE statement need not include a ddname.

It is not necessary to invoke the preprocessor if your source program, and any text to be included, does not contain any macro statements. Under these circumstances, you can obtain faster inclusion of text by specifying the INCLUDE compile-time option.

```
//OPT4#9     JOB
//STEP3      EXEC IEL1CLG,PARM.PLI='INC,S,A,X,NEST'
//PLI.SYSLIB DD DSN=HPU8.NEWLIB,DISP=OLD
//PLI.SYSIN  DD *
   TEST: PROC OPTIONS(MAIN) REORDER;
     DCL ZIP PIC '99999';          /* ZIP CODE                         */
     DCL EOF BIT INIT('0'B);
     ON ENDFILE(SYSIN) EOF = '1'B;
     GET EDIT(ZIP) (COL(1), P'99999');
     DO WHILE(¬EOF);
       PUT SKIP EDIT(ZIP, CITYFUN(ZIP)) (P'99999', A(16));
       GET EDIT(ZIP) (COL(1), P'99999');
     END;
     %PAGE;
     %INCLUDE FUN;
   END;                            /* TEST                             */
//GO.SYSIN DD *
95141
95030
94101
//
```

Figure 2. Including Source Statements from a Library

Using the PL/I Preprocessor in Program Testing

You can use the %INCLUDE PL/I preprocessor statement to include program-testing statements from the source statement library in your program when you test it. You can use these statements in conjunction with program checkout statements to help track your program's operation and handle errors that occur.

Using % Statements

Statements that direct the operation of the compiler, begin with a percent (%) symbol. These statements must not have label or condition prefixes, and cannot be a “unit” of a compound statement.

The % statements allow you to control the source program listing and to include external strings in the source program. These control statements, %INCLUDE, %PRINT, %NOPRINT, %PAGE, and %SKIP, are listed below and described fully in the *PL/I for MVS & VM Language Reference*.

%INCLUDE Directs the compiler to incorporate external strings of characters and/or graphics into the source program.

%PRINT Directs the compiler to resume printing the source and insource listings.

%NOPRINT Directs the compiler to suspend printing the source and insource listings until a %PRINT statement is encountered.

%PAGE Directs the compiler to print the statement immediately after a %PAGE statement in the program listing on the first line of the next page.

%SKIP Specifies the number of lines to be skipped.

Note: You should place each % statement on a line by itself.

Invoking the Compiler from an Assembler Routine

You can invoke the compiler from an assembler language program by using one of the macro instructions ATTACH, CALL, LINK, or XCTL. The following information supplements the description of these macro instructions given in the supervisor and data management manual.

You cannot dynamically invoke the compiler under VM from an assembler routine running in a user area.

To invoke the compiler specify IEL1AA as the entry point name.

You can pass three address parameters to the compiler:

1. The address of a compile-time option list
2. The address of a list of ddnames for the data sets used by the compiler
3. The address of a page number that is to be used for the first page of the compiler listing on SYSPRINT

These addresses must be in adjacent fullwords, aligned on a fullword boundary. Register 1 must point to the first address in the list, and the first (left-hand) bit of the last address must be set to 1, to indicate the end of the list.

Note: If you want to pass parameters in an XCTL macro instruction, you must use the execute (E) form of the macro instruction. Remember also that the XCTL macro instruction indicates to the control program that the load module containing the XCTL macro instruction is completed. Thus the parameters must be established in a portion of main storage outside the load module containing the XCTL macro instruction, in case the load module is deleted before the compiler can use the parameters.

The format of the three parameters for all the macro instructions is described below.

Option List

The option list must begin on a halfword boundary. The first two bytes contain a binary count of the number of bytes in the list (excluding the count field). The remainder of the list can comprise any of the compile-time option keywords, separated by one or more blanks, a comma, or both of these.

DDNAME List

The ddname list must begin on a halfword boundary. The first two bytes contain a binary count of the number of bytes in the list (excluding the count field). Each entry in the list must occupy an 8-byte field; the sequence of entries is given in Table 7.

If a ddname is shorter than 8 bytes, fill the field with blanks on the right. If you omit an entry, fill its field with binary zeros; however, you can omit entries at the end of the list entirely.

Table 7. Entry Dequence in the DDNAME List

Entry	Standard DDNAME
1	SYSLIN
2	not applicable
3	not applicable
4	SYSLIB
5	SYSIN
6	SYSPRINT
7	SYSPUNCH
8	SYSUT1
9	not applicable
10	not applicable
11	not applicable
12	not applicable
13	not applicable
14	SYSCIN

Page Number

The compiler adds 1 to the last page number used in the compiler listing and put this value in the page-number field before returning control to the invoking routine. Thus, if the compiler is invoked again, page numbering is continuous.

Using the Compiler Listing

During compilation, the compiler generates a listing, most of which is optional, that contains information about the source program, the compilation, and the object module. It places this listing in the data set defined by the DD statement with the name SYSPRINT (usually output to a printer). In a conversational environment, you can also request a listing at your terminal (using the TERMINAL option). The following description of the listing refers to its appearance on a printed page.

The first part of Table 4 on page 7 shows the components that can be included in the compiler listing. The rest of this section describes them in detail.

Of course, if compilation terminates before reaching a particular stage of processing, the corresponding listings do not appear.

The listing comprises a small amount of standard information that always appears, together with those items of optional information specified or supplied by default. The listing at the terminal contains only the optional information that has been requested in the TERMINAL option.

Heading Information

The first page of the listing is identified by the product number, the compiler version number, and the date and the time compilation commenced. This page and subsequent pages are numbered.

Near the end of the listing you will find either a statement that no errors or warning conditions were detected during the compilation, or a message that one or more errors were detected. The format of the messages is described under “Messages” on page 44. The second to the last line of the listing shows the CPU time taken for the compilation. The last line of the listing is “END OF COMPILATION OF xxxx” where “xxxx” is the external procedure name. If you specify the NOSYNTAX compile-time option, or the compiler aborts early in the compilation, the external procedure name “xxxx” is not included and the line truncates to “END OF COMPILATION.”

The following paragraphs describe the optional parts of the listing in the order in which they appear.

Options Used for the Compilation

If the option OPTIONS applies, a complete list of the options specified for the compilation, including the default options, appears on the first page.

Preprocessor Input

If both the options MACRO and INSOURCE apply, the compiler lists input to the preprocessor, one record per line, each line numbered sequentially at the left.

If the preprocessor detects an error, or the possibility of an error, it prints a message on the page or pages following the input listing. The format of these messages is the same as the format for the compiler messages described under “Messages” on page 44.

SOURCE Program

If the option SOURCE applies, the input to the compiler is listed, one record per line. If the input records contain printer control characters or %SKIP or %PAGE statements, the lines are spaced accordingly. You can use %NOPRINT and %PRINT statements to stop and restart the printing of the listing.

If the MACRO option applies, the source listing shows the included text in place of the %INCLUDE statements in the primary input data set.

If the MACRO option does not apply but the INCLUDE option does, the included text is bracketed by comments indicating the %INCLUDE statement that caused the text to be included. Each nested %INCLUDE has the comment text indented two positions to the right.

Assume the following source input on SYSIN:

```
MAIN: PROC REORDER;
%INCLUDE MEMBER1;
END;
```

and the following content of MEMBER1:

```
J=K;
%INCLUDE DSALIB1(DECLARES);
L=M;
```

and the following content of DECLARES:

```
DCL (NULL,DATE) BUILTIN;
```

produces in the source listing:

```
 MAIN: PROC REORDER;
 /*BEGIN %INCLUDE SYSLIB  (MEMBER1 )********/
 J=K;
 /***BEGIN %INCLUDE DSALIB1 (DECLARES)******/
 DCL (NULL,DATE) BUILTIN;
 /***END   %INCLUDE DSALIB1 (DECLARES)******/
 L=M;
 /*END   %INCLUDE SYSLIB  (MEMBER1 )********/
 END;
```

If the STMT compile-time option applies, the statement numbers are derived from a count of the number of statements in the program after %INCLUDEs have been processed.

If the NUMBER option applies, the compiler derives statement numbers from the sequence numbers of the statements in the source records after %INCLUDE statements have been processed. Normally the compiler uses the last five digits as statement numbers. If, however, this does not produce a progression of statements with successively higher numbers, the compiler adds 100000 to all statement numbers starting from the one that would otherwise be equal to or less than its predecessor.

For instance, if a V-format primary input data set had the following lines:

```
00001000 A:PROC;
00002000 %INCLUDE B;
00003000 END;
```

and member B contained:

```
00001000 C=D;
00002000 E=F;
00003000 G=H;
```

then the source listing would be as follows:

```
SOURCE LISTING
    NUMBER

    1000   00001000 A:PROC;
           00002000      /*BEGIN %INCLUDE SYSLIB  (B       )******/
  101000   00001000 C=D;
  102000   00002000 E=F;
  103000   00003000 G=H;
                         /*END   %INCLUDE SYSLIB  (B       )******/
  203000   00003000 END;
```

The additional 100000 has been introduced into the statement numbers at two points:

1. Beginning at the first statement of the included text (the statement C=D;)
2. Beginning with the first statement after the included text (the END statement)

If the source statements are generated by the preprocessor, columns 82-84 contain diagnostic information, as shown in Table 6 on page 29.

Statement Nesting Level

If the option NEST applies, the block level and the DO-level are printed to the right of the statement or line number under the headings LEV and NT respectively, for example:

```
STMT  LEV  NT

   1         0  A: PROC OPTIONS(MAIN);
   2     1   0  B: PROC;
   3     2   0     DCL K(10,10) FIXED BIN (15);
   4     2   0     DCL Y FIXED BIN (15) INIT (6);
   5     2   0     DO I=1 TO 10;
   6     2   1        DO J=1 TO 10;
   7     2   2           K(I,J) = N;
   8     2   2        END;
   9     2   1     BEGIN;
  10     3   1        K(1,1)=Y;
  11     3   1     END;
  12     2   1  END B;
  13     1   0  END A;
```

ATTRIBUTE and Cross-Reference Table

If the option ATTRIBUTES applies, the compiler prints an attribute table containing a list of the identifiers in the source program together with their declared and default attributes. In this context, the attributes include any relevant options, such as REFER, and also descriptive comments, such as:

```
/*STRUCTURE*/
```

If the option XREF applies, the compiler prints a cross-reference table containing a list of the identifiers in the source program together with the numbers of the statements in which they appear. If both ATTRIBUTES and XREF apply, the two tables are combined. If the suboption SHORT applies, unreferenced identifiers are not listed.

If the following conditions apply:

- GRAPHIC compile-time option is in effect
- Compilation is being done under MVS
- At least one DBCS identifier is found in the compilation unit
- ATTRIBUTES and/or XREF are in effect

then the PL/I compiler uses the DBCS Ordering Support Product to perform the sorting of the DBCS identifiers for the XREF listing.

The types of ordering available are the Total Stroke Count (KS), Radical Stroke Count (KR), and the IBM Unique Pronunciation (KU). The default is KU. To select the other types you must supply a special AKSLDFLT CSECT specifying the desired ordering type.

All sorted DBCS identifiers appear in the listing before the SBCS identifiers, which are sorted in collating sequence.

The DBCSOS Ordering Product requires 128K of free storage. For information about reserving storage, see the SIZE option, “Under MVS” on page 23.

Attribute Table

If you declare an identifier explicitly, the compiler lists the number of the DECLARE statement. The compiler indicates an undeclared variable by asterisks. (The compiler also lists undeclared variables in error messages.) It also gives the statement numbers of statement labels and entry labels.

The compiler never includes the attributes INTERNAL and REAL. You can assume them unless the respective conflicting attributes, EXTERNAL and COMPLEX, appear.

For a file identifier, the attribute FILE always appears, and the attribute EXTERNAL appears if it applies; otherwise, the compiler only lists explicitly declared attributes.

The compiler prints the dimension attribute for an array first. It prints the bounds as in the array declaration, but it replaces expressions with asterisks. Structure levels other than base elements also have their bounds replaced by asterisks.

For a character string or a bit string, the compiler prints the length, preceded by the word BIT or CHARACTER, as in the declaration, but it replaces an expression with an asterisk.

Cross-Reference Table

If you combine the cross-reference table with the attribute table, the numbers of the statements or lines in which a name appears follow the list of attributes for the name. The order in which the statement numbers appear is subject to any reordering of blocks that has occurred during compilation. In general, the compiler gives the statement numbers for the outermost block first, followed on the next line by the statement numbers for the inner blocks.

The compiler expands and optimizes PL/I text before it produces the cross-reference table. Consequently, some names that appear only once within a source statement can acquire multiple references to the same statement number. By the same token, other names can appear to have incomplete lists of references, while still others can have references to statements in which the name does not appear explicitly.

For example:

- Duplicate references can be listed for items such as do-loop control variables, and for some aggregates.
- Optimization of certain operations on structures can result in incomplete listings in the cross-reference table. The numbers of statements in which these operations are performed on major or minor structures are listed against the names of the elements, instead of against the structure names.
- No references to PROCEDURE or ENTRY statements in which a name appears as a parameter are listed in the cross-reference table entry for that name.
- References within DECLARE statements to variables that are not being declared are not listed. For example, in the statements:

  ```
  DCL ARRAY(N);
  DCL STRING CHAR(N);
  ```

  no references to these statements would appear in the cross-reference table entry for N.
- The number of a statement in which an implicitly pointer-qualified based variable name appears is included not only in the list of statement numbers for that name, but also in the list of statement numbers for the pointer implicitly associated with it.
- The statement number of an END or LEAVE statement that refers to a label is not listed in the entry for the label.
- Automatic variables declared with the INITIAL attribute have a reference to the PROCEDURE or BEGIN statement for the block containing the declaration included in the list of statement numbers.

Aggregate Length Table

An aggregate length table is obtained by using the AGGREGATE option. The table shows how the compiler maps each aggregate in the program. It contains the following information:

- The statement number in which the aggregate is declared.
- The name of the aggregate and the element within the aggregate.
- The level number of each item in a structure.
- The number of dimensions in an array.
- The byte offset of each element from the beginning of the aggregate. (The compiler does not give bit offsets for unaligned bit-string data). As a word of caution, be careful when interpreting the data offsets indicated in the data length table. An odd offset does not necessarily represent a data element without halfword, fullword, or even double word alignment. If you specify or infer the aligned attribute for a structure or its elements, the proper alignment requirements are consistent with respect to other elements in the structure, even though the table does not indicate the proper alignment relative to the beginning of the table.
- The length of each element.

- The total length of each aggregate, structure, and substructure.

If there is padding between two structure elements, a /*PADDING*/ comment appears, with appropriate diagnostic information.

The table is completed with the sum of the lengths of all aggregates that do not contain adjustable elements.

The statement or line number identifies either the DECLARE statement for the aggregate, or, for a controlled aggregate, an ALLOCATE statement for the aggregate. An entry appears for each ALLOCATE statement involving a controlled aggregate, as such statements can have the effect of changing the length of the aggregate during run time. Allocation of a based aggregate does not have this effect, and only one entry, which is that corresponding to the DECLARE statement, appears.

When passing an aggregate to a subroutine, the length of an aggregate might not be known during compilation, either because the aggregate contains elements having adjustable lengths or dimensions, or because the aggregate is dynamically defined. In these cases, the compiler prints the word *adjustable* or *defined* in the *offset* column and *param* for parameter in the *element length* and *total length* columns. Because the compiler might not know the length of an aggregate during compilation, it does not print padding information.

An entry for a COBOL mapped structure has the word COBOL appended. COBOL mapped structures are structures into which a program reads or writes a COBOL record, or a structure that can be passed between PL/I programs and COBOL programs. The COBOL entry appears if the compiler determines that the COBOL and PL/I mapping for the structure is different, and the creation of a temporary structure mapped according to COBOL synchronized structure rules is not suppressed by NOMAP, NOMAPIN, or NOMAPOUT.

If a COBOL entry does appear it is additional to the entry for the PL/I mapped version of the structure.

The compiler makes a separate entry in the aggregate table for every aggregate dummy argument or COBOL mapped structure.

Storage Requirements

If the option STORAGE applies, the compiler lists the following information under the heading *Storage Requirements* on the page following the end of the aggregate length table:

- The length of the program control section. The program control section is the part of the object that contains the executable part of the program.
- The length of the static internal control section. This control section contains all storage for variables declared STATIC INTERNAL.
- The storage area in bytes for each procedure.
- The storage area in bytes for each begin-block.
- The storage area in bytes for each ON-unit.
- The dynamic storage area in bytes for each procedure, begin-block, and ON-unit. The dynamic storage area is acquired at activation of the block.

Statement Offset Addresses

If the option LIST applies, the compiler includes a pseudo-assembler listing in the compiler listing. You can use the offset given in run-time error messages to discover the erroneous statement, because the offsets in both run-time messages and the pseudo-assembler listing are relative to the start of the external procedure. Simply match the offset given in the error message with the offset in the listing to find the erroneous statement.

In the example shown in Figure 3, compile unit offset +17E occurs in the object listing under statement 6. Statement 6 is the erroneous statement.

```
            SOURCE LISTING

        1    M:PROC OPTIONS(MAIN);
        2      CALL A2;
        3      A1:PROC;
        4        N=3;
        5        A2:ENTRY;
        6          N=N/0;
        7      END;
        8    END;


-  OBJECT LISTING

 * STATEMENT NUMBER  6
 00016C  58 70 D 0C0              L     7,192(0,13)
 000170  48 60 3 02A              LH    6,42(0,3)
 000174  48 80 7 0B8              LH    8,N
 000178  1B 99                    SR    9,9
 00017A  8E 80 0 010              SRDA  8,16
 00017E  1D 86                    DR    8,6
 000180  12 99                    LTR   9,9
 000182  47 B0 2 02A              BNM   CL.13
 000186  5A 90 3 034              A     9,52(0,3)
 00018A                   CL.13   EQU   *
 00018A  8A 90 0 010              SRA   9,16
 00018E  40 90 7 0B8              STH   9,N

Message:

IBM0301S ONCODE=320  The ZERODIVIDE condition was raised.
         From compile unit M at entry point A2 at compile
         unit offset +0000017E at address 000201FE.
```

Figure 3. Finding Statement Number from a Compile Unit Offset in an Error Message

If the OFFSET option applies, the compiler lists for each primary entry point the offsets at which statements occur. This information is found in the compiler listing under the heading, “Table of Offsets and Statement Numbers.”

Entry offsets given in dump and on-unit SNAP error messages can be compared with this table and the erroneous statement discovered. The statement is identified by finding the section of the table that relates to the block named in the message and then finding the largest offset less than or equal to the offset in the message. The statement number associated with this offset is the one needed.

If a secondary entry point is used, first find the name of the block that contains this entry and the corresponding section of the offset table that relates to this name. Next, add the offset given in the message to the offset of the secondary entry point in the table. This will convert the message offset so that it is relative to the primary entry point versus the secondary entry point, which was entered during execution.

Use this converted offset to search the section of the offset table for the largest offset as described above.

In the example in Figure 4, secondary entry point P2 is contained in procedure block P1 at offset X'78'. Adding X'78' to the message entry offset of X'44' yields a value of X'BC'. The largest offset table entry less than or equal to X'BC' is X'B4', which corresponds to statement number 7.

```
               SOURCE LISTING
    STMT

       1     Q: PROC OPTIONS(MAIN);
       2       ON ERROR SNAP GOTO L;
       3       CALL P2;
       4       P1: PROC;
       5           N=1;
       6       P2: ENTRY;
       7           SIGNAL ERROR;
       8           END;
       9       L: END;


          TABLE OF OFFSETS AND STATEMENT NUMBERS

               WITHIN PROCEDURE Q
 OFFSET (HEX)        0     A8     C0     CA
 STATEMENT NO.       1      2      3      9

               WITHIN PROCEDURE P1
 OFFSET (HEX)        0      78    A8     B4     BE
 STATEMENT NO.       4       6     5      7      8


 Messages:

 'ERROR' condition was raised
 Traceback of user routines:
 Compile Unit   Entry Statement   CU offset   Entry offset   Address
 Q              P2                +000001A0   +00000044      00020220
 Q              Q                 +000000CC   +000000C8      0002014C
```

Figure 4. Finding Statement Number from an Entry Offset in an Error Message

External Symbol Dictionary

If the option ESD applies, the compiler lists the contents of the external symbol dictionary (ESD).

The ESD is a table containing all the external symbols that appear in the object module. (The machine instructions in the object module are grouped together in *control sections*; an external symbol is a name that can be referred to in a control section other than the one in which it is defined.) The contents of an ESD appear under the following headings:

SYMBOL An 8-character field that identifies the external symbol.

TYPE Two characters from the following list to identify the type of entry:

SD Section definition: the name of a control section within the object module.

CM Common area: a type of control section that contains no data or executable instructions.

ER External reference: an external symbol that is not defined in the object module.

WX Weak external reference: an external symbol that is not defined in this module and that is not to be resolved unless an ER entry is encountered for the same reference.

PR Pseudoregister: a field used to address files, controlled variables, and FETCHed procedures.

LD Label definition: the name of an entry point to the external procedure other than that used as the name of the program control section.

ID Four-digit hexadecimal number: all entries in the ESD, except LD-type entries, are numbered sequentially, beginning with 0001.

ADDRESS Hexadecimal representation of the address of the external symbol.

LENGTH The hexadecimal length in bytes of the control section (SD, CM and PR entries only).

ESD Entries

The external symbol dictionary usually starts with the standard entries shown in Figure 5, which assumes the existence of an external procedure called NAME.

```
SYMBOL       TYPE          ID       ADDRESS    LENGTH

CEESTART     SD            0001     000000     000080
***NAME1     SD            0002     000000     0000A8
***NAME2     SD            0003     000000     00005C
CEEMAIN      WX            0004     000000
CEEMAIN      SD            0005     000000     000010
IBMRINP1     ER            0006     000000
CEEFMAIN     WX            0007     000000
CEEBETBL     ER            0008     000000
CEEROOTA     ER            0009     000000
CEESG010     ER            000A     000000
NAME         LD                     000008
```

Figure 5. External Symbol Dictionary

*****name1**

SD-type entry for the program control section (the control section that contains the executable instructions of the object module). This name is the first label of the external procedure, padded on the left with asterisks to 7 characters if necessary, and extended on the right with the character 1.

*****name2**

SD-type entry for the static internal control section (which contains main storage for all variables declared STATIC INTERNAL). This name is the first label of the external procedure, padded on the left with asterisks to 7 characters if necessary, and extended on the right with the character 2.

CEESTART

SD-type entry for CEESTART. This control section transfers control to CEEROOTA, the initialization routine for the library environment. When initialization is complete, control passes to the address stored in the control section CEEMAIN. (Initialization is required only once while a PL/I program is running, even if it calls another external procedure. In such a case, control passes directly to the entry point named in the CALL statement, and not to the address contained in CEEMAIN.)

CEEROOTA, CEESG010, CEEBETBL, IBMRINP1
These ER-type entries are generated to support environment initialization for the program.

The other entries in the external symbol dictionary vary, but can include the following:

- SD-type entry for the control section CEEMAIN, which contains the address of the primary entry point to the external procedure. This control section is present only if the procedure statement includes the option MAIN. A WX-type entry for CEEMAIN is always generated to support environment initialization for the program.
- Reference to a number of control sections as follows:

  CEEFMAIN A control section used in *fetch* processing. It indicates the presence of a fetchable entry point within the load module.

  IBMSEATA A module in the PL/I library used to set the attention exit for use in procedures compiled with the INTERRUPT option. This is an ER type entry if the procedure was compiled with the INTERRUPT option.

  CEEUOPT A control section that contains the run-time options specified at compile time.

  PLIXOPT Run-time options string control section.
- LD-type entries for all names of entry points to the external procedure.
- ER-type entries for all the library subroutines and external procedures called by the source program.
- CM-type entries for variables declared STATIC EXTERNAL without the INITIAL attribute.
- SD-type entries for all other STATIC EXTERNAL variables and for external file names.
- PR-type entries for all file names. For external file names, the name of the pseudoregister is the same as the file name; for internal file names, the compiler generates pseudoregister names.
- PR-type entries for all controlled variables. For external variables, the name of the variable is used for the pseudoregister name; for internal variables, the compiler generates names.
- PR-type entries for fetched entry names.

Static Internal Storage Map

The MAP option produces a Variable Offset Map. This map shows how PL/I data items are mapped in main storage. It names each PL/I identifier, its level, its offset from the start of the storage area in both decimal and hexadecimal form, its storage class, and the name of the PL/I block in which it is declared.

If the LIST option is also specified a map of the static internal and external control sections is also produced.

For more information about the static internal storage map and an example, see the *Language Environment for MVS & VM Debugging Guide and Run-Time Messages*.

Object Listing

If the option LIST applies, the compiler generates a listing of the machine instructions of the object module, including any compiler-generated subroutines, in a form similar to assembler language.

For more information about the object listing and an example, see the *Language Environment for MVS & VM Debugging Guide and Run-Time Messages*.

Messages

If the preprocessor or the compiler detects an error, or the possibility of an error, they generate messages. Messages generated by the preprocessor appear in the listing immediately after the listing of the statements processed by the preprocessor. You can generate your own messages in the preprocessing stage by use of the %NOTE statement. Such messages might be used to show how many times a particular replacement had been made. Messages generated by the compiler appear at the end of the listing. All messages are graded according to their severity, as follows:

I An information message that calls attention to a possible inefficiency in the program or gives other information generated by the compiler.

W A warning message that calls attention to a possible error, although the statement to which it refers is syntactically valid.

E An error message that describes an error detected by the compiler for which the compiler applied a *fix-up* with confidence. The resulting program will run, and it will probably give correct results.

S A severe error message that specifies an error detected by the compiler for which the compiler cannot apply a *fix-up* with confidence. The resulting program will run but will not give correct results.

U An unrecoverable error message that describes an error that forces termination of the compilation.

The compiler only lists messages that have a severity equal to or greater than that specified by the FLAG option, as shown in Table 8 on page 45.

Each message is identified by an eight-character code of the form *IELnnnnI*, where:

- The first three characters *IEL* identify the message as coming from the compiler.
- The next four characters, *nnnn*, are a four-digit message number.
- The last character, *I*, is an operating system code for the operator indicating that the message is for information only.

The text of each message, an explanation, and any recommended programmer response, are given in the *PL/I for MVS & VM Compile-Time Messages and Codes*.

Table 8. Using the FLAG Option To Select the Lowest Message Severity Listed

Type of Message	Option
Information	FLAG(I)
Warning	FLAG(W)
Error	FLAG(E)
Severe Error	FLAG(S)
Unrecoverable Error	Always listed

Return Codes

For every compilation job or job step, the compiler generates a return code that indicates to the operating system the degree of success or failure it achieved. For MVS, this code appears in the *end-of-step* message that follows the listing of the job control statements and job scheduler messages for each step. The meaning of the codes are given in Table 9.

Table 9. Return Codes from Compilation of a PL/I Program

Return code	Description
0000	No error detected; compilation completed, successful execution anticipated.
0004	Warning; possible error detected; compilation completed, execution probable.
0008	Error detected; compilation completed; successful execution probable.
0012	Severe error detected; compilation not necessarily completed; successful execution improbable.
0016	Unrecoverable error detected; compilation terminated abnormally; successful execution impossible.

Chapter 2. Using PL/I Cataloged Procedures under MVS

This chapter describes the standard cataloged procedures supplied by IBM for use with the IBM PL/I for MVS & VM compiler. It explains how to invoke them, and how to temporarily or permanently modify them. You must be linked to Language Environment befor using any of the catalogued procedures described in this chapter.

A cataloged procedure is a set of job control statements stored in a library. A cataloged procedure includes one or more EXEC statements, each of which can be followed by one or more DD statements. You can retrieve the statements by naming the cataloged procedure in the PROC parameter of an EXEC statement in the input stream.

You can use cataloged procedures to save time and reduce Job Control Language errors. If the statements in a cataloged procedure do not match your requirements exactly, you can easily modify them or add new statements for the duration of a job. You should review these procedures and modify them to obtain the most efficient use of the facilities available and to allow for your own conventions.

IBM-Supplied Cataloged Procedures

The PL/I cataloged procedures supplied for use with the IBM PL/I for MVS & VM are:

IEL1C	Compile only
IEL1CL	Compile and link-edit
IEL1CLG	Compile, link-edit, and run
IEL1CG	Compile, load and run

The information in this section describes the procedure steps of the different cataloged procedures. For a description of the individual statements for compiling and link editing, see “Using JCL during Compilation” on page 64 and the *Language Environment for MVS & VM Programming Guide*. These cataloged procedures do not include a DD statement for the input data set; you must always provide one. The example shown in Figure 6 on page 47 illustrates the JCL statements you might use to invoke the cataloged procedure IEL1CLG to compile, link-edit, and run a PL/I program.

Note: The IBM PL/I for MVS & VM requires a minimum REGION size of 512K. Large programs require more storage. If you do not specify REGION on the EXEC statement that invokes the cataloged procedure you are running, the compiler uses the default REGION size for your site. The default size might or might not be adequate, depending on the size of your PL/I program. For an example of specifying REGION on the EXEC statement, see Figure 6 on page 47.

```
//COLEGO    JOB
//STEP1     EXEC IEL1CLG, REGION.PLI=1M
//PLI.SYSIN DD *
               .
               .
               .
    (insert PL/I program to be compiled here)
               .
               .
               .
/*
```

Figure 6. Invoking a Cataloged Procedure

Compile Only (IEL1C)

This cataloged procedure, shown in Figure 7 on page 48, includes only one procedure step, in which the options specified for the compilation are OBJECT and NODECK. (IEL1AA is the symbolic name of the compiler.) In common with the other cataloged procedures that include a compilation procedure step, IEL1C does not include a DD statement for the input data set; you must always supply an appropriate statement with the qualified ddname PLI.SYSIN.

The OBJECT option causes the compiler to place the object module, in a syntax suitable for input to the linkage editor, in the standard data set defined by the DD statement with the name SYSLIN. This statement defines a temporary data set named &&LOADSET on a sequential device; if you want to retain the object module after the end of your job, you must substitute a permanent name for &&LOADSET (that is, a name that does not start with &&) and specify KEEP in the appropriate DISP parameter for the last procedure step that used the data set. You can do this by providing your own SYSLIN DD statement, as shown below. The data set name and disposition parameters on this statement will override those on the IEL1C procedure SYSLIN DD statement. In this example, the compile step is the only step in the job.

```
//PLICOMP EXEC IEL1C
//PLI.SYSLIN  DD  DSN=MYPROG,DISP=(MOD,KEEP)
//PLI.SYSIN   DD ...
```

The term MOD in the DISP parameter in Figure 7 on page 48 allows the compiler to place more than one object module in the data set, and PASS ensures that the data set is available to a later procedure step providing a corresponding DD statement is included there.

The SYSLIN SPACE parameter allows an initial allocation of 250 eighty-byte records and, if necessary, 15 further allocations of 100 records (a total of 1750 records).

```
//IEL1C   PROC LNGPRFX='IEL.V1R1M1',LIBPRFX='CEE.V1R4M0',               00010000
//             SYSLBLK=3200                                             00020000
//*                                                                     00030000
//********************************************************************  00040000
//*                                                                  *  00050000
//* LICENSED MATERIALS - PROPERTY OF IBM                             *  00060000
//*                                                                  *  00070000
//* 5688-235 (C) COPYRIGHT IBM CORP. 1964, 1995                      *  00080000
//* ALL RIGHTS RESERVED                                              *  00090000
//* US GOVERNMENT USERS RESTRICTED RIGHTS - USE,                     *  00100000
//* DUPLICATION OR DISCLOSURE RESTRICTED BY GSA                      *  00110000
//* ADP SCHEDULE CONTRACT WITH IBM CORP.                             *  00120000
//*                                                                  *  00130000
//* SEE COPYRIGHT INSTRUCTIONS                                       *  00140000
//*                                                                  *  00150000
//********************************************************************  00160000
//*                                                                     00170000
//* IBM PL/I FOR MVS & VM                                               00180000
//*                                                                     00190000
//*  COMPILE A PL/I PROGRAM                                             00200000
//*                                                                     00210000
//*  RELEASE LEVEL: 01.01.01  (VERSION.RELEASE.MODIFICATION LEVEL)      00220000
//*                                                                     00230000
//*  PARAMETER  DEFAULT VALUE    USAGE                                  00240000
//*   LNGPRFX   IEL.V1R1M1       PREFIX FOR LANGUAGE DATA SET NAMES     00250000
//*   LIBPRFX   CEE.V1R4M0       PREFIX FOR LIBRARY DATA SET NAMES      00260000
//*   SYSLBLK   3200             BLKSIZE FOR OBJECT DATA SET            00270000
//*                                                                     00280000
//PLI      EXEC PGM=IEL1AA,PARM='OBJECT,NODECK',REGION=512K             00290000
//STEPLIB  DD  DSN=&LNGPRFX..SIELCOMP,DISP=SHR                          00300000
//         DD  DSN=&LIBPRFX..SCEERUN,DISP=SHR                           00310000
//SYSPRINT DD  SYSOUT=*                                                 00320000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,                00330000
//             SPACE=(80,(250,100)),DCB=(BLKSIZE=&SYSLBLK)              00340000
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,                                 00350000
//             SPACE=(1024,(200,50),,CONTIG,ROUND),DCB=BLKSIZE=1024     00360000
```

Figure 7. Cataloged Procedure IEL1C

Compile and Link-Edit (IEL1CL)

This cataloged procedure, shown in Figure 8 on page 49, includes two procedure steps: PLI, which is identical to cataloged procedure IEL1C, and LKED, which invokes the linkage editor (symbolic name IEWL) to link-edit the object module produced in the first procedure step.

Input data for the compilation procedure step requires the qualified ddname PLI.SYSIN. The COND parameter in the EXEC statement LKED specifies that this procedure step should be bypassed if the return code produced by the compiler is greater than 8 (that is, if a severe or unrecoverable error occurs during compilation).

```
//IEL1CL  PROC LNGPRFX='IEL.V1R1M1',LIBPRFX='CEE.V1R4M0',               00010000
//             SYSLBLK=3200,GOPGM=GO                                    00020000
//*                                                                     00030000
//********************************************************************  00040000
//*                                                                  *  00050000
//* LICENSED MATERIALS - PROPERTY OF IBM                             *  00060000
//*                                                                  *  00070000
//* 5688-235 (C) COPYRIGHT IBM CORP. 1964, 1995                      *  00080000
//* ALL RIGHTS RESERVED                                              *  00090000
//* US GOVERNMENT USERS RESTRICTED RIGHTS - USE,                     *  00100000
//* DUPLICATION OR DISCLOSURE RESTRICTED BY GSA                      *  00110000
//* ADP SCHEDULE CONTRACT WITH IBM CORP.                             *  00120000
//*                                                                  *  00130000
//* SEE COPYRIGHT INSTRUCTIONS                                       *  00140000
//*                                                                  *  00150000
//********************************************************************  00160000
//*                                                                     00170000
//* IBM PL/I FOR MVS & VM                                               00180000
//*                                                                     00190000
//*  COMPILE AND LINK EDIT A PL/I PROGRAM                               00200000
//*                                                                     00210000
//*  RELEASE LEVEL: 01.01.01  (VERSION.RELEASE.MODIFICATION LEVEL)      00220000
//*                                                                     00230000
//*  PARAMETER  DEFAULT VALUE    USAGE                                  00240000
//*   LNGPRFX   IEL.V1R1M1       PREFIX FOR LANGUAGE DATA SET NAMES     00250000
//*   LIBPRFX   CEE.V1R4M0       PREFIX FOR LIBRARY DATA SET NAMES      00260000
//*   SYSLBLK   3200             BLKSIZE FOR OBJECT DATA SET            00270000
//*   GOPGM     GO               MEMBER NAME FOR LOAD MODULE            00280000
//*                                                                     00290000
//PLI      EXEC PGM=IEL1AA,PARM='OBJECT,NODECK',REGION=512K             00300000
//STEPLIB  DD  DSN=&LNGPRFX..SIELCOMP,DISP=SHR                          00310000
//         DD  DSN=&LIBPRFX..SCEERUN,DISP=SHR                           00320000
//SYSPRINT DD  SYSOUT=*                                                 00330000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,                00340000
//             SPACE=(80,(250,100)),DCB=(BLKSIZE=&SYSLBLK)              00350000
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,                                 00360000
//             SPACE=(1024,(200,50),,CONTIG,ROUND),DCB=BLKSIZE=1024     00370000
//LKED     EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=512K   00380000
//SYSLIB   DD  DSN=&LIBPRFX..SCEELKED,DISP=SHR                          00390000
//SYSPRINT DD  SYSOUT=*                                                 00400000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(OLD,DELETE)                          00410000
//         DD  DDNAME=SYSIN                                             00420000
//SYSLMOD  DD  DSN=&&GOSET(&GOPGM),DISP=(MOD,PASS),UNIT=SYSDA,          00430000
//             SPACE=(1024,(50,20,1))                                   00440000
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),           00450000
//             DCB=BLKSIZE=1024                                         00460000
//SYSIN    DD  DUMMY                                                    00470000
```

Figure 8. Cataloged Procedure IEL1CL

The linkage editor always places the load modules it creates in the standard data set defined by the DD statement with the name SYSLMOD. This statement in the cataloged procedure specifies a new temporary library &&GOSET, in which the load module will be placed and given the member name GO (unless you specify the NAME compile-time option for the compiler procedure step). In specifying a temporary library, the cataloged procedure assumes that you will run the load module in the same job; if you want to retain the module, you must substitute your own statement for the DD statement with the name SYSLMOD.

The SYSLIN DD statement in Figure 8 shows how to concatenate a data set defined by a DD statement named SYSIN with the primary input (SYSLIN) to the linkage editor. You could place linkage editor control statements in the input stream by this means, as described in the *Language Environment for MVS & VM Programming Guide*.

Compile, Link-Edit, and Run (IEL1CLG)

This cataloged procedure, shown in Figure 9, includes three procedure steps: PLI, LKED, and GO. PLI and LKED are identical to the two procedure steps of IEL1CL, and GO runs the load module created in the step LKED. The GO step is executed only if no severe or unrecoverable errors occurred in the preceding procedure steps.

Input data for the compilation procedure step should be specified in a DD statement with the name PLI.SYSIN, and for the GO step in a DD statement with the name GO.SYSIN.

```
//IEL1CLG PROC LNGPRFX='IEL.V1R1M1',LIBPRFX='CEE.V1R4M0',               00010000
//             SYSLBLK=3200,GOPGM=GO                                    00020000
//*                                                                     00030000
//********************************************************************* 00040000
//*                                                                   * 00050000
//* LICENSED MATERIALS - PROPERTY OF IBM                              * 00060000
//*                                                                   * 00070000
//* 5688-235 (C) COPYRIGHT IBM CORP. 1964, 1995                       * 00080000
//* ALL RIGHTS RESERVED                                               * 00090000
//* US GOVERNMENT USERS RESTRICTED RIGHTS - USE,                       * 00100000
//* DUPLICATION OR DISCLOSURE RESTRICTED BY GSA                       * 00110000
//* ADP SCHEDULE CONTRACT WITH IBM CORP.                              * 00120000
//*                                                                   * 00130000
//* SEE COPYRIGHT INSTRUCTIONS                                        * 00140000
//*                                                                   * 00150000
//********************************************************************* 00160000
//*                                                                     00170000
//* IBM PL/I FOR MVS & VM                                               00180000
//*                                                                     00190000
//*  COMPILE, LINK EDIT AND RUN A PL/I PROGRAM                          00200000
//*                                                                     00210000
//*  RELEASE LEVEL: 01.01.01  (VERSION.RELEASE.MODIFICATION LEVEL)      00220000
//*                                                                     00230000
//*  PARAMETER  DEFAULT VALUE    USAGE                                  00240000
//*   LNGPRFX   IEL.V1R1M1       PREFIX FOR LANGUAGE DATA SET NAMES     00250000
//*   LIBPRFX   CEE.V1R4M0       PREFIX FOR LIBRARY DATA SET NAMES      00260000
//*   SYSLBLK   3200             BLKSIZE FOR OBJECT DATA SET            00270000
//*   GOPGM     GO               MEMBER NAME FOR LOAD MODULE            00280000
//*                                                                     00290000
//PLI      EXEC PGM=IEL1AA,PARM='OBJECT,NODECK',REGION=512K             00300000
//STEPLIB  DD  DSN=&LNGPRFX..SIELCOMP,DISP=SHR                          00310000
//         DD  DSN=&LIBPRFX..SCEERUN,DISP=SHR                           00320000
//SYSPRINT DD  SYSOUT=*                                                 00330000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,                00340000
//             SPACE=(80,(250,100)),DCB=(BLKSIZE=&SYSLBLK)              00350000
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,                                 00360000
//             SPACE=(1024,(200,50),,CONTIG,ROUND),DCB=BLKSIZE=1024     00370000
//LKED     EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=512K   00380000
//SYSLIB   DD  DSN=&LIBPRFX..SCEELKED,DISP=SHR                          00390000
//SYSPRINT DD  SYSOUT=*                                                 00400000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(OLD,DELETE)                          00410000
//         DD  DDNAME=SYSIN                                             00420000
//SYSLMOD  DD  DSN=&&GOSET(&GOPGM),DISP=(MOD,PASS),UNIT=SYSDA,          00430000
//             SPACE=(1024,(50,20,1))                                   00440000
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),           00450000
//             DCB=BLKSIZE=1024                                         00460000
//SYSIN    DD  DUMMY                                                    00470000
//GO       EXEC PGM=*.LKED.SYSLMOD,COND=((9,LT,PLI),(9,LT,LKED)),       00480000
//             REGION=2048K                                             00490000
//STEPLIB  DD  DSN=&LIBPRFX..SCEERUN,DISP=SHR                           00500000
//SYSPRINT DD  SYSOUT=*                                                 00510000
//CEEDUMP  DD  SYSOUT=*                                                 00520000
//SYSUDUMP DD  SYSOUT=*                                                 00530000
```

Figure 9. Cataloged Procedure IEL1CLG

Compile, Load and Run (IEL1CG)

This cataloged procedure, shown in Figure 10, achieves the same results as IEL1CLG but uses the loader instead of the linkage editor. However, instead of using three procedure steps (compile, link-edit, and run), it has only two (compile and load-and-run). The second procedure step runs the loader program. The loader program processes the object module produced by the compiler and runs the resultant executable program immediately. Input data for the compilation procedure step requires the qualified ddname PLI.SYSIN.

The use of the loader imposes certain restrictions on your PL/I program; before using this cataloged procedure, see *Language Environment for MVS & VM Programming Guide*, which explains how to use the loader.

```
//IEL1CG  PROC LNGPRFX='IEL.V1R1M1',LIBPRFX='CEE.V1R4M0',               00010000
//             SYSLBLK=3200                                             00020000
//*                                                                     00030000
//********************************************************************* 00040000
//*                                                                   * 00050000
//* LICENSED MATERIALS - PROPERTY OF IBM                              * 00060000
//*                                                                   * 00070000
//* 5688-235 (C) COPYRIGHT IBM CORP. 1964, 1995                       * 00080000
//* ALL RIGHTS RESERVED                                               * 00090000
//* US GOVERNMENT USERS RESTRICTED RIGHTS - USE,                      * 00100000
//* DUPLICATION OR DISCLOSURE RESTRICTED BY GSA                       * 00110000
//* ADP SCHEDULE CONTRACT WITH IBM CORP.                              * 00120000
//*                                                                   * 00130000
//* SEE COPYRIGHT INSTRUCTIONS                                        * 00140000
//*                                                                   * 00150000
//********************************************************************* 00160000
//*                                                                     00170000
//* IBM PL/I FOR MVS & VM                                               00180000
//*                                                                     00190000
//*  COMPILE, LOAD AND RUN A PL/I PROGRAM                               00200000
//*                                                                     00210000
//*  RELEASE LEVEL: 01.01.01  (VERSION.RELEASE.MODIFICATION LEVEL)      00220000
//*                                                                     00230000
//*  PARAMETER  DEFAULT VALUE    USAGE                                  00240000
//*   LNGPRFX   IEL.V1R1M1       PREFIX FOR LANGUAGE DATA SET NAMES     00250000
//*   LIBPRFX   CEE.V1R4M0       PREFIX FOR LIBRARY DATA SET NAMES      00260000
//*   SYSLBLK   3200             BLKSIZE FOR OBJECT DATA SET            00270000
//*   GOPGM     GO               MEMBER NAME FOR LOAD MODULE            00280000
//*                                                                     00290000
//PLI      EXEC PGM=IEL1AA,PARM='OBJECT,NODECK',REGION=512K             00300000
//STEPLIB  DD  DSN=&LNGPRFX..SIELCOMP,DISP=SHR                          00310000
//         DD  DSN=&LIBPRFX..SCEERUN,DISP=SHR                           00320000
//SYSPRINT DD  SYSOUT=*                                                 00330000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,                00340000
//             SPACE=(80,(250,100)),DCB=(BLKSIZE=&SYSLBLK)              00350000
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,                                 00360000
//             SPACE=(1024,(200,50),,CONTIG,ROUND),DCB=BLKSIZE=1024     00370000
//GO       EXEC PGM=LOADER,PARM='MAP,PRINT',COND=(9,LT,PLI),            00380000
//             REGION=2048K                                             00390000
//STEPLIB  DD  DSN=&LIBPRFX..SCEERUN,DISP=SHR                           00400000
//SYSLIB   DD  DSN=&LIBPRFX..SCEELKED,DISP=SHR                          00410000
//SYSPRINT DD  SYSOUT=*                                                 00420000
//SYSLIN   DD  DSN=&&LOADSET,DISP=(OLD,DELETE)                          00430000
//SYSLOUT  DD  SYSOUT=*                                                 00440000
//CEEDUMP  DD  SYSOUT=*                                                 00450000
//SYSUDUMP DD  SYSOUT=*                                                 00460000
```

Figure 10. Cataloged Procedure IEL1CG

For more information on other cataloged procedures, see the *Language Environment for MVS & VM Programming Guide*.

Invoking a Cataloged Procedure

To invoke a cataloged procedure, specify its name in the PROC parameter of an EXEC statement. For example, to use the cataloged procedure IEL1C, you could include the following statement in the appropriate position among your other job control statements in the input stream:

```
//stepname EXEC PROC=IEL1C
```

You do not need to code the keyword PROC. If the first operand in the EXEC statement does not begin PGM= or PROC=, the job scheduler interprets it as the name of a cataloged procedure. The following statement is equivalent to that given above:

```
//stepname EXEC IEL1C
```

If you include the parameter MSGLEVEL=1 in your JOB statement, the operating system will include the original EXEC statement in its listing, and will add the statements from the cataloged procedure. In the listing, cataloged procedure statements are identified by XX or X/ as the first two characters; X/ signifies a statement that was modified for the current invocation of the cataloged procedure.

You might be required to modify the statements of a cataloged procedure for the duration of the job step in which it is invoked, either by adding DD statements or by overriding one or more parameters in the EXEC or DD statements. For example, cataloged procedures that invoke the compiler require the addition of a DD statement with the name SYSIN to define the data set containing the source statements. Also, whenever you use more than one standard link-edit procedure step in a job, you must modify all but the first cataloged procedure that you invoke if you want to run more than one of the load modules.

Specifying Multiple Invocations

You can invoke different cataloged procedures, or invoke the same cataloged procedure several times, in the same job. No special problems are likely to arise unless more than one of these cataloged procedures involves a link-edit procedure step, in which case you must take the following precautions to ensure that all your load modules can be run.

When the linkage editor creates a load module, it places the load module in the standard data set defined by the DD statement with the name SYSLMOD. In the absence of a linkage editor NAME statement (or the NAME compile-time option), it uses the member name specified in the DSNAME parameter as the name of the module. In the standard cataloged procedures, the DD statement with the name SYSLMOD always specifies a temporary library &&GOSET with the member name GO.

If you use the cataloged procedure IEL1CLG twice within the same job to compile, link-edit, and run two PL/I programs, and do not name each of the two load modules that the linkage editor creates, the first load module runs twice, and the second one not at all.

To prevent this, use one of the following methods:

- Delete the library &&GOSET at the end of the GO step. In the first invocation of the cataloged procedure at the end of the GO step, add a DD statement with the syntax:

  ```
  //GO.SYSLMOD DD DSN=&&GOSET,
  //   DISP=(OLD,DELETE)
  ```

- Modify the DD statement with the name SYSLMOD in the second and subsequent invocations of the cataloged procedure so as to vary the names of the load modules.
  For example:

  ```
  //LKED.SYSLMOD DD DSN=&&GOSET(GO1)
  ```

  and so on.

- Use the NAME compile-time option to give a different name to each load module and change each job step EXEC statement to specify the running of the load module with the name for that job step.

- Use the NAME linkage editor option to give a different name to each load module and change each job step EXEC statement to specify the running of the load module with the name for that job step.

Note: To assign a membername to the load module, you can use either the compile-time or linkage editor NAME option with the DSNAME parameter on the SYSLMOD DD statement. When you use this procedure, the membername *must* be identical to the name on the NAME option if the EXEC statement that runs the program refers to the SYSLMOD DD statement for the name of the module to be run.

Another option is to give each program a different name by using GOPGM on the EXEC procedure statement. For example:

```
//  EXEC IEL1CLG,GOPGM=GO2
```

Link-Editing Multitasking Programs

When you use a cataloged procedure to link-edit a multitasking program, the load module must include the multitasking versions of the PL/I library subroutines.

To ensure that the multitasking library (SYS1.SIBMTASK) is searched before the base library, include the parameter LKLBDSN='SYS1.SIBMTASK' in the EXEC statement that invokes the cataloged procedure.

For example:

```
//STEPA EXEC IEL1CLG,LKLBDSN='SYS1.PLITASK'
```

In the standard cataloged procedures the DD statement SYSLIB is always followed by another, unnamed, DD statement that includes the parameter DSNAME=SYS1.SCEELKED. The effect of this statement is to concatenate the base library with the multitasking library. When LKLBDSN=SYS1.SIBMBASE is specified, the second DD statement has no effect.

Modifying the PL/I Cataloged Procedures

You can modify a cataloged procedure temporarily by including parameters in the EXEC statement that invokes the cataloged procedure, or by placing additional DD statements after the EXEC statement. Temporary modifications apply only for the duration of the job step in which the procedure is invoked. They do not affect the master copy of the cataloged procedure in the procedure library.

Temporary modifications can apply to EXEC or DD statements in a cataloged procedure. To change a parameter of an EXEC statement, you must include a corresponding parameter in the EXEC statement that invokes the cataloged procedure. To change one or more parameters of a DD statement, you must include a corresponding DD statement after the EXEC statement that invokes the cataloged procedure. Although you cannot add a new EXEC statement to a cataloged procedure, you can always include additional DD statements.

EXEC Statement

If a parameter of an EXEC statement that invokes a cataloged procedure has an unqualified name, the parameter applies to all the EXEC statements in the cataloged procedure. The effect on the cataloged procedure depends on the parameters, as follows:

- PARM applies to the first procedure step and nullifies any other PARM parameters.
- COND and ACCT apply to all the procedure steps.
- TIME and REGION apply to all the procedure steps and override existing values.

For example, the statement:

```
//stepname EXEC IEL1CLG,PARM='SIZE(MAX)',REGION=512K
```

- Invokes the cataloged procedure IEL1CLG.
- Substitutes the option SIZE(MAX) for OBJECT and NODECK in the EXEC statement for procedure step PLI.
- Nullifies the PARM parameter in the EXEC statement for procedure step LKED.
- Specifies a region size of 512K for all three procedure steps.

To change the value of a parameter in only one EXEC statement of a cataloged procedure, or to add a new parameter to one EXEC statement, you must identify the EXEC statement by qualifying the name of the parameter with the name of the procedure step. For example, to alter the region size for procedure step PLI only in the preceding example, code:

```
//stepname EXEC PROC=IEL1CLG,PARM='SIZE(MAX)',REGION.PLI=512K
```

A new parameter specified in the invoking EXEC statement overrides completely the corresponding parameter in the procedure EXEC statement.

You can nullify all the options specified by a parameter by coding the keyword and equal sign without a value. For example, to suppress the bulk of the linkage editor listing when invoking the cataloged procedure IEL1CLG, code:

```
//stepname EXEC IEL1CLG,PARM.LKED=
```

DD Statement

To add a DD statement to a cataloged procedure, or to modify one or more parameters of an existing DD statement, you must include a DD statement with the form “procstepname.ddname” in the appropriate position in the input stream. If “ddname” is the name of a DD statement already present in the procedure step identified by “procstepname,” the parameters in the new DD statement override the corresponding parameters in the existing DD statement; otherwise, the new DD statement is added to the procedure step. For example, the statement:

```
//PLI.SYSIN DD *
```

adds a DD statement to the procedure step PLI of cataloged procedure IEL1C and the effect of the statement:

```
//PLI.SYSPRINT DD SYSOUT=C
```

is to modify the existing DD statement SYSPRINT (causing the compiler listing to be transmitted to the system output device of class C).

Overriding DD statements must appear after the procedure invocation and in the same order as they appear in the cataloged procedure. Additional DD statements can appear after the overriding DD statements are specified for that step.

To override a parameter of a DD statement, code either a revised form of the parameter or a replacement parameter that performs a similar function (for example, SPLIT for SPACE). To nullify a parameter, code the keyword and equal sign without a value. You can override DCB subparameters by coding only those you wish to modify; that is, the DCB parameter in an overriding DD statement does not necessarily override the entire DCB parameter of the corresponding statement in the cataloged procedures.

Chapter 3. Compiling under MVS

This chapter describes how to invoke the compiler under TSO and the job control statements used for compiling under MVS. You must be linked to Language Environment before you can compile your program.

Invoking the Compiler under TSO

The usual method of invoking the compiler is with the PLI command. In its simplest form the command consists of the keyword and the name of the TSO data set holding the PL/I source program. For example:

```
PLI CALTROP
```

In addition to the data set name, you can specify the PRINT operand to control the compiler listings, and the LIB operand to specify secondary input data sets for the %INCLUDE statements. You can also specify compile-time options as operands of the PLI command.

The command processor for the PLI command is a program known as the *PL/I prompter*. When you enter the command, this program checks the operands and allocates the data sets required by the compiler. Then, it passes control to the compiler and displays a message.

If the source data set has a conventional TSO data set name, you can use the simple name, as in the example above. If not, you need to specify the full name and enclose it in single quotation marks:

```
PLI 'DIANTHUS'
```

or

```
PLI 'JJONES.ERICA.PLI'
```

The compiler translates the source program into object modules, which it stores on external data sets. You can link-edit and run these object modules conversationally.

If you use an unqualified data set name, as in the example at the start of this section, the system generates a name for the object module data set. It takes the simple name of the source data set—CALTROP in the example—and adds your user-identification and the descriptive qualifier OBJ. Hence, if the user who entered the example PLI command had the identification WSMITH, the object module would be written onto a data set called WSMITH.CALTROP.OBJ.

You can make your own choice of name for the object module data set by including the OBJECT compile-time option as an operand of the PLI command. For example:

```
PLI CALTROP OBJECT(TRAPA)
```

The system adds the same qualifiers to this name as it does to the source data set simple name, so the object module is written onto a data set, in this example, called `WSMITH.TRAPA.OBJ`.

You can specify the full name of the object module data set by enclosing it in quotation marks. For example:

```
PLI CALTROP OBJECT('NATANS')
```

The system in this case adds no qualifiers, so the object module is stored on a data set called NATANS.

You can specify a full name to store the object module with another user's user-identification. For instance, the following command would store the object module using the user-identification JJONES:

```
PLI CALTROP OBJECT('JJONES.CALTROP.OBJ')
```

An alternative to the PLI command is the RUN command or subcommand.

Allocating Data Sets

The compiler requires the use of a number of data sets in order to process a PL/I program. These are listed in Table 10 on page 58. The following data sets are always required by the compiler:

- The data set holding the PL/I program
- A data set for the compiler listing.

Up to six data sets, including the above two, can be required, depending on which compile-time options have been specified.

These data sets must be allocated before the compiler can use them. If you use the PLI command or the RUN command or subcommand, you invoke the compiler via the prompter, and the prompter allocates the necessary data sets. If you invoke the compiler without the prompter, you must allocate the necessary data sets yourself.

When the prompter allocates compiler data sets, it uses ddnames generated by TSO rather than the ddnames that are used in batch mode. Table 10 on page 58 includes the batch-mode ddnames of the data sets. If the compiler is invoked via the prompter, you cannot refer to the data sets by these names. To control the allocation of compiler data sets, you need to use the appropriate operand of the PLI command. For instance, to allocate the standard output file (ddname SYSPRINT in batch mode) to the terminal, you should use the PRINT(*) operand of the PLI command. You cannot make the allocation by using the ALLOCATE command with FILE(SYSPRINT) and DATASET(*) operands. Table 10 on page 58 shows which operands to use for those data sets whose allocation you can control.

When the prompter is not invoked, the batch-mode ddnames are recognized as referring to the compiler data sets.

Table 10. Compiler Data Sets

Data set (and batch-mode ddname)	When required	Where to specify data set in PLI command	Descriptive qualifier	Allocated by	Parameters used by prompter[1] SPACE=[2]	Parameters used by prompter[1] DISP=[3]
Primary input (SYSCIN or SYSIN)	Always	1st operand	PLI	Prompter	—[4]	SHR
Temporary work data set (SYSUT1)	When large program spills internal text pages	Cannot specify	—	Prompter	(1024,(60,60))	(NEW,DELETE)
Compiler listing (SYSPRINT)	Always	Argument of PRINT operand	LIST	Prompter	(629,(n,m))	(OLD,KEEP) or[5] (NEW,CATLG)
Object module (SYSLIN)	When OBJECT option applies	1st argument of OBJECT operand	OBJ	Prompter, when required[6]	(400,(50,50))	(OLD,KEEP) or (NEW,CATLG)
Object module or preprocessor output in card format (SYSPUNCH)	When either DECK or MACRO and MDECK options apply	Argument of MDECK DECK operand	DECK or MACRO and MDECK	Prompter, when required[6]	(400,(50,50))	(OLD,KEEP) or (NEW,CATLG)
Secondary input to preprocessor (SYSLIB)[7]	When &INCLUDE files are used	Arguments of LIB operand	INCLUDE or MACRO	Prompter, when required	—[7]	SHR

Notes:

1. Unit is determined by entry in User Attribute Data Set.
2. These space allocations apply only if the data set is new. The first argument of the SPACE parameter establishes the block size. For the SYSUT1, SYSPRINT, SYSLIN, and SYSPUNCH data sets, the record format, record length, and number of buffers are established by the compiler when it opens the data sets.
3. The prompter first tries to allocate the SYSPRINT, SYSLIN, and SYSPUNCH data sets with DISP=(OLD,KEEP). This will cause any existing data set (or partitioned data set member) with the same name to be replaced with the new one. If the data set name cannot be found in the system catalog, the data set is allocated with DISP=(NEW,CATLG).
4. The data set already exists; therefore, SPACE (and also UNI T) are already established.
5. DISP parameter used only if PRINT(dsname) operand applies. Otherwise, prompter supplies the following parameters:

   TERM=TS if PRINT(*) operand applies
   DUMMY if NOPRINT operand applies
   SYSOUT if SYSPRINT operand applies.
6. Except when the associated option has been specified by means of a %PROCESS statement. In this case, the data set(s) must be allocated by the user.
7. If any ddnames are specified in %INCLUDE statements, allocate the data sets with the ALLOCATE statement.

Using the PLI Command

Use the PLI command to compile a PL/I program. The command invokes the PL/I prompter to process the operands and call the compiler, according to the syntax shown in the following table:

Table 11. Syntax of the PLI Command

COMMAND	OPERANDS

PLI	data-set-name
	[option-list]
	   PRINT[(*)│
	         (dsname[,[n][,m]])]
	   SYSPRINT[(sysout-class[,[n][,m]])]
	   NOPRINT
	[LIB(dslist)]

data-set-name

specifies the name of the primary input data set for the compiler. This can be either a fully qualified name (enclosed in single quotation marks) or a simple name (for which the prompter adds the identification qualifier, and the descriptive qualifier PLI). This must be the first operand specified.

option-list specifies one or more compile-time options that apply for this compilation.

The compile-time options that you can specify in a TSO environment are described later in this section. Programmers familiar with batch processing should note that defaults are altered for TSO, and that the DECK, MDECK, and OBJECT options are extended to allow specific names of data sets onto which the output is written.

Separate the options by at least one blank or one comma; you can add any number of extra blanks. The order of the options is unimportant. In fact, the PRINT/NOPRINT and LIB operands can be interspersed in the option-list since they are recognized by their keywords. If two contradictory options are specified, the last is accepted and the first ignored.

Options specified in the PLI command can be overridden by options specified on the %PROCESS compiler control statements in the primary input. If the DECK, MDECK, and OBJECT options are required for any program in a batched compilation, the option should be specified in the PLI command so that the prompter allocates the required data sets. The negative forms can then be used on the %PROCESS statements for the programs that do not require the option. The options are described below.

DECK[(dsname)]: This can be a fully qualified name (enclosed in single quotation marks) or a simple name (to which the user identification and descriptive qualifier DECK is added). If *dsname* is not specified, the user-supplied name is taken from the first operand of the PLI command, and the user-identification and descriptive qualifier DECK is added. If *dsname* is not specified and the first operand of the PL/I command specifies a member of a partitioned data set, the member name is ignored—the generated data set name is based on the name of the partitioned data set. For more information on this option see DECK on page 10.

MDECK[(dsname)]: This can be a fully qualified name (enclosed in single quotation marks) or a simple name (to which the user identification and descriptive qualifier MDECK is added). If *dsname* is not specified, the user-supplied name is taken from the first operand of the PLI command, and the user-identification and descriptive qualifier MDECK are added. If *dsname* is not specified and the first operand of the PL/I command specifies a member of a partitioned data set, the member name is ignored—the generated data set name is based on the name of the partitioned data set. For more information on this option, see MDECK on page 17.

OBJECT [(dsname)]: This can be a fully qualified name (enclosed in single quotation marks) or a simple name (to which the user identification and the descriptive qualifier OBJ is added). If *dsname* is not specified, the user-supplied name is taken from the first operand of the PLI command, and the user-identification and descriptive qualifier OBJ are added. If *dsname* is not specified and the first operand of the PL/I command specifies a member of a partitioned data set, the member name is ignored—the generated data set name is based on the name of the partitioned data set. For more information on this option, see OBJECT on page 19.

PRINT(*) specifies that the compiler listing, on the SYSPRINT file, is written at the terminal; no other copy will be available. The PRINT(*) operand is implemented by generating a TERMINAL option with a list of options which correspond to the listings printed at the terminal. If you specify the TERMINAL option after the PRINT(*) operand, this overrides the TERMINAL option generated by the PRINT(*) operand.

PRINT(dsname[,[n][,m]])
specifies that the compiler listing, on the SYSPRINT file, is written on the data set named in parentheses. This can be either a fully qualified name (enclosed in single quotation marks) or a simple name (for which the prompter adds the identification qualifier, and the description qualifier LIST).

If you do not specify a dsname argument for the PRINT operand, the prompter adds the identification and descriptive qualifiers to the data set name specified in the first operand, producing a data set name of the form:

```
user-identification.user-supplied-name.LIST
```

If *dsname* is not specified and the first operand of PLI specifies a member of a partitioned data set, the member name is ignored—the generated data set name is based on the name of the partitioned data set.

In this command, *n* and *m* specify the space allocation in lines for the listing data set. They should be used when the size of the listing has caused a B37 abend during compilation.

n specifies the number of lines in the primary allocation.

m specifies the number of lines in the secondary allocation.

If *n* is omitted, the preceding comma must be included. For example, to enter only the size of the secondary allocation and accept the default for the primary, you would enter:

```
PRINT(printds,,500)
```

The space allocation used if *n* and *m* are not specified is the allocation specified during compiler installation.

SYSPRINT [(sysout-class[,[n][,m]])]
specifies that the compiler listing, on the SYSPRINT file, is to be written to the sysout class named in parentheses. If no class is specified, the output is written to a default sysout class. The IBM-supplied standard for this default is class A. For an explanation of the *n* and *m* see the “PRINT” operand above.

NOPRINT specifies that the compiler listing is not produced on the SYSPRINT file. You can still get most of the listing written at the terminal by using the TERMINAL compile-time option.

LIB(dslist) specifies one or more data sets that are used as the secondary input to the preprocessor. These data sets are concatenated in the order specified and then associated with the ddname in the %INCLUDE statement in the PL/I program. You must allocate the data sets associated with that ddname yourself.

The data set names can be either fully qualified (each enclosed in single quotation marks) or simple names (for which the prompter adds the identification qualifier, but no descriptive qualifier).

Separate the data set names by at least one blank or one comma; you can add any number of extra blanks.

If you use the LIB operand, either the INCLUDE or the MACRO compile-time option must also apply.

The following examples give an operation to be performed and the known variables, and show you how to enter the command to perform that particular function.

Example 1

```
Operation:  Invoke the compiler to process a PL/I program.

    Known:  – User-identification is ABC.

            – Data set containing the program is named
              ABC.UPDATE.PLI.

            – SYSPRINT file is to be directed to the terminal.

            – Default options and data set names are to be used.

  Command:  PLI UPDATE PRINT(*)
```

Example 2

```
Operation:  Invoke the compiler to process a PL/I program.

    Known:  – User-identification is XYZ.

            – Data set containing the program is named
              ABC.MATRIX.PLI.

            – SYSPRINT file is to be written on a data set named
              MATLIST.

            – MACRO and MDECK options are required, with the
              associated output to be written on a data set named
              MATCARD.

            – Secondary input to preprocessor to be read from
              a library named XYZ.SOURCE.

            – Otherwise default options and data set names
              are to be used.
  Command:  PLI 'ABC.MATRIX.PLI' +
             PRINT('MATLIST'),MACRO,MDECK('MATCARD'), +
                 LIB(SOURCE)
```

Compiler Listings

In conversational mode, as in batch mode, compile-time options control which listings the compiler produces (see Chapter 1, “Using Compile-Time Options and Facilities” on page 5). You can specify the options as operands of the PLI command.

In addition to specifying which listings are to be produced, you need to indicate where they are to be transmitted. If you wish to have them displayed at the terminal, you can specify either the PRINT(*) operand, which allocates the compiler listing file to the terminal, or the TERMINAL option. The latter should contain a list of the options corresponding to the listings you require at the terminal. For instance, to produce a source listing at the terminal, you could enter either:

```
PLI CALTROP PRINT(*) SOURCE
```

or:

```
PLI CALTROP TERM(SOURCE)
```

Compiler listings can be directed to a data set by specifying the PRINT operand with the data set's name, or to a SYSOUT class by specifying the SYSPRINT operand. For further details see “Using the Compiler Listing” on page 33 and “Listing (SYSPRINT)” on page 67.

Using %INCLUDE under TSO

In conversational mode, as in batch mode, you can incorporate PL/I source code into your program by means of the %INCLUDE statement. This statement names members of partitioned data sets that hold the code to be included. You can create these secondary input data sets either under TSO or in batch mode.

To use %INCLUDE you must specify the MACRO or INCLUDE compile-time option.

The %INCLUDE statement can specify simply the name of the data set member that holds the text to be included. For instance:

```
%INCLUDE RECDCL;
```

It can also specify a ddname that is associated with the member. For example:

```
%INCLUDE STDCL (F726);
```

STDCL is the ddname, and F726 is the member name. A single %INCLUDE statement can specify several data set members, and can contain both forms of specification. For example:

```
%INCLUDE SUBA(READ5),SUBC(REPORT1),DATEFUNC;
```

Allocating Data Sets in %INCLUDE

All data sets containing secondary input must be allocated before the compiler is invoked. If a data set member is specified in an %INCLUDE statement without a ddname, the data set can be allocated by specifying the data set name in the LIB operand of the PLI command. (This operand is the equivalent of the batch-mode SYSLIB DD statement.) The necessary allocation is made by the PL/I prompter.

If a ddname has been specified in the %INCLUDE statement, the corresponding data set must be allocated by means of either an ALLOCATE command or the logon procedure.

Suppose the data set members specified in the %INCLUDE statements in the preceding section are held on data sets as follows (the ddname used in the %INCLUDE statement is also shown):

Member:	Data Set Name:	DDNAME:
RECDCL	LDSRCE	none
F726	WPSRCE	STDCL
READ5	JESRCE	SUBA
REPORT	GHSRCE	SUBC
DATEFUNC	DRSRCE	none

Then the necessary data sets could be allocated by the following commands:

```
ALLOCATE FILE(STDCL) DATASET(WPSRCE)
ALLOCATE FILE(SUBA) DATASET(JESRCE)
ALLOCATE FILE(SUBC) DATASET(GHSRCE)
PLI MNTHCOST LIB(LDSRCE,DRSRCE) INCLUDE
```

Running Jobs in a Background Region

If you have the necessary authorization, you can submit jobs for processing in a background region. Your installation must record the authorization in your UADS (User Attribute Data Set) entry.

Jobs are submitted by means of the SUBMIT command. The command must include the name of the data set holding the job or jobs to be processed, and the data set must contain the necessary Job Control Language statements. Jobs will run under the same version of the operating system as is used for TSO. Output from the jobs can be manipulated from your terminal.

Further details about submitting background jobs are given in the manual *TSO Terminal User's Guide*.

Using JCL during Compilation

Although you will probably use cataloged procedures rather than supply all the job control required for a job step that invokes the compiler, you should be familiar with these statements so that you can make the best use of the compiler and, if necessary, override the statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a compilation procedure step are:

IEL1C	Compile only
IEL1CL	Compile and link-edit
IEL1CLG	Compile, link-edit, and run
IEL1CG	Compile, load and run

The following paragraphs describe the job control statements needed for compilation. The IBM-supplied cataloged procedures described in “IBM-Supplied Cataloged Procedures” on page 46 contain these statements. Therefore, you need to code them yourself only if you are not using the cataloged procedures.

EXEC Statement

The basic EXEC statement is:

```
//stepname EXEC PGM=IEL1AA
```

512K is required for the REGION parameter of this statement. The PARM parameter of the EXEC statement can be used to specify one or more of the optional facilities provided by the compiler. These facilities are described under “Specifying Options in the EXEC Statement” on page 68. See Chapter 1, “Using Compile-Time Options and Facilities” on page 5 for a description of the options.

DD Statements for the Standard Data Sets

The compiler requires several standard data sets, the number of data sets depends on the optional facilities specified. You must define these data sets in DD statements with the standard ddnames which are shown, together with other characteristics of the data sets, in Table 12 on page 65. The DD statements SYSIN, SYSUT1, and SYSPRINT are always required.

You can store any of the standard data sets on a direct-access device, but you must include the SPACE parameter in the DD statement. This parameter defines the data set to specify the amount of auxiliary storage required. The amount of auxiliary storage allocated in the IBM-supplied cataloged procedures should suffice for most applications.

Table 12. Compiler Standard Data Sets

Standard DDNAME	Contents of data set	Possible device classes[1]	Record format (RECFM)[2]	Record size (LRECL)[3]	BLKSIZE
SYSIN (or SYSCIN)[4]	Input to the compiler	SYSSQ	F,FB,*U* VB,V	<101(100) <105(104)	—
SYSLIN	Object module	SYSSQ	FB	80	80
SYSPUNCH	Preprocessor output, compiler output	SYSSQ SYSCP	FB	80	80
SYSUT1	Temporary workfile	SYSDA	*F*	4051	—
SYSPRINT	Listing, including messages	SYSSQ	*VBA*	125	129
SYSLIB	Source statements for preprocessor	SYSDA	*F*,FB,U V,VB	<101 <105	—

Notes:

The only value for compile-time SYSPRINT that can be overridden is BLKSIZE.

1. The possible device classes are:

SYSSQ	Sequential device
SYSDA	Direct-access device
SYSCP	Card-punch device.

   Block size can be specified except for SYSUT1. The block size and logical record length for SYSUT1 is chosen by the compiler.

2. If the record format is not specified in a DD statement, the default value is provided by the compiler. (Default values are shown in italics.)
3. The numbers in parentheses in the “Record Size” column are the defaults, which you can override.
4. The compiler will attempt to obtain source input from SYSCIN if a DD statement for this data set is provided. Otherwise it will obtain its input from SYSIN.

Input (SYSIN or SYSCIN)

Input to the compiler must be a data set defined by a DD statement with the name SYSIN or SYSCIN. This data set must have CONSECUTIVE organization. The input must be one or more external PL/I procedures. If you want to compile more than one external procedure in a single job or job step, precede each procedure, except possibly the first, with a %PROCESS statement. For further detail, see “Compiling Multiple Procedures in a Single Job Step” on page 69.

80-byte records are commonly used as the input medium for PL/I source programs. The input data set can be on a direct-access device, magnetic tape, or some other sequential media. The input data set can contain either fixed-length records (blocked or unblocked), variable-length records (coded or uncoded), or undefined-length records. The maximum record size is 100 bytes.

When data sets are concatenated for input to the compiler, the concatenated data sets must have similar characteristics (for example, block size and record format).

Output (SYSLIN, SYSPUNCH)

Output in the form of one or more object modules from the compiler can be stored in either of two data sets. You can store it in the data set SYSLIN (if you specify the OBJECT compile-time option) or in the data set SYSPUNCH (if you specify the DECK compile-time option). Both of these data sets are defined by the DD statement. You can specify both the OBJECT and DECK options in one program, if the output will be stored in both data sets.

The object module is always in the form of 80-byte fixed-length records, blocked or unblocked. The data set defined by the DD statement with the name SYSPUNCH is also used to store the output from the preprocessor if you specify the MDECK compile-time option.

Temporary Workfile (SYSUT1)

The compiler requires a data set for use as a temporary workfile. It is defined by a DD statement with the name SYSUT1, and is known as the *spill file*. It must be on a direct-access device, and must not be allocated as a multi-volume data set.

The spill file is used as a logical extension to main storage and is used by the compiler and by the preprocessor to contain text and dictionary information. The LRECL and BLKSIZE for SYSUT1 is chosen by the compiler based on the amount of storage available for spill file pages.

The DD statements given in this publication and in the cataloged procedures for SYSUT1 request a space allocation in blocks of 1024 bytes. This is to insure that adequate secondary allocations of direct-access storage space are acquired.

Statement Lengths

The compiler has a restriction that any statement must fit into the compiler's work area. The maximum size of this work area varies with the amount of space available to the compiler. The maximum length of a statement is 3400 characters.

The DECLARE statement is an exception in that it can be regarded as a sequence of separate statements, each of which starts wherever a comma occurs that is not contained within parentheses. For example:

```
DCL 1 A,
    2 B(10,10) INIT(1,2,3,...),
    2 C(10,100) INIT((1000)(0)),
    (D,E) CHAR(20) VAR,...
```

In this example, each line can be treated by the compiler as a separate DECLARE statement in order to accommodate it in the work area. The compiler will also treat the INITIAL attribute in the same way when it is followed by a list of items separated by commas that are not contained within parentheses. Each item can contain initial values that, when expanded, do not exceed the maximum length. The above also applies to the use of the INITIAL attribute in a DEFAULT statement.

If a DECLARE statement cannot be compiled, the following techniques are suggested to overcome this problem:

- Simplify the DECLARE statement so that the compiler can treat the statement in the manner described above.

- Modify any lists of items following the INITIAL attribute so that individual items are smaller and separated by commas not contained in parentheses. For example, the following declaration is followed by an expanded form of the same declaration. The compiler can more readily accommodate the second declaration in its work area:

```
1.  DCL Y (1000) CHAR(8)
    INIT ((1000) (8)'Y');
2.  DCL Y (1000) CHAR(8) INIT
    ((250)(8)'Y',(250)(8)'Y',
    (250)(8)'Y',(250)(8)'Y');
```

Listing (SYSPRINT)

The compiler generates a listing that includes all the source statements that it processed, information relating to the object module, and, when necessary, messages. Most of the information included in the listing is optional, and you can specify those parts that you require by including the appropriate compile-time options. The information that can appear, and the associated compile-time options, are described under “Using the Compiler Listing” on page 33.

You must define the data set, in which you wish the compiler to store its listing, in a DD statement with the name SYSPRINT. This data set must have CONSECUTIVE organization. Although the listing is usually printed, it can be stored on any sequential or direct-access device. For printed output, the following statement will suffice if your installation follows the convention that output class A refers to a printer:

```
//SYSPRINT DD SYSOUT=A
```

The compiler always reserves 258 bytes of main storage (129 bytes each) for two buffers for this data set. However, you can specify a block size of more than 129 bytes, provided that sufficient main storage is available to the compiler. (For further details of the SIZE compile-time option, see SIZE on page 22.)

Source Statement Library (SYSLIB)

If you use the preprocessor %INCLUDE statement to introduce source statements into the PL/I program from a library, you can either define the library in a DD statement with the name SYSLIB, or you can choose your own ddname (or ddnames) and specify a ddname in each %INCLUDE statement. (For further information on the preprocessor, see “Using the Preprocessor” on page 29.)

If the statements are included from a SYSLIB, they must have a form that is similar to the %INCLUDE statement. For example, they must have the same record format (fixed, variable, undefined), the same logical record length, and matching left and right margins.

The BLOCKSIZE of the library must be less than or equal to 32,760 bytes.

Example of Compiler JCL

A typical sequence of job control statements for compiling a PL/I program is shown in Figure 11 on page 68. The DECK and NOOBJECT compile-time options, described below, have been specified to obtain an object module as a card deck only.

```
//OPT4#4 JOB
//STEP     EXEC  PGM=IEL1AA,PARM='DECK,NOOBJECT'
//STEPLIB DD DSN=IEL.V1R1M1.SIELCOMP,DISP=SHR
//       DD DSN=CEE.V1R2M0.SCEERUN,DISP=SHR
//SYSPUNCH DD SYSOUT=B
//SYSUT1 DD UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG)
//SYSPRINT DD SYSOUT=A
//SYSIN DD *
/*
```

Figure 11. Job Control Statements for Compiling a PL/I Program Not Using Cataloged Procedures

Specifying Options

For each compilation, the IBM-supplied or installation default for a compile-time option applies unless it is overridden by specifying the option in a %PROCESS statement or in the PARM parameter of an EXEC statement.

An option specified in the PARM parameter overrides the default value, and an option specified in a %PROCESS statement overrides both that specified in the PARM parameter and the default value.

Note: When conflicting attributes are specified either explicitly or implicitly by the specification of other options, the latest implied or explicit option is accepted. No diagnostic message is issued to indicate that any options are overridden in this way.

Specifying Options in the EXEC Statement

To specify options in the EXEC statement, code PARM= followed by the list of options, in any order (except that CONTROL, if used, must be first) separating the options with commas and enclosing the list within single quotation marks, for example:

```
//STEP1 EXEC PGM=IEL1AA,PARM='OBJECT,LIST'
```

Any option that has quotation marks, for example MARGINI('c'), must have the quotation marks duplicated. The length of the option list must not exceed 100 characters, including the separating commas. However, many of the options have an abbreviated syntax that you can use to save space. If you need to continue the statement onto another line, you must enclose the list of options in parentheses (instead of in quotation marks) enclose the options list on each line in quotation marks, and ensure that the last comma on each line except the last line is outside of the quotation marks. An example covering all the above points is as follows:

```
//STEP1 EXEC PGM=IEL1AA,PARM=('AG,A',
//       'C,ESD,F(I)',
// 'M,MI(''X''),NEST,STG,X')
```

If you are using a cataloged procedure, and want to specify options explicitly, you must include the PARM parameter in the EXEC statement that invokes it, qualifying the keyword PARM with the name of the procedure step that invokes the compiler. For example:

```
//STEP1 EXEC IEL1CLG,PARM.PLI='A,LIST,ESD'
```

Compiling Multiple Procedures in a Single Job Step

Batched compilation allows the compiler to compile more than one external PL/I procedure in a single job step. The compiler creates an object module for each external procedure and stores it sequentially either in the data set defined by the DD statement with the name SYSPUNCH, or in the data set defined by the DD statement with the name SYSLIN. Batched compilation can increase compiler throughput by reducing operating system and compiler initialization overheads.

To specify batched compilation, include a compiler %PROCESS statement as the first statement of each external procedure except possibly the first. The %PROCESS statements identify the start of each external procedure and allow compile-time options to be specified individually for each compilation. The first procedure might require a %PROCESS statement of its own, because the options in the PARM parameter of the EXEC statement apply to all procedures in the batch, and can conflict with the requirements of subsequent procedures.

Note: The options specified in the %PROCESS statement override those specified in the PARM parameter of the EXEC statement.

The method of coding a %PROCESS statement and the options that can be included are described under “Specifying Options in the %PROCESS or *PROCESS statements” on page 28. The options specified in a %PROCESS statement apply to the compilation of the source statements between that %PROCESS statement and the next %PROCESS statement. Options other than these, either the defaults or those specified in the PARM field, will also apply to the compilation of these source statements. Two options, the SIZE option and the NAME option have a particular significance in batched compilations, and are discussed below.

Note: OBJECT, MDECK, and DECK can cause problems if they are specified on second or subsequent compilations but not on the first. This is because they require the opening of SYSLIN or SYSPUNCH and there might not be room for the associated data management routines and control blocks. When this happens, compilation ends with a storage abend.

SIZE Option

In a batched compilation, the SIZE specified in the first procedure of a batch (by a %PROCESS or EXEC statement, or by default) is used throughout. If SIZE is specified in subsequent procedures of the batch, it is diagnosed and ignored.

NAME Option

The NAME option specifies that the compiler places a linkage editor NAME statement as the last statement of the object module. The use of this option in the PARM parameter of the EXEC statement, or in a %PROCESS statement, determines how the object modules produced by a batched compilation are handled by the linkage editor. When the batch of object modules is link-edited, the linkage editor combines all the object modules between one NAME statement and the preceding NAME statement into a single load module. It takes the name of the load module from the NAME statement that follows the last object module that is included. When combining two object modules into one load module, the NAME option should not be used in the EXEC statement. An example of the use of the NAME option is given in Figure 12 on page 70.

```
//    EXEC IEL1C,PARM.PLI='LIST'
             .
             .
             .
%  PROCESS NAME('A');
   ALPHA: PROC OPTIONS(MAIN);
             .
             .
             .
          END ALPHA;
%  PROCESS;
   BETA: PROC;
             .
             .
             .
         END BETA;
%  PROCESS NAME('B');
   GAMMA: PROC;
             .
             .
             .
          END GAMMA;
```

Figure 12. Use of the NAME Option in Batched Compilation

Compilation of the PL/I procedures ALPHA, BETA, and GAMMA, results in the following object modules and NAME statements:

```
OBJECT MODULE FOR ALPHA
       NAME A (R)
OBJECT MODULE FOR BETA
OBJECT MODULE FOR GAMMA
       NAME B (R)
```

From this sequence of object modules and control statements, the linkage editor produces two load modules, one named A containing the object module for the external PL/I procedure ALPHA, and the other named B containing the object modules for the external PL/I procedures BETA and GAMMA.

Note: You should not specify the option NAME if you intend to process the object modules with the loader. The loader processes all object modules into a single load module. If there is more than one name, the loader recognizes the first one only and ignores the others.

Return Codes in Batched Compilation

The return code generated by a batched compilation is the highest code that is returned if the procedures are compiled separately.

Job Control Language for Batched Processing

The only special consideration relating to JCL for batched processing refers to the data set defined by the DD statement with the name SYSLIN. If you include the option OBJECT, ensure that this DD statement contains the parameter DISP=(MOD,KEEP) or DISP=(MOD,PASS). (The IBM-supplied cataloged procedures specify DISP=(MOD,PASS).) If you do not specify DISP=MOD, successive object modules will overwrite the preceding modules.

Examples of Batched Compilations

If the external procedures are components of a large program and need to be run together, you can link-edit them together and run them in subsequent job steps. Cataloged procedure IEL1CG can be used, as shown in Figure 13.

```
//OPT4#13 JOB
//STEP1 EXEC IEL1CG
//PLI.SYSIN DD *
           First PL/I source program
% PROCESS;
           Second PL/I source program
% PROCESS;
           Third PL/I source program
/*
//GO.SYSIN DD *
           Data processed by combined
           PL/I programs

/*
```

Figure 13. Example of Batched Compilation, Including Execution

If the external procedures are independent programs to be invoked individually from a load module library, cataloged procedure IEL1CL can be used. For example, a job that contains three compile and link-edit operations can be run as a single batched compilation, as shown in Figure 14.

```
//OPT4#14 JOB
//STEP1 EXEC IEL1CL,
// PARM.PLI='NAME(''PROG1'')',
// PARM.LKED=LIST
//PLI.SYSIN DD *
           First PL/I source program
% PROCESS NAME('PROG2');
           Second PL/I source program
% PROCESS NAME('PROG3');
           Third PL/I source program
/*
//LKED.SYSLMOD DD DSN=PUBPGM,
// DISP=OLD
```

Figure 14. Example of Batched Compilation, Excluding Execution

Correcting Compiler-Detected Errors

At compile time, both the preprocessor and the compiler can produce diagnostic messages and listings. For information on correcting errors, see “Correcting Compiler-Detected Errors” on page 78 in Chapter 4, “Compiling under VM.”

The PL/I Compiler and MVS/ESA

Care should be taken when using large region sizes with the SIZE(MAX) compiler option. SIZE(MAX) indicates that the compiler obtains as much main storage in the region as it can. Since the compiler runs below the line, the storage obtained will be below the line. This can cause unpredictable problems as there will not be enough storage left for the system to use.

Compiling for CICS

When coding a CICS transaction in PL/I, prior to compiling your transaction, you must invoke the CICS Command Language Translator. You can find information on the CICS Command Language Translator in the *CICS/ESA Application Programmer's Reference Manual*. After the CICS translator step ends, compile your PL/I program with the SYSTEM(CICS) option. NOEXECOPS is implied with this option. For a description of the SYSTEM compile-time option, see "SYSTEM" on page 24.

Chapter 4. Compiling under VM

This chapter explains how to use the PLIOPT command to compile your program under VM. You must be linked to Language Environment before using PLIOPT, or your program will not compile. Language Environment must always be present when the PL/I compiler is active. The information in the chapter includes where the compiler stores its output, the types of files the compiler uses, and how to use the compile-time options. There is also information on special cases. The chapter describes how to include previously written PL/I statements with your program, compile your program to be run under MVS, and how to have your output placed in a TXTLIB. At the end of the chapter there are examples of PL/I batched compilation and information on compiler-detected errors.

To compile a program under VM, use the PLIOPT command followed by the name of the file that contains the source program. If the file type is not PLIOPT or PLI, you must specify the file type. If the file is not on the A disk, you must also specify the filemode naming the disk where the file is stored.

"PLIOPT Command Format" on page 76 shows the syntax for the PLIOPT command. If you want to specify any compile-time or PLIOPT options, these must follow the file name, file type, or file mode, whichever is the last you specified. You must put a left parenthesis before these options. Options are separated from each other by blanks, and you should use the abbreviated form of options.

During compilation, two new disk files are produced with the file types TEXT and LISTING and the same file name as the file specified in the PLIOPT command. The TEXT file contains the object code. The LISTING file contains the listings produced during compilation. Any error messages produced are transmitted to your terminal and contained in your listing.

If compilation reveals source program errors, you can alter the PLIOPT file that contains the source by use of the VM editor. You can then reissue the PLIOPT command. This results in the creation of new TEXT and LISTING files corresponding to the newly edited source programs. If previous versions were available they are overwritten. When you have a satisfactory compilation, you can run the program, which is now in the form of a TEXT file.

Using the PLIOPT Command

Invoke the compiler by issuing the PLIOPT command. The compiler creates two output files. One file contains the object code, and the other file contains the listing. Refer to Table 3 on page 5 for a listing of compile-time options and their IBM-supplied defaults.

Compiler Output and Its Destination

The compiler creates two new files and places them on VM disks by default. These files have the same file name as the file that contains the source type TEXT and the listing has the file type LISTING. Thus, if you compiled a PLIOPT file called ROBIN you would, by default, create two more files called ROBIN TEXT which contains the object code and ROBIN LISTING which contains the listing information. These files would be placed on your VM disks according to the rules shown in Table 13. (The relationship between VM disks is explained in the *VM/ESA: CMS User's Guide*.)

It is possible to specify a name for the TEXT file other than that of the file compiled in the PLIOPT command by specifying a filename with the OBJECT option.

The creation of the LISTING file can be suppressed by use of the NOPRINT option of the PLIOPT command. (See “PLIOPT Command Options” on page 75.) The creation of the TEXT file can be suppressed by use of the NOOBJECT option of the PLIOPT command.

Table 13. The disks on Which the Compiler Output Is Stored

If the disk that contains the PL/I source file is accessed...	**then the disk that contains the output files (TEXT, LISTING) is:**
Read/Write...	the disk that holds the PL/I source.
as an extension of a Read/Write disk...	the Read/Write Disk.
as an extension of a Read-only Disk and the A-disk is accessed Read/Write...	the A-disk.
as an extension of a Read-only Disk and the A-disk is accessed Read Only...	ERROR DMSPLI006E — program terminates.

Compile-Time Options

The PLIOPT command expects all options to be a maximum of eight characters long. You should always use the abbreviated form of the options. All options and suboptions must be separated by blanks. Parentheses need not be separated from options or suboptions even if the option has a total length of more than eight characters. Thus TERMINAL(XREF) is acceptable, although the total length is greater than eight characters.

Where options of the PLIOPT command contradict those of the %PROCESS statement, the options in the %PROCESS statement override those in the PLIOPT command. For options whose length is greater than eight characters, the abbreviation for that option must be used in the PLIOPT command.

Files Used by the Compiler

During compilation the compiler uses a number of files. These files are allocated by the interface module that invokes the compiler. The files used are shown in Table 14. At the end of the compilation, the interface module will issue a FILEDEF * CLEAR command to clear the definition of these files. As a result, all your file definitions without the PERM option active prior to the compilation will also be cleared.

Table 14 (Page 1 of 2). Files That Can Be Used by the Compiler

FILE TYPE	**FUNCTION**	**DEVICE TYPE**	**WHEN REQUIRED**
PLIOPT or PLI	Input	DASD, magnetic tape, card reader	Always
LISTING	Print	DASD, magnetic tape, printer	Optional
TEXT	Object module output	DASD, magnetic tape	When object module is to be created

Table 14 (Page 2 of 2). Files That Can Be Used by the Compiler

FILE TYPE	FUNCTION	DEVICE TYPE	WHEN REQUIRED
SYSPUNCH	System punch	DASD, magnetic tape, card punch	When MDECK and/or DECK is in effect
SYSUT1	Spill	DASD	When insufficient main storage is available
MACLIB	Preprocessor %INCLUDE	DASD	When %INCLUDE is used from VM disks
SYSLIB	Preprocessor %INCLUDE	DASD	When %INCLUDE is used from PL/I Library

PLIOPT Command Options

The PLIOPT command compiles a PL/I program or a series of PL/I programs into machine language object code. If the file type is missing, the file type defaults to PLIOPT or PLI.

The following options are applicable only to the PLIOPT command and cannot appear on the %PROCESS statement in the PL/I source file.

- PRINT—The listing file is directed to the PRINTER and is not placed on a disk.
- DISK—The listing file is placed on a disk. To determine which disk, see Table 13 on page 74.
- TYPE—The listing file is displayed at your terminal and is not placed on a disk.
- NOPRINT—A listing file is not produced.
- OBJECT—An additional facility, OBJECT[(file name)], allows you to specify a different file name for your file.

  In the OBJECT option specification, (file name) is the name that will be given to the text file. If it is omitted, the text file will be given the same name as the file specified in the PLIOPT command. The TEXT file will be placed on one of your disks in accordance with the rules shown in Table 13 on page 74.

%INCLUDE Statement

If you want to use the %INCLUDE statement within your PL/I program, you must take the following steps:

- Create the file that you want to INCLUDE into your PL/I program. The file type must be COPY.
- Put the COPY file into an existing or new macro library (MACLIB).
- Use the %INCLUDE statement in your PL/I program.
- Issue a FILEDEF for the MACLIB that contains the COPY file you want included.
- If you have only %INCLUDE and no other preprocessor statements, compile your program using the compile-time option INC. If you have other preprocessor statements, use the compile time option MACRO.

The syntax of %INCLUDE is:

```
%INCLUDE DDNAME(member name);
```

The following example demonstrates the use of the %INCLUDE statement.

Example of Using %INCLUDE

The COPY file called PLIXOPT COPY is created:

```
DCL PLIXOPT CHAR(255) VAR STATIC EXTERNAL
   INIT ('STACK(4K),HEAP(4K),RPTSTG(ON)');
```

The COPY file PLIXOPT is added to the MACLIB called MYLIB:

```
MACLIB ADD MYLIB PLIXOPT
```

If a MACLIB does not exist, use the command MACLIB GEN instead of MACLIB ADD. This will generate a MACLIB called MYLIB.

In the PL/I source file, the following %INCLUDE statement is included:

```
%INCLUDE PLICOPY(PLIXOPT);
```

A FILEDEF is issued for the ddname specified in the %INCLUDE statement to tell PL/I where to obtain the member PLIXOPT within a library:

```
FILEDEF PLICOPY DISK MYLIB MACLIB
```

The PL/I program is compiled. The program has no other preprocessor statements, so the INC option is used:

```
PLIOPT EXAMPLE ( INC
```

For complete information on the VM Commands which are used above, see the *VM/ESA: CMS Command Reference*.

PLIOPT Command Format

The format of the PLIOPT command is:

```
PLIOPT filename[filetype[filemode]] [(options-list [)]]
```

where `filename[filetype[filemode]]` is the identification of the file that contains the PL/I source program. If filetype is omitted, a search will be made first for PLIOPT files of the specified filename and then for PLI files of the specified filename. If filemode is omitted, A will be assumed.

If the options list is (`option1 option2 option3...` then the options must be separated from each other by at least one blank. The right hand parenthesis is optional. If contradicting options are specified, the rightmost option applies. See Table 3 on page 5 for information on options and their correct syntax.

Examples:

To compile a PLIOPT or PLI file called RABBIT on the A-disk with the OPTIONS and SOURCE options:

```
PLIOPT RABBIT (OPTIONS SOURCE
```

To compile a file with the name RABBIT and the type FORMAT on the B-disk with the options PRINT, XREF, and ATTRIBUTES:

```
PLIOPT RABBIT FORMAT B (PRI X A
```

Note that the abbreviations are used for these options.

Special Action Will Be Required:

1. If your source uses the %INCLUDE statement to incorporate secondary input text.
2. If you intend to run your program under MVS.
3. If you want to place the compiled program into a TXTLIB. You might want to do this if you want to use separately compiled subroutines.

The following paragraphs describe the actions required in each of these circumstances.

Using %INCLUDE under VM: If your program uses %INCLUDE statements to include previously written PL/I statements or procedures, the libraries on which they are held must be made available to VM before issuing the PLIOPT command. To do this you must insert the statements into a VM MACLIB using the MACLIB command. You then issue a GLOBAL command taking the form “GLOBAL MACLIB filename.”

For example, if your secondary input text was held in MACLIB called “MYLIB” you would enter:

```
GLOBAL MACLIB MYLIB
```

before issuing the PLIOPT command. The PLIOPT command must specify either the INCLUDE or the MACRO option.

If your %INCLUDE statement takes the form %INCLUDE MYLIB (CUCKOO), as opposed to %INCLUDE CUCKOO, you will also need to specify a FILEDEF command for MYLIB. This should take the form:

```
FILEDEF MYLIB DISK MYLIB MACLIB
```

If in the MACLIB the LRECL is not 80 and the BLOCKSIZE not 400, format information must be included in the FILEDEF command.

Compiling a Program to Run under MVS: If you intend to run your program under MVS, you should specify the SYSTEM(MVS) option:

```
PLIOPT RABBIT (SYSTEM(MVS)
```

An attempt to run a program compiled without the SYSTEM(MVS) option under MVS results in an OS linkage editor error of severity level 8.

Compiling a Program to be Placed in a TXTLIB: If you intend to include the compiled TEXT file as a member of a TXTLIB it is necessary to use the NAME option when you specify the PLIOPT command. This is because members of a TXTLIB file are given the name of their primary entry point if they have no external name. The primary entry point of every TEXT file produced by the compiler is the same, consequently only one compiled program can be included in a TXTLIB if the NAME option is not used. (The NAME option gives the TEXT file an external name.)

Commands required to create a TEXT file suitable for including in a TXTLIB are shown below. This code gives the file the external name used in the PLIOPT command. However, any other name can be used provided that it does not exceed six characters.

Note: If the name exceeds six characters, the NAME option is ignored.

The commands below compile a PLIOPT file RABBIT with the external name RABBIT and add it to an existing text library called BIOLIB.

```
PLIOPT RABBIT (NAME('RABBIT'
[compiler messages etc.]
TXTLIB ADD BIOLIB RABBIT
```

If the BIOLIB TXTLIB does not exist yet, use the command TXTLIB GEN instead of TXTLIB ADD.

PL/I Batched Compilation

An example of VM batched compilation is shown in Figure 15.

```
PLIOPT FIRST

where FIRST and SECND are a single file that looks like:
    first: proc;
      .
      .
      .
    end;
%process;
     secnd:proc;
       .
       .
       .
     end;
```

Figure 15. Example of Batched Compilation under VM

Correcting Compiler-Detected Errors

At compile time, both the preprocessor and the compiler can produce diagnostic messages and listings according to the compile-time options selected for a particular compilation. The listings and the associated compile-time options are discussed in Chapter 1, “Using Compile-Time Options and Facilities” on page 5. The diagnostic messages produced by the compiler are identified by a number with an “IEL” prefix. These diagnostic messages are available in both a long form and a short form. The short messages are obtained by specifying the SMESSAGE compiler option. Each message is listed in *PL/I for MVS & VM Compile-Time Messages and Codes*. This publication includes explanatory notes, examples, and any action to be taken.

Always check the compilation listing for occurrences of these messages to determine whether the syntax of the program is correct. Messages of greater severity than warning (that is, error, severe error, and unrecoverable error) should be acted upon if the message does not indicate that the compiler has been able to “fix” the error correctly. You should be aware that the compiler, in making an assumption as to the intended meaning of any erroneous statement in the source program, can introduce another, perhaps more severe, error which in turn can produce yet another error, and so on. When this occurs, the compiler produces a number of diagnostic messages which are all caused either directly or indirectly by the one error.

Other useful diagnostic aids produced by the compiler are the attribute table and cross-reference table. The attribute table, specified by the ATTRIBUTES option, is useful for checking that program identifiers, especially those whose attributes are contextually and implicitly declared, have the correct attributes. The cross-reference table is requested by the XREF option, and indicates, for each program variable, the number of each statement that refers to the variable.

To prevent unnecessary waste of time and resources during the early stages of developing programs, use the NOOPTIMIZE, NOSYNTAX, and NOCOMPILE options. The NOOPTIMIZE option suppresses optimization unconditionally, and the remaining options suppress compilation, link-editing, and execution if the appropriate error conditions are detected.

Chapter 5. Link-Editing and Running

After compilation, your program consists of one or more object modules that contain unresolved references to each other, as well as references to the Language Environment for MVS & VM run-time library. These references are resolved during link-editing or during execution (dynamically).

So after you compile your PL/I program, the next step is to link and run your program with test data to verify that it produces the results you expect.

Language Environment for MVS & VM provides the run-time environment and services you need to execute your program. For instructions on linking and running PL/I and all other Language Environment for MVS & VM-conforming language programs, refer to the *Language Environment for MVS & VM Programming Guide*. For information about migrating your existing PL/I programs to Language Environment for MVS & VM, see the *PL/I for MVS & VM Compiler and Run-Time Migration Guide*.

This chapter contains the following sections:

Selecting math results at link-edit time
VM run-time considerations
MVS run-time considerations
SYSPRINT Considerations

Selecting Math Results at Link-Edit Time

You can select math results that are compatible with Language Environment for MVS & VM or with OS PL/I. When you link your load module, you select the math results by linking in the stubs for the Language Environment for MVS & VM math routines or the OS PL/I math routines. You select the results on a load module basis; a load module that uses the Language Environment for MVS & VM results can fetch a load module that uses the OS PL/I results.

Because the Language Environment for MVS & VM routines are defaults, if you relink an OS PL/I application, you receive the Language Environment for MVS & VM results. To maintain the OS PL/I results, you need to ensure that the stubs for the PL/I math routines are linked into the application. You can do so by overriding the linkedit library SYSLIB data set name with the name of the PL/I math link-edit library data set, SIBMMATH.

Use the following JCL or equivalent:

```
//SYSLIB DD DSN=CEE.V1R2M0.SIBMMATH,DISP=SHR
//       DD DSN=CEE.V1R2M0.SCEELKED,DISP=SHR
```

VM Run-Time Considerations

Various special topics are covered in this section, including PL/I restrictions under VM.

Separately Compiled PL/I MAIN Programs

You can load separately compiled procedures with the MAIN option into one executable program in PL/I. The PL/I procedure that you want to receive control first must be specified first on the LOAD command. For example, if you have two MAIN PL/I procedures CALLING and CALLED (see Figure 16 and Figure 17) and you want CALLING to receive control first, you issue these VM commands:

```
global txtlib plilib sceelked cmslib /* make the libraries available */
Ready;
pliopt calling (system(cms)          /* compile the one of the procs */
Ready;
pliopt called (system(cms)           /* compile the other one        */
Ready;
global loadlib sceerun               /* make the libraries available */
load calling called ( nodup          /* CALLING will receive control */
Ready;                               /* ...first. NODUP suppresses   */
                                     /* ...duplicate identifier msgs */
start                                /* invoke the program           */
Ready;
```

```
%PROCESS F(I) AG A(F) ESD MAP OP STG NEST X(F) SOURCE LIST ;
 Calling: Proc Options(Main);
 Dcl Sysprint File Output;
 Dcl Called External Entry;

   Put Skip List ('CALLING - started');
   Call Called;
   Put Skip List ('CALLING - Ended');

 END Calling;
```

Figure 16. PL/I Main Calling Another PL/I Main

```
%PROCESS F(I) AG A(F) ESD MAP OP STG TEST X(F) SOURCE LIST ;
 Called: Proc Options(Main);
 Dcl Sysprint File ;

   Put Skip List ('CALLED - started');
   Put Skip List ('CALLED - ended');

 END Called;
```

Figure 17. PL/I Main Called by Another PL/I Main

Using Data Sets and Files

VM files and other OS data sets can be written and read by programs run under VM, with varying restrictions.

VM files are completely accessible for read, write, and update to programs running under VM. You can make these files available to a number of virtual machines, but they are not accessible from outside the VM system except by copying and recreation.

Only sequential OS data sets are available, on a read-only basis, to VM programs.

Within a program, a file is identified by the declared name or the name given in the title option. Outside the program, the FILEDEF command, or the DLBL command for VSAM, binds a file name to a particular data set.

VSAM data sets are different from other types of files because their management is handled by a set of programs known as Access Method Services. The services are available to the VM user by the AMSERV command. This command uses a previously created file containing Access Method Services statements to specify the required services.

VM uses the DOS data management routines which must be installed during VM program installation. Your program is not affected by the use of DOS routines, but certain OS Access Method Services functions are not available for data set handling. Full details of this and other aspects of VM VSAM are given in the *VM/ESA CMS User's Guide*.

To test programs that create or modify OS data sets, you can write “OS-Simulated data sets.” These are VM files that are maintained on VM disks in OS format, rather than in VM format. You can perform any VM file operation on these files. However, since they are in the OS-Simulated format, files with variable-blocked records can contain block and record descriptor words, so that the access methods can manipulate the files properly. If you specify the filemode number as 4, VM creates a file that is in OS-Simulated data set format.

The following three examples show the PL/I statements and the CMS commands necessary to access VM files, VSAM data sets, and non-VSAM OS data sets, respectively.

Using VM Files — Example

To access a VM file, issue a FILEDEF command associating a PL/I file name with particular VM file(s).

In the example that follows, the PL/I program reads the file known in the program as “OLDFILE”. This refers to the VM file “INPUT DATA B”. The program creates the file known in the program as “NEWFILE”, which corresponds to the VM file “OUTPUT DATA A”. A third file, PL/I file “HISTORY”, is assigned to the virtual printer.

PL/I Program Statements

```
DCL OLDFILE FILE RECORD INPUT ENV (F RECSIZE(40)),
    NEWFILE FILE RECORD OUTPUT ENV (F RECSIZE(40)),
    HISTORY FILE STREAM PRINT;
```

VM Commands

`filedef oldfile disk input data b`	Associates OLDFILE with the file INPUT DATA B.
`filedef newfile disk output data a`	Associates NEWFILE with the file OUTPUT DATA A.
`filedef history printer`	Associates the file HISTORY with the virtual printer.

The full syntax of the FILEDEF and other commands is given in *VM/ESA CMS Command Reference*.

Using VSAM Data Sets — Example

VSAM data sets differ from other data sets because they are always accessed through a catalog and because they have their routine management performed by Access Method Services. Use the AMSERV command to invoke Access Method Services functions and the DLBL command to associate an actual VSAM data set with the file identifier in a PL/I program.

To use the AMSERV command, a file of the filetype AMSERV must be created that contains the necessary Access Method Services commands. An AMSERV command, specifying the name of this file, is then issued and the requested Access Method Services are performed. Such services must always be used for cataloging and formatting purposes before creating a VSAM data set. They are also used for deleting, renaming, making portable copies, and other routine tasks.

For VSAM data sets, catalog entries are created by the DEFINE statement of Access Method Services. They contain information such as the space used or reserved for the data set, the record size, and the position of a key within the record. The catalog entry also contains the address of the data set.

To use a VSAM data set, you must identify the catalog to be searched and associate the PL/I file with the VSAM data set. The DLBL command is used for both these purposes. Where the data set is being newly created, you must specify the AMSERV command to catalog and define the data set before the PL/I program is executed. Details of how to use VSAM under VM are given in the *VM/ESA CMS User's Guide*.

The relevant PL/I statements and VM commands to access an existing VSAM data set and to create a new VSAM data set are shown in the example that follows.

The PL/I program reads the file OLDRAB from the VSAM data set called RABBIT1 on the VM B-disk. It writes the file NEWRAB onto the data set RABBIT2, also on the VM B-disk. RABBIT2 is defined using an AMSERV command. In the example, this master catalog is already assigned and the VSAM space is also already assigned.

PL/I File Declaration

```
     DCL OLDRAB FILE RECORD SEQUENTIAL KEYED INPUT ENV(VSAM);
     DCL NEWRAB FILE RECORD SEQUENTIAL KEYED OUTPUT ENV(VSAM);
```

VM Commands: A file with the filetype of AMSERV must be created with the appropriate Access Method Services commands, and is named `'AMSIN AMSERV'`. For this example, the file must contain the following information:

```
DEFINE CLUSTER(NAME(RABBIT2.C) VOL(VOLSER)) -
       DATA (CYL(4,1) KEYS(5,5) RECSZ(23,23) -
       FREESPACE(20,30)) -
       INDEX(CYL(1,1))
```

The VM commands that you need to issue are:

`dlbl ijsyscat b dsn mastca (perm`	Issue a DLBL for the master catalog. Note that this need only be done once for terminal session if PERM is specified.
`amserv amsin`	Execute statements in the AMSERV file to catalog and format data set.

`dlbl oldrab b dsn rabbit1 (vsam)`
`dlbl newrab b dsn rabbit2 (vsam)`
	Issue DLBL commands to associate PL/I files with the VSAM data sets.

Notes:

1. The closing parenthesis is optional in VM commands but *required* in Access Method Services commands.
2. PL/I MVS & VM programs with files declared with ENV(INDEXED) can, in certain instances, operate correctly if the data set being accessed is a VSAM data set.

Using OS Data Sets — Example

Before you can access an OS data set that resides on an OS formatted disk, it must be made available to your virtual machine. Using the ACCESS command, you can access the OS formatted disk as one of your VM minidisks. Once this has been done, you can use a FILEDEF command to access the disk in the usual manner.

In the example that follows, the PL/I file OLDRAB is used to access the OS data set RABBIT.OS.DATA. The disk containing the data set has been mounted and is known to the user as virtual disk number 196.

PL/I Statement

```
DCL OLDRAB FILE RECORD ENV (F RECSIZE(40));
```

VM Commands

`access 196 g`
`DMSACP723I G (196) R/O`
	Connect disk containing data set to your virtual machine.

`filedef oldrab g dsn rabbit os data`	Associate PL/I file OLDRAB with OS data set RABBIT.OS.DATA.

Using Tapes with Standard Labels: VM assumes that tapes do not have standard labels. If you want to process a standard label tape, you can use the VM commands LABELDEF, FILEDEF, and/or TAPE. More information can be found in the *VM/ESA CMS Command Reference*.

Restrictions Using PL/I under VM

PL/I features that are not available under VM are:

- ASCII data sets
- BACKWARDS attribute with magnetic tapes
- INDEXED Files (except for use with VSAM)
- PL/I checkpoint restart facilities (PLICKPT)
- Tasking
- Regional(2) and Regional(3) files
- Teleprocessing* files (TCAM)
- VS or VBS record formats.

PL/I features that have restricted use under VM are:

Regional(1) files
Regional(1) files can be used with the following restrictions:

- More than one regional file with keys cannot be open at the same time.
- KEY(TRACKID/REGION NUMBER) must not be incremented unless 255 records are written on the first logical track, and 256 records on each subsequent logical track.
- Files must not be written with a dependency on the physical track length of a direct access device.
- When a file is created, the XTENT option of the FILEDEF command must be specified, and it must be equal to the number of records in the file to be created.

READ
This can only be used if the NCP parameter is included in the ENVIRONMENT option of the PL/I file.

Blanks
Blanks cannot be passed in the parameter string to the main procedure using SYSTEM(CMSTPL). The blanks are removed from the string and the items separated by them are concatenated. Use of SYSTEM(CMS) does not have this restriction.

TIME
The TIME built-in function returns values calculated to the nearest second.

VSAM
VSAM data sets can be used only if DOS/VS VSAM was incorporated into VM during PL/I VM installation. DOS VSAM is used and any features not available to DOS VSAM cannot be used. CMS/DOS must also be generated into VM. For details of how to do this, see *VM/ESA Installation*.

Environment options: SIS cannot be used, SKIP cannot be used on ESDS.

Using Record I/O at the Terminal

There is no provision for input prompting or synchronization of output for RECORD files assigned to the terminal. Terminal interaction logic is generally easier to write using stream I/O, but when you use record I/O at the terminal, keep the following points in mind:

Output: Output files should be declared with BUFFERS(1) if you must synchronize input with output.

Use V-format records; otherwise trailing blanks are transmitted.

Input: Use V-format records, as doing otherwise raises the RECORD condition unless the record is filled out with trailing blanks. Note than when V-format records are used and the data is read into a fixed length string, the string is not padded with blanks. By default, RECORD files assigned to the terminal are given F-format records with the record length the same as the linesize for the terminal.

PL/I Conventions under VM

Two types of conventions apply to PL/I when used under VM. The first type is adopted to make input/output simpler and more efficient at the terminal. The second type results from the terminal being considered as the console of a virtual machine. These affect the DISPLAY statement and the REPLY option.

Stream I/O Conventions at the Terminal: To simplify input/output at the terminal, various conventions have been adopted for stream files that are assigned to the terminal. Three areas are affected:

1. Formatting of PRINT files
2. The automatic prompting feature
3. Spacing and punctuation rules for input.

Formatting onventions for PRINT Files

When a PRINT file is assigned to the terminal, it is assumed that it will be read as it is being printed. Spacing is therefore reduced to a minimum to reduce printing time. The following rules apply to the PAGE, SKIP, and ENDPAGE keywords:

- PAGE options or format items result in three lines being skipped.
- SKIP options or format items large than SKIP (2) result in three lines being skipped. SKIP (2) or less is treated in the usual manner.
- The ENDPAGE condition is never raised.

Changing the Format on PRINT Files

If you want normal spacing to apply to output from a PRINT file at the terminal, you must supply your own tab table for PL/I. This is done by declaring an external structure called PLITABS in the program and initializing the element PAGELENGTH to the number of lines that can fit on your page. This value differs from PAGESIZE, which defines the number of lines you want to be printed on the page before ENDPAGE is raised. (See Figure 18 and Figure 19 on page 90 in “MVS Run-Time Considerations.”)

Automatic Prompting

When the program requires input from a file that is associated with a terminal, it issues a prompt. This takes the form of printing a colon on the next line and then skipping to column 1 on the line following the colon. This gives you a full line to enter your input, as follows:

```
:
(space for entry of your data)
```

This type of prompt is referred to as a primary prompt.

Overriding Automatic Prompting: It is possible to override the primary prompt by making a colon the last item in the request for the data. The secondary prompt cannot be overridden. For example, the two PL/I statements:

```
PUT SKIP EDIT ('ENTER TIME OF PERIHELION') (A);
GET EDIT (PERITIME) (A(10));
```

result in the terminal printing:

```
ENTER TIME OF PERIHELION
:         (automatic prompt)
(space for entry of data)
```

However, if the first statement has a colon at the end of the output, as follows:

```
PUT EDIT ('ENTER TIME OF PERIHELION:') (A);
```

the sequence is:

```
ENTER TIME OF PERIHELION: (space for entry of data)
```

Note: The override remains in force for only one prompt. You will be automatically prompted for the next item unless the automatic prompt is again overridden.

Punctuating Long Input Lines

Line Continuation Character: To transmit data that requires 2 or more lines of space at the terminal as one data-item, type an SBCS hyphen as the last character in each line except the last line. For example, to transmit the sentence “this data must be transmitted as one unit.” you enter:

```
:
  'this data must be transmitted -
:
  as one unit.'
```

Transmission does not occur until you press ENTER after “unit.'” The hyphen is removed. The item transmitted is called a “logical line.”

Note: To transmit a line whose last data character is a hyphen or a PL/I minus sign, enter two hyphens at the end of the line, followed by a null line as the next line.

For example:

```
xyz--
(press ENTER only, on this line)
```

Punctuating GET LIST and GET DATA Statements

For GET LIST and GET DATA statements, a comma is added to the end of each logical line transmitted from the terminal, if the programmer omitted it. Thus there is no need to enter blanks or commas to delimit items if they are entered on separate logical lines. For the PL/I statement GET LIST(A,B,C); you can enter at the terminal:

```
:
  1
+:
  2
+:
  3
```

This rule also applies when entering character-string data. A character string must therefore transmit as one logical line. Otherwise, commas are placed at the break points. For example, if you enter:

```
:
  'COMMAS SHOULD NOT BREAK
+:
  UP A CLAUSE.'
```

the resulting string is “COMMAS SHOULD NOT BREAK, UP A CLAUSE.” The comma is not added if a hyphen was used as a line continuation character.

Automatic Padding for GET EDIT: For a GET EDIT statement, there is no need to enter blanks at the end of the line. The data will be padded to the specified length. Thus, for the PL/I statement:

```
GET EDIT (NAME) (A(15));
```

you can enter the 5 characters SMITH. The data will be padded with ten blanks so that the program receives the fifteen characters:

```
'SMITH          '
```

Note: A single data item must transmit as a logical line. Otherwise, the first line transmitted will be padded with the necessary blanks and taken as the complete data item.

Use of SKIP for Terminal Input: All uses of SKIP for input are interpreted as SKIP(1) when the file is allocated to the terminal. SKIP(1) is treated as an instruction to ignore all unused data on the currently available logical line.

ENDFILE

The end-of-file can be entered at the terminal by keying in a logical line that consists of the two characters “/*”. Any further attempts to use the file without closing it result in the ENDFILE condition being raised.

DISPLAY and REPLY under VM

Because your terminal is the console of the virtual machine, you can use the DISPLAY statement and the REPLY option to create conversational programs. The DISPLAY statement transmits the message to your terminal, and the REPLY option allows you to respond. For example, the PL/I statement:

```
DISPLAY ('ENTER NAME') REPLY (NAME);
```

results in the message “ENTER NAME” being printed at your terminal. The program then waits for your response and places your data in the variable NAME after you press ENTER. The terminal display looks like:

```
ENTER NAME
Esther Summers
```

The reply can contain DBCS characters but they must be processable as a mixed string.

Note: File I/O can be buffered if the file is directed to the terminal. If you are using I/O directed to the terminal as well as the DISPLAY statement, the order of the lines written cannot be the same as the program intended.

MVS Run-Time Considerations

To simplify input/output at the terminal, various conventions have been adopted for stream files that are assigned to the terminal. Three areas are affected:

1. Formatting of PRINT files
2. The automatic prompting feature
3. Spacing and punctuation rules for input.

Note: No prompting or other facilities are provided for record I/O at the terminal, so you are strongly advised to use stream I/O for any transmission to or from a terminal.

Formatting Conventions for PRINT Files

When a PRINT file is assigned to the terminal, it is assumed that it will be read as it is being printed. Spacing is therefore reduced to a minimum to reduce printing time. The following rules apply to the PAGE, SKIP, and ENDPAGE keywords:

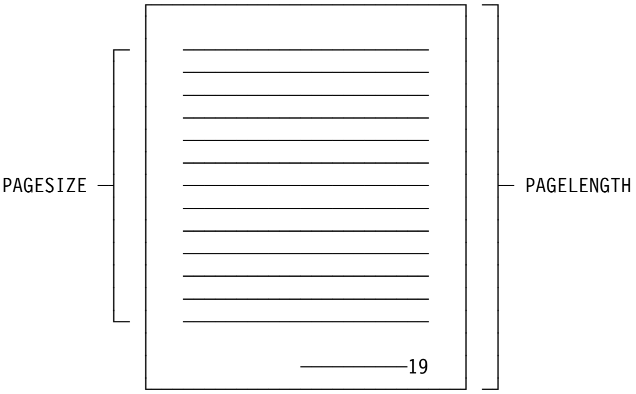
- PAGE options or format items result in three lines being skipped.
- SKIP options or format items larger than SKIP (2) result in three lines being skipped. SKIP (2) or less is treated in the usual manner.
- The ENDPAGE condition is never raised.

Changing the Format on PRINT Files

If you want normal spacing to apply to output from a PRINT file at the terminal, you must supply your own tab table for PL/I. This is done by declaring an external structure called PLITABS in the program and initializing the element PAGELENGTH to the number of lines that can fit on your page. This value differs from PAGESIZE, which defines the number of lines you want to print on the page before ENDPAGE is raised (see Figure 19 on page 90). If you require a PAGELENGTH of 64 lines, declare PLITABS as shown in Figure 18 on page 90. For information on overriding the tab table, see “Overriding the Tab Control Table” on page 140.

```
DCL 1 PLITABS STATIC EXTERNAL,
  ( 2   OFFSET INIT (14),
    2    PAGESIZE INIT (60),
    2    LINESIZE INIT (120),
    2    PAGELENGTH INIT (64),
    2    FILL1 INIT (0),
    2    FILL2 INIT (0),
    2    FILL3 INIT (0),
    2    NUMBER_OF_TABS INIT (5),
    2    TAB1 INIT (25),
    2    TAB2 INIT (49),
    2    TAB3 INIT (73),
    2    TAB4 INIT (97),
    2    TAB5 INIT (121)) FIXED BIN (15,0);
```

Figure 18. Declaration of PLITABS. This declaration gives the standard page size, line size and tabulating positions



PAGELENGTH: the number of lines that can be printed on a page

PAGESIZE: the number of lines that will be printed on a page
before the ENDPAGE condition is raised

Figure 19. PAGELENGTH and PAGESIZE. PAGELENGTH defines the size of your paper, PAGESIZE the number of lines in the main printing area.

Automatic Prompting

When the program requires input from a file that is associated with a terminal, it issues a prompt. This takes the form of printing a colon on the next line and then skipping to column 1 on the line following the colon. This gives you a full line to enter your input, as follows:

```
:
(space for entry of your data)
```

This type of prompt is referred to as a primary prompt.

Overriding Automatic Prompting: You can override the primary prompt by making a colon the last item in the request for the data. You cannot override the secondary prompt. For example, the two PL/I statements:

```
PUT SKIP EDIT ('ENTER TIME OF PERIHELION') (A);
GET EDIT (PERITIME) (A(10));
```

result in the terminal displaying:

```
ENTER TIME OF PERIHELION
:         (automatic prompt)
(space for entry of data)
```

However, if the first statement has a colon at the end of the output, as follows:

```
PUT EDIT ('ENTER TIME OF PERIHELION:') (A);
```

the sequence is:

```
ENTER TIME OF PERIHELION: (space for entry of data)
```

Note: The override remains in force for only one prompt. You will be automatically prompted for the next item unless the automatic prompt is again overridden.

Punctuating Long Input Lines

Line Continuation Character: To transmit data that requires 2 or more lines of space at the terminal as one data-item, type an SBCS hyphen as the last character in each line except the last line. For example, to transmit the sentence “this data must be transmitted as one unit.” you enter:

```
:'this data must be transmitted -
+:as one unit.'
```

Transmission does not occur until you press ENTER after “unit.'”. The hyphen is removed. The item transmitted is called a “logical line.”

Note: To transmit a line whose last data character is a hyphen or a PL/I minus sign, enter two hyphens at the end of the line, followed by a null line as the next line. For example:

```
xyz--
(press ENTER only, on this line)
```

Punctuating GET LIST and GET DATA Statements

For GET LIST and GET DATA statements, a comma is added to the end of each logical line transmitted from the terminal, if the programmer omits it. Thus there is no need to enter blanks or commas to delimit items if they are entered on separate logical lines. For the PL/I statement GET LIST(A,B,C); you can enter at the terminal:

```
:1
+:2
+:3
```

This rule also applies when entering character-string data. Therefore, a character string must transmit as one logical line. Otherwise, commas are placed at the break points. For example, if you enter:

```
:'COMMAS SHOULD NOT BREAK
+:UP A CLAUSE.'
```

the resulting string is: “COMMAS SHOULD NOT BREAK, UP A CLAUSE.” The comma is not added if a hyphen was used as a line continuation character.

Automatic Padding for GET EDIT: For a GET EDIT statement, there is no need to enter blanks at the end of the line. The data will be padded to the specified length. Thus, for the PL/I statement:

```
GET EDIT (NAME) (A(15));
```

you can enter the 5 characters SMITH. The data will be padded with ten blanks so that the program receives the fifteen characters:

```
'SMITH          '
```

Note: A single data item must transmit as a logical line. Otherwise, the first line transmitted will be padded with the necessary blanks and taken as the complete data item.

Use of SKIP for Terminal Input: All uses of SKIP for input are interpreted as SKIP(1) when the file is allocated to the terminal. SKIP(1) is treated as an instruction to ignore all unused data on the currently available logical line.

ENDFILE

The end-of-file can be entered at the terminal by keying in a logical line that consists of the two characters "/*". Any further attempts to use the file without closing it result in the ENDFILE condition being raised.

SYSPRINT Considerations

The PL/I standard SYSPRINT file is shared by multiple enclaves within an application. You can issue I/O requests, for example STREAM PUT, from the same or different enclaves. These requests are handled using the standard PL/I SYSPRINT file as a file which is common to the entire application. The SYSPRINT file is implicitly closed only when the application terminates, not at the termination of the enclave.

The standard PL/I SYSPRINT file contains user-initiated output only, such as STREAM PUTs. Run-time library messages and other similar diagnostic output are directed to the Language Environment MSGFILE. See the *Language Environment for MVS & VM Programming Guide* for details on redirecting SYSPRINT file output to the Language Environment MSGFILE.

To be shared by multiple enclaves within an application, the PL/I SYSPRINT file must be declared as an EXTERNAL FILE constant with a file name of SYSPRINT and also have the attributes STREAM and OUTPUT as well as the (implied) attribute of PRINT, when OPENed. This is the standard SYSPRINT file as defaulted by the compiler.

There exists only one standard PL/I SYSPRINT FILE within an application and this file is shared by all enclaves within the application. For example, the SYSPRINT file can be shared by multiple nested enclaves within an application or by a series of enclaves that are created and terminated within an application by the Language Environment preinitialization function. To be shared by an enclave within an application, the PL/I SYSPRINT file must be declared in that enclave. The standard SYSPRINT file cannot be shared by passing it as a file argument between enclaves. The declared attributes of the standard SYSPRINT file should be the same throughout the application, as with any EXTERNALly declared constant. PL/I does not enforce this rule.

Having a common SYSPRINT file within an application can be an advantage to applications that utilize enclaves that are closely tied together. However, since all enclaves in an application write to the same shared data set, this might require some coordination among the enclaves.

The SYSPRINT file is opened (implicitly or explicitly) when first referenced within an enclave of the application. When the SYSPRINT file is CLOSEd, the file resources are released (as though the file had never been opened) and all enclaves are updated to reflect the closed status.

If SYSPRINT is utilized in a multiple enclave application, the LINENO built-in function only returns the current line number until after the first PUT or OPEN in an enclave has been issued. This is required in order to maintain full compatibility with old programs.

The COUNT built-in function is maintained at an enclave level. It always returns a value of zero until the first PUT in the enclave is issued. If a nested child enclave is invoked from a parent enclave, the value of the COUNT built-in function is undefined when the parent enclave regains control from the child enclave.

When opened, the TITLE option can be used to associate the standard SYSPRINT file with different operating system data sets. This association is retained across enclaves for the duration of the open.

PL/I condition handling associated with the standard PL/I SYSPRINT file retains its current semantics and scope. For example, an ENDPAGE condition raised within a child enclave will only invoke an established on-unit within that child enclave. It does not cause invocation of an on-unit within the parent enclave.

The tabs for the standard PL/I SYSPRINT file can vary when PUTs are done from different enclaves, if the enclaves contain a user PLITABS table.

OS PL/I I/O FETCH/RELEASE restrictions continue to apply to the SYSPRINT file. If SYSPRINT is declared as a file constant in a load module, the declared SYSPRINT file information is statically and locally bound to that load module and the following rules apply:

- If the load module has been released from storage, explicit use of this file constant by the user program can cause unpredictable results.
- If file comparison or I/O on-units are involved, the use of these language features is scoped to the load module.

  For example, if SYSPRINT is declared in load module A and also in load module B, a file comparison of the two SYSPRINTs will not compare equal. Similarly, if an ENDPAGE on-unit for SYSPRINT is established in load module A and a PUT is done in load module B, the ENDPAGE on-unit might not gain control if the PUT overflows a page.

The scoping rules for file comparison and I/O units can be avoided if you declare SYSPRINT as a file constant in a particular load module and use a file variable parameter to pass that SYSPRINT declaration to other load modules for file comparison or PUTs. In this case, the load module boundary scoping rules do not apply.

When the PL/I SYSPRINT file is used with the PL/I multitasking facility, the task-level file-sharing rules apply. This maintains full compatibility for old PL/I multitasking programs.

If the PL/I SYSPRINT file is utilized as a RECORD file or as a STREAM INPUT file, PL/I supports it at an individual enclave or task level, but not as a sharable file among enclaves. If the PL/I SYSPRINT file is open at the same time with different file attributes (e.g. RECORD and STREAM) in different enclaves of the same application, results are unpredictable.

Part 3. Using I/O facilities

Chapter 6. Using Data Sets and Files

Your PL/I programs process and transmit units of information called *records*. On MVS systems, a collection of records is called a *data set*. On VM, a collection of records is called a *file*. Data sets, and VM files, are physical collections of information external to PL/I programs; they can be created, accessed, or modified by programs written in PL/I or other languages or by the utility programs of the operating system.

Your PL/I program recognizes and processes information in a data set by using a symbolic or logical representation of the data set called a *file*. (Yes, in VM there are files defined within your program that are symbolic representations of files external to your program.) This chapter describes how to associate data sets or VM files with the files known within your program. It introduces the five major types of data sets, how they are organized and accessed, and some of the file and data set characteristics you need to know how to specify.

Associating Data Sets with Files

A file used within a PL/I program has a *PL/I file name*. The physical data set external to the program has a name by which it is known to the operating system: under MVS or TSO it is a *data set name* or *dsname*, and on VM it is a *VM file name*. In some cases the data set or file has no name; it is known to the system by the device on which it exists.

The operating system needs a way to recognize which physical data set is referred to by your program, so you must provide a statement, external to your program, that associates the PL/I file name with a dsname or a VM file name:

- Under MVS batch, you must write a *data definition* or *DD* statement. For example, if you have the following file declaration in your program:

  ```
  DCL STOCK FILE STREAM INPUT;
  ```

  you should create a DD statement with a *data definition name* (*ddname*) that matches the name of the PL/I file. The DD statement specifies a physical data set name (dsname) and gives its characteristics:

  ```
  //GO.STOCK  DD DSN=PARTS.INSTOCK, . . .
  ```

  You'll find some guidance in writing DD statements in this manual, but for more detail refer to the job control language (JCL) manuals for your system.

- Under TSO, you must write an *ALLOCATE* command. In the declaration shown above for the PL/I file STOCK, you should write a TSO ALLOCATE statement that associates the PL/I file name with the MVS data set name:

  ```
  ALLOCATE FILE(STOCK) DATASET(PARTS.INSTOCK)
  ```

- Under VM, you must write a *FILEDEF* command. For the same STOCK file declaration, a VM FILEDEF should look something like this:

  ```
  FILEDEF STOCK DISK INSTOCK PARTS fm
  ```

There is more than one way to associate a data set with a PL/I file. You associate a data set with a PL/I file by ensuring that the ddname of the DD statement that defines the data set is the same as *either*:

- The declared PL/I file name, *or*
- The character-string value of the expression specified in the TITLE option of the associated OPEN statement.

You must choose your PL/I file names so that the corresponding ddnames conform to the following restrictions:

- If a file is opened implicitly, or if no TITLE option is included in the OPEN statement that explicitly opens the file, the ddname defaults to the file name. If the file name is longer than 8 characters, the default ddname is composed of the first 8 characters of the file name.
- The character set of the job control language does not contain the break character (_). Consequently, this character cannot appear in ddnames. Do not use break characters among the first 8 characters of file names, unless the file is to be opened with a TITLE option with a valid ddname as its expression. The alphabetic extender characters $, @, and #, however, are valid for ddnames, but the first character must be one of the letters A through Z.

Since external names are limited to 7 characters, an external file name of more than 7 characters is shortened into a concatenation of the first 4 and the last 3 characters of the file name. Such a shortened name is *not*, however, the name used as the ddname in the associated DD statement.

Consider the following statements:

1. `OPEN FILE(MASTER);`
2. `OPEN FILE(OLDMASTER);`
3. `READ FILE(DETAIL) ...;`

When statement number 1 is run, the file name MASTER is taken to be the same as the ddname of a DD statement in the current job step. When statement number 2 is run, the name OLDMASTE is taken to be the same as the ddname of a DD statement in the current job step. (The first 8 characters of a file name form the ddname. If OLDMASTER is an external name, it will be shortened by the compiler to OLDMTER for use within the program.) If statement number 3 causes implicit opening of the file DETAIL, the name DETAIL is taken to be the same as the ddname of a DD statement in the current job step.

In each of the above cases, a corresponding DD statement or an equivalent TSO allocate or VM FILEDEF must appear in the job stream; otherwise, the UNDEFINEDFILE condition is raised. The three DD statements could start as follows:

1. `//MASTER   DD ...`
2. `//OLDMASTE DD ...`
3. `//DETAIL   DD ...`

If the file reference in the statement which explicitly or implicitly opens the file is not a file constant, the DD statement name must be the same as the *value* of the file reference. The following example illustrates how a DD statement should be associated with the value of a file variable:

```
DCL PRICES FILE VARIABLE,
    RPRICE FILE;
      PRICES = RPRICE;
      OPEN FILE(PRICES);
```

The DD statement should associate the data set with the file constant RPRICE, which is the value of the file variable PRICES, thus:

```
//RPRICE DD DSNAME=...
```

Use of a file variable also allows you to manipulate a number of files at various times by a single statement. For example:

```
DECLARE F FILE VARIABLE,
        A FILE,
        B FILE,
        C FILE;
          .
          .
          .
     DO F=A,B,C;
        READ FILE (F) ...;
          .
          .
          .
     END;
```

The READ statement reads the three files A, B, and C, each of which can be associated with a different data set. The files A, B, and C remain open after the READ statement is executed in each instance.

The following OPEN statement illustrates use of the TITLE option:

```
OPEN FILE(DETAIL) TITLE('DETAIL1');
```

For this statement to be executed successfully, you must have a DD statement in the current job step with DETAIL1 as its ddname. It could start as follows:

```
//DETAIL1 DD DSNAME=DETAILA,...
```

Thus, you associate the data set DETAILA with the file DETAIL through the ddname DETAIL1.

Associating Several Files with One Data Set

You can use the TITLE option to associate two or more PL/I files with the same external data set at the same time. This is illustrated in the following example, where INVNTRY is the name of a DD statement defining a data set to be associated with two files:

```
OPEN FILE (FILE1) TITLE('INVNTRY');
OPEN FILE (FILE2) TITLE('INVNTRY');
```

If you do this, be careful. These two files access a common data set through separate control blocks and data buffers. When records are written to the data set from one file, the control information for the second file will not record that fact. Records written from the second file could then destroy records written from the first file. PL/I does not protect against data set damage that might occur. If the data set is extended, the extension is reflected only in the control blocks associated with the file that wrote the data; this can cause an abend when other files access the data set.

Associating Several Data Sets with One File

The file name can, at different times, represent entirely different data sets. In the above example of the OPEN statement, the file DETAIL1 is associated with the data set named in the DSNAME parameter of the DD statement DETAIL1. If you closed and reopened the file, you could specify a different ddname in the TITLE option to associate the file with a different data set.

Use of the TITLE option allows you to choose dynamically, at open time, one among several data sets to be associated with a particular file name. Consider the following example:

```
DO IDENT='A','B','C';
   OPEN FILE(MASTER)
        TITLE('MASTER1'||IDENT);
    .
    .
    .
   CLOSE FILE(MASTER);
END;
```

In this example, when MASTER is opened during the first iteration of the do-group, the associated ddname is taken to be MASTER1A. After processing, the file is closed, dissociating the file name and the ddname. During the second iteration of the do-group, MASTER is opened again. This time, MASTER is associated with the ddname MASTER1B. Similarly, during the final iteration of the do-group, MASTER is associated with the ddname MASTER1C.

Concatenating Several Data Sets

Under MVS, for input only, you can concatenate two or more sequential or regional data sets (that is, link them so that they are processed as one continuous data set) by omitting the ddname from all but the first of the DD statements that describe them. For example, the following DD statements cause the data sets LIST1, LIST2, and LIST3 to be treated as a single data set for the duration of the job step in which the statements appear:

```
//GO.LIST DD DSNAME=LIST1,DISP=OLD
//        DD DSNAME=LIST2,DISP=OLD
//        DD DSNAME=LIST3,DISP=OLD
```

When read from a PL/I program, the concatenated data sets need not be on the same volume. You cannot process concatenated data sets backward.

Establishing Data Set Characteristics

A data set consists of records stored in a particular format which the operating system data management routines understand. When you declare or open a file in your program, you are describing to PL/I and to the operating system the characteristics of the records that file will contain. You can also use JCL, TSO ALLOCATEs, or CMS FILEDEFs, to describe to the operating system the characteristics of the data in data sets or in the PL/I files associated with them.

You do not always need to describe your data both within the program and outside it; often one description will serve for both data sets and their associated PL/I files. There are, in fact, advantages to describing your data's characteristics in only one place. These are described later in this chapter and in following chapters.

To effectively describe your program data and the data sets you will be using, you need to understand something of how the operating system moves and stores data.

Blocks and Records

The items of data in a data set are arranged in blocks separated by interblock gaps (IBG). (Some manuals refer to these as interrecord gaps.)

A *block* is the unit of data transmitted to and from a data set. Each block contains one record, part of a record, or several records. You can specify the block size in the BLKSIZE parameter of the DD, ALLOCATE, or FILEDEF statement or in the BLKSIZE option of the ENVIRONMENT attribute.

A *record* is the unit of data transmitted to and from a program. You can specify the record length in the LRECL parameter of the DD, ALLOCATE, or FILEDEF statement or in the RECSIZE option of the ENVIRONMENT attribute.

When writing a PL/I program, you need consider only the records that you are reading or writing; but when you describe the data sets that your program will create or access, you must be aware of the relationship between blocks and records.

Blocking conserves storage space in a magnetic storage volume because it reduces the number of interblock gaps, and it can increase efficiency by reducing the number of input/output operations required to process a data set. Records are blocked and deblocked by the data management routines.

Information Interchange Codes: The normal code in which data is recorded is the Extended Binary Coded Decimal Interchange Code (EBCDIC). However, for magnetic tape only, the operating system accepts data recorded in the American Standard Code for Information Interchange (ASCII). You use the ASCII and BUFOFF options of the ENVIRONMENT attribute if your program will read or write data sets recorded in ASCII.

A prefix field up to 99 bytes in length might be present at the beginning of each block in an ASCII data set. The use of this field is controlled by the BUFOFF option of the ENVIRONMENT attribute. For a full description of the ASCII option, see “ASCII” on page 154.

Each character in the ASCII code is represented by a 7-bit pattern and there are 128 such patterns. The ASCII set includes a substitute character (the SUB control character) that is used to represent EBCDIC characters having no valid ASCII code. The ASCII substitute character is translated to the EBCDIC SUB character, which has the bit pattern 00111111.

Record Formats

The records in a data set have one of the following formats:

Fixed-length
Variable-length
Undefined-length.

Records can be blocked if required. The operating system will deblock fixed-length and variable-length records, but you must provide code in your program to deblock undefined-length records.

You specify the record format in the RECFM parameter of the DD, ALLOCATE, or FILEDEF statement or as an option of the ENVIRONMENT attribute.

Fixed-Length Records

You can specify the following formats for fixed-length records:

F	Fixed-length, unblocked
FB	Fixed-length, blocked
FS	Fixed-length, unblocked, standard
FBS	Fixed-length, blocked, standard.

In a data set with fixed-length records, as shown in Figure 20, all records have the same length. If the records are blocked, each block usually contains an equal number of fixed-length records (although a block can be truncated). If the records are unblocked, each record constitutes a block.

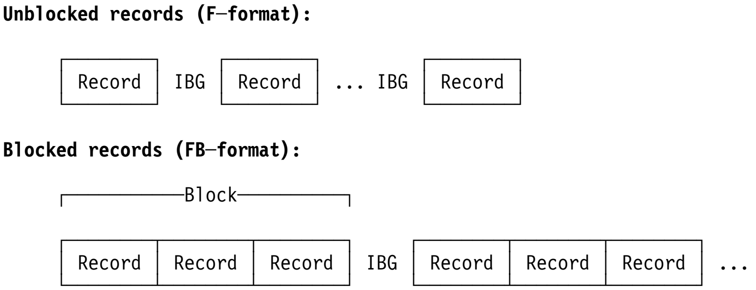


Figure 20. Fixed-Length Records

Because it bases blocking and deblocking on a constant record length, the operating system processes fixed-length records faster than variable-length records.

The use of “standard” (FS-format and FBS-format) records further optimizes the sequential processing of a data set on a direct-access device. A standard format data set must contain fixed-length records and must have no embedded empty tracks or short blocks (apart from the last block). With a standard format data set, the operating system can predict whether the next block of data will be on a new track and, if necessary, can select a new read/write head in anticipation of the transmission of that block. A PL/I program never places embedded short blocks in a data set with fixed-length records. A data set containing fixed-length records can be processed as a standard data set even if it is not created as such, providing it contains no embedded short blocks or empty tracks.

Variable-Length Records

You can specify the following formats for variable-length records:

V	Variable-length, unblocked
VB	Variable-length, blocked
VS	Variable-length, unblocked, spanned
VBS	Variable-length, blocked, spanned
D	Variable-length, unblocked, ASCII
DB	Variable-length, blocked, ASCII.

V-format allows both variable-length records and variable-length blocks. A 4-byte prefix of each record and the first 4 bytes of each block contain control information for use by the operating system (including the length in bytes of the record or block). Because of these control fields, variable-length records cannot be read backward. Illustrations of variable-length records are shown in Figure 21 on page 105.

V-format signifies unblocked variable-length records. Each record is treated as a block containing only one record. The first 4 bytes of the block contain block control information, and the next 4 contain record control information.

VB-format signifies blocked variable-length records. Each block contains as many complete records as it can accommodate. The first 4 bytes of the block contain block control information, and a 4-byte prefix of each record contains record control information.

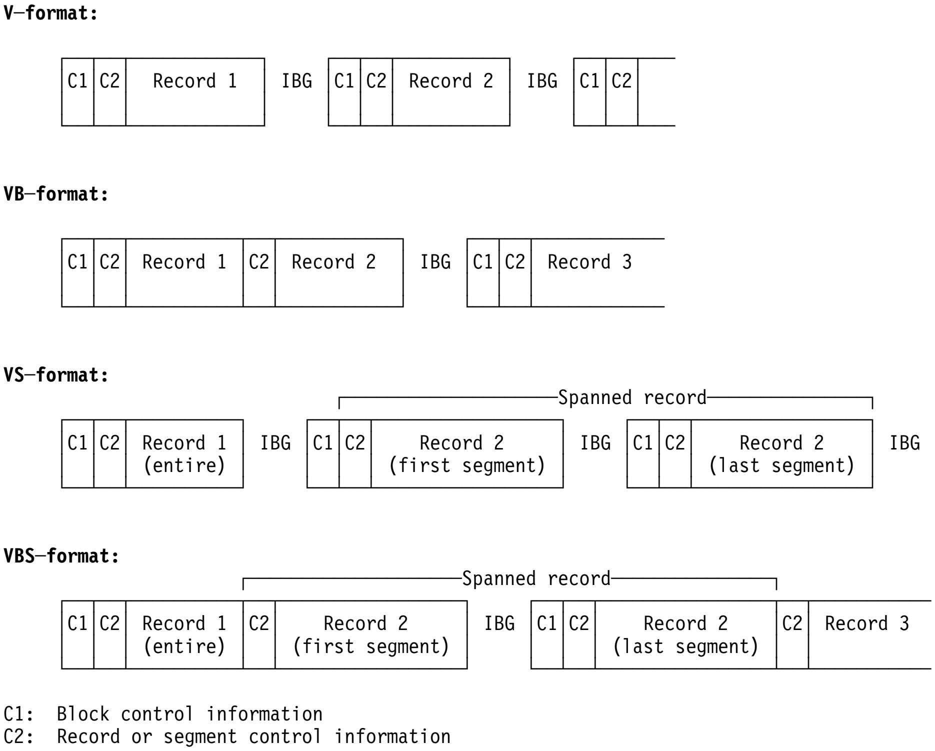

V–format:
C1 C2 Record 1 IBG C1 C2 Record 2 IBG C1 C2
VB–format:
C1 C2 Record 1 C2 Record 2 IBG C1 C2 Record 3
VS–format:
Spanned record
C1 C2 Record 1 (entire) IBG C1 C2 Record 2 (first segment) IBG C1 C2 Record 2 (last segment) IBG
VBS–format:
Spanned record
C1 C2 Record 1 (entire) C2 Record 2 (first segment) IBG C1 C2 Record 2 (last segment) C2 Record 3
C1: Block control information
C2: Record or segment control information

Figure 21. Variable-Length Records

Spanned Records: A spanned record is a variable-length record in which the length of the record can exceed the size of a block. If this occurs, the record is divided into segments and accommodated in two or more consecutive blocks by specifying the record format as either VS or VBS. Segmentation and reassembly are handled by the operating system. The use of spanned records allows you to select a block size, independently of record length, that will combine optimum use of auxiliary storage with maximum efficiency of transmission.

VS-format is similar to V-format. Each block contains only one record or segment of a record. The first 4 bytes of the block contain block control information, and the next 4 contain record or segment control information (including an indication of whether the record is complete or is a first, intermediate, or last segment).

With REGIONAL(3) organization, the use of VS-format removes the limitations on block size imposed by the physical characteristics of the direct-access device. If the record length exceeds the size of a track, or if there is no room left on the current track for the record, the record will be spanned over one or more tracks.

VBS-format differs from VS-format in that each block contains as many complete records or segments as it can accommodate; each block is, therefore, approximately the same size (although there can be a variation of up to 4 bytes, since each segment must contain at least 1 byte of data).

ASCII Records: For data sets that are recorded in ASCII, use D-format as follows:

- D-format records are similar to V-format, except that the data they contain is recorded in ASCII.
- DB-format records are similar to VB-format, except that the data they contain is recorded in ASCII.

Undefined-Length Records

U-format allows the processing of records that do not conform to F- and V-formats. The operating system and the compiler treat each block as a record; your program must perform any required blocking or deblocking.

Data Set Organization

The data management routines of the operating system can handle a number of types of data sets, which differ in the way data is stored within them and in the allowed means of access to the data. The three main types of non-VSAM data sets and the corresponding keywords describing their PL/I organization[1] are as follows:

Type of data set	**PL/I organization**
Sequential	CONSECUTIVE
Indexed sequential	INDEXED
Direct	REGIONAL

The compiler recognizes a fourth type, *teleprocessing*, by the file attribute TRANSIENT.

A fifth type, *partitioned*, has no corresponding PL/I organization.

PL/I also provides support for three types of VSAM data organization: *ESDS*, *KSDS*, and *RRDS*. For more information about VSAM data sets, see Chapter 11, “Defining and Using VSAM Data Sets” on page 211.

In a *sequential* (or CONSECUTIVE) data set, records are placed in physical sequence. Given one record, the location of the next record is determined by its physical position in the data set. Sequential organization is used for all magnetic tapes, and can be selected for direct-access devices.

An *indexed sequential* (or INDEXED) data set must reside on a direct-access volume. An index or set of indexes maintained by the operating system gives the

[1] Do not confuse the terms “sequential” and “direct” with the PL/I file attributes SEQUENTIAL and DIRECT. The attributes refer to how the file is to be processed, and not to the way the corresponding data set is organized.

location of certain principal records. This allows direct retrieval, replacement, addition, and deletion of records, as well as sequential processing.

A *direct* (or REGIONAL) data set must reside on a direct-access volume. The records within the data set can be organized in three ways: REGIONAL(1), REGIONAL(2), and REGIONAL(3); in each case, the data set is divided into regions, each of which contains one or more records. A key that specifies the region number and, for REGIONAL(2) and REGIONAL(3), identifies the record, allows direct-access to any record; sequential processing is also possible.

A *teleprocessing* data set (associated with a TRANSIENT file in a PL/I program) must reside in storage. Records are placed in physical sequence.

In a *partitioned* data set, independent groups of sequentially organized data, each called a member, reside in a direct-access data set. The data set includes a directory that lists the location of each member. Partitioned data sets are often called *libraries*. The compiler includes no special facilities for creating and accessing partitioned data sets. Each member can be processed as a CONSECUTIVE data set by a PL/I program. The use of partitioned data sets as libraries is described under Chapter 7, “Using Libraries” on page 123.

Labels

The operating system uses internal labels to identify magnetic-tape and direct-access volumes, and to store data set attributes (for example, record length and block size). The attribute information must originally come from a DD statement or from your program.

Magnetic-tape volumes can have IBM standard or nonstandard labels, or they can be unlabeled. IBM standard labels have two parts: the initial volume label, and header and trailer labels. The initial volume label identifies a volume and its owner; the header and trailer labels precede and follow each data set on the volume. Header labels contain system information, device-dependent information (for example, recording technique), and data-set characteristics. Trailer labels are almost identical with header labels, and are used when magnetic tape is read backward.

Direct-access volumes have IBM standard labels. Each volume is identified by a volume label, which is stored on the volume. This label contains a volume serial number and the address of a volume table of contents (VTOC). The table of contents, in turn, contains a label, termed a *data set control block* (DSCB), for each data set stored on the volume.

Data Definition (DD) Statement

A data definition (DD) statement is a job control statement that defines a data set to the operating system, and is a request to the operating system for the allocation of input/output resources. If the data sets are not dynamically allocated, each job step must include a DD statement for each data set that is processed by the step.

Your *MVS/ESA JCL User's Guide* describes the syntax of job control statements. The operand field of the DD statement can contain keyword parameters that describe the location of the data set (for example, volume serial number and identification of the unit on which the volume will be mounted) and the attributes of the data itself (for example, record format).

The DD statement enables you to write PL/I source programs that are independent of the data sets and input/output devices they will use. You can modify the parameters of a data set or process different data sets without recompiling your program.

The following paragraphs describe the relationship of some operands of the DD statement to your PL/I program.

The LEAVE and REREAD options of the ENVIRONMENT attribute allow you to use the DISP parameter to control the action taken when the end of a magnetic-tape volume is reached or when a magnetic-tape data set is closed. The LEAVE and REREAD options are described under “LEAVE|REREAD” on page 153, and are also described under “CLOSE Statement” in *PL/I for MVS & VM Language Reference*.

Write validity checking, which was standard in PL/I Version 1, is no longer performed. Write validity checking can be requested through the OPTCD subparameter of the DCB parameter of the JCL DD statement. See the *OS/VS2 TSO Command Language Reference* and *OS/VS2 Job Control Language* manuals.

Use of the Conditional Subparameters

If you use the conditional subparameters of the DISP parameter for data sets processed by PL/I programs, the step abend facility must be used. The step abend facility is obtained as follows:

1. The ERROR condition should be raised or signaled whenever the program is to terminate execution after a failure that requires the application of the conditional subparameters.
2. The PL/I user exit must be changed to request an ABEND.

Data Set Characteristics

The DCB (data control block) parameter of the DD statement allows you to describe the characteristics of the data in a data set, and the way it will be processed, at run time. Whereas the other parameters of the DD statement deal chiefly with the identity, location, and disposal of the data set, the DCB parameter specifies information required for the processing of the records themselves. The subparameters of the DCB parameter are described in your *MVS/ESA JCL User's Guide*.

The DCB parameter contains subparameters that describe:

- The organization of the data set and how it will be accessed (CYLOFL, DSORG, LIMCT, NCP, NTM, and OPTCD subparameters)
- Device-dependent information such as the recording technique for magnetic tape or the line spacing for a printer (CODE, DEN, FUNC, MODE, OPTCD=J, PRTSP, STACK, and TRTCH subparameters)
- The record format (BLKSIZE, KEYLEN, LRECL, RECFM, and RKP subparameters)
- The number of buffers that are to be used (BUFNO subparameter)
- The ASA control characters (if any) that will be inserted in the first byte of each record (RECFM subparameter).

You can specify BLKSIZE, BUFNO, LRECL, KEYLEN, NCP, RECFM, RKP, and TRKOFL (or their equivalents) in the ENVIRONMENT attribute of a file declaration in your PL/I program instead of in the DCB parameter.

You cannot use the DCB parameter to override information already established for the data set in your PL/I program (by the file attributes declared and the other attributes that are implied by them). DCB subparameters that attempt to change information already supplied are ignored.

An example of the DCB parameter is:

```
DCB=(RECFM=FB,BLKSIZE=400,LRECL=40)
```

which specifies that fixed-length records, 40 bytes in length, are to be grouped together in a block 400 bytes long.

Associating PL/I Files with Data Sets

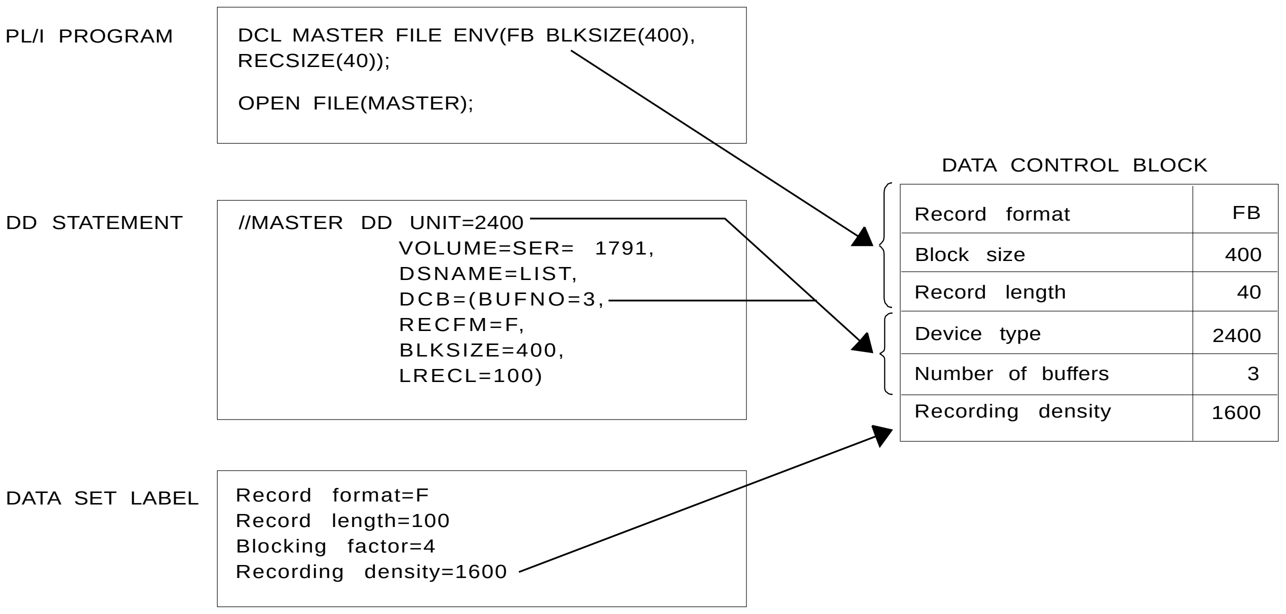
Opening a File: The execution of a PL/I OPEN statement associates a file with a data set. This requires merging of the information describing the file and the data set. If any conflict is detected between file attributes and data set characteristics, the UNDEFINEDFILE condition is raised.

Subroutines of the PL/I library create a skeleton data control block for the data set. They use the file attributes from the DECLARE and OPEN statements and any attributes implied by the declared attributes, to complete the data control block as far as possible. (See Figure 22 on page 110.) They then issue an OPEN macro instruction, which calls the data management routines to check that the correct volume is mounted and to complete the data control block.

The data management routines examine the data control block to see what information is still needed and then look for this information, first in the DD statement, and finally, if the data set exists and has standard labels, in the data set labels. For new data sets, the data management routines begin to create the labels (if they are required) and to fill them with information from the data control block.

Neither the DD statement nor the data set label can override information provided by the PL/I program; nor can the data set label override information provided by the DD statement.

When the DCB fields are filled in from these sources, control returns to the PL/I library subroutines. If any fields still are not filled in, the PL/I OPEN subroutine provides default information for some of them. For example, if LRECL is not specified, it is provided from the value given for BLKSIZE.



```
DCL MASTER FILE ENV(FB BLKSIZE(400),
RECSIZE(40));

OPEN FILE(MASTER);
```

```
//MASTER  DD  UNIT=2400
              VOLUME=SER= 1791,
              DSNAME=LIST,
              DCB=(BUFNO=3,
              RECFM=F,
              BLKSIZE=400,
              LRECL=100)
```

```
Record format=F
Record length=100
Blocking factor=4
Recording density=1600
```

Record format	FB
Block size	400
Record length	40
Device type	2400
Number of buffers	3
Recording density	1600

Note: Information from the PL/I program overrides that from the DD statement and the data set label.
Information from the DD statement overrides that from the data set label.

Figure 22. How the Operating System Completes the DCB

Closing a File: The execution of a PL/I CLOSE statement dissociates a file from the data set with which it was associated. The PL/I library subroutines first issue a CLOSE macro instruction and, when control returns from the data management routines, release the data control block that was created when the file was opened. The data management routines complete the writing of labels for new data sets and update the labels of existing data sets.

Specifying Characteristics in the ENVIRONMENT Attribute

You can use various options in the ENVIRONMENT attribute. Each type of file has different attributes and environment options, which are listed below.

The ENVIRONMENT Attribute: You use the ENVIRONMENT attribute of a PL/I file declaration file to specify information about the physical organization of the data set associated with a file, and other related information. The format of this information must be a parenthesized option list.

```
►►──ENVIRONMENT──(──option-list──)──────────────────────────────►◄
```

Abbreviation: ENV

You can specify the options in any order, separated by blanks or commas.

The following example illustrates the syntax of the ENVIRONMENT attribute in the context of a complete file declaration (the options specified are for VSAM and are discussed in Chapter 11, “Defining and Using VSAM Data Sets” on page 211).

```
DCL FILENAME FILE RECORD SEQUENTIAL
    INPUT ENV(VSAM GENKEY);
```

Table 15 summarizes the ENVIRONMENT options and file attributes. Certain qualifications on their use are presented in the notes and comments for the figure. Those options that apply to more than one data set organization are described in the remainder of this chapter. In addition, in the following chapters, each option is described with each data set organization to which it applies.

Table 15 (Page 1 of 2). Attributes of PL/I File Declarations

Data set type	**Stream**	**Record**										**Legend:** **C Checked for VSAM** **D Default** **I Must be specified or implied** **N Ignored for VSAM** **O Optional** **S Must be specified** **- Invalid**
		Sequential							**Direct**			
		Consecutive		**Regional**		**Teleprocessing**						
File Type	**Consecutive**	**Buffered**	**Unbuffered**	**Buffered**	**Unbuffered**		**Indexed**	**VSAM**	**Regional**	**Indexed**	**VSAM**	
File attributes[1]												**Attributes implied**
File	I	I	I	I	I	I	I	I	I	I	I	
Input[1]	D	D	D	D	D	D	D	D	D	D	D	File
Output	O	O	O	O	O	O	O	O	O	O	O	File
Environment	I	I	I	S	S	S	S	S	S	S	S	File
Stream	D	-	-	-	-	-	-	-	-	-	-	File
Print[1]	O	-	-	-	-	-	-	-	-	-	-	File stream output
Record	-	I	I	I	I	I	I	I	I	I	I	File
Update[2]	-	O	O	O	O	-	O	O	O	O	O	File record
Sequential	-	D	D	D	D	-	D	D	-	-	D	File record
Buffered	-	D	-	D	-	I	D	D	-	-	S	File record
Unbuffered	-	-	S	-	S	-	-	S	D	D	D	File record
Backwards[3]	-	O	O	-	-	-	-	-	-	-	-	File record sequential input
Transient	-	-	-	-	-	I	-	-	-	-	-	File
Keyed[4]	-	-	-	O	O	I	O	O	I	I	O	File record
Direct	-	-	-	-	-	-	-	S	S	S	S	File record keyed
Exclusive	-	-	-	-	-	-	-	-	O	O	-	File record direct keyed update
ENVIRONMENT options												**Comments**
F|FB|FS|FBS|V| VB||VS|VBS|U	I	S	S	-	-	-	-	N	-	-	N	VS and VBS are invalid with STREAM
F|FB|D|DB|U	S	S	-	-	-	-	-	N	-	-	N	ASCII data sets only
F|V|VS|U	-	-	-	S	S	-	-	N	S	-	N	Only F for REGIONAL(1) and (2)
F|FB|V|VB	-	-	-	-	-	-	S	N	-	S	N	VS invalid with UNBUF
RECSIZE(n)	I	I	I	I	I	S	I	C	I	I	C	RECSIZE and/or BLKSIZE must be specified
BLKSIZE(n)	I	I	I	I	I	-	I	N	I	I	N	for consecutive, indexed, and regional files
NCP(n)	-	O	O	O	O	-	O	N	O	O	N	NCP>1 for VSAM specifies ISAM compatibility
TRKOFL	-	O	O	O	O	-	-	-	O	-	-	Invalid for REGIONAL(3)
KEYLENGTH(n)	-	-	-	S	S	-	S	C	S	S	C	For REGIONAL(2) and (3) OUTPUT ONLY
COBOL	-	O	O	O	O	-	O	O	O	O	O	
BUFFERS(n)	I	I	-	I	-	I	I	N	-	-	N	
SCALARVARYING	-	O	O	O	O	-	O	O	O	O	O	Invalid for ASCII data sets
CONSECUTIVE	D	D	D	-	-	-	-	O	-	-	O	Allowed for VSAM ESDS
TOTAL	-	O	-	-	-	-	-	-	-	-	-	
LEAVE	O	O	O	-	-	-	-	-	-	-	-	
REREAD	O	O	O	-	-	-	-	-	-	-	-	
ASCII	O	O	-	-	-	-	-	-	-	-	-	
BUFOFF(n)	O	O	-	-	-	-	-	-	-	-	-	
CTLASA|CTL360	-	O	O	-	-	-	-	-	-	-	-	Invalid for ASCII data sets
GRAPHIC	O	-	-	-	-	-	-	-	-	-	-	
TP({M|R})	-	-	-	-	-	S	-	-	-	-	-	
INDEXED	-	-	-	-	-	-	S	O	-	S	O	Allowed for VSAM ESDS
KEYLOC(n)	-	-	-	-	-	-	O	-	-	O	-	
INDEXAREA(n)	-	-	-	-	-	-	-	-	-	O	-	
ADDBUFF	-	-	-	-	-	-	-	-	-	O	-	
NOWRITE	-	-	-	-	-	-	-	-	-	O	-	UPDATE files only
GENKEY	-	-	-	-	-	-	O	O	-	O	O	INPUT or UPDATE files only; KEYED is required
REGIONAL({1|2|3})	-	-	-	S	S	-	-	-	S	-	-	
VSAM	-	-	-	-	-	-	-	S	-	-	S	

Table 15 (Page 2 of 2). Attributes of PL/I File Declarations

Data set type	Stream	Record										Legend: C Checked for VSAM D Default I Must be specified or implied N Ignored for VSAM O Optional S Must be specified - Invalid
File Type		Sequential							Direct			
		Consecutive		Regional		Teleprocessing	Indexed	VSAM	Regional	Indexed	VSAM	
	Consecutive	Buffered	Unbuffered	Buffered	Unbuffered							
PASSWORD	-	-	-	-	-	-	-	O	-	-	O	
SIS	-	-	-	-	-	-	-	-	-	-	O	
SKIP	-	-	-	-	-	-	-	O	-	-	-	
BKWD	-	-	-	-	-	-	-	O	-	-	O	
REUSE	-	-	-	-	-	-	-	O	-	-	O	OUTPUT file only
BUFND(n)	-	-	-	-	-	-	-	O	-	-	O	
BUFNI(n)	-	-	-	-	-	-	-	O	-	-	O	
BUFSP(n)	-	-	-	-	-	-	-	O	-	-	O	

Notes:

1. A file with the INPUT attribute cannot have the PRINT attribute.
2. UPDATE is invalid for tape files.
3. BACKWARDS is valid only for input tape files.
4. Keyed is required for INDEXED and REGIONAL output.

Data Set Organization Options: The options that specify data set organization are:

```
►►──┬─CONSECUTIVE───────────────┬──────────────────────────────────────────►◄
    ├─INDEXED───────────────────┤
    ├─REGIONAL──(──┬─1─┬──)─────┤
    │              ├─2─┤        │
    │              └─3─┘        │
    ├─TP──(──┬─M─┬──)───────────┤
    │        └─R─┘              │
    └─VSAM──────────────────────┘
```

Each option is described in the discussion of the data set organization to which it applies.

If you don't specify the data set organization option in the ENVIRONMENT attribute, it defaults in the following manner when the file is opened:

- If merged attributes from DECLARE and OPEN statements do not include TRANSIENT, the default is CONSECUTIVE.
- If the attributes include TRANSIENT, the default is TP(M).

Other ENVIRONMENT Options: You can use a constant or variable with those ENVIRONMENT options that require integer arguments, such as block sizes and record lengths. The variable must not be subscripted or qualified, and must have attributes FIXED BINARY(31,0) and STATIC.

Some of the information that can be specified in the options of the ENVIRONMENT attribute can also be specified—when TOTAL is not specified—in the subparameters of the DCB parameter of a DD statement. The list of equivalents for ENVIRONMENT options and DCB parameters are:

ENVIRONMENT option	**DCB subparameter**
Record format	RECFM[1]
RECSIZE	LRECL
BLKSIZE	BLKSIZE
BUFFERS	BUFNO
CTLASA|CTL360	RECFM
NCP	NCP
TRKOFL	RECFM
KEYLENGTH	KEYLEN
KEYLOC	RKP
ASCII	ASCII
BUFOFF	BUFOFF

Note: [1]VS must be specified as an ENVIRONMENT option, not in the DCB.

Record Formats for Record-Oriented Data Transmission: Record formats supported depend on the data set organization.

```
►►──┬─F───┬────────────────────────────────────────────────────►◄
    ├─FB──┤
    ├─FS──┤
    ├─FBS─┤
    ├─V───┤
    ├─VB──┤
    ├─VS──┤
    ├─VBS─┤
    ├─D───┤
    ├─DB──┤
    └─U───┘
```

Records can have one of the following formats:

Fixed-length	F	unblocked
	FB	blocked
	FS	unblocked, standard
	FBS	blocked, standard
Variable-length	V	unblocked
	VB	blocked
	VS	spanned
	VBS	blocked, spanned
	D	unblocked, ASCII
	DB	blocked, ASCII
Undefined-length	U	(cannot be blocked)

When U-format records are read into a varying-length string, PL/I sets the length of the string to the block length of the retrieved data.

These record format options do not apply to VSAM data sets. If you specify a record format option for a file associated with a VSAM data set, the option is ignored.

You can only specify VS-format records for data sets with consecutive or REGIONAL(3) organization.

Record Formats for Stream-Oriented Data Transmission: The record format options for stream-oriented data transmission are discussed in “Using Stream-Oriented Data Transmission” on page 129.

RECSIZE Option: The RECSIZE option specifies the record length.

```
►►──RECSIZE──(──record-length──)──────────────────────────────────────►◄
```

For files other than TRANSIENT files and files associated with VSAM data sets, **record-length** is the sum of:

1. The length required for data. For variable-length and undefined-length records, this is the maximum length.
2. Any control bytes required. Variable-length records require 4 (for the record-length prefix); fixed-length and undefined-length records do not require any.

For a TRANSIENT file, it is the sum of:

1. The four V-format control bytes
2. One flag byte
3. Eight bytes for the key (origin or destination identifier)
4. The maximum length required for the data.

For VSAM data sets, the maximum and average lengths of the records are specified to the Access Method Services utility when the data set is defined. If you include the RECSIZE option in the file declaration for checking purposes, you should specify the maximum record size. If you specify RECSIZE and it conflicts with the values defined for the data set, the UNDEFINEDFILE condition is raised.

You can specify **record-length** as an integer or as a variable with attributes FIXED BINARY(31,0) STATIC.

The value is subject to the following conventions:

Maximum:

Fixed-length, and undefined (except ASCII data sets): 32760

V-format, and VS- and VBS-format with UPDATE files: 32756

VS- and VBS-format with INPUT and OUTPUT files: 16777215

ASCII data sets: 9999

VSAM data sets: 32761 for unspanned records. For spanned records, the maximum is the size of the control area.

Note: For VS- and VBS-format records longer than 32,756 bytes, you must specify the length in the RECSIZE option of ENVIRONMENT, and for the DCB subparameter of the DD statement you must specify LRECL=X. If RECSIZE exceeds the allowed maximum for INPUT or OUTPUT, either a record condition occurs or the record is truncated.

Zero value:

A search for a valid value is made *first*:

- In the DD statement for the data set associated with the file, and *second*
- In the data set label.

If neither of these provides a value, default action is taken (see “Record Format, BLKSIZE, and RECSIZE Defaults” on page 117).

Negative Value:

The UNDEFINEDFILE condition is raised.

BLKSIZE Option: The BLKSIZE option specifies the maximum block size on the data set.

```
►►──BLKSIZE──(──block-size──)──────────────────────────────────────────►◄
```

block-size is the sum of:

1. The total length(s) of one of the following:

   - A single record
   - A single record and either one or two record segments
   - Several records
   - Several records and either one or two record segments
   - Two record segments
   - A single record segment.

   For variable-length records, the length of each record or record segment includes the 4 control bytes for the record or segment length.

   The above list summarizes all the possible combinations of records and record segments options: fixed- or variable-length blocked or unblocked, spanned or unspanned. When specifying a block size for spanned records, you must be aware that each record and each record segment requires 4 control bytes for the record length, and that these quantities are in addition to the 4 control bytes required for each block.

2. Any further control bytes required.

   - Variable-length blocked records require 4 (for the block size).
   - Fixed-length and undefined-length records do not require any further control bytes.

3. Any block prefix bytes required (ASCII data sets only).

block-size can be specified as an integer, or as a variable with attributes FIXED BINARY(31,0) STATIC.

The value is subject to the following conventions:

Maximum:
: 32760 (or 9999 for an ASCII data set for which BUFOFF without a prefix-length value has been specified).

  In regional 3 files, the maximum declared block size must not exceed 32,680 bytes. This is because the 32,760 byte maximum for block size consists of the declared block size plus the key length plus the length of the IOCB. If you declare “BLKSIZE=32760”, when the keylength and IOCB length are added to it, the maximum is exceeded and an “UNDEFINED FILE” error message is issued.

Zero value:
: If you set BLKSIZE to 0, under MVS, the Data Facility Product sets the block size. For an elaboration of this topic, see “Record Format, BLKSIZE, and RECSIZE Defaults” on page 117. BLKSIZE defaults.

Negative value:
: The UNDEFINEDFILE condition is raised.

The relationship of block size to record length depends on the record format:

FB-format or FBS-format:
: The block size must be a multiple of the record length.

VB-format:
: The block size must be equal to or greater than the sum of:

  1. The maximum length of any record
  2. Four control bytes.

VS-format or VBS-format:
: The block size can be less than, equal to, or greater than the record length.

DB-format:
: The block size must be equal to or greater than the sum of:

  1. The maximum length of any record
  2. The length of the block prefix (if block is prefixed).

Notes:

- Use the BLKSIZE option with unblocked (F-, V-, or D-format) records in either of the following ways:

  – Specify the BLKSIZE option, but not the RECSIZE option. Set the record length equal to the block size (minus any control or prefix bytes), and leave the record format unchanged.

  - Specify both BLKSIZE and RECSIZE and ensure that the relationship of the two values is compatible with blocking for the record format you use. Set the record format to FB, VB, or DB, whichever is appropriate.

- If for FB-format or FBS-format records the block size equals the record length, the record format is set to F.

- For REGIONAL(3) data sets with VS format, record length cannot be greater than block size.

- The BLKSIZE option does not apply to VSAM data sets, and is ignored if you specify it for one.

Record Format, BLKSIZE, and RECSIZE Defaults: If you do not specify either the record format, block size, or record length for a non-VSAM data set, the following default action is taken:

Record format:

A search is made in the associated DD statement or data set label. If the search does not provide a value, the UNDEFINEDFILE condition is raised, except for files associated with dummy data sets or the foreground terminal, in which case the record format is set to U.

Block size or record length:

If one of these is specified, a search is made for the other in the associated DD statement or data set label. If the search provides a value, and if this value is incompatible with the value in the specified option, the UNDEFINEDFILE condition is raised. If the search is unsuccessful, a value is derived from the specified option (with the addition or subtraction of any control or prefix bytes).

If neither is specified, the UNDEFINEDFILE condition is raised, except for files associated with dummy data sets, in which case BLKSIZE is set to 121 for F-format or U-format records and to 129 for V-format records. For files associated with the foreground terminal, RECSIZE is set to 120.

If you are using MVS with the Data Facility Product system-determined block size, DFP determines the optimum block size for the device type assigned. If you specify BLKSIZE(0) in either the DD assignment or the ENVIRONMENT statement, DFP calculates BLKSIZE using the record length, record format, and device type.

BUFFERS Option: A buffer is a storage area that is used for the intermediate storage of data transmitted to and from a data set. The use of buffers can speed up processing of SEQUENTIAL files. Buffers are essential for blocking and deblocking records and for locate-mode transmission.

Use the BUFFERS option in the ENVIRONMENT attribute to specify buffers to be allocated for CONSECUTIVE and INDEXED data sets, according to the following syntax:

```
►►──BUFFERS──(──n──)──────────────────────────────────────────────────►◄
```

where *n* is the number of buffers you want allocated for your data set, not to exceed 255 (or such other maximum as is established for your PL/I installation).

If you specify zero, PL/I uses two buffers. A REGIONAL data set is always allocated two buffers.

In teleprocessing, the BUFFERS option specifies the number of buffers available for a particular message queue; that is, for a particular TRANSIENT file. The buffer size is specified in the message control program for the installation. The number of buffers specified should, if possible, be sufficient to provide for the longest message to be transmitted.

The BUFFERS option is ignored for VSAM; you use the BUFNI, BUFND, and BUFSP options instead.

GENKEY Option — Key Classification: The GENKEY (generic key) option applies only to INDEXED and VSAM key-sequenced data sets. It enables you to classify keys recorded in a data set and to use a SEQUENTIAL KEYED INPUT or SEQUENTIAL KEYED UPDATE file to access records according to their key classes.

```
►►──GENKEY────────────────────────────────────────────────────────────►◄
```

A generic key is a character string that identifies a class of keys; all keys that begin with the string are members of that class. For example, the recorded keys “ABCD”, “ABCE”, and “ABDF” are all members of the classes identified by the generic keys “A” and “AB”, and the first two are also members of the class “ABC”; and the three recorded keys can be considered to be unique members of the classes “ABCD”, “ABCE”, and “ABDF”, respectively.

The GENKEY option allows you to start sequential reading or updating of a VSAM data set from the first record that has a key in a particular class, and for an INDEXED data set from the first nondummy record that has a key in a particular class. You identify the class by including its generic key in the KEY option of a READ statement. Subsequent records can be read by READ statements without the KEY option. No indication is given when the end of a key class is reached.

Although you can retrieve the first record having a key in a particular class by using a READ with the KEY option, you cannot obtain the actual key unless the records have embedded keys, since the KEYTO option cannot be used in the same statement as the KEY option.

In the following example, a key length of more than 3 bytes is assumed:

```
DCL IND FILE RECORD SEQUENTIAL KEYED
   UPDATE ENV (INDEXED GENKEY);
          .
          .
          .
       READ FILE(IND) INTO(INFIELD)
                      KEY ('ABC');
          .
          .
          .
NEXT:  READ FILE (IND) INTO (INFIELD);
          .
          .
          .
       GO TO NEXT;
```

The first READ statement causes the first nondummy record in the data set whose key begins with “ABC” to be read into INFIELD; each time the second READ statement is executed, the nondummy record with the next higher key is retrieved. Repeated execution of the second READ statement could result in reading records from higher key classes, since no indication is given when the end of a key class is reached. It is your responsibility to check each key if you do not wish to read beyond the key class. Any subsequent execution of the first READ statement would reposition the file to the first record of the key class “ABC”.

If the data set contains no records with keys in the specified class, or if all the records with keys in the specified class are dummy records, the KEY condition is raised. The data set is then positioned either at the next record that has a higher key or at the end of the file.

The presence or absence of the GENKEY option affects the execution of a READ statement which supplies a source key that is shorter than the key length specified in the KEYLEN subparameter. This KEYLEN subparameter is found in the DD statement that defines the indexed data set. If you specify the GENKEY option, it causes the source key to be interpreted as a generic key, and the data set is positioned to the first nondummy record in the data set whose key begins with the source key. If you do not specify the GENKEY option, a READ statement's short source key is padded on the right with blanks to the specified key length, and the data set is positioned to the record that has this padded key (if such a record exists). For a WRITE statement, a short source key is always padded with blanks.

Use of the GENKEY option does not affect the result of supplying a source key whose length is greater than or equal to the specified key length. The source key, truncated on the right if necessary, identifies a specific record (whose key can be considered to be the only member of its class).

NCP Option — Number of Channel Programs: The NCP option specifies the number of incomplete input/output operations with the EVENT option that can be handled for the file at any one time.

```
►►──NCP──(──n──)──────────────────────────────────────────────────►◄
```

For *n* you specify an integer in the range 1 through 99. If you do not specify anything, *n* defaults to 1.

For consecutive and regional sequential files, it is an error to allow more than the specified number of events to be outstanding.

For indexed files, any excess operations are queued, and no condition is raised. However, specifying the number of channel programs required can aid optimization of I/O with an indexed file. The NCP option has no effect with a regional direct file.

A file declared with ENVIRONMENT(VSAM) can never have more than one incomplete input/output operation at any one time. If you specify the NCP option for such a file, it is ignored. For information about the NCP option for VSAM with the ISAM compatibility interface, see "Using the VSAM Compatibility Interface" on page 225.

TRKOFL Option — Track Overflow: Track overflow is a feature of the operating system that can be incorporated at PL/I installation time; it requires the record overflow feature on the direct-access storage control unit. Track overflow allows a record to overflow from one track to another. It is useful in achieving a greater data-packing efficiency, and allows the size of a record to exceed the capacity of a track.

```
►►──TRKOFL──────────────────────────────────────────────────────────►◄
```

Track overflow is not available for REGIONAL(3) or INDEXED data sets.

COBOL Option — Data Interchange: The COBOL option specifies that structures in the data set associated with the file will be mapped as they would be in a COBOL compiler. The COBOL structures can be synchronized or unsynchronized; it is your responsibility to ensure that the associated PL/I structure has the equivalent alignment stringency; that is, it must be ALIGNED or UNALIGNED, respectively.

```
►►──COBOL───────────────────────────────────────────────────────────►◄
```

The following restrictions apply to the handling of a file with the COBOL option:

- You can only use a file with the COBOL option for READ INTO, WRITE FROM, and REWRITE FROM statements.
- You cannot pass the file name as an argument or assign it to a file variable.
- You must subscript any array variable to be transmitted.
- If a condition is raised during the execution of a READ statement, you cannot use the variable named in the INTO option in the ON-unit. If the completed INTO variable is required, there must be a normal return from the ON-unit.
- You can use the EVENT option only if the compiler determines that the PL/I and COBOL structure mappings are identical (that is, all elementary items have identical boundaries). If the mappings are not identical, or if the compiler cannot tell whether they are identical, an intermediate variable is created to represent the level-1 item as mapped by the COBOL algorithm. The PL/I

variable is assigned to the intermediate variable before a WRITE statement is executed, or assigned from it after a READ statement has been executed.

SCALARVARYING Option — Varying-Length Strings: You use the SCALARVARYING option in the input/output of varying-length strings; you can use it with records of any format.

```
►►──SCALARVARYING─────────────────────────────────────────────────────►◄
```

When storage is allocated for a varying-length string, the compiler includes a 2-byte prefix that specifies the current length of the string. For an element varying-length string, this prefix is included on output, or recognized on input, only if SCALARVARYING is specified for the file.

When you use locate mode statements (LOCATE and READ SET) to create and read a data set with element varying-length strings, you must specify SCALARVARYING to indicate that a length prefix is present, since the pointer that locates the buffer is always assumed to point to the start of the length prefix.

When you specify SCALARVARYING and element varying-length strings are transmitted, you must allow two bytes in the record length to include the length prefix.

A data set created using SCALARVARYING should be accessed only by a file that also specifies SCALARVARYING.

You must not specify SCALARVARYING and CTLASA/CTL360 for the same file, as this causes the first data byte to be ambiguous.

KEYLENGTH Option: Use the KEYLENGTH option to specify the length of the recorded key for KEYED files where *n* is the length. You can specify KEYLENGTH for INDEXED or REGIONAL(3) files.

```
►►──KEYLENGTH──(──n──)────────────────────────────────────────────────►◄
```

If you include the KEYLENGTH option in a VSAM file declaration for checking purposes, and the key length you specify in the option conflicts with the value defined for the data set, the UNDEFINEDFILE condition is raised.

Data Set Types Used by PL/I Record I/O

Data sets with the RECORD attribute are processed by record-oriented data transmission in which data is transmitted to and from auxiliary storage exactly as it appears in the program variables; no data conversion takes place. A record in a data set corresponds to a variable in the program.

Table 16 on page 122 shows the facilities that are available with the various types of data sets that can be used with PL/I Record I/O.

The following chapters describe how to use Record I/O data sets for different types of data sets:

- Chapter 8, “Defining and Using Consecutive Data Sets” on page 129
- Chapter 9, “Defining and Using Indexed Data Sets” on page 163

- Chapter 10, “Defining and Using Regional Data Sets” on page 185
- Chapter 11, “Defining and Using VSAM Data Sets” on page 211
- Chapter 12, “Defining and Using Teleprocessing Data Sets” on page 255

Table 16. A Comparison of Data Set Types Available to PL/I Record I/O

	VSAM KSDS	VSAM ESDS	VSAM RRDS	INDEXED	CONSECUTIVE	REGIONAL (1)	REGIONAL (2)	REGIONAL (3)
SEQUENCE	Key order	Entry order	Numbered	Key order	Entry order	By region	By region	By region
DEVICES	DASD	DASD	DASD	DASD	DASD, tape, card, etc.	DASD	DASD	DASD
ACCESS 1 By key 2 Sequential 3 Backward	123	123	123	12	2 3 tape only	12	12	12
Alternate index access as above	123	123	No	No	No	No	No	No
How extended	With new keys	At end	In empty slots	With new keys	At end	In empty slots	With new keys	With new keys
SPANNED RECORDS	Yes	Yes	No	Yes	Yes	No	No	Yes
DELETION 1 Space reusable 2 Space not reusable	Yes, 1	No	Yes, 1	Yes, 2	No	Yes, 2	Yes, 2	Yes, 2

Chapter 7. Using Libraries

Within the MVS operating system, the terms “partitioned data set” and “library” are synonymous and refer to a type of data set that can be used for the storage of other data sets (usually programs in the form of source, object or load modules). A library must be stored on direct-access storage and be wholly contained in one volume. It contains independent, consecutively organized data sets, called members. Each member has a unique name, not more than 8 characters long, which is stored in a directory that is part of the library. All the members of one library must have the same data characteristics because only one data set label is maintained.

You can create members individually until there is insufficient space left for a new entry in the directory, or until there is insufficient space for the member itself. You can access members individually by specifying the member name.

Use DD statements or their conversational mode equivalent to create and access members.

You can delete members by means of the IBM utility program IEHPROGM. This deletes the member name from the directory so that the member can no longer be accessed, but you cannot use the space occupied by the member itself again unless you recreate the library or compress the unused space using, for example, the IBM utility program IEBCOPY. If you attempt to delete a member by using the DISP parameter of a DD statement, it causes the whole data set to be deleted.

PL/I does not support VM MACLIBS as libraries.

Types of libraries

You can use the following types of libraries with a PL/I program:

- The system program library SYS1.LINKLIB or its equivalent. This can contain all system processing programs such as compilers and the linkage editor.
- Private program libraries. These usually contain user-written programs. It is often convenient to create a temporary private library to store the load module output from the linkage editor until it is executed by a later job step in the same job. The temporary library will be deleted at the end of the job. Private libraries are also used for automatic library call by the linkage editor and the loader.
- The system procedure library SYS1.PROCLIB or its equivalent. This contains the job control procedures that have been cataloged for your installation.

How to Use a Library

A PL/I program can use a library directly. If you are adding a new member to a library, its directory entry will be made by the operating system when the associated file is closed, using the member name specified as part of the data set name.

If you are accessing a member of a library, its directory entry can be found by the operating system from the member name that you specify as part of the data set name.

More than one member of the same library can be processed by the same PL/I program, but only one such output file can be open at any one time. You access different members by giving the member name in a DD statement.

Creating a Library

To create a library include in your job step a DD statement containing the information given in Table 17. The information required is similar to that for a consecutively organized data set (see “Defining Files Using Record I/O” on page 150) except for the SPACE parameter.

Table 17. Information Required When Creating a Library

Information required	Parameter of DD statement
Type of device that will be used	UNIT=
Serial number of the volume that will contain the library	VOLUME=SER
Name of the library	DSNAME=
Amount of space required for the library	SPACE=
Disposition of the library	DISP=

SPACE Parameter

The SPACE parameter in a DD statement that defines a library must always be of the form:

```
SPACE=(units,(quantity,increment,directory))
```

Although you can omit the third term (increment), indicating its absence by a comma, the last term, specifying the number of directory blocks to be allocated, must always be present.

The amount of auxiliary storage required for a library depends on the number and sizes of the members to be stored in it and on how often members will be added or replaced. (Space occupied by deleted members is not released.) The number of directory blocks required depends on the number of members and the number of aliases. You can specify an incremental quantity in the SPACE parameter that allows the operating system to obtain more space for the data set, if such is necessary at the time of creation or at the time a new member is added; the number of directory blocks, however, is fixed at the time of creation and cannot be increased.

For example, the DD statement:

```
//PDS DD UNIT=SYSDA,VOL=SER=3412,
//   DSNAME=ALIB,
//   SPACE=(CYL,(5,,10)),
//   DISP=(,CATLG)
```

requests the job scheduler to allocate 5 cylinders of the DASD with a volume serial number 3412 for a new library name ALIB, and to enter this name in the system catalog. The last term of the SPACE parameter requests that part of the space allocated to the data set be reserved for ten directory blocks.

Creating and Updating a Library Member

The members of a library must have identical characteristics. Otherwise, you might later have difficulty retrieving them. Identical characteristics are necessary because the volume table of contents (VTOC) will contain only one data set control block (DSCB) for the library and not one for each member. When using a PL/I program to create a member, the operating system creates the directory entry; you cannot place information in the user data field.

When creating a library and a member at the same time, your DD statement must include all the parameters listed under "Creating a Library" on page 124 (although you can omit the DISP parameter if the data set is to be temporary). The DSNAME parameter must include the member name in parentheses. For example, DSNAME=ALIB(MEM1) names the member MEM1 in the data set ALIB. If the member is placed in the library by the linkage editor, you can use the linkage editor NAME statement or the NAME compile-time option instead of including the member name in the DSNAME parameter. You must also describe the characteristics of the member (record format, etc.) either in the DCB parameter or in your PL/I program. These characteristics will also apply to other members added to the data set.

When creating a member to be added to an existing library, you do not need the SPACE parameter. The original space allocation applies to the whole of the library and not to an individual member. Furthermore, you do not need to describe the characteristics of the member, since these are already recorded in the DSCB for the library.

To add two more members to a library in one job step, you must include a DD statement for each member, and you must close one file that refers to the library before you open another.

Examples

The use of the cataloged procedure IEL1C to compile a simple PL/I program and place the object module in a new library named EXLIB is shown in Figure 23 on page 126. The DD statement that defines the new library and names the object module overrides the DD statement SYSLIN in the cataloged procedure. (The PL/I program is a function procedure that, given two values in the form of the character string produced by the TIME built-in function, returns the difference in milliseconds.)

The use of the cataloged procedure IEL1CL to compile and link-edit a PL/I program and place the load module in the existing library HPU8.CCLM is shown in Figure 24 on page 126.

```
//OPT10#1 JOB
//TR        EXEC  IEL1C
//PLI.SYSLIN  DD  UNIT=SYSDA,DSNAME=HPU8.EXLIB(ELAPSE),
//      SPACE=(TRK,(1,,1)),DISP=(NEW,CATLG)
//PLI.SYSIN   DD  *
   ELAPSE:  PROC(TIME1,TIME2);
     DCL (TIME1,TIME2) CHAR(9),
         H1 PIC '99' DEF TIME1,
         M1 PIC '99' DEF TIME1 POS(3),
         MS1 PIC '99999' DEF TIME1 POS(5),
         H2 PIC '99' DEF TIME2,
         M2 PIC '99' DEF TIME2 POS(3),
         MS2 PIC '99999' DEF TIME2 POS(5),
         ETIME FIXED DEC(7);
     IF H2<H1 THEN H2=H2+24;
     ETIME=((H2*60+M2)*60000+MS2)-((H1*60+M1)*60000+MS1);
     RETURN(ETIME);
   END ELAPSE;
/*
```

Figure 23. Creating New Libraries for Compiled Object Modules

```
//OPT10#2  JOB
//TRLE      EXEC  IEL1CL
//PLI.SYSIN   DD  *
   MNAME:  PROC  OPTIONS(MAIN);
     .
     .
     .
     program
     .
     .
     .

   END MNAME;
/*
//LKED.SYSLMOD  DD  DSNAME=HPU8.CCLM(DIRLIST),DISP=OLD
```

Figure 24. Placing a Load Module in an Existing Library

To use a PL/I program to add or delete one or more records within a member of a library, you must rewrite the entire member in another part of the library. This is rarely an economic proposition, since the space originally occupied by the member cannot be used again. You must use two files in your PL/I program, but both can be associated with the same DD statement. The program shown in Figure 26 on page 127 updates the member created by the program in Figure 25 on page 127. It copies all the records of the original member except those that contain only blanks.

```
//OPT10#3  JOB
//TREX  EXEC IEL1CLG
//PLI.SYSIN      DD *
  NMEM:  PROC OPTIONS(MAIN);
     DCL IN FILE RECORD SEQUENTIAL INPUT,
         OUT FILE RECORD SEQUENTIAL OUTPUT,
         P POINTER,
         IOFIELD CHAR(80) BASED(P),
         EOF BIT(1) INIT('0'B);
     OPEN FILE(IN),FILE (OUT);
     ON ENDFILE(IN) EOF='1'B;
     READ FILE(IN) SET(P);
     DO WHILE (¬EOF);
     PUT FILE(SYSPRINT) SKIP EDIT (IOFIELD) (A);
     WRITE FILE(OUT) FROM(IOFIELD);
     READ FILE(IN) SET(P);
     END;
     CLOSE FILE(IN),FILE(OUT);
  END NMEM;
/*
//GO.OUT   DD  UNIT=SYSDA,DSNAME=HPU8.ALIB(NMEM),
//     DISP=(NEW,CATLG),SPACE=(TRK,(1,1,1)),
//     DCB=(RECFM=FB,BLKSIZE=3600,LRECL=80)
//GO.IN DD *
  MEM:  PROC OPTIONS(MAIN);
        /* this is an incomplete dummy library member */
```

Figure 25. Creating a Library Member in a PL/I Program

```
//OPT10#4  JOB
//TREX  EXEC IEL1CLG
//PLI.SYSIN      DD *
  UPDTM: PROC OPTIONS(MAIN);
     DCL (OLD,NEW) FILE RECORD SEQUENTIAL,
         EOF BIT(1) INIT('0'B),
         DATA CHAR(80);
     ON ENDFILE(OLD)  EOF = '1'B;
     OPEN FILE(OLD) INPUT,FILE(NEW) OUTPUT TITLE('OLD');
     READ FILE(OLD) INTO(DATA);
     DO WHILE (¬EOF);
     PUT FILE(SYSPRINT) SKIP EDIT (DATA) (A);
     IF DATA=' ' THEN ;
     ELSE WRITE FILE(NEW) FROM(DATA);
     READ FILE(OLD) INTO(DATA);
     END;
   CLOSE FILE(OLD),FILE(NEW);
  END UPDTM;
/*
//GO.OLD DD  DSNAME=HPU8.ALIB(NMEM),DISP=(OLD,KEEP)
```

Figure 26. Updating a Library Member

Extracting Information from a Library Directory

The directory of a library is a series of records (entries) at the beginning of the data set. There is at least one directory entry for each member. Each entry contains a member name, the relative address of the member within the library, and a variable amount of user data.

User data is information inserted by the program that created the member. An entry that refers to a member (load module) written by the linkage editor includes user data in a standard format, described in the systems manuals.

If you use a PL/I program to create a member, the operating system creates the directory entry for you and you cannot write any user data. However, you can use assembler language macro instructions to create a member and write your own user data. The method for using macro instructions to do this is described in the data management manuals.

Chapter 8. Defining and Using Consecutive Data Sets

This chapter covers consecutive data set organization and the ENVIRONMENT options that define consecutive data sets for stream and record-oriented data transmission. It then covers how to create, access, and update consecutive data sets for each type of transmission.

In a data set with consecutive organization, records are organized solely on the basis of their successive physical positions; when the data set is created, records are written consecutively in the order in which they are presented. You can retrieve the records only in the order in which they were written, or, for RECORD I/O only, also in the reverse order when using the BACKWARDS attribute. See Table 15 on page 111 for valid file attributes and ENVIRONMENT options for consecutive data sets.

VM supports consecutive data set organization, and you can use PL/I to access these types of files. The examples in this chapter are given using JCL. However, the information presented in the JCL examples is applicable to the FILEDEF VM command you issue. For more information on the FILEDEF command, see the *VM/ESA CMS Command Reference* and the *VM/ESA CMS User's Guide*.

Using Stream-Oriented Data Transmission

This section covers how to define data sets for use with PL/I files that have the STREAM attribute. It covers the ENVIRONMENT options you can use and how to create and access data sets. The essential parameters of the DD statements you use in creating and accessing these data sets are summarized in tables, and several examples of PL/I programs are included to illustrate the text.

Data sets with the STREAM attribute are processed by stream-oriented data transmission, which allows your PL/I program to ignore block and record boundaries and treat a data set as a continuous stream of data values in character or graphic form.

You create and access data sets for stream-oriented data transmission using the list-, data-, and edit-directed input and output statements described in the *PL/I for MVS & VM Language Reference*.

For output, PL/I converts the data items from program variables into character form if necessary, and builds the stream of characters or graphics into records for transmission to the data set.

For input, PL/I takes records from the data set and separates them into the data items requested by your program, converting them into the appropriate form for assignment to program variables.

You can use stream-oriented data transmission to read or write graphic data. There are terminals, printers, and data-entry devices that, with the appropriate programming support, can display, print, and enter graphics. You must be sure that your data is in a format acceptable for the intended device, or for a print utility program.

Defining Files Using Stream I/O

You define files for stream-oriented data transmission by a file declaration with the following attributes:

```
DCL filename FILE STREAM
             INPUT | {OUTPUT [PRINT]}
             ENVIRONMENT(options);
```

Default file attributes are shown in Table 15 on page 111; the FILE attribute is described in the *PL/I for MVS & VM Language Reference*. The PRINT attribute is described further in “Using PRINT Files with Stream I/O” on page 138. Options of the ENVIRONMENT attribute are discussed below.

Specifying ENVIRONMENT Options

Table 15 on page 111 summarizes the ENVIRONMENT options. The options applicable to stream-oriented data transmission are:

```
CONSECUTIVE
F|FB|FS|FBS|V|VB|D|DB|U
RECSIZE(record-length)
BLKSIZE(block-size)
BUFFERS(n)
GRAPHIC
LEAVE
REREAD
ASCII
BUFOFF[(n)]
```

BLKSIZE and BUFFERS are described in Chapter 6, “Using Data Sets and Files,” beginning on page 115. LEAVE, REREAD, ASCII, and BUFOFF are described later in this chapter, beginning on page 153. Descriptions of the rest of these options follow immediately below.

CONSECUTIVE

STREAM files must have CONSECUTIVE data set organization; however, it is not necessary to specify this in the ENVIRONMENT options since CONSECUTIVE is the default data set organization. The CONSECUTIVE option for STREAM files is the same as that described in “Data Set Organization” on page 106.

```
►►──CONSECUTIVE──────────────────────────────────────────────────►◄
```

Record format options

Although record boundaries are ignored in stream-oriented data transmission, record format is important when creating a data set. This is not only because record format affects the amount of storage space occupied by the data set and the efficiency of the program that processes the data, but also because the data set can later be processed by record-oriented data transmission.

Having specified the record format, you need not concern yourself with records and blocks as long as you use stream-oriented data transmission. You can consider your data set a series of characters or graphics arranged in lines, and you can use the SKIP option or format item (and, for a PRINT file, the PAGE and LINE options and format items) to select a new line.

```
►►──┬─F───┬──────────────────────────────────────────────────────────►◄
    ├─FB──┤
    ├─FBS─┤
    ├─FS──┤
    ├─V───┤
    ├─VB──┤
    ├─D───┤
    ├─DB──┤
    └─U───┘
```

Records can have one of the following formats, which are described in “Record Formats” on page 103.

Fixed-length	F	unblocked
	FB	blocked
	FBS	blocked, standard
	FS	unblocked, standard
Variable-length	V	unblocked
	VB	blocked
	D	unblocked ASCII
	DB	blocked ASCII
Undefined-length	U	(cannot be blocked)

Blocking and deblocking of records are performed automatically.

RECSIZE

RECSIZE for stream-oriented data transmission is the same as that described in “Specifying Characteristics in the ENVIRONMENT Attribute” on page 110. Additionally, a value specified by the LINESIZE option of the OPEN statement overrides a value specified in the RECSIZE option. LINESIZE is discussed in the *PL/I for MVS & VM Language Reference*.

Additional record-size considerations for list- and data-directed transmission of graphics are given in the *PL/I for MVS & VM Language Reference*.

Defaults for Record Format, BLKSIZE, and RECSIZE

If you do not specify the record format, BLKSIZE, or RECSIZE option in the ENVIRONMENT attribute, or in the associated DD statement or data set label, the following action is taken:

Input files:

Defaults are applied as for record-oriented data transmission, described in “Record Format, BLKSIZE, and RECSIZE Defaults” on page 117.

Output files:

Record format:

Set to VB-format, or if ASCII option specified, to DB-format.

Record length:
The specified or default LINESIZE value is used:

PRINT files:

F, FB, FBS, or U:	line size + 1
V, VB, D, or DB:	line size + 5

Non-PRINT files:

F, FB, FBS, or U:	linesize
V, VB, D, or DB:	linesize + 4

Block size:

F, FB, or FBS:	record length
V or VB:	record length + 4
D or DB:	record length + block prefix (see “Information Interchange Codes” on page 103)

GRAPHIC Option

You must specify the GRAPHIC option of the ENVIRONMENT attribute if you use DBCS variables or DBCS constants in GET and PUT statements for list- and data-directed I/O. You can also specify the GRAPHIC option for edit-directed I/O.

```
►►──GRAPHIC──────────────────────────────────────────────────────►◄
```

The ERROR condition is raised for list- and data-directed I/O if you have graphics in input or output data and do not specify the GRAPHIC option.

For edit-directed I/O, the GRAPHIC option specifies that left and right delimiters are added to DBCS variables and constants on output, and that input graphics will have left and right delimiters. If you do not specify the GRAPHIC option, left and right delimiters are not added to output data, and input graphics do not require left and right delimiters. When you do specify the GRAPHIC option, the ERROR condition is raised if left and right delimiters are missing from the input data.

For information on the graphic data type, and on the G-format item for edit-directed I/O, see the *PL/I for MVS & VM Language Reference*.

Creating a Data Set with Stream I/O

To create a data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you can supply.

Essential Information

You must supply the following information, summarized in Table 18 on page 133, when creating a data set:

- Device that will write your data set (UNIT, SYSOUT, or VOLUME parameter of DD statement).
- Block size: You can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option of the OPEN statement) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length,

unblocked records are the default and the record length is determined from the block size. If you do not specify a record format, U-format is the default (except for PRINT files when V-format is the default; see “Controlling Printed Line Length” on page 139).

If you want to keep a magnetic-tape or direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need the data set after the end of your job.

Table 18. Creating a data set with stream I/O: essential parameters of the DD statement

Storage device	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSOUT= or VOLUME=REF=
		Block size[1]	DCB=(BLKSIZE=...)
Direct access only	Always	Storage space required	SPACE=
Magnetic tape only	Data set not first in volume and for magnetic tapes that do not have standard labels	Sequence number	LABEL=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but not required at end of job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSNAME=
	Data set to be on particular volume	Volume serial number	VOLUME=SER or VOLUME=REF=

[1] Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.

When creating a data set on a direct-access device, you must specify the amount of space required for it (SPACE parameter of DD statement).

If you want your data set stored on a particular magnetic-tape or direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a magnetic-tape data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing.

If your data set is to follow another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

Examples

The use of edit-directed stream-oriented data transmission to create a data set on a direct access storage device is shown in Figure 27 on page 134. The data read from the input stream by the file SYSIN includes a field VREC that contains five unnamed 7-character subfields; the field NUM defines the number of these subfields that contain information. The output file WORK transmits to the data set the whole of the field FREC and only those subfields of VREC that contain information.

```
//EX7#2  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN     DD *
 PEOPLE: PROC OPTIONS(MAIN);
        DCL WORK FILE STREAM OUTPUT,
            1 REC,
              2 FREC,
                3 NAME CHAR(19),
                3 NUM CHAR(1),
                3 PAD CHAR(25),
              2 VREC CHAR(35),
            EOF BIT(1) INIT('0'B),
            IN CHAR(80) DEF REC;
        ON ENDFILE(SYSIN) EOF='1'B;
        OPEN FILE(WORK) LINESIZE(400);
        GET FILE(SYSIN) EDIT(IN)(A(80));
        DO WHILE (¬EOF);
        PUT FILE(WORK) EDIT(IN)(A(45+7*NUM));
        GET FILE(SYSIN) EDIT(IN)(A(80));
        END;
        CLOSE FILE(WORK);
        END PEOPLE;
/*
//GO.WORK DD DSN=HPU8.PEOPLE,DISP=(NEW,CATLG),UNIT=SYSDA,
//          SPACE=(TRK,(1,1))
//GO.SYSIN DD *
R.C.ANDERSON       0 202848 DOCTOR
B.F.BENNETT        2 771239 PLUMBER          VICTOR HAZEL
R.E.COLE           5 698635 COOK             ELLEN  VICTOR JOAN   ANN    OTTO
J.F.COOPER         5 418915 LAWYER           FRANK  CAROL  DONALD NORMAN BRENDA
A.J.CORNELL        3 237837 BARBER           ALBERT ERIC   JANET
E.F.FERRIS         4 158636 CARPENTER        GERALD ANNA   MARY   HAROLD
/*
```

Figure 27. Creating a Data Set with Stream-Oriented Data Transmission

Figure 28 on page 135 shows an example of a program using list-directed output to write graphics to a stream file. It assumes that you have an output device that can print graphic data. The program reads employee records and selects persons living in a certain area. It then edits the address field, inserting one graphic blank between each address item, and prints the employee number, name, and address.

```
//EX7#3  JOB
//STEP1 EXEC IEL1CLG
//PLI.SYSIN      DD *
% PROCESS GRAPHIC;
  XAMPLE1:  PROC OPTIONS(MAIN);
            DCL  INFILE FILE INPUT RECORD,
                 OUTFILE FILE OUTPUT STREAM ENV(GRAPHIC);
 /* GRAPHIC OPTION MEANS DELIMITERS WILL BE INSERTED ON OUTPUT FILES. */
           DCL
                1 IN,
                   3 EMPNO CHAR(6),
                   3 SHIFT1 CHAR(1),
                   3 NAME,
                      5 LAST G(7),
                      5 FIRST G(7),
                   3 SHIFT2 CHAR(1),
                   3 ADDRESS,
                      5 ZIP CHAR(6),
                      5 SHIFT3 CHAR(1),
                      5 DISTRICT G(5),
                      5 CITY G(5),
                      5 OTHER G(8),
                      5 SHIFT4 CHAR(1);
           DCL EOF BIT(1) INIT('0'B);
           DCL ADDRWK G(20);
     ON ENDFILE (INFILE) EOF = '1'B;
     READ FILE(INFILE) INTO(IN);
     DO WHILE(¬EOF);
             DO;
                 IF SUBSTR(ZIP,1,3)¬='300'
                    THEN LEAVE;
                 L=0;
                 ADDRWK=DISTRICT;
                 DO I=1 TO 5;
                 IF SUBSTR(DISTRICT,I,1)= < '     ' G>
                    THEN LEAVE;               /* SUBSTR BIF PICKS UP  */
                 END;                         /* THE ITH GRAPHIC CHAR */
                 L=L+I+1;                     /* IN DISTRICT          */
                 SUBSTR(ADDRWK,L,5)=CITY;
                 DO I=1 TO 5;
                 IF SUBSTR(CITY,I,1)= < '     ' G>
                    THEN LEAVE;
                 END;
                 L=L+I;
                 SUBSTR(ADDRWK,L,8)=OTHER;
                 PUT FILE(OUTFILE) SKIP           /* THIS DATA SET    */
                 EDIT(EMPNO,IN.LAST,FIRST,ADDRWK) /* REQUIRES UTILITY */
                     (A(8),G(7),G(7),X(4),G(20)); /* TO PRINT GRAPHIC */
                                                  /* DATA             */
                 END;                      /* END OF NON-ITERATIVE DO */
         READ FILE(INFILE) INTO (IN);
         END;                                /* END OF DO WHILE(¬EOF) */
     END XAMPLE1;
/*
//GO.OUTFILE   DD  SYSOUT=A,DCB=(RECFM=VB,LRECL=121,BLKSIZE=129)
//GO.INFILE DD *
ABCDEF<山山山山山山山日日日日日日日>300099<          3 3 3 3 3 3 3   >
ABCD  <山山山山      日日日日      >300011<          3 3 3 3         >
/*
```

Figure 28. Writing Graphic Data to a Stream File

Accessing a Data Set with Stream I/O

A data set accessed using stream-oriented data transmission need not have been created by stream-oriented data transmission, but it must have CONSECUTIVE organization, and all the data in it must be in character or graphic form. You can open the associated file for input, and read the records the data set contains; or you can open the file for output, and extend the data set by adding records at the end.

To access a data set, you must identify it to the operating system in a DD statement. Table 19 summarizes the DD statement parameters needed to access a consecutive data set.

Table 19. Accessing a Data Set with Stream I/O: Essential Parameters of the DD Statement

When required	What you must state	Parameters
Always	Name of data set Disposition of data set	DSNAME= DISP=
If data set not cataloged (all devices)	Input device	UNIT= or VOLUME=REF=
If data set not cataloged (standard labeled magnetic tape and direct access)	Volume serial number	VOLUME=SER=
Magnetic tape (if data set not first in volume or which does not have standard labels)	Sequence number	LABEL=
If data set does not have standard labels	Block size[1]	DCB=(BLKSIZE=.

[1] Or you could specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.

The following paragraphs describe the essential information you must include in the DD statement, and discuss some of the optional information you can supply. The discussions do not apply to data sets in the input stream.

Essential Information

If the data set is cataloged, you need supply only the following information in the DD statement:

- The name of the data set (DSNAME parameter). The operating system locates the information describing the data set in the system catalog, and, if necessary, requests the operator to mount the volume containing it.
- Confirmation that the data set exists (DISP parameter). If you open the data set for output with the intention of extending it by adding records at the end, code DISP=MOD; otherwise, opening the data set for output results in it being overwritten.

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and, for magnetic-tape and direct-access devices, give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

If the data set follows another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

Magnetic Tape without IBM Standard Labels: If a magnetic-tape data set has nonstandard labels or is unlabeled, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). The DSNAME parameter is not essential if the data set is not cataloged.

PL/I includes no facilities for processing nonstandard labels, which appear to the operating system as data sets preceding or following your data set. You can either process the labels as independent data sets or use the LABEL parameter of the DD statement to bypass them. To bypass the labels, code `LABEL=(2,NL)` or `LABEL=(,BLP)`

Record Format

When using stream-oriented data transmission to access a data set, you do not need to know the record format of the data set (except when you must specify a block size); each GET statement transfers a discrete number of characters or graphics to your program from the data stream.

If you do give record-format information, it must be compatible with the actual structure of the data set. For example, if a data set is created with F-format records, a record size of 600 bytes, and a block size of 3600 bytes, you can access the records as if they are U-format with a maximum block size of 3600 bytes; but if you specify a block size of 3500 bytes, your data will be truncated.

Example

The program in Figure 29 on page 138 reads the data set created by the program in Figure 27 on page 134 and uses the file SYSPRINT to list the data it contains. (For details on SYSPRINT, see “Using SYSIN and SYSPRINT Files” on page 142.) Each set of data is read, by the GET statement, into two variables: FREC, which always contains 45 characters; and VREC, which always contains 35 characters. At each execution of the GET statement, VREC consists of the number of characters generated by the expression 7*NUM, together with sufficient blanks to bring the total number of characters to 35. The DISP parameter of the DD statement could read simply DISP=OLD; if DELETE is omitted, an existing data set will not be deleted.

```
//EX7#5  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN      DD *
 PEOPLE: PROC OPTIONS(MAIN);
         DCL WORK FILE STREAM INPUT,
             1 REC,
               2 FREC,
                 3 NAME CHAR(19),
                 3 NUM CHAR(1),
                 3 SERNO CHAR(7),
                 3 PROF CHAR(18),
               2 VREC CHAR(35),
             IN CHAR(80) DEF REC,
             EOF BIT(1) INIT('0'B);
         ON ENDFILE(WORK) EOF='1'B;
         OPEN FILE(WORK);
         GET FILE(WORK) EDIT(IN,VREC)(A(45),A(7*NUM));
         DO WHILE (¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT(IN)(A);
         GET FILE(WORK) EDIT(IN,VREC)(A(45),A(7*NUM));
         END;
         CLOSE FILE(WORK);
         END PEOPLE;
/*
//GO.WORK DD DSN=HPU8.PEOPLE,DISP=(OLD,DELETE)
```

Figure 29. Accessing a Data Set with Stream-Oriented Data Transmission

Using PRINT Files with Stream I/O

Both the operating system and the PL/I language include features that facilitate the formatting of printed output. The operating system allows you to use the first byte of each record for a print control character. The control characters, which are not printed, cause the printer to skip to a new line or page. (Tables of print control characters are given in Figure 33 on page 153 and Figure 34 on page 153.)

In a PL/I program, the use of a PRINT file provides a convenient means of controlling the layout of printed output from stream-oriented data transmission. The compiler automatically inserts print control characters in response to the PAGE, SKIP, and LINE options and format items.

You can apply the PRINT attribute to any STREAM OUTPUT file, even if you do not intend to print the associated data set directly. When a PRINT file is associated with a magnetic-tape or direct-access data set, the print control characters have no effect on the layout of the data set, but appear as part of the data in the records.

The compiler reserves the first byte of each record transmitted by a PRINT file for an American National Standard print control character, and inserts the appropriate characters automatically.

A PRINT file uses only the following five print control characters:

Character	Action
	Space 1 line before printing (blank character)
0	Space 2 lines before printing
–	Space 3 lines before printing
+	No space before printing
1	Start new page

The compiler handles the PAGE, SKIP, and LINE options or format items by padding the remainder of the current record with blanks and inserting the appropriate control character in the next record. If SKIP or LINE specifies more than a 3-line space, the compiler inserts sufficient blank records with appropriate control characters to accomplish the required spacing. In the absence of a print control option or format item, when a record is full the compiler inserts a blank character (single line space) in the first byte of the next record.

If a PRINT file is being transmitted to a terminal, the PAGE, SKIP, and LINE options will never cause more than 3 lines to be skipped, unless formatted output is specified. (For information about TSO see "Using the PLI Command" on page 59, and for information about VM see "PLIOPT Command Options" on page 75.)

Controlling Printed Line Length

You can limit the length of the printed line produced by a PRINT file either by specifying a record length in your PL/I program (ENVIRONMENT attribute) or in a DD statement, or by giving a line size in an OPEN statement (LINESIZE option). The record length must include the extra byte for the print control character, that is, it must be 1 byte larger than the length of the printed line (5 bytes larger for V-format records). The value you specify in the LINESIZE option refers to the number of characters in the printed line; the compiler adds the print control character.

The blocking of records has no effect on the appearance of the output produced by a PRINT file, but it does result in more efficient use of auxiliary storage when the file is associated with a data set on a magnetic-tape or direct-access device. If you use the LINESIZE option, ensure that your line size is compatible with your block size. For F-format records, block size must be an exact multiple of (line size+1); for V-format records, block size must be at least 9 bytes greater than line size.

Although you can vary the line size for a PRINT file during execution by closing the file and opening it again with a new line size, you must do so with caution if you are using the PRINT file to create a data set on a magnetic-tape or direct-access device. You cannot change the record format that is established for the data set when the file is first opened. If the line size you specify in an OPEN statement conflicts with the record format already established, the UNDEFINEDFILE condition is raised. To prevent this, either specify V-format records with a block size at least 9 bytes greater than the maximum line size you intend to use, or ensure that the first OPEN statement specifies the maximum line size. (Output destined for the printer can be stored temporarily on a direct-access device, unless you specify a printer by using UNIT=, even if you intend it to be fed directly to the printer.)

Since PRINT files have a default line size of 120 characters, you need not give any record format information for them. In the absence of other information, the compiler assumes V-format records. The complete default information is:

BLKSIZE=129

LRECL=125

RECFM=VBA.

Example: Figure 30 on page 141 illustrates the use of a PRINT file and the printing options of stream-oriented data transmission statements to format a table and write it onto a direct-access device for printing on a later occasion. The table comprises the natural sines of the angles from 0° to 359° 54' in steps of 6'.

The statements in the ENDPAGE ON-unit insert a page number at the bottom of each page, and set up the headings for the following page.

The DD statement defining the data set created by this program includes no record-format information. The compiler infers the following from the file declaration and the line size specified in the statement that opens the file TABLE:

Record format	=	V (the default for a PRINT file).
Record size	=	98 (line size + 1 byte for print control character + 4 bytes for record control field).
Block size	=	102 (record length + 4 bytes for block control field).

The program in Figure 36 on page 162 uses record-oriented data transmission to print the table created by the program in Figure 30 on page 141.

Overriding the Tab Control Table

Data-directed and list-directed output to a PRINT file are aligned on preset tabulator positions. See Figure 18 on page 90 and Figure 31 on page 142 for examples of declaring a tab table. The definitions of the fields in the table are as follows:

OFFSET OF TAB COUNT:
Halfword binary integer that gives the offset of “Tab count,” the field that indicates the number of tabs to be used.

PAGESIZE:
Halfword binary integer that defines the default page size. This page size is used for dump output to the PLIDUMP data set as well as for stream output.

LINESIZE: Halfword binary integer that defines the default line size.

PAGELENGTH:
Halfword binary integer that defines the default page length for printing at a terminal. For TSO and VM, the value 0 indicates unformatted output.

FILLERS: Three halfword binary integers; reserved for future use.

TAB COUNT:
Halfword binary integer that defines the number of tab position entries in the table (maximum 255). If tab count = 0, any specified tab positions are ignored.

```
%PROCESS INT F(I) AG A(F) ESD MAP OP STG NEST X(F) SOURCE ;
%PROCESS LIST;

 SINE: PROC OPTIONS(MAIN);
   DCL TABLE       FILE STREAM OUTPUT PRINT;
   DCL DEG         FIXED DEC(5,1) INIT(0);  /* INIT(0) FOR ENDPAGE  */
   DCL MIN         FIXED DEC(3,1);
   DCL PGNO        FIXED DEC(2)   INIT(0);
   DCL ONCODE      BUILTIN;

   ON ERROR
     BEGIN;
       ON ERROR SYSTEM;
       DISPLAY ('ONCODE = '|| ONCODE);
     END;

   ON ENDPAGE(TABLE)
     BEGIN;
       DCL I;
       IF PGNO ¬= 0 THEN
         PUT FILE(TABLE) EDIT ('PAGE',PGNO)
             (LINE(55),COL(80),A,F(3));
       IF DEG ¬= 360 THEN
         DO;
           PUT FILE(TABLE) PAGE EDIT ('NATURAL SINES') (A);
           IF PGNO ¬= 0 THEN
             PUT FILE(TABLE) EDIT ((I DO I = 0 TO 54 BY 6))
                                  (SKIP(3),10 F(9));
           PGNO = PGNO + 1;
         END;
       ELSE
         PUT FILE(TABLE) PAGE;
     END;

   OPEN FILE(TABLE) PAGESIZE(52) LINESIZE(93);
   SIGNAL ENDPAGE(TABLE);

   PUT FILE(TABLE) EDIT
    ((DEG,(SIND(DEG+MIN) DO MIN = 0 TO .9 BY .1) DO DEG = 0 TO 359))
    (SKIP(2), 5 (COL(1), F(3), 10 F(9,4) ));
   PUT FILE(TABLE) SKIP(52);
 END SINE;
```

Figure 30. Creating a Print File Via Stream Data Transmission. The example in Figure 36 on page 162 will print the resultant file.

Tab1–Tab*n*:

n halfword binary integers that define the tab positions within the print line. The first position is numbered 1, and the highest position is numbered 255. The value of each tab should be greater than that of the tab preceding it in the table; otherwise, it is ignored. The first data field in the printed output begins at the next available tab position.

You can override the default PL/I tab settings for your program by causing the linkage editor to resolve an external reference to PLITABS. To cause the reference to be resolved, supply a table with the name PLITABS, in the format described above.

There are two methods of supplying the tab table. One method is to include a PL/I structure in your source program with the name PLITABS, which you must declare to be STATIC EXTERNAL. An example of the PL/I structure is shown in Figure 31 on page 142. This example creates three tab settings, in positions 30, 60, and 90, and uses the defaults for page size and line size. Note that TAB1 identifies the position of the second item printed on a line; the first item on a line always starts at the left margin. The first item in the structure is the offset to the NO_OF_TABS field; FILL1, FILL2, and FILL3 can be omitted by adjusting the offset value by –6.

The second method is to create an assembler language control section named PLITABS, equivalent to the structure shown in Figure 31, and to include it when link-editing your PL/I program.

```
DCL 1 PLITABS STATIC EXT,
    2 (OFFSET INIT(14),
      PAGESIZE INIT(60),
      LINESIZE INIT(120),
      PAGELENGTH INIT(0),
      FILL1 INIT(0),
      FILL2 INIT(0),
      FILL3 INIT(0),
      NO_OF_TABS INIT(3),
      TAB1 INIT(30),
      TAB2 INIT(60),
      TAB3 INIT(90)) FIXED BIN(15,0);
```

Figure 31. PL/I Structure PLITABS for Modifying the Preset Tab Settings

Using SYSIN and SYSPRINT Files

If you code a GET statement without the FILE option in your program, the compiler inserts the file name SYSIN. If you code a PUT statement without the FILE option, the compiler inserts the name SYSPRINT.

If you do not declare SYSPRINT, the compiler gives the file the attribute PRINT in addition to the normal default attributes; the complete set of attributes will be:

```
FILE STREAM OUTPUT PRINT EXTERNAL
```

Since SYSPRINT is a PRINT file, the compiler also supplies a default line size of 120 characters and a V-format record. You need give only a minimum of information in the corresponding DD statement; if your installation uses the usual convention that the system output device of class A is a printer, the following is sufficient:

```
//SYSPRINT DD SYSOUT=A
```

Note: SYSIN and SYSPRINT are established in the User Exit during initialization. IBM-supplied defaults for SYSIN and SYSPRINT are directed to the terminal.

You can override the attributes given to SYSPRINT by the compiler by explicitly declaring or opening the file. For more information about the interaction between SYSPRINT and the Language Environment for MVS & VM message file option, see the *Language Environment for MVS & VM Programming Guide*.

The compiler does not supply any special attributes for the input file SYSIN; if you do not declare it, it receives only the default attributes. The data set associated with SYSIN is usually in the input stream; if it is not in the input stream, you must supply full DD information.

For more information about SYSPRINT, see “SYSPRINT Considerations” on page 92.

Controlling Input from the Terminal

You can enter data at the terminal for an input file in your PL/I program if you:

1. Declare the input file explicitly or implicitly with the CONSECUTIVE environment option (all stream files meet this condition), *and*
2. Allocate the input file to the terminal.

You can usually use the standard default input file SYSIN because it is a stream file and can be allocated to the terminal. In TSO, you can allocate SYSIN to the terminal in your logon procedure. In VM, SYSIN is allocated to the terminal by the IBM-supplied User Exit.

You are prompted for input to stream files by a colon (:). You will see the colon each time a GET statement is executed in the program. The GET statement causes the system to go to the next line. You can then enter the required data. If you enter a line that does not contain enough data to complete execution of the GET statement, a further prompt, which is a plus sign followed by a colon (+:), is displayed.

By adding a hyphen to the end of any line that is to continue, you can delay transmission of the data to your program until you enter two or more lines. The hyphen is an explicit continuation character in TSO.

If you include output statements that prompt you for input in your program, you can inhibit the initial system prompt by ending your own prompt with a colon. For example, the GET statement could be preceded by a PUT statement such as:

```
PUT SKIP LIST('ENTER NEXT ITEM:');
```

To inhibit the system prompt for the next GET statement, your own prompt must meet the following conditions:

1. It must be either list-directed or edit-directed, and if list-directed, must be to a PRINT file.
2. The file transmitting the prompt must be allocated to the terminal. If you are merely copying the file at the terminal, the system prompt is not inhibited.

Using Files Conversationally

TSO allows you to interact conversationally with your own programs, as well as the computing system as a whole. You can perform nearly all your operations from a terminal in TSO: compile PL/I source programs, print the diagnostic messages at the terminal, and write the object modules onto a data set. These object modules can then be conversationally link-edited and run.

While the object modules are running, you can use the terminal as an input and output device for consecutive files in the program. Conversational I/O needs no special PL/I code, so any stream file can be used conversationally.

Format of Data

The data you enter at the terminal should have exactly the same format as stream input data in batch mode, except for the following variations:

- Simplified punctuation for input: If you enter separate items of input on separate lines, there is no need to enter intervening blanks or commas; the compiler will insert a comma at the end of each line.

For instance, in response to the statement:

```
GET LIST(I,J,K);
```

your terminal interaction could be as follows:

```
:
1
+:2
+:3
```

with a carriage return following each item. It would be equivalent to:

```
:
1,2,3
```

If you wish to continue an item onto another line, you must end the first line with a continuation character. Otherwise, for a GET LIST or GET DATA statement, a comma will be inserted, and for a GET EDIT statement, the item will be padded (see next paragraph).

- Automatic padding for GET EDIT: There is no need to enter blanks at the end of a line of input for a GET EDIT statement. The item you enter will be padded to the correct length.

  For instance, for the PL/I statement:

  ```
  GET EDIT(NAME)(A(15));
  ```

  you could enter the five characters:

  ```
  SMITH
  ```

  followed immediately by a carriage return. The item will be padded with 10 blanks, so that the program receives a string 15 characters long. If you wish to continue an item on a second or subsequent line, you must add a continuation character to the end of every line except the last; the first line transmitted would otherwise be padded and treated as the complete data item.

- SKIP option or format item: A SKIP in a GET statement asks the program to ignore data not yet entered. All uses of SKIP(n) where *n* is greater than one are taken to mean SKIP(1). SKIP(1) is taken to mean that all unused data on the current line is ignored.

Stream and Record Files

You can allocate both stream and record files to the terminal. However, no prompting is provided for record files. If you allocate more than one file to the terminal, and one or more of them is a record file, the output of the files will not necessarily be synchronized. The order in which data is transmitted to and from the terminal is not guaranteed to be the same order in which the corresponding PL/I I/O statements are executed.

Also, record file input from the terminal is received in upper case letters because of a TCAM restriction. To avoid problems you should use stream files wherever possible.

Capital and Lowercase Letters

For stream files, character strings are transmitted to the program as entered in lowercase or uppercase. For record files, all characters become uppercase.

End-of-File

The characters /* in positions one and two of a line that contains no other characters are treated as an end-of-file mark, that is, they raise the ENDFILE condition.

COPY Option of GET Statement

The GET statement can specify the COPY option; but if the COPY file, as well as the input file, is allocated to the terminal, no copy of the data will be printed.

Controlling Output to the Terminal

At your terminal you can obtain data from a PL/I file that has been both:

1. Declared explicitly or implicitly with the CONSECUTIVE environment option. All stream files meet this condition.
2. Allocated to the terminal.

The standard print file SYSPRINT generally meets both these conditions.

Format of PRINT Files

Data from SYSPRINT or other PRINT files is not normally formatted into pages at the terminal. Three lines are always skipped for PAGE and LINE options and format items. The ENDPAGE condition is normally never raised. SKIP(n), where *n* is greater than three, causes only three lines to be skipped. SKIP(0) is implemented by backspacing, and should therefore not be used with terminals that do not have a backspace feature.

You can cause a PRINT file to be formatted into pages by inserting a tab control table in your program. The table must be called PLITABS, and its contents are explained in “Overriding the Tab Control Table” on page 140. You must initialize the element PAGELENGTH to the length of page you require—that is, the length of the sheet of paper on which each page is to be printed, expressed as the maximum number of lines that could be printed on it. You must initialize the element PAGESIZE to the actual number of lines to be printed on each page. After the number of lines in PAGESIZE has been printed on a page, ENDPAGE is raised, for which standard system action is to skip the number of lines equal to PAGELENGTH minus PAGESIZE, and then start printing the next page. For other than standard layout, you must initialize the other elements in PLITABS to the values shown in Figure 18 on page 90. You can also use PLITABS to alter the tabulating positions of list-directed and data-directed output. You can use PLITABS for SYSPRINT when you need to format page breaks in ILC applications. Set PAGESIZE to 32767 and use the PUT PAGE statement to control page breaks.

Although some types of terminals have a tabulating facility, tabulating of list-directed and data-directed output is always achieved by transmission of blank characters.

Stream and Record Files

You can allocate both stream and record files to the terminal. However, if you allocate more than one file to the terminal and one or more is a record file, the files' output will not necessarily be synchronized. There is no guarantee that the order in which data is transmitted between the program and the terminal will be the same as the order in which the corresponding PL/I input and output statements are executed. In addition, because of a TCAM restriction, any output to record files at the terminal is printed in uppercase (capital) letters. It is therefore advisable to use stream files wherever possible.

Capital and Lowercase Characters

For stream files, characters are displayed at the terminal as they are held in the program, provided the terminal can display them. For instance, with an IBM 327*x* terminal, capital and lowercase letters are displayed as such, without translation. For record files, all characters are translated to uppercase. A variable or constant in the program can contain lowercase letters if the program was created under the EDIT command with the ASIS operand, or if the program has read lowercase letters from the terminal.

Output from the PUT EDIT Command

The format of the output from a PUT EDIT command to a terminal has different forms depending on whether the TSO session manager is on or off. Decide whether you want to have it on or off, because if you are using the PUT EDIT command, and change output devices, you will have to rewrite the output procedure. The results of setting TSO session manager on or off are:

ON PUT EDIT is converted to full screen TPUTs. The output looks exactly the same as on a disk data set or SYSOUT file.

OFF PUT EDIT is converted to line mode TPUTs. “Start of field” and “end of field” characters are added which appear as blanks on the screen.

Note: If TSO session manager is not available, format of output will be the same as session manager being off.

Example of an Interactive Program

The example program in Figure 32 on page 148 prints a report based on information retrieved from a database. The content of the report is controlled by a list of parameters that contains the name of the person requiring the report and a set of numbers indicating the information that is to be printed. In the example, the parameters are read from the terminal. The program includes a prompt for the name parameter, and a message confirming its acceptance. The report is printed on a system output device.

The program uses four files:

SYSPRINT Standard stream output file. Prints prompt and confirmation at the terminal.

PARMS Stream input file. Reads parameters from terminal.

INBASE Record input file. Reads database, namely, member MEM3 of data set BDATA.

REPORT Sends report to SYSOUT device.

SYSPRINT has been allocated to the terminal by the logon procedure. The other three files are allocated by ALLOCATE commands entered in TSO submode.

The example program in Figure 32 is called REPORTR, and it is held on a conventionally named TSO data set whose user-supplied name is REPORTER. The compiler is invoked with the SOURCE option to provide a list of the PL/I source code.

```
READY
pli reporter print(*) source                     “print(*)” allocates
                                                 source listing to terminal
15668-910 IBM OS PL/I OPTIMIZING COMPILER  VER 2 REL 2 MOD 0
OPTIONS SPECIFIED
S;
                          SOURCE LISTING
NUMBER
     10 00000010 REPORTR: PROC OPTIONS(MAIN);
           .
           .
    180 00000180 ON ENDFILE(PARMS) GO TO READER;
           .
           .
   1000 00001000 PUT LIST('ENTER NAME:');        print prompt at terminal
   1010 00001010 GET FILE(PARMS) LIST(NAME);     read name parameter from
           .                                     terminal
           .
   1050 00001050 PUT LIST('NAME ACCEPTED');      confirmation message
           .
           .
   2000 00002000 GET FILE(PARMS) LIST((A(I) DO I=1 TO 50));
           .                                     read other parameters
           .                                     from terminal
   2010 00002010 READER:
        00002020 READ FILE(INBASE) INTO(B);
           .                                     read database
           .
   4010 00004010 PRINTER:
        00004020 PUT FILE(REPORT) EDIT(HEAD1||NAME)(A);
           .                                     print line of report
           .                                     on system printer
   5000 00005000 END REPORTR;

NO MESSAGES PRODUCED FOR THIS COMPILATION
COMPILE TIME      0.30 MINS        SPILL FILE:  0 RECORDS, SIZE 4051
END of COMPILATION of REPORTR

READY
alloc file(parms) dataset(*)                     file to read parameters
READY                                            from terminal
alloc file(inbase) dataset('bdata(mem3)') old    file to read database
READY
alloc file(report) sysout                        file to print report on
READY                                            system printer
loadgo reporter plibase

ENTER NAME:  'F W Williams'                      prompt & name parameter
NAME ACCEPTED                                    confirmation message
:                                                automatic prompt for
                                                 parameters
1 3 5 7 10 14 15 19                              parameters entered
+:/*                                             prompt for further
                                                 parameters
READY                                            end-of-file entered
```

Figure 32. Example of an Interactive Program

Using Record-Oriented Data Transmission

PL/I supports various types of data sets with the RECORD attribute (see Table 23 on page 156). This section covers how to use consecutive data sets.

Table 20 lists the statements and options that you can use to create and access a consecutive data set using record-oriented data transmission.

Table 20. Statements and Options Allowed for Creating and Accessing Consecutive Data Sets

File declaration[1]	**Valid statements,**[2] **with Options you must specify**	**Other options you can specify**
SEQUENTIAL OUTPUT BUFFERED	WRITE FILE(file-reference) FROM(reference);	
	LOCATE based-variable FILE(file-reference);	SET(pointer-reference)
SEQUENTIAL OUTPUT UNBUFFERED	WRITE FILE(file-reference) FROM(reference);	EVENT(event-reference)
SEQUENTIAL INPUT BUFFERED[3]	READ FILE(file-reference) INTO(reference);	
	READ FILE(file-reference) SET(pointer-reference);	
	READ FILE(file-reference) IGNORE(expression);	
SEQUENTIAL INPUT UNBUFFERED[3]	READ FILE(file-reference) INPUT(reference);	EVENT(event-reference)
	READ FILE(file-reference) IGNORE(expression);	EVENT(event-reference)
SEQUENTIAL UPDATE BUFFERED	READ FILE(file-reference) INTO(reference);	
	READ FILE(file-reference) SET(pointer-reference);	
	READ FILE(file-reference) IGNORE(expression);	
	REWRITE FILE(file-reference);	FROM(reference)
SEQUENTIAL UPDATE UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference)
	READ FILE(file-reference) IGNORE(expression);	EVENT(event-reference)
	REWRITE FILE(file-reference) FROM(reference);	EVENT(event-reference)

Notes:

1. The complete file declaration would include the attributes FILE, RECORD and ENVIRONMENT.
2. The statement READ FILE (file-reference); is a valid statement and is equivalent to READ FILE(file-reference) IGNORE (1);
3. You can specify the BACKWARDS attribute for files on magnetic tape.

Using Magnetic Tape without Standard Labels

If a magnetic-tape data set has nonstandard labels or is unlabeled, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). The DSNAME parameter is not essential if the data set is not cataloged.

PL/I includes no facilities for processing nonstandard labels which to the operating system appear as data sets preceding or following your data set. You can either process the labels as independent data sets or use the LABEL parameter of the DD statement to bypass them. To bypass the labels, code LABEL=(2,NL) or LABEL=(,BLP).

Specifying Record Format

If you give record-format information, it must be compatible with the actual structure of the data set. For example, if you create a data set with FB-format records, with a record size of 600 bytes and a block size of 3600 bytes, you can access the records as if they are U-format with a maximum block size of 3600 bytes. If you specify a block size of 3500 bytes, your data is truncated.

Defining Files Using Record I/O

You define files for record-oriented data transmission by using a file declaration with the following attributes:

```
DCL filename FILE RECORD
              INPUT | OUTPUT | UPDATE
              SEQUENTIAL
              BUFFERED | UNBUFFERED
             [BACKWARDS]
              ENVIRONMENT(options);
```

Default file attributes are shown in Table 15 on page 111. The file attributes are described in the *PL/I for MVS & VM Language Reference*. Options of the ENVIRONMENT attribute are discussed below.

Specifying ENVIRONMENT Options

The ENVIRONMENT options applicable to consecutive data sets are:

```
F|FB|FS|FBS|V|VB|VS|VBS|D|DB|U
RECSIZE(record-length)
BLKSIZE(block-size)
SCALARVARYING
COBOL
BUFFERS(n)
NCP(n)
TRKOFL

CONSECUTIVE
TOTAL
CTLASA|CTL360
LEAVE|REREAD
ASCII
BUFOFF[(n)]
```

The options above the blank line are described in “Specifying Characteristics in the ENVIRONMENT Attribute” on page 110, and those below the blank line are described below. D- and DB-format records are also described below.

See Table 15 on page 111 to find which options you must specify, which are optional, and which are defaults.

CONSECUTIVE

The CONSECUTIVE option defines a file with consecutive data set organization, which is described in this chapter and in “Data Set Organization” on page 106.

```
►►──CONSECUTIVE──────────────────────────────────────────────────►◄
```

CONSECUTIVE is the default when the merged attributes from the DECLARE and OPEN statements do not include the TRANSIENT attribute.

TOTAL

In general, run-time library subroutines called from object code perform I/O operations. Under certain conditions, however, the compiler can, when requested, provide in-line code to carry out these operations. This gives faster execution of the I/O statements.

Use the TOTAL option to aid the compiler in the production of efficient object code. In particular, it requests the compiler to use in-line code for certain I/O operations. It specifies that no attributes will be merged from the OPEN statement or the I/O statement or the DCB parameter; if a complete set of attributes can be built up at compile time from explicitly declared and default attributes, in-line code will be used for certain I/O operations.

```
►►──TOTAL────────────────────────────────────────────────────────►◄
```

The UNDEFINEDFILE condition is raised if any attribute that was not explicitly declared appears on the OPEN statement, or if the I/O statement implies a file attribute that conflicts with a declared or default attribute.

You cannot specify the TOTAL option for device-associated files or files reading Optical Mark Read data.

The use of in-line I/O code can result in reduced error-handling capability. In particular, if a program-check interrupt or an abend occurs during in-line I/O, the error message produced can contain incorrect offset and statement number information. Also, execution of a GO TO statement in an ERROR ON-unit for such an interrupt can cause a second program check.

There are some differences in the optimized code generated under OS PL/I Version 1 Release 5 and later releases. The implementation of these releases generates code to call modules in the run-time library so that mode-switching can be performed if necessary. This implementation results in a longer instruction path than it does with prior releases, but it is still faster than not using the TOTAL option.

Table 21 on page 152 shows the conditions under which I/O statements are handled in-line.

When in-line code is employed to implement an I/O statement, the compiler gives an informational message.

Table 21. Conditions under Which I/O Statements Are Handled In-Line (TOTAL Option Used)

Statement[1]	**Record variable requirements**	**File attribute**[3] **or ENVIRONMENT option requirements**[4]
READ SET	None	Not BACKWARDS for record types U, V, VB
READ INTO	Length known at compile time, maximum length for a varying string or area.[2]	RECSIZE known at compile time.[5] SCALARVARYING option if varying string.
WRITE FROM (fixed string)	Length known at compile time.	RECSIZE known at compile time.[5]
WRITE FROM (varying string)		RECSIZE known at compile time.[5] SCALARVARYING option used.
WRITE FROM Area[2]		RECSIZE known at compile time.[5]
LOCATE A	Length known at compile time, maximum length for a varying string or area.[2]	RECSIZE known at compile time.[5] SCALARVARYING if varying string.

Notes:

1. All statements must be found to be valid during compilation. File parameters or file variables are *never* handled by in-line code.
2. Including structures wherein the last element is an unsubscripted area.
3. File attributes are SEQUENTIAL BUFFERED, INPUT, or OUTPUT.
4. Data set organization must be CONSECUTIVE; allowable record formats are F, FB, FS, FBS, U, V, or VB.
5. You can specify BLKSIZE instead of RECSIZE for unblocked record formats F, FS, V, and U.

CTLASA|CTL360

The printer control options CTLASA and CTL360 apply only to OUTPUT files associated with consecutive data sets. They specify that the first character of a record is to be interpreted as a control character.

```
►►──┬─CTLASA─┬──────────────────────────────────────────────────────►◄
    └─CTL360─┘
```

The CTLASA option specifies American National Standard Vertical Carriage Positioning Characters or American National Standard Pocket Select Characters (Level 1). The CTL360 option specifies IBM machine-code control characters.

The American National Standard control characters, listed in Figure 33 on page 153, cause the specified action to occur before the associated record is printed or punched.

The machine code control characters differ according to the type of device. The IBM machine code control characters for printers are listed in Figure 34 on page 153.

Code	Action
	Space 1 line before printing (blank code)
0	Space 2 lines before printing
–	Space 3 lines before printing
+	Suppress space before printing
1	Skip to channel 1
2	Skip to channel 2
3	Skip to channel 3
4	Skip to channel 4
5	Skip to channel 5
6	Skip to channel 6
7	Skip to channel 7
8	Skip to channel 8
9	Skip to channel 9
A	Skip to channel 10
B	Skip to channel 11
C	Skip to channel 12
V	Select stacker 1
W	Select stacker 2

Figure 33. American National Standard Print and Card Punch Control Characters (CTLASA)

Print and Then Act	Action	Act immediately (no printing)
Code byte		**Code byte**
00000001	Print only (no space)	—
00001001	Space 1 line	00001011
00010001	Space 2 lines	00010011
00011001	Space 3 lines	00011011
10001001	Skip to channel 1	10001011
10010001	Skip to channel 2	10010011
10011001	Skip to channel 3	10011011
10100001	Skip to channel 4	10100011
10101001	Skip to channel 5	10101011
10110001	Skip to channel 6	10110011
10111001	Skip to channel 7	10111011
11000001	Skip to channel 8	11000011
11001001	Skip to channel 9	11001011
11010001	Skip to channel 10	11010011
11011001	Skip to channel 11	11011011
11100001	Skip to channel 12	11100011

Figure 34. IBM Machine Code Print Control Characters (CTL360)

LEAVE|REREAD

The magnetic tape handling options LEAVE and REREAD allow you to specify the action to be taken when the end of a magnetic tape volume is reached, or when a data set on a magnetic tape volume is closed. The LEAVE option prevents the tape from being rewound. The REREAD option rewinds the tape to allow reprocessing of the data set. If you do not specify either of these, the action at end-of-volume or on closing of a data set is controlled by the DISP parameter of the associated DD statement.

```
►►──┬─LEAVE──┬──────────────────────────────────────────────────────►◄
    └─REREAD─┘
```

If a data set is first read or written forward and then read backward in the same program, specify the LEAVE option to prevent rewinding when the file is closed (or, with a multivolume data set, when volume switching occurs).

You can also specify LEAVE and REREAD on the CLOSE statement, as described in the *PL/I for MVS & VM Language Reference*.

The effects of the LEAVE and REREAD options are summarized in Table 22.

Table 22. Effect of LEAVE and REREAD Options

ENVIRONMENT option	**DISP parameter**	**Action**
REREAD	—	Positions the current volume to reprocess the data set. Repositioning for a BACKWARDS file is at the physical end of the data set.
LEAVE	—	Positions the current volume at the logical end of the data set. Repositioning for a BACKWARDS file is at the physical beginning of the data set.
Neither REREAD nor LEAVE	PASS	Positions the volume at the end of the data set.
	DELETE	Rewinds the current volume.
	KEEP, CATLG, UNCATLG	Rewinds and unloads the current volume.

ASCII

The ASCII option specifies that the code used to represent data on the data set is ASCII.

```
►►──ASCII──────────────────────────────────────────────────────────────►◄
```

You can create and access data sets on magnetic tape using ASCII in PL/I. The implementation supports F, FB, U, D, and DB record formats. F, FB, and U formats are treated in the same way as other data sets; D and DB formats, which correspond to V and VB formats in other data sets, are described below.

Only character data can be written to an ASCII data set; therefore, when you create the data set, you must transmit your data from character variables. You can give these variables the attribute VARYING as well as CHARACTER, but you cannot transmit the two length bytes of varying-length character strings. In other words, you cannot use a SCALARVARYING file to transmit varying-length character strings to an ASCII data set. Also, you cannot transmit data aggregates containing varying-length strings.

Since an ASCII data set must be on magnetic tape, it must be of consecutive organization. The associated file must be BUFFERED. You can also specify the BUFOFF ENVIRONMENT option for ASCII data sets.

If you do not specify ASCII in either the ENVIRONMENT option or the DD statement, but you specify BUFOFF, D, or DB, then ASCII is the default.

BUFOFF

You need not concern yourself with the BUFOFF option unless you are dealing with ASCII data sets.

The BUFOFF (buffer offset) option specifies a *block prefix* field *n* bytes in length at the beginning of each block in an ASCII data set, according to the following syntax:

```
►►──BUFOFF──┬─────────┬──────────────────────────────────────────────►◄
            └─(──n──)─┘
```

n is either:

- An integer from 0 to 99
- A variable with attributes FIXED BINARY(31,0) STATIC having an integer value from 0 to 99.

When you are accessing an ASCII data set for input to your program, specifying BUFOFF and *n* identifies to data management how far into the block the beginning of the data is. Specifying BUFOFF without *n* signifies to data management that the first 4 bytes of the data set comprise a block-length field.

When you are creating an ASCII data set for output from your program, PL/I does not allow you to create a prefix field at the beginning of the block using BUFOFF, *unless* it is for data management's use as a 4-byte block-length indicator. In this case, you do not need to specify the BUFOFF option anyway, because for D- or DB-formats PL/I automatically sets up the required field. You *can* code BUFOFF without *n* (though it isn't needed), but that is the only explicit specification of the BUFOFF option that PL/I accepts for output. Therefore, by not coding the BUFOFF option you allow PL/I to set the default values needed for creating your output ASCII data set (4 for D- and DB-formats, 0 for other acceptable formats).

D-Format and DB-Format Records

The data contained in D- and DB-format records is recorded in ASCII. Each record can be of a different length. The two formats are:

D-format:

The records are unblocked; each record constitutes a single block. Each record consists of:

Four control bytes
Data bytes.

The four control bytes contain the length of the record; this value is inserted by data management and requires no action by you. In addition, there can be, at the start of the block, a block prefix field, which can contain the length of the block.

DB-format:

The records are blocked. All other information given for D-format applies to DB-format.

Creating a Data Set with Record I/O

When you create a consecutive data set, you must open the associated file for SEQUENTIAL OUTPUT. You can use either the WRITE or LOCATE statement to write records. Table 20 on page 149 shows the statements and options for creating a consecutive data set.

When creating a data set, you must identify it to the operating system in a DD statement. The following paragraphs, summarized in Table 23, tell what essential information you must include in the DD statement and discuss some of the optional information you can supply.

Table 23. Creating a Consecutive Data Set with Record I/O: Essential Parameters of the DD Statement

Storage device	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSOUT= or VOLUME=REF=
		Block size[1]	DCB=(BLKSIZE=...
Direct access only	Always	Storage space required	SPACE=
Magnetic tape only	Data set not first in volume and for magnetic tapes that do not have standard labels	Sequence number	LABEL=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but not required at end of job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSNAME=
	Data set to be on particular device	Volume serial number	VOLUME=SER= or VOLUME=REF=

[1] Or you could specify the block size in your PL/I program by using the ENVIRONMENT attribute.

Essential Information

When you create a consecutive data set you must specify:

- The device that will write your data set (UNIT, SYSOUT, or VOLUME parameter of DD statement): A data set with consecutive organization can exist on any type of auxiliary storage device.
- The block size: You can specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are the default and the record length is determined from the block size. If you do not specify a record format, U-format is the default. If you specify a record size and either specify a block size of zero or omit a specification for it, under MVS/ESA, DFP calculates a block size.

If you want to keep a magnetic-tape or direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

When creating a data set on a direct-access device, you must specify the amount of space required for it (SPACE parameter of DD statement).

If you want your data set stored on a particular magnetic-tape or direct-access device, you must specify the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not specify a serial number for a magnetic-tape data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing.

If your data set is to follow another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

The DCB subparameters of the DD statement that apply to consecutive data sets are listed below. They are described in your *MVS/ESA JCL User's Guide*. Table 15 on page 111 shows which options of the ENVIRONMENT attribute you can specify for consecutive data sets.

Subparameter	**Specifies**
BLKSIZE	Maximum number of bytes per block
BUFNO	Number of data management buffers
CODE	Paper tape: code in which the tape is punched
DEN	Magnetic tape: tape recording density
FUNC	Card reader or punch: function to be performed
LRECL	Maximum number of bytes per record
MODE	Card reader or punch: mode or operation (column binary or EBCDIC and Read Column Eliminate or Optical Mark Read)
OPTCD	Optional data-management services and data-set attributes
PRTSP	Printer line spacing (0, 1, 2, or 3)
RECFM	Record format and characteristics
STACK	Card reader or punch: stacker selection
TRTCH	Magnetic tape: tape recording technique for 7-track tape

Accessing and Updating a Data Set with Record I/O

Once you create a consecutive data set, you can open the file that accesses it for sequential input, for sequential output, or, for data sets on direct-access devices, for updating. See Figure 35 on page 160 for an example of a program that accesses and updates a consecutive data set. If you open the file for output, and extend the data set by adding records at the end, you must specify DISP=MOD in the DD statement. If you do not, the data set will be overwritten. If you open a file for updating, you can only update records in their existing sequence, and if you want to insert records, you must create a new data set. Table 20 on page 149 shows the statements and options for accessing and updating a consecutive data set.

When you access a consecutive data set by a SEQUENTIAL UPDATE file, you must retrieve a record with a READ statement before you can update it with a REWRITE statement; however, every record that is retrieved need not be rewritten. A REWRITE statement will always update the last record read.

Consider the following:

```
READ FILE(F) INTO(A);
     .
     .
     .
READ FILE(F) INTO(B);
     .
     .
     .
REWRITE FILE(F) FROM(A);
```

The REWRITE statement updates the record that was read by the second READ statement. The record that was read by the first statement cannot be rewritten after the second READ statement has been executed.

The operating system does not allow updating a consecutive data set on magnetic tape except by adding records at the end. To replace or insert records, you must read the data set and write the updated records into a new data set.

You can read a consecutive data set on magnetic tape forward or backward. If you want to read the data set backward, you must give the associated file the BACKWARDS attribute. You cannot specify the BACKWARDS attribute when a data set has V-, VB-, VS-, VBS-, D-, or DB-format records.

To access a data set, you must identify it to the operating system in a DD statement. Table 24 summarizes the DD statement parameters needed to access a consecutive data set.

Table 24. Accessing a Consecutive Data Set with Record I/O: Essential Parameters of the DD Statement

When required	What you must state	Parameters
Always	Name of data set Disposition of data set	DSNAME= DISP=
If data set not cataloged (all devices)	Input device	UNIT= or VOLUME=REF=
If data set not cataloged (standard labeled magnetic tape and direct access)	Volume serial number	VOLUME=SER=
Magnetic tape (if data set not first in volume or which does not have standard labels)	Sequence number	LABEL=
If data set does not have standard labels	Block size[1]	DCB=(BLKSIZE=.

[1] Or you could specify the block size in your PL/I program by using the ENVIRONMENT attribute.

The following paragraphs indicate the essential information you must include in the DD statement, and discuss some of the optional information you can supply. The discussions do not apply to data sets in the input stream.

Essential Information

If the data set is cataloged, you need to supply only the following information in the DD statement:

- The name of the data set (DSNAME parameter). The operating system will locate the information describing the data set in the system catalog, and, if necessary, will request the operator to mount the volume containing it.
- Confirmation that the data set exists (DISP parameter). If you open the data set for output with the intention of extending it by adding records at the end, code DISP=MOD; otherwise, opening the data set for output will result in it being overwritten.

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and, for magnetic-tape and direct-access devices, give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

If the data set follows another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

Example of Consecutive Data Sets

Creating and accessing consecutive data sets are illustrated in the program in Figure 35 on page 160. The program merges the contents of two data sets, in the input stream, and writes them onto a new data set, &&TEMP; each of the original data sets contains 15-byte fixed-length records arranged in EBCDIC collating sequence. The two input files, INPUT1 and INPUT2, have the default attribute BUFFERED, and locate mode is used to read records from the associated data sets into the respective buffers. Access of based variables in the buffers should not be attempted after the file has been closed; in MVS/XA DFP has released the buffer, and a protection error might result.

```
//EXAMPLE  JOB
//STEP1 EXEC IEL1CLG
//PLI.SYSIN   DD *
%PROCESS INT F(I) AG A(F) ESD MAP OP STG NEST X(F) SOURCE ;
%PROCESS LIST;

 MERGE: PROC OPTIONS(MAIN);
   DCL (INPUT1,                             /* FIRST INPUT FILE     */
        INPUT2,                             /* SECOND INPUT FILE    */
        OUT )      FILE RECORD SEQUENTIAL;  /* RESULTING MERGED FILE*/
   DCL SYSPRINT    FILE PRINT;              /* NORMAL PRINT FILE    */

   DCL INPUT1_EOF  BIT(1) INIT('0'B);       /* EOF FLAG FOR INPUT1  */
   DCL INPUT2_EOF  BIT(1) INIT('0'B);       /* EOF FLAG FOR INPUT2  */
   DCL OUT_EOF     BIT(1) INIT('0'B);       /* EOF FLAG FOR OUT     */
   DCL TRUE        BIT(1) INIT('1'B);       /* CONSTANT TRUE        */
   DCL FALSE       BIT(1) INIT('0'B);       /* CONSTANT FALSE       */

   DCL ITEM1       CHAR(15) BASED(A);       /* ITEM FROM INPUT1     */
   DCL ITEM2       CHAR(15) BASED(B);       /* ITEM FROM INPUT2     */
   DCL INPUT_LINE  CHAR(15);                /* INPUT FOR READ INTO  */
   DCL A           POINTER;                 /* POINTER VAR          */
   DCL B           POINTER;                 /* POINTER VAR          */

   ON ENDFILE(INPUT1) INPUT1_EOF = TRUE;
   ON ENDFILE(INPUT2) INPUT2_EOF = TRUE;
   ON ENDFILE(OUT)    OUT_EOF    = TRUE;

   OPEN FILE(INPUT1) INPUT,
        FILE(INPUT2) INPUT,
        FILE(OUT)    OUTPUT;

   READ FILE(INPUT1) SET(A);                /* PRIMING READ         */
   READ FILE(INPUT2) SET(B);

   DO WHILE ((INPUT1_EOF = FALSE) & (INPUT2_EOF = FALSE));
     IF ITEM1 > ITEM2 THEN
       DO;
         WRITE FILE(OUT) FROM(ITEM2);
         PUT FILE(SYSPRINT) SKIP EDIT('1>2', ITEM1, ITEM2)
             (A(5),A,A);
         READ FILE(INPUT2) SET(B);
       END;
     ELSE
       DO;
         WRITE FILE(OUT) FROM(ITEM1);
         PUT FILE(SYSPRINT) SKIP EDIT('1<2', ITEM1, ITEM2)
             (A(5),A,A);
         READ FILE(INPUT1) SET(A);
       END;
   END;
```

Figure 35 (Part 1 of 2). Merge Sort—Creating and Accessing a Consecutive Data Set

```
   DO WHILE (INPUT1_EOF = FALSE);           /* INPUT2 IS EXHAUSTED  */
     WRITE FILE(OUT) FROM(ITEM1);
     PUT FILE(SYSPRINT) SKIP EDIT('1', ITEM1) (A(2),A);
     READ FILE(INPUT1) SET(A);
   END;

   DO WHILE (INPUT2_EOF = FALSE);           /* INPUT1 IS EXHAUSTED  */
     WRITE FILE(OUT) FROM(ITEM2);
     PUT FILE(SYSPRINT) SKIP EDIT('2', ITEM2) (A(2),A);
     READ FILE(INPUT2) SET(B);
   END;

   CLOSE FILE(INPUT1), FILE(INPUT2), FILE(OUT);
   PUT FILE(SYSPRINT) PAGE;
   OPEN FILE(OUT) SEQUENTIAL INPUT;

   READ FILE(OUT) INTO(INPUT_LINE);         /* DISPLAY OUT FILE     */
   DO WHILE (OUT_EOF = FALSE);
     PUT FILE(SYSPRINT) SKIP EDIT(INPUT_LINE) (A);
     READ FILE(OUT) INTO(INPUT_LINE);
   END;
   CLOSE FILE(OUT);

 END MERGE;
/*
//GO.INPUT1 DD *
AAAAAA
CCCCCC
EEEEEE
GGGGGG
IIIIII
/*
//GO.INPUT2 DD *
BBBBBB
DDDDDD
FFFFFF
HHHHHH
JJJJJJ
KKKKKK
/*
//GO.OUT DD DSN=&&TEMP,DISP=(NEW,DELETE),UNIT=SYSDA,
//          DCB=(RECFM=FB,BLKSIZE=150,LRECL=15),SPACE=(TRK,(1,1))
```

Figure 35 (Part 2 of 2). Merge Sort—Creating and Accessing a Consecutive Data Set

The program in Figure 36 on page 162 uses record-oriented data transmission to print the table created by the program in Figure 30 on page 141.

```
%PROCESS INT F(I) AG A(F) ESD MAP OP STG NEST X(F) SOURCE ;
%PROCESS LIST;

 PRT: PROC OPTIONS(MAIN);
   DCL TABLE       FILE RECORD INPUT SEQUENTIAL;
   DCL PRINTER     FILE RECORD OUTPUT SEQL
                        ENV(V BLKSIZE(102) CTLASA);
   DCL LINE        CHAR(94) VAR;

   DCL TABLE_EOF   BIT(1) INIT('0'B);       /* EOF FLAG FOR TABLE   */
   DCL TRUE        BIT(1) INIT('1'B);       /* CONSTANT TRUE        */
   DCL FALSE       BIT(1) INIT('0'B);       /* CONSTANT FALSE       */


   ON ENDFILE(TABLE) TABLE_EOF = TRUE;

   OPEN FILE(TABLE),
        FILE(PRINTER);

   READ FILE(TABLE) INTO(LINE);             /* PRIMING READ         */

   DO WHILE (TABLE_EOF = FALSE);
     WRITE FILE(PRINTER) FROM(LINE);
     READ FILE(TABLE) INTO(LINE);
   END;

   CLOSE FILE(TABLE),
         FILE(PRINTER);
 END PRT;
```

Figure 36. Printing Record-Oriented Data Transmission

Chapter 9. Defining and Using Indexed Data Sets

This chapter describes indexed data set organization (ISAM), data transmission statements, and ENVIRONMENT options that define indexed data sets. It then describes how to create, access, and reorganize indexed data sets. Use of ISAM is discouraged for new data sets because VSAM gives better performance with PL/I. ISAM is retained for compatibility with existing data sets.

Under VM, PL/I supports the use of Indexed Data Sets through VSAM. See “Using Data Sets and Files” on page 81 for more information on VSAM data sets under VM.

Indexed Organization

A data set with indexed organization must be on a direct-access device. Its records can be either F-format or V-format records, blocked or unblocked. The records are arranged in logical sequence, according to keys associated with each record. A *key* is a character string that can identify each record uniquely. Logical records are arranged in the data set in ascending key sequence according to the EBCDIC collating sequence. Indexes associated with the data set are used by the operating system data-management routines to locate a record when the key is supplied.

Unlike consecutive organization, indexed organization does not require you to access every record in sequential fashion. You must create an indexed data set sequentially; but once you create it, you can open the associated file for SEQUENTIAL or DIRECT access, as well as INPUT or UPDATE. When the file has the DIRECT attribute, you can retrieve, add, delete, and replace records at random.

Sequential processing of an indexed data set is slower than that of a corresponding consecutive data set, because the records it contains are not necessarily retrieved in physical sequence. Furthermore, random access is less efficient for an indexed data set than for a regional data set, because the indexes must be searched to locate a record. An indexed data set requires more external storage space than a consecutive data set, and all volumes of a multivolume data set must be mounted, even for sequential processing.

Table 25 on page 164 lists the data-transmission statements and options that you can use to create and access an indexed data set.

Using keys

There are two kinds of keys—recorded keys and source keys. A *recorded key* is a character string that actually appears with each record in the data set to identify that record. The length of the recorded key cannot exceed 255 characters and all keys in a data set must have the same length. The recorded keys in an indexed data set can be separate from, or embedded within, the logical records. A *source key* is the character value of the expression that appears in the KEY or KEYFROM option of a data transmission statement to identify the record to which the statement refers. For direct access of an indexed data set, you must include a source key in each transmission statement.

Note: All VSAM key-sequenced data sets have embedded keys, even if they have been converted from ISAM data sets with nonembedded keys.

Table 25 (Page 1 of 2). Statements and Options Allowed for Creating and Accessing Indexed Data Sets

File declaration[1]	**Valid statements, with options you must include**	**Other options you can include**
SEQUENTIAL OUTPUT	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
	LOCATE based-variable FILE(file-reference) KEYFROM(expression);	SET(pointer-reference)
SEQUENTIAL INPUT	READ FILE(file-reference) INTO(reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) IGNORE(expression);	
SEQUENTIAL UPDATE	READ FILE(file-reference) INTO(reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) IGNORE(expression);	
	REWRITE FILE(file-reference);	FROM(reference)
	DELETE FILE(file-reference);[2]	KEY(expression)
DIRECT INPUT	READ FILE(file-reference) INTO(reference) KEY(expression);	EVENT(event-reference)
DIRECT UPDATE	READ FILE(file reference) INTO(reference) KEY(expression);	EVENT(event-reference)
	REWRITE FILE(file-reference) FROM(reference) KEY(expression);	EVENT(event-reference)
	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)
	DELETE FILE(file-reference) KEY(expression);[2]	EVENT(event-reference)

Table 25 (Page 2 of 2). Statements and Options Allowed for Creating and Accessing Indexed Data Sets

File declaration[1]	Valid statements, with options you must include	Other options you can include

DIRECT UPDATE EXCLUSIVE	READ FILE(file-reference)
	INTO(reference)
	KEY(expression);
		EVENT(event-reference)
		and/or
		NOLOCK

	REWRITE FILE(file-reference)
	FROM(reference)
	KEY(expression);
		EVENT(event-reference)

	WRITE FILE(file-reference)
	FROM(reference)
	KEYFROM(expression);
		EVENT(event-reference)

	DELETE FILE(file-reference) KEY(expression);[2]	EVENT(event-reference)
	UNLOCK FILE(file-reference) KEY(expression)	

Notes:

1. The complete file declaration would include the attributes FILE, RECORD, and ENVIRONMENT. If you use any of the options KEY, KEYFROM, or KEYTO, you must also include the attribute KEYED in the file declaration. The attribute BUFFERED is the default, and UNBUFFERED is ignored for INDEXED SEQUENTIAL and SEQUENTIAL files.
2. Use of the DELETE statement is invalid if you did not specify OPTCD=L (DCB subparameter) when the data set was created or if the RKP subparameter is 0 for FB records, or 4 for V and VB records.

The use of embedded keys avoids the need for the KEYTO option during sequential input, but the KEYFROM option is still required for output. (However, the data specified by the KEYFROM option can be the embedded key portion of the record variable itself.) In a data set with unblocked records, a separate recorded key precedes each record, even when there is already an embedded key. If the records are blocked, the key of only the last record in each block is recorded separately in front of the block.

During execution of a WRITE statement that adds a record to a data set with embedded keys, the value of the expression in the KEYFROM option is assigned to the embedded key position in the record variable. Note that you can declare a record variable as a structure with an embedded key declared as a structure member, but that you must not declare such an embedded key as a VARYING string.

For a REWRITE statement using SEQUENTIAL files with indexed data set organization, you must ensure that the rewritten key is the same as the key in the replaced record.

For a LOCATE statement, the KEYFROM string is assigned to the embedded key when the next operation on the file is encountered.

Using Indexes

To provide faster access to the records in the data set, the operating system creates and maintains a system of indexes to the records in the data set.

The lowest level of index is the *track index*. There is a track index for each cylinder in the data set. The track index occupies the first track (or tracks) of the cylinder, and lists the key of the last record on each track in the cylinder. A search can then be directed to the first track that has a key that is higher than or equal to the key of the required record.

If the data set occupies more than one cylinder, the operating system develops a higher-level index called a *cylinder index*. Each entry in the cylinder index identifies the key of the last record in the cylinder.

To increase the speed of searching the cylinder index, you can request in a DD statement that the operating system develop a *master index* for a specified number of cylinders. You can have up to three levels of master index.

Figure 37 illustrates the index structure. The part of the data set that contains the cylinder and master indexes is termed the *index area*.

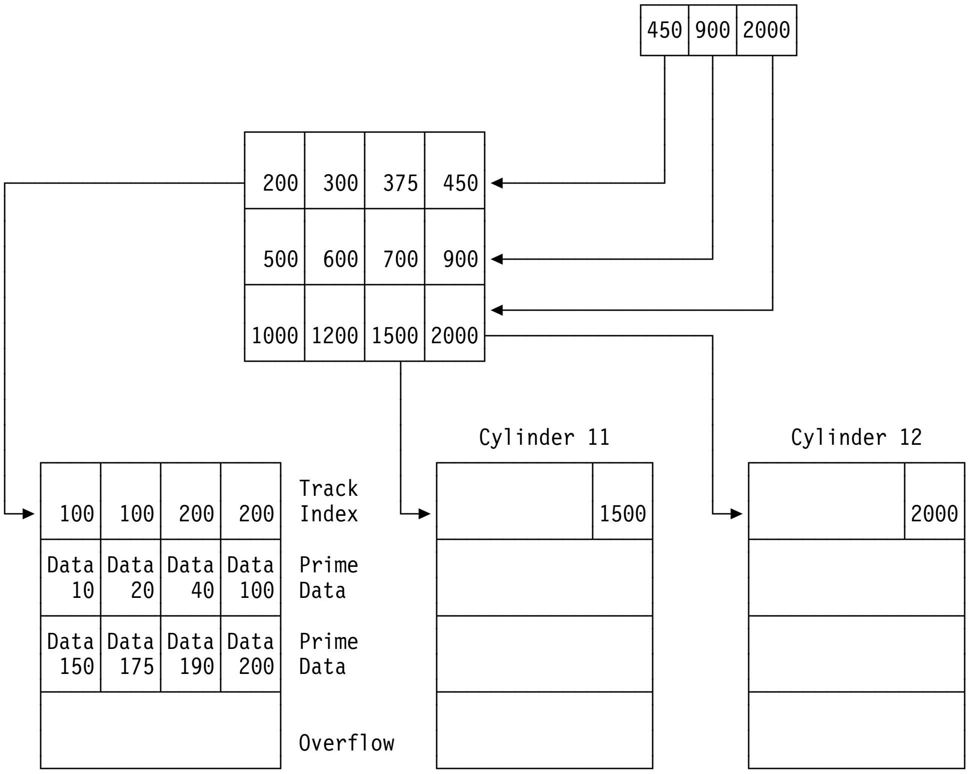


Figure 37. Index Structure of an Indexed Data Set

When you create an indexed data set, all the records are written in what is called the *prime data area*. If you add more records later, the operating system does not rearrange the entire data set; it inserts each new record in the appropriate position and moves up the other records on the same track. Any records forced off the track by the insertion of a new record are placed in an *overflow area*. The overflow area can be either a number of tracks set aside in each cylinder for the overflow records from that cylinder (*cylinder overflow area*), or a separate area for all overflow records (*independent overflow area*).

Records in the overflow area are chained together to the track index so as to maintain the logical sequence of the data set. This is illustrated in Figure 38 on page 168. Each entry in the track index consists of two parts:

- The normal entry, which points to the last record on the track
- The overflow entry, which contains the key of the first record transferred to the overflow area and also points to the last record transferred from the track to the overflow area.

If there are no overflow records from the track, both index entries point to the last record on the track. An additional field is added to each record that is placed in the overflow area. It points to the previous record transferred from the same track. The first record from each track is linked to the corresponding overflow entry in the track index.

Dummy Records

Records within an indexed data set are either actual records, containing valid data, or dummy records. A dummy record, identified by the constant (8)`'1'`B in its first byte, can be one that you insert or it can be created by the operating system. You insert dummy records by setting the first byte to (8)`'1'`B and writing the records in the usual way. The operating system creates dummy records by placing (8)`'1'`B in a record that is named in a DELETE statement.

When creating an indexed data set, you might want to insert dummy records to reserve space in the prime data area. You can replace dummy records later with actual data records having the same key.

The operating system removes dummy records when the data set is reorganized, as described later in this section, and removes those forced off the track during an update.

If you include the DCB subparameter OPTCD=L in the DD statement that defines the data set when you create it, dummy records will not be retrieved by READ statements and the operating system will write the dummy identifier in records being deleted.

100	Track 1	100	Track 1	200	Track 2	200	Track 2	Track Index

10	20	40	100	Prime Data
150	175	190	200	

				Overflow

40	Track 1	100	Track 3 record 1	190	Track 2	200	Track 3 record 2	Track Index

10	20	25	40	Prime Data
101	150	175	190	

100	Track 1	200	Track 2			Overflow

26	Track 1	100	Track 3 record 3	190	Track 2	200	Track 3 record 4	Track Index

10	20	25	26	Prime Data
101	150	175	190	

100	Track 1	200	Track 2	40	Track 3 record 1	199	Track 3 record 2	Overflow

Figure 38. Adding Records to an Indexed Data Set

Defining Files for an Indexed Data Set

You define a sequential indexed data set by a file declaration with the following attributes:

```
DCL filename FILE RECORD
             INPUT | OUTPUT | UPDATE
             SEQUENTIAL
             BUFFERED
            [KEYED]
             ENVIRONMENT(options);
```

You define a direct indexed data set by a file declaration with the following attributes:

```
DCL filename FILE RECORD
             INPUT | OUTPUT | UPDATE
             DIRECT
             UNBUFFERED
             KEYED
            [EXCLUSIVE]
             ENVIRONMENT(options);
```

Default file attributes are shown in Table 15 on page 111. The file attributes are described in the *PL/I for MVS & VM Language Reference*. Options of the ENVIRONMENT attribute are discussed below.

Specifying ENVIRONMENT Options

The ENVIRONMENT options applicable to indexed data sets are:

```
F|FB|V|VB
RECSIZE(record-length)
BLKSIZE(block-size)
SCALARVARYING
COBOL
BUFFERS(n)
KEYLENGTH(n)
NCP(n)
GENKEY

ADDBUFF
INDEXAREA[(index-area-size)]
INDEXED
KEYLOC(n)
NOWRITE
```

The options above the blank line are described in “Specifying Characteristics in the ENVIRONMENT Attribute” on page 110, and those below the blank line are described below.

ADDBUFF Option

Specify the ADDBUFF option for a DIRECT INPUT or DIRECT UPDATE file with indexed data set organization and F-format records to indicate that an area of internal storage is used as a workspace in which records on the data set can be rearranged when new records are added. The size of the workspace is equivalent to one track of the direct-access device used.

You do not need to specify the ADDBUFF option for DIRECT INDEXED files with V-format records, as the workspace is automatically allocated for such files.

```
►►──ADDBUF──────────────────────────────────────────────────────►◄
```

INDEXAREA Option

With the INDEXAREA option you improve the input/output speed of a DIRECT INPUT or DIRECT UPDATE file with indexed data set organization, by having the highest level of index placed in main storage.

```
►►──INDEXAREA──(──index-area-size──)────────────────────────────►◄
```

index-area-size enables you to limit the amount of main storage allowed for an index area. The size you specify must be an integer or a variable with attributes FIXED BINARY(31,0) STATIC from 0 to 64,000 in value. If you do not specify *index-area-size*, the highest level index is moved unconditionally into main storage. If you do specify *index-area-size*, the highest level index is held in main storage, provided that its size does not exceed that specified. If you specify a size less than 0 or greater than 64,000, unpredictable results will occur.

INDEXED Option

Use the INDEXED option to define a file with indexed organization (which is described above). It is usually used with a data set created and accessed by the Indexed Sequential Access Method (ISAM), but you can also use it in some cases with VSAM data sets (as described in Chapter 11, “Defining and Using VSAM Data Sets”).

```
►►──INDEXED─────────────────────────────────────────────────────►◄
```

KEYLOC Option — Key Location

Use the KEYLOC option with indexed data sets when you create the data set to specify the starting position of an embedded key in a record.

```
►►──KEYLOC──────────────────────────────────────────────────────►◄
```

The position, *n*, must be within the limits:

$1 \leq n \leq$ recordsize − keylength + 1

That is, the key cannot be larger than the record, and must be contained completely within the record.

If the keys are embedded within the records, either specify the KEYLOC option, or include the DCB subparameter RKP in the DD statement for the associated data set.

If you do not specify KEYLOC, the value specified with RKP is used. If you specify neither, then RKP=0 is the default.

The KEYLOC option specifies the absolute position of an embedded key from the start of the data in a record, while the RKP subparameter specifies the position of an embedded key relative to the start of the record.

Thus the equivalent KEYLOC and RKP values for a particular byte are affected by the following:

- The KEYLOC byte count starts at 1; the RKP count starts at 0.
- The record format.

For example, if the embedded key begins at the tenth byte of a record variable, the specifications are:

Fixed-length:	`KEYLOC(10)`
	`RKP=9`

Variable-length:	`KEYLOC(10)`
	`RKP=13`

If KEYLOC is specified with a value equal to or greater than 1, embedded keys exist in the record variable and on the data set. If KEYLOC is equal to zero, or is not specified, the RKP value is used. When RKP is specified, the key is part of the variable only when RKP≥1. As a result, embedded keys might not always be present in the record variable or the data set. If you specify `KEYLOC(1)`, you must specify it for every file that accesses the data set. This is necessary because KEYLOC(1) cannot be converted to an unambiguous RKP value. (Its equivalent is RKP=0 for fixed format, which in turn implies nonembedded keys.) The effect of the use of both options is shown in Table 26.

Table 26. Effect of KEYLOC and RKP Values on Establishing Embedded Keys in Record Variables or Data Sets

KEYLOC(n)	**RKP**	**Record variable**	**Data set unblocked records**	**Data set blocked records**
n>1	RKP equivalent = n–1+C[1]	Key	Key	Key
n=1	No equivalent	Key	Key[2]	Key
n=0 or not specified	RKP=C[1]	No Key	No Key	Key[3]
	RKP>C[1]	Key	Key	Key

Notes:

1. C = number of control bytes, if any:
   C=0 for fixed-length records.
   C=4 for variable-length records.
2. In this instance the key is not recognized by data management .
3. Each logical record in the block has a key.

If you specify SCALARVARYING, the embedded key must not immediately precede or follow the first byte; hence, the value specified for KEYLOC must be greater than 2.

If you include the KEYLOC option in a VSAM file declaration for checking purposes, and the key location you specify in the option conflicts with the value defined for the data set, the UNDEFINEDFILE condition is raised.

NOWRITE Option

Use the NOWRITE option for DIRECT UPDATE files. It specifies that no records are to be added to the data set and that data management modules concerned solely with adding records are not required. Thus, it allows the size of the object program to be reduced.

```
►►──NOWRITE──────────────────────────────────────────────────────────►◄
```

Creating an Indexed Data Set

When you create an indexed data set, you must open the associated file for SEQUENTIAL OUTPUT, and you must present the records in the order of ascending key values. (If there is an error in the key sequence, the KEY condition is raised.) You cannot use a DIRECT file for the creation of an indexed data set.

Table 25 on page 164 shows the statements and options for creating an indexed data set.

You can extend an indexed data set consisting of fixed-length records by adding records sequentially at the end, until the original space allocated for the prime data is filled. You must open the corresponding file for SEQUENTIAL OUTPUT and you must include DISP=MOD in the DD statement.

You can use a single DD statement to define the whole data set (index area, prime area, and overflow area), or you can use two or three statements to define the areas independently. If you use two DD statements, you can define either the index area and the prime area together, or the prime area and the overflow area together.

If you want the entire data set to be on a single volume, there is no advantage to be gained by using more than one DD statement except to define an independent overflow area (see “Overflow Area” on page 177). But, if you use separate DD statements to define the index and/or overflow area on volumes separate from that which contains the prime area, you will increase the speed of direct-access to the records in the data set by reducing the number of access mechanism movements required.

When you use two or three DD statements to define an indexed data set, the statements must appear in the order: index area; prime area; overflow area. The first DD statement must have a name (ddname), but the name fields of a second or third DD statement must be blank. The DD statements for the prime and overflow areas must specify the same type of unit (UNIT parameter). You must include all the DCB information for the data set in the first DD statement. DCB=DSORG=IS will suffice in the other statements.

Essential Information

To create an indexed data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you can supply.

You must supply the following information when creating an indexed data set:

- Direct-access device that will write your data set (UNIT or VOLUME parameter of DD statement). Do not request DEFER.
- Block size: You can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are the default and the record length is determined from the block size.
- Space requirements: Include space for future needs when you specify the size of the prime, index, and overflow areas. Once you have created an indexed data set, you cannot change its specification.

If you want to keep a direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

If you want your data set stored on a particular direct-access device, you must specify the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not specify a serial number for a data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing. All the essential parameters required in a DD statement for the creation of an indexed data set are summarized in Table 27. Table 28 on page 174 lists the DCB subparameters needed. See the *MVS/370 JCL User's Guide* for a description of the DCB subparameters.

You must request space for the prime data area in the SPACE parameter. You cannot specify a secondary quantity for an indexed data set. Your request must be in units of cylinders unless you place the data set in a specific position on the volume (by specifying a track number in the SPACE parameter). In the latter case, the number of tracks you specify must be equivalent to an integral number of cylinders, and the first track must be the first track of a cylinder other than the first cylinder in the volume.

You can also use the SPACE parameter to specify the amount of space to be used for the cylinder and master indexes (unless you use a separate DD statement for this purpose). If you do not specify the space for the indexes, the operating system will use part of the independent overflow area. If there is no independent overflow area, it will use part of the prime data area.

Table 27 (Page 1 of 2). Creating an Indexed Data Set: Essential Parameters of DD Statement

When required	What you must state	Parameters

Always	Output device	UNIT= or
		VOLUME=REF=

	Storage space required	SPACE=
	Data control block information: see Table 28 on page 174	DCB=

Table 27 (Page 2 of 2). Creating an Indexed Data Set: Essential Parameters of DD Statement

When required	What you must state	Parameters
More than one DD statement	Name of data set and area (index, prime, overflow)	DSNAME=
Data set to be used in another job step but not required at end of job	Disposition	DISP=
Data set to be kept after end of job	Disposition	DISP=
	Name of data set	DSNAME=
Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

Table 28. DCB Subparameters for an Indexed Data Set

When required	To specify	Subparameters
These are always required[2]	Record format[1]	RECFM=F, FB, V, or VB
	Block size[1]	BLKSIZE=
	Data set organization	DSORG=IS
	Key length[1]	KEYLEN=
Include at least one of these if overflow is required	Cylinder overflow area and number of tracks per cylinder for overflow records	OPTCD=Y and CYLOFL=
	Independent overflow area	OPTCD=I
These are optional	Record length[1]	LRECL=
	Embedded key (relative key position)[1]	RKP= [2]
	Master index	OPTCD=M
	Automatic processing of dummy records	OPTCD=L
	Number of data management buffers[1]	BUFNO=
	Number of tracks in cylinder index for each master index entry	NTM=

Notes:

Full DCB information must appear in the first, or only, DD statement. Subsequent statements require only DSORG=IS.

1. Or you could specify BUFNO in the ENVIRONMENT attribute.
2. RKP is required if the data set has embedded keys, unless you specify the KEYLOC option of ENVIRONMENT instead.

You must always specify the data set organization (DSORG=IS subparameter of the DCB parameter), and in the first (or only) DD statement you must also specify the length of the key (KEYLEN subparameter of the DCB parameter) unless it is specified in the ENVIRONMENT attribute.

If you want the operating system to recognize dummy records, you must code OPTCD=L in the DCB subparameter of the DD statement. This will cause the operating system to write the dummy identifier in deleted records and to ignore dummy records during sequential read processing. Do not specify OPTCD=L when using blocked or variable-length records with nonembedded keys. If you do this, the dummy record identifier (8)'1'B will overwrite the key of deleted records.

You cannot place an indexed data set on a system output (SYSOUT) device.

Name of the Data Set

If you use only one DD statement to define your data set, you need not name the data set unless you intend to access it in another job. But if you include two or three DD statements, you must specify a data set name, even for a temporary data set.

The DSNAME parameter in a DD statement that defines an indexed data set not only gives the data set a name, but it also identifies the area of the data set to which the DD statement refers:

```
DSNAME=name(INDEX)
DSNAME=name(PRIME)
DSNAME=name(OVFLOW)
```

If you use one DD statement to define the prime and index or one DD statement to define the prime and overflow area, code DSNAME=name(PRIME). If you use one DD statement for the entire file (prime, index, and overflow), code DSNAME=name(PRIME) or simply DSNAME=name.

Record Format and Keys

An indexed data set can contain either fixed- or variable-length records, blocked or unblocked. You must always specify the record format, either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (RECFM subparameter).

The key associated with each record can be contiguous with or embedded within the data in the record.

If the records are unblocked, the key of each record is recorded in the data set in front of the record even if it is also embedded within the record, as shown in (a) and (b) of Figure 39 on page 176.

If blocked records do not have embedded keys, the key of each record is recorded within the block in front of the record, and the key of the last record in the block is also recorded just ahead of the block, as shown in (c) of Figure 39.

When blocked records have embedded keys, the individual keys are not recorded separately in front of each record in the block: the key of the last record in the block is recorded in front of the block, as shown in (d) of Figure 39.

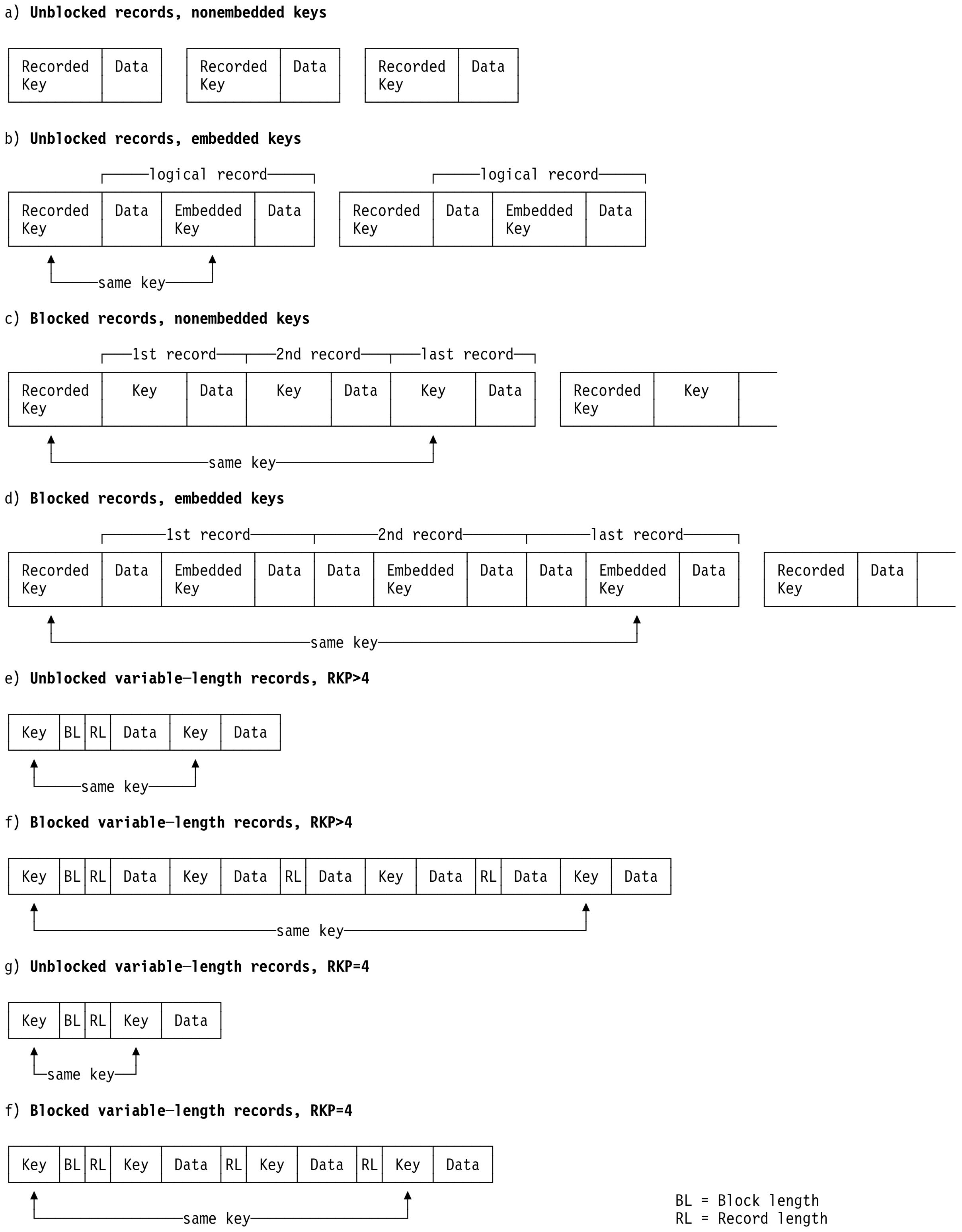


Figure 39. Record Formats in an Indexed Data Set

If you use blocked records with nonembedded keys, the record size that you specify must include the length of the key, and the block size must be a multiple of this combined length. Otherwise, record length and block size refer only to the data in the record. Record format information is shown in Figure 40.

If you use records with embedded keys, you must include the DCB subparameter RKP to indicate the position of the key within the record. For fixed-length records the value specified in the RKP subparameter is 1 less than the byte number of the first character of the key. That is, if RKP=1, the key starts in the second byte of the record. The default value if you omit this subparameter is RKP=0, which specifies that the key is not embedded in the record but is separate from it.

For variable-length records, the value you specify in the RKP subparameter must be the relative position of the key within the record plus 4. The extra 4 bytes take into account the 4-byte control field used with variable-length records. For this reason, you must never specify RKP less than 4. When deleting records, you must always specify RKP equal to or greater than 5, since the first byte of the data is used to indicate deletion.

For unblocked records, the key, even if embedded, is always recorded in a position preceding the actual data. Consequently, you do not need to specify the RKP subparameter for unblocked records.

RECORDS	**RKP**	**LRECL**	**BLKSIZE**
Blocked	Not zero	R	R * B
	Zero or omitted	R + K	B*(R+K)
Unblocked	Not zero	R	R
	Zero or omitted	R	R

R = Size of data in record
K = Length of keys (as specified in KEYLEN subparameter)
B = Blocking factor

```
Example:  For blocked records, nonembedded keys, 100 bytes of
          data per record, 10 records per block, key length = 20:

             LRECL=120,BLKSIZE=1200,RECFM=FB
```

Figure 40. Record Format Information for an Indexed Data Set

Overflow Area

If you intend to add records to the data set on a future occasion, you must request either a cylinder overflow area or an independent overflow area, or both.

For a cylinder overflow area, include the DCB subparameter OPTCD=Y and use the subparameter CYLOFL to specify the number of tracks in each cylinder to be reserved for overflow records. A cylinder overflow area has the advantage of a short search time for overflow records, but the amount of space available for overflow records is limited, and much of the space might be unused if the overflow records are not evenly distributed throughout the data set.

For an independent overflow area, use the DCB subparameter OPTCD=I to indicate that overflow records are to be placed in an area reserved for overflow records from all cylinders, and include a separate DD statement to define the overflow area. The use of an independent area has the advantage of reducing the amount of unused space for overflow records, but entails an increased search time for overflow records.

It is good practice to request cylinder overflow areas large enough to contain a reasonable number of additional records and an independent overflow area to be used as the cylinder overflow areas are filled.

If the prime data area is not filled during creation, you cannot use the unused portion for overflow records, nor for any records subsequently added during direct-access (although you can fill the unfilled portion of the last track used). You can reserve space for later use within the prime data area by writing dummy records during creation (see "Dummy Records" on page 167).

Master Index

If you want the operating system to create a master index for you, include the DCB subparameter OPTCD=M, and indicate in the NTM subparameter the number of tracks in the cylinder index you wish to be referred to by each entry in the master index. The operating system will create up to three levels of master index, the first two levels addressing tracks in the next lower level of the master index.

The creation of a simple indexed data set is illustrated in Figure 41 on page 179. The data set contains a telephone directory, using the subscribers' names as keys to the telephone numbers.

```
//EX8#19  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN     DD *
 TELNOS: PROC OPTIONS(MAIN);
         DCL DIREC FILE RECORD SEQUENTIAL KEYED ENV(INDEXED),
             CARD CHAR(80),
             NAME CHAR(20) DEF CARD,
             NUMBER CHAR(3) DEF CARD POS(21),
             IOFIELD CHAR(3),
             EOF BIT(1) INIT('0'B);
         ON ENDFILE(SYSIN) EOF='1'B;
         OPEN FILE(DIREC) OUTPUT;
         GET FILE(SYSIN) EDIT(CARD)(A(80));
         DO WHILE (¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT (CARD) (A);
         IOFIELD=NUMBER;
         WRITE FILE(DIREC) FROM(IOFIELD) KEYFROM(NAME);
         GET FILE(SYSIN) EDIT(CARD)(A(80));
         END;
         CLOSE FILE(DIREC);
 END TELNOS;
/*
//GO.DIREC DD DSN=HPU8.TELNO(INDEX),UNIT=SYSDA,SPACE=(CYL,1),
//            DCB=(RECFM=F,BLKSIZE=3,DSORG=IS,KEYLEN=20,OPTCD=LIY,
//            CYLOFL=2),DISP=(NEW,KEEP)
//         DD DSN=HPU8.TELNO(PRIME),UNIT=SYSDA,SPACE=(CYL,1),
//            DISP=(NEW,KEEP),DCB=DSORG=IS
//         DD DSN=HPU8.TELNO(OVFLOW),UNIT=SYSDA,SPACE=(CYL,1),
//            DISP=(NEW,KEEP),DCB=DSORG=IS
//GO.SYSIN DD *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESEMAN,D.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,S.          413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF,D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
/*
```

Figure 41. Creating an Indexed Data Set

Accessing and Updating an Indexed Data Set

Once you create an indexed data set, you can open the file that accesses it for SEQUENTIAL INPUT or UPDATE, or for DIRECT INPUT or UPDATE. In the case of F-format records, you can also open it for OUTPUT to add records at the end of the data set. The keys for these records must have higher values than the existing keys for that data set and must be in ascending order. Table 25 on page 164 shows the statements and options for accessing an indexed data set.

Sequential input allows you to read the records in ascending key sequence, and in sequential update you can read and rewrite each record in turn. Using direct input, you can read records using the READ statement, and in direct update you can read or delete existing records or add new ones. Sequential and direct-access are discussed in further detail below.

Using Sequential Access

You can open a sequential file that is used to access an indexed data set with either the INPUT or the UPDATE attribute. You do not need to include source keys in the data transmission statements, nor do you need to give the file the KEYED attribute. Sequential access is in order of ascending recorded-key values. Records are retrieved in this order, and not necessarily in the order in which they were added to the data set. Dummy records are not retrieved if you include the subparameter OPTCD=L in the DD statement that defines the data set.

Except that you cannot use the EVENT option, rules governing the relationship between the READ and REWRITE statements for a SEQUENTIAL UPDATE file that accesses an indexed data set are identical to those for a consecutive data set (described in Chapter 8, “Defining and Using Consecutive Data Sets” on page 129).

You must not alter embedded keys in a record to be updated. The modified record must always overwrite the update record in the data set.

Additionally, records can be effectively deleted from the data set. Using a DELETE statement marks a record as a dummy by putting (8)`'1'`B in the first byte. You should not use the DELETE statement to process a data set with F-format blocked records and either KEYLOC=1 or RKP=0, or a data set with V- or VB-format records and either KEYLOC=1 or RKP=4. (The code (8)`'1'`B would overwrite the first byte of the recorded key.) Note that the EVENT option is not supported for SEQUENTIAL access of indexed data sets.

You can position INDEXED KEYED files opened for SEQUENTIAL INPUT and SEQUENTIAL UPDATE to a particular record within the data set by using either a READ KEY or a DELETE KEY operation that specifies the key of the desired record. Thereafter, successive READ statements without the KEY option access the next records in the data set sequentially. A subsequent READ statement without the KEY option causes the record with the next higher recorded key to be read (even if the keyed record has not been found).

Define the length of the recorded keys in an indexed data set with the KEYLENGTH ENVIRONMENT option or the KEYLEN subparameter of the DD statement that defines the data set. If the length of a source key is greater than the specified length of the recorded keys, the source key is truncated on the right.

The effect of supplying a source key that is shorter than the recorded keys in the data set differs according to whether or not you specify the GENKEY option in the ENVIRONMENT attribute. In the absence of the GENKEY option, the source key is padded on the right with blanks to the length you specify in the KEYLENGTH option of the ENVIRONMENT attribute, and the record with this padded key is read (if such a record exists). If you specify the GENKEY option, the source key is interpreted as a generic key, and the first record with a key in the class identified by this generic key is read. (For further details, see “GENKEY Option — Key Classification” on page 118.)

Using Direct Access

You can open a direct file that is used to access an indexed data set with either the INPUT or the UPDATE attribute. You must include source keys in all data transmission statements; the DIRECT attribute implies the KEYED attribute.

You can use a DIRECT UPDATE file to retrieve, add, delete, or replace records in an indexed data set according to the following conventions:

Retrieval If you include the subparameter OPTCD=L in the DD statement that defines the data set, dummy records are not made available by a READ statement (the KEY condition is raised).

Addition A WRITE statement that includes a unique key causes a record to be inserted into the data set. If the key is the same as the recorded key of a dummy record, the new record replaces the dummy record. If the key is the same as the recorded key of a record that is not marked as deleted, or if there is no space in the data set for the record, the KEY condition is raised.

Deletion The record specified by the source key in a DELETE statement is retrieved, marked as deleted, and rewritten into the data set. The effect of the DELETE statement is to insert the value (8)'1'B in the first byte of the data in a record. Deletion is possible only if you specify OPTCD=L in the DD statement that defines the data set when you create it. If the data set has F-format blocked records with RKP=0 or KEYLOC=1, or V-format records with RKP=4 or KEYLOC=1, records cannot be deleted. (The code (8)'1'B would overwrite the embedded keys.)

Replacement The record specified by a source key in a REWRITE statement is replaced by the new record. If the data set contains F-format blocked records, a record replaced with a REWRITE statement causes an implicit READ statement to be executed unless the previous I/O statement was a READ statement that obtained the record to be replaced. If the data set contains V-format records and the updated record has a length different from that of the record read, the whole of the remainder of the track will be removed, and can cause data to be moved to an overflow track.

Essential Information

To access an indexed data set, you must define it in one, two, or three DD statements. The DD statements must correspond with those used when the data set is created. The following paragraphs indicate the essential information you must include in each DD statement. Table 29 on page 182 summarizes this information.

Table 29. Accessing an Indexed Data Set: Essential Parameters of DD Statement

When required	What you must state	Parameters
Always	Name of data set	DSNAME=
	Disposition of data set	DISP=
	Data control block information	DCB=

If data set not cataloged	Input device	UNIT= or
		VOLUME=REF=

	Volume serial number	VOLUME=SER=

If the data set is cataloged, you need supply only the following information in each DD statement:

- The name of the data set (DSNAME parameter). The operating system will locate the information that describes the data set in the system catalog and, if necessary, will request the operator to mount the volume that contains it.
- Confirmation that the data set exists (DISP parameter).

If the data set is not cataloged, you must, in addition, specify the device that will process the data set and give the serial number of the volume that contains it (UNIT and VOLUME parameters).

Example

The program in Figure 42 on page 183 updates the data set of the previous example (Figure 41 on page 179) and prints out its new contents. The input data includes the following codes to indicate the operations required:

A	Add a new record.
C	Change an existing record.
D	Delete an existing record.

```
//EX8#20  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN     DD *
 DIRUPDT: PROC OPTIONS(MAIN);
         DCL DIREC FILE RECORD KEYED ENV(INDEXED),
             NUMBER CHAR(3),NAME CHAR(20),CODE CHAR(1),ONCODE BUILTIN,
             EOF BIT(1) INIT('0'B);
         ON ENDFILE(SYSIN) EOF='1'B;
         ON KEY(DIREC) BEGIN;
          IF ONCODE=51 THEN PUT FILE(SYSPRINT) SKIP EDIT
                            ('NOT FOUND:',NAME)(A(15),A);
          IF ONCODE=52 THEN PUT FILE(SYSPRINT) SKIP EDIT
                            ('DUPLICATE:',NAME)(A(15),A);
          END;
         OPEN FILE(DIREC) DIRECT UPDATE;
         GET FILE(SYSIN) EDIT(NAME,NUMBER,CODE)
           (COLUMN(1),A(20),A(3),A(1));
         DO WHILE (¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT (' ',NAME,'#',NUMBER,' ',CODE)
            (A(1),A(20),A(1),A(3),A(1),A(1));
         SELECT (CODE);
            WHEN('A') WRITE FILE(DIREC) FROM(NUMBER) KEYFROM(NAME);
            WHEN('C') REWRITE FILE(DIREC) FROM(NUMBER) KEY(NAME);
            WHEN('D') DELETE FILE(DIREC) KEY(NAME);
            OTHERWISE PUT FILE(SYSPRINT) SKIP
              EDIT('INVALID CODE:',NAME)(A(15),A);
         END;
         GET FILE(SYSIN) EDIT(NAME,NUMBER,CODE)
         (COLUMN(1),A(20),A(3),A(1));
         END;
         CLOSE FILE(DIREC);
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(DIREC) SEQUENTIAL INPUT;
         EOF='0'B;
         ON ENDFILE(DIREC) EOF='1'B;
         READ FILE(DIREC) INTO(NUMBER) KEYTO(NAME);
         DO WHILE (¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT(NAME,NUMBER)(A);
         READ FILE(DIREC) INTO(NUMBER) KEYTO(NAME);
         END;
         CLOSE FILE(DIREC);       END DIRUPDT;
/*
//GO.DIREC DD DSN=HPU8.TELNO(INDEX),DISP=(OLD,DELETE),
//     VOL=SER=nnnnnn,UNIT=SYSDA
//         DD DSN=HPU8.TELNO(PRIME),DISP=(OLD,DELETE),
//     VOL=SER=nnnnnn,UNIT=SYSDA
//         DD DSN=HPU8.TELNO(OVFLOW),DISP=(OLD,DELETE),
//     VOL=SER=nnnnnn,UNIT=SYSDA
//GO.SYSIN DD *
NEWMAN,M.W.         516C
GOODFELLOW,D.T.     889A
MILES,R.               D
HARVEY,C.D.W.       209A
BARTLETT,S.G.       183A
CORY,G.                D
READ,K.M.           001A
PITT,W.H.
ROLF,D.E.              D
ELLIOTT,D.          291C
HASTINS,G.M.           D
BRAMLEY,O.H.        439
/*
```

Figure 42. Updating an Indexed Data Set

Reorganizing an Indexed Data Set

It is necessary to reorganize an indexed data set periodically because the addition of records to the data set results in an increasing number of records in the overflow area. Therefore, even if the overflow area does not eventually become full, the average time required for the direct retrieval of a record will increase. The frequency of reorganization depends on how often you update the data set, on how much storage is available in the data set, and on your timing requirements.

Reorganizing the data set also eliminates records that are marked as “deleted” but are still present within the data set.

There are two ways to reorganize an indexed data set:

- Read the data set into an area of main storage or onto a temporary consecutive data set, and then recreate it in the original area of auxiliary storage.
- Read the data set sequentially and write it into a new area of auxiliary storage. You can then release the original auxiliary storage.

Chapter 10. Defining and Using Regional Data Sets

This chapter covers regional data set organization, data transmission statements, and ENVIRONMENT options that define regional data sets. How to create and access regional data sets for each type of regional organization is then discussed.

A data set with regional organization is divided into regions, each of which is identified by a region number, and each of which can contain one record or more than one record, depending on the type of regional organization. The regions are numbered in succession, beginning with zero, and a record can be accessed by specifying its region number, and perhaps a key, in a data transmission statement.

Regional data sets are confined to direct-access devices.

Regional organization of a data set allows you to control the physical placement of records in the data set, and to optimize the access time for a particular application. Such optimization is not available with consecutive or indexed organization, in which successive records are written either in strict physical sequence or in logical sequence depending on ascending key values; neither of these methods takes full advantage of the characteristics of direct-access storage devices.

You can create a regional data set in a manner similar to a consecutive or indexed data set, presenting records in the order of ascending region numbers; alternatively, you can use direct-access, in which you present records in random sequence and insert them directly into preformatted regions. Once you create a regional data set, you can access it by using a file with the attributes SEQUENTIAL or DIRECT as well as INPUT or UPDATE. You do not need to specify either a region number or a key if the data set is associated with a SEQUENTIAL INPUT or SEQUENTIAL UPDATE file. When the file has the DIRECT attribute, you can retrieve, add, delete, and replace records at random.

Records within a regional data set are either actual records containing valid data or dummy records. The nature of the dummy records depends on the type of regional organization; the three types of regional organization are described below.

The major advantage of regional organization over other types of data set organization is that it allows you to control the relative placement of records; by judicious programming, you can optimize record access in terms of device capabilities and the requirements of particular applications.

Direct access of regional data sets is quicker than that of indexed data sets, but regional data sets have the disadvantage that sequential processing can present records in random sequence; the order of sequential retrieval is not necessarily that in which the records were presented, nor need it be related to the relative key values.

Table 30 on page 186 lists the data transmission statements and options that you can use to create and access a regional data set.

Table 30 (Page 1 of 2). Statements and options allowed for creating and accessing regional data sets

File declaration[1]	**Valid statements,**[2] **with options you must include**	**Other options you can also include**
SEQUENTIAL OUTPUT BUFFERED	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
	LOCATE based-variable FROM(file-reference) KEYFROM(expression);	SET(pointer-reference)
SEQUENTIAL OUTPUT UNBUFFERED	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)
SEQUENTIAL INPUT BUFFERED	READ FILE(file-reference) INTO(reference);	KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEYTO(reference)
	READ FILE(file-reference) IGNORE(expression);	
SEQUENTIAL INPUT UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or KEYTO(reference)
	READ FILE(file-reference) IGNORE(expression);	EVENT(event-reference)
SEQUENTIAL UPDATE[3] BUFFERED	READ FILE(file-reference) INTO(reference);	KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEYTO(reference)
	READ FILE(file-reference) IGNORE(expression);	
	REWRITE FILE(file-reference);	FROM(reference)
SEQUENTIAL UPDATE UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or KEYTO(reference)
	READ FILE(file-reference) IGNORE(expression);	EVENT(event-reference)
	REWRITE FILE(file-reference) FROM(reference);	EVENT(event-reference)
DIRECT OUTPUT	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)
DIRECT INPUT	READ FILE(file-reference) INTO(reference) KEY(expression);	EVENT(event-reference)

Table 30 (Page 2 of 2). Statements and options allowed for creating and accessing regional data sets

File declaration[1]	**Valid statements,**[2] **with options you must include**	**Other options you can also include**

DIRECT UPDATE	READ FILE(file-reference)
	INTO(reference)
	KEY(expression);
		EVENT(event-reference)

	REWRITE FILE(file-reference)
	FROM(reference)
	KEY(expression);
		EVENT(event-reference)

	WRITE FILE(file-reference)
	FROM(reference)
	KEYFROM(expression);
		EVENT(event-reference)

	DELETE FILE(file-reference) KEY(expression);	EVENT(event-reference)

DIRECT UPDATE EXCLUSIVE	READ FILE(file-reference)
	INTO(reference)
	KEY(expression);
		EVENT(event-reference)
		and/or
		NOLOCK

	REWRITE FILE(file-reference)
	FROM(reference)
	KEY(expression);
		EVENT(event-reference)

	WRITE FILE(file-reference)
	FROM(reference)
	KEYFROM(expression);
		EVENT(event-reference)

	DELETE FILE(file-reference) KEY(expression);	EVENT(event-reference)
	UNLOCK FILE(file-reference) KEY(expression);	

Notes:

1. The complete file declaration would include the attributes FILE, RECORD, and ENVIRONMENT; if you use any of the options KEY, KEYFROM, or KEYTO, you must also include the attribute KEYED.
2. The statement READ FILE(file-reference); is equivalent to the statement READ FILE(file-reference) IGNORE(1);
3. The file must not have the UPDATE attribute when creating new data sets.

Regional(1) files are supported under VM with the following restrictions:

- More than one regional file with keys cannot be open at the same time.
- You must not increment KEY(TRACKID/REGION NUMBER) unless 255 records are written on the first logical track, and 256 records on each subsequent logical track.
- You must not write files with a dependency on the physical track length of a direct access device.
- When you create a file, you must specify the XTENT option of the FILEDEF command and it must be equal to the number of records in the file to be created.

The examples in this chapter are given using JCL. However, the information presented in the JCL examples is applicable to the FILEDEF VM command you issue. For more information on the FILEDEF command, see the *VM/ESA CMS Command Reference* and the *VM/ESA CMS User's Guide*.

Defining Files for a Regional Data Set

Use a file declaration with the following attributes to define a sequential regional data set:

```
DCL filename FILE RECORD
             INPUT | OUTPUT | UPDATE
             SEQUENTIAL
             BUFFERED | UNBUFFERED
            [KEYED]
             ENVIRONMENT(options);
```

To define a direct regional data set, use a file declaration with the following attributes:

```
DCL filename FILE RECORD
             INPUT | OUTPUT | UPDATE
             DIRECT
             UNBUFFERED
            [EXCLUSIVE] (cannot be used with INPUT or OUTPUT)
             ENVIRONMENT(options);
```

Default file attributes are shown in Table 15 on page 111. The file attributes are described in the *PL/I for MVS & VM Language Reference*. Options of the ENVIRONMENT attribute are discussed below.

Specifying ENVIRONMENT Options

The ENVIRONMENT options applicable to regional data sets are:

```
REGIONAL({1|2|3})
F|V|VS|U
RECSIZE(record-length)
BLKSIZE(block-size)
SCALARVARYING
COBOL
BUFFERS(n)
KEYLENGTH(n)
NCP(n)
TRKOFL
```

REGIONAL Option

Use the REGIONAL option to define a file with regional organization.

```
►►──REGIONAL──(──┬─1─┬──)──────────────────────────────────────────────►◄
                 ├─2─┤
                 └─3─┘
```

1 | 2 | 3
specifies REGIONAL(1), REGIONAL(2), or REGIONAL(3), respectively.

REGIONAL(1)
specifies that the data set contains F-format records that do not have recorded keys. Each region in the data set contains only one record; therefore, each

region number corresponds to a relative record within the data set (that is, region numbers start with 0 at the beginning of the data set).

Although REGIONAL(1) data sets have no recorded keys, you can use REGIONAL(1) DIRECT INPUT or UPDATE files to process data sets that do have recorded keys. In particular, to access REGIONAL(2) and REGIONAL(3) data sets, use a file declared with REGIONAL(1) organization.

REGIONAL(2)

specifies that the data set contains F-format records that have recorded keys. Each region in the data set contains only one record.

REGIONAL(2) differs from REGIONAL(1) in that REGIONAL(2) records contain recorded keys and that records are not necessarily in the specified region; the specified region identifies a starting point.

For files you create sequentially, the record is written in the specified region.

For files with the DIRECT attribute, a record is written in the first vacant space on or after the track that contains the region number you specify in the WRITE statement. For retrieval, the region number specified in the source key is employed to locate the specified region. The method of search is described further in the REGIONAL(2) discussion later in this chapter.

REGIONAL(3)

specifies that the data set contains F-format, V-format, VS-format, or U-format records with recorded keys. Each region in the data set corresponds with a track on a direct-access device and can contain one or more records.

REGIONAL(3) organization is similar to REGIONAL(2) in that records contain recorded keys, but differs in that a region for REGIONAL(3) corresponds to a track and not a record position.

Direct access of a REGIONAL(3) data set employs the region number specified in a source key to locate the required region. Once the region has been located, a sequential search is made for space to add a record, or for a record that has a recorded key identical with that supplied in the source key.

VS-format records can span more than one region. With REGIONAL(3) organization, the use of VS-format removes the limitations on block size imposed by the physical characteristics of the direct-access device. If the record length exceeds the size of a track, or if there is no room left on the current track for the record, the record will be spanned over one or more tracks.

REGIONAL(1) organization is most suited to applications where there are no duplicate region numbers, and where most of the regions will be filled (reducing wasted space in the data set). REGIONAL(2) and REGIONAL(3) are more appropriate where records are identified by numbers that are thinly distributed over a wide range. You can include in your program an algorithm that derives the region number from the number that identifies a record in such a manner as to optimize the use of space within the data set; duplicate region numbers can occur but, unless they are on the same track, their only effect might be to lengthen the search time for records with duplicate region numbers.

The examples throughout this chapter illustrate typical applications of all three types of regional organization.

Using Keys with REGIONAL Data Sets

There are two kinds of keys, recorded keys and source keys. A *recorded key* is a character string that immediately precedes each record in the data set to identify that record; its length cannot exceed 255 characters. A *source key* is the character value of the expression that appears in the KEY or KEYFROM option of a data transmission statement to identify the record to which the statement refers. When you access a record in a regional data set, the source key gives a region number, and can also give a recorded key.

You specify the length of the recorded keys in a regional data set with the KEYLENGTH option of the ENVIRONMENT attribute, or the KEYLEN subparameter on the DD statement. Unlike the keys for indexed data sets, recorded keys in a regional data set are never embedded within the record.

Using REGIONAL(1) Data Sets

In a REGIONAL(1) data set, since there are no recorded keys, the region number serves as the sole identification of a particular record. The character value of the source key should represent an unsigned decimal integer that should not exceed 16777215 (although the actual number of records allowed can be smaller, depending on a combination of record size, device capacity, and limits of your access method. For direct regional(1) files with fixed format records, the maximum number of tracks which can be addressed by relative track addressing is 65,536.) If the region number exceeds this figure, it is treated as modulo 16777216; for instance, 16777226 is treated as 10. Only the characters 0 through 9 and the blank character are valid in the source key; leading blanks are interpreted as zeros. Embedded blanks are not allowed in the number; the first embedded blank, if any, terminates the region number. If more than 8 characters appear in the source key, only the rightmost 8 are used as the region number; if there are fewer than 8 characters, blanks (interpreted as zeros) are inserted on the left.

Dummy Records

Records in a REGIONAL(1) data set are either actual records containing valid data or dummy records. A dummy record in a REGIONAL(1) data set is identified by the constant (8)'1'B in its first byte. Although such dummy records are inserted in the data set either when it is created or when a record is deleted, they are not ignored when the data set is read; your PL/I program must be prepared to recognize them. You can replace dummy records with valid data. Note that if you insert (8)'1'B in the first byte, the record can be lost if you copy the file onto a data set that has dummy records that are not retrieved.

Creating a REGIONAL(1) Data Set

You can create a REGIONAL(1) data set either sequentially or by direct-access. Table 30 on page 186 shows the statements and options for creating a regional data set.

When you use a SEQUENTIAL OUTPUT file to create the data set, the opening of the file causes all tracks on the data set to be cleared, and a capacity record to be written at the beginning of each track to record the amount of space available on that track. You must present records in ascending order of region numbers; any region you omit from the sequence is filled with a dummy record. If there is an error in the sequence, or if you present a duplicate key, the KEY condition is raised. When the file is closed, any space remaining at the end of the current extent is filled with dummy records.

If you create a data set using a buffered file, and the last WRITE or LOCATE statement before the file is closed attempts to transmit a record beyond the limits of the data set, the CLOSE statement might raise the ERROR condition.

If you use a DIRECT OUTPUT file to create the data set, the whole primary extent allocated to the data set is filled with dummy records when the file is opened. You can present records in random order; if you present a duplicate, the existing record will be overwritten.

For sequential creation, the data set can have up to 15 extents, which can be on more than one volume. For direct creation, the data set can have only one extent, and can therefore reside on only one volume.

Example

Creating a REGIONAL(1) data set is illustrated in Figure 43 on page 192. The data set is a list of telephone numbers with the names of the subscribers to whom they are allocated. The telephone numbers correspond with the region numbers in the data set, the data in each occupied region being a subscriber's name.

```
//EX9    JOB
//STEP1  EXEC IEL1CLG,PARM.PLI='NOP,MAR(1,72)',PARM.LKED='LIST'
//PLI.SYSIN  DD  *
 CRR1:   PROC OPTIONS(MAIN);
  /*  CREATING A REGIONAL(1) DATA SET  -  PHONE DIRECTORY     */

   DCL NOS FILE RECORD OUTPUT DIRECT KEYED ENV(REGIONAL(1));
   DCL  SYSIN FILE INPUT RECORD;
   DCL  SYSIN_REC BIT(1) INIT('1'B);
   DCL 1   CARD,
        2   NAME   CHAR(20),
        2   NUMBER CHAR( 2),
        2   CARD_1 CHAR(58);
   DCL IOFIELD CHAR(20);

      ON ENDFILE (SYSIN) SYSIN_REC = '0'B;
      OPEN FILE(NOS);
      READ FILE(SYSIN) INTO(CARD);

      DO WHILE(SYSIN_REC);
         IOFIELD = NAME;
         WRITE FILE(NOS) FROM(IOFIELD) KEYFROM(NUMBER);
         PUT FILE(SYSPRINT) SKIP EDIT (CARD) (A);
         READ FILE(SYSIN) INTO(CARD);
      END;

      CLOSE FILE(NOS);
  END CRR1;
/*
//GO.SYSLMOD DD DSN=&&GOSET,DISP=(OLD,DELETE)
//GO.NOS     DD DSN=NOS,UNIT=SYSDA,SPACE=(20,100),
//           DCB=(RECFM=F,BLKSIZE=20,DSORG=DA),DISP=(NEW,KEEP)
//GO.SYSIN DD *
ACTION,G.           12
BAKER,R.            13
BRAMLEY,O.H.        28
CHEESNAME,L.        11
CORY,G.             36
ELLIOTT,D.          85
FIGGINS,E.S.        43
HARVEY,C.D.W.       25
HASTINGS,G.M.       31
KENDALL,J.G.        24
LANCASTER,W.R.      64
MILES,R.            23
NEWMAN,M.W.         40
PITT,W.H.           55
ROLF,D.E.           14
SHEERS,C.D.         21
SURCLIFFE,M.        42
TAYLOR,G.C.         47
WILTON,L.W.         44
WINSTONE,E.M.       37
/*
```

Figure 43. Creating a REGIONAL(1) Data Set

Accessing and Updating a REGIONAL(1) Data Set

Once you create a REGIONAL(1) data set, you can open the file that accesses it for SEQUENTIAL INPUT or UPDATE, or for DIRECT INPUT or UPDATE. You can open it for OUTPUT only if the existing data set is to be overwritten. Table 30 on page 186 shows the statements and options for accessing a regional data set.

Sequential Access

To open a SEQUENTIAL file that is used to process a REGIONAL(1) data set, use either the INPUT or UPDATE attribute. You must not include the KEY option in data transmission statements, but the file can have the KEYED attribute, since you can use the KEYTO option. If the target character string referenced in the KEYTO option has more than 8 characters, the value returned (the 8-character region number) is padded on the left with blanks. If the target string has fewer than 8 characters, the value returned is truncated on the left.

Sequential access is in the order of ascending region numbers. All records are retrieved, whether dummy or actual, and you must ensure that your PL/I program recognizes dummy records.

Using sequential input with a REGIONAL(1) data set, you can read all the records in ascending region-number sequence, and in sequential update you can read and rewrite each record in turn.

The rules governing the relationship between READ and REWRITE statements for a SEQUENTIAL UPDATE file that accesses a REGIONAL(1) data set are identical to those for a consecutive data set. Consecutive data sets are discussed in detail in Chapter 8, “Defining and Using Consecutive Data Sets” on page 129.

Direct Access

To open a DIRECT file that is used to process a REGIONAL(1) data set you can use either the INPUT or the UPDATE attribute. All data transmission statements must include source keys; the DIRECT attribute implies the KEYED attribute.

Use DIRECT UPDATE files to retrieve, add, delete, or replace records in a REGIONAL(1) data set according to the following conventions:

Retrieval All records, whether dummy or actual, are retrieved. Your program must recognize dummy records.

Addition A WRITE statement substitutes a new record for the existing record (actual or dummy) in the region specified by the source key.

Deletion The record you specify by the source key in a DELETE statement is converted to a dummy record.

Replacement The record you specify by the source key in a REWRITE statement, whether dummy or actual, is replaced.

Example

Updating a REGIONAL(1) data set is illustrated in Figure 44 on page 194. Like the program in Figure 42 on page 183, this program updates the data set and lists its contents. Before each new or updated record is written, the existing record in the region is tested to ensure that it is a dummy; this is necessary because a WRITE statement can overwrite an existing record in a REGIONAL(1) data set even if it is not a dummy. Similarly, during the sequential reading and printing of the contents of the data set, each record is tested and dummy records are not printed.

```
//EX10    JOB
//STEP2   EXEC  IEL1CLG,PARM.PLI='NOP,MAR(1,72)',PARM.LKED='LIST'
//PLI.SYSIN  DD  *
 ACR1: PROC OPTIONS(MAIN);
   /*  UPDATING A REGIONAL(1) DATA SET  -  PHONE DIRECTORY      */
    DCL NOS FILE RECORD  KEYED ENV(REGIONAL(1));
    DCL  SYSIN FILE INPUT RECORD;
    DCL  (SYSIN_REC,NOS_REC) BIT(1) INIT('1'B);
    DCL 1   CARD,
         2   NAME   CHAR(20),
         2   (NEWNO,OLDNO)  CHAR( 2),
         2   CARD_1 CHAR( 1),
         2   CODE   CHAR( 1),
         2   CARD_2 CHAR(54);
    DCL IOFIELD CHAR(20);
    DCL BYTE    CHAR(1) DEF IOFIELD;

   ON ENDFILE(SYSIN) SYSIN_REC = '0'B;
   OPEN FILE (NOS) DIRECT UPDATE;
   READ FILE(SYSIN) INTO(CARD);

   DO WHILE(SYSIN_REC);
      SELECT(CODE);
         WHEN('A','C') DO;
             IF CODE = 'C' THEN
                DELETE FILE(NOS) KEY(OLDNO);
             READ FILE(NOS) KEY(NEWNO) INTO(IOFIELD);
             IF UNSPEC(BYTE) = (8)'1'B
                THEN WRITE FILE(NOS) KEYFROM(NEWNO) FROM(NAME);
             ELSE PUT FILE(SYSPRINT) SKIP LIST ('DUPLICATE:',NAME);
         END;
         WHEN('D') DELETE FILE(NOS) KEY(OLDNO);
      OTHERWISE PUT FILE(SYSPRINT) SKIP LIST ('INVALID CODE:',NAME);
      END;
      READ FILE(SYSIN) INTO(CARD);
   END;

   CLOSE FILE(SYSIN),FILE(NOS);
   PUT FILE(SYSPRINT) PAGE;
   OPEN FILE(NOS) SEQUENTIAL INPUT;
   ON ENDFILE(NOS) NOS_REC = '0'B;
   READ FILE(NOS) INTO(IOFIELD) KEYTO(NEWNO);
   DO WHILE(NOS_REC);
      IF UNSPEC(BYTE) ¬= (8)'1'B
         THEN PUT FILE(SYSPRINT) SKIP EDIT (NEWNO,IOFIELD)(A(2),X(3),A);
      PUT FILE(SYSPRINT) SKIP EDIT (IOFIELD) (A);
      READ FILE(NOS) INTO(IOFIELD) KEYTO(NEWNO);
   END;
  CLOSE FILE(NOS);
  END ACR1;
/*
//GO.NOS   DD DSN=J44PLI.NOS,DISP=(OLD,DELETE),UNIT=SYSDA,VOL=SER=nnnnnn
//GO.SYSIN DD *
NEWMAN,M.W.         5640 C
GOODFELLOW,D.T.     89   A
MILES,R.              23 D
HARVEY,C.D.W.       29   A
BARTLETT,S.G.       13   A
CORY,G.               36 D
READ,K.M.           01   A
PITT,W.H.             55
ROLF,D.F.             14 D
ELLIOTT,D.          4285 C
HASTINGS,G.M.         31 D
BRAMLEY,O.H.        4928 C
/*
```

Figure 44. Updating a REGIONAL(1) Data Set

Using REGIONAL(2) Data Sets

In a REGIONAL(2) data set, each record is identified by a recorded key that immediately precedes the record. The actual position of the record in the data set relative to other records is determined not by its recorded key, but by the region number that you supply in the source key of the WRITE statement that adds the record to the data set.

When you add a record to the data set by direct-access, it is written with its recorded key in the first available space after the beginning of the track that contains the region specified. When a record is read by direct-access, the search for a record with the appropriate recorded key begins at the start of the track that contains the region specified. Unless it is limited by the LIMCT subparameter of the DD statement that defines the data set, the search for a record or for space to add a record continues right through to the end of the data set and then from the beginning until the entire data set has been covered. The closer a record is to the specified region, the more quickly it can be accessed.

Using Keys for REGIONAL(2) and (3) Data Sets

The character value of the source key can be thought of as having two logical parts—the region number and a comparison key. On output, the comparison key is written as the recorded key; for input, it is compared with the recorded key.

The rightmost 8 characters of the source key make up the region number, which must be the character representation of a fixed decimal integer that does not exceed 16777215 (although the actual number of records allowed can be smaller, depending on a combination of record size, device capacity, and limits of your access method). If the region number exceeds this figure, it is treated as modulo 16777216; for instance, 16777226 is treated as 10. You can only specify the characters 0 through 9 and the blank character; leading blanks are interpreted as zeros. Embedded blanks are not allowed in the number; the first embedded blank, if any, terminates the region number. The comparison key is a character string that occupies the left hand side of the source key, and can overlap or be distinct from the region number, from which it can be separated by other nonsignificant characters.

Specify the length of the comparison key either with the KEYLEN subparameter of the DD statement for the data set or the KEYLENGTH option of the ENVIRONMENT attribute. If the source key is shorter than the key length you specify, it is extended on the right with blanks. To retrieve a record, the comparison key must exactly match the recorded key of the record. The comparison key can include the region number, in which case the source key and the comparison key are identical; or, you can use only part of the source key. The length of the comparison key is always equal to KEYLENGTH or KEYLEN; if the source key is longer than KEYLEN+8, the characters in the source key between the comparison key and the region number are ignored.

When generating the key, you should consider the rules for conversion from arithmetic to character string. For example, the following group is incorrect:

```
DCL KEYS CHAR(8);
DO I=1 TO 10;
   KEYS=I;
   WRITE FILE(F) FROM (R)
     KEYFROM (KEYS);
END;
```

The default for I is FIXED BINARY(15,0), which requires not 8 but 9 characters to contain the character string representation of the arithmetic values. In this example the rightmost digit is truncated.

Consider the following examples of source keys (the character “b” represents a blank):

```
KEY ('JOHNbDOEbbbbbb12363251')
```

The rightmost 8 characters make up the region specification, the relative number of the record. Assume that the associated DD statement has the subparameter KEYLEN=14. In retrieving a record, the search begins with the beginning of the track that contains the region number 12363251, until the record is found having the recorded key of JOHNbDOEbbbbbb.

If the subparameter is KEYLEN=22, the search still begins at the same place, but since the comparison and the source key are the same length, the search would be for a record having the recorded key 'JOHNbDOEbbbbbb12363251'.

```
KEY('JOHNbDOEbbbbbbDIVISIONb423bbbb34627')
```

In this example, the rightmost 8 characters contain leading blanks, which are interpreted as zeros. The search begins at region number 00034627. If KEYLEN=14 is specified, the characters DIVISIONb423b will be ignored.

Assume that COUNTER is declared FIXED BINARY(21) and NAME is declared CHARACTER(15). You could specify the key like so:

```
KEY (NAME || COUNTER)
```

The value of COUNTER will be converted to a character string of 11 characters. (The rules for conversion specify that a binary value of this length, when converted to character, will result in a string of length 11—three blanks followed by eight decimal digits.) The value of the rightmost eight characters of the converted string is taken to be the region specification. Then if the keylength specification is KEYLEN=15, the value of NAME is taken to be the comparison specification.

Dummy Records

A REGIONAL(2) data set can contain dummy records. A dummy record consists of a dummy key and dummy data. A dummy key is identified by the constant (8)'1'B in its first byte. The first byte of the data contains the sequence number of the record on the track.

The program inserts dummy records either when the data set is created or when a record is deleted. The dummy records are ignored when the program reads the data set.

However, you can replace dummy records with valid data.

Creating a REGIONAL(2) Data Set

You can create a REGIONAL(2) data set either sequentially or by direct-access. In either case, when the file associated with the data set is opened, the data set is initialized with capacity records specifying the amount of space available on each track. Table 30 on page 186 shows the statements and options for creating a regional data set.

When you use a SEQUENTIAL OUTPUT file to create the data set, you must present records in ascending order of region numbers; any region you omit from the sequence is filled with a dummy record. If you make an error in the sequence, including attempting to place more than one record in the same region, the KEY condition is raised. When the file is closed, any space remaining at the end of the current extent is filled with dummy records.

If you create a data set using a buffered file, and the last WRITE or LOCATE statement before the file is closed attempts to transmit a record beyond the limits of the data set, the CLOSE statement can raise the ERROR condition.

If you use a DIRECT OUTPUT file to create the current extent of a data set, the whole primary extent allocated to the data set is filled with dummy records when the file is opened. You can present records in random order, and no condition is raised by duplicate keys. Each record is substituted for the first dummy record on the track that contains the region specified in the source key; if there are no dummy records on the track, the record is substituted for the first dummy record encountered on a subsequent track, unless the LIMCT subparameter specifies that the search cannot reach beyond this track. (Note that it is possible to place records with identical recorded keys in the data set).

For sequential creation, the data set can have up to 15 extents, which can be on more than one volume. For direct creation, the data set can have only one extent, and can therefore reside on only one volume.

Example

The use of REGIONAL(2) data sets is illustrated in Figure 45 on page 198, Figure 46 on page 200, and Figure 47 on page 201. The programs in these figures perform the same functions as those given for REGIONAL(3), with which they can be compared.

The programs depict a library processing scheme, in which loans of books are recorded and reminders are issued for overdue books. Two data sets, SAMPL.STOCK and SAMPL.LOANS are used. SAMPL.STOCK contains descriptions of the books in the library, and uses the 4-digit book reference numbers as recorded keys; a simple algorithm is used to derive the region numbers from the reference numbers. (It is assumed that there are about 1000 books, each with a number in the range 1000–9999.) SAMPL.LOANS contains records of books that are on loan; each record comprises two dates, the date of issue and the date of the last reminder. Each reader is identified by a 3-digit reference number, which is used as a region number in SAMPL.LOANS; the reader and book numbers are concatenated to form the recorded keys.

Figure 45 on page 198 shows the creation of the data sets SAMPL.STOCK and SAMPL.LOANS. The file LOANS, which is used to create the data set SAMPL.LOANS, is opened for direct output to format the data set; the file is closed immediately without any records being written onto the data set. Direct creation is also used for the data set SAMPL.STOCK because, even if the input data is presented in ascending reference number order, identical region numbers might be derived from successive reference numbers.

```
//EX11  JOB
//STEP1  EXEC IEL1CLG,PARM.PLI='NOP',PARM.LKED='LIST'
//PLI.SYSIN  DD *
%PROCESS MAR(1,72);
 /*  CREATING A REGIONAL(2) DATA SET - LIBRARY LOANS                 */
CRR2: PROC OPTIONS(MAIN);

DCL (LOANS,STOCK) FILE RECORD KEYED ENV(REGIONAL(2));

DCL 1 BOOK,
     2 AUTHOR CHAR(25),
     2 TITLE  CHAR(50),
     2 QTY    FIXED DEC(3);

DCL NUMBER CHAR(4);
DCL INTER FIXED DEC(5);
DCL REGION CHAR(8);
DCL EOF BIT(1) INIT('0'B);
      /* INITIALIZE (FORMAT) LOANS DATA SET                         */

      OPEN FILE(LOANS) DIRECT OUTPUT;
      CLOSE FILE(LOANS);

      ON ENDFILE(SYSIN) EOF='1'B;
      OPEN FILE(STOCK) DIRECT OUTPUT;

      GET FILE(SYSIN) SKIP LIST(NUMBER,BOOK);
      DO WHILE (¬EOF);
      INTER = (NUMBER-1000)/9;        /* REGIONS 0 TO 999           */
      REGION = INTER;
      WRITE FILE(STOCK) FROM (BOOK) KEYFROM(NUMBER||REGION);
      PUT FILE(SYSPRINT) SKIP EDIT (BOOK) (A);
      GET FILE(SYSIN) SKIP LIST(NUMBER,BOOK);
      END;

      CLOSE FILE(STOCK);
  END CRR2;
/*
//GO.LOANS DD DSN=SAMPL.LOANS,UNIT=SYSDA,SPACE=(12,1000),
//           DCB=(RECFM=F,BLKSIZE=12,KEYLEN=7),
//           DISP=(NEW,CATLG)
//GO.STOCK DD DSN=SAMPL.STOCK,UNIT=SYSDA,SPACE=(77,1050),
//           DCB=(RECFM=F,BLKSIZE=77,KEYLEN=4),
//           DISP=(NEW,CATLG)
//GO.SYSIN DD *
'1015' 'W.SHAKESPEARE' 'MUCH ADO ABOUT NOTHING'  1
'1214' 'L.CARROLL' 'THE HUNTING OF THE SNARK'  1
'3079' 'G.FLAUBERT' 'MADAME BOVARY'  1
'3083' 'V.M.HUGO' 'LES MISERABLES'  2
'3085' 'J.K.JEROME' 'THREE MEN IN A BOAT'  2
'4295' 'W.LANGLAND' 'THE BOOK CONCERNING PIERS THE PLOWMAN'  1
'5999' 'O.KHAYYAM' 'THE RUBAIYAT OF OMAR KHAYYAM'  3
'6591' 'F.RABELAIS' 'THE HEROIC DEEDS OF GARGANTUA AND PANTAGRUEL'  1
'8362' 'H.D.THOREAU' 'WALDEN, OR LIFE IN THE WOODS'  1
'9795' 'H.G.WELLS' 'THE TIME MACHINE'  3
/*
```

Figure 45. Creating a REGIONAL(2) Data Set

Accessing and Updating a REGIONAL(2) Data Set

Once you create a REGIONAL(2) data set, you can open the file that accesses it for SEQUENTIAL INPUT or UPDATE, or for DIRECT INPUT or UPDATE. It cannot be opened for OUTPUT. Table 30 on page 186 shows the statements and options for accessing a regional data set.

Sequential Access

To open a SEQUENTIAL file that is used to process a REGIONAL(2) data set, use either the INPUT or UPDATE attribute. The data transmission statements must not include the KEY option, but the file can have the KEYED attribute since you can use the KEYTO option. With the KEYTO option you specify that the *recorded key only* is to be assigned to the specified variable. If the character string referenced in the KEYTO option has more characters than are specified in the KEYLEN subparameter, the value returned (the recorded key) is extended on the right with blanks; if it has fewer characters than specified by KEYLEN, the value returned is truncated on the right.

Sequential access is in the physical order in which the records exist on the data set, not necessarily in the order in which they were added to the data set. The recorded keys do not affect the order of sequential access. Dummy records are not retrieved.

The rules governing the relationship between READ and REWRITE statements for a SEQUENTIAL UPDATE file that accesses a REGIONAL(2) data set are identical with those for a CONSECUTIVE data set (described above).

Direct Access

To open a DIRECT file that is used to process a REGIONAL(2) data set, use either the INPUT or the UPDATE attribute. You must include source keys in all data transmission statements; the DIRECT attribute implies the KEYED attribute. The search for each record is commenced at the start of the track containing the region number indicated by the key.

Using direct input, you can read any record by supplying its region number and its recorded key; in direct update, you can read or delete existing records or add new ones.

Retrieval Dummy records are not made available by a READ statement. The KEY condition is raised if a record with the recorded key you specify is not found.

Addition A WRITE statement substitutes the new record for the first dummy record on the track containing the region specified by the source key. If there are no dummy records on this track, and you allow an extended search by the LIMCT subparameter, the new record replaces the first dummy record encountered during the search.

Deletion The record you specify by the source key in a DELETE statement is converted to a dummy record.

Replacement The record you specify by the source key in a REWRITE statement must exist; a REWRITE statement cannot be used to replace a dummy record. If it does not exist, the KEY condition is raised.

Example

The data set SAMPL.LOANS, described in “Example” on page 197, is updated directly in Figure 46 on page 200. Each item of input data, read from a source input, comprises a book number, a reader number, and a code to indicate whether it refers to a new issue (I), a returned book (R), or a renewal (A). The date is written in both the issue-date and reminder-date portions of a new record or an updated record.

A sequential update of the same program is shown in the program in Figure 47 on page 201. The sequential update file (LOANS) processes the records in the data set SAMPL.LOANS, and a direct input file (STOCK) obtains the book description from the data set SAMPL.STOCK for use in a reminder note. Each record from SAMPL.LOANS is tested to see whether the last reminder was issued more than a month ago; if necessary, a reminder note is issued and the current date is written in the reminder-date field of the record.

```
//EX12   JOB
//STEP2  EXEC IEL1CLG,PARM.PLI='NOP',PARM.LKED='LIST'
//PLI.SYSIN  DD  *
%PROCESS MAR(1,72);
  DUR2: PROC OPTIONS(MAIN);
 /*  UPDATING A REGIONAL(2) DATA SET DIRECTLY - LIBRARY LOANS*/

   DCL LOANS FILE RECORD UPDATE DIRECT KEYED ENV(REGIONAL(2));
   DCL 1   RECORD,
        2   (ISSUE,REMINDER) CHAR(6);
   DCL SYSIN FILE RECORD INPUT SEQUENTIAL;
   DCL SYSIN_REC BIT(1) INIT('1'B) STATIC;
   DCL 1   CARD,
        2   BOOK   CHAR(4),
        2   CARD_1 CHAR(5),
        2   READER CHAR(3),
        2   CARD_2 CHAR(7),
        2   CODE   CHAR(1),
        2   CARD_3 CHAR(1),
        2   DATE   CHAR(6),   /* YYMMDD */
        2   CARD_4 CHAR(53);
   DCL REGION CHAR(8) INIT(' ');

   ON ENDFILE(SYSIN) SYSIN_REC = '0'B;
   OPEN FILE(SYSIN), FILE(LOANS);
   READ FILE(SYSIN) INTO(CARD);

   DO WHILE(SYSIN_REC);
      SUBSTR(REGION,6) = CARD.READER;
      ISSUE,REMINDER = CARD.DATE;
      PUT FILE(SYSPRINT) SKIP EDIT (CARD) (A);
      SELECT(CODE);
         WHEN('I') WRITE FILE(LOANS) FROM(RECORD)   /* NEW ISSUE    */
                   KEYFROM(READER||BOOK||REGION);
         WHEN('R') DELETE FILE(LOANS)               /* RETURNED     */
                   KEY    (READER||BOOK||REGION);
         WHEN('A') REWRITE FILE(LOANS) FROM(RECORD) /* RENEWAL      */
                   KEY    (READER||BOOK||REGION);
         OTHERWISE PUT FILE(SYSPRINT) SKIP LIST     /* INVALID CODE */
                   ('INVALID CODE:',BOOK,READER);
      END;
      READ FILE(SYSIN) INTO(CARD);
   END;

   CLOSE FILE(SYSIN),FILE(LOANS);
  END DUR2;
/*
//GO.SYSLMOD DD DSN=&&GOSET,DISP=(OLD,DELETE)
//GO.LOANS DD DSN=SAMPL.LOANS,DISP=(OLD,KEEP)
//GO.SYSIN DD *
5999     003       I 781221
3083     091       I 790104
1214     049       I 790205
5999     003       A 790212
3083     091       R 790212
3517     095       X 790213
/*
```

Figure 46. Updating a REGIONAL(2) Data Set Directly

```
//EX13   JOB
//STEP3  EXEC  IEL1CLG,PARM.PLI='NOP',PARM.LKED='LIST',PARM.GO='/790308'
//PLI.SYSIN  DD  *
%PROCESS MAR(1,72);
  SUR2: PROC OPTIONS(MAIN);
  /* UPDATING A REGIONAL(2) DATA SET SEQUENTIALLY - LIBRARY LOANS     */

   DCL LOANS FILE RECORD SEQUENTIAL UPDATE KEYED ENV(REGIONAL(2));
   DCL LOANS_REC BIT(1) INIT('1'B) STATIC;
   DCL 1   RECORD,
        2   (ISSUE,REMINDER)  CHAR(6);
   DCL LOANKEY CHAR(7),
       READER CHAR(3) DEF LOANKEY,
       BKNO   CHAR(4) DEF LOANKEY POS(4);
   DCL STOCK FILE RECORD DIRECT INPUT KEYED ENV(REGIONAL(2));
   DCL 1   BOOK,
        2   AUTHOR CHAR(25),
        2   TITLE  CHAR(50),
        2   QTY    FIXED DEC(3);
   DCL TODAY CHAR(6);  /* YY/MM/DD */
   DCL INTER FIXED DEC(5);
   DCL REGION CHAR(8);

   TODAY  = '790210';
   OPEN FILE(LOANS),
        FILE(STOCK);
   ON ENDFILE(LOANS) LOANS_REC = '0'B;
   READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
     X = 1;

   DO WHILE(LOANS_REC);
      PUT FILE(SYSPRINT) SKIP EDIT
      (X,'REM DATE ',REMINDER,' TODAY ',TODAY) (A(3),A(9),A,A(7),A);
        X = X+1;

      IF REMINDER < TODAY THEN              /* ? LAST REMINDER ISSUED */
         DO;                                /*   MORE THAN A MONTH AGO*/
         INTER = (BKNO-1000)/9;             /* YES, PRINT NEW REMINDER*/
         REGION = INTER;
         READ FILE(STOCK) INTO(BOOK) KEY(BKNO||REGION);
         REMINDER = TODAY;                  /* UPDATE REMINDER DATE   */
         PUT FILE(SYSPRINT) SKIP EDIT
           ('NEW REM DATE',REMINDER,READER,AUTHOR,TITLE)
           (A(12),A,X(2),A,X(2),A,X(2),A);
         REWRITE FILE(LOANS) FROM(RECORD);
         END;
      READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
   END;

   CLOSE FILE(LOANS),FILE(STOCK);
   END SUR2;
/*
//GO.SYSLMOD DD DSN=&&GOSET,DISP=(OLD,DELETE)
//GO.LOANS DD DSN=SAMPL.LOANS,DISP=(OLD,KEEP)
//GO.STOCK DD DSN=SAMPL.STOCK,DISP=(OLD,KEEP)
/*
```

Figure 47. Updating a REGIONAL(2) Data Set Sequentially

Using REGIONAL(3) Data Sets

A REGIONAL(3) data set differs from a REGIONAL(2) data set (described above) only in the following respects:

- Each region number identifies a *track* on the direct-access device that contains the data set; the region number should not exceed 32767. A region in excess of 32767 is treated as modulo 32768; for example, 32778 is treated as 10.
- A region can contain one or more records, or a segment of a VS-format record.
- The data set can contain F-format, V-format, VS-format, or U-format records. You can create dummy records, but a data set that has V-format, VS-format, or U-format records is not preformatted with dummy records because the lengths of records cannot be known until they are written; however, all tracks in the primary extent are cleared and the operating system maintains a *capacity record* at the beginning of each track, in which it records the amount of space available on that track.

Source keys for a REGIONAL(3) data set are interpreted exactly as those for a REGIONAL(2) data set are, and the search for a record or space to add a record is conducted in a similar manner.

Dummy Records

Dummy records for REGIONAL(3) data sets with F-format records are identical to those for REGIONAL(2) data sets.

You can identify V-format, VS-format, and U-format dummy records because they have dummy recorded keys ((8)'1'B in the first byte). The four control bytes in each V-format and VS-format dummy record are retained, but the contents of V-format, VS-format, and U-format dummy records are undefined. V-format, VS-format, and U-format records convert to dummy records only when a record is deleted, and you cannot reconvert them to valid records.

Creating a REGIONAL(3) Data Set

You can create a REGIONAL(3) data set either sequentially or by direct-access. In either case, when the file associated with the data set is opened, the data set is initialized with capacity records specifying the amount of space available on each track. Table 30 on page 186 shows the statements and options for creating a regional data set.

When you use a SEQUENTIAL OUTPUT file to create the data set, you must present records in ascending order of region numbers, but you can specify the same region number for successive records. For F-format records, any record you omit from the sequence is filled with a dummy record. If you make an error in the sequence, the KEY condition is raised. If a track becomes filled by records for which the same region number was specified, the region number is incremented by one; an attempt to add a further record with the same region number raises the KEY condition (sequence error).

If you create a data set using a buffered file, and the last WRITE or LOCATE statement before the file is closed attempts to transmit a record beyond the limits of the data set, the CLOSE statement can raise the ERROR condition.

If you use a DIRECT OUTPUT file to create the data set, the whole primary extent allocated to the data set is initialized when the data set is opened. For F-format records, the space is filled with dummy records, and for V-format, VS-format, and U-format records, the capacity record for each track is written to indicate empty tracks. You can present records in random order, and no condition is raised by duplicate keys or duplicate region specifications. If the data set has F-format records, each record is substituted for the first dummy record in the region (track) specified on the source key; if there are no dummy records on the track, and you allow an extended search by the LIMCT subparameter, the record is substituted for the first dummy record encountered during the search. If the data set has V-format, VS-format, or U-format records, the new record is inserted on the specified track, if sufficient space is available; otherwise, if you allow an extended search, the new record is inserted in the next available space.

Note that for spanned records, space might be required for overflow onto subsequent tracks.

For sequential creation, the data set can have up to 15 extents, which can be on more than one volume. For direct creation, the data set can have only one extent, and can therefore reside on only one volume.

Example

A program for creating a REGIONAL(3) data set is shown in Figure 48. This program is similar to creating a REGIONAL(2) data set, discussed in "Example" on page 197 and illustrated in Figure 45 on page 198. The only important difference is that in REGIONAL(3) the data set SAMPL.STOCK is created sequentially. In REGIONAL(3) data sets, duplicate region numbers are acceptable, because each region can contain more than one record.

```
//EX14  JOB
//STEP1  EXEC IEL1CLG,PARM.PLI='NOP',PARM.LKED='LIST'
//PLI.SYSIN      DD *
%PROCESS MAR(1,72);
 /*   CREATING A REGIONAL(3) DATA SET - LIBRARY LOANS                */
CRR3: PROC OPTIONS(MAIN);

DCL LOANS FILE RECORD KEYED ENV(REGIONAL(3));

DCL STOCK FILE RECORD KEYED ENV(REGIONAL(3));
DCL 1   BOOK,
     2   AUTHOR CHAR(25),
     2   TITLE  CHAR(50),
     2   QTY    FIXED DEC(3);

DCL NUMBER CHAR(4);
DCL INTER FIXED DEC(5);
DCL REGION CHAR(8);
DCL EOF BIT(1) INIT('0'B);
```

Figure 48 (Part 1 of 2). Creating a REGIONAL(3) Data Set

```
      /* INITIALIZE (FORMAT) LOANS DATA SET                          */

      OPEN FILE(LOANS) DIRECT OUTPUT;
      CLOSE FILE(LOANS);

      ON ENDFILE(SYSIN) EOF='1'B;
      OPEN FILE(STOCK) SEQUENTIAL OUTPUT;

      GET FILE(SYSIN) SKIP LIST(NUMBER,BOOK);
      DO WHILE (¬EOF);
      INTER = (NUMBER-1000)/2250; /* REGIONS = 0,1,2,3,4 FOR A DEVICE */
                                  /* HOLDING 200 (OR MORE) BOOKS/TRACK*/
      REGION = INTER;
      WRITE FILE(STOCK) FROM(BOOK) KEYFROM(NUMBER||REGION);
      PUT FILE(SYSPRINT) SKIP EDIT (BOOK) (A);
      GET FILE(SYSIN) SKIP LIST(NUMBER,BOOK);
      END;

      CLOSE FILE(STOCK);
   END CRR3;
/*
//GO.LOANS DD DSN=SAMPL.LOANS,UNIT=SYSDA,SPACE=(TRK,3),
//            DCB=(RECFM=F,BLKSIZE=12,KEYLEN=7),
//            DISP=(NEW,CATLG)
//GO.STOCK DD DSN=SAMPL.STOCK,UNIT=SYSDA,SPACE=(TRK,5),
//            DCB=(RECFM=F,BLKSIZE=77,KEYLEN=4),
//            DISP=(NEW,CATLG)
//GO.SYSIN DD *
'1015' 'W.SHAKESPEARE' 'MUCH ADO ABOUT NOTHING'  1
'1214' 'L.CARROLL' 'THE HUNTING OF THE SNARK'  1
'3079' 'G.FLAUBERT' 'MADAME BOVARY'  1
'3083' 'V.M.HUGO' 'LES MISERABLES'  2
'3085' 'J.K.JEROME' 'THREE MEN IN A BOAT'  2
'4295' 'W.LANGLAND' 'THE BOOK CONCERNING PIERS THE PLOWMAN'  1
'5999' 'O.KHAYYAM' 'THE RUBAIYAT OF OMAR KHAYYAM'  3
'6591' 'F.RABELAIS' 'THE HEROIC DEEDS OF GARGANTUA AND PANTAGRUEL'  1
'8362' 'H.D.THOREAU' 'WALDEN, OR LIFE IN THE WOODS'  1
'9795' 'H.G.WELLS' 'THE TIME MACHINE'  3
/*
```

Figure 48 (Part 2 of 2). Creating a REGIONAL(3) Data Set

Accessing and Updating a REGIONAL(3) Data Set

Once you create a REGIONAL(3) data set, you can open the file that accesses it for SEQUENTIAL INPUT or UPDATE, or for DIRECT INPUT or UPDATE. You can only open it for OUTPUT if the entire existing data set is to be deleted and replaced. Table 30 on page 186 shows the statements and options for accessing a regional data set.

Sequential Access

To open a SEQUENTIAL file that is used to access a REGIONAL(3) data set, use either the INPUT or UPDATE attribute. You must not include the KEY option in the data transmission statements, but the file can have the KEYED attribute since you can use the KEYTO option.

With the KEYTO option you can specify that the *recorded key only* is to be assigned to the specified variable. If the character string referenced in the KEYTO option has more characters than you specify in the KEYLEN subparameter, the value returned (the recorded key) is extended on the right with blanks; if it has fewer characters than you specify by KEYLEN, the value returned is truncated on the right.

Sequential access is in the order of ascending relative tracks. Records are retrieved in this order, and not necessarily in the order in which they were added to the data set. The recorded keys do not affect the order of sequential access. Dummy records are not retrieved.

The rules governing the relationship between READ and REWRITE statements for a SEQUENTIAL UPDATE file that accesses a REGIONAL(3) data set are identical with those for a CONSECUTIVE data set (described above).

Direct Access

To open a DIRECT file that is used to process a REGIONAL(3) data set, use either the INPUT or the UPDATE attribute. You must include source keys in all data transmission statements; the DIRECT attribute implies the KEYED attribute.

Using direct input, you can read any record by supplying its region number and its recorded key; in direct update, you can read or delete existing records or add new ones.

Retrieval Dummy records are not made available by a READ statement. The KEY condition is raised if a record with the specified recorded key is not found.

Addition In a data set with F-format records, a WRITE statement substitutes the new record for a dummy record in the region (track) specified by the source key. If there are no dummy records on the specified track, and you use the LIMCT subparameter to allow an extended search, the new record replaces the first dummy record encountered during the search. If the data set has V-format, VS-format, or U-format records, a WRITE statement inserts the new record after any records already present on the specified track if space is available; otherwise, if you allow an extended search, the new record is inserted in the next available space.

Deletion A record you specify by the source key in a DELETE statement is converted to a dummy record. You can re-use the space formerly occupied by an F-format record; space formerly occupied by V-format, VS-format, or U-format records is not available for reuse.

Replacement The record you specify by the source key in a REWRITE statement must exist; you cannot use a REWRITE statement to replace a dummy record. When a VS-format record is replaced, the new one must not be shorter than the old.

Note: If a track contains records with duplicate recorded keys, the record farthest from the beginning of the track will never be retrieved during direct-access.

Example

Updating REGIONAL(3) data sets is shown in the following two figures, Figure 49 on page 206 and Figure 50 on page 207. These are similar to the REGIONAL(2) figures, Figure 46 on page 200 and Figure 47 on page 201.

You should note that REGIONAL(3) updating differs from REGIONAL(2) updating in only one important way. When you update the data set directly, illustrated in Figure 49 on page 206, the region number for the data set SAMPL.LOANS is obtained simply by testing the reader number.

Sequential updating, shown in Figure 50 on page 207, is very much like Figure 47 on page 201, the REGIONAL(2) example.

```
//EX15   JOB
//STEP2  EXEC  IEL1CLG,PARM.PLI='NOP',PARM.LKED='LIST'
//PLI.SYSIN  DD  *
%PROCESS MAR(1,72);
 DUR3: PROC OPTIONS(MAIN);
 /* UPDATING A REGIONAL(3) DATA SET DIRECTLY - LIBRARY LOANS     */
   DCL LOANS FILE RECORD UPDATE DIRECT KEYED ENV(REGIONAL(3));
   DCL 1   RECORD,
        2   (ISSUE,REMINDER) CHAR(6);
   DCL SYSIN FILE RECORD INPUT SEQUENTIAL;
   DCL SYSIN_REC BIT(1) INIT('1'B);
   DCL 1   CARD,
        2   BOOK CHAR(4),
        2   CARD_1 CHAR(5),
        2   READER CHAR(3),
        2   CARD_2 CHAR(7),
        2   CODE   CHAR(1),
        2   CARD_3 CHAR(1),
        2   DATE   CHAR(6),
        2   CARD_4 CHAR(53);
   DCL REGION CHAR(8);
   ON ENDFILE(SYSIN) SYSIN_REC= '0'B;
   OPEN FILE(SYSIN),FILE(LOANS);
   READ FILE(SYSIN) INTO(CARD);
  DO WHILE(SYSIN_REC);
    ISSUE,REMINDER = DATE;
      SELECT;
         WHEN(READER < '034') REGION = '00000000';
         WHEN(READER < '067') REGION = '00000001';
         OTHERWISE            REGION = '00000002';
      END;
      SELECT(CODE);
         WHEN('I') WRITE FILE(LOANS) FROM(RECORD)
                   KEYFROM(READER||BOOK||REGION);
         WHEN('R') DELETE FILE(LOANS)
                   KEY    (READER||BOOK||REGION);
         WHEN('A') REWRITE FILE(LOANS) FROM(RECORD)
                   KEY    (READER||BOOK||REGION);
         OTHERWISE PUT FILE(SYSPRINT) SKIP LIST
                   ('INVALID CODE: ',BOOK,READER);
      END;
   PUT FILE(SYSPRINT) SKIP EDIT (CARD) (A);
   READ FILE(SYSIN) INTO(CARD);
   END;
  CLOSE FILE(SYSIN),FILE(LOANS);
 END DUR3;
/*
//GO.SYSLMOD DD DSN=&&GOSET,DISP=(OLD,DELETE)
//GO.LOANS DD DSN=SAMPL.LOANS,DISP=(OLD,KEEP)
//GO.SYSIN DD *
5999     003       I 781221
3083     091       I 790104
1214     049       I 790205
5999     003       A 790212
3083     091       R 790212
3517     095       X 790213
/*
```

Figure 49. Updating a REGIONAL(3) Data Set Directly

```
//EX16   JOB
//STEP3  EXEC  IEL1CLG,PARM.PLI='NOP',PARM.LKED='LIST',PARM.GO='/790308'
//PLI.SYSIN  DD  *
%PROCESS MAR(1,72);
 SUR3: PROC OPTIONS(MAIN);
 /* UPDATING A REGIONAL(3) DATA SET SEQUENTIALLY - LIBRARY LOANS      */

   DCL LOANS FILE RECORD SEQUENTIAL UPDATE KEYED ENV(REGIONAL(3));
   DCL LOANS_REC BIT(1) INIT('1'B);
   DCL 1   RECORD,
        2  (ISSUE,REMINDER) CHAR(6);
   DCL LOANKEY CHAR(7),
       READER  CHAR(3) DEF LOANKEY,
       BKNO    CHAR(4) DEF LOANKEY POS(4);
   DCL STOCK FILE RECORD DIRECT INPUT KEYED ENV(REGIONAL(3));
   DCL 1   BOOK,
        2   AUTHOR CHAR(25),
        2   TITLE  CHAR(50),
        2   QTY    FIXED DEC(3);
   DCL TODAY CHAR(6);/*YYMMDD*/
   DCL INTER FIXED DEC(5),
       REGION CHAR(8);

   TODAY = '790210';
   OPEN FILE (LOANS), FILE(STOCK);
   ON ENDFILE(LOANS) LOANS_REC = '0'B;
   READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
      X = 1;

   DO WHILE(LOANS_REC);
      PUT FILE(SYSPRINT) SKIP EDIT
      (X,'REM DATE ',REMINDER,' TODAY ',TODAY) (A(3),A(9),A,A(7),A);
        X = X+1;

      IF REMINDER < TODAY THEN
         DO;
         INTER = (BKNO-1000)/2250;
         REGION = INTER;
         READ FILE(STOCK) INTO(BOOK) KEY(BKNO||REGION);
         REMINDER = TODAY;
         PUT FILE(SYSPRINT) SKIP EDIT
           ('NEW REM DATE',REMINDER,READER,AUTHOR,TITLE)
           (A(12),A,X(2),A,X(2),A,X(2),A);
         REWRITE FILE(LOANS) FROM(RECORD);
         END;
   READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
   END;

   CLOSE FILE(LOANS),FILE(STOCK);
 END SUR3;
/*
//GO.LOANS DD DSN=SAMPL.LOANS,DISP=(OLD,KEEP)
//GO.STOCK DD DSN=SAMPL.STOCK,DISP=(OLD,KEEP)
```

Figure 50. Updating a REGIONAL(3) Data Set Sequentially

Essential Information for Creating and Accessing Regional Data Sets

To create a regional data set, you must give the operating system certain information, either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you can supply.

You must supply the following information when creating a regional data set:

- Device that will write your data set (UNIT or VOLUME parameter of DD statement).
- Block size: You can specify the block size either in your PL/I program (in the BLKSIZE option of the ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are the default and the record length is determined from the block size.

If you want to keep a data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but do not need it after the end of your job.

If you want your data set stored on a particular direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a data set that you want to keep, the operating system allocates one, informs the operator, and prints the number on your program listing. All the essential parameters required in a DD statement for the creation of a regional data set are summarized in Table 31 on page 209; and Table 32 on page 210 lists the DCB subparameters needed. See your *MVS/ESA JCL User's Guide* for a description of the DCB subparameters.

You cannot place a regional data set on a system output (SYSOUT) device.

In the DCB parameter, you must always specify the data set organization as direct by coding DSORG=DA. You cannot specify the DUMMY or DSN=NULLFILE parameters in a DD statement for a regional data set. For REGIONAL(2) and REGIONAL(3), you must also specify the length of the recorded key (KEYLEN) unless it is specified in the ENVIRONMENT attribute; see “Using Keys for REGIONAL(2) and (3) Data Sets” on page 195 for a description of how the recorded key is derived from the source key supplied in the KEYFROM option.

For REGIONAL(2) and REGIONAL(3), if you want to restrict the search for space to add a new record, or the search for an existing record, to a limited number of tracks beyond the track that contains the specified region, use the LIMCT subparameter of the DCB parameter. If you omit this parameter, the search continues to the end of the data set, and then from the beginning of the data set back to the starting point.

Table 31. Creating a regional data set: essential parameters of the DD statement

When required	What you must state	Parameters

Always	Output device[1]	UNIT= or
		VOLUME=REF=

	Storage space required[2]	SPACE=
	Data control block information: see Table 32 on page 210	DCB=
Data set to be used in another job step but not required in another job	Disposition	DISP=
Data set to be kept after end of job	Disposition	DISP=
	Name of data set	DSNAME=

Data set to be on particular volume	Volume serial number	VOLUME=SER= or
		VOLUME=REF=

[1] Regional data sets are confined to direct-access devices.

[2] For sequential access, the data set can have up to 15 extents, which can be on more than one volume. For creation with DIRECT access, the data set can have only one extent.

To access a regional data set, you must identify it to the operating system in a DD statement. The following paragraphs indicate the minimum information you must include in the DD statement; this information is summarized in Table 33 on page 210.

If the data set is cataloged, you only need to supply the following information in your DD statement:

- The name of the data set (DSNAME parameter). The operating system locates the information that describes the data set in the system catalog and, if necessary, requests the operator to mount the volume that contains it.
- Confirmation that the data set exists (DISP parameter).

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

Unlike indexed data sets, regional data sets do not require the subparameter OPTCD=L in the DD statement.

When opening a multiple-volume regional data set for sequential update, the ENDFILE condition is raised at the end of the first volume.

Table 32. DCB subparameters for a regional data set

When required	To specify	Subparameters

These are always required	Record format[1]	RECFM=F or
		RECFM=V[2] REGIONAL(3) only, or
		RECFM=U REGIONAL(3) only

	Block size[1]	BLKSIZE=
	Data set organization	DSORG=DA
	Key length (REGIONAL(2) and (3) only)[1]	KEYLEN=
These are optional	Limited search for a record or space to add a record (REGIONAL(2) and (3) only)	LIMCT=
	Number of data management buffers[1]	BUFNO=

[1] Or you can specify the block size in the ENVIRONMENT attribute.

[2] RECFM=VS must be specified in the ENVIRONMENT attribute for sequential input or update.

Table 33. Accessing a regional data set: essential parameters of the DD statement

When required	What you must state	Parameters
Always	Name of data set	DSNAME=
	Disposition of data set	DISP=

If data set not cataloged	Input device	UNIT= or
		VOLUME=REF=

	Volume serial number	VOLUME=SER=

Chapter 11. Defining and Using VSAM Data Sets

This chapter covers VSAM (the Virtual Storage Access Method) organization for record-oriented data transmission, VSAM ENVIRONMENT options, compatibility with other PL/I data set organizations, and the statements you use to load and access the three types of VSAM data sets that PL/I supports—entry-sequenced, key-sequenced, and relative record. The chapter is concluded by a series of examples showing the PL/I statements, Access Method Services commands, and JCL statements necessary to create and access VSAM data sets.

For additional information about the facilities of VSAM, the structure of VSAM data sets and indexes, the way in which they are defined by Access Method Services, and the required JCL statements, see the VSAM publications for your system.

PL/I supports the use of VSAM data sets under VM. VSAM under VM has some restrictions. See the *VM/ESA CMS User's Guide* for those restrictions.

Using VSAM Data Sets

How to Run a Program with VSAM Data Sets

Before you execute a program that accesses a VSAM data set, you need to know:

- The name of the VSAM data set
- The name of the PL/I file
- Whether you intend to share the data set with other users

Then you can write the required DD statement to access the data set:

```
//filename DD DSNAME=dsname,DISP=OLD|SHR
```

For example, if your file is named PL1FILE, your data set named VSAMDS, and you want exclusive control of the data set, enter:

```
//PL1FILE DD DSNAME=VSAMDS,DISP=OLD
```

To share your data set, use DISP=SHR.

For a PL/I program originally written for ISAM data sets that requires a simulation of ISAM data-set handling, you need to use the AMP parameter of the DD statement. You might also want to use it to optimize VSAM's performance.

To optimize VSAM's performance by controlling the number of VSAM buffers used for your data set, see the VSAM publications.

Pairing an Alternate Index Path with a File

When using an alternate index, you simply specify the name of the *path* in the DSNAME parameter of the DD statement associating the base data set/alternate index pair with your PL/I file. Before using an alternate index, you should be aware of the restrictions on processing; these are summarized in Table 35 on page 218.

Given a PL/I file called PL1FILE and the alternate index path called PERSALPH, the DD statement required would be:

```
 //PL1FILE DD  DSNAME=PERSALPH,DISP=OLD
```

VSAM Organization

PL/I provides support for three types of VSAM data sets:

- Key-sequenced data sets (KSDS)
- Entry-sequenced data sets (ESDS)
- Relative record data sets (RRDS).

These correspond roughly to PL/I indexed, consecutive, and regional data set organizations, respectively. They are all ordered, and they can all have keys associated with their records. Both sequential and keyed access are possible with all three types.

Although only key-sequenced data sets have keys as part of their logical records, keyed access is also possible for entry-sequenced data sets (using relative-byte addresses) and relative record data sets (using relative record numbers).

All VSAM data sets are held on direct-access storage devices, and a virtual storage operating system is required to use them.

The physical organization of VSAM data sets differs from those used by other access methods. VSAM does not use the concept of blocking, and, except for relative record data sets, records need not be of a fixed length. In data sets with VSAM organization, the data items are arranged in *control intervals*, which are in turn arranged in *control areas*. For processing purposes, the data items within a control interval are arranged in logical records. A control interval can contain one or more logical records, and a logical record can span two or more control intervals. Concern about blocking factors and record length is largely removed by VSAM, although records cannot exceed the maximum specified size. VSAM allows access to the control intervals, but this type of access is not supported by PL/I.

VSAM data sets can have two types of indexes—prime and alternate. A *prime index* is the index to a KSDS that is established when you define a data set; it always exists and can be the only index for a KSDS. You can have one or more *alternate indexes* on a KSDS or an ESDS. Defining an alternate index for an ESDS enables you to treat the ESDS, in general, as a KSDS. An alternate index on a KSDS enables a field in the logical record different from that in the prime index to be used as the key field. Alternate indexes can be either *nonunique*, in which duplicate keys are allowed, or *unique*, in which they are not. The prime index can never have duplicate keys.

Any change in a data set that has alternate indexes must be reflected in all the indexes if they are to remain useful. This activity is known as *index upgrade*, and is done by VSAM for any index in the *index upgrade set* of the data set. (For a KSDS, the prime index is always a member of the index upgrade set.) However, you must avoid making changes in the data set that would cause duplicate keys in the prime index or in a unique alternate index.

Before using a VSAM data set for the first time, you need to define it to the system with the DEFINE command of Access Method Services, which you can use to completely define the type, structure, and required space of the data set. This command also defines the data set's indexes (together with their key lengths and locations) and the index upgrade set if the data set is a KSDS or has one or more alternate indexes. A VSAM data set is thus “created” by Access Method Services.

The operation of writing the initial data into a newly created VSAM data set is referred to as *loading* in this publication.

Use the three different types of data sets according to the following purposes:

- Use *entry-sequenced data sets* for data that you primarily access in the order in which it was created (or the reverse order).
- Use *key-sequenced data sets* when you normally access records through keys within the records (for example, a stock-control file where the part number is used to access a record).
- Use *relative record data sets* for data in which each item has a particular number, and you normally access the relevant record by that number (for example, a telephone system with a record associated with each number).

You can access records in all types of VSAM data sets either directly by means of a key, or sequentially (backward or forward). You can also use a combination of the two ways: Select a starting point with a key and then read forward or backward from that point.

You can create alternate indexes for key-sequenced and entry-sequenced data sets. You can then access your data in many sequences or by one of many keys. For example, you could take a data set held or indexed in order of employee number and index it by name in an alternate index. Then you could access it in alphabetic order, in reverse alphabetic order, or directly using the name as a key. You could also access it in the same kind of combinations by employee number.

Figure 51 on page 214 and Table 34 on page 215 show how the same data could be held in the three different types of VSAM data sets and illustrates their respective advantages and disadvantages.

The diagrams show how the information contained in the family tree below could be held in VSAM data sets of different types.

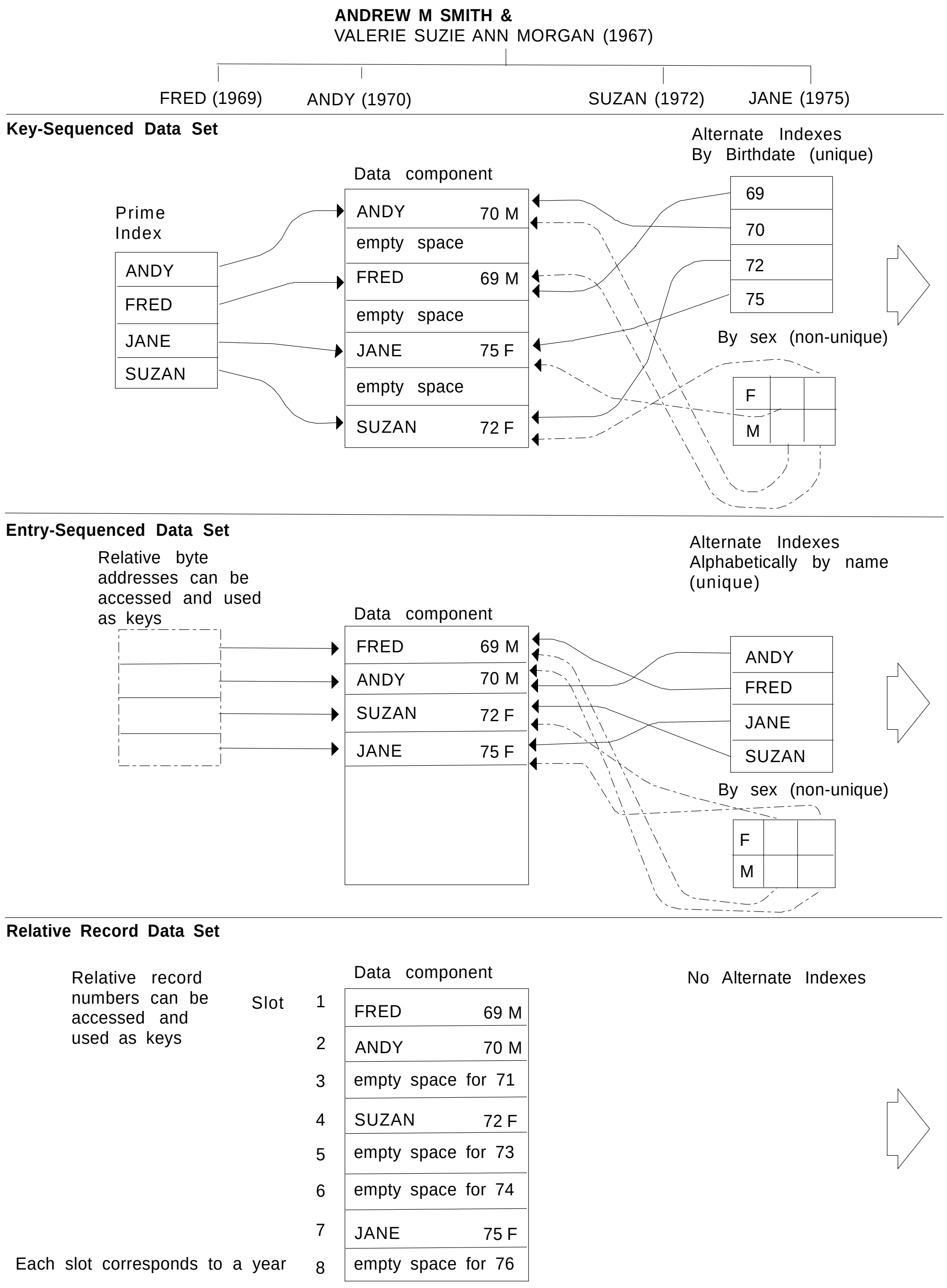


Figure 51. Information Storage in VSAM Data Sets of Different Types

Table 34. Types and Advantages of VSAM Data Sets

Data set type	Method of loading	Method of reading	Method of updating	Pros and cons
Key-Sequenced	Sequentially in order or prime index which must be unique	KEYED by specifying key of record in prime or unique alternate index SEQUENTIAL backward or forward in order of any index Positioning by key followed by sequential reading either backward or forward	KEYED specifying a unique key in any index SEQUENTIAL following positioning by unique key Record deletion allowed Record insertion allowed	***Advantages*** Complete access and updating ***Disadvantages*** Records must be in order of prime index before loading ***Uses*** For uses where access will be related to key
Entry-Sequenced	Sequentially (forward only) The RBA of each record can be obtained and used as a key	SEQUENTIAL backward or forward KEYED using unique alternate index or RBA Positioning by key followed by sequential either backward or forward	New records at end only Existing records cannot have length changed Access can be sequential or KEYED using alternate index Record deletion not allowed	***Advantages*** Simple fast creation No requirement for a unique index ***Disadvantages*** Limited updating facilities ***Uses*** For uses where data will primarily be accessed sequentially
Relative Record	Sequentially starting from slot 1 KEYED specifying number of slot Positioning by key followed by sequential writes	KEYED specifying numbers as key Sequential forward or backward omitting empty records	Sequentially starting at a specified slot and continuing with next slot Keyed specifying numbers as key Record deletion allowed Record insertion into empty slots allowed	***Advantages*** Speedy access to record by number ***Disadvantages*** Structure tied to numbering sequences No alternate index Fixed length records ***Uses*** For use where records will be accessed by number

Keys for VSAM Data Sets

All VSAM data sets can have keys associated with their records. For key-sequenced data sets, and for entry-sequenced data sets accessed via an alternate index, the key is a defined field within the logical record. For entry-sequenced data sets, the key is the *relative byte address* (RBA) of the record. For relative-record data sets, the key is a *relative record number*.

Keys for Indexed VSAM Data Sets

Keys for key-sequenced data sets and for entry-sequenced data sets accessed via an alternate index are part of the logical records recorded on the data set. You define the length and location of the keys when you create the data set.

The ways you can reference the keys in the KEY, KEYFROM, and KEYTO options are as described under “KEY(expression) Option,” “KEYFROM(expression) Option,” and “KEYTO(reference) Option” in Chapter 12 of the *PL/I for MVS & VM Language Reference* See also “Using keys” on page 163.

Relative Byte Addresses (RBA)

Relative byte addresses allow you to use keyed access on an ESDS associated with a KEYED SEQUENTIAL file. The RBAs, or keys, are character strings of length 4, and their values are defined by VSAM. You cannot construct or manipulate RBAs in PL/I; you can, however, compare their values in order to determine the relative positions of records within the data set. RBAs are not normally printable.

You can obtain the RBA for a record by using the KEYTO option, either on a WRITE statement when you are loading or extending the data set, or on a READ statement when the data set is being read. You can subsequently use an RBA obtained in either of these ways in the KEY option of a READ or REWRITE statement.

Do not use an RBA in the KEYFROM option of a WRITE statement.

VSAM allows use of the relative byte address as a key to a KSDS, but this use is not supported by PL/I.

Relative Record Numbers

Records in an RRDS are identified by a relative record number that starts at 1 and is incremented by 1 for each succeeding record. You can use these relative record numbers as keys for keyed access to the data set.

Keys used as relative record numbers are character strings of length 8. The character value of a source key you use in the KEY or KEYFROM option must represent an unsigned integer. If the source key is not 8 characters long, it is truncated or padded with blanks (interpreted as zeros) on the *left*. The value returned by the KEYTO option is a character string of length 8, with leading zeros suppressed.

Choosing a Data Set Type

When planning your program, the first decision to be made is which type of data set to use. There are three types of VSAM data sets and five types of non-VSAM data sets available to you. VSAM data sets can provide all the function of the other types of data sets, plus additional function available only in VSAM. VSAM can usually match other data set types in performance, and often improve upon it. However, VSAM is more subject to performance degradation through misuse of function.

The comparison of all eight types of data sets given in Table 16 on page 122 is helpful; however, many factors in the choice of data set type for a large installation are beyond the scope of this book.

Figure 51 on page 214 shows you the possibilities available with the types of VSAM data sets. When choosing between the VSAM data set types, you should base your choice on the most common sequence in which you will require your data. The following is a suggested procedure that you can use to help ensure a combination of data sets and indexes that provide the function you require.

1. Determine the type of data and how it will be accessed.

   a. Primarily sequentially — favors ESDS.
   b. Primarily by key — favors KSDS.
   c. Primarily by number — favors RRDS.

2. Determine how you will load the data set. Note that you must load a KSDS in key sequence; thus an ESDS with an alternate index path can be a more practical alternative for some applications.

3. Determine whether you require access through an alternate index path. These are only supported on KSDS and ESDS. If you require an alternate index path, determine whether the alternate index will have unique or nonunique keys. Use of nonunique keys can limit key processing. However, it might also be impractical to assume that you will use unique keys for all future records; if you attempt to insert a record with a nonunique key in an index that you have created for unique keys, it will cause an error.

4. When you have determined the data sets and paths that you require, ensure that the operations you have in mind are supported. Figure 52 on page 218 and Table 35 on page 218 might be helpful.

Do not try to access a dummy VSAM data set, because you will receive an error message indicating that you have an undefined file.

Table 36 on page 228, Table 37 on page 232, and Table 39 on page 247 show the statements allowed for entry-sequenced data sets, indexed data sets, and relative record data sets, respectively.

```
        SEQUENTIAL       KEYED SEQUENTIAL    DIRECT

INPUT   ESDS             ESDS                KSDS
        KSDS             KSDS                RRDS
        RRDS             RRDS                Path(U)
        Path(N)          Path(N)
        Path(U)          Path(U)

OUTPUT  ESDS             ESDS                KSDS
        RRDS             KSDS                RRDS
                         RRDS                Path(U)

UPDATE  ESDS             ESDS                KSDS
        KSDS             KSDS                RRDS
        RRDS             RRDS                Path(U)
        Path(N)          Path(N)
        Path(U)          Path(U)


Key:  ESDS     Entry-sequenced data set
      KSDS     Key-sequenced data set
      RRDS     Relative record data set
      Path(N)  Alternate index path with nonunique keys
      Path(U)  Alternate index path with unique keys

You can combine the attributes on the left with those at the top of the
figure for the data sets and paths shown.  For example, only an ESDS and
an RRDS can be SEQUENTIAL OUTPUT.

PL/I does not support dummy VSAM data sets.
```

Figure 52. VSAM Data Sets and Allowed File Attributes

Table 35. Processing Allowed on Alternate Index Paths

Base cluster type	**Alternate index key type**	**Processing**	**Restrictions**
KSDS	Unique key	As normal KSDS	Cannot modify key of access.
	Nonunique key	Limited keyed access	Cannot modify key of access.
ESDS	Unique key	As KSDS	No deletion. Cannot modify key of access.
	Nonunique key	Limited keyed access	No deletion. Cannot modify key of access.

Defining Files for VSAM Data Sets

You define a sequential VSAM data set by using a file declaration with the following attributes:

```
DCL filename FILE RECORD
              INPUT | OUTPUT | UPDATE
              SEQUENTIAL
              BUFFERED
             [KEYED]
              ENVIRONMENT(options);
```

You define a direct VSAM data set by using a file declaration with the following attributes:

```
DCL filename FILE RECORD
             INPUT | OUTPUT | UPDATE
             DIRECT
             UNBUFFERED
            [KEYED]
             ENVIRONMENT(options);
```

Table 15 on page 111 shows the default attributes. The file attributes are described in the *PL/I for MVS & VM Language Reference*. Options of the ENVIRONMENT attribute are discussed below.

Some combinations of the file attributes INPUT or OUTPUT or UPDATE and DIRECT or SEQUENTIAL or KEYED SEQUENTIAL are allowed only for certain types of VSAM data sets. Figure 52 on page 218 shows the compatible combinations.

Specifying ENVIRONMENT Options

Many of the options of the ENVIRONMENT attribute affecting data set structure are not needed for VSAM data sets. If you specify them, they are either ignored or are used for checking purposes. If those that are checked conflict with the values defined for the data set, the UNDEFINEDFILE condition is raised when an attempt is made to open the file.

The ENVIRONMENT options applicable to VSAM data sets are:

```
BKWD
BUFND(n)
BUFNI(n)
BUFSP(n)
COBOL
GENKEY
PASSWORD(password-specification)
REUSE
SCALARVARYING
SIS
SKIP
VSAM
```

COBOL, GENKEY, and SCALARVARYING options have the same effect as they do when you use them for non-VSAM data sets.

The options that are checked for a VSAM data set are RECSIZE and, for a key-sequenced data set, KEYLENGTH and KEYLOC. NCP has meaning when you are using the ISAM compatibility interface. Table 15 on page 111 shows which options are ignored for VSAM. Table 15 on page 111 also shows the required and default options.

For VSAM data sets, you specify the maximum and average lengths of the records to the Access Method Services utility when you define the data set. If you include the RECSIZE option in the file declaration for checking purposes, specify the maximum record size. If you specify RECSIZE and it conflicts with the values defined for the data set, the UNDEFINEDFILE condition is raised.

BKWD Option

Use the BKWD option to specify backward processing for a SEQUENTIAL INPUT or SEQUENTIAL UPDATE file associated with a VSAM data set.

```
►►──BKWD─────────────────────────────────────────────────────────────►◄
```

Sequential reads (that is, reads without the KEY option) retrieve the previous record in sequence. For indexed data sets, the previous record is, in general, the record with the next lower key. However, if you are accessing the data set via a nonunique alternate index, records with the same key are recovered in their normal sequence. For example, if the records are:

```
A B C1 C2 C3 D E
```

where C1, C2, and C3 have the same key, they are recovered in the sequence:

```
E D C1 C2 C3 B A
```

When a file with the BKWD option is opened, the data set is positioned at the last record. ENDFILE is raised in the normal way when the start of the data set is reached.

Do not specify the BKWD option with either the REUSE option or the GENKEY option. Also, the WRITE statement is not allowed for files declared with the BKWD option.

BUFND Option

Use the BUFND option to specify the number of data buffers required for a VSAM data set.

```
►►──BUFND──(──n──)───────────────────────────────────────────────────►◄
```

n specifies an integer, or a variable with attributes FIXED BINARY(31) STATIC.

Multiple data buffers help performance when the file has the SEQUENTIAL attribute and you are processing long groups of contiguous records sequentially.

BUFNI Option

Use the BUFNI option to specify the number of index buffers required for a VSAM key-sequenced data set.

```
►►──BUFNI──(──n──)───────────────────────────────────────────────────►◄
```

n specifies an integer, or a variable with the attributes FIXED BINARY(31) STATIC.

Multiple index buffers help performance when the file has the KEYED attribute. Specify at least as many index buffers as there are levels in the index.

BUFSP Option

Use the BUFSP option to specify, in bytes, the total buffer space required for a VSAM data set (for both the data and index components).

```
►►──BUFSP──(──n──)──────────────────────────────────────────────────►◄
```

n specifies an integer, or a variable with the attributes FIXED BINARY(31) STATIC.

It is usually preferable to specify the BUFNI and BUFND options rather than BUFSP.

GENKEY Option

For the description of this option, see “GENKEY Option — Key Classification” on page 118.

PASSWORD Option

When you define a VSAM data set to the system (using the DEFINE command of Access Method Services), you can associate READ and UPDATE passwords with it. From that point on, you must include the appropriate password in the declaration of any PL/I file that you use to access the data set.

```
►►──PASSWORD──(──password-specification──)──────────────────────────►◄
```

password-specification
is a character constant or character variable that specifies the password for the type of access your program requires. If you specify a constant, it must not contain a repetition factor; if you specify a variable, it must be level-1, element, static, and unsubscripted.

The character string is padded or truncated to 8 characters and passed to VSAM for inspection. If the password is incorrect, the system operator is given a number of chances to specify the correct password. You specify the number of chances to be allowed when you define the data set. After this number of unsuccessful tries, the UNDEFINEDFILE condition is raised.

The three levels of password supported by PL/I are:

- Master
- Update
- Read.

Specify the highest level of password needed for the type of access that your program performs.

REUSE Option

Use the REUSE option to specify that an OUTPUT file associated with a VSAM data set is to be used as a work file.

```
►►──REUSE───────────────────────────────────────────────────────────►◄
```

The data set is treated as an empty data set each time the file is opened. Any secondary allocations for the data set are released, and the data set is treated exactly as if it were being opened for the first time.

Do not associate a file that has the REUSE option with a data set that has alternate indexes or the BKWD option, and do not open it for INPUT or UPDATE.

The REUSE option takes effect only if you specify REUSE in the Access Method Services DEFINE CLUSTER command.

SIS Option

The SIS option is applicable to key-sequenced data sets accessed by means of a DIRECT file.

```
►►──SIS──────────────────────────────────────────────────────────────►◄
```

If you use mass sequential insert for a VSAM data set (that is, if you insert records with ascending keys), a KEYED SEQUENTIAL UPDATE file is normally appropriate. In this case, however, VSAM delays writing the records to the data set until a complete control interval has been built. If you specify DIRECT, VSAM writes each record as soon as it is presented. Thus, in order to achieve immediate writing *and* faster access with efficient use of disk space, use a DIRECT file and specify the SIS option.

The SIS option is intended primarily for use in online applications.

It is never an error to specify (or omit) the SIS option; its effect on performance is significant only in the circumstances described.

SKIP Option

Use the SKIP option of the ENVIRONMENT attribute to specify that the VSAM OPTCD “SKP” is to be used wherever possible. It is applicable to key-sequenced data sets that you access by means of a KEYED SEQUENTIAL INPUT or UPDATE file.

```
►►──SKIP─────────────────────────────────────────────────────────────►◄
```

You should specify this option for the file if your program accesses individual records scattered throughout the data set, but does so primarily in ascending key order.

Omit this option if your program reads large numbers of records sequentially without the use of the KEY option, or if it inserts large numbers of records at specific points in the data set (mass sequential insert).

It is never an error to specify (or omit) the SKIP option; its effect on performance is significant only in the circumstances described.

VSAM Option

Specify the VSAM option for VSAM data sets, unless you also intend to use the file to access non-VSAM data sets (if this is the case, see “Using the VSAM Compatibility Interface” on page 225).

```
►►──VSAM───────────────────────────────────────────────────────────────►◄
```

Performance Options

SKIP, SIS, BUFND, BUFNI, and BUFSP are options you can specify to optimize VSAM's performance. You can also specify the buffer options in the AMP parameter of the DD statement; they are explained in your Access Method Services manual.

Defining Files for Alternate Index Paths

VSAM allows you to define alternate indexes on key sequenced and entry sequenced data sets. This enables you to access key sequenced data sets in a number of ways other than from the prime index. This also allows you to index and access entry sequenced data sets by key or sequentially in order of the keys. Consequently, data created in one form can be accessed in a large number of different ways. For example, an employee file might be indexed by personnel number, by name, and also by department number.

When an alternate index has been built, you actually access the data set through a third object known as an alternate index *path* that acts as a connection between the alternate index and the data set.

Two types of alternate indexes are allowed—unique key and nonunique key. For a unique key alternate index, each record must have a different alternate key. For a nonunique key alternate index, any number of records can have the same alternate key. In the example suggested above, the alternate index using the names could be a unique key alternate index (provided each person had a different name). The alternate index using the department number would be a nonunique key alternate index because more than one person would be in each department. An example of alternate indexes applied to a family tree is given in Figure 51 on page 214.

In most respects, you can treat a data set accessed through a unique key alternate index path like a KSDS accessed through its prime index. You can access the records by key or sequentially, you can update records, and you can add new records. If the data set is a KSDS, you can delete records, and alter the length of updated records. Restrictions and allowed processing are shown in Table 35 on page 218. When you add or delete records, all indexes associated with the data set are by default altered to reflect the new situation.

In data sets accessed through a nonunique key alternate index path, the record accessed is determined by the key and the sequence. The key can be used to establish positioning so that sequential access can follow. The use of the key accesses the first record with that key. When the data set is read backwards, only the order of the keys is reversed. The order of the records with the same key remains the same whichever way the data set is read.

Using Files Defined for non-VSAM Data Sets

In most cases, if your PL/I program uses files declared with ENVIRONMENT (CONSECUTIVE) or ENVIRONMENT(INDEXED) or with no ENVIRONMENT, it can access VSAM data sets without alteration. If your program uses REGIONAL files, you must alter it and recompile before it can use VSAM data sets. PL/I can detect that a VSAM data set is being opened and can provide the correct access, either directly or by use of a compatibility interface.

If your PL/I program uses REGIONAL(1) files, it cannot be used unaltered to access VSAM relative-record data sets.

The aspects of compatibility that affect your usage of VSAM if your data sets or programs were created for other access methods are as follows:

- The recreation of your data sets as VSAM data sets. The Access Method Services REPRO command recreates data sets in VSAM format. This command is described in the *MVS/DFP Access Method Services* manual.
- All VSAM key-sequenced data sets have embedded keys, even if they have been converted from ISAM data sets with nonembedded keys.
- JCL DD statement changes.
- The unaltered use of your programs with VSAM data sets. This is described in the following section.
- The alteration of your programs to allow them to use VSAM data sets. A brief discussion of this is given later in this section.

CONSECUTIVE Files

For CONSECUTIVE files, compatibility depends on the ability of the PL/I routines to recognize the data set type and use the correct access method.

You should realize, however, that there is no concept of fixed-length records in VSAM. Therefore, if your program relies on the RECORD condition to detect incorrect length records, it will not function in the same way using VSAM data sets as it does with non-VSAM data sets.

INDEXED Files

Complete compatibility is provided for INDEXED files. For files that you declare with the INDEXED ENVIRONMENT option, the PL/I library routines recognize a VSAM data set and will process it as VSAM.

However, because ISAM record handling differs in detail from VSAM record handling, use of VSAM processing might not always give the required result. To ensure complete compatibility with PL/I ENV(INDEXED) files, VSAM provides the compatibility interface—a program that simulates ISAM-type handling of VSAM data sets.

Because VSAM does not support EXCLUSIVE files, your program will not be compatible on VSAM and ISAM if it relies on this feature.

Using the VSAM Compatibility Interface

The compatibility interface simulates ISAM-type handling on VSAM key-sequenced data sets. This allows compatibility for any program whose logic depends on ISAM-type record handling. The VSAM compatibility interface is VSAM supplied (See the VSAM publications.)

The compatibility interface is used when you specify the RECFM or OPTCD keyword in a DD statement associated with a file declared with the INDEXED ENVIRONMENT option, or when you use an NCP value greater than 1 in the ENVIRONMENT option. These conditions are taken by the PL/I library routines to mean that the compatibility interface is required. Choose the RECFM value, either F, V, or VS, to match the type of record that would be used by an ISAM data set. Use the OPTCD value “OPTCD=I,” which is the default, if you require complete ISAM compatibility (see 3 below).

You cannot use the compatibility interface for a data set having a nonzero RKP (KEYLOC) and RECFM=F. If your program uses such files you must recompile to change the INDEXED file declaration to VSAM.

You need the compatibility interface in the following circumstances:

1. If your program uses nonembedded keys.
2. If your program relies on the raising of the RECORD condition when an incorrect-length record is encountered.
3. If your program relies on checking for deleted records. In ISAM, deleted records remain in the data set but are flagged as deleted. In VSAM, they become inaccessible to you, and their space is available for overwriting.

   Note on Deletion: If you want the compatibility interface but want deletion of records handled in the VSAM manner, you must use `'OPTCD=IL'` in the DD statement.

An example of DD statements that would result in the compatibility interface being used when accessing a VSAM data set is:

```
//PLIFILE DD DSNAME=VSAM1,
//           DISP=OLD,AMP='RECFM=F'
```

or, to use the compatibility interface with VSAM-type deletion of records:

```
//PLIFILE DD DSNAME=VSAM1,
//           DISP=OLD,AMP='OPTCD=IL'
```

Adapting Existing Programs for VSAM

You can readily adapt existing programs with indexed, consecutive, or REGIONAL(1) files for use with VSAM data sets. As indicated above, programs with consecutive files might not need alteration, and there is never any necessity to alter programs with indexed files unless you wish to avoid the use of the compatibility interface or if the logic depends on EXCLUSIVE files. Programs with REGIONAL(1) data sets require only minor revision. Programs with REGIONAL(2) or REGIONAL(3) files need restructuring before you can use them with VSAM data sets.

CONSECUTIVE Files

If the logic of the program depends on raising the RECORD condition when a record of an incorrect length is found, you will have to write your own code to check for the record length and take the necessary action. This is because records of any length up to the maximum specified are allowed in VSAM data sets.

INDEXED Files

You need to change programs using indexed (that is, ISAM) files only if you wish to avoid using the compatibility interface.

You should remove dependence on the RECORD condition, and insert your own code to check for record length if this is necessary.

Also remove any checking for deleted records.

REGIONAL(1) Files

You can alter programs using REGIONAL(1) data sets to use VSAM relative record data sets.

Remove REGIONAL(1) and any other non-VSAM ENVIRONMENT options from the file declaration and replace them with ENV(VSAM).

Also remove any checking for deleted records, because VSAM deleted records are not accessible to you.

Using Several Files in One VSAM Data Set

You can associate multiple files with one VSAM data set in the following ways:

- Use a common DD statement. You can use the TITLE option of the OPEN statement for this purpose, as described on page spotref refid=assfile..
- Use separate DD statements, ensure that the DD statements reference the same data set name, or a path accessing the same underlying VSAM data set. PL/I OPEN specifies the VSAM MACRF=DSN option, indicating that VSAM is to share control blocks based on a common data set name.

In both cases, PL/I creates one set of control blocks—an Access Method Control Block and a Request Parameter List (RPL)—for each file and does not provide for associating multiple RPLs with a single ACB. These control blocks are described in the VSAM publications. and normally need not concern you.

Multiple files can perform retrievals against a single data set with no difficulty. However, if one or more files perform updates, the following can occur:

- There is a risk that other files will retrieve down-level records. You can avoid this by having all files open with the UPDATE attribute.
- When more than one file is open with the UPDATE attribute, retrieval of any record in a control interval makes all other records in that control interval unavailable until the update is complete. This raises the ERROR condition with condition code 1027 if a second file tries to access one of the unavailable records. You could design your application to retry the retrieval after completion of the other file's data transmission, or you can avoid the error by not having two files associated with the same data set at one time.
- When one or more of the multiple files is an alternate index path, an update through an alternate index path might update the alternate index before the data record is written, resulting in a mismatch between index and data.

Using Shared Data Sets

PL/I does not support cross-region or cross-system sharing of data sets.

Defining VSAM Data Sets

Use the DEFINE CLUSTER command of Access Method Services to define and catalog VSAM data sets. To use the DEFINE command, you need to know:

- The name and password of the master catalog if the master catalog is password protected
- The name and password of the VSAM private catalog you are using if you are not using the master catalog
- Whether VSAM space for your data set is available
- The type of VSAM data set you are going to create
- The volume on which your data set is to be placed
- The average and maximum record size in your data set
- The position and length of the key for an indexed data set
- The space to be allocated for your data set
- How to code the DEFINE command
- How to use the Access Method Services program.

When you have the information, you are in a position to code the DEFINE command and then define and catalog the data set using Access Method Services.

Entry-Sequenced Data Sets

The statements and options allowed for files associated with an ESDS are shown in Table 36.

Table 36 (Page 1 of 2). Statements and Options Allowed for Loading and Accessing VSAM Entry-Sequenced Data Sets

File declaration[1]	Valid statements, with options you must include	Other options you can also include
SEQUENTIAL OUTPUT BUFFERED	WRITE FILE(file-reference) FROM(reference);	KEYTO(reference)
	LOCATE based-variable FILE(file-reference);	SET(pointer-reference)
SEQUENTIAL OUTPUT UNBUFFERED	WRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or KEYTO(reference)
SEQUENTIAL INPUT BUFFERED	READ FILE(file-reference) INTO(reference);	KEYTO(reference) or KEY(expression)[3]
	READ FILE(file-reference) SET(pointer-reference);	KEYTO(reference) or KEY(expression)[3]
	READ FILE(file-reference);	IGNORE(expression)
SEQUENTIAL INPUT UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or either KEY(expression)[3] KEYTO(reference)
	READ FILE(file-reference);[2]	EVENT(event-reference) and/or IGNORE(expression)
SEQUENTIAL UPDATE BUFFERED	READ FILE(file-reference) INTO(reference);	KEYTO(reference) or KEY(expression)[3]
	READ FILE(file-reference) SET(pointer-reference);	KEYTO(reference) or KEY(expression)[3]
	READ FILE(file-reference)[2]	IGNORE(expression)
	WRITE FILE(file-reference) FROM(reference);	KEYTO(reference)
	REWRITE FILE(file-reference);	FROM(reference) and/or KEY(expression)[3]

Table 36 (Page 2 of 2). Statements and Options Allowed for Loading and Accessing VSAM Entry-Sequenced Data Sets

File declaration[1]	Valid statements, with options you must include	Other options you can also include
SEQUENTIAL UPDATE UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or either KEY(expression)[3] or KEYTO(reference)
	READ FILE(file-reference);[2]	EVENT(event-reference) and/or IGNORE(expression)
	WRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or KEYTO(reference)
	REWRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or KEY(expression)[3]

Notes:

1. The complete file declaration would include the attributes FILE, RECORD, and ENVIRONMENT; if you use either of the options KEY or KEYTO, it must also include the attribute KEYED.
2. The statement “READ FILE(file-reference);” is equivalent to the statement “READ FILE(file-reference) IGNORE (1);.”
3. The expression used in the KEY option must be a relative byte address, previously obtained by means of the KEYTO option.

Loading an ESDS

When an ESDS is being loaded, the associated file must be opened for SEQUENTIAL OUTPUT. The records are retained in the order in which they are presented.

You can use the KEYTO option to obtain the relative byte address of each record as it is written. You can subsequently use these keys to achieve keyed access to the data set.

Using a SEQUENTIAL File to Access an ESDS

You can open a SEQUENTIAL file that is used to access an ESDS with either the INPUT or the UPDATE attribute. If you use either of the options KEY or KEYTO, the file must also have the KEYED attribute.

Sequential access is in the order that the records were originally loaded into the data set. You can use the KEYTO option on the READ statements to recover the RBAs of the records that are read. If you use the KEY option, the record that is recovered is the one with the RBA you specify. Subsequent sequential access continues from the new position in the data set.

For an UPDATE file, the WRITE statement adds a new record at the end of the data set. With a REWRITE statement, the record rewritten is the one with the specified RBA if you use the KEY option; otherwise, it is the record accessed on the previous READ. You must not attempt to change the length of the record that is being replaced with a REWRITE statement.

The DELETE statement is not allowed for entry-sequenced data sets.

Defining and Loading an ESDS

In Figure 53 on page 231, the data set is defined with the DEFINE CLUSTER command and given the name PLIVSAM.AJC1.BASE. The NONINDEXED keyword causes an ESDS to be defined.

The PL/I program writes the data set using a SEQUENTIAL OUTPUT file and a WRITE FROM statement. The DD statement for the file contains the DSNAME of the data set given in the NAME parameter of the DEFINE CLUSTER command.

The RBA of the records could have been obtained during the writing for subsequent use as keys in a KEYED file. To do this, a suitable variable would have to be declared to hold the key and the WRITE...KEYTO statement used. For example:

```
DCL CHARS CHAR(4);
WRITE FILE(FAMFILE) FROM (STRING)
 KEYTO(CHARS);
```

Note that the keys would not normally be printable, but could be retained for subsequent use.

The cataloged procedure IEL1CLG is used. Because the same program (in Figure 53 on page 231) can be used for adding records to the data set, it is retained in a library. This procedure is shown in the next example.

```
//OPT9#7  JOB
//STEP1    EXEC   PGM=IDCAMS,REGION=512K
//SYSPRINT DD SYSOUT=A
//SYSIN    DD    *
     DEFINE CLUSTER -
      (NAME(PLIVSAM.AJC1.BASE) -
      VOLUMES(nnnnnn) -
      NONINDEXED -
      RECORDSIZE(80 80) -
      TRACKS(2 2))
/*
//STEP2  EXEC IEL1CLG
//PLI.SYSIN      DD *
   CREATE: PROC OPTIONS(MAIN);

      DCL
        FAMFILE FILE SEQUENTIAL OUTPUT ENV(VSAM),
        IN FILE RECORD INPUT,
        STRING CHAR(80),
        EOF BIT(1) INIT('0'B);

      ON ENDFILE(IN) EOF='1'B;

      READ FILE(IN) INTO (STRING);
      DO I=1 BY 1 WHILE (¬EOF);
        PUT FILE(SYSPRINT) SKIP EDIT (STRING) (A);
        WRITE FILE(FAMFILE) FROM (STRING);
        READ FILE(IN) INTO (STRING);
      END;

      PUT SKIP EDIT(I-1,' RECORDS PROCESSED')(A);
    END;
/*
//LKED.SYSLMOD  DD  DSN=HPU8.MYDS(PGMA),DISP=(NEW,CATLG),
//         UNIT=SYSDA,SPACE=(CYL,(1,1,1))
//GO.FAMFILE DD   DSNAME=PLIVSAM.AJC1.BASE,DISP=OLD
//GO.IN      DD     *
FRED                     69          M
ANDY                     70          M
SUZAN                    72          F
/*
```

Figure 53. Defining and Loading an Entry-Sequenced Data Set (ESDS)

Updating an Entry-Sequenced Data Set

Figure 54 shows the addition of a new record on the end of an ESDS. This is done by executing again the program shown in Figure 53. A SEQUENTIAL OUTPUT file is used and the data set associated with it by use of the DSNAME parameter specifying the name PLIVSAM.AJC1.BASE specified in the DEFINE command shown in Figure 53.

```
//OPT9#8   JOB
//STEP1    EXEC  PGM=PGMA
//STEPLIB   DD   DSN=HPU8.MYDS(PGMA),DISP=(OLD,KEEP)
//          DD   DSN=CEE.V1R2M0.SCEERUN,DISP=SHR
//SYSPRINT  DD   SYSOUT=A
//FAMFILE   DD   DSN=PLIVSAM.AJC1.BASE,DISP=SHR
//IN        DD   *
JANE                     75          F
//
```

Figure 54. Updating an ESDS

You can rewrite existing records in an ESDS, provided that the length of the record is not changed. You can use a SEQUENTIAL or KEYED SEQUENTIAL update file to do this. If you use keys, they can be the RBAs or keys of an alternate index path.

Delete is not allowed for ESDS.

Key-Sequenced and Indexed Entry-Sequenced Data Sets

The statements and options allowed for indexed VSAM data sets are shown in Table 37. An indexed data set can be a KSDS with its prime index, or either a KSDS or an ESDS with an alternate index. Except where otherwise stated, the following description applies to all indexed VSAM data sets.

Table 37 (Page 1 of 3). Statements and Options Allowed for Loading and Accessing VSAM Indexed Data Sets

File declaration[1]	**Valid statements, with options you must include**	**Other options you can also include**
SEQUENTIAL OUTPUT BUFFERED[3]	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
	LOCATE based-variable FILE(file-reference) KEYFROM(expression);	SET(pointer-reference)
SEQUENTIAL OUTPUT UNBUFFERED[3]	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)
SEQUENTIAL INPUT BUFFERED	READ FILE(file-reference) INTO(reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	IGNORE(expression)
SEQUENTIAL INPUT UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or either KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	EVENT(event-reference) and/or IGNORE(expression)
SEQUENTIAL UPDATE BUFFERED	READ FILE(file-reference) INTO(reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	IGNORE(expression)
	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
	REWRITE FILE(file-reference);	FROM(reference) and/or KEY(expression)
	DELETE FILE(file-reference)[5]	KEY(expression)

Table 37 (Page 2 of 3). Statements and Options Allowed for Loading and Accessing VSAM Indexed Data Sets

File declaration[1]	**Valid statements, with options you must include**	**Other options you can also include**
SEQUENTIAL UPDATE UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or either KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	EVENT(event-reference) and/or IGNORE(expression)
	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event reference)
	REWRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or KEY(expression)
	DELETE FILE(file-reference);[5]	KEY(expression) and/or EVENT(event-reference)
DIRECT[4] INPUT BUFFERED	READ FILE(file-reference) INTO(reference) KEY(expression);	
	READ FILE(file-reference) SET(pointer-reference) KEY(expression);	
DIRECT[4] INPUT UNBUFFERED	READ FILE(file-reference) INTO(reference) KEY(expression);	EVENT(event-reference)
DIRECT OUTPUT BUFFERED	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
DIRECT OUTPUT UNBUFFERED	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)
DIRECT[4] UPDATE BUFFERED	READ FILE(file-reference) INTO(reference) KEY(expression);	
	READ FILE(file-reference) SET(pointer-reference) KEY(expression);	
	REWRITE FILE(file-reference) FROM(reference) KEY(expression);	
	DELETE FILE(file-reference) KEY(expression);[5]	
	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	

Table 37 (Page 3 of 3). Statements and Options Allowed for Loading and Accessing VSAM Indexed Data Sets

File declaration[1]	Valid statements, with options you must include	Other options you can also include

DIRECT[4] UPDATE
UNBUFFERED
	READ FILE(file-reference)
	INTO(reference)
	KEY(expression);
		EVENT(event-reference)

	REWRITE FILE(file-reference)
	FROM(reference)
	KEY(expression);
		EVENT(event-reference)

	DELETE FILE(file-reference) KEY(expression);[5]	EVENT(event-reference)

	WRITE FILE(file-reference)
	FROM(reference)
	KEYFROM(expression);
		EVENT(event-reference)

Notes:

1. The complete file declaration would include the attributes FILE and RECORD. If you use any of the options KEY, KEYFROM, or KEYTO, you must also include the attribute KEYED in the declaration.

   The EXCLUSIVE attribute for DIRECT INPUT or UPDATE files, the UNLOCK statement for DIRECT UPDATE files, or the NOLOCK option of the READ statement for DIRECT INPUT files are ignored if you use them for files associated with a VSAM KSDS.
2. The statement READ FILE(file-reference); is equivalent to the statement READ FILE(file-reference) IGNORE(1);
3. Do not associate a SEQUENTIAL OUTPUT file with a data set accessed via an alternate index.
4. Do not associate a DIRECT file with a data set accessed via a nonunique alternate index.
5. DELETE statements are not allowed for a file associated with an ESDS accessed via an alternate index.

Loading a KSDS or Indexed ESDS

When a KSDS is being loaded, you must open the associated file for KEYED SEQUENTIAL OUTPUT. You must present the records in ascending key order, and you must use the KEYFROM option. Note that you must use the prime index for loading the data set; you cannot load a VSAM data set via an alternate index.

If a KSDS already contains some records, and you open the associated file with the SEQUENTIAL and OUTPUT attributes, you can only add records at the end of the data set. The rules given in the previous paragraph apply; in particular, the first record you present must have a key greater than the highest key present on the data set.

Figure 55 on page 235 shows the DEFINE command used to define a KSDS. The data set is given the name PLIVSAM.AJC2.BASE and defined as a KSDS because of the use of the INDEXED operand. The position of the keys within the record is defined in the KEYS operand.

Within the PL/I program, a KEYED SEQUENTIAL OUTPUT file is used with a WRITE...FROM...KEYFROM statement. The data is presented in ascending key order. A KSDS must be loaded in this manner.

The file is associated with the data set by a DD statement which uses the name given in the DEFINE command as the DSNAME parameter.

```
//OPT9#12  JOB
//   EXEC  PGM=IDCAMS,REGION=512K
//SYSPRINT  DD  SYSOUT=A
//SYSIN     DD  *
   DEFINE CLUSTER -
     (NAME(PLIVSAM.AJC2.BASE) -
     VOLUMES(nnnnnn) -
     INDEXED -
     TRACKS(3 1) -
     KEYS(20 0) -
     RECORDSIZE(23 80))
/*
//   EXEC IEL1CLG
//PLI.SYSIN      DD *
 TELNOS: PROC OPTIONS(MAIN);

        DCL DIREC FILE RECORD SEQUENTIAL OUTPUT KEYED ENV(VSAM),
            CARD CHAR(80),
            NAME CHAR(20) DEF CARD POS(1),
            NUMBER CHAR(3) DEF CARD POS(21),
            OUTREC CHAR(23) DEF CARD POS(1),
            EOF BIT(1) INIT('0'B);

        ON ENDFILE(SYSIN) EOF='1'B;

        OPEN FILE(DIREC) OUTPUT;

        GET FILE(SYSIN) EDIT(CARD)(A(80));
        DO WHILE (¬EOF);
        WRITE FILE(DIREC) FROM(OUTREC) KEYFROM(NAME);
        GET FILE(SYSIN) EDIT(CARD)(A(80));
        END;

       CLOSE FILE(DIREC);

        END TELNOS;
/*
//GO.DIREC  DD  DSNAME=PLIVSAM.AJC2.BASE,DISP=OLD
//GO.SYSIN  DD  *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESEMAN,D.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,S.          413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF,D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
//
```

Figure 55. Defining and Loading a Key-Sequenced Data Set (KSDS)

Using a SEQUENTIAL File to Access a KSDS or Indexed ESDS

You can open a SEQUENTIAL file that is used to access a KSDS with either the INPUT or the UPDATE attribute.

For READ statements without the KEY option, the records are recovered in ascending key order (or in descending key order if the BKWD option is used). You can obtain the key of a record recovered in this way by means of the KEYTO option.

If you use the KEY option, the record recovered by a READ statement is the one with the specified key. Such a READ statement positions the data set at the specified record; subsequent sequential reads will recover the following records in sequence.

WRITE statements with the KEYFROM option are allowed for KEYED SEQUENTIAL UPDATE files. You can make insertions anywhere in the data set, without respect to the position of any previous access. If you are accessing the data set via a unique index, the KEY condition is raised if an attempt is made to insert a record with the same key as a record that already exists on the data set. For a nonunique index, subsequent retrieval of records with the same key is in the order that they were added to the data set.

REWRITE statements with or without the KEY option are allowed for UPDATE files. If you use the KEY option, the record that is rewritten is the first record with the specified key; otherwise, it is the record that was accessed by the previous READ statement. When you rewrite a record using an alternate index, do not change the prime key of the record.

Using a DIRECT File to Access a KSDS or Indexed ESDS

You can open a DIRECT file that is used to access an indexed VSAM data set with the INPUT, OUTPUT, or UPDATE attribute. Do not use a DIRECT file to access the data set via a nonunique index.

If you use a DIRECT OUTPUT file to add records to the data set, and if an attempt is made to insert a record with the same key as a record that already exists, the KEY condition is raised.

If you use a DIRECT INPUT or DIRECT UPDATE file, you can read, write, rewrite, or delete records in the same way as for a KEYED SEQUENTIAL file.

Figure 56 on page 237 shows one method by which a KSDS can be updated using the prime index.

```
//OPT9#13  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN      DD *
 DIRUPDT: PROC OPTIONS(MAIN);

         DCL DIREC FILE RECORD KEYED ENV(VSAM),
             ONCODE BUILTIN,
             OUTREC CHAR(23),
             NUMBER CHAR(3) DEF OUTREC POS(21),
             NAME CHAR(20) DEF OUTREC,
             CODE CHAR(1),
             EOF BIT(1) INIT('0'B);

         ON ENDFILE(SYSIN) EOF='1'B;

         ON KEY(DIREC) BEGIN;
          IF ONCODE=51 THEN PUT FILE(SYSPRINT) SKIP EDIT
                            ('NOT FOUND: ',NAME)(A(15),A);
          IF ONCODE=52 THEN PUT FILE(SYSPRINT) SKIP EDIT
                           ('DUPLICATE: ',NAME)(A(15),A);
          END;

         OPEN FILE(DIREC) DIRECT UPDATE;

       GET FILE(SYSIN) EDIT (NAME,NUMBER,CODE)
         (COLUMN(1),A(20),A(3),A(1));
       DO WHILE (¬EOF);
       PUT FILE(SYSPRINT) SKIP EDIT (' ',NAME,'#',NUMBER,' ',CODE)
       (A(1),A(20),A(1),A(3),A(1),A(1));
       SELECT (CODE);
          WHEN('A') WRITE FILE(DIREC) FROM(OUTREC) KEYFROM(NAME);
          WHEN('C') REWRITE FILE(DIREC) FROM(OUTREC) KEY(NAME);
          WHEN('D') DELETE FILE(DIREC) KEY(NAME);
          OTHERWISE PUT FILE(SYSPRINT) SKIP EDIT
             ('INVALID CODE: ',NAME) (A(15),A);
       END;
       GET FILE(SYSIN) EDIT (NAME,NUMBER,CODE)
         (COLUMN(1),A(20),A(3),A(1));
       END;
```

Figure 56 (Part 1 of 2). Updating a KSDS

```
         CLOSE FILE(DIREC);
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(DIREC) SEQUENTIAL INPUT;

         EOF='0'B;
         ON ENDFILE(DIREC) EOF='1'B;

         READ FILE(DIREC) INTO(OUTREC);
         DO WHILE(¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT(OUTREC)(A);
         READ FILE(DIREC) INTO(OUTREC);
         END;
         CLOSE FILE(DIREC);
   END DIRUPDT;
/*
//GO.DIREC DD DSNAME=PLIVSAM.AJC2.BASE,DISP=OLD
//GO.SYSIN DD *
NEWMAN,M.W.         516C
GOODFELLOW,D.T.     889A
MILES,R.               D
HARVEY,C.D.W.       209A
BARTLETT,S.G.       183A
CORY,G.                D
READ,K.M.           001A
PITT,W.H.
ROLF,D.F.              D
ELLIOTT,D.          291C
HASTINGS,G.M.          D
BRAMLEY,O.H.        439C
/*
```

Figure 56 (Part 2 of 2). Updating a KSDS

A DIRECT update file is used and the data is altered according to a code that is passed in the records in the file SYSIN:

A Add a new record
C Change the number of an existing name
D Delete a record

At the label NEXT, the name, number, and code are read in and action taken according to the value of the code. A KEY ON-unit is used to handle any incorrect keys. When the updating is finished (at the label PRINT), the file DIREC is closed and reopened with the attributes SEQUENTIAL INPUT. The file is then read sequentially and printed.

The file is associated with the data set by a DD statement that uses the DSNAME PLIVSAM.AJC2.BASE defined in the Access Method Services DEFINE CLUSTER command in Figure 55 on page 235.

Methods of Updating a KSDS: There are a number of methods of updating a KSDS. The method shown using a DIRECT file is suitable for the data as it is shown in the example. If the data had been presented in ascending key order (or even something approaching it), performance might have been improved by use of the SKIP ENVIRONMENT option. For mass sequential insertion, use a KEYED SEQUENTIAL UPDATE file. This gives faster performance because the data is written onto the data set only when strictly necessary and not after every write statement, and because the balance of free space within the data set is retained.

Statements to achieve effective mass sequential insertion are:

```
DCL DIREC KEYED SEQUENTIAL UPDATE
    ENV(VSAM);
WRITE FILE(DIREC) FROM(OUTREC)
 KEYFROM(NAME);
```

The PL/I input/output routines detect that the keys are in sequence and make the correct requests to VSAM. If the keys are not in sequence, this too is detected and no error occurs, although the performance advantage is lost. VSAM provides three methods of insertion as shown in Table 38.

Table 38. VSAM Methods of Insertion into a KSDS

Method	Requirements	Freespace	When written onto data set	PL/I attributes required
SEQ	Keys in sequence	Kept	Only when necessary	KEYED SEQUENTIAL UPDATE
SKP	Keys in sequence	Used	Only when necessary	KEYED SEQUENTIAL UPDATE ENV(VSAM SKIP)
DIR	Keys in any order	Used	After every statement	DIRECT
DIR(MACRF=SIS)	Keys in any order	Kept	After every statement	DIRECT ENV(VSAM SIS)

SKIP means that you must follow the sequence but that you can omit records. You do not need to maintain absolute sequence or order if SEQ or SKIP is used. The PL/I routines determine which type of request to make to VSAM for each statement, first checking the keys to determine which would be appropriate. The retention of free space ensures that the structure of the data set at the point of mass sequential insertion is not destroyed, enabling you to make further normal alterations in that area without loss of performance. To preserve free space balance when you require immediate writing of the data set during mass sequential insertion, as it can be on interactive systems, use the SIS ENVIRONMENT option with DIRECT files.

Alternate Indexes for KSDSs or Indexed ESDSs

Alternate indexes allow you to access KSDSs or indexed ESDSs in various ways, using either unique or nonunique keys.

Unique Key Alternate Index Path

Figure 57 on page 240 shows the creation of a unique key alternative index path for the ESDS defined and loaded in Figure 53 on page 231. Using this path, the data set is indexed by the name of the child in the first 15 bytes of the record.

Three Access Method Services commands are used. These are:

DEFINE ALTERNATEINDEX
defines the alternate index as a data set to VSAM.

BLDINDEX
places the pointers to the relevant records in the alternate index.

DEFINE PATH
defines an entity that can be associated with a PL/I file in a DD statement.

DD statements are required for the INFILE and OUTFILE operands of BLDINDEX and for the sort files. Make sure that you specify the correct names at the various points.

```
//OPT9#9   JOB
//STEP1    EXEC    PGM=IDCAMS,REGION=512K
//SYSPRINT   DD   SYSOUT=A
//SYSIN   DD    *
         DEFINE ALTERNATEINDEX -
           (NAME(PLIVSAM.AJC1.ALPHIND) -
            VOLUMES(nnnnnn) -
            TRACKS(4 1) -
            KEYS(15 0) -
            RECORDSIZE(20 40) -
            UNIQUEKEY -
           RELATE(PLIVSAM.AJC1.BASE))
/*
//STEP2    EXEC    PGM=IDCAMS,REGION=512K
//DD1     DD    DSNAME=PLIVSAM.AJC1.BASE,DISP=SHR
//DD2     DD    DSNAME=PLIVSAM.AJC1.ALPHIND,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSIN   DD    *
         BLDINDEX  INFILE(DD1)  OUTFILE(DD2)
         DEFINE PATH -
           (NAME(PLIVSAM.AJC1.ALPHPATH) -
           PATHENTRY(PLIVSAM.AJC1.ALPHIND))
//
```

Figure 57. Creating a Unique Key Alternate Index Path for an ESDS

Nonunique Key Alternate Index Path

Figure 58 on page 241 shows the creation of a nonunique key alternate index path for an ESDS. The alternate index enables the data to be selected by the sex of the children. This enables the girls or the boys to be accessed separately and every member of each group to be accessed by use of the key.

The three Access Method Services commands and the DD statement are as described in “Unique Key Alternate Index Path” on page 239. The fact that the index has nonunique keys is specified by the use of the NONUNIQUEKEY operand. When creating an index with nonunique keys, be careful to ensure that the RECORDSIZE you specify is large enough. In a nonunique alternate index, each alternate index record contains pointers to all the records that have the associated alternate index key. The pointer takes the form of an RBA for an ESDS and the prime key for a KSDS. When a large number of records might have the same key, a large record is required.

```
//OPT9#10 JOB
//STEP1    EXEC   PGM=IDCAMS,REGION=512K
//SYSPRINT  DD   SYSOUT=A
//SYSIN     DD     *
     /*care must be taken with record size */
     DEFINE ALTERNATEINDEX -
       (NAME(PLIVSAM.AJC1.SEXIND) -
        VOLUMES(nnnnnn) -
        TRACKS(4 1) -
        KEYS(1 37) -
        NONUNIQUEKEY -
        RELATE(PLIVSAM.AJC1.BASE) -
        RECORDSIZE(20 400))
/*
//STEP2    EXEC   PGM=IDCAMS,REGION=512K
//DD1     DD  DSNAME=PLIVSAM.AJC1.BASE,DISP=OLD
//DD2     DD  DSNAME=PLIVSAM.AJC1.SEXIND,DISP=OLD
//SYSPRINT  DD   SYSOUT=A
//SYSIN   DD     *
    BLDINDEX  INFILE(DD1)  OUTFILE(DD2)
    DEFINE PATH -
      (NAME(PLIVSAM.AJC1.SEXPATH) -
       PATHENTRY(PLIVSAM.AJC1.SEXIND))
//
```

Figure 58. Creating a Nonunique Key Alternate Index Path for an ESDS

Figure 59 on page 242 shows the creation of a unique key alternate index path for a KSDS. The data set is indexed by the telephone number, enabling the number to be used as a key to discover the name of person on that extension. The fact that keys are to be unique is specified by UNIQUEKEY. Also, the data set will be able to be listed in numerical order to show which numbers are not used. Three Access Method Services commands are used:

DEFINE ALTERNATEINDEX
defines the data set that will hold the alternate index data.

BLDINDEX
places the pointers to the relevant records in the alternate index.

DEFINE PATH
defines the entity that can be associated with a PL/I file in a DD statement.

DD statements are required for the INFILE and OUTFILE of BLDINDEX and for the sort files. Be careful not to confuse the names involved.

```
//OPT9#14   JOB
//STEP1    EXEC  PGM=IDCAMS,REGION=512K
//SYSPRINT  DD   SYSOUT=A
//SYSIN     DD   *
        DEFINE ALTERNATEINDEX -
          (NAME(PLIVSAM.AJC2.NUMIND) -
           VOLUMES(nnnnnn) -
           TRACKS(4 4) -
           KEYS(3 20) -
           RELATE(PLIVSAM.AJC2.BASE) -
           UNIQUEKEY -
           RECORDSIZE(24 48))
/*
//STEP2   EXEC  PGM=IDCAMS,REGION=512K
//SYSPRINT   DD     SYSOUT=A
//DD1    DD    DSN=PLIVSAM.AJC2.BASE,DISP=OLD
//DD2    DD    DSN=PLIVSAM.AJC2.NUMIND,DISP=OLD
//SYSIN    DD    *
        BLDINDEX  INFILE(DD1)  OUTFILE(DD2)

        DEFINE PATH -
          (NAME(PLIVSAM.AJC2.NUMPATH) -
           PATHENTRY(PLIVSAM.AJC2.NUMIND))
//
```

Figure 59. Creating an Alternate Index Path for a KSDS

When creating an alternate index with a unique key, you should ensure that no further records could be included with the same alternative key. In practice, a unique key alternate index would not be entirely satisfactory for a telephone directory as it would not allow two people to have the same number. Similarly, the prime key would prevent one person having two numbers. A solution would be to have an ESDS with two nonunique key alternate indexes, or to restructure the data format to allow more than one number per person and to have a nonunique key alternate index for the numbers. See Figure 57 on page 240 for an example of creation of an alternate index with nonunique keys.

Detecting Nonunique Alternate Index Keys

If you are accessing a VSAM data set by means of an alternate index path, the presence of nonunique keys can be detected by means of the SAMEKEY built-in function. After each retrieval, SAMEKEY indicates whether any further records exist with the same alternate index key as the record just retrieved. Hence, it is possible to stop at the last of a series of records with nonunique keys without having to read beyond the last record. SAMEKEY (file-reference) returns '1'B if the input/output statement has completed successfully and the accessed record is followed by another with the same key; otherwise, it returns '0'B.

Using Alternate Indexes with ESDSs

Figure 60 on page 244 shows the use of alternate indexes and backward reading on an ESDS. The program has four files:

BASEFLE reads the base data set forward.
BACKFLE reads the base data set backward.
ALPHFLE is the alphabetic alternate index path indexing the children by name.
SEXFILE is the alternate index path that corresponds to the sex of the children.

There are DD statements for all the files. They connect BASEFLE and BACKFLE to the base data set by specifying the name of the base data set in the DSNAME parameter, and connect ALPHFLE and SEXFLE by specifying the names of the paths given in Figure 57 on page 240 and Figure 58 on page 241.

The program uses SEQUENTIAL files to access the data and print it first in the normal order, then in the reverse order. At the label AGEQUERY, a DIRECT file is used to read the data associated with an alternate index key in the unique alternate index.

Finally, at the label SPRINT, a KEYED SEQUENTIAL file is used to print a list of the females in the family, using the nonunique key alternate index path. The SAMEKEY built-in function is used to read all the records with the same key. The names of the females will be accessed in the order in which they were originally entered. This will happen whether the file is read forward or backward. For a nonunique key path, the BKWD option only affects the order in which the keys are read; the order of items with the same key remains the same as it is when the file is read forward.

Deletion: At the end of the example, the Access Method Services DELETE command is used to delete the base data set. When this is done, the associated alternate indexes and paths will also be deleted.

Using Alternate Indexes with KSDSs

Figure 61 on page 246 shows the use of a path with a unique alternate index key to update a KSDS and then to access and print it in the order of the alternate index.

The alternate index path is associated with the PL/I file by a DD statement that specifies the name of the path (PLIVSAM.AJC2.NUMPATH, given in the DEFINE PATH command in Figure 59 on page 242) as the DSNAME.

In the first section of the program, a DIRECT OUTPUT file is used to insert a new record using the alternate index key. Note that any alteration made with an alternate index must not alter the prime key or the alternate index key of access of an existing record. Also, the alteration must not add a duplicate key in the prime index or any unique key alternate index.

In the second section of the program (at the label PRINTIT), the data set is read in the order of the alternate index keys using a SEQUENTIAL INPUT file. It is then printed onto SYSPRINT.

```
//OPT9#15  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN      DD *
  READIT: PROC OPTIONS(MAIN);
    DCL   BASEFLE FILE SEQUENTIAL INPUT ENV(VSAM),
                 /*File to read base data set forward */
          BACKFLE FILE SEQUENTIAL INPUT ENV(VSAM BKWD),
                 /*File to read base data set backward */
          ALPHFLE FILE DIRECT INPUT ENV(VSAM),
          /*File to access via unique alternate index path */
          SEXFILE FILE KEYED SEQUENTIAL INPUT ENV(VSAM),
           /*File to access via nonunique alternate index path */
          STRING CHAR(80),  /*String to be read into */
          1 STRUC DEF (STRING),
            2 NAME CHAR(25),
            2 DATE_OF_BIRTH CHAR(2),
            2 FILL CHAR(10),
            2 SEX CHAR(1);
            DCL NAMEHOLD CHAR(25),SAMEKEY BUILTIN;
            DCL EOF BIT(1) INIT('0'B);

    /*Print out the family eldest first*/

    ON ENDFILE(BASEFLE) EOF='1'B;
    PUT EDIT('FAMILY ELDEST FIRST')(A);
    READ FILE(BASEFLE) INTO (STRING);
    DO WHILE(¬EOF);
       PUT SKIP EDIT(STRING)(A);
       READ FILE(BASEFLE) INTO (STRING);
    END;
    CLOSE FILE(BASEFLE);
    PUT SKIP(2);
     /*Close before using data set from other file not
       necessary but good practice to prevent potential
       problems*/

    EOF='0'B;
    ON ENDFILE(BACKFLE) EOF='1'B;
    PUT SKIP(3) EDIT('FAMILY YOUNGEST FIRST')(A);
    READ FILE(BACKFLE) INTO(STRING);
    DO WHILE(¬EOF);
      PUT SKIP EDIT(STRING)(A);
      READ FILE(BACKFLE) INTO (STRING);
    END;
    CLOSE FILE(BACKFLE);
    PUT SKIP(2);

    /*Print date of birth of child specified in the file
      SYSIN*/
    ON KEY(ALPHFLE) BEGIN;
       PUT SKIP EDIT
          (NAMEHOLD,' NOT A MEMBER OF THE SMITH FAMILY') (A);
       GO TO SPRINT;
    END;
```

Figure 60 (Part 1 of 2). Alternate Index Paths and Backward Reading with an ESDS

```
 AGEQUERY:
    EOF='0'B;
    ON ENDFILE(SYSIN) EOF='1'B;
    GET SKIP EDIT(NAMEHOLD)(A(25));
    DO WHILE(¬EOF);
          READ FILE(ALPHFLE) INTO (STRING) KEY(NAMEHOLD);
          PUT SKIP (2) EDIT(NAMEHOLD,' WAS BORN IN ',
              DATE_OF_BIRTH)(A,X(1),A,X(1),A);
          GET SKIP EDIT(NAMEHOLD)(A(25));
    END;
 SPRINT:
    CLOSE FILE(ALPHFLE);
    PUT SKIP(1);

   /*Use the alternate index to print out all the females in the
     family*/
        ON ENDFILE(SEXFILE) GOTO FINITO;
        PUT SKIP(2) EDIT('ALL THE FEMALES')(A);
        READ FILE(SEXFILE) INTO (STRING) KEY('F');
        PUT SKIP EDIT(STRING)(A);
        DO WHILE(SAMEKEY(SEXFILE));
           READ FILE(SEXFILE) INTO (STRING);
           PUT SKIP EDIT(STRING)(A);
        END;

 FINITO:
     END;
/*
//GO.BASEFLE   DD   DSN=PLIVSAM.AJC1.BASE,DISP=SHR
//GO.BACKFLE   DD   DSN=PLIVSAM.AJC1.BASE,DISP=SHR
//GO.ALPHFLE   DD   DSN=PLIVSAM.AJC1.ALPHPATH,DISP=SHR
//GO.SEXFILE   DD   DSN=PLIVSAM.AJC1.SEXPATH,DISP=SHR
//GO.SYSIN     DD    *
ANDY
/*
//STEP2    EXEC PGM=IDCAMS,REGION=512K
//SYSPRINT    DD    SYSOUT=A
//SYSIN       DD     *
     DELETE -
          PLIVSAM.AJC1.BASE
//
```

Figure 60 (Part 2 of 2). Alternate Index Paths and Backward Reading with an ESDS

```
//OPT9#16  JOB
//STEP1  EXEC IEL1CLG,REGION.GO=256K
//PLI.SYSIN      DD *
    ALTER: PROC OPTIONS(MAIN);
       DCL NUMFLE1 FILE RECORD DIRECT OUTPUT ENV(VSAM),
           NUMFLE2 FILE RECORD SEQUENTIAL INPUT ENV(VSAM),
           IN FILE RECORD,
           STRING CHAR(80),
           NAME CHAR(20) DEF STRING,
           NUMBER CHAR(3) DEF STRING POS(21),
           DATA CHAR(23) DEF STRING,
           EOF BIT(1) INIT('0'B);

      ON KEY (NUMFLE1) BEGIN;
         PUT SKIP EDIT('DUPLICATE NUMBER')(A);
      END;

      ON ENDFILE(IN) EOF='1'B;

      READ FILE(IN) INTO (STRING);
      DO WHILE(¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT (STRING) (A);
         WRITE FILE(NUMFLE1) FROM (STRING) KEYFROM(NUMBER);
         READ FILE(IN) INTO (STRING);
      END;

      CLOSE FILE(NUMFLE1);

      EOF='0'B;
      ON ENDFILE(NUMFLE2) EOF='1'B;

      READ FILE(NUMFLE2) INTO (STRING);
      DO WHILE(¬EOF);
        PUT SKIP EDIT(DATA)(A);
        READ FILE(NUMFLE2) INTO (STRING);
      END;

      PUT SKIP(3) EDIT('****SO ENDS THE PHONE DIRECTORY****')(A);
    END;
/*
//GO.IN    DD   *
RIERA L             123
/*
//NUMFLE1    DD   DSN=PLIVSAM.AJC2.NUMPATH,DISP=OLD
//NUMFLE2    DD   DSN=PLIVSAM.AJC2.NUMPATH,DISP=OLD
//STEP2    EXEC PGM=IDCAMS,COND=EVEN
//SYSPRINT   DD  SYSOUT=A
//SYSIN   DD    *
    DELETE -
         PLIVSAM.AJC2.BASE
//
```

Figure 61. Using a Unique Alternate Index Path to Access a KSDS

Relative-Record Data Sets

The statements and options allowed for VSAM relative-record data sets (RRDS) are shown in Table 39.

Table 39 (Page 1 of 3). Statements and Options Allowed for Loading and Accessing VSAM Relative-Record Data Sets

File declaration[1]	**Valid statements, with options you must include**	**Other options you can also include**
SEQUENTIAL OUTPUT BUFFERED	WRITE FILE(file-reference) FROM(reference);	KEYFROM(expression) or KEYTO(reference)
	LOCATE based-variable FILE(file-reference);	SET(pointer-reference)
SEQUENTIAL OUTPUT UNBUFFERED	WRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or either KEYFROM(expression) or KEYTO(reference)
SEQUENTIAL INPUT BUFFERED	READ FILE(file-reference) INTO(reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	IGNORE(expression)
SEQUENTIAL INPUT UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or either KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	EVENT(event-reference) and/or IGNORE(expression)
SEQUENTIAL UPDATE BUFFERED	READ FILE(file-reference) INTO(reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference) SET(pointer-reference);	KEY(expression) or KEYTO(reference)
	READ FILE(file-reference);[2]	IGNORE(expression)
	WRITE FILE(file-reference) FROM(reference);	KEYFROM(expression) or KEYTO(reference)
	REWRITE FILE(file-reference);	FROM(reference) and/or KEY(expression)
	DELETE FILE(file-reference);	KEY(expression)

Table 39 (Page 2 of 3). Statements and Options Allowed for Loading and Accessing VSAM Relative-Record Data Sets

File declaration[1]	**Valid statements, with options you must include**	**Other options you can also include**
SEQUENTIAL UPDATE UNBUFFERED	READ FILE(file-reference) INTO(reference);	EVENT(event-reference) and/or either KEY(expression) or KEYTO(reference)
	READ FILE(file-expression);[2]	EVENT(event-reference) and/or IGNORE(expression)
	WRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or either KEYFROM(expression) or KEYTO(reference)
	REWRITE FILE(file-reference) FROM(reference);	EVENT(event-reference) and/or KEY(expression)
	DELETE FILE(file-reference);	EVENT(event-reference) and/or KEY(expression)
DIRECT OUTPUT BUFFERED	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
DIRECT OUTPUT UNBUFFERED	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)
DIRECT INPUT BUFFERED	READ FILE(file-reference) INTO(reference) KEY(expression);	
	READ FILE(file-reference) SET(pointer-reference) KEY(expression);	
DIRECT INPUT UNBUFFERED	READ FILE(file-reference) KEY(expression);	EVENT(event-reference)
DIRECT UPDATE BUFFERED	READ FILE(file-reference) INTO(reference) KEY(expression);	
	READ FILE(file-reference) SET(pointer-reference) KEY(expression);	
	REWRITE FILE(file-reference) FROM(reference) KEY(expression);	
	DELETE FILE(file-reference) KEY(expression);	
	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	

Table 39 (Page 3 of 3). Statements and Options Allowed for Loading and Accessing VSAM Relative-Record Data Sets

File declaration[1]	Valid statements, with options you must include	Other options you can also include
DIRECT UPDATE UNBUFFERED	READ FILE(file-reference) INTO(reference) KEY(expression);	EVENT(event-reference)
	REWRITE FILE(file-reference) FROM(reference) KEY(expression);	EVENT(event-reference)
	DELETE FILE(file-reference) KEY(expression);	EVENT(event-reference)
	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	EVENT(event-reference)

Notes:

1. The complete file declaration would include the attributes FILE and RECORD. If you use any of the options KEY, KEYFROM, or KEYTO, your declaration must also include the attribute KEYED.

   The EXCLUSIVE attribute for DIRECT INPUT or UPDATE files, the UNLOCK statement for DIRECT UPDATE files, or the NOLOCK option of the READ statement for DIRECT INPUT files are ignored if you use them for files associated with a VSAM RRDS.

2. The statement READ FILE(file-reference); is equivalent to the statement READ FILE(file-reference) IGNORE(1);

Loading an RRDS

When an RRDS is being loaded, you must open the associated file for OUTPUT. Use either a DIRECT or a SEQUENTIAL file.

For a DIRECT OUTPUT file, each record is placed in the position specified by the relative record number (or key) in the KEYFROM option of the WRITE statement (see “Keys for VSAM Data Sets” on page 215).

For a SEQUENTIAL OUTPUT file, use WRITE statements with or without the KEYFROM option. If you specify the KEYFROM option, the record is placed in the specified slot; if you omit it, the record is placed in the slot following the current position. There is no requirement for the records to be presented in ascending relative record number order. If you omit the KEYFROM option, you can obtain the relative record number of the written record by means of the KEYTO option.

If you want to load an RRDS sequentially, without use of the KEYFROM or KEYTO options, your file is not required to have the KEYED attribute.

It is an error to attempt to load a record into a position that already contains a record: if you use the KEYFROM option, the KEY condition is raised; if you omit it, the ERROR condition is raised.

In Figure 62 on page 250, the data set is defined with a DEFINE CLUSTER command and given the name PLIVSAM.AJC3.BASE. The fact that it is an RRDS is determined by the NUMBERED keyword. In the PL/I program, it is loaded with a DIRECT OUTPUT file and a WRITE...FROM...KEYFROM statement is used.

If the data had been in order and the keys in sequence, it would have been possible to use a SEQUENTIAL file and write into the data set from the start. The records would then have been placed in the next available slot and given the appropriate number. The number of the key for each record could have been returned using the KEYTO option.

The PL/I file is associated with the data set by the DD statement, which uses as the DSNAME the name given in the DEFINE CLUSTER command.

```
//OPT9#17  JOB
//STEP1 EXEC PGM=IDCAMS,REGION=512K
//SYSPRINT DD SYSOUT=A
//SYSIN    DD *
         DEFINE CLUSTER -
             (NAME(PLIVSAM.AJC3.BASE) -
             VOLUMES(nnnnnn) -
             NUMBERED -
             TRACKS(2 2) -
             RECORDSIZE(20 20))
/*
//STEP2  EXEC IEL1CLG
//PLI.SYSIN      DD *
 CRR1:   PROC OPTIONS(MAIN);
         DCL NOS FILE RECORD OUTPUT DIRECT KEYED ENV(VSAM),
             CARD CHAR(80),
             NAME CHAR(20) DEF CARD,
             NUMBER CHAR(2) DEF CARD POS(21),
             IOFIELD CHAR(20),
             EOF BIT(1) INIT('0'B);
         ON ENDFILE (SYSIN) EOF='1'B;
         OPEN FILE(NOS);
         GET FILE(SYSIN) EDIT(CARD)(A(80));
        DO WHILE (¬EOF);
         PUT FILE(SYSPRINT) SKIP EDIT (CARD) (A);
         IOFIELD=NAME;
         WRITE FILE(NOS) FROM(IOFIELD) KEYFROM(NUMBER);
         GET FILE(SYSIN) EDIT(CARD)(A(80));
         END;
         CLOSE FILE(NOS);
 END CRR1;
```

Figure 62 (Part 1 of 2). Defining and Loading a Relative-Record Data Set (RRDS)

```
/*
//GO.NOS DD DSN=PLIVSAM.AJC3.BASE,DISP=OLD
//GO.SYSIN DD *
ACTION,G.           12
BAKER,R.            13
BRAMLEY,O.H.        28
CHEESNAME,L.        11
CORY,G.             36
ELLIOTT,D.          85
FIGGINS.E.S.        43
HARVEY,C.D.W.       25
HASTINGS,G.M.       31
KENDALL,J.G.        24
LANCASTER,W.R.      64
MILES,R.            23
NEWMAN,M.W.         40
PITT,W.H.           55
ROLF,D.E.           14
SHEERS,C.D.         21
SURCLIFFE,M.        42
TAYLOR,G.C.         47
WILTON,L.W.         44
WINSTONE,E.M.       37
//
```

Figure 62 (Part 2 of 2). Defining and Loading a Relative-Record Data Set (RRDS)

Using a SEQUENTIAL File to Access an RRDS

You can open a SEQUENTIAL file that is used to access an RRDS with either the INPUT or the UPDATE attribute. If you use any of the options KEY, KEYTO, or KEYFROM, your file must also have the KEYED attribute.

For READ statements without the KEY option, the records are recovered in ascending relative record number order. Any empty slots in the data set are skipped.

If you use the KEY option, the record recovered by a READ statement is the one with the relative record number you specify. Such a READ statement positions the data set at the specified record; subsequent sequential reads will recover the following records in sequence.

WRITE statements with or without the KEYFROM option are allowed for KEYED SEQUENTIAL UPDATE files. You can make insertions anywhere in the data set, regardless of the position of any previous access. For WRITE with the KEYFROM option, the KEY condition is raised if an attempt is made to insert a record with the same relative record number as a record that already exists on the data set. If you omit the KEYFROM option, an attempt is made to write the record in the next slot, relative to the current position. The ERROR condition is raised if this slot is not empty.

You can use the KEYTO option to recover the key of a record that is added by means of a WRITE statement without the KEYFROM option.

REWRITE statements, with or without the KEY option, are allowed for UPDATE files. If you use the KEY option, the record that is rewritten is the record with the relative record number you specify; otherwise, it is the record that was accessed by the previous READ statement.

DELETE statements, with or without the KEY option, can be used to delete records from the dataset.

Using a DIRECT File to Access an RRDS

A DIRECT file used to access an RRDS can have the OUTPUT, INPUT, or UPDATE attribute. You can read, write, rewrite, or delete records exactly as though a KEYED SEQUENTIAL file were used.

Figure 63 on page 253 shows an RRDS being updated. A DIRECT UPDATE file is used and new records are written by key. There is no need to check for the records being empty, because the empty records are not available under VSAM.

In the second half of the program, starting at the label PRINT, the updated file is printed out. Again there is no need to check for the empty records as there is in REGIONAL(1).

The PL/I file is associated with the data sets by a DD statement that specifies the DSNAME PLIVSAM.AJC3.BASE, the name given in the DEFINE CLUSTER command in Figure 63 on page 253.

At the end of the example, the DELETE command is used to delete the data set.

```
//* NOTE: WITH A WRITE STATEMENT AFTER THE DELETE FILE STATEMENT,
//*       A “DUPLICATE” MESSAGE IS EXPECTED FOR CODE 'C' ITEMS
//*       WHOSE NEWNO CORRESPONDS TO AN EXISTING NUMBER IN THE LIST,
//*       FOR EXAMPLE, ELLIOT.
//*       WITH A REWRITE STATEMENT AFTER THE DELETE FILE STATEMENT,
//*       A “NOT FOUND” MESSAGE IS EXPECTED FOR CODE 'C' ITEMS
//*       WHOSE NEWNO DOES NOT CORRESPOND TO AN EXISTING NUMBER IN
//*       THE LIST, FOR EXAMPLE, NEWMAN AND BRAMLEY.
//OPT9#18  JOB
//STEP1  EXEC IEL1CLG
//PLI.SYSIN      DD *
 ACR1:  PROC OPTIONS(MAIN);
                DCL NOS FILE RECORD KEYED ENV(VSAM),NAME CHAR(20),
                  (NEWNO,OLDNO) CHAR(2),CODE CHAR(1),IOFIELD CHAR(20),
                  BYTE CHAR(1) DEF IOFIELD, EOF BIT(1) INIT('0'B),
                  ONCODE BUILTIN;
        ON ENDFILE(SYSIN) EOF='1'B;
        OPEN FILE(NOS) DIRECT UPDATE;
        ON KEY(NOS) BEGIN;
           IF ONCODE=51 THEN PUT FILE(SYSPRINT) SKIP EDIT
                    ('NOT FOUND:',NAME)(A(15),A);
           IF ONCODE=52 THEN PUT FILE(SYSPRINT) SKIP EDIT
                    ('DUPLICATE:',NAME)(A(15),A);
        END;
        GET FILE(SYSIN) EDIT(NAME,NEWNO,OLDNO,CODE)
           (COLUMN(1),A(20),A(2),A(2),A(1));
        DO WHILE (¬EOF);
        PUT FILE(SYSPRINT) SKIP EDIT (' ',NAME,'#',NEWNO,OLDNO,' ',CODE)
           (A(1),A(20),A(1),2(A(2)),X(5),2(A(1)));
        SELECT(CODE);
           WHEN('A') WRITE FILE(NOS) KEYFROM(NEWNO) FROM(NAME);
           WHEN('C') DO;
            DELETE FILE(NOS) KEY(OLDNO);
            WRITE FILE(NOS) KEYFROM(NEWNO) FROM(NAME);
           END;
           WHEN('D') DELETE FILE(NOS) KEY(OLDNO);
           OTHERWISE PUT FILE(SYSPRINT) SKIP EDIT
             ('INVALID CODE: ',NAME)(A(15),A);
        END;
```

Figure 63 (Part 1 of 2). Updating an RRDS

```
        GET FILE(SYSIN) EDIT(NAME,NEWNO,OLDNO,CODE)
           (COLUMN(1),A(20),A(2),A(2),A(1));
        END;
         CLOSE FILE(NOS);
            PRINT:
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(NOS) SEQUENTIAL INPUT;
         EOF='0'B;
         ON ENDFILE(NOS) EOF='1'B;
          READ FILE(NOS) INTO(IOFIELD) KEYTO(NEWNO);
          DO WHILE (¬EOF);
          PUT FILE(SYSPRINT) SKIP EDIT(NEWNO,IOFIELD)(A(5),A);
          READ FILE(NOS) INTO(IOFIELD) KEYTO(NEWNO);
          END;
       CLOSE FILE(NOS);
 END ACR1;
/*
//GO.NOS     DD DSN=PLIVSAM.AJC3.BASE,DISP=OLD
//GO.SYSIN   DD  *
NEWMAN,M.W.         5640C
GOODFELLOW,D.T.     89  A
MILES,R.              23D
HARVEY,C.D.W.       29  A
BARTLETT,S.G.       13  A
CORY,G.               36D
READ,K.M.           01  A
PITT,W.H.             55
ROLF,D.F.             14D
ELLIOTT,D.          4285C
HASTINGS,G.M.         31D
BRAMLEY,O.H.        4928C
//STEP3    EXEC PGM=IDCAMS,REGION=512K,COND=EVEN
//SYSPRINT DD SYSOUT=A
//SYSIN   DD   *
      DELETE -
          PLIVSAM.AJC3.BASE
//
```

Figure 63 (Part 2 of 2). Updating an RRDS

Chapter 12. Defining and Using Teleprocessing Data Sets

Teleprocessing in PL/I is supported by record-oriented data transmission using the Telecommunications Access Method (TCAM) and PL/I files declared with the TRANSIENT attribute. A teleprocessing data set is a queue of messages originating from or destined for remote terminals (or application programs). A PL/I TRANSIENT file allows a PL/I program to access a teleprocessing data set as an INPUT file for retrieving messages or as an OUTPUT file for writing messages.

In a teleprocessing system using TCAM, the user must write a message control program (MCP) and can write one or more message processing programs (TCAM MPPs). The MCP is part of TCAM and must be written in assembler language using macros supplied by TCAM. The TCAM MPPs are application programs and can be written in PL/I.

This section briefly covers the message control program (MCP) and the message processing program (TCAM MPP). It also covers teleprocessing organization, ENVIRONMENT options for teleprocessing, and condition handling for teleprocessing.

A TCAM overview is given in *OS/VS TCAM Concepts and Applications*. If you want more detailed information about TCAM programming facilities, see the *ACF TCAM Application Programmer's Guide*.

TCAM is not available under VM using PL/I.

Message Control Program (MCP)

A TCAM message control program (MCP) controls the routing of messages originating from and destined for the remote terminals and message processing programs in your TCAM installation. Each origin or destination associated with a message is identified by a name known in the MCP, and carried within the message. The MCP routes messages to and from message processing programs and terminals by means of in-storage queues. The queues can also be on disk storage when the in-storage queue is full. This support is provided by TCAM. TCAM queues can also be simulated by sequential data sets on direct-access devices; however, the data sets cannot be accessed by your PL/I program, since PL/I supports only the use of queues.

A message can be transmitted in one of several formats, only two of which are supported by PL/I. You specify the message format in the MCP, and also in your PL/I program by means of the ENVIRONMENT attribute, described later in this section.

Note for System Programmers: Of the several message formats allowed by a TCAM MCP, PL/I supports those represented by:

- DCBOPTCD=WUC,DCBRECFM=V for PL/I ENVIRONMENT option TP(M)
- DCBOPTCD=WC,DCBRECFM=V for PL/I ENVIRONMENT option TP(R).

TCAM Message Processing Program (TCAM MPP)

A message processing program (TCAM MPP) is an application program that retrieves messages from TCAM queues and/or writes messages to TCAM queues. A TCAM MPP allows you to provide data to a problem program from a terminal and to receive output from the program with a minimum of delay. You can write TCAM MPPs in PL/I; they can perform other data processing functions in addition to teleprocessing.

A TCAM MPP for reading or writing TCAM queues is not mandatory for teleprocessing installations. If the messages you transmit are not processed, because they are simply switched between terminals, then a TCAM MPP is not required.

The following sections describe PL/I teleprocessing data sets and the PL/I language features that you use to write TCAM MPPs.

Teleprocessing Organization

A teleprocessing data set is a queue of messages that constitutes the input to a PL/I message processing program. You write and retrieve the messages sequentially. You use keys to identify the terminal or application associated with the message. Include the TRANSIENT attribute in the PL/I file declaration to specify access type. TRANSIENT indicates that the contents of the data set associated with the file are reestablished each time the data set is accessed. You can continually add records to the data set with one program while another program is running that continually removes records from the data set. Thus the data set can be considered to be a continuous first-in/first-out queue through which the records pass in transit between the message control program and the message processing program.

A data set associated with a TRANSIENT file differs from one associated with a DIRECT or SEQUENTIAL file in the following ways:

- Its contents are dynamic. Reading a record removes it from the data set.
- The ENDFILE condition is not defined for a TRANSIENT file. Instead, the PENDING condition is raised when the input queue is empty. This does not imply the queue will remain empty since records can be continually added.

In addition to TRANSIENT access, you can access a teleprocessing queue for input as a SEQUENTIAL file with consecutive organization (unless you use a READ statement option, such as EVENT, that is invalid for a TRANSIENT file). This support is provided by TCAM when it detects a request from a sequential access method (BSAM or QSAM). Your program is unaware of the fact that a TCAM queue is the source of input. You will not receive terminal identifiers in the character string referenced in the KEYTO option of the READ statement and the PENDING condition will not be raised. You can create a teleprocessing data set only by using a file with TRANSIENT access.

Essential Information

To access a teleprocessing data set, the file name or value of the TITLE option on the OPEN statement must be the name of a DD statement that identifies the message queue in the QNAME parameter. For example:

```
//PLIFILE  DD  QNAME=process name
```

“process name” is the symbolic name of the TPROCESS macro, coded in your MCP, that defines the destination queue through which your messages will be routed. Your system programmer can provide the queue names to be used for your application.

For TRANSIENT OUTPUT files, the element expression you specify in the KEYFROM option must have as its value a terminal or program identifier known to your MCP. If you specify the TP(R) ENVIRONMENT option, indicating multiple-segment messages, you must indicate the position of record segments within a message, as described above.

Defining Files for a Teleprocessing Data Set

You define a teleprocessing file with the attributes shown in the following declaration:

```
DCL filename FILE TRANSIENT RECORD
             INPUT | OUTPUT
             BUFFERED KEYED
             ENVIRONMENT(option-list);
```

The file attributes are described in the *PL/I for MVS & VM Language Reference*. Required attributes and defaults are shown in Table 15 on page 111.

Specifying ENVIRONMENT Options

For teleprocessing applications, the ENVIRONMENT options that you can specify are TP(M|R), RECSIZE(record-length), and BUFFERS(n).

TP Option

Use TP to specify that the file is associated with a teleprocessing data set. A message can consist of one logical record or several logical records on the teleprocessing data set.

```
►►──TP──(──┬─M─┬──)──────────────────────────────────────────────►◄
           └─R─┘
```

TP(M)
: specifies that each data transmission statement in your PL/I program transmits a complete message (which can be several logical records) to or from the data set.

TP(R)
: specifies that each data transmission statement in your PL/I program transmits a single logical record, which is a segment of a complete message.

One or more PL/I data transmission statements are required to completely transmit a message. On input, your PL/I application program must determine the end of a message by its own means; for example, this can be from information embedded in the message. On output, your PL/I program must provide, for each logical record, its segment position within the message.

You indicate the position by a code in the first byte of the KEYFROM value, preceding the destination ID. The valid codes and their meanings are:

1	First segment of a message
blank	Intermediate segment of a message
2	Last segment in a message
3	Only segment in a message.

Selection of TP(M) or TP(R) is dependent on the message format you specify in your MCP. Your system programmer can tell you which code to use.

RECSIZE Option

Use the RECSIZE option to specify the size of the record variable (or input or output buffer, for locate mode) in your PL/I program. If you use the TP(M) option, this size should be equal to the length of all the logical records that constitute the message. If it is smaller, part of the message will be lost. If it is greater, the contents of the last part of the variable (or buffer) are undefined. If you specify the TP(R) option, this size must be the same as the logical record length.

You must specify RECSIZE.

BUFFERS Option

Use the BUFFERS option to specify the number of intermediate buffers required to contain the longest message to be transmitted. The buffer size is defined in the message control program. If a message is too long for the buffers you specified, extra buffers must be obtained before processing can continue, which increases run time. The extra buffers are obtained by the operating system; you need not take any action.

Writing a TCAM Message Processing Program (TCAM MPP)

You can access a TRANSIENT file with READ, WRITE, and LOCATE statements. You cannot use the EVENT option.

Use the READ statement for input, with either the INTO option or the SET option. You must give the KEYTO option. The origin name is assigned to the variable referenced in the KEYTO option. If the origin name is shorter than the character string referenced in the KEYTO option, it is padded on the right with blanks. If the KEYTO variable is a varying-length string, its current length is set to that of the origin name. The origin name should not be longer than the KEYTO variable (if it is, it is truncated), but in any case will not be longer than 8 characters. The data part of the message or record is assigned to the variable referenced in the INTO option, or the pointer variable referenced in the SET option is set to point to the data in the READ SET buffer.

A READ statement for the file will take the next message (or the next record from the current message) from the associated queue, assign the data part to the variable referenced in the READ INTO option (or set a pointer to point to the data in a READ SET buffer), and assign the character string origin identifier to the variable referenced in the KEYTO option. The PENDING condition is raised if the input queue is empty when a READ statement is executed.

You can use either the WRITE or the LOCATE statement for output. Either statement must have the KEYFROM option—for files declared with the TP(M) option, the first 8 characters of the value of the KEYFROM expression are used to identify the destination, which must be a recognized terminal or program identifier. For files declared with the TP(R) option, indicating multiple-segment messages, the first character of the value you specify in the KEYFROM expression must contain the message segment code as discussed above. The next 8 characters of the value are used to identify the destination. The data part of the message is transmitted from the variable referenced in the FROM option of the WRITE statement, or, in the case of LOCATE, a pointer variable is set to point to the location of the data in the output buffer.

The statements and options allowed for TRANSIENT files are given in Table 40. Some examples follow the figure.

Table 40. Statements and Options Allowed for TRANSIENT Files

File declaration[1]	Valid statements, with options you must include	Other options you can also include

TRANSIENT INPUT	READ FILE(file-reference) INTO(reference) KEYTO(reference);
	READ FILE(file-reference) SET(pointer-reference) KEYTO(reference);	

TRANSIENT OUTPUT	WRITE FILE(file-reference) FROM(reference) KEYFROM(expression);	
	LOCATE(based-variable) FILE(file-reference) KEYFROM(expression);	SET(pointer-reference)

Notes:

1. The complete file declaration would include the attributes FILE, RECORD, KEYED, BUFFERED, and the ENVIRONMENT attribute with either the TP(M) or the TP(R) option.

The following example illustrates the use of move mode in teleprocessing applications:

```
DECLARE (IN INPUT,OUT OUTPUT) FILE
   TRANSIENT ENV(TP(M) RECSIZE(124)),
   (INREC, OUTREC) CHARACTER(120)
   VARYING, TERM CHARACTER(8);

READ FILE(IN) INTO(INREC) KEYTO(TERM);
  .
  .
  .
WRITE FILE(OUT) FROM(OUTREC)
  KEYFROM(TERM);
```

The files IN and OUT are given the attributes KEYED and BUFFERED because TRANSIENT implies these attributes. The TP(M) option indicates that a complete message will be transmitted. The input buffer for file IN contains the next message from the input queue.

The READ statement moves the message or record from the input buffer into the variable INREC. The character string identifying the origin is assigned to TERM. If the buffer is empty when the READ statement is executed (that is, if there are no messages in the queue), the PENDING condition is raised. The implicit action for the condition is described under “Handling PL/I Conditions.”

After processing, the message or record is held in OUTREC. The WRITE statement moves it to the output buffer, together with the value of TERM (which still contains the origin name unless another name has been assigned to it during processing). From the buffer, the message is transmitted to the correct queue for the destination, as specified by the value of TERM.

The next example is similar to the previous one, except that locate mode input is used.

```
DECLARE (IN INPUT,OUT OUTPUT) FILE
   TRANSIENT ENV(TP(M) RECSIZE(124)),
   MESSAGE CHARACTER(120) VARYING
   BASED(INPTR),
   TERM CHARACTER(8);

READ FILE(IN) SET(INPTR) KEYTO(TERM);
  .
  .
  .
WRITE FILE(OUT) FROM(MESSAGE)
  KEYFROM(TERM);
```

The message data is processed in the input buffer, using the based variable MESSAGE, which has been declared with the pointer reference INPTR. (The variable MESSAGE will be aligned on a double word boundary.) The WRITE statement moves the processed data from the input to the output buffer; otherwise its effect is as described for the WRITE statement in the first example.

The technique used in this example would be useful in applications where the differences between processed and unprocessed messages were relatively simple, since the maximum size of input and output messages would be the same. If the length and structure of the output message could vary widely, depending on the text of the input message, locate mode output could be used to advantage. After the input message had been read in, a suitable based variable could be located in the output buffer (using the LOCATE statement), where further processing would take place. The message would be transmitted immediately before execution of the next WRITE or LOCATE statement for the file.

Handling PL/I Conditions

The conditions that can be raised during teleprocessing transmission are TRANSMIT, KEY, RECORD, ERROR, and PENDING.

The TRANSMIT condition can be raised on input or output, as described for other types of transmission. In addition, for a TRANSIENT OUTPUT file, TRANSMIT can be raised in the following circumstances:

- The destination queue is full—TCAM rejected the message.
- For a file declared with the TP(R) ENVIRONMENT option, message segments were presented out of sequence.

The RECORD condition is raised under the same circumstances as for other types of transmission. The messages and records are treated as V-format records.

The ERROR condition is raised as for other types of transmission. It is also raised when the expression in the KEYFROM option is missing or invalid.

The KEY condition is raised if the expression in the KEYFROM option is syntactically valid but does not represent an origin or a destination name recognized by the MCP.

The PENDING condition is raised only during execution of a READ statement for a TRANSIENT file. When the PENDING condition is raised, the value returned by the ONKEY built-in function is a null string. The PL/I implicit action for the PENDING condition is as follows:

- If there is no ON-unit for the PENDING condition, the PL/I transmitter module waits for a message.
- If there is an ON-unit for the PENDING condition, and it executes a normal return, the transmitter waits for a message.
- If there is an ON-unit for the PENDING condition, and it does not return normally, the next execution of a READ statement again raises PENDING if no records have been added to the queue.

There is no PL/I condition associated with the occurrence of the last segment of a message. When you specify the TP(R) option, indicating multiple-segment messages, you are responsible for arranging the recognition of the end of the message.

TCAM MPP Example

An example of a TCAM MPP and the job control language required to run it is shown in Figure 64 on page 262. The EXEC statement in the first part of the figure invokes the cataloged procedure IEL1CL to compile and link-edit the PL/I message processing program. The load module is stored in the library SYS1.MSGLIB under the member name MPPROC.

Part 1. Compiling and link-editing the TCAM MPP

```
//JOBNAME    JOB
//  EXEC  IEL1CL
//PLI.SYSIN DD *
  MPPROC: PROC OPTIONS(MAIN);
      DCL INMSG FILE RECORD KEYED TRANSIENT ENV(TP(M) RECSIZE(100)),
          OUTMSG FILE RECORD KEYED TRANSIENT ENV(TP(M) RECSIZE(500)),
          INDATA CHAR(100),
          OUTDATA CHAR(500),
          TKEY CHAR(6);
            .
            .
            .
      OPEN FILE(INMSG) INPUT,FILE(OUTMSG) OUTPUT;
            .
            .
            .
      READ FILE(INMSG) KEYTO(TKEY) INTO(INDATA);
            .
            .
            .
      WRITE FILE(OUTMSG) KEYFROM(TKEY) FROM(OUTDATA);
            .
            .
            .
 ENDTP:  CLOSE FILE(INMSG),FILE(OUTMSG);
         END MPPROC;
/*
//LKED.SYSLMOD DD DSNAME=SYS1.MSGLIB(MPPROC),DISP=OLD
```

Part 2. Executing the TCAM MPP

```
//JOBNAME    JOB  ...
//JOBLIB     DD   DSNAME=SYS1.MSGLIB(MPPROC),DISP=SHR
//           EXEC  PGM=MPPROC
//INMSG   DD  QNAME=(INQUIRY)
//OUTMSG  DD  QNAME=(RESPONSE)
```

Figure 64. PL/I Message Processing Program

In the PL/I program, INMSG is declared as a teleprocessing file that can process messages up to 100 bytes long. Similarly, OUTMSG is declared as a teleprocessing file that can process messages up to 500 bytes long.

The READ statement gets a message from the queue. The terminal identifier, which is passed as a key by TCAM, is inserted into TKEY, the character string referenced in the KEYTO option. The record is placed in the INDATA variable for processing. The appropriate READ SET statement could also have been used here. The statements that process the data and place it in OUTDATA are omitted to simplify the example.

The WRITE statement moves the data from OUTDATA into the destination queue. The terminal identifier is taken from the character string in TKEY. An appropriate LOCATE statement could also have been used.

The TCAM MPP is executed in the second part of the example. The INMSG and OUTMSG DD statements associate the PL/I files TCAM MPP and OUTMSG with their respective main storage queues, that is, INQUIRY and RESPONSE.

Part 4. Improving your program

Chapter 13. Examining and Tuning Compiled Modules

This chapter discusses how to obtain static information about your compiled program or other object modules of interest either during execution of your program or at any time. Specifically, it discusses:

- How to turn hooks on prior to execution by calling IBMBHKS (see "Activating Hooks in Your Compiled Program Using IBMBHKS")
- How to call the Static Information Retrieval service IBMBSIR to retrieve static information about compiled modules (see "Obtaining Static Information about Compiled Modules Using IBMBSIR" on page 266)
- How to call the Hook Information Retrieval service IBMBHIR to obtain static information relative to hooks that are executed during your program's run (see "Obtaining Static Information as Hooks Are Executed Using IBMBHIR" on page 271)
- How to use IBMBHKS, IBMBSIR, and IBMBHIR via the hook exit in CEEBINT to examine your program's run-time behavior (see "Examining Your Program's Run-Time Behavior" on page 272).

These services are useful if you want to do any of the following:

- Examine and fine tune your program's run-time behavior by, for example, checking which statements, blocks, paths, labels, or calls are visited most
- Perform function tracing during your program's execution
- Examine CPU timing characteristics of your program's execution
- Find out information about any object module such as:
  - What options it was compiled with
  - Its size
  - The number and location of blocks in the module
  - The number and location of hooks in the module
  - The number and addresses of external entries in the module

These services are available in batch, PL/I multitasking, and CICS environments.

For information on how to establish the hook exit in CEEBINT, see the *Language Environment for MVS & VM Programming Guide*.

Activating Hooks in Your Compiled Program Using IBMBHKS

The callable service IBMBHKS is provided to turn hooks on and off without the use of a debugging tool. It is available in batch, PL/I multitasking, and CICS environments.

The IBMBHKS Programming Interface

You can declare IBMBHKS in a PL/I program as follows:

```
DECLARE IBMBHKS EXTERNAL ENTRY( FIXED BIN(31,0), FIXED BIN(31,0) );
```

and invoke it with the following PL/I CALL statement:

```
CALL IBMBHKS( Function_code, Return_code );
```

The possible function codes are:

1	Turn on statement hooks
-1	Turn off statement hooks
2	Turn on block entry hooks
-2	Turn off block entry hooks
3	Turn on block exit hooks
-3	Turn off block exit hooks
4	Turn on path hooks
-4	Turn off path hooks
5	Turn on label hooks
-5	Turn off label hooks
6	Turn on before-call hooks
-6	Turn off before-call hooks
7	Turn on after-call hooks
-7	Turn off after-call hooks.

The possible return codes are:

0	Successful
12	The debugging tool is active
16	Invalid function code passed.

Note: Turning on or off statement hooks or path hooks also turns on or off respectively block entry and block exit hooks. The reverse, however, is not true.

Warning

This service is meant to be used with the hook exit. It is an error to use IBMBHKS to turn on hooks when a hook exit has not been established in CEEBINT, and unpredictable results will occur in this case.

For examples of possible uses of IBMBHKS see “Examining Your Program's Run-Time Behavior” on page 272.

Obtaining Static Information about Compiled Modules Using IBMBSIR

IBMBSIR is a Static Information Retrieval module that lets you determine static information about PL/I modules compiled with the TEST option. You can use it to interrogate static information about a compiled module (to find out, for example, what options it was compiled with), or you can use it recursively as part of a run-time monitoring process.

It is available in batch, PL/I multitasking, and CICS environments.

The IBMBSIR Programming Interface

You invoke IBMBSIR with a PL/I CALL passing the address of a control block containing the following elements:

```
DECLARE
  1 SIR_DATA       BASED,
    2 SIR_FNCCODE   FIXED BIN(31), /* Function code            */
    2 SIR_RETCODE   FIXED BIN(31), /* Return code              */
    2 SIR_ENTRY     ENTRY,         /* Entry variable for module */
    2 SIR_MOD_DATA  POINTER,       /* Addr of module_data      */
    2 SIR_A_DATA    POINTER,       /* Addr of data for fnc code */
    2 SIR_END       CHAR(0);
```

where:

SIR_FNCCODE
specifies what type of information is desired, according to the following definitions:

1 Fill in the compile-time options information and the count of blocks in the module information control block (see the MODULE_OPTIONS array and MODULE_BLOCKS in Figure 65 on page 269).

2 Same function as **1** but also fill in the module's size, MODULE_SIZE, in the module information control block.

3 Fill in all information specified in the module information control block; namely, compile-time options, count of blocks, module size, and counts of statements, paths, and external entries declared explicitly or implicitly.

Before invoking IBMBSIR with a function code of 4, you must have already invoked it with one of the first three function codes:

4 Fill in the information specified in the block information control block. The layout of this control block is given in Figure 66 on page 270.

BLOCK_NAME_LEN can be zero for unlabeled begin-blocks.

Before you invoke IBMBSIR with this function code, you must allocate the area for the control block and correctly set the fields BLOCK_DATA and BLOCK_COUNT.

Before invoking IBMBSIR with any of the following function codes, you must have already invoked it with a function code of 3:

5 Fill in the hook information block for all statement hooks. The layout of this control block is given in Figure 67 on page 270.

Note that statement hooks include block entry and exit hooks.

Before you invoke IBMBSIR with this function code, you must allocate the area for the control block and correctly set the fields HOOK_DATA and HOOK_COUNT.

HOOK_IN_LINE will be zero for all programs compiled with the STMT compile-time option, and for programs compiled with the NUMBER compile-time option, it will be nonzero only when a statement is one of a multiple in a source line.

HOOK_OFFSET is always the offset of the hook from the primary entry point for the module, not the offset of the hook from the primary entry point for the block in which the hook occurs.

6 Fill in the hook information control block (see Figure 67 on page 270) for all path hooks.

Before you invoke IBMBSIR with this function code, you must allocate the area for the control block and correctly set the fields HOOK_DATA and HOOK_COUNT.

7 Fill in the external entry information control block. The layout of this control block is given in Figure 68 on page 270.

Before you invoke IBMBSIR with this function code, you must allocate the area for the control block and correctly set the fields EXTS_DATA and EXTS_COUNT.

EXTS_EPA will give the entry point address for a module declared explicitly or implicitly in the program. It will be zero if the module has not been resolved at link-edit time.

Note: For all of the function codes you must also supply the SIR_ENTRY and SIR_MOD_DATA parameters described below.

For function codes 4, 5, 6, and 7 you must supply the SIR_A_DATA parameter described below.

SIR_RETCODE
is the return code:

0 Successful.
4 Module not compiled with appropriate TEST option.
8 Module not PL/I or not compiled with TEST option.
12 Invalid parameters passed.
16 Unknown function code.

SIR_ENTRY
is the main entry point to your module.

SIR_MOD_DATA
is a pointer to the module information control block, shown in Figure 65 on page 269.

SIR_A_DATA
is a pointer to the block information control block, the hook information control block, or the external entries information control block, depending on which function code you are using.

The following figures show the layout of the control blocks:

Figure 66 on page 270 shows the block information control block.
Figure 67 on page 270 shows the hook information control block.
Figure 68 on page 270 shows the external entries information control block.

This field must be zero if you specify a function code of 1, 2, or 3. If you specify function codes 4, 5, 6, or 7, this field must point to the applicable control block:

Function Code	*Set Pointer to*
4	Block information control block
5 or 6	Hook information control block
7	External entries information control block.

```
DECLARE
  1 MODULE_DATA     BASED,
                                      /*                           */
    2 MODULE_LEN    FIXED BIN(31),    /* = Stg(Module_data)        */
                                      /*                           */
    2 MODULE_OPTIONS,                 /* Compile time options      */
                                      /*                           */
      3 MODULE_GENERAL_OPTIONS,       /*                           */
        4 MODULE_STMTNO  BIT(01),     /*   Stmt number table does  */
                                      /*   not exist               */
        4 MODULE_GONUM   BIT(01),     /*   Table has GONUMBER form */
        4 MODULE_CMPATV1 BIT(01),     /*   compiled with CMPAT(V1) */
        4 MODULE_GRAPHIC BIT(01),     /*   compiled with GRAPHIC   */
        4 MODULE_OPT     BIT(01),     /*   compiled with OPTIMIZE  */
        4 MODULE_INTER   BIT(01),     /*   compiled with INTERRUPT */
        4 MODULE_GEN1X   BIT(02),     /*   Reserved                */
                                      /*                           */
      3 MODULE_GENERAL_OPTIONS2,      /*                           */
        4 MODULE_GEN2X   BIT(08),     /*   Reserved                */
                                      /*                           */
      3 MODULE_TEST_OPTIONS,          /*                           */
        4 MODULE_TEST    BIT(01),     /*   compiled with TEST      */
        4 MODULE_STMT    BIT(01),     /*      with STMT  suboption */
        4 MODULE_PATH    BIT(01),     /*      with PATH  suboption */
        4 MODULE_BLOCK   BIT(01),     /*      with BLOCK suboption */
        4 MODULE_TESTX   BIT(03),     /*   Reserved                */
        4 MODULE_SYM     BIT(01),     /*      with SYM   suboption */
                                      /*                           */
      3 MODULE_SYS_OPTIONS,           /*                           */
        4 MODULE_CMS     BIT(01),     /*   SYSTEM(CMS)             */
        4 MODULE_CMSTP   BIT(01),     /*   SYSTEM(CMSTPL)          */
        4 MODULE_MVS     BIT(01),     /*   SYSTEM(MVS)             */
        4 MODULE_TSO     BIT(01),     /*   SYSTEM(TSO)             */
        4 MODULE_CICS    BIT(01),     /*   SYSTEM(CICS)            */
        4 MODULE_IMS     BIT(01),     /*   SYSTEM(IMS)             */
        4 MODULE_SYSX    BIT(02),     /*   Reserved                */
                                      /*                           */
    2 MODULE_BLOCKS FIXED BIN(31),    /* Count of blocks           */
    2 MODULE_SIZE   FIXED BIN(31),    /* Size of module            */
    2 MODULE_SHOOKS FIXED BIN(31),    /* Count of stmt hooks       */
    2 MODULE_PHOOKS FIXED BIN(31),    /* Count of path hooks       */
    2 MODULE_EXTS   FIXED BIN(31),    /* Count of external entries */

    2 MODULE_DATA_END    CHAR(0);
```

Figure 65. Module Information Control Block

```
DECLARE

  1 BLOCK_TABLE    BASED,

    2 BLOCK_DATA       POINTER,         /*  Addr of BLOCK_INFO      */
    2 BLOCK_COUNT      FIXED BIN(31),   /*  Count of blocks         */

    2 BLOCK_INFO( BLOCKS REFER(BLOCK_COUNT) ),

      3 BLOCK_OFFSET   FIXED BIN(31),   /* Offset of block entry    */
      3 BLOCK_SIZE     FIXED BIN(31),   /* Size of block            */
      3 BLOCK_LEVEL    FIXED BIN(15),   /* Block nesting level      */
      3 BLOCK_PARENT   FIXED BIN(15),   /* Index for parent block   */
      3 BLOCK_CHILD    FIXED BIN(15),   /* Index for first child    */
      3 BLOCK_SIBLING  FIXED BIN(15),   /* Index for next sibling   */
      3 BLOCK_NAME_LEN FIXED BIN(15),   /* Length of block name     */
      3 BLOCK_NAME_STR CHAR(34),        /* Block name               */

    2 BLOCK_TABLE_END    CHAR(0);
```

Figure 66. Block Information Control Block

```
DECLARE

  1 HOOK_TABLE     BASED,

    2 HOOK_DATA        POINTER,         /*  Addr of HOOK_INFO       */
    2 HOOK_COUNT       FIXED BIN(31),   /*  Count of hooks          */

    2 HOOK_INFO( HOOKS REFER(HOOK_COUNT) ),

      2 HOOK_OFFSET   FIXED BIN(31),    /* Offset of hook           */
      2 HOOK_NO       FIXED BIN(31),    /* Stmt number for hook     */
      2 HOOK_IN_LINE  FIXED BIN(15),    /* Stmt number within line  */
      2 HOOK_RESERVED FIXED BIN(15),    /* Reserved                 */
      2 HOOK_TYPE     FIXED BIN(15),    /* Hook type (=%PATHCODE)   */
      2 HOOK_BLOCK    FIXED BIN(15),    /* Block number for hook    */

    2 HOOK_TABLE_END  CHAR(0);
```

Figure 67. Hook Information Control Block

```
DECLARE

  1 EXTS_TABLE     BASED,

    2 EXTS_DATA        POINTER,          /*  Addr of EXTS_INFO      */
    2 EXTS_COUNT       FIXED BIN(31),    /*  Count of entries       */

    2 EXTS_INFO( EXTS REFER(EXTS_COUNT) ),

      2 EXTS_EPA       POINTER,          /*  EPA for entry          */

    2 EXTS_TABLE_END  CHAR(0);
```

Figure 68. External Entries Information Control Block

For examples of possible uses of IBMBSIR see “Examining Your Program's Run-Time Behavior” on page 272.

Obtaining Static Information as Hooks Are Executed Using IBMBHIR

IBMBHIR is a Hook Information Retrieval module that lets you determine static information about hooks executed in modules compiled with the TEST option. It is available in batch, PL/I multitasking, and CICS environments.

The IBMBHIR Programming Interface

You invoke IBMBHIR with a PL/I CALL passing, in order, the address of the control block shown below, the value of register 13 when the hook was executed, and the address of the hook that was executed. (These last two items are also the last two items passed to the hook exit.)

```
DECLARE
  1 HIR_DATA       BASED(HIR_PARMS),
    2 HIR_STG      FIXED BIN(31),    /* Size of this control block */
    2 HIR_EPA      POINTER,          /* Addr of module entry point */
    2 HIR_LANG_CODE BIT(8),          /* Language code              */
    2 HIR_PATH_CODE BIT(8),          /* Path code for hook         */
    2 HIR_NAME_LEN  FIXED BIN(15),   /* Length of module name      */
    2 HIR_NAME_ADDR POINTER,         /* Addr of module name        */
    2 HIR_BLOCK    FIXED BIN(31),    /* Block count                */
    2 HIR_END      CHAR(0);
```

These parameters, upon return from IBMBHIR, supply:

- Information about the module in which the hook was executed:

  HIR_EPA
  the primary entry point address of the module (you could use this value as a parameter to IBMBSIR to obtain more data)

  HIR_LANG_CODE
  the programming language used to compile the module ('0A'BX representing PL/I, and '03'BX representing C)

  HIR_NAME_LEN
  the length of the name of the module

  HIR_NAME_ADDR
  the address of a nonvarying string containing the module name

- Information about the block in which the hook was executed:

  HIR_BLOCK
  the block number for that block

- Information about the hook itself:

  HIR_PATH_CODE
  the %PATHCODE value associated with the hook.

The next section contains an example of one of the possible uses of IBMBHIR.

Examining Your Program's Run-Time Behavior

This section shows some practical ways of using the services discussed in the first part of this chapter (IBMBHKS, IBMBSIR, and IBMBHIR) via the hook exit in CEEBINT to monitor your program's run-time behavior. In particular, three sample facilities are presented, which demonstrate, respectively, how you can:

- Examine code coverage (see “Sample Facility 1: Examining Code Coverage”)
- Perform function tracing (see “Sample Facility 2: Performing Function Tracing” on page 284)
- Analyze CPU-time usage (see page “Sample Facility 3: Analyzing CPU-Time Usage” on page 288).

For each facility, the overall setup is outlined briefly, the output is given, and the source code for the facility is shown.

Sample Facility 1: Examining Code Coverage

The following example programs show how to establish a rather simple hook exit to report on code coverage.

Overall Setup

This facility consists of two programs: CEEBINT and HOOKUP. The CEEBINT module is coded so that:

- A hook exit to the HOOKUP program is established
- Calls to IBMBHKS are made to set hooks prior to execution.

At run time, whenever HOOKUP gains control (via the established hook exit), it calls IBMBSIR to obtain code coverage information on the MAIN procedure and those linked with it.

Note: The CEEBINT routine uses a recursive routine `Add_Module_to_List` to locate and save information on the MAIN module and all the modules linked with it. Before this routine is recursively invoked, a check should be made to see if the module to be added has already been added. If such a check is not made, the subroutine could call itself endlessly.

The SPROG suboption of the LANGLVL compile-time option is specified in order to enable the adding to a pointer that takes place in CEEBINT and the comparing of two pointers that takes place in HOOKUP.

Output Generated

The output given in Figure 69 on page 273 is generated during execution of a PL/I program called KNIGHT. The KNIGHT program's function is to determine the moves a knight must make to land on each square of a chess board only once.

The output is created by the HOOKUP program as employed in this facility.

```
Post processing


Data for block KNIGHT

     Statement  Type                    Visits    Percent

             1  block entry                  1     0.0264
            14  before call                  1     0.0264
            14  after call                   1     0.0264
            21  start of do loop            63     1.6662
            23  start of do loop           504    13.3298
            25  if-true                    229     6.0565
            25  if-true                     91     2.4067
            29  if-false                   138     3.6498
            30  if-false                   275     7.2732
            32  if-true                     63     1.6662
            33  start of do loop           504    13.3298
            34  if-true                    224     5.9243
            35  if-false                   280     7.4054
            42  if-false                     0     0.0000
            44  start of do loop             8     0.2115
            65  block exit                   1     0.0264

Data for block INITIALIZE_RANKINGS

     Statement  Type                    Visits    Percent

            48  block entry                  1     0.0264
            50  start of do loop            12     0.3173
            51  start of do loop           144     3.8085
            52  if-true                     80     2.1158
            53  if-false                    64     1.6926
            56  start of do loop             8     0.2115
            57  start of do loop            64     1.6926
            58  start of do loop           512    13.5413
            59  if-true                    176     4.6548
            60  if-false                   336     8.8865
            64  block exit                   1     0.0264
```

Figure 69. Code Coverage Produced by Sample Facility 1

Source Code

The source code for Sample Facility 1 follows (CEEBINT in Figure 70, and HOOKUP in Figure 71 on page 280).

```
%PROCESS FLAG(I) GOSTMT STMT SOURCE;
%PROCESS OPT(2) TEST(NONE,NOSYM) LANGLVL(SPROG);
 CEEBINT: Proc( Number, RetCode, RsnCode, FncCode, A_Main,
                UserWd, A_Exits )
                options(reentrant) reorder;

   Dcl Number     fixed bin(31);      /* Number of args = 7        */
   Dcl RetCode    fixed bin(31);      /* Return Code = 0           */
   Dcl RsnCode    fixed bin(31);      /* Reason Code = 0           */
   Dcl FncCode    fixed bin(31);      /* Function Code = 1         */
   Dcl A_Main     pointer;            /* Address of Main Routine   */
   Dcl UserWd     fixed bin(31);      /* User Word                 */
   Dcl A_Exits    pointer;            /* A(Exits list)             */

   Declare A_exit_list       pointer;

   Declare
     1 Exit_list         based(A_exit_list),
       2 Exit_list_count    fixed bin(31),
       2 Exit_list_slots,
         3 Exit_for_hooks   pointer,
       2 Exit_list_end      char(0);

   Declare
     1 Hook_exit_block   based(Exit_for_hooks),
       2 Hook_exit_len      fixed bin(31),
       2 Hook_exit_rtn      pointer,
       2 Hook_exit_fnccode  fixed bin(31),
       2 Hook_exit_retcode  fixed bin(31),
       2 Hook_exit_rsncode  fixed bin(31),
       2 Hook_exit_userword pointer,
       2 Hook_exit_ptr      pointer,
       2 Hook_exit_reserved pointer,
       2 Hook_exit_dsa      pointer,
       2 Hook_exit_addr     pointer,
       2 Hook_exit_end      char(0);

   Declare
     1 Exit_area       based(Hook_exit_ptr),
       2 Exit_bdata      pointer,
       2 Exit_pdata      pointer,
       2 Exit_epa        pointer,
       2 Exit_mod_end    pointer,
       2 Exit_a_visits   pointer,
       2 Exit_prev_mod   pointer,
       2 Exit_area_end   char(0);

   Declare (Addr,Entryaddr)  builtin;
   Declare (Stg,Sysnull)     builtin;

   Declare IBMBHKS external entry( fixed bin(31), fixed bin(31));

   Dcl HksFncStmt  fixed bin(31) init(1) static;
   Dcl HksFncEntry fixed bin(31) init(2) static;
   Dcl HksFncExit  fixed bin(31) init(3) static;
   Dcl HksFncPath  fixed bin(31) init(4) static;
   Dcl HksFncLabel fixed bin(31) init(5) static;
   Dcl HksFncBCall fixed bin(31) init(6) static;
   Dcl HksFncACall fixed bin(31) init(7) static;
   Dcl HksRetCode  fixed bin(31);
```

Figure 70 (Part 1 of 6). Sample Facility 1: CEEBINT Module

```
/******************************************************************/
/*                                                                */
/* Following declares are used in setting up HOOKUP as the exit   */
/*                                                                */
/******************************************************************/

Declare HOOKUP           external entry;

Declare IBMBSIR external entry( pointer );

Declare
  1 Sir_data,
                                   /*                             */
    2 Sir_fnccode   fixed bin(31), /* Function code               */
                                   /*   3: supply data for module */
                                   /*   4: supply data for blocks */
                                   /*   5: supply data for stmts  */
                                   /*   6: supply data for paths  */
                                   /*                             */
    2 Sir_retcode   fixed bin(31), /* Return code                 */
                                   /*   0: successful             */
                                   /*   4: not compiled with      */
                                   /*      appropriate TEST opt.  */
                                   /*   8: not PL/I or not        */
                                   /*      compiled with TEST     */
                                   /*  12: unknown function code  */
                                   /*                             */
    2 Sir_entry     entry,         /* Entry var for module        */
                                   /*                             */
    2 Sir_mod_data  pointer,       /* A(module_data)              */
                                   /*                             */
    2 Sir_a_data    pointer,       /* A(data for function code)   */
                                   /*                             */
    2 Sir_end       char(0);       /*                             */

Declare
  1 Module_data,
                                   /*                             */
    2 Module_len    fixed bin(31), /* = STG(Module_data)          */
                                   /*                             */
    2 Module_options,              /* Compile time options        */
                                   /*                             */
      3 Module_general_options,    /*                             */
                                   /*                             */
        4 Module_stmtno  BIT(01),  /*   Stmt number table does    */
                                   /*   not exist                 */
        4 Module_gonum   BIT(01),  /*   Table has GONUMBER format */
        4 Module_cmpatv1 BIT(01),  /*   compiled with CMPAT(V1)   */
        4 Module_graphic BIT(01),  /*   compiled with GRAPHIC     */
        4 Module_opt     BIT(01),  /*   compiled with OPTIMIZE    */
        4 Module_inter   BIT(01),  /*   compiled with INTERRUPT   */
        4 Module_gen1x   BIT(02),  /*   Reserved                  */
                                   /*                             */
      3 Module_general_options2,   /*                             */
                                   /*                             */
        4 Module_gen2x   BIT(08),  /*   Reserved                  */
                                   /*                             */
      3 Module_test_options,       /*                             */
        4 Module_test    BIT(01),  /*   compiled with TEST        */
        4 Module_stmt    BIT(01),  /*   STMT  suboption is valid  */
        4 Module_path    BIT(01),  /*   PATH  suboption is valid  */
        4 Module_block   BIT(01),  /*   BLOCK suboption is valid  */
        4 Module_testx   BIT(03),  /*   Reserved                  */
        4 Module_sym     BIT(01),  /*   SYM   suboption is valid  */
                                   /*                             */
```

Figure 70 (Part 2 of 6). Sample Facility 1: CEEBINT Module

```
      3 Module_sys_options,        /*                             */
        4 Module_cms     BIT(01),  /*   SYSTEM(CMS)               */
        4 Module_cmstp   BIT(01),  /*   SYSTEM(CMSTP)             */
        4 Module_mvs     BIT(01),  /*   SYSTEM(MVS)               */
        4 Module_tso     BIT(01),  /*   SYSTEM(TSO)               */
        4 Module_cics    BIT(01),  /*   SYSTEM(CICS               */
        4 Module_ims     BIT(01),  /*   SYSTEM(IMS)               */
        4 Module_sysx    BIT(02),  /*   Reserved                  */
                                   /*                             */
    2 Module_blocks fixed bin(31), /* Count of blocks             */
                                   /*                             */
    2 Module_size   fixed bin(31), /* Size of module              */
                                   /*                             */
    2 Module_shooks fixed bin(31), /* Count of stmt hooks         */
                                   /*                             */
    2 Module_phooks fixed bin(31), /* Count of path hooks         */
                                   /*                             */
    2 Module_exts   fixed bin(31), /* Count of external entries   */
                                   /*                             */
    2 Module_data_end    char(0);
Declare
  1 Block_table       based(A_block_table),
    2 Block_a_data       pointer,
    2 Block_count        fixed bin(31),
    2 Block_data(Blocks refer(Block_count)),
      3 Block_offset     fixed bin(31),
      3 Block_size       fixed bin(31),
      3 Block_level      fixed bin(15),
      3 Block_parent     fixed bin(15),
      3 Block_child      fixed bin(15),
      3 Block_sibling    fixed bin(15),
      3 Block_name       char(34) varying,
    2 Block_table_end    char(0);

Declare
  1 Stmt_table        based(A_stmt_table),
    2 Stmt_a_data        pointer,
    2 Stmt_count         fixed bin(31),
    2 Stmt_data(Stmts  refer(Stmt_count)),
      3 Stmt_offset      fixed bin(31),
      3 Stmt_no          fixed bin(31),
      3 Stmt_lineno      fixed bin(15),
      3 Stmt_reserved    fixed bin(15),
      3 Stmt_type        fixed bin(15),
      3 Stmt_block       fixed bin(15),
    2 Stmt_table_end     char(0);

Declare
  1 Path_table        based(A_path_table),
    2 Path_a_data        pointer,
    2 Path_count         fixed bin(31),
    2 Path_data(Paths  refer(Path_count)),
      3 Path_offset      fixed bin(31),
      3 Path_no          fixed bin(31),
      3 Path_lineno      fixed bin(15),
      3 Path_reserved    fixed bin(15),
      3 Path_type        fixed bin(15),
      3 Path_block       fixed bin(15),
    2 Path_table_end     char(0);

Declare Blocks           fixed bin(31);
Declare Stmts            fixed bin(31);
Declare Paths            fixed bin(31);
Declare Visits           fixed bin(31);
```

Figure 70 (Part 3 of 6). Sample Facility 1: CEEBINT Module

```
Declare A_block_table     pointer;
Declare A_path_table      pointer;
Declare A_stmt_table      pointer;

Declare
  1 Hook_table        based(Exit_a_visits),
    2 Hook_data_size     fixed bin(31),
    2 Hook_data(Visits refer(Hook_data_size)),
      3 Hook_visits      fixed bin(31),
    2 Hook_data_end      char(0);

Declare A_visits          pointer;
Declare A_type            pointer;
Declare Previous_in_chain pointer;

/******************************************************************/
/*                                                                */
/* Following code is used to set up the hook exit control block   */
/*                                                                */
/******************************************************************/

Allocate Exit_list;
Exit_list_count = 1;

A_Exits = A_exit_list;

Allocate Hook_exit_block;
Hook_exit_len = Stg(Hook_Exit_block);

/******************************************************************/
/*                                                                */
/* Following code sets up HOOKUP as the hook exit                 */
/*                                                                */
/******************************************************************/

Hook_exit_rtn = Entryaddr(HOOKUP);

Previous_in_chain = Sysnull();

Call Add_module_to_list( A_main );

Call IBMBHKS( HksFncEntry, HksRetCode );
Call IBMBHKS( HksFncExit, HksRetCode );
Call IBMBHKS( HksFncPath, HksRetCode );
```

Figure 70 (Part 4 of 6). Sample Facility 1: CEEBINT Module

```
/******************************************************************/
/*                                                                */
/* Following subroutine retrieves all the static information      */
/* available on the MAIN routine and those linked with it         */
/*                                                                */
/******************************************************************/

Add_module_to_list: Proc( In_epa ) recursive;

  Dcl In_epa       pointer;
  Dcl Next_epa     pointer;
  Dcl Inx          fixed bin(31);

  Declare
    1 Exts_table        based(A_exts_table),
      2 Exts_a_data        pointer,
      2 Exts_count         fixed bin(31),
      2 Exts_data(Exts   refer(Exts_count)),
        3 Exts_epa         pointer,
      2 Exts_table_end     char(0);

  Declare Exts             fixed bin(31);
  Declare A_exts_table     pointer;

  Sir_fnccode = 3;

  Entryaddr(Sir_entry) = In_epa;
  Sir_mod_data = Addr(Module_data);

  Module_len = Stg(Module_data);

  Call IBMBSIR(Addr(Sir_data));

  If ( Sir_retcode = 0 )
   & ( Module_path ) then
    Do;
      Sir_fnccode = 4;

      Blocks = Module_blocks;
      Allocate Block_table;
      Block_a_data = ADDR(Block_data);
      Sir_a_data = A_block_table;

      Call IBMBSIR(Addr(Sir_data));

      Sir_fnccode = 6;

      Paths = Module_phooks;
      Allocate Path_table;
      Path_a_data = Addr(Path_data);
      Sir_a_data = A_path_table;

      Call IBMBSIR(Addr(Sir_data));

      /* Allocate areas needed                  */

      Allocate Exit_area;

      Exit_prev_mod = Previous_in_chain;
      Previous_in_chain = Hook_exit_ptr;

      Exit_pdata = A_path_table;
      Exit_bdata = A_block_table;

      Exit_epa = In_epa;
      Exit_mod_end = Exit_epa + module_size;
```

Figure 70 (Part 5 of 6). Sample Facility 1: CEEBINT Module

```
        Visits = Paths;
        Allocate Hook_table Set(Exit_a_visits);
        Hook_visits = 0;

        If Module_exts = 0 then;
        Else
          Do;
            Sir_fnccode = 7;

            Exts = Module_exts;
            Allocate Exts_table;
            Exts_a_data = Addr(Exts_data);
            Sir_a_data = A_exts_table;

            Call IBMBSIR(Addr(Sir_data));

            If Sir_retcode = 0 then
              Do;
                Do Inx = 1 to Exts;
                  Next_epa = A_exts_table->Exts_epa(Inx);
                  Call Add_module_to_list( Next_epa );
                End;
                Free Exts_table;
              End;
            Else;
          End;
      End;
    Else;

  End Add_module_to_list;

End;
```

Figure 70 (Part 6 of 6). Sample Facility 1: CEEBINT Module

.

```
%PROCESS FLAG(I) GOSTMT STMT SOURCE;
%PROCESS OPT(2) TEST(NONE,NOSYM) LANGLVL(SPROG);
 HOOKUP: Proc( Exit_for_hooks ) reorder;

   Dcl Exit_for_hooks    pointer;    /* Address of exit list      */

   Declare
     1 Hook_exit_block   based(Exit_for_hooks),
       2 Hook_exit_len      fixed bin(31),
       2 Hook_exit_rtn      pointer,
       2 Hook_exit_fnccode  fixed bin(31),
       2 Hook_exit_retcode  fixed bin(31),
       2 Hook_exit_rsncode  fixed bin(31),
       2 Hook_exit_userword pointer,
       2 Hook_exit_ptr      pointer,
       2 Hook_exit_reserved pointer,
       2 Hook_exit_dsa      pointer,
       2 Hook_exit_addr     pointer,
       2 Hook_exit_end      char(0);

   Declare
     1 Exit_area       based(Module_data),
       2 Exit_bdata      pointer,
       2 Exit_pdata      pointer,
       2 Exit_epa        pointer,
       2 Exit_last       pointer,
       2 Exit_a_visits   pointer,
       2 Exit_prev_mod   pointer,
       2 Exit_area_end   char(0);

   Declare
     1 Path_table        based(Exit_pdata),
       2 Path_a_data        pointer,
       2 Path_count         fixed bin(31),
       2 Path_data(32767),
         3 Path_offset      fixed bin(31),
         3 Path_no          fixed bin(31),
         3 Path_lineno      fixed bin(15),
         3 Path_reserved    fixed bin(15),
         3 Path_type        fixed bin(15),
         3 Path_block       fixed bin(15),
       2 Path_table_end     char(0);


   Declare
     1 Block_table       based(Exit_bdata),
       2 Block_a_data       pointer,
       2 Block_count        fixed bin(31),
       2 Block_data(32767),
         3 Block_offset     fixed bin(31),
         3 Block_size       fixed bin(31),
         3 Block_level      fixed bin(15),
         3 Block_parent     fixed bin(15),
         3 Block_child      fixed bin(15),
         3 Block_sibling    fixed bin(15),
         3 Block_name       char(34) varying,
       2 Block_table_end    char(0);

   Declare
     1 Hook_table        based(Exit_a_visits),
       2 Hook_data_size     fixed bin(31),
       2 Hook_data(32767),
         3 Hook_visits      fixed bin(31),
       2 Hook_data_end      char(0);
```

Figure 71 (Part 1 of 4). Sample Facility 1: HOOKUP Program

```
Declare Ps            fixed bin(31);
Declare Ix            fixed bin(31);
Declare Jx            fixed bin(31);
Declare Total         float dec(06);
Declare Percent       Fixed dec(6,4);
Declare Col1          char(33);
Declare Col2          char(14);
Declare Col3          char(10);

Declare Sysnull       Builtin;

Declare Module_data   pointer;


Module_data = Hook_exit_ptr;

/******************************************************************/
/*                                                                */
/* Search for hook address in chain of modules                    */
/*                                                                */
/******************************************************************/

Do While ( Hook_exit_addr < Exit_epa | Hook_exit_addr > Exit_last )
   Until ( Module_data = Sysnull() );
  Module_data = Exit_prev_mod;
End;

/******************************************************************/
/*                                                                */
/* If not, found                                                  */
/*   IBMBHIR could be called to find address of entry point       */
/*   for the module                                               */
/*   IBMBSIR could then be called as in CEEBINT to add            */
/*   module to the chain of known modules                         */
/*                                                                */
/******************************************************************/

If Module_data = Sysnull() then;
Else
  Do;
    Ps = Hook_exit_addr - Exit_epa;

    /**************************************************************/
    /*                                                            */
    /*  A binary search could be done here and such a search      */
    /*  would be much more efficient for large programs           */
    /*                                                            */
    /**************************************************************/

    Do Ix = 1 to Path_count
      While ( Ps ¬= Path_offset(Ix) );
    End;

    If (Ix > 0) & (Ix <= Path_count) then
      Hook_visits(Ix) = Hook_visits(Ix) + 1;
    Else;
```

Figure 71 (Part 2 of 4). Sample Facility 1: HOOKUP Program

```
    /**************************************************************/
    /*                                                            */
    /*  If hook type is for block exit                            */
    /*   AND                                                      */
    /*     block being exited is the first block in a procedure   */
    /*   AND                                                      */
    /*     that procedure is the MAIN procedure, then             */
    /*   invoke the post processing routine                       */
    /*                                                            */
    /*  Note that these conditions might never be met, for        */
    /*  example, if SIGNAL FINISH were issued or if an            */
    /*  EXEC CICS RETURN were issued                              */
    /*                                                            */
    /**************************************************************/

    If Path_type(Ix) = 2
     & Path_block(Ix) = 1
     & Exit_prev_mod = Sysnull() then
      Do;
        Put skip list ( ' ' );
        Put skip list ( ' ' );

        Put skip list ( 'Post processing' );

        Module_data = Hook_exit_ptr;

        Do Until ( Module_data = Sysnull() );
          Call Report_data;
          Module_data = Exit_prev_mod;
        End;

      End;
    Else;
  End;

Hook_exit_retcode = 4;
Hook_exit_rsncode = 0;


Report_data: Proc;

  Total = 0;
  Do Jx = 1 to Path_count;
    Total = Total + Hook_visits(Jx);
  End;

  Put skip list ( ' ' );
  Do Jx = 1 to Path_count;
    If Path_type(Jx) = 1 then
      do;
        Put skip list ( ' ' );
        Put skip list ( 'Data for block ' ||
               Block_name(Path_block(Jx)) );
        Put skip list ( ' ' );
        Col1 = '     Statement  Type';
        Col2 = '        Visits';
        Col3 = '   Percent';
        Put skip list ( Col1 || ' ' || Col2 || ' ' || Col3 );
        Put skip list ( ' ' );
      end;
    Else;
```

Figure 71 (Part 3 of 4). Sample Facility 1: HOOKUP Program

```
   Select ( Path_type(Jx) );
     When ( 1 )
       Col1 = Path_no(Jx) || '  block entry';
     When ( 2 )
       Col1 = Path_no(Jx) || '  block exit';
     When ( 3 )
       Col1 = Path_no(Jx) || '  label';
     When ( 4 )
       Col1 = Path_no(Jx) || '  before call';
     When ( 5 )
       Col1 = Path_no(Jx) || '  after call';
     When ( 6 )
       Col1 = Path_no(Jx) || '  start of do loop';
     When ( 7 )
       Col1 = Path_no(Jx) || '  if-true';
     When ( 8 )
       Col1 = Path_no(Jx) || '  if-false';
     Otherwise
       Col1 = Path_no(Jx);
   End;

   Col2 = Hook_visits(Jx);
   Percent = 100 * (Hook_visits(Jx)/Total);
   Put skip list ( Col1 || ' ' || Col2 || '  ' || Percent );
  End;

  Put skip list ( ' ' );
  Put skip list ( ' ' );
  Put skip list ( ' ' );

 End Report_data;

End;
```

Figure 71 (Part 4 of 4). Sample Facility 1: HOOKUP Program

Sample Facility 2: Performing Function Tracing

The following example programs show how to establish a rather simple hook exit to perform function tracing.

Overall Setup

This facility consists of two programs: CEEBINT and HOOKUPT. The CEEBINT module is coded such that:

- A hook exit to the HOOKUPT program is established
- Calls to IBMBHKS are made to set hooks prior to execution.

At run time, whenever HOOKUPT gains control (via the established hook exit), it calls IBMBHIR to obtain information to create a function trace.

Output Generated

The output given in Figure 72 below is generated during execution of a PL/I program called KNIGHT. The KNIGHT program's function is to determine the moves a knight must make to land on each square of a chess board only once.

The output is created by the HOOKUPT program as employed in this facility.

```
Entry hook in KNIGHT
Exit hook in KNIGHT
```

Figure 72. Function Trace Produced by Sample Facility 2

Note: In a more complicated program, many more entry and exit messages would be produced.

Source Code

The source code for Sample Facility 2 follows (CEEBINT in Figure 73, and HOOKUPT in Figure 74 on page 287).

```
%PROCESS FLAG(I) GOSTMT STMT SOURCE;
%PROCESS OPT(2) TEST(NONE,NOSYM) LANGLVL(SPROG);
 CEEBINT: Proc( Number, RetCode, RsnCode, FncCode, A_Main,
                UserWd, A_Exits )
                options(reentrant) reorder;

   Dcl Number     fixed bin(31);      /* Number of args = 7        */
   Dcl RetCode    fixed bin(31);      /* Return Code = 0           */
   Dcl RsnCode    fixed bin(31);      /* Reason Code = 0           */
   Dcl FncCode    fixed bin(31);      /* Function Code = 1         */
   Dcl A_Main     pointer;            /* Address of Main Routine   */
   Dcl UserWd     fixed bin(31);      /* User Word                 */
   Dcl A_Exits    pointer;            /* A(Exits list)             */

   Declare A_exit_list       pointer;

   Declare
     1 Exit_list         based(A_exit_list),
       2 Exit_list_count    fixed bin(31),
       2 Exit_list_slots,
         3 Exit_for_hooks   pointer,
       2 Exit_list_end      char(0);

   Declare
     1 Hook_exit_block   based(Exit_for_hooks),
       2 Hook_exit_len      fixed bin(31),
       2 Hook_exit_rtn      pointer,
       2 Hook_exit_fnccode  fixed bin(31),
       2 Hook_exit_retcode  fixed bin(31),
       2 Hook_exit_rsncode  fixed bin(31),
       2 Hook_exit_userword pointer,
       2 Hook_exit_ptr      pointer,
       2 Hook_exit_reserved pointer,
       2 Hook_exit_dsa      pointer,
       2 Hook_exit_addr     pointer,
       2 Hook_exit_end      char(0);

   Declare
     1 Exit_area       based(Hook_exit_ptr),
       2 Exit_bdata      pointer,
       2 Exit_pdata      pointer,
       2 Exit_epa        pointer,
       2 Exit_mod_end    pointer,
       2 Exit_a_visits   pointer,
       2 Exit_prev_mod   pointer,
       2 Exit_area_end   char(0);

   Declare (Addr,Entryaddr)  builtin;
   Declare (Stg,Sysnull)     builtin;

   Declare IBMBHKS external entry( fixed bin(31), fixed bin(31));

   Dcl HksFncStmt  fixed bin(31) init(1) static;
   Dcl HksFncEntry fixed bin(31) init(2) static;
   Dcl HksFncExit  fixed bin(31) init(3) static;
   Dcl HksFncPath  fixed bin(31) init(4) static;
   Dcl HksFncLabel fixed bin(31) init(5) static;
   Dcl HksFncBCall fixed bin(31) init(6) static;
   Dcl HksFncACall fixed bin(31) init(7) static;
   Dcl HksRetCode  fixed bin(31);
```

Figure 73 (Part 1 of 2). Sample Facility 2: CEEBINT Module

```
   /******************************************************************/
   /*                                                                */
   /* Following code is used to set up the hook exit control block   */
   /*                                                                */
   /******************************************************************/

   Allocate Exit_list;
   Exit_list_count = 1;

   A_Exits = A_exit_list;

   Allocate Hook_exit_block;
   Hook_exit_len = Stg(Hook_Exit_block);

   /******************************************************************/
   /*                                                                */
   /* Following code sets up HOOKUPT as the hook exit                */
   /*                                                                */
   /******************************************************************/

   Declare HOOKUPT   external entry;

   Hook_exit_rtn = Entryaddr(HOOKUPT);

   Call IBMBHKS( HksFncEntry, HksRetCode );
   Call IBMBHKS( HksFncExit, HksRetCode );

 End;
```

Figure 73 (Part 2 of 2). Sample Facility 2: CEEBINT Module

```
%PROCESS FLAG(I) GOSTMT STMT SOURCE;
%PROCESS OPT(2) TEST(NONE,NOSYM) LANGLVL(SPROG);
 HOOKUPT: Proc( Exit_for_hooks ) reorder;

   Dcl Exit_for_hooks    pointer;    /* Address of exit list      */

   Declare
     1 Hook_exit_block   based(Exit_for_hooks),
       2 Hook_exit_len      fixed bin(31),
       2 Hook_exit_rtn      pointer,
       2 Hook_exit_fnccode  fixed bin(31),
       2 Hook_exit_retcode  fixed bin(31),
       2 Hook_exit_rsncode  fixed bin(31),
       2 Hook_exit_userword pointer,
       2 Hook_exit_ptr      pointer,
       2 Hook_exit_reserved pointer,
       2 Hook_exit_dsa      pointer,
       2 Hook_exit_addr     pointer,
       2 Hook_exit_end      char(0);

   Declare
     1 Hook_data,
       2 Hook_stg           fixed bin(31),
       2 Hook_epa           pointer,
       2 Hook_lang_code     aligned bit(8),
       2 Hook_path_code     aligned bit(8),
       2 Hook_name_len      fixed bin(15),
       2 Hook_name_addr     pointer,
       2 Hook_block_count   fixed bin(31),
       2 Hook_reserved      fixed bin(31),
       2 Hook_data_end      char(0);

   Declare IBMBHIR          external entry;
   Declare Chars            char(256) based;
   Declare (Addr,Substr)    builtin;


   Call IBMBHIR( Addr(Hook_data), Hook_exit_dsa, Hook_exit_addr );

   If Hook_block_count = 1 then
     Select ( Hook_path_code );
       When ( 1 )
         Put skip list( 'Entry hook in ' ||
                        Substr(Hook_name_addr->Chars,1,Hook_name_len) );
       When ( 2 )
         Put skip list( 'Exit hook in ' ||
                        Substr(Hook_name_addr->Chars,1,Hook_name_len) );
       Otherwise
         ;
     End;
   Else;

 End;
```

Figure 74. Sample Facility 2: HOOKUPT Program

Sample Facility 3: Analyzing CPU-Time Usage

This facility extends the code-coverage function of Sample Facility 1 to also report on CPU-time usage.

Overall Setup

This facility consists of four programs: CEEBINT, HOOKUP, TIMINI, and TIMCPU. The CEEBINT module is coded so that:

- A hook exit to the HOOKUP program is established
- Calls to IBMBHKS are made to set hooks prior to execution.

At run time, whenever HOOKUP gains control (via the established hook exit), it calls IBMBSIR to obtain code coverage information on the MAIN procedure and those linked with it. This is identical to the function of Sample Facility 1.

In addition, this HOOKUP program makes calls to the assembler routines TIMINI and TIMCPU to obtain information on CPU-time usage.

The SPROG suboption of the LANGLVL compile-time option is specified in order to enable the adding to a pointer that takes place in CEEBINT and the comparing of two pointers that takes place in HOOKUP.

Output Generated

The output given in Figure 75 on page 289 is generated during execution of a sample program named EXP98 under CMS or MVS. The main procedure was compiled with the TEST(ALL) option.

The output is created by the HOOKUP program as employed in this facility.

```
Data for block EXP98

     Statement Type                  --- Visits ---       --- CPU Time ---
                                    Number   Percent    Milliseconds  Percent

         1 block entry                   1    0.0201
        16 start of do loop             24    0.4832        83.768    0.6036
        26 start of do loop             38    0.7652       107.254    0.7729
        27 start of do loop             38    0.7652       102.159    0.7362
        28 if true                      38    0.7652       103.066    0.7427
        30 start of do loop            456    9.1824      1233.827    8.8915
        31 before call                 456    9.1824      1237.831    8.9203
        31 after call                  456    9.1824      1238.400    8.9244
        41 before call                  38    0.7652       102.491    0.7385
        41 after call                   38    0.7652       103.038    0.7425
        49 start of do loop             38    0.7652       102.029    0.7352
        50 if true                       0    0.0000         0.000    0.0000
        51 if true                       0    0.0000         0.000    0.0000
        52 if true                       0    0.0000         0.000    0.0000
        54 start of do loop            304    6.1216       827.971    5.9667
        55 if true                      76    1.5304       206.831    1.4905
        56 if true                       0    0.0000         0.000    0.0000
        57 if true                      38    0.7652       104.351    0.7520
        61 block exit                    1    0.0201         2.703    0.0194
     Totals for block                 2040   41.0790      5555.719   40.0364

Data for block V1B

     Statement Type                  --- Visits ---       --- CPU Time ---
                                    Number   Percent    Milliseconds  Percent

        32 block entry                 456    9.1824
        33 start of do loop            456    9.1824      1251.487    9.0187
        34 if true                     456    9.1824      1251.125    9.0161
        35 if true                     456    9.1824      1501.528   10.8206
        36 if true                       0    0.0000         0.000    0.0000
        37 if true                     456    9.1824      1275.072    9.1887
        39 block exit                  456    9.1824      1256.781    9.0569
     Totals for block                 2736   55.0944      6535.993   47.1010

Data for block V1C

     Statement Type                  --- Visits ---       --- CPU Time ---
                                    Number   Percent    Milliseconds  Percent

        42 block entry                  38    0.7652
        43 start of do loop             38    0.7652       105.529    0.7604
        44 if true                      38    0.7652       106.233    0.7655
        45 if true                       0    0.0000         0.000    0.0000
        46 if true                      38    0.7652       106.481    0.7673
        48 block exit                   38    0.7652       104.547    0.7534
     Totals for block                  190    3.8260       422.790    3.0466
```

Figure 75. CPU-Time Usage and Code Coverage Reported by Sample Facility 3

The performance of this facility depends on the number of hook exits invoked. Collecting the data above increased the CPU time of EXP98 by approximately forty-four times. Each CPU-time measurement indicates the amount of virtual CPU time that was used since the previous hook was executed. Note that the previous hook is not necessarily the previous hook in the figure.

In the above data, the percent columns for the number of visits and the CPU time are very similar. This will not always be the case, especially where hidden code (like library calls or supervisor services) is involved.

Source Code

The source code for Sample Facility 3 is shown in the following figures:

CEEBINT	Figure 76
HOOKUP	Figure 77 on page 297
TIMINI (MVS)	Figure 78 on page 302
TIMINI (CMS)	Figure 79 on page 302
TIMCPU (MVS)	Figure 80 on page 303
TIMCPU (CMS)	Figure 81 on page 304.

```
%PROCESS TEST(NONE,NOSYM) LANGLVL(SPROG);
 CEEBINT: PROC( Number, RetCode, RsnCode, FncCode, A_Main,
                UserWd, A_Exits )
                OPTIONS(REENTRANT) REORDER;

   DCL Number     FIXED BIN(31);      /* Number of args = 7        */
   DCL RetCode    FIXED BIN(31);      /* Return Code = 0           */
   DCL RsnCode    FIXED BIN(31);      /* Reason Code = 0           */
   DCL FncCode    FIXED BIN(31);      /* Function Code = 1         */
   DCL A_Main     POINTER;            /* Address of Main Routine   */
   DCL UserWd     FIXED BIN(31);      /* User Word                 */
   DCL A_Exits    POINTER;            /* A(Exits list)             */

   /******************************************************************/
   /* This routine gets invoked at initialization of the MAIN       */
   /* Structures and variables for use in establishing a hook exit   */
   /*                                                                */
   /******************************************************************/

   DECLARE A_exit_list       POINTER;
   DECLARE Based_ptr         POINTER BASED;
   DECLARE Entry_var         ENTRY VARIABLE;

   DECLARE Entryaddr         BUILTIN;
   DECLARE (Stg,Sysnull)     BUILTIN;

   DECLARE
     1 Exit_list         BASED(A_exit_list),
       2 Exit_list_count    FIXED BIN(31),
       2 Exit_list_slots,
         3 Exit_for_hooks   POINTER,
       2 Exit_list_end      CHAR(0);

   DECLARE
     1 Hook_exit_block   BASED(Exit_for_hooks),
       2 Hook_exit_len      FIXED BIN(31),
       2 Hook_exit_rtn      POINTER,
       2 Hook_exit_fnccode  FIXED BIN(31),
       2 Hook_exit_retcode  FIXED BIN(31),
       2 Hook_exit_rsncode  FIXED BIN(31),
       2 Hook_exit_userword FIXED BIN(31),
       2 Hook_exit_ptr      POINTER,
       2 Hook_exit_reserved POINTER,
       2 Hook_exit_dsa      POINTER,
       2 Hook_exit_addr     POINTER,
       2 Hook_exit_end      CHAR(0);

   DECLARE
     1 Exit_area         BASED(Hook_exit_ptr),
       2 Exit_bdata         POINTER,
       2 Exit_pdata         POINTER,
       2 Exit_epa           POINTER,
       2 Exit_xtra          POINTER,
       2 Exit_area_end      CHAR(0);
```

Figure 76 (Part 1 of 7). Sample Facility 3: CEEBINT Module

```
DECLARE
  1 Hook_table        BASED(Exit_xtra),
    2 Hook_data_size     FIXED BIN(31),
    2 Hook_data(Visits REFER(Hook_data_size)),
      3 Hook_visits      FIXED BIN(31),
    2 Hook_data_end      CHAR(0);

   /* the name of the routine that gets control at hook exit */

   DECLARE HOOKUP           EXTERNAL ENTRY ( POINTER );

/******************************************************************/
/*                                                                */
/* End of structures and variables for use with hook exit         */
/*                                                                */
/******************************************************************/

/******************************************************************/
/*                                                                */
/* Structures and variables for use in invoking IBMBSIR           */
/*                                                                */
/******************************************************************/

DECLARE
  1 Sir_data,
                                   /*                             */
    2 Sir_fnccode   FIXED BIN(31), /* Function code               */
                                   /*   1: supply data for module */
                                   /*   2: supply data for blocks */
                                   /*   3: supply data for stmts  */
                                   /*   4: supply data for paths  */
                                   /*                             */
    2 Sir_retcode   FIXED BIN(31), /* Return code                 */
                                   /*   0: successful             */
                                   /*   4: not compiled with      */
                                   /*      appropriate TEST opt.  */
                                   /*   8: not PL/I or not        */
                                   /*      compiled with TEST     */
                                   /*  12: unknown function code  */
                                   /*                             */
    2 Sir_entry     ENTRY,         /* Entry var for module        */
                                   /*                             */
    2 Sir_mod_data  POINTER,       /* A(module_data)              */
                                   /*                             */
    2 Sir_a_data    POINTER,       /* A(data for function code)   */
                                   /*                             */
    2 Sir_end       CHAR(0);       /*                             */
                                   /*                             */

DECLARE
  1 Module_data,
                                   /*                             */
    2 Module_len    FIXED BIN(31), /* = STG(Module_data)          */
                                   /*                             */
    2 Module_options,              /* Compile time options        */
                                   /*                             */
      3 Module_general_options,    /*                             */
                                   /*                             */
        4 Module_stmtno  BIT(01),  /*   Stmt number table does    */
                                   /*   not exist                 */
```

Figure 76 (Part 2 of 7). Sample Facility 3: CEEBINT Module

```
        4 Module_gonum   BIT(01),  /*   Table has GONUMBER format */
        4 Module_cmpatv1 BIT(01),  /*   compiled with CMPAT(V1)   */
        4 Module_graphic BIT(01),  /*   compiled with GRAPHIC     */
        4 Module_opt     BIT(01),  /*   compiled with OPTIMIZE    */
        4 Module_inter   BIT(01),  /*   compiled with INTERRUPT   */
        4 Module_gen1x   BIT(02),  /*   Reserved                  */
                                   /*                             */
      3 Module_general_options2,   /*                             */
                                   /*                             */
        4 Module_gen2x   BIT(08),  /*   Reserved                  */
                                   /*                             */
      3 Module_test_options,       /*                             */
        4 Module_test    BIT(01),  /*   compiled with TEST        */
        4 Module_stmt    BIT(01),  /*   STMT  suboption is valid  */
        4 Module_path    BIT(01),  /*   PATH  suboption is valid  */
        4 Module_block   BIT(01),  /*   BLOCK suboption is valid  */
        4 Module_testx   BIT(03),  /*   Reserved                  */
        4 Module_sym     BIT(01),  /*   SYM   suboption is valid  */
                                   /*                             */
      3 Module_sys_options,        /*                             */
        4 Module_cms     BIT(01),  /*   SYSTEM(CMS)               */
        4 Module_cmstp   BIT(01),  /*   SYSTEM(CMSTP)             */
        4 Module_mvs     BIT(01),  /*   SYSTEM(MVS)               */
        4 Module_tso     BIT(01),  /*   SYSTEM(TSO)               */
        4 Module_cics    BIT(01),  /*   SYSTEM(CICS               */
        4 Module_ims     BIT(01),  /*   SYSTEM(IMS)               */
        4 Module_sysx    BIT(02),  /*   Reserved                  */

    2 Module_blocks FIXED BIN(31), /* Count of blocks             */
                                   /*                             */
    2 Module_size   FIXED BIN(31), /* Size of module              */
                                   /*                             */
    2 Module_shooks FIXED BIN(31), /* Count of stmt hooks         */
                                   /*                             */
    2 Module_phooks FIXED BIN(31), /* Count of path hooks         */
                                   /*                             */
    2 Module_data_end    CHAR(0);

DECLARE
  1 Block_table       BASED(A_block_table),
    2 Block_a_data       POINTER,
    2 Block_count        FIXED BIN(31),
    2 Block_data(Blocks REFER(Block_count)),
      3 Block_offset     FIXED BIN(31),
      3 Block_size       FIXED BIN(31),
      3 Block_level      FIXED BIN(15),
      3 Block_parent     FIXED BIN(15),
      3 Block_child      FIXED BIN(15),
      3 Block_sibling    FIXED BIN(15),
      3 Block_name       CHAR(34) VARYING,
    2 Block_table_end    CHAR(0);

DECLARE
  1 Stmt_table        BASED(A_stmt_table),
    2 Stmt_a_data        POINTER,
    2 Stmt_count         FIXED BIN(31),
    2 Stmt_data(Stmts  REFER(Stmt_count)),
      3 Stmt_offset      FIXED BIN(31),
      3 Stmt_no          FIXED BIN(31),
      3 Stmt_lineno      FIXED BIN(15),
      3 Stmt_reserved    FIXED BIN(15),
      3 Stmt_type        FIXED BIN(15),
      3 Stmt_block       FIXED BIN(15),
    2 Stmt_table_end     CHAR(0);
```

Figure 76 (Part 3 of 7). Sample Facility 3: CEEBINT Module

```
DECLARE
  1 Path_table        BASED(A_path_table),
    2 Path_a_data        POINTER,
    2 Path_count         FIXED BIN(31),
    2 Path_data(Paths  REFER(Path_count)),
      3 Path_offset      FIXED BIN(31),
      3 Path_no          FIXED BIN(31),
      3 Path_lineno      FIXED BIN(15),
      3 Path_reserved    FIXED BIN(15),
      3 Path_type        FIXED BIN(15),
      3 Path_block       FIXED BIN(15),
    2 Path_table_end     CHAR(0);

DECLARE Blocks           FIXED BIN(31);
DECLARE Stmts            FIXED BIN(31);
DECLARE Paths            FIXED BIN(31);
DECLARE Visits           FIXED BIN(31);

DECLARE A_block_table    POINTER;
DECLARE A_stmt_table     POINTER;
DECLARE A_path_table     POINTER;

DECLARE Addr              BUILTIN;


Declare IBMBHKS external entry( fixed bin(31), fixed bin(31));

Dcl HksFncStmt  fixed bin(31) init(1) static;
Dcl HksFncEntry fixed bin(31) init(2) static;
Dcl HksFncExit  fixed bin(31) init(3) static;
Dcl HksFncPath  fixed bin(31) init(4) static;
Dcl HksFncLabel fixed bin(31) init(5) static;
Dcl HksFncBCall fixed bin(31) init(6) static;
Dcl HksFncACall fixed bin(31) init(7) static;
Dcl HksRetCode  fixed bin(31);

DECLARE IBMBSIR          EXTERNAL ENTRY ( POINTER );

/******************************************************************/
/*                                                                */
/* End of structures and variables for use in invoking IBMBSIR    */
/*                                                                */
/******************************************************************/
```

Figure 76 (Part 4 of 7). Sample Facility 3: CEEBINT Module

```
/******************************************************************/
/*                                                                */
/* Sample code for invoking IBMBSIR                               */
/*                                                                */
/* IBMBSIR is first invoked to get the block and hook counts.     */
/*                                                                */
/* If that invocation is successful, the block table is allocated */
/* and IBMBSIR is invoked to fill in that table.                  */
/*                                                                */
/* If that invocation is also successful, the path hook table is  */
/* allocated and IBMBSIR is invoked to fill in that table.        */
/*                                                                */
/******************************************************************/


Sir_fnccode = 3;

/*- If counts are to be obtained from a non-MAIN routine   -*/
/*- then put comments around the “Entryaddr(Sir_entry) =   -*/
/*- A_Main” statement and remove the comments from         -*/
/*- around the DCL and the “Sir_entry = P00” statements    -*/
/*- and change P00 (both places to the name of the         -*/
/*- non-MAIN routine:                                      -*/

      Entryaddr(Sir_entry) = A_main;
/*-   DCL P00 External entry;                              -*/
/*-   Sir_entry = P00;                                     -*/

Sir_mod_data = Addr(Module_data);

Call IBMBSIR( Addr(Sir_data) );

If Sir_retcode = 0 then
  Do;
    Sir_fnccode = 4;

    Blocks = Module_blocks;
    Allocate Block_table;
    Block_a_data = Addr(Block_data);
    Sir_a_data = A_block_table;

    Call IBMBSIR( Addr(Sir_data) );

    If Sir_retcode = 0 then
      Do;
        Sir_fnccode = 6;

        Paths = Module_phooks;
        Allocate Path_table;
        Path_a_data = Addr(Path_data);
        Sir_a_data = A_path_table;

        Call IBMBSIR( Addr(Sir_data) );
      End;
    Else
      Do ;
        Put skip list('CEEBINT MSG_2: Sir_retcode was not zero');
        Put skip list('CEEBINT MSG_2: Sir_retcode = ',Sir_retcode);
        Put skip list('CEEBINT MSG_2: Path table not allocated');
      End;
  End;
```

Figure 76 (Part 5 of 7). Sample Facility 3: CEEBINT Module

```
Else
  Do ;
    Put skip list('CEEBINT MSG_1: Sir_retcode was not zero');
    Put skip list('CEEBINT MSG_1: Sir_retcode = ',Sir_retcode);
    Put skip list('CEEBINT MSG_1: Block table not allocated');
    Put skip list('CEEBINT MSG_1: Path table not allocated');
  End;

/******************************************************************/
/*                                                                */
/* End of sample code for invoking IBMBSIR                        */
/*                                                                */
/******************************************************************/

/******************************************************************/
/*                                                                */
/* Sample code for setting up hook exit                           */
/*                                                                */
/* The first two sets of instructions merely create an exit list  */
/* containing one element and create the hook exit block to which */
/* that element will point. Note that the hook exit is enabled    */
/* by this code, but it is not activated since Hook_exit_rtn = 0. */
/*                                                                */
/******************************************************************/


Allocate Exit_list;
A_Exits = A_exit_list;
Exit_list_count = 1;

Allocate Hook_exit_block;
Hook_exit_len = Stg(Hook_Exit_block);
Hook_exit_userword = UserWd;
Hook_exit_rtn = Sysnull();
Hook_exit_ptr = Sysnull();


/******************************************************************/
/*                                                                */
/*                                                                */
/* The following code will cause the hook exit to invoke a        */
/* routine called HOOKUP that will keep count of how often each   */
/* path hook in the MAIN routine is executed.                     */
/*                                                                */
/* First, the address of HOOKUP is put into the slot for the      */
/* address of the routine to be invoked when each hook is hit.    */
/*                                                                */
/* Then, pointers to the block table and the path hook table      */
/* obtained from IBMBSIR in the sample code above are put into    */
/* the exit area. Next, the address of the routine being          */
/* monitored, in this case the MAIN routine, is put into the      */
/* exit area. Additionally, a table to keep count of the number   */
/* of visits is created, and its address is also put into the     */
/* exit area.                                                     */
/*                                                                */
/* Finally IBMBHKS is invoked to turn on the PATH hooks.          */
/*                                                                */
/******************************************************************/

If Sir_retcode = 0 then
  Do;
    Entry_var = HOOKUP;
    Hook_exit_rtn = Addr(Entry_var)->Based_ptr;

    Allocate Exit_area;
```

Figure 76 (Part 6 of 7). Sample Facility 3: CEEBINT Module

```
       Exit_bdata = A_block_table;
       Exit_pdata = A_path_table;

       /*- If counts are to be obtained from a non-MAIN    -*/
       /*- routine then replace “A_Main” in the following  -*/
       /*- statement with the name of the non-MAIN routine -*/
       /*- (the name declared earlier as EXTERNAL ENTRY).  -*/

       Exit_epa = A_main;

       Visits = Paths;
       Allocate Hook_table;
       Hook_visits = 0;

       Call IBMBHKS( HksFncPath, HksRetCode );
     End;
   Else
     Do ;
       Put skip list('CEEBINT MSG_1: Sir_retcode was not zero');
       Put skip list('CEEBINT MSG_1: Sir_retcode = ',Sir_retcode);
       Put skip list('CEEBINT MSG_1: Exit area not allocated');
       Put skip list('CEEBINT MSG_1: Hook table not allocated');
     End;


   /******************************************************************/
   /*                                                                */
   /* End of sample code for setting up hook exit                    */
   /*                                                                */
   /******************************************************************/



   /******************************************************************/
   /*                                                                */
   /* Place your actual user code here                               */
   /*                                                                */
   /******************************************************************/
   Put skip list('CEEBINT: At end of CEEBINT initialization');

 END CEEBINT;
```

Figure 76 (Part 7 of 7). Sample Facility 3: CEEBINT Module

```
%PROCESS TEST(NONE,NOSYM) LANGLVL(SPROG);
 Hookup : PROC( exit_for_hooks );

   DECLARE  Exit_for_hooks  Pointer;

   DECLARE
     1 Hook_exit_block   BASED(Exit_for_hooks),
       2 Hook_exit_len      FIXED BIN(31),
       2 Hook_exit_rtn      POINTER,
       2 Hook_exit_fnccode  FIXED BIN(31),
       2 Hook_exit_retcode  FIXED BIN(31),
       2 Hook_exit_rsncode  FIXED BIN(31),
       2 Hook_exit_userword POINTER,
       2 Hook_exit_ptr      POINTER,
       2 Hook_exit_reserved POINTER,
       2 Hook_exit_dsa      POINTER,
       2 Hook_exit_addr     POINTER,
       2 Hook_exit_end      CHAR(0);

   DECLARE
     1 Exit_area         BASED(Hook_exit_ptr),
       2 Exit_bdata         POINTER,
       2 Exit_pdata         POINTER,
       2 Exit_epa           POINTER,
       2 Exit_a_visits      POINTER,
       2 Exit_area_end      CHAR(0);


   DECLARE
     1 Block_table       BASED(exit_bdata),
       2 Block_a_data       POINTER,
       2 Block_count        FIXED BIN(31),
       2 Block_data(Blocks REFER(Block_count)),
         3 Block_offset     FIXED BIN(31),
         3 Block_size       FIXED BIN(31),
         3 Block_level      FIXED BIN(15),
         3 Block_parent     FIXED BIN(15),
         3 Block_child      FIXED BIN(15),
         3 Block_sibling    FIXED BIN(15),
         3 Block_name       CHAR(34) VARYING,
       2 Block_table_end    CHAR(0);


   DECLARE
     1 Path_table        BASED(exit_pdata),
       2 Path_a_data        POINTER,
       2 Path_count         FIXED BIN(31),
       2 Path_data(Paths  REFER(Path_count)),
         3 Path_offset      FIXED BIN(31),
         3 Path_no          FIXED BIN(31),
         3 Path_lineno      FIXED BIN(15),
         3 Path_reserved    FIXED BIN(15),
         3 Path_type        FIXED BIN(15),
         3 Path_block       FIXED BIN(15),
       2 Path_table_end     CHAR(0);

   DECLARE
     1 Hook_table        BASED(Exit_a_visits),
       2 Hook_data_size     FIXED BIN(31),
       2 Hook_data(Visits REFER(Hook_data_size)),
         3 Hook_visits      FIXED BIN(31),
       2 Hook_data_end      CHAR(0);


   DECLARE Ps               FIXED BIN(31);
   DECLARE Ix               FIXED BIN(31);
   DECLARE Jx               FIXED BIN(31);
```

Figure 77 (Part 1 of 5). Sample Facility 3: HOOKUP Program

```
/* ---------- Notes on cpu timing ----------------------- */
/*                                                        */
/*  TIMCPU is an assembler routine (TIMCPUVM is the CMS   */
/*  filename) which uses DIAG to get the cpu time in      */
/*  microseconds since the last system reset.  Since      */
/*  only the low order 31-bits is returned to this        */
/*  procedure it is possible that a negative number may   */
/*  result when subtracting the after_time from the       */
/*  before time.                                          */

/* -------------- Declares for cpu timing --------------- */
DCL  TIMINI              ENTRY OPTIONS (ASSEMBLER INTER);
DCL  TIMCPU              ENTRY OPTIONS (ASSEMBLER INTER);
DCL  Decimal             BUILTIN;
DCL  cpu_visits          FIXED BIN(31) STATIC;  /* = visits */
DCL  Hook_cpu_visits     Pointer STATIC  ;
DCL  exe_mon     FIXED BIN(31) EXTERNAL;
  /* exe_mon <=0  no cpu timing data is printed          */
  /* exe_mon  =1  only block data is obtained - default  */
  /* exe_mon >=2  all hooks are timed                    */
DECLARE
  1 Hook_time_table        BASED(Hook_cpu_visits),
   2 Hooksw,
       3 BLK_entry_time       FIXED BIN(31,0),
       3 Before               FIXED BIN(31,0),
       3 After                FIXED BIN(31,0),
       3 Temp_cpu             FIXED BIN(31,0),
    2 Hook_time_data_size     FIXED BIN(31),
    2 Hook_time_data(cpu_visits Refer(Hook_time_data_size)),
      3 Hook_time             Fixed Bin(31),
    2 Hook_time_data_end      Char(0);
/* ---------- END Declares for cpu timing --------------- */

/* compute offset */
ps = hook_exit_addr - exit_epa;

/* search for hook */
do ix = 1 to path_count
   while ( ps ¬= path_offset(ix) );
end;

/* if hook found - update table */
if (ix > 0) & (ix <=path_count) then do;
   hook_visits(ix) = hook_visits(ix) + 1;

   /* -------- this SELECT gets the cpu timings --------  */
   Select;
     When(path_type(ix)=1 & ix=1) do;  /* external block entry */
       exe_mon = 1;  /* default can be overridden in Main */
       cpu_visits = hook_data_size;  /* number of hooks */
       allocate hook_time_table;  /* cpu time table */
       hook_time = 0;  /* initialize the table */
       call TIMINI;               /* initialize timers */
       call TIMCPU  (BLK_entry_time);  /* get block entry time */
       hooksw.before = BLK_entry_time;      /* block entry */
       hooksw.after  = BLK_entry_time;      /* block entry */
     end;  /* end of the When(1) do */
```

Figure 77 (Part 2 of 5). Sample Facility 3: HOOKUP Program

```
     Otherwise do;
       if (exe_mon > 0) then do;
         /* collect cpu time data */
         /* get CPU time in microseconds since last call */
         call TIMCPU (hooksw.after);
         temp_cpu = hooksw.after - hooksw.before;
         hook_time(ix) =  hook_time(ix) + temp_cpu;
         hooksw.before = hooksw.after;
       end;  /* end of the if exe_mon > 0 then do */
     end;  /* end of the otherwise do */
   End;  /* end of the Select */
   /* ---End of the SELECT to get the cpu timings --------  */
end;  /* end of the if (ix > 0) & (ix <=path_count) then do */
else;

/* if exit from external (main), report */
if path_type(ix) = 2  & path_block(ix) = 1  then
   Do;
     call post_hook_processing;
     free hook_time_table;
   End;
else;

/* don't invoke the debugging tool */
hook_exit_retcode = 4;
hook_exit_rsncode = 0;
/* ---------------------------------------------------------- */
Post_hook_processing:  Procedure;
/* ---------------------------------------------------------- */
DECLARE Total_v_count       FLOAT DEC(06);
DECLARE Total_c_count       FLOAT DEC(06);
DECLARE Tot_vst_per_blk     FIXED BIN(31,0);
DECLARE Tot_v_pcnt_per_blk  FIXED DEC(6,4);
DECLARE Tot_cpu_per_blk     FIXED BIN(31,0);
DECLARE Tot_c_pcnt_per_blk  FIXED DEC(6,4);
DECLARE Percent_v           FIXED DEC(6,4);
DECLARE Percent_c           FIXED DEC(6,4);
DECLARE Col1                CHAR(30);
DECLARE Col2                CHAR(14);
DECLARE Col2_3              CHAR(30);
DECLARE Col3                CHAR(10);
DECLARE Col4                CHAR(14);
DECLARE Col5                CHAR(14);
DECLARE Col4_5              CHAR(28);
DECLARE Millisec_out        FIXED DEC(10,3);

 total_v_count = 0;
 total_c_count = 0;

 do jx = 1 to path_count;  /* get total hook_visits */
    total_v_count  = total_v_count + hook_visits(jx);
    total_c_count  = total_c_count + hook_time  (jx);
 end;

 do Jx = 1 to path_count;
   if path_type(jx) = 1 then
    do;  /* at block entry so print (block) headers */
      put skip list( ' ' );
      put skip list( 'Data for block ' ||
             block_name(path_block(jx)) );
      put skip list( ' ' );
      col1   = '     Statement Type';
      col2_3 = '         --- Visits ---';
      if exe_mon > 0
         then col4_5 = '--- CPU Time ---';
         else col4_5 = ' ';
      put skip list( col1 || ' ' || col2_3 || ' ' || col4_5 );
```

Figure 77 (Part 3 of 5). Sample Facility 3: HOOKUP Program

```
    col1 = ' ';
    col2 = '        Number';
    col3 = '  Percent';
    if exe_mon > 0 then
      do;
        col4 = '  Milliseconds';
        col5 = '  Percent';
      end;
      else
      do;
       col4 = ' ';
       col5 = ' ';
      end;
    put skip list( col1 || ' ' || col2 || ' ' || col3 ||
                           ' ' || col4 || col5);
    put skip list( ' ' );
  end;
else;

Select ( path_type(jx) );
  when ( 1 )
    col1 = Substr(char(path_no(jx)),4,11) || ' block entry';
  when ( 2 )
    col1 = Substr(char(path_no(jx)),4,11) || ' block exit';
  when ( 3 )
    col1 = Substr(char(path_no(jx)),4,11) || ' label';
  when ( 4 )
    col1 = Substr(char(path_no(jx)),4,11) || ' before call';
  when ( 5 )
    col1 = Substr(char(path_no(jx)),4,11) || ' after call';
  when ( 6 )
    col1 = Substr(char(path_no(jx)),4,11) || ' start of do loop';
  when ( 7 )
    col1 = Substr(char(path_no(jx)),4,11) || ' if true';
  when ( 8 )
    col1 = Substr(char(path_no(jx)),4,11) || ' if false';
  otherwise
    col1 = Substr(char(path_no(jx)),4,11);
end;  /* end of the select */

col2 = hook_visits(jx);
percent_v = 100* (hook_visits(jx)/total_v_count) ;
percent_c = 100* (hook_time  (jx)/total_c_count) ;

/* ------ print out the cpu timings ------ */
if exe_mon <= 0 then  /* no cpu time wanted */
   put skip list ( col1 || ' ' || col2 || ' ' || percent_v);
else do;  /* compute and print cpu times */
  Select;
    When (path_type(jx) = 1 & jx = 1) Do;
      /* at external block entry */
      /* initialize block counters */
      tot_vst_per_blk = hook_visits(jx);
      tot_v_pcnt_per_blk = percent_v;
      tot_cpu_per_blk    = 0;
      tot_c_pcnt_per_blk = 0;
      /* no CPU time on ext block entry line */
      put skip list ( col1 || ' ' || col2 || ' ' || percent_v);
    End;  /* End of the When (... = 1 & jx = 1) */
```

Figure 77 (Part 4 of 5). Sample Facility 3: HOOKUP Program

```
        When (path_type(jx) = 2) Do;
          /* @ block exit so print cpu summary line */
          /* write the "block exit" line */
          tot_vst_per_blk = tot_vst_per_blk + hook_visits(jx);
          tot_v_pcnt_per_blk = tot_v_pcnt_per_blk + percent_v;
          tot_cpu_per_blk = tot_cpu_per_blk + hook_time  (jx);
          tot_c_pcnt_per_blk = tot_c_pcnt_per_blk + percent_c;
          if exe_mon > 1 then do;
             millisec_out = Decimal(hook_time(jx),11,3)/1000;
             put skip list ( col1 || ' ' || col2 || ' ' || percent_v
                     || ' ' || millisec_out || ' ' || percent_c);
          end;
          Else do;  /* only want cpu time on summary line */
             put skip list ( col1 || ' ' || col2 || ' ' || percent_v);
          end;
          /* write the "Totals for Block" line */
          col1 = '     Totals for block';
          col2 = tot_vst_per_blk;
          millisec_out  = Decimal(tot_cpu_per_blk,11,3) / 1000;
          put skip list ( col1 || ' '|| col2 || ' ' ||
               tot_v_pcnt_per_blk || ' ' || millisec_out || ' ' ||
               tot_c_pcnt_per_blk);
        End;  /* End of the When (path_type(jx) = 2) */

        Otherwise do; /* cpu hook timing */
          if path_type(jx) = 1 then do;
            /* at internal block entry */
            /* initialize block counters */
            tot_vst_per_blk = hook_visits(jx);
            tot_v_pcnt_per_blk = percent_v;
            tot_cpu_per_blk    = hook_time(jx);
            tot_c_pcnt_per_blk = percent_c;
          end;
          else do;
            /* not at block entry */
            tot_vst_per_blk = tot_vst_per_blk + hook_visits(jx);
            tot_v_pcnt_per_blk = tot_v_pcnt_per_blk + percent_v;
            tot_cpu_per_blk = tot_cpu_per_blk + hook_time  (jx);
            tot_c_pcnt_per_blk = tot_c_pcnt_per_blk + percent_c;
          end;
          if exe_mon > 1 then do;
            millisec_out = Decimal(hook_time(jx),11,3)/1000;
            put skip list ( col1 || ' ' || col2 || ' ' || percent_v
                     || ' ' || millisec_out || ' ' || percent_c);
          end;  /* end of the if exe_mon > 1 then do */
          else  /* only want total cpu time for the block */
            put skip list ( col1 || ' ' || col2 || ' ' || percent_v);
        End;  /* End of the Otherwise Do */
      End;  /* End of the Select */
    end;  /* end of the else do */
   end;  /* end of the do Jx = 1 to path_count */

  put skip list( ' ' );

  END post_hook_processing;
END Hookup;
```

Figure 77 (Part 5 of 5). Sample Facility 3: HOOKUP Program

```
TIMINI   CSECT
*  MVS Version
*  This program will initialize the interval timer for
*  measuring the task execution (CPU) time so that calls to
*  the TIMCPU routine will return the proper result. Reg 0
*  will contain the value of 0 at exit of this program.
*  No arguments are passed to this program.
*
*   STANDARD PROLOGUE
         STM   14,12,12(13)         Save caller's registers
         LR    12,15                Get base address
         USING TIMINI,12            Establish addressability
         ST    13,SAVE+4            Forward link of save areas
         LA    10,SAVE              Our save area address
         ST    10,8(,13)            Backward link of save areas
         LR    13,10                Our save area is now the current one
         STIMER TASK,MICVL=TIME     Set interval timer (MVS)
*
*   STANDARD EPILOG
EXIT     L     13,4(,13)            Get previous save area address
         L     14,12(,13)           Restore register 14
         LM    1,12,24(13)          Restore regs 1 - 12
         SR    0,0                  Return value = 0
         MVI   12(13),X'FF'         Flag return
         SR    15,15                Return code = 0
         BR    14                   Return to caller
         DS    0D
TIME     DC    XL8'000007FFFFFFF000' Initial interval timer
*                                       time (MVS)
SAVE     DS    18F'0'               Our save area
         END   TIMINI
```

Figure 78. Sample Facility 3: TIMINI Module for MVS

```
TIMINI   CSECT
*
         SR     0,0                   Return value = 0
         SR     15,15                 Return code = 0
         BR     14                    Return to caller
*
         END    TIMINI
```

Figure 79. Sample Facility 3: TIMINI Module for VM

```
TIMCPU   CSECT
*   MVS version
*   This program will get the amount of time, in microseconds,
*   remaining in the interval timer that has been previously
*   set by the TIMINI routine.  The result is placed in the
*   full-word argument that is passed to this program.
*
*   STANDARD PROLOGUE
         STM   14,12,12(13)         Save caller's registers
         LR    12,15                Get base address
         USING TIMCPU,12            Establish addressability
         ST    13,SAVE+4            Forward link of save areas
         LA    10,SAVE              Our save area address
         ST    10,8(,13)            Backward link of save areas
         LR    13,10                Our save area is now the current one
*
         L     5,0(,1)              Get address of parameter
         TTIMER ,MIC,CPU            Get the remaining time and save it
*
         L     2,CPU                Get high order part ...
         L     3,CPU+4                and low order part ...
         SLDL  2,20                   and only keep time (no date)
         L     0,INITTIME           Get initial timer value
         SR    0,2                  Subtract to get elapsed CPU time
         ST    0,0(,5)              Put CPU time into parameter
*
*   STANDARD EPILOG
EXIT     L     13,4(,13)            Get previous save area address
         L     14,12(,13)           Restore register 14
         LM    1,12,24(13)          Restore registers 1 - 12
*                                     (r0 has time)
         MVI   12(13),X'FF'         Flag return
         SR    15,15                Return code = 0
         BR    14                   Return to caller
         DS    0D
CPU      DS    CL8                  Area to store remaining time
INITTIME DC    XL4'7FFFFFFF'        Initial timer value
SAVE     DS    18F'0'               Our save area
         END   TIMCPU
```

Figure 80. Sample Facility 3: TIMCPU Module for MVS

```
TIMCPU   CSECT
*   CMS version
*   This program will get the amount of time, in microseconds,
*   remaining in the interval timer that has been previously
*   set by the TIMINI routine and will return the result to
*   the calling routine.  The calling routine calls this
*   routine as a procedure, passing one fullword argument.
*
*   STANDARD PROLOGUE
         STM   14,12,12(13)         Save caller's registers
         LR    12,15                Get base address
         USING TIMCPU,12            Establish addressability
         ST    13,SAVE+4            Forward link save areas
         LA    10,SAVE              Our save area address
         ST    10,8(,13)            Backward link save areas
         LR    13,10                Our save area is now the current one
*
         L     5,0(,1)              Get address of parameter
*
         LA    1,DATETIME           Address of CMS pseudo timer info
         DIAG  1,0,X'C'             Get the time from CMS
         L     0,CPU+4                and low order part
         ST    0,0(,5)              Put CPU time into parameter
*
*   STANDARD EPILOG
EXIT     L     13,4(,13)            Get previous save area address
         L     14,12(,13)           Restore register 14
         LM    1,12,24(13)          Restore registers 1 - 12
*                                      (r0 has time)
         SR    15,15                Return code = 0
         BR    14                   Return to caller
         DS    0D
DATETIME DS    0CL32                CMS date and time info
DATE     DS    CL8                  Date mm/dd/yy
TOD      DS    CL8                  Time of day HH:MM:SS
CPU      DS    CL8                  Virtual CPU time
TOTCPU   DS    CL8                  Total CPU time
SAVE     DS    18F'0'               Our save area
         END   TIMCPU
```

Figure 81. Sample Facility 3: TIMCPU Module for VM

Chapter 14. Efficient Programming

This chapter describes methods for improving the efficiency of PL/I programs.

The section titled “Efficient Performance” suggests how to tune run-time performance of PL/I programs.

The “Global Optimization Features” section discusses the various types of global optimization performed by the compiler when OPTIMIZE(TIME) is specified. The section also contains some hints on coding PL/I programs to take advantage of global optimization.

Finally, pages 323 through 345 cover performance-related topics. Each of these sections has a title that begins “Notes about... .” They cover the following topics:

- Data elements
- Expressions and references
- Data conversion
- Program organization
- Recognition of names
- Storage control
- General statements
- Subroutines and functions
- Built-in functions and pseudovariables
- Input and output
- Record-oriented data transmission
- Stream-oriented data transmission
- Picture specification characters
- Condition handling.
- Multitasking.

Efficient Performance

Because of the modularity of the PL/I libraries and the wide range of optimization performed by the compiler, many PL/I application programs have acceptable performance and do not require tuning.

This section suggests ways in which you can improve the performance of programs that do not fall into the above category. Other ways to improve performance are described later in this chapter under the notes for the various topics.

It is assumed that you have resolved system considerations (for example, the organization of the PL/I libraries), and also that you have some knowledge of the compile-time and run-time options (see Chapter 1, “Using Compile-Time Options and Facilities” and *Language Environment for MVS & VM Programming Guide*).

Tuning a PL/I Program

Remove all debugging aids from the program.

The overhead incurred by some debugging aids is immediately obvious because these aids produce large amounts of output. However, debugging aids such as the SUBSCRIPTRANGE and STRINGRANGE condition prefixes which produce output only when an error occurs, also significantly increase both the storage requirements and the execution time of the program.

You should also remove PUT DATA statements from the program, especially those for which no data list is specified. These statements require control blocks to describe the variables and library modules to convert the control block values to external format. Both of these operations increase the program's storage requirements.

Using the GOSTMT or GONUMBER compile-time option does not increase the execution time of the program, but will increase its storage requirements. The overhead is approximately 4 bytes per PL/I statement for GOSTMT, and approximately 6 bytes per PL/I statement for GONUMBER.

Specify run-time options in the PLIXOPT variable, rather than as parameters passed to the program initialization routines. It might prove beneficial to alter existing programs to take advantage of the PLIXOPT variable, and to recompile them. For a description of using PLIXOPT, see the *Language Environment for MVS & VM Programming Guide*.

After removing the debugging aids, compile and run the program with the RPTSTG run-time option. The output from the RPTSTG option gives the size that you should specify in the STACK run-time option to enable all PL/I storage to be obtained from a single allocation of system storage. For a full description of the output from the RPTSTG option, see the *Language Environment for MVS & VM Programming Guide*.

Manipulating Source Code: Many operations are handled in-line. You should determine which operations are performed in-line and which require a library call, and to arrange your program to use the former wherever possible. The majority of these in-line operations are concerned with data conversion and string handling. (For conditions under which string operations are handled in-line, see Table 41 on page 328. For implicit data conversion performed in-line, see Table 42 on page 330. For conditions under which string built-in functions are handled in-line, see “In-Line Code” on page 314.)

In PL/I there are often several different ways of producing a given effect. One of these ways is usually more efficient than another, depending largely on the method of implementation of the language features concerned. The difference might be only one or two machine instructions, or it might be several hundred.

You can also tune your program for efficient performance by looking for alternative source code that is more efficiently implemented by the compiler. This will be beneficial in heavily used parts of the program.

It is important to realize, however, that a particular use of the language is not necessarily bad just because the correct implementation is less efficient than that for some other usage; it must be reviewed in the context of what the program is doing now and what it will be required to do in the future.

Tuning a Program for a Virtual Storage System

The output of the compiler is well suited to the requirements of a virtual storage system. The executable code is read-only and is separate from the data, which is itself held in discrete segments. For these reasons there is usually little cause to tune the program to reduce paging. Where such action is essential, there are a number of steps that you can take. However, keep in mind that the effects of tuning are usually small.

The object of tuning for a virtual storage system is to minimize the paging; that is, to reduce the number of times the data moves from auxiliary storage into main storage and vice-versa. You can do this by making sure that items accessed together are held together, and by making as many pages as possible read-only.

When using the compiler, you can write the source program so that the compiler produces the most advantageous use of virtual storage. If further tuning is required, you can use linkage editor statements to manipulate the output of the compiler so that certain items appear on certain pages.

By designing and programming modular programs, you can often achieve further tuning of programs for a virtual storage system.

To enable the compiler to produce output that uses virtual storage effectively, take care both in writing the source code and in declaring the data. When you write source code, avoid large branches around the program. Place statements frequently executed together in the same section of the source program.

When you declare data, your most important consideration should be the handling of data aggregates that are considerably larger than the page size. You should take care that items within the aggregate that are accessed together are held together. In this situation, the choice between arrays of structures and structures of arrays can be critical.

Consider an aggregate containing 3000 members and each member consisting of a name and a number. If it is declared:

```
DCL 1 A(3000),
2 NAME CHAR(14),
2 NUMBER FIXED BINARY;
```

the 100th name would be held adjacently with the 100th number and so they could easily be accessed together.

However, if it is declared:

```
DCL 1 A,
2 NAME(3000) CHAR(14),
2 NUMBER(3000) FIXED BINARY;
```

all the names would be held contiguously followed by all the numbers, thus the 100th name and the 100th number would be widely separated.

When choosing the storage class for variables, there is little difference in access time between STATIC INTERNAL or AUTOMATIC. The storage where both types of variable are held is required during execution for reasons other than access to the variables. If the program is to be used by several independent users simultaneously, declare the procedure REENTRANT and use AUTOMATIC to provide separate copies of the variables for each user. The storage used for based or controlled variables is not, however, required and avoiding these storage classes can reduce paging.

You can control the positioning of variables by declaring them BASED within an AREA variable. All variables held within the area will be held together.

A further refinement is possible that increases the number of read-only pages. You can declare STATIC INITIAL only those variables that remain unaltered throughout the program and declare the procedure in which they are contained REENTRANT. If you do this, the static internal CSECT produced by the compiler will be made read-only, with a consequent reduction in paging overhead.

The compiler output is a series of CSECTs (control sections). You can control the linkage editor so that the CSECTs you specify are placed together within pages, or so that a particular CSECT will be placed at the start of a page. The linkage editor statements you need to do this are given in your Linkage Editor and Loader publication.

The compiler produces at least two CSECTs for every external procedure. One CSECT contains the executable code and is known as the *program CSECT*; the other CSECT contains addressing data and static internal variables and is known as the *static CSECT*. In addition, the compiler produces a CSECT for every static external variable. A number of other CSECTs are produced for storage management. A description of compiler output is given in *Language Environment for MVS & VM Debugging Guide and Run-Time Messages*.

You can declare variables STATIC EXTERNAL and make procedures external, thus getting a CSECT for each external variable and a program CSECT and a static internal CSECT for each external procedure. It is possible to place a number of variables in one CSECT by declaring them BASED in an AREA that has been declared STATIC EXTERNAL.

When you have divided your program into a satisfactory arrangement of CSECTs, you can then analyze the use of the CSECTs and arrange them to minimize paging. You should realize, however, that this can be a difficult and time-consuming operation.

Global Optimization Features

The PL/I compiler attempts to generate object programs that run rapidly. In many cases, the compiler generates efficient code for statements in the sequence written by the programmer. In other cases, however, the compiler might alter the sequence of statements or operations to improve the performance, while producing the same result.

The compiler carries out the following types of optimization:

- Expressions:
  - Common expression elimination
  - Redundant expression elimination
  - Simplification of expressions.
- Loops:
  - Transfer of expressions from loops
  - Special-case code for DO statements.

- Arrays and structures:
  - Initialization
  - Assignments
  - Elimination of common control data.
- In-line code for:
  - Conversions
  - RECORD I/O
  - String manipulation
  - Built-in functions.
- Input/output:
  - Key handling for REGIONAL data sets
  - Matching format lists with data lists.
- Other:
  - Library subroutines
  - Use of registers
  - Analyzing run-time options during compile time (the PLIXOPT variable).

PL/I performs some of these types of optimization even when the NOOPTIMIZE option is specified. PL/I attempts full optimization, however, only when a programmer specifies the OPTIMIZE (TIME) compile-time option.

Expressions

The following sections describe optimization of expressions.

Common Expression Elimination

A *common expression* is an expression that occurs more than once in a program, but is intended to result in the same value each time it is evaluated. A *common expression* is also an expression that is identical to another expression, with no intervening modification to any operand in the expression. The compiler eliminates a common expression by saving the value of the first occurrence of the expression either in a temporary (compiler generated) variable, or in the program variable to which the result of the expression is assigned. For example:

```
X1 = A1 * B1;
⋮
Y1 = A1 * B1;
```

Provided that the values of A1, B1, and X1 do not change between the processing of these statements, the statements can be optimized to the equivalent of the following PL/I statements:

```
X1 = A1 * B1;
⋮
Y1 = X1;
```

Sometimes the first occurrence of a common expression involves the assignment of a value to a variable that is modified before it occurs in a later expression. In this case, the compiler assigns the value to a temporary variable. The example given above becomes:

```
Temp = A1 * B1;
X1 = Temp;
⋮
X1 = X1 + 2;
⋮
Y1 = Temp;
```

If the common expression occurs as a subexpression within a larger expression, the compiler creates a temporary variable to hold the value of the common subexpression. For example, in the expression C1 + A1 * B1, a temporary variable contains the value of A1 * B1, if this were a common subexpression.

An important application of this technique occurs in statements containing subscripted variables that use the same subscript value for each variable. For example:

```
PAYTAX(MNO)=PAYCODE(MNO)*WKPMNT(MNO);
```

The compiler computes the value of the subscript MNO only once, when the statement processes. The computation involves the conversion of a value from decimal to binary, if MNO is declared to be a decimal variable.

Redundant Expression Elimination

A *redundant expression* is an expression that need not be evaluated for a program to run correctly. For example, the logical expression:

```
(A=D)|(C=D)
```

contains the subexpressions (A=D) and (C=D). The second expression need not be evaluated if the first one is true. This optimization makes using a compound logical expression in a single IF statement more efficient than using an equivalent series of nested IF statements.

Simplification of Expressions

There are two types of expression simplification processes explained below.

Modification of Loop Control Variables: Where possible, the expression-simplification process modifies both the control variable and the iteration specification of a do-loop for more efficient processing when using the control variable as a subscript. The compiler calculates addresses of array elements faster by replacing multiplication operations with addition operations. For example, the loop:

```
Do I = 1 To N By 1;
  A(I) = B(I);
End;
```

assigns N element values from array B to corresponding elements in array A. Assuming that each element is 4 bytes long, the address calculations used for each iteration of the loop are:

Base(A)+(4*I)   for array A, and

Base(B)+(4*I)   for array B,

where Base represents the base address of the array in storage. The compiler can convert repeated multiplication of the control variable by a constant (that represents the length of an element) to faster addition operations. It converts the optimized DO statement above into object code equivalent to the following statement:

```
Do Temp = 4 By 4 To 4*N;
```

The compiler converts the element address calculations to the equivalent of:

Base(A) + Temp for array A, and

Base(B) + Temp for array B.

This optimization of a loop control variable and its iteration can occur only when the control variable (used as a subscript) increases by a constant value. Programs should not use the value of the control variable outside the loop in which it controls iteration.

Defactorization: Where possible, a constant in an array subscript expression is an offset in the address calculation. For example, PL/I calculates the address of a 4-byte element:

```
A(I+10)
```

as:

```
(Base(A)+4*10)+I*4
```

Replacement of Constant Expressions

Expression simplification replaces constant expressions of the form A+B or A*B, where A and B are integer constants, with the equivalent constant. For example, the compiler replaces the expression 2+5 with 7.

Replacement of Constant Multipliers and Exponents: The expression-simplification process replaces certain constant multipliers and exponents. For example:

```
A*2 becomes A+A,
```

and

```
A**2 becomes A*A.
```

Elimination of Common Constants: If a constant occurs more than once in a program, the compiler stores only a single copy of that constant. For example, in the following statements:

```
Week_No = Week_No + 1;
Record_Count = Record_Count + 1;
```

the compiler stores the 1 only once, provided that Week_No and Record_Count have the same attributes.

Code for Program Branches: The compiler allocates base registers for branch instructions in the object program in accordance with the logical structure of the program. This minimizes the occurrence of program-addressing load instructions in the middle of deeply nested loops.

Also, the compiler arranges the branch instructions generated for IF statements as efficiently as possible. For example, a statement such as:

```
IF condition THEN GOTO label;
```

is defined by the PL/I language as being a test of *condition* followed by a branch on *false* to the statement following the THEN clause. However, when the THEN clause consists only of a GOTO statement, the statement compiles as a branch on *true* to the label specified in the THEN clause.

Loops

In addition to the optimization described in “Modification of Loop Control Variables” on page 310, PL/I provides optimization features for loops as described in the following sections.

Transfer of Expressions from Loops

Where it is possible to produce an error-free run without affecting program results, optimization moves invariant expressions or statements from inside a loop to a point that immediately precedes the loop. An expression or statement occurring within a loop is said to be *invariant* if the compiler can detect that the value of the expression or the action of the statement would be identical for each iteration of the loop. A loop can be either a do-loop or a loop in a program detectable by analyzing the flow of control within the program. For example:

```
Do I = 1 To N;
  B(I) = C(I) * SQRT(N);
  P = N * J;
End;
```

This loop can be optimized to produce object code corresponding to the following statements:

```
Temp = SQRT(N);
P = N * J;
DO I = 1 TO N;
  B(I) = C(I) * Temp;
End;
```

If programmers want to use this type of optimization, they must specify REORDER for a BEGIN or PROCEDURE block that contains the loop. If a programmer does not specify the option, the compiler assumes the default option, ORDER, which inhibits optimization.

Programming Considerations: The compiler transfers expressions from inside to outside a loop on the assumption that every expression in the loop runs more frequently than expressions immediately outside the loop. Occasionally this assumption fails, and the compiler moves expressions out of loops to positions in which they run more frequently than if they had remained inside the loop. For example:

```
Do I = J To K While(X(I)=0);
  X(I) = Y(I) * SQRT(N);
End;
```

The compiler might move the expression SQRT(N) out of the loop to a position in which it is *possible* for the expression to be processed more frequently than in its original position inside the loop. This undesired effect of optimization is prevented by using the ORDER option for the block in which the loop occurs.

The compiler detects loops by analyzing the flow of control. The compiler can fail to recognize a loop if programmers use label variables because of flowpaths that they know are seldom or never used. Using label variables can inadvertently inhibit optimization by making a loop undetectable.

Special Case Code for DO Statements

Where possible for a do-loop, the compiler generates code in which the value of the control variable, and the values of the iteration specification, are contained in registers throughout loop execution. For example, the compiler attempts to maintain in registers the values of the variables I, K, and L in the following statement:

```
Do I = A To K By L;
```

This optimization uses the most efficient loop control instructions.

Arrays and Structures

PL/I provides optimization for array and structure variables as described in the following sections.

Initialization of Arrays and Structures

When arrays and some structures that have the BASED, AUTOMATIC, or CONTROLLED storage class are to be initialized by a constant specified in the INITIAL attribute, the compiler initializes the first element of the variable by the constant. The remainder of the initialization is a single move that propagates the value through all the elements of the variable. For example, for the following declaration:

```
DCL A(20,20) Fixed Binary Init((400)0);
```

the compiler initializes array A using this method.

Structure and Array Assignments

The compiler implements structure and array assignment statements by single move instructions whenever possible. Otherwise, the compiler assigns values by the simplest loop possible for the operands in the declaration. For example:

```
DCL A(10),B(10), 1 S(10), 2 T, 2 U;
    A=B;
    A=T;
```

The compiler implements the first assignment statement by a single move instruction, and the second by a loop. This occurs because array T is interleaved with array U, thereby making a single move impossible.

Elimination of Common Control Data

The compiler generates control information to describe certain program elements such as arrays. If there are two or more similar arrays, the compiler generates this descriptive information only once.

In-Line Code

To increase efficiency, the PL/I compiler produces *in-line* code (code that it incorporates within programs) as a substitute for calls to generalized subroutines.

In-line Code for Conversions

The compiler performs most conversions by in-line code, rather than by calls to the Library. The exceptions are:

- Conversions between character and arithmetic data
- Conversions from numeric character (PICTURE) data, where the picture includes characters other than 9, V, Z, or a single sign or currency character
- Conversions to numeric character (PICTURE) data, where the picture includes scale factors or floating point picture characters.

For example, the compiler converts data to PICTURE 'ZZ9V99' with in-line code.

In-line Code for Record I/O

For consecutive buffered files under certain conditions, in-line code implements the input and output transmission statements READ, WRITE, and LOCATE rather than calls to the Library.

In-line Code for String Manipulation

In-line code performs operations on many character strings (such as concatenation and assignment of adjustable, varying-length, and fixed-length strings). In-line code performs similar operations on many aligned bit strings that have a length that is a multiple of 8.

In-line Code for Built-In Functions

The compiler uses in-line code to implement many built-in functions. INDEX and SUBSTR are examples of functions for which the compiler usually generates in-line code. TRANSLATE, VERIFY, and REPEAT are examples where the compiler generates in-line code for simple cases.

Key handling for REGIONAL data sets

In certain circumstances, avoiding unnecessary conversions between fixed-binary and character-string data types simplifies key handling for REGIONAL data sets, as follows:

REGIONAL(1)

If the key is a fixed binary integer with precision (12,0) through (23,0), there is no conversion from fixed binary to character string and back again.

REGIONAL(2) and REGIONAL(3)

If the key is in the form K||I, where K is a character string and I is fixed binary with precision (12,0) through (23,0), the rightmost eight (8) characters of the resultant string do not reconvert to fixed binary. (This conversion would otherwise be necessary to obtain the region number.)

Matching Format Lists with Data Lists

Where possible, the compiler matches format and data lists of edit-directed input/output statements at compile time. This is possible only when neither list contains repetition factors at compile time that are expressions with unknown values. This allows in-line code to convert to or from the data list item. Also, on input, PL/I can take the item directly from the buffer or, on output, place it directly into the buffer. This eliminates Library calls, except when necessary to transmit a block of data between the input or output device and the buffer. For example:

```
DCL (A,B,X,Y,Z) CHAR(25);
Get File(SYSIN) Edit(X,Y,Z) (A(25));
Put File(SYSPRINT) Edit(A,B) (A(25));
```

In this example, format list matching occurs at compile time; at run time, Library calls are required only when PL/I transmits the buffer contents to or from the input or output device.

Run-time Library Routines

Language Environment for MVS & VM and PL/I library routines are packaged as a set, in such a manner that a link-edited object program contains only stubs that correspond to these routines. This packaging minimizes program main storage requirements. It can also reduce the time required for loading the program into main storage.

Use of Registers

The compiler achieves more efficient loop processing by maintaining in registers the values of loop variables that are subject to frequent modification. Keeping values of variables in registers, as the flow of program control allows, results in considerable efficiency. This efficiency is a result of dispensing with time-consuming load-and-store operations that reset the values of variables in their storage locations. When, after loop processing, the latest value of a variable is not required, the compiler does not assign the value to the storage location of the variable as control passes out of the loop.

Specifying REORDER for the block significantly optimizes the allocation of registers. However, because the latest value of a variable can exist in a register but not in the storage location of that variable, the values of variables reset in the block might not be the latest assigned values when a computational interrupt occurs. Specifying ORDER impedes optimizing the allocation of registers but guarantees that all values of variables are reset in the block, thereby immediately assigning values to their storage locations.

Program Constructs that Inhibit Optimization

The following sections describe source program constructs that can inhibit optimization.

Global Optimization of Variables

The compiler considers 255 variables in the program for global optimization. It considers the remainder solely for local optimization.

The compiler considers explicitly declared variables for global optimization in preference to contextually declared variables, and then gives preference to contextually declared variables over implicitly declared variables. The highest preference is given to those variables declared in the final DECLARE statements in the outermost block.

If your program contains more than 255 variables, you can benefit most from the global optimization of arithmetic variables—particularly do-loop control variables and subscripting variables. You will gain little or no benefit from the optimization of string variables or program control data.

You should declare arithmetic variables in the final DECLARE statements in the outermost block rather than implicitly. You can benefit further if you eliminate declared but unreferenced variables from the program.

ORDER and REORDER Options

ORDER and REORDER are optimization options specified for a procedure or begin-block in a PROCEDURE or BEGIN statement.

ORDER is the default for external procedures. The default for internal blocks is to inherit ORDER or REORDER from the containing block.

ORDER Option

Specify the ORDER option for a procedure or begin-block if you must be sure that only the most recently assigned values of variables modified in the block are available for ON-units, which are entered because of computational conditions raised during the execution of statements and expressions in the block.

In a block with the ORDER option specified, the compiler might eliminate common expressions, causing fewer computational conditions to be raised during execution of the block than if common expressions had not been eliminated. But if a computational condition is raised during execution of an ORDER block, the values of variables in statements that precede the condition are the most recent values assigned when an ON-unit refers to them for the condition.

You can use other forms of optimization in an ORDER block, except for forward or backward move-out of any expression that can raise a condition. Since it would be necessary to disable all the possible conditions that might be encountered, the use of ORDER virtually suppresses any move-out of statements or expressions from loops.

REORDER Option

The REORDER option allows the compiler to generate optimized code to produce the result specified by the source program, when error-free execution takes place. Move-out is allowed for any invariant statements and expressions from inside a loop to a point in the source program, either preceding or following such a loop. Thus, the statement or expression is executed once only, either before or after the loop.

More efficient execution of loops can be achieved by maintaining, in registers, the values of variables that are subject to frequent modification during the execution of the loops. When error-free execution allows, values can be kept in registers. This dispenses with time-consuming load-and-store operations needed to reset the values of variables in their storage locations. If the latest value of a variable is required after a loop has been executed, the value is assigned to the storage location of the variable when control passes out of the loop.

You can more significantly optimize register allocation if you specify REORDER for the block. However, the values of variables that are reset in the block are not guaranteed to be the latest assigned values when a computational condition is raised, since the latest value of a variable can be present in a register but not in the storage location of the variable. Thus, any ON-unit entered for a computational condition must not refer to variables set in the reorder block. However, use of the built-in functions ONSOURCE and ONCHAR is still valid in this context.

A program is in error if during execution there is a computational or system action interrupt in a REORDER block followed by the use of a variable whose value is not guaranteed.

Because of the REORDER restrictions, the only way you can correct erroneous data is by using the ONSOURCE and ONCHAR pseudovariables for a CONVERSION ON-unit. Otherwise, you must either depend on the implicit action, which terminates execution of the program, or use the ON-unit to perform error recovery and to restart execution by obtaining fresh data for computation. The second approach should ensure that all valid data is processed, and that invalid data is noted, while still taking advantage of any possible optimization. For example:

```
ON OVERFLOW PUT DATA;
DO J = 1 TO M;
DO I = 1 TO N;
X(I,J) = Y(I) + Z(J) *L + SQRT(W);
P = I*J;
END;
END;
```

When the above statements appear in a reorder block, the source code compiled is interpreted as follows:

```
ON OVERFLOW PUT DATA;
TEMP1 = SQRT(W);
DO J = 1 TO M;
TEMP2 = J;
DO I = 1 TO N;
X(I,J) = Y(I) +Z(J)*L+TEMP1;
P=TEMP2;
TEMP2=TEMP2+J;
END;
END;
```

TEMP1 and TEMP2 are temporary variables created to hold the values of expressions moved backward out of the loops, and the statement P=I*J can be simplified to P=N*M. If the OVERFLOW condition is raised, the values of the variables used in the loops cannot be guaranteed to be the most recent values assigned before the condition was raised, since the current values can be held in registers, and not in the storage location to which the ON-unit must refer.

Although this example does not show it, the subscript calculations for X, Y, and Z are also optimized.

Common Expression Elimination

Common expression elimination is inhibited by:

- The use in expressions of variables whose values can be reset in either an input/output or computational ON-unit.
- If a based variable is, at some point in the program, overlaid on top of a variable used in the common expression, assigning a new value to the based variable in between the two occurrences of the common expression, inhibits optimization.

  For instance, the common expression X+Z, in the following example, is not eliminated because the based variable A which, earlier in the program, is overlaid on the variable X, is assigned a value in between the two occurrences of X+Z.

  ```
  DCL A BASED(P);
  P=ADDR(X);
      .
      .
      .
  P=ADDR(Y);
      .
      .
      .
  B=X+Z;
  P->A=2;
  C=X+Z;
  ```

- The use of aliased variables. An aliased variable is any variable whose value can be modified by references to names other than its own name. Examples are variables with the DEFINED attribute, variables used as the base for defined variables, parameters, arguments, and based variables.

  Variables whose addresses are known to an external procedure by means of pointers that are either external or used as arguments are also assumed to be aliased variables.

  The effect of an aliased variable does not completely prevent common expression elimination, but inhibits it slightly. For all aliased variables, the compiler builds a list of all variables that could possibly reference the aliased variable. The list is the same for each member of the list, and in a given program there can be many such lists.

  When an expression containing an aliased variable is checked for its use as a common expression, the possible flow paths along which related common expressions could occur are also searched for assignments. The search is not only for the variable referenced in the expression, but also for all the members of the alias list to which that variable belongs. If the program contains an external pointer variable, it is assumed that this pointer could be set to all variables whose addresses are known to external procedures; that is, all external variables, all arguments passed to external procedures, and all variables whose addresses could be assigned to the external pointer. Thus, variables addressed by the external pointer, or by any other pointer that has a value assigned to it from the external pointer, are assumed to belong to the same alias list as the external variables.

- The form of an expression. If the expression B+C could be treated as a common expression, the compiler would not be able to detect it as a common expression in the following statement:

  ```
  D=A+B+C;
  ```

  The compiler processes the expression A+B+C from left to right. Consequently, it only recognizes the expressions A+B and (A+B)+C. However, by coding the expression D=A+(B+C), you can ensure that it is recognized.

- The scope of a common expression. In order to determine the presence of common expressions, the program is analyzed and the existence of flow units is determined. A *flow unit* is a unit of object code that can only be entered at the first instruction and left at the last instruction. A flow unit can contain several PL/I source statements; conversely, a single PL/I source statement can comprise several flow units. Common expressions are recognized across individual flow units. However, if the program flow paths between flow units are complex, the recognition of common expressions is inhibited across flow units.

Common expression elimination is assisted by these points:

- Variables in expressions should not be external, associated with external pointers, or arguments to ADDR built-in functions.
- The source program should not contain external procedures, external label variables, or label constants known to external procedures.
- Variables in expressions should not be set or accessed in ON-units, if possible.
- Expressions to be commoned or transferred must be arithmetic (for example, A+B) or string (for example, E||F or STRING(G)) rather than compiler generated.

The type of source program construct discussed below could cause common expression elimination to be carried out when it should not be.

A PL/I block can access any element of an array or structure variable if the variable is within the block's name scope, or if it has been passed to the block. When using BASED or DEFINED variables, or pointer arithmetic under the control of the LANGLVL(SPROG) compile-time option, be careful not to access any element that has not been passed to the block, and whose containing structure or array has not been passed to the block and is not within the block's name scope. Any such attempt is invalid and might lead to unpredictable results.

In the following example, procedure X passes only the address of element A.C to procedure Y. The first assignment statement in procedure Y makes a valid change to A.C. However, other statements in procedure Y are invalid because they attempt to change the values of A.B and A.D, which procedure Y cannot legally access.

Because neither the containing structure A nor its elements B, D, and E are passed to procedure Y, elements B, D, and E are not aliased for use by procedure Y. Therefore, the compiler cannot detect that their values might change in procedure Y, so it performs common expression elimination on the expression “B + D + E” in procedure X. Changing the values of A.B and A.D in procedure Y would then cause unpredictable results.

The GOTO statement in procedure Y is another error. It causes a flow of control change between blocks that is hidden from the compiler because neither A.F nor its containing variable A are passed to procedure Y. This invalid change in the flow of control can also cause unpredictable results.

```
X: PROCEDURE OPTIONS(MAIN);
     DECLARE Y ENTRY(POINTER) EXTERNAL;
      DECLARE
       1 A,
         2 B FIXED BIN(31)  INIT(1),
         2 C FIXED BIN(31)  INIT(2),
         2 D FIXED BIN(31)  INIT(3),
         2 E FIXED BIN(31)  INIT(4),
         2 F LABEL VARIABLE INIT(L1);
     N = B + D + E;
     CALL Y(ADDR(C));
L1:  M = B + D + E;
     END X;
Y: PROCEDURE (P);
     DECLARE
       (P,Q) POINTER,
       XX    FIXED BIN(31) BASED;
     DECLARE
       1 AA   BASED,
         2 CC FIXED BIN(31),
         2 DD FIXED BIN(31),
         2 EE FIXED BIN(31),
         2 FF LABEL VARIABLE;
     P->XX = 17;              /* valid change to A.C      */
     Q     = P - 4;           /* invalid                  */
     Q->XX = 13;              /* invalid change to A.B    */
     P->DD = 11;              /* invalid change to A.D    */
     GOTO P->FF;              /* invalid flow to label L1 */
     END Y;
```

Condition Handling for Programs with Common Expression Elimination

The order of most operations in each PL/I statement depends on the priority of the operators involved. However, for sub-expressions whose results form the operands of operators of lower priority, the order of evaluation is not defined beyond the rule that an operand must be fully evaluated before its value can be used in another operation. These operands include subscript expressions, locator qualifier expressions, and function references. Therefore, ON-units associated with conditions raised during the evaluation of such sub-expressions can be entered in an unpredictable order. Consequently, an expression might have several possible values, according to the order of, and action taken by, the ON-units that are entered. When a computational ON-unit is entered:

- The values of all variables set by the execution of previous statements are guaranteed to be the latest values assigned to the variables, and can be used by the ON-unit. For instance the PUT DATA statement can be used to record the values of all variables on entry to an ON-unit.

- The value of any variable set in an ON-unit resulting from a computational interrupt is guaranteed to be the latest value assigned to the variable, for any part of the program.

Where there is a possibility that variables might be modified as the result of a computational interrupt, either in the associated ON-unit, or as the result of the execution of a branch from the ON-unit, common expression elimination is inhibited. For example:

```
ON ZERODIVIDE B,C=1;
   .
   .
   .
X=A*B+B/C;
Y=A*B+D;
```

The compiler normally attempts to eliminate the reevaluation of the subexpression A*B in the second assignment statement. However, in this example, if the ZERODIVIDE condition is raised during the evaluation of B/C, the two values for A*B would be different. Common expression elimination is inhibited to allow for this possibility.

The above discussion applies only when the optimization option ORDER is specified or defaulted. If you do not require the guarantees described above, you can specify the optimization option REORDER. In this case, common expression elimination is not inhibited.

Transfer of Invariant Expressions

Transfer of invariant expressions out of loops is inhibited by:

- ORDER specified for the block. However, transfer is not entirely prevented by the ORDER option. It is only inhibited for operations that can raise computational conditions. Such operations do not include array subscript manipulation where the subscripts are calculated with logical arithmetic which cannot raise OVERFLOW.
- The use of variables whose values can be set or used by input or output statements.
- The use of variables whose values can be set in input/output or computational ON-units, or which are aliased variables.
- A complicated program flow, involving external procedures, external label variables, and label constants.
- The use of a WHILE option in a repetitive DO statement. An invariant expression can be moved out of a do-group only if it appears in a statement that would have been executed during every repetition of the do-group. The appearance of a WHILE option in the DO statement of a repetitive do-group effectively causes each statement in the do-group to be considered “not always executed,” since it might prevent the do-group from being executed at all. (You could, instead, have an equivalent do-group using an UNTIL option.)
- The appearance in an expression of a variant term or sub-expression preceding an invariant term or sub-expression. For example, assume that V is variant, and that NV1 and NV2 are invariant, in a loop containing the following statement:

```
X = V * NV1 * NV2;
```

The appearance of V preceding the sub-expression NV1*NV2 prevents the movement of the evaluation of NV1*NV2 out of the loop. (You could, instead, write X = NV1 * NV2 * V; getting the same result while allowing the sub-expression to be moved out of the loop.)

- The appearance in an expression of a constant that is not of the same data type as subsequent invariant elements in the expression. For example, assume that NV1 and NV2 are declared FLOAT DECIMAL, and are invariant in a loop containing the following statement:

  ```
  X = 100 * NV1 * NV2;
  ```

  The constant 100 has the attributes FIXED DECIMAL. For technical reasons beyond the scope of this discussion, this mismatch of attributes prevents the movement of the entire expression. (You could, instead, write the constant as 100E0, which has the attributes FLOAT DECIMAL.)

You can assist transfer by specifying REORDER for the block.

Redundant Expression Elimination

Redundant expression elimination is inhibited or assisted by the same factors as for transfer of invariant expressions, described above.

Other Optimization Features

Optimized code can be generated for the following items:

- A do-loop control variable, except when its value can be modified either explicitly or by an ON-unit during execution of a do-loop.
- Do-loops that do not contain other do-loops. This applies only if the scope of the control variable extends beyond the block containing the do-loop, it is given a definite value after the do-loop and before the end of the block.
- Assignment of arrays or structures, unless noncontiguous storage is used.
- Array initialization where the same value is assigned to each element, unless the array occupies noncontiguous storage.
- In-line conversions, unless they involve complicated picture or character-to-arithmetic conversions.
- In-line code for the string built-in functions SUBSTR and INDEX, unless the on-conditions STRINGSIZE or STRINGRANGE are enabled.
- Register allocation and addressing schemes, unless the program flow is complicated by use of external procedures, external label variables, or label constants known to external procedures. Optimized register usage is also inhibited by the use of aliased variables and variables that are referenced or set in an ON-unit.

Assignments and Initialization

When a variable is accessed, it is assumed to have a value which was previously assigned to it, and which is consistent with the attributes of the variable. If this assumption is incorrect, the program either proceeds with incorrect data or raises the ERROR condition. Invalid values can result from failure to initialize the variable, or it can occur as a result of the variable being set in one of the following ways:

- By the use of the UNSPEC pseudovariable
- By record-oriented input
- By overlay defining a picture on a character string, with subsequent assignment to the character string and then access to the picture
- By passing as an argument an incompatible value to an external procedure, without matching the attributes of the parameter by an appropriate parameter-descriptor list
- By assignment to a based variable with different attributes, but at the same location.

Failure to initialize a variable results in the variable having an unpredictable value at run time. Do not assume this value to be zero.

Failure to initialize a subscript can be detected by enabling SUBSCRIPTRANGE, when debugging the program (provided the uninitialized value does not lie within the range of the subscript).

Referencing a variable that has not been initialized can raise a condition. For example:

```
DCL A(10) FIXED;
A(1)=10;
PUT LIST (A);
```

The array should be initialized before the assignment statement, thus:

```
A=0;
```

Notes about Data Elements

- Take special care to make structures match when you intend to move data from one structure to another. This avoids conversion and also allows the structure to be moved as a unit instead of element by element.
- Use pictured data rather than character data if possible. For example, if a piece of input data contains 3 decimal digits, and neither ONSOURCE nor ONCHAR is used to correct invalid data:

  ```
  DCL EXTREP CHARACTER(3),
      INTREP FIXED DECIMAL (5,0);

  ON CONVERSION GOTO ERR;
  INTREP = EXTREP;
  ```

  is less efficient than:

```
DCL EXTREP CHARACTER(3),
    PICREP PIC '999' DEF EXTREP,
    INTREP FIXED DECIMAL (5,0);

IF VERIFY(EXTREP,'0123456789')
    ¬= 0 THEN GOTO ERR;
INTREP = PICREP;
```

- Declare the FIXED BINARY (31,0) attribute for internal switches and counters, and variables used as array subscripts.
- Exercise care in specifying the precision and scale factor of variables that are used in expressions. Using variables that have different scale factors in an expression can generate additional object code that creates intermediate results.
- You should, if possible, specify and test bit strings as multiples of eight bits. However, you should specify bit strings used as logical switches according to the number of switches required. In the following examples, (a) is preferable to (b), and (b) is preferable to (c):

  Example 1:

  ```
  Single switches

     (a)  DCL SW BIT(1) INIT('1'B);
          IF SW THEN...

     (b)  DCL SW BIT(8) INIT('1'B);
          IF SW THEN...

     (c)  DCL SW BIT(8) INIT ('1'B);
          IF SW = '10000000'B THEN...
  ```

  Example 2:

  ```
  Multiple switches

     (a)  DCL B BIT(3);
          B = '111'B;
            .
            .
            .
          IF B = '111'B THEN DO;

     (b)  DCL B BIT(8);
          B = '11100000'B;
            .
            .
            .
          IF B = '11100000'B THEN DO;

     (c)  DCL (SW1,SW2,SW3) BIT(1);
          SW1, SW2, SW3 = '1'B;
            .
            .
            .
          IF SW1&SW2&SW3 THEN DO;
  ```

- If bit-string data whose length is not a multiple of 8 is to be held in structures, you should declare such structures ALIGNED.

- Varying-length strings are generally less efficient than fixed-length strings.

  Fixed-length strings are not efficient if their lengths are not known at compile time, as in the following example:

  ```
  DCL A CHAR(N);
  ```

- When storage conservation is important, use the UNALIGNED attribute to obtain denser packing of data, with a minimum of padding.

- The precision of complex expressions follows the rules for expression evaluation. For example, the precision of 1 + 1i is (2,0).

- Do not use control characters in a source program for other than their defined meanings, such as delimiting a graphic string. (Control characters are those characters whose hexadecimal value is in the range from 00 to 3F, or is FF.) Although such use is not invalid, it can make it impossible for the source program to be processed by products (both hardware and software) that implement functions for the control characters.

  For example, you might write a program to edit data for a device that recognizes hexadecimal FF embedded in the data as a control character meant to suppress display. Then, if you write:

  ```
  DCL SUPPRESS CHAR(1) STATIC INIT(' ');
  ```

  where the INIT value is hexadecimal FF, your program is not displayed on that device, because the control character is recognized and suppresses all displaying after the INIT.

  Or, suppose you are creating a record that requires 1-byte numeric fields and you choose to code the following:

  ```
  DCL X01 CHAR(1) STATIC INIT(' '); /* HEXADECIMAL'01' */
  ```

  Your program can fail if it is processed by a product that recognizes control characters.

  To avoid these problems, represent control character values by using X character string constants. For example:

  ```
  DCL SUPPRESS CHAR(1) INIT('FF'X);

  DCL X01 CHAR(1) INIT('01'X);
  ```

  Thus you have the values required for execution without having control characters in the source program, you are not dependent on the bit representation of characters, and the values used are “visible” in your source program.

- In the case of unaligned fields, code is sometimes generated to move data to aligned fields. Thus, if you correctly align your data and specify the ALIGNED attribute you will avoid extraneous move instructions and improve execution speed for aligned data.

- If you test a read-only bit field in protected storage such that modification of that field would result in a protection exception, certain coding should be avoided. For example:

  ```
  Dcl bitfld bit(64) based(p);   /* Multiple of 8 bits */
  If bitfld then ...             /* NC hardware instruction */
  ```

  where bitfld is a whole number of bytes and is byte aligned. To test whether bitfld is zeros, the compiler attempts to generate efficient code and so executes an NC hardware instruction, which ANDs the bitfld to itself and sets the appropriate hardware condition code. The field is unchanged by this operation. However, if the field is not modifiable (read-only at a hardware level), a protection exception will occur.

To avoid such a protection exception, you should explicitly test for a non=zero bit string, as shown in the following example:

```
Dcl bitfld bit(64) based(p);
Dcl b0     bit(0)  static;
If bitfld¬=b0 then ...
```

Notes about Expressions and References

- Do not use operator expressions, variables, or function references where constants can be substituted.

  For example:

  ```
      DECLARE A(8);
  ```

  is more efficient than

  ```
      DECLARE A(5+3);
  ```

  and

  ```
      VERIFY(DATA,'0123456789')...;
  ```

  is more efficient than

  ```
      DCL NUMBERS CHAR(10) STATIC INIT('0123456789');
      VERIFY(DATA,NUMBERS)...;
  ```

  The preprocessor is very effective in allowing the source program to be symbolic, with expression evaluation and constant substitution taking place at compile time. The examples above could be:

  ```
      % DCL DIMA FIXED;
      % DIMA = 5+...;
      DCL A(DIMA);
  ```

  and

  ```
      % DCL NUMBERS CHAR;
      % NUMBERS='''0123456789''';
      VERIFY(DATA,NUMBERS)...;
  ```

- Use additional variables to avoid conversions. For example, consider a program in which a character variable is to be regularly incremented by 1:

  ```
      DECLARE CTLNO CHARACTER(8);
      CTLNO = CTLNO + 1;
  ```

This example requires two conversions (one of which involves a library call), while:

```
DECLARE CTLNO CHARACTER(8), DCTLNO FIXED DECIMAL;
DCTLNO = DCTLNO + 1;
CTLNO = DCTLNO;
```

requires only one conversion.

- You must ensure that the lengths of the intermediate results of string expressions do not exceed 32767 bytes for CHARACTER strings, 32767 bits for BIT strings, or 16383 double-byte characters for GRAPHIC strings. Take special care with VARYING strings, because the length used in intermediate results is the maximum possible length of the VARYING string.

  For example, the following code is incorrect because the concatenation operation in the PUT statement requires an intermediate CHARACTER string length greater than 32767 bytes. The compiler will not diagnose this error, but if the code were executed, the results would be unpredictable.

  ```
  DECLARE
    BITSTR  BIT(32767) VARYING,
    LEN_B   FIXED BIN(31,0);

  BITSTR = '00000000000000000000000000100010'B;

  LEN_B  = LENGTH(BITSTR);

  PUT SKIP LIST (SUBSTR(BITSTR,1,LEN_B) ||
                 SUBSTR(BITSTR,1,LEN_B));
  ```

  For this reason, avoid declaring strings with lengths close to the limit. And if you use such strings, be especially careful not to exceed the limit when you manipulate these strings.

- Avoid mixed mode arithmetic, especially the use of character strings in arithmetic calculations.
- Concatenation operations on bit-strings are time-consuming.
- The string operations performed in-line are shown in Table 41 on page 328.
- X>Y|Z is not equivalent to X>Y|X>Z, but is equivalent to (X>Y)|Z.
- You can use parentheses to modify the rules of priority. You might also want to use redundant parentheses to explicitly specify the order of operations.
- Array arithmetic is a convenient way of specifying an iterative computation. For example:

  ```
  DCL A(10,20);
  A=A/A(1,1);
  ```

  has the same effect as:

  ```
  DCL A(10,20);
  DO I=1 TO 10;
  DO J=1 TO 20;
  A(I,J)=A(I,J)/A(1,1);
  END; END;
  ```

  The effect is to change the value of A(1,1) only, since the first iteration produces a value of 1 for A(1,1) if A(1,1) is not equal to zero. If you want to divide each element of A by the original value of A(1,1), you can write:

```
B=A(1,1);
A=A/B;
```

or:

```
DCL A(10,20),
    B(10,20);
B=A/A(1,1);
```

- Array multiplication does not affect matrix multiplication. For example:

```
DCL (A,B,C) (10,10);
A=B*C;
```

is equivalent to:

```
DCL (A,B,C) (10,10);
DO I=1 TO 10;
DO J=1 TO 10;
A(I,J)=B(I,J)*C(I,J);
END; END;
```

Table 41. Conditions under Which String Operations Are Handled In-Line

String operation	**Comments and conditions**		
	Source	**Target**	**Comments**
Assign	Nonadjustable, ALIGNED, fixed-length bit string	Nonadjustable, ALIGNED, bit string	No length restriction if OPTIMIZE(TIME) is specified; otherwise maximum length of 8192 bits
	Adjustable or VARYING, ALIGNED bit string	Nonadjustable, ALIGNED bit string of length ≤2048	Only if OPTIMIZE(TIME) is specified
	Nonadjustable, fixed-length character string	Nonadjustable character string	
	Adjustable or VARYING character string	Nonadjustable character string of length ≤256	
`'and'`, `'not'`, `'or'`	As for bit string assignments but no adjustable or varying-length operands are handled		
Compare	As for string assignment with the two operands taking the roles of source and target, but no adjustable or varying-length operands are handled		
Concatenate	As for string assignments, but no adjustable or varying-length source strings are handled		
STRING built-in function	When the argument is an element variable, or a nonadjustable array or structure variable in connected storage		

Note: If the target is fixed-length, the maximum length is the target length. If the target is VARYING, the maximum length is the lesser of the operand lengths.

Notes about Data Conversion

The data conversions performed in-line are shown in Table 42 on page 330. A conversion outside the range or condition given is performed by a library call.

Not all the picture characters available can be used in a picture involved in an in-line arithmetic conversion. The only ones allowed are:

- V and 9
- Drifting or nondrifting characters $ S and +
- Zero suppression characters Z and *
- Punctuation characters , . / and B.

For in-line conversions, pictures with this subset of characters are divided into three types:

Picture type 1:
Pictures of all 9s with an optional V and a leading or trailing sign. For example:

```
'99V999',   '99',   'S99V9',   '99V+',   '$999'
```

Picture type 2:
Pictures with zero suppression characters and optional punctuation characters and a sign character. Also, type 1 pictures with punctuation characters. For example:

```
'ZZZ',   '**/**9',   'ZZ9V.99',   '+ZZ.ZZZ',   '$///99',   '9.9'
```

Picture type 3:
Pictures with drifting strings and optional punctuation characters and a sign character. For example:

```
'$$$$',   '-,--9',   'S/SS/S9',   '+++9V.9',   '$$$9-'
```

Sometimes a picture conversion is not performed in-line even though the picture is one of the above types. This might be because:

- SIZE is enabled and could be raised.
- There is no correspondence between the digit positions in the source and target. For example, DECIMAL (6,8) or DECIMAL (5,-3) to PIC '999V99' will not be performed in-line.
- The picture can have certain characteristics that make it difficult to handle in-line. For example:
  - Punctuation between a drifting Z or a drifting * and the first 9 is not preceded by a V. For example:

    ```
    'ZZ.99'
    ```

  - Drifting or zero suppression characters to the right of the decimal point. For example:

    ```
    'ZZV.ZZ'  or  '++V++'
    ```

Table 42 (Page 1 of 2). Implicit Data Conversion Performed In-Line

Conversion		**Comments and conditions**
Source	**Target**	
FIXED BINARY	FIXED BINARY	None.
	FIXED DECIMAL	None.
	FLOAT	Long or short FLOAT target.
	Bit string	String must be fixed-length, ALIGNED, and with length less than or equal to 2048. STRINGSIZE condition must be disabled.
	Character string or Numeric picture	Via FIXED DECIMAL. String must be fixed-length with length less than or equal to 256 and STRINGSIZE disabled. Picture types 1, 2, or 3 when SIZE disabled.
FIXED DECIMAL	FIXED BINARY	None.
	FIXED DECIMAL	None.
	FLOAT	If q1+p1 less than or equal to 75. Long or short-FLOAT target.
	Bit string	String must be fixed-length, ALIGNED, and with length less than or equal to 2048. STRINGSIZE condition must be disabled.
	Character string	If precision = scale factor, it must be even. String must be fixed-length and length less than or equal to 256. STRINGSIZE must be disabled.
	Numeric picture	Picture types 1, 2, and 3.
FLOAT (Long or Short)	FIXED BINARY	None.
	FIXED DECIMAL	Scale factor less than 80.
	FLOAT	Source and target can be single or double length.
	Bit string	String must be fixed-length, ALIGNED, and with length less than or equal to 2048. STRINGSIZE condition must be disabled.
Bit string	FIXED BINARY	Source string must be fixed-length, ALIGNED, and with length less than or equal to 32.
	FIXED DECIMAL and FLOAT	Source must be fixed-length, ALIGNED, and with length less than 32.
	Character string	Source must be fixed-length, ALIGNED, and length 1 only.
Character	Bit string	None.
	FIXED DECIMAL	Source length 1 only. CONVERSION condition must be disabled.
	FLOAT	None.
	FIXED BINARY	None.
Character picture	Character string	String must be fixed-length with length less or equal to 256.
	Character picture	Pictures must be identical.

Table 42 (Page 2 of 2). Implicit Data Conversion Performed In-Line

Conversion		**Comments and conditions**
Source	**Target**	
Numeric picture type 1 and 2	FIXED BINARY	Via FIXED DECIMAL. SIZE condition disabled.
	FIXED DECIMAL	Type 2 picture without * or embedded punctuation. SIZE condition disabled.
	FLOAT	Via FIXED DECIMAL. Size condition disabled.
	Numeric picture	Picture types 1, 2, or 3. SIZE condition disabled.
Locator	Locator	None.

Notes about Program Organization

- Although you can write a program as a single external procedure, it is often desirable to design and write the program as a number of smaller external procedures, or modules. In PL/I, the basic units of modularity are the procedure and the begin-block.

  Some of the advantages of modular programming are:

  - Program size affects the time and space required for compilation. Generally, compilation time increases more than linearly with program size, especially if the compiler has to spill text onto auxiliary storage. Also, the process of adding code to a program and then recompiling it leads to wasteful multiple-compilation of existing text. Modular programming eliminates the above possibilities.
  - If you design a procedure to perform a single function it needs to contain only the data areas for that function. Because of the nature of AUTOMATIC storage, there is less danger of corruption of data areas for other functions.
  - If you design a procedure to perform a single function, you can more easily replace it with a different version. Also, you can use the same procedure in several different applications.
  - Storage allocation for all the automatic variables in a procedure occurs when the procedure is invoked at any of its entry points. If you reduce the number of functions performed by a procedure, you can often reduce the number of variables declared in the procedure. This in turn can reduce the overall demand for storage for automatic variables.

  More important (from the efficient programming viewpoint) are the following considerations:

  - The compiler has a limitation on the number of variables that it can consider for global optimization. (The number of variables does not affect other forms of optimization.)
  - The compiler has a limitation on the number of flow units that it can consider for flow analysis and, subsequently, for global optimization.
  - If the static CSECT or the DSA exceeds 4096 bytes in size, the compiler has to generate additional code to address the more remote storage.

  - If the object code for a procedure exceeds 4096 bytes in size, the compiler might have to repeatedly reset base registers.

  Extra invocation of procedures increases run time, but the use of modular programming often offsets the increase, because the additional optimization can cause significantly fewer instructions to be executed.

- Avoid *unnecessary* program segmentation and block structure. This includes all procedures, ON-units, and begin-blocks that need activation and termination. The initialization and program management for these carry an overhead.

  You should assess this recommendation in conjunction with the notes on modular programming given earlier in this section.

- The procedure given initial control at run time must have the OPTIONS(MAIN) attribute. If more than one procedure has the MAIN option, the first one encountered by the linkage editor receives control.

- Under the compiler, attempting the recursive use of a procedure that was not given the RECURSIVE attribute can result in the ERROR condition after exit from the procedure. This occurs if reference is made to automatic data from an earlier invocation of the procedure.

Notes about Recognition of Names

Separate external declarations for the same variable must not specify conflicting attributes (CONTROLLED EXTERNAL variables are an exception), either explicitly or by default. If this occurs, the compiler is not able to detect the conflict.

Notes about Storage Control

- Using self-defining data (the REFER option) enables data to be held in a compact form; it can, however, produce less-than-optimum object code. For example, with the structure:

  ```
  DCL 1 STR BASED(P),
        2 N,
        2 BEFORE,
        2 ADJUST (NMAX REFER(N)),
          3 BELOW,
        2 AFTER;
  ```

  a reference to BEFORE requires one instruction to address the variable, whereas a reference to AFTER or BELOW requires approximately 18 instructions, plus a call to a resident library module.

  You can organize a self-defining structure more efficiently by ensuring that the members whose lengths are known appear before any adjustable members, and that the most frequently used adjustable members appear before those that are less frequently used. The previous example could thus be changed to:

  ```
  DCL 1 STR BASED(P),
        2 N,
        2 BEFORE,
        2 AFTER,
        2 ADJUST (NMAX REFER(N)),
          3 BELOW;
  ```

- PL/I does not allow the use of the INITIAL attribute for arrays that have the attributes STATIC and LABEL, because the environmental information for the array does not exist until run time.

  However, when compiling procedures containing STATIC LABEL arrays, you might improve performance by specifying the INITIAL attribute, provided that the number of elements in the array is less than 512. What happens under these conditions is:

  – The compiler diagnoses the invalid language (STATIC, LABEL, and INITIAL) and produces message IEL0580I, but it accepts the combination of attributes.

  – If OPT(TIME) is in effect, the compiler checks GO TO statements that refer to STATIC LABEL variables to see whether the value of the label variable is a label constant in the same block as the GO TO statement. If the value is a label constant in the same block, the compiler replaces the normal interpretative code with direct branching code. If it is not, the compiler produces message IEL0918I and the interpretative code remains unchanged.

  – If OPT(0) is in effect, or if message IEL0918I is produced, or if the array is larger than 512 elements, execution is liable to terminate with an interrupt, or go into a loop, or produce other unpredictable results.

- AUTOMATIC variables are allocated at entry to a block; sequences of the following type allocate B with the value that N had on entry to the block (not necessarily 4):

```
A: PROC;
   N=4;
   DCL B(N) FIXED;
    .
    .
    .
   END;
```

- If you specify the INITIAL attribute for an external noncontrolled variable, you must specify it, with the same value, on all the declarations for that variable. An exception to this rule is that an INITIAL attribute specified for an external variable in a compiled procedure need not be repeated elsewhere.

- String lengths, area sizes, and array bounds of controlled variables can be recomputed at the time of an ALLOCATE statement. As a result, even if the declaration asserts that a structure element (for example, X) is CHARACTER(16) or BIT(1), PL/I treats the declaration as CHARACTER(*) or BIT(*). Thus, library subroutines manipulate these strings. The compiler allocates and releases the temporary space needed for calculations (for instance, concatenation) using these strings each time the calculation is performed, since the compiler does not know the true size of the temporary space.

  An alternate way of declaring character strings of known length is to declare PICTURE '(16)X' to hold a 16-character string. Because the number “16” is not subject to change at ALLOCATE time, better code results.

|
| - A variable with adjustable size that is defined on an external variable cannot be passed as an argument to a procedure.

Notes about Statements

- If a GOTO statement references a label variable, it is more efficient if the label constants that are the values of the label variable appear in the same block as the GOTO statement.
- When storage conservation is important, avoid the use of iterative do-groups with multiple specifications. The following is inefficient in terms of storage requirements:

  ```
  DO I = 1,3,-5,15,31;
    .
    .
    .
  END;
  ```

- A repetitive do-group is not executed if the terminating condition is satisfied at initialization:

  ```
  I=6;
  DO J=I TO 4;
     X=X+J;
  END;
  ```

  This group does not alter X, since BY 1 is implied. Iterations can step backwards, and if BY -1 was specified, three iterations would take place.

- Expressions in a DO statement are assigned to temporaries with the same characteristics as the expression, not the variable. For example:

  ```
  DCL A DECIMAL FIXED(5,0);
      A=10;
      DO I=1 TO A/2;
       .
       .
       .
      END;
  ```

  This loop is not executed, because A/2 has decimal precision (15,10), which, on conversion to binary (for comparison with I), becomes binary (31,34).

  Five iterations result if the DO statement is replaced by:

  ```
  ITEMP=A/2;
  DO I=1 TO ITEMP;
  ```

  or:

  ```
  DO I=1 TO PREC(A/2,6,1)
  ```

- Upper and lower bounds of iterative do-groups are computed only once, even if the variables involved are reassigned within the group. This applies also to the BY expression.

  Any new values assigned to the variables involved take effect only if the do-group is started again.

- In a do-group with both a control variable and a WHILE option, the evaluation and testing of the WHILE expression is carried out only after determination (from the value of the control variable) that iteration can be performed. For example, the following group is executed at most once:

```
DO I=1 WHILE(X>Y);
 .
 .
 .
END;
```

- If the control variable is used as a subscript within the do-group, ensure that the variable does not run beyond the bounds of the array dimension. For instance:

  ```
  DECLARE A(10);
  DO I = 1 TO N;
   .
   .
   .
  A(I) = X;
   .
   .
   .
  END;
  ```

  If N is greater than 10, the assignment statement can overwrite data beyond the storage allocated to the array A. A bounds error can be difficult to find, particularly if the overwritten storage happens to contain object code. You can detect the error by enabling SUBSCRIPTRANGE.

  For CMPAT(V2), you should explicitly declare the control variable as FIXED BIN (31,0), because the default is FIXED BIN (15,0) which cannot hold fullword subscripts.

- If a Type 2 DO specification includes both the WHEN and UNTIL options, the DO statement provides for repetitive execution, as defined by the following:

  ```
  LABEL:  DO WHILE (expression1)
             UNTIL (expression2)
          statement-1
          .
          .
          .
          statement-n
          END;
  NEXT:   statement /* STATEMENT FOLLOWING THE DO GROUP */
  ```

  The above is exactly equivalent to the following expansion:

  ```
  LABEL:  IF (expression 1) THEN; ELSE
            GO TO NEXT;
          statement-1
          .
          .
          .
          statement-n
  LABEL2: IF (expression2) THEN; ELSE
            GO TO LABEL;
  NEXT:   statement /* STATEMENT FOLLOWING THE DO GROUP */
  ```

  The statement GO TO LABEL; replaces the IF statement at label LABEL2 in the expansion if the UNTIL option is omitted.

  A null statement replaces the IF statement at label LABEL Note that, if the WHILE option is omitted, statements 1 through n are executed at least once.

- If the Type 3 DO specification includes the TO and BY options, the action of the do-group is defined by the following:

```
LABEL:  DO variable=
            expression1
            TO expression2
            BY expression3
            WHILE (expression4)
            UNTIL(expression5);
            statement-1
            .
            .
            .
            statement-m
LABEL1:  END;
NEXT:    statement
```

  For a variable that is not a pseudovariable, the above action of the do-group definition is exactly equivalent to the following expansion, in which 'p' is a compiler-created pointer, 'v' is a compiler-created based variable based on a 'p' and with the same attributes as 'variable,' and 'e*n*' (*n*=1, 2, or 3) is a compiler-created variable: For example:

```
LABEL:  p=ADDR(variable);
        e1=expression1;
        e2=expression2;
        e3=expression3;
        v=e1;
LABEL2: IF (e3>=0)&(v>e2)|
           (e3<0)&(v<e2)
           THEN GO TO NEXT;
        IF (expression4) THEN;
           ELSE GO TO NEXT;
        statement-1
        .
        .
        .
        statement-m
LABEL1: IF (expression5) THEN
        GO TO NEXT;
LABEL3: v=v+e3;
        GO TO LABEL2;
NEXT:   statement
```

If the specification includes the REPEAT option, the action of the do-group is defined by the following:

```
LABEL:  DO variable=
            expression1
            REPEAT expression6
            WHILE (expression4)
            UNTIL(expression5);
            statement-1
            .
            .
            .
            statement-m
LABEL1:  END;
NEXT:    statement
```

For a variable that is not a pseudovariable, the above action of the do-group definition is exactly equivalent to the following expansion:

```
LABEL:  p=ADDR(variable);
        e1=expression1;
        v=e1;
LABEL2: ;
        IF (expression4) THEN;
          ELSE GO TO NEXT;
          statement-1
          .
          .
          .
          statement-m
LABEL1: IF (expression5) THEN
          GO TO NEXT;
LABEL3: v=expression6;
          GO TO LABEL2;
NEXT:   statement
```

Additional rules for the above expansions follow:

– The above expansion only shows the result of one specification. If the DO statement contains more than one specification, the statement labeled NEXT is the first statement in the expansion for the next specification. The second expansion is analogous to the first expansion in every respect. Note, however, that statements 1 through m are not actually duplicated in the program.

– Omitting the WHILE clause also omits the IF statement immediately preceding statement-1 in each of the expansions.

– Omitting the UNTIL clause also omits the IF statement immediately following statement-m in each of the expansions.

Notes about Subroutines and Functions

- You should consider the precision of decimal constants when such constants are passed. For example:

  ```
  CALL ALPHA(6);

  ALPHA:PROCEDURE(X);
         DCL X FIXED DECIMAL;
         END;
  ```

  If ALPHA is an external procedure, the above example is incorrect because X is given default precision (5,0), while the decimal constant, 6, is passed with precision (1,0).

- When a procedure contains more than one entry point, with different parameter lists on each entry, do not make references to parameters other than those associated with the point at which control entered the procedure. For example:

  ```
  A:PROCEDURE(P,Q);
     P=Q+8; RETURN;
  B: ENTRY(R,S);
     R=P+S;       /* THE REFERENCE TO P IS AN ERROR */
     END;
  ```

When an EXTERNAL ENTRY is declared with no parameter descriptor list or with no parameters, no matching between parameters and arguments will be done. Therefore, if any arguments are specified in a CALL to such an entry point, no diagnostic message will be issued.

If one of the following examples is used:

```
DECLARE X ENTRY EXTERNAL;
```

or

```
DECLARE X ENTRY() EXTERNAL;
```

any corresponding CALL statement, for example:

```
CALL X(parameter);
```

will not be diagnosed, although it might be an error.

Notes about Built-In Functions and Pseudovariables

For efficiency, do not refer to the DATE built-in function more than once in a run. For example, instead of:

```
PAGEA= TITLEA||DATE;
PAGEB= TITLEB||DATE;
```

it is more efficient to write:

```
DTE=DATE;
PAGEA= TITLEA||DTE;
PAGEB= TITLEB||DTE;
```

Table 43 on page 339 shows the conditions under which string built-in functions are performed in-line.

Assignments made to a varying string by means of the SUBSTR pseudovariable do not set the length of the string. A varying string initially has an undefined length, so that if all assignments to the string are made using the SUBSTR pseudovariable, the string still has an undefined length and cannot be successfully assigned to another variable or written out.

When UNSPEC is used as a pseudovariable, the expression on the right is converted to a bit string. Consequently, the expression must not be invalid for such conversion. For example, if the expression is a character string containing characters other than 0 or 1, a conversion error will result.

If both operands of the MULTIPLY built-in function are FIXED DECIMAL and have precision greater than or equal to 14, unpredictable results can occur if SIZE is enabled.

If an array or structure, whose first element is an unaligned bit string that does not start on a byte boundary, is used as an argument in a call to a subroutine or a built-in function, the results are unpredictable.

Table 43. Conditions under Which String Built-In Functions Are Handled In-Line

String function	Comments and conditions
BIT	Always
BOOL	The third argument must be a constant. The first two arguments must satisfy the conditions for `'and'`, `'or'`, and `'not'` operations in Table 41 on page 328.
CHAR	Always
HIGH	Always
INDEX	Second argument must be a nonadjustable character string less than 256 characters long.
LENGTH	Always
LOW	Always
REPEAT	Second argument must be constant.
SUBSTR	STRINGRANGE must be disabled.
TRANSLATE	First argument must be fixed-length; second and third arguments must be constant.
UNSPEC	Always
VERIFY	First argument must be fixed-length: • If CHARACTER it must be less than or equal to 256 characters, • If BIT it must be ALIGNED, less than or equal to 2048 bits. Second argument must be constant.

Notes about Input and Output

- Allocate sufficient buffers to prevent the program from becoming I/O bound, and use blocked output records. However, consider the impact on other programs executing within the system.
- When creating or accessing a data set having fixed-length records, specify FS or FBS record format, whenever possible.

- When a number of data sets are accessed by a single statement, use of a file variable rather than the TITLE option can improve program efficiency by allowing a file for each data set to remain open for as long as the data set is required by the program. Using the TITLE option requires closing and reopening a file whenever the statement accesses a new data set.
- The OPEN statement is executed by library routines that are loaded dynamically at the time the OPEN statement is executed. Consequently, run time could be improved if you specify more than one file in the same OPEN statement, since the routines need be loaded only once, regardless of the number of files being opened. However, opening multiple files can temporarily require more internal storage than might otherwise be needed.

  As with the OPEN statement, closing more than one file with a single CLOSE statement can save run time, but it can require the temporary use of more internal storage than would otherwise be needed.

Notes about Record-Oriented Data Transmission

- If you declare a file DIRECT with the INDEXED option of the ENVIRONMENT attribute, you should also apply the ENVIRONMENT options INDEXAREA, NOWRITE, and ADDBUFF if possible.
- When you create or access a CONSECUTIVE data set, use file and record variable declarations that generate in-line code, if possible. Details of the declarations are given in Chapter 8, “Defining and Using Consecutive Data Sets” on page 129.
- Conversion of source keys for REGIONAL data sets can be avoided if the following special cases are observed:
  - For REGIONAL(1): When the source key is a fixed binary element variable or constant, use precision in the range (12,0) to (23,0).
  - For REGIONAL(2) and (3): When the source key is of the form (character expression||r), where r is a fixed binary element variable or constant, use precision in the range (12,0) to (23,0).
- Direct update of an INDEXED data set slows down if an input/output operation on the same file intervenes between a READ and a REWRITE for the same key. This can cause the REWRITE statement to issue an extra READ.
- A pointer set in READ SET or LOCATE SET is not valid beyond the next operation on the file, or beyond a CLOSE statement. In OUTPUT files, you can mix WRITE and LOCATE statements freely.
- When you need to rewrite a record that was read into a buffer (using a READ SET statement that specifies a SEQUENTIAL UPDATE file) and then updated, you can use the REWRITE statement without a FROM option. A REWRITE after a READ SET always rewrites the contents of the last buffer onto the data set.

For example:

```
3  READ FILE (F) SET (P);
         .
         .
         .
5  P->R = S;
         .
         .
         .
7  REWRITE FILE (F);
         .
         .
         .
11  READ FILE (F) INTO (X);
         .
         .
         .
15  REWRITE FILE (F);
         .
         .
         .
19  REWRITE FILE (F) FROM (X);
```

Statement 7 rewrites a record updated in the buffer.

Statement 15 does not change the record on the data set at all.

Statement 19 raises the ERROR condition, since there is no preceding READ statement.

- There is one case where it is not possible to check for the KEY condition on a LOCATE statement until transmission of a record is attempted. This is when there is insufficient room in the specified region to output the record on a REGIONAL(3) V- or U-format file. Neither the record raising the condition nor the current record is transmitted.

  If a LOCATE is the last I/O statement executed before the file closes, the record is not transmitted and the condition can be raised by the CLOSE statement.

Notes about Stream-Oriented Data Transmission

- A common programming practice is to put the format list used by edit-directed input/output statements into a FORMAT statement. The FORMAT statement is then referenced from the input/output statement by means of the R-format item. For example:

```
DECLARE NAME CHARACTER(20), MANNO DEC FIXED(5,0);
   .
   .
   .
PUT EDIT (MANNO,NAME)(R(OUTF));
   .
   .
   .
OUTF:FORMAT(F(8),X(5),A(20));
```

Programming in this way reduces the level of optimization that the compiler is able to provide for edit-directed input/output. If the format list repeats in each input/output statement:

```
PUT EDIT (MANNO,NAME) (F(8),X(5),A(20));
```

the compiler is able to generate more efficient object code which calls fewer library modules, with a consequent saving in run time and load module size.

- In STREAM input/output, do as much as possible in each input/output statement. For example:

  ```
  PUT EDIT ((A(I) DO I = 1 TO 10))(...;
  ```

  is more efficient than:

  ```
  DO I = 1 TO 10;
     PUT EDIT (A(I))(...
  END;
  ```

- Use edit-directed input/output in preference to list- or data-directed input/output.
- Consider the use of overlay defining to simplify transmission to or from a character string structure. For example:

  ```
  DCL 1 IN,
         2 TYPE CHAR(2),
         2 REC,
           3 A CHAR(5),
           3 B CHAR(7),
           3 C CHAR(66);
   GET EDIT(IN) (A(2),A(5),A(7),A(66));
  ```

  In the above example, each format-item/data-list-item pair is matched separately, code being generated for each matching operation. It would be more efficient to define a character string on the structure and apply the GET statement to the string:

  ```
  DCL STRNG CHAR(80) DEF IN;
  GET EDIT (STRNG) (A(80));
  ```

- When an edit-directed data list is exhausted, no further format items will be processed, even if the next format item does not require a matching data item. For example:

  ```
  DCL A FIXED(5),
      B FIXED(5,2);
  GET EDIT (A,B) (F(5),F(5,2),X(70));
  ```

  The X(70) format item is not processed. To read a following card with data in the first ten columns only, the SKIP option can be used:

  ```
  GET SKIP EDIT (A,B) (F(5), F(5,2));
  ```

- The number of data items represented by an array or structure name appearing in a data list is equal to the number of elements in the array or structure; thus if more than one format item appears in the format list, successive elements will be matched with successive format items.

For example:

```
DCL 1 A,
      2 B CHAR(5),
      2 C FIXED(5,2);
   .
   .
   .
PUT EDIT (A) (A(5),F(5,2));
```

B is matched with the A(5) item, and C is matched with the F(5,2) item.

- If the ON statement:

  ```
  ON ERROR PUT DATA;
  ```

  is used in an outer block, you must remember that variables in inner blocks are not known and, therefore, are not dumped. You might wish, therefore, to repeat the ON-unit in all inner blocks during debugging.

- When you use PUT DATA without a data-list, every variable known at that point in the program is transmitted in data-directed output format to the specified file. Users of this facility, however, should note that:

  – Uninitialized FIXED DECIMAL data might raise the CONVERSION condition or the ERROR condition.

  – Unallocated CONTROLLED data causes arbitrary values to print and, in the case of FIXED DECIMAL, can raise the CONVERSION condition or the ERROR condition.

- An output file generated with PUT LIST contains a blank after the last value in each record. If the file is edited with an edit program that deletes trailing blanks, then values are no longer separated and the file cannot be processed by GET LIST statements.

Notes about Picture Specification Characters

- In a PICTURE declaration, the V character indicates the scale factor, but does not in itself produce a decimal point on output. The point picture character produces a point on output, but is purely an editing character and does not indicate the scale factor. In a decimal constant, however, the point does indicate the scale factor. For example:

  ```
  DCL A PIC'99.9',
      B PIC'99V9',
      C PIC'99.V9';
  A,C=45.6;
  B=7.8;
  PUT LIST (A,B,C);
  ```

  This puts out the following values for A, B, and C, respectively:

  ```
  04.5    078     45.6
  ```

  If these values were now read back into the variables by a GET LIST statement, A, B, and C would be set to the following respective values:

  ```
  004     780    45.6
  ```

If the PUT statement were then repeated, the result would be:

```
00.4    780     45.6
```

- Checking of a picture is performed only on assignment into the picture variable:

```
DCL A PIC'999999',
    B CHAR(6) DEF A,
    C CHAR(6);
B='ABCDEF';
C=A;       /* WILL NOT RAISE CONV CONDITION */
A=C;       /* WILL RAISE CONV */
```

Note also (A, B, C as declared above):

```
A=123456;  /* A HAS VALUE 123456   */
           /* B HAS VALUE '123456' */
C=123456;  /* C HAS VALUE 'bbb123' */
C=A;       /* C HAS VALUE '123456' */
```

Notes about Condition Handling

- Even though a condition was explicitly disabled by means of a condition prefix, a lot of processing can be required if the condition is raised. For example, consider a random number generator in which the previous random number is multiplied by some factor and the effects of overflow are ignored:

```
DECLARE (RANDOM,FACTOR) FIXED BINARY(31,0);
(NOFOFL):RANDOM=RANDOM*FACTOR;
```

If the product of RANDOM and FACTOR cannot be held as FIXED BINARY(31,0), a hardware program-check interrupt occurs. This has to be processed by both the operating system interrupt handler and the PL/I error handler before it can be determined that the FIXEDOVERFLOW condition was disabled.

- If possible, avoid using ON-units for the FINISH condition. These increase the time taken to terminate a PL/I program, and can also cause loops, abends, or other unpredictable results.

- After debugging, disable any normally disabled conditions that were enabled for debugging purposes by removing the relevant prefixes, rather than by including NO-condition prefixes. For instance, disable the SIZE condition by removing the SIZE prefix, rather than by adding a NOSIZE prefix. The former method allows the compiler to eliminate code that checks for the condition, whereas the latter method necessitates the generation of extra code to prevent the checks being carried out.

- If the specified action is to apply when the named condition is raised by a given statement, the ON statement must be executed before that statement. The statements:

```
GET FILE (ACCTS) LIST (A,B,C);
ON TRANSMIT (ACCTS) GO TO TRERR;
```

result in the ERROR condition being raised in the event of a transmission error during the first GET operation, and the required branch is not taken (assuming that no previous ON statement applies). Furthermore, the ON statement is executed after each execution of the GET statement.

- At normal exit from an AREA ON-unit, the implicit action is to try again to make the allocation. As a result, the ON-unit is entered again, and an indefinite loop is created. To avoid this, you should modify the amount allocated in the ON-unit, for example, by using the EMPTY built-in function or by changing a pointer variable.
- Do not use ON-units to implement the program's logic; use them only to recover from truly exceptional conditions. Whenever an ON-unit is entered, considerable error-handling overhead is incurred. To implement the logic, you should perform the necessary tests, rather than use the compiler's condition-detecting facilities.

  For example, in a program using record-oriented output to a keyed data set, you might wish to eliminate certain keys because they would not fit into the limits of the data set. You can rely on the raising of the KEY condition to detect unsuitable keys, but it is considerably more efficient to test each key yourself.
- The SIZE condition might not be raised if a floating-point variable with a value between 2,147,483,648 and 4,294,967,295 is assigned to a fixed-decimal variable with less than 10 digits.

Notes about multitasking

The use of bit strings in a multitasking program can occasionally cause incorrect results. When the program references the bit string, it might be necessary for a PL/I library routine to access adjacent storage, as well as the string itself. If another task modifies this adjacent storage at the same time, the results can be unpredictable. The problem is less likely to occur with aligned bit strings than unaligned.

Part 5. Using interfaces to other products

Chapter 15. Using the Sort Program

The compiler provides an interface called PLISRT*x* (*x* = A, B, C, or D) that allows you to make use of the IBM-supplied Sort programs in MVS and VM.

To use the MVS or VM Sort program with PLISRT*x*, you must:

1. Include a call to one of the entry points of PLISRT*x*, passing it the information on the fields to be sorted. This information includes the length of the records, the maximum amount of storage to use, the name of a variable to be used as a return code, and other information required to carry out the sort.
2. Specify the data sets required by the Sort program in JCL DD statements or by use of the ALLOCATE command on TSO and FILEDEF commands on VM.

When used from PL/I, the Sort program sorts records of all normal lengths on a large number of sorting fields. Data of most types can be sorted into ascending or descending order. The source of the data to be sorted can be either a data set or a user-written PL/I procedure that the Sort program will call each time a record is required for the sort. Similarly, the destination of the sort can be a data set or a PL/I procedure that handles the sorted records.

Using PL/I procedures allows processing to be done before or after the sort itself, thus allowing a complete sorting operation to be handled completely by a call to the sort interface. It is important to understand that the PL/I procedures handling input or output are called from the Sort program itself and will effectively become part of it.

PL/I can operate with DFSORT or a program with the same interface. DFSORT is a release of the program product 5740-SM1. PL/I can also operate with DFSORT/CMS. DFSORT has many built-in features you can use to eliminate the need for writing program logic (for example, INCLUDE, OMIT, OUTREC and SUM statement plus the many ICETOOL operators). See *DFSORT Application Programming Guide* for details and *Getting Started with DFSORT* for a tutorial.

Note: None of your routines should have the name SORT if you are using DFSORT/CMS.

The following material applies to DFSORT. Because you can use programs other than DFSORT, the actual capabilities and restrictions vary. For these capabilities and restrictions, see *DFSORT Application Programming Guide*, or the equivalent publication for your sort product.

To use the Sort program you must include the correct PL/I statements in your source program and specify the correct data sets in your JCL, or in your TSO ALLOCATE or VM FILEDEF commands.

Preparing to Use Sort

Before using Sort, you must determine the type of sort you require, the length and format of the sorting fields in the data, the length of your data records, and the amount of auxiliary and main storage you will allow for sorting.

To determine the PLISRT*x* entry point that you will use, you must decide the source of your unsorted data, and the destination of your sorted data. You must choose between data sets and PL/I subroutines. Using data sets is simpler to understand and gives faster performance. Using PL/I subroutines gives you more flexibility and more function, enabling you to manipulate or print the data before it is sorted, and to make immediate use of it in its sorted form. If you decide to use an input or output handling subroutine, you will need to read “Data Input and Output Handling Routines” on page 360.

The entry points and the source and destination of data are as follows:

Entry point	Source	Destination
PLISRTA	Data set	Data set
PLISRTB	Subroutine	Data set
PLISRTC	Data set	Subroutine
PLISRTD	Subroutine	Subroutine

Having determined the entry point you are using, you must now determine the following things about your data set:

- The position of the sorting fields; these can be either the complete record or any part or parts of it
- The type of data these fields represent, for example, character or binary
- Whether you want the sort on each field to be in ascending or descending order
- Whether you want equal records to be retained in the order of the input, or whether their order can be altered during sorting

Specify these options on the SORT statement, which is the first argument to PLISRT*x*. After you have determined these, you must determine two things about the records to be sorted:

- Whether the record format is fixed or varying
- The length of the record, which is the maximum length for varying

Specify these on the RECORD statement, which is the second argument to PLISRT*x*.

Finally, you must decide on the amount of main and auxiliary storage you will allow for the Sort program. For further details, see “Determining Storage Needed for Sort” on page 355.

Choosing the Type of Sort

If you want to make the best use of the Sort program, you must understand something of how it works. In your PL/I program you specify a sort by using a CALL statement to the sort interface subroutine PLISRT*x*. This subroutine has four entry points: *x*=A, B, C, and D. Each specifies a different source for the unsorted data and destination for the data when it has been sorted. For example, a call to PLISRTA specifies that the unsorted data (the input to sort) is on a data set, and that the sorted data (the output from sort) is to be placed on another data set. The CALL PLISRT*x* statement must contain an argument list giving the Sort program information about the data set to be sorted, the fields on which it is to be sorted, the amount of space available, the name of a variable into which Sort will place a return code indicating the success or failure of the sort, and the name of any output or input handling procedure that can be used.

The sort interface routine builds an argument list for the Sort program from the information supplied by the PLISRT*x* argument list and the choice of PLISRT*x* entry point. Control is then transferred to the Sort program. If you have specified an output- or input-handling routine, this will be called by the Sort program as many times as is necessary to handle each of the unsorted or sorted records. When the sort operation is complete, the Sort program returns to the PL/I calling procedure communicating its success or failure in a return code, which is placed in one of the arguments passed to the interface routine. The return code can then be tested in the PL/I routine to discover whether processing should continue. Figure 82 on page 351 is a simplified flowchart showing this operation.

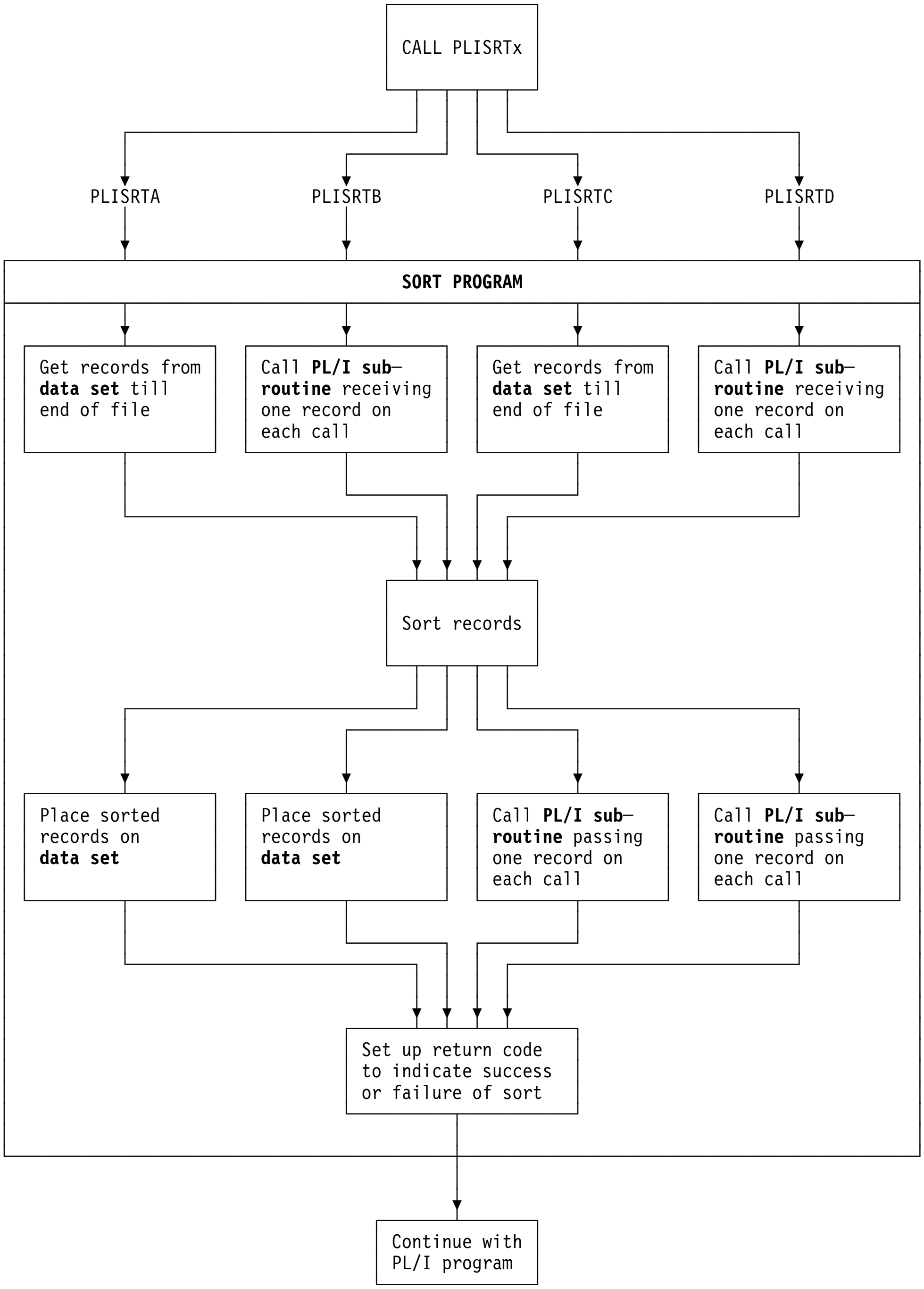

CALL PLISRTx
PLISRTA
PLISRTB
PLISRTC
PLISRTD
SORT PROGRAM
Get records from data set till end of file
Call PL/I sub–routine receiving one record on each call
Get records from data set till end of file
Call PL/I sub–routine receiving one record on each call
Sort records
Place sorted records on data set
Place sorted records on data set
Call PL/I sub–routine passing one record on each call
Call PL/I sub–routine passing one record on each call
Set up return code to indicate success or failure of sort
Continue with PL/I program

Figure 82. Flow of Control for Sort Program

Within the Sort program itself, the flow of control between the Sort program and input- and output-handling routines is controlled by return codes. The Sort program calls these routines at the appropriate point in its processing. (Within the Sort program, and its associated documentation, these routines are known as *user exits*. The routine that passes input to be sorted is the E15 sort user exit. The routine that processes sorted output is the E35 sort user exit.) From the routines, Sort expects a return code indicating either that it should call the routine again, or that it should continue with the next stage of processing.

The important points to remember about Sort are: (1) it is a self-contained program that handles the complete sort operation, and (2) it communicates with the caller, and with the user exits that it calls, by means of return codes.

The remainder of this chapter gives detailed information on how to use Sort from PL/I. First the required PL/I statements are described, and then the data set requirements. The chapter finishes with a series of examples showing the use of the four entry points of the sort interface routine.

Specifying the Sorting Field

The SORT statement is the first argument to PLISRT*x*. The syntax of the SORT statement must be a character string expression that takes the form:

```
'bSORTbFIELDS=(start1,length1,form1,seq1,
 ...startn,lengthn,formn,seqn)[,other options]b'
```

For example:

```
' SORT FIELDS=(1,10,CH,A) '
```

b represents one or more blanks. Blanks shown are mandatory. No other blanks are allowed.

start,length,form,seq
defines a sorting field. You can specify any number of sorting fields, but there is a limit on the total length of the fields. If more than one field is to be sorted on, the records are sorted first according to the first field, and then those that are of equal value are sorted according to the second field, and so on. If all the sorting values are equal, the order of equal records will be arbitrary unless you use the EQUALS option. (See later in this definition list.) Fields can overlay each other.

| For DFSORT (5740-SM1), the maximum total length of the sorting fields is
| restricted to 4092 bytes and all sorting fields must be within 4092 bytes of the
| start of the record. Other sort products might have different restrictions.

start is the starting position within the record. Give the value in bytes except for binary data where you can use a “byte.bit” notation. The first byte in a string is considered to be byte 1, the first bit is bit 0. (Thus the second bit in byte 2 is referred to as 2.1.) For varying length records you must include the 4-byte length prefix, making 5 the first byte of data.

length is the length of the sorting field. Give the value in bytes except for binary where you can use “byte.bit” notation. The length of sorting fields is restricted according to their data type.

form is the format of the data. This is the format assumed for the purpose of sorting. All data passed between PL/I routines and Sort must be in the form of character strings. The main data types and the restrictions on their length are shown below. Additional data types are available for special-purpose sorts. See the *DFSORT Application Programming Guide*, or the equivalent publication for your sort product.

Code	**Data type and length**
CH	character 1–4096
ZD	zoned decimal, signed 1–32
PD	packed decimal, signed 1–32
FI	fixed point, signed 1–256
BI	binary, unsigned 1 bit to 4092 bytes
FL	floating-point, signed 1–256
FS	floating-sign, 1–16

The sum of the lengths of all fields must not exceed 4092 bytes.

seq is the sequence in which the data will be sorted as follows:

A	ascending (that is, 1,2,3,...)
D	descending (that is, ...,3,2,1)

Note: You cannot specify E, because PL/I does not provide a method of passing a user-supplied sequence.

other options
You can specify a number of other options, depending on your Sort program. You must separate them from the FIELDS operand and from each other by commas. Do not place blanks between operands.

FILSZ=*y*
specifies the number of records in the sort and allows for optimization by Sort. If *y* is only approximate, E should precede *y*.

SKIPREC=*y*
specifies that *y* records at the start of the input file are to be ignored before sorting the remaining records.

CKPT or CHKPT
specifies that checkpoints are to be taken. If you use this option, you must provide a SORTCKPT data set and DFSORT's 16NCKPT=NO installation option must be specified.

EQUALS|NOEQUALS
specifies whether the order of equal records will be preserved as it was in the input (EQUALS) or will be arbitrary (NOEQUALS). You could improve sort performance by using the NOEQUALS. The default option is chosen when Sort is installed. The IBM-supplied default is NOEQUALS.

DYNALLOC=(d,n)
(OS/VS Sort only) specifies that the program dynamically allocates intermediate storage.

d is the device type (3380, etc.).
n is the number of work areas.

Specifying the Records to be Sorted

Use the RECORD statement as the second argument to PLISRT*x*. The syntax of the RECORD statement must be a character string expression which, when evaluated, takes the syntax shown below:

```
'bRECORDbTYPE=rectype[,LENGTH=(L1,[,,L4,L5])]b'
```

For example:

```
' RECORD TYPE=F,LENGTH=(80) '
```

b represents one or more blanks. Blanks shown are mandatory. No other blanks are allowed.

TYPE
specifies the type of record as follows:

F fixed length
V varying length EBCDIC
D varying length ASCII

Even when you use input and output routines to handle the unsorted and sorted data, you must specify the record type as it applies to the work data sets used by Sort.

If varying length strings are passed to Sort from an input routine (E15 exit), you should normally specify V as a record format. However, if you specify F, the records are padded to the maximum length with blanks.

LENGTH
specifies the length of the record to be sorted. You can omit LENGTH if you use PLISRTA or PLISRTC, because the length will be taken from the input data set. Note that there is a restriction on the maximum and minimum length of the record that can be sorted (see below). For varying length records, you must include the four-byte prefix.

11 is the length of the record to be sorted. For VSAM data sets sorted as varying records it is the maximum record size+4.

,, represent two arguments that are not applicable to Sort when called from PL/I. You must include the commas if the arguments that follow are used.

14 specifies the minimum length of record when varying length records are used. If supplied, it is used by Sort for optimization purposes.

15 specifies the modal (most common) length of record when varying length records are used. If supplied, it is used by Sort for optimization purposes.

Maximum Record Lengths

The length of a record can never exceed the maximum length specified by the user. The maximum record length for variable length records is 32756 bytes, for fixed length records it is 32760 bytes, and for spanned records it is 32767 bytes.

The minimum block length for tape work units (which should be avoided for performance reasons) is 18 bytes; the minimum record length is 14 bytes.

Determining Storage Needed for Sort

Main Storage

Sort requires both main and auxiliary storage. The minimum main storage for DFSORT is 88K bytes, but for best performance, more storage (on the order of 1 megabyte or more) is recommended. DFSORT can take advantage of storage above 16M virtual or extended architecture processors. Under MVS/ESA, DFSORT can also take advantage of expanded storage. You can specify that Sort use the maximum amount of storage available by passing a storage parameter in the following manner:

```
DCL MAXSTOR FIXED BINARY (31,0);
UNSPEC(MAXSTOR)='00000000'B||UNSPEC('MAX');
CALL PLISRTA
    (' SORT FIELDS=(1,80,CH,A) ',
     ' RECORD TYPE=F,LENGTH=(80) ',
       MAXSTOR,
       RETCODE,
       'TASK');
```

If files are opened in E15 or E35 exit routines, enough residual storage should be allowed for the files to open successfully.

Auxiliary Storage

Calculating the minimum auxiliary storage for a particular sorting operation is a complicated task. To achieve maximum efficiency with auxiliary storage, use direct access storage devices (DASDs) whenever possible. For more information on improving program efficiency, see the *DFSORT Application Programming Guide*, particularly the information about dynamic allocation of workspace which allos DFSORT to determine the auxiliary storage needed and allocate it for you.

If you are interested only in providing enough storage to ensure that the sort will work, make the total size of the SORTWK data sets large enough to hold three sets of the records being sorted. (You will not gain any advantage by specifying more than three if you have enough space in three data sets.)

However, because this suggestion is an approximation, it might not work, so you should check the sort manuals. If this suggestion does work, you will probably have wasted space.

Calling the Sort Program

When you have determined the points described above, you are in a position to write the CALL PLISRT*x* statement. You should do this with some care; for the entry points and arguments to use, see Table 44.

Table 44 (Page 1 of 2). The Entry Points and Arguments to PLISRTx (x = A, B, C, or D)

Entry points	**Arguments**
PLISRTA Sort input: data set Sort output: data set	(sort statement,record statement,storage,return code [,data set prefix,message level, sort technique])
PLISRTB Sort input: PL/I subroutine Sort output: data set	(sort statement,record statement,storage,return code,input routine [,data set prefix,message level,sort technique])

Table 44 (Page 2 of 2). The Entry Points and Arguments to PLISRTx (x = A, B, C, or D)

Entry points	Arguments
PLISRTC Sort input: data set Sort output: PL/I subroutine	(sort statement,record statement,storage,return code,output routine [,data set prefix,message level,sort technique])
PLISRTD Sort input: PL/I subroutine Sort output: PL/I subroutine	(sort statement,record statement,storage,return code,input routine,output routine[,data set prefix,message level,sort technique])
Sort statement	Character string expression containing the Sort program SORT statement. Describes sorting fields and format. See “Specifying the Sorting Field” on page 352.
Record statement	Character string expression containing the Sort program RECORD statement. Describes the length and record format of data. See “Specifying the Records to be Sorted” on page 354.
Storage	Fixed binary expression giving maximum amount of main storage to be used by the Sort program. Must be >88K bytes for DFSORT. See also “Determining Storage Needed for Sort.”
Return code	Fixed binary variable of precision (31,0) in which Sort places a return code when it has completed. The meaning of the return code is: 0=Sort successful 16=Sort failed 20=Sort message data set missing
Input routine	(PLISRTB and PLISRTD only.) Name of the PL/I external or internal procedure used to supply the records for the Sort program at sort exit E15.
Output routine	(PLISRTC and PLISRTD only.) Name of the PL/I external or internal procedure to which Sort passes the sorted records at sort exit E35.
Data set prefix	Character string expression of four characters that replaces the default prefix of 'SORT' in the names of the sort data sets SORTIN, SORTOUT, SORTWKnn and SORTCNTL, if used. Thus if the argument is “TASK”, the data sets TASKIN, TASKOUT, TASKWKnn, and TASKCNTL can be used. This facility enables multiple invocations of Sort to be made in the same job step. The four characters must start with an alphabetic character and must not be one of the reserved names PEER, BALN, CRCX, OSCL, POLY, DIAG, SYSC, or LIST. You must code a null string for this argument if you require either of the following arguments but do not require this argument.
Message level	Character string expression of two characters indicating how Sort's diagnostic messages are to be handled, as follows: NO No messages to SYSOUT AP All messages to SYSOUT CP Critical messages to SYSOUT SYSOUT will normally be allocated to the printer, hence the use of the mnemonic letter “P”. Other codes are also allowed for certain of the Sort programs. For further details on these codes, see *DFSORT Application Programming Guide*. You must code a null string for this argument if you require the following argument but you do not require this argument.
Sort technique	(This is not used by DFSORT; it appears for compatibility reasons only.) Character string of length 4 that indicates the type of sort to be carried out, as follows: PEER Peerage sort BALN Balanced CRCX Criss-cross sort OSCL Oscillating POLY Polyphase sort Normally the Sort program will analyze the amount of space available and choose the most effective technique without any action from you. You should use this argument only as a bypass for sorting problems or when you are certain that performance could be improved by another technique. See *DFSORT Application Programming Guide* for further information.

The examples below indicate the form that the CALL PLISRT*x* statement normally takes.

Example 1

A call to PLISRTA sorting 80-byte records from SORTIN to SORTOUT using 1048576 (1 megabyte) of storage, and a return code, RETCODE, declared as FIXED BINARY (31,0).

```
CALL PLISRTA (' SORT FIELDS=(1,80,CH,A) ',
              ' RECORD TYPE=F,LENGTH=(80) ',
                1048576,
                RETCODE);
```

Example 2

This example is the same as example 1 except that the input, output, and work data sets are called TASKIN, TASKOUT, TASKWK01, and so forth. This might occur if Sort was being called twice in one job step.

```
CALL PLISRTA (' SORT FIELDS=(1,80,CH,A) ',
              ' RECORD TYPE=F,LENGTH=(80) ',
                1048576,
                RETCODE,
                'TASK');
```

Example 3

This example is the same as example 1 except that the sort is to be undertaken on two fields. First, bytes 1 to 10 which are characters, and then, if these are equal, bytes 11 and 12 which contain a binary field, both fields are to be sorted in ascending order.

```
CALL PLISRTA (' SORT FIELDS=(1,10,CH,A,11,2,BI,A) ',
              ' RECORD TYPE=F,LENGTH=(80) ',
                1048576,
                RETCODE);
```

Example 4

This example shows a call to PLISRTB. The input is to be passed to Sort by the PL/I routine PUTIN, the sort is to be carried out on characters 1 to 10 of an 80 byte fixed length record. Other information as above.

```
CALL PLISRTB (' SORT FIELDS=(1,10,CH,A) ',
              ' RECORD TYPE=F,LENGTH=(80) ',
                1048576,
                RETCODE,
                PUTIN);
```

Example 5

This example shows a call to PLISRTD. The input is to be supplied by the PL/I routine PUTIN and the output is to be passed to the PL/I routine PUTOUT. The record to be sorted is 84 bytes varying (including the length prefix). It is to be sorted on bytes 1 through 5 of the data in ascending order, then if these fields are equal, on bytes 6 through 10 in descending order. (Note that the 4-byte length prefix is included so that the actual values used are 5 and 10 for the starting points.) If both these fields are the same, the order of the input is to be retained. (The EQUALS option does this.)

```
CALL PLISRTD (' SORT FIELDS=(5,5,CH,A,10,5,CH,D),EQUALS ',
              ' RECORD TYPE=V,LENGTH=(84) ',
                1048576,
                RETCODE,
                PUTIN,      /*input routine (sort exit E15)*/
                PUTOUT);    /*output routine (sort exit E35)*/
```

Determining Whether the Sort Was Successful

When the sort is completed, Sort sets a return code in the variable named in the fourth argument of the call to PLISRT*x*. It then returns control to the statement that follows the CALL PLISRT*x* statement. The value returned indicates the success or failure of the sort as follows:

0	Sort successful
16	Sort failed
20	Sort message data set missing

You must declare the variable to which the return code is passed as FIXED BINARY (31,0). It is standard practice to test the value of the return code after the CALL PLISRT*x* statement and take appropriate action according to the success or failure of the operation.

For example (assuming the return code was called RETCODE):

```
IF RETCODE¬=0 THEN DO;
  PUT DATA(RETCODE);
  SIGNAL ERROR;
END;
```

If the job step that follows the sort depends on the success or failure of the sort, you should set the value returned in the Sort program as the return code from the PL/I program. This return code is then available for the following job step. The PL/I return code is set by a call to PLIRETC. You can call PLIRETC with the value returned from Sort thus:

```
CALL PLIRETC(RETCODE);
```

You should not confuse this call to PLIRETC with the calls made in the input and output routines, where a return code is used for passing control information to Sort.

Establishing Data Sets for Sort

If DFSORT was installed in a library not know to the system, you must specify the DFSORT library in a JOBLIB or STEPLIB DD statement.

When you call Sort, certain sort data sets must not be open. These are:

SORTLIB
This library is only required if your work data sets (see below) are on magnetic tape (which is not recommended for performance reasons). You must get the name of this data set from your system programmer.

SYSOUT
A data set (normally the printer) on which messages from the Sort program will be written.

Sort Work Data Sets

SORTWK01–SORTWK32

Note: If you specify more than 32 sort work data sets, DFSORT will only use the first 32.

******WK01–****WK32**
From 1 to 32 working data sets used in the sorting process. These can be direct-access or on magnetic tape. For a discussion of space required and number of data sets, see “Determining Storage Needed for Sort” on page 355.

**** represents the four characters that you can specify as the data set prefix argument in calls to PLISRT*x*. This allows you to use data sets with prefixes other than SORT. They must start with an alphabetic character and must not be the names PEER, BALN, CRCX, OSCL, POLY, SYSC, LIST, or DIAG.

Input Data Set

SORTIN

******IN**
The input data set used when PLISRTA and PLISRTC are called.

See *****WK01–****WK32* above for a detailed description.

Output Data Set

SORTOUT

******OUT**
The output data set used when PLISRTA and PLISRTB are called.

See *****WK01–****WK32* above for a detailed description.

Checkpoint Data Set

SORTCKPT

Data set used to hold checkpoint data, if CKPT or CHKPT option was used in the SORT statement argument and DFSORT's 16NCKPT=NO installation option was specified. For information on this program DD statement, see *DFSORT Application Programming Guide*.

DFSPARM
SORTCNTL

Data set from which additional or changed control statements can be read (optional). For additional information on this program DD statement, see *DFSORT Application Programming Guide*.

See *****WK01–****WK32* above for a detailed description.

Sort Data Input and Output

The source of the data to be sorted is provided either directly from a data set or indirectly by a routine (Sort Exit E15) written by the user. Similarly, the destination of the sorted output is either a data set or a routine (Sort Exit E35) provided by the user.

PLISRTA is the simplest of all of the interfaces because it sorts from data set to data set. An example of a PLISRTA program is in Figure 86 on page 365. Other interfaces require either the input handling routine or the output handling routine, or both.

Data Input and Output Handling Routines

The input handling and output handling routines are called by Sort when PLISRTB, PLISRTC, or PLISRTD is used. They must be written in PL/I, and can be either internal or external procedures. If they are internal to the routine that calls PLISRT*x*, they behave in the same way as ordinary internal procedures in respect of scope of names. The input and output procedure names must themselves be known in the procedure that makes the call to PLISRT*x*.

The routines are called individually for each record required by Sort or passed from Sort. Therefore, each routine must be written to handle one record at a time. Variables declared as AUTOMATIC within the procedures will not retain their values between calls. Consequently, items such as counters, which need to be retained from one call to the next, should either be declared as STATIC or be declared in the containing block.

E15 — Input Handling Routine (Sort Exit E15)

Input routines are normally used to process the data in some way before it is sorted. You can use input routines to print the data, as shown in the Figure 87 on page 366 and Figure 89 on page 368, or to generate or manipulate the sorting fields to achieve the correct results.

The input handling routine is used by Sort when a call is made to either PLISRTB or PLISRTD. When Sort requires a record, it calls the input routine which should return a record in character string format, with a return code of 12. This return code means that the record passed is to be included in the sort. Sort continues to call the routine until a return code of 8 is passed. A return code of 8 means that all records have *already* been passed, and that Sort is not to call the routine again. If a record is returned when the return code is 8, it is ignored by Sort.

The data returned by the routine must be a character string. It can be fixed or varying. If it is varying, you should normally specify V as the record format in the RECORD statement which is the second argument in the call to PLISRT*x*. However, you can specify F, in which case the string will be padded to its maximum length with blanks. The record is returned with a RETURN statement, and you must specify the RETURNS attribute in the PROCEDURE statement. The return code is set in a call to PLIRETC. A flowchart for a typical input routine is shown in Figure 83 on page 362.

Skeletal code for a typical input routine is shown in Figure 84 on page 363.

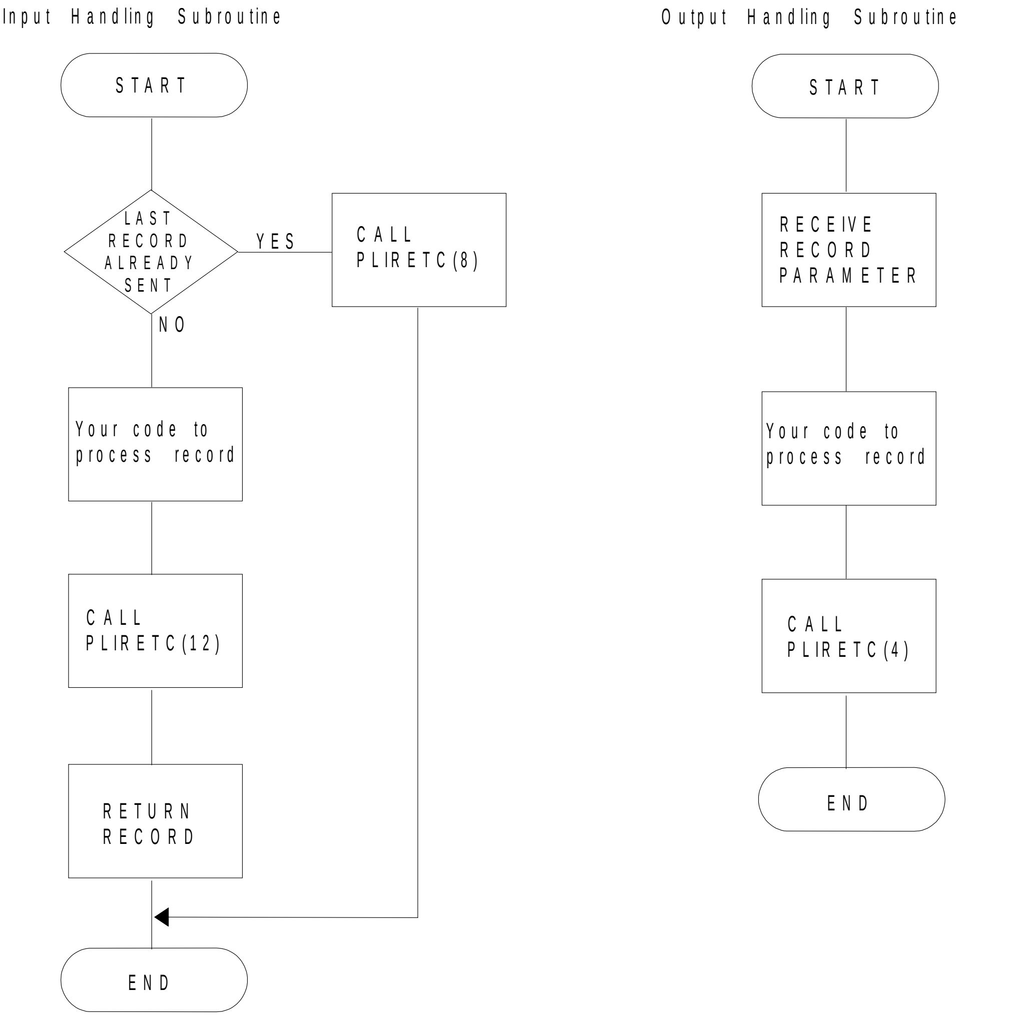


Figure 83. Flowcharts for Input and Output Handling Subroutines

```
E15: PROC RETURNS (CHAR(80));
     /*---------------------------------------------------------------*/
     /*RETURNS attribute must be used specifying length of data to be */
     /* sorted, maximum length if varying strings are passed to Sort. */
     /*---------------------------------------------------------------*/
   DCL STRING CHAR(80); /*--------------------------------------------*/
                        /*A character string variable will normally be*/
                        /* required to return the data to Sort        */
                        /*--------------------------------------------*/

   IF LAST_RECORD_SENT THEN
     DO;
      /*---------------------------------------------------------------*/
      /*A test must be made to see if all the records have been sent,  */
      /*if they have, a return code of 8 is set up and control returned*/
      /*to Sort                                                        */
      /*---------------------------------------------------------------*/

        CALL PLIRETC(8);  /*-------------------------------------------*/
                          /* Set return code of 8, meaning last record */
                          /* already sent.                             */
                          /*-------------------------------------------*/
        GOTO FINAL;

     END;

   ELSE
     DO;
      /*------------------------------------------------*/
      /* If another record is to be sent to Sort, do the*/
      /* necessary processing, set a return code of 12  */
      /* by calling PLIRETC, and return the data as a   */
      /* character string to Sort                       */
      /*------------------------------------------------*/

   ****(The code to do your processing goes here)

       CALL PLIRETC (12);  /*--------------------------------------*/
                           /* Set return code of 12, meaning this  */
                           /* record is to be included in the sort */
                           /*--------------------------------------*/
       RETURN (STRING);  /*Return data with RETURN statement*/
     END;
FINAL:
  END;   /*End of the input procedure*/
```

Figure 84. Skeletal Code for an Input Procedure

Examples of an input routine are given in Figure 87 on page 366 and Figure 89 on page 368.

In addition to the return codes of 12 (include current record in sort) and 8 (all records sent), Sort allows the use of a return code of 16. This ends the sort and causes Sort to return to your PL/I program with a return code of 16–Sort failed.

Note: A call to PLIRETC sets a return code that will be passed by your PL/I program, and will be available to any job steps that follow it. When an output handling routine has been used, it is good practice to reset the return code with a call to PLIRETC after the call to PLISRT*x* to avoid receiving a nonzero completion code. By calling PLIRETC with the return code from Sort as the argument, you can make the PL/I return code reflect the success or failure of the sort. This practice is shown in Figure 88 on page 367.

E35 — Output Handling Routine (Sort Exit E35)

Output handling routines are normally used for any processing that is necessary after the sort. This could be to print the sorted data, as shown in Figure 88 on page 367 and Figure 89 on page 368, or to use the sorted data to generate further information. The output handling routine is used by Sort when a call is made to PLISRTC or PLISRTD. When the records have been sorted, Sort passes them, one at a time, to the output handling routine. The output routine then processes them as required. When all the records have been passed, Sort sets up its return code and returns to the statement after the CALL PLISRT*x* statement. There is no indication from Sort to the output handling routine that the last record has been reached. Any end-of-data handling must therefore be done in the procedure that calls PLISRT*x*.

The record is passed from Sort to the output routine as a character string, and you must declare a character string parameter in the output handling subroutine to receive the data. The output handling subroutine must also pass a return code of 4 to Sort to indicate that it is ready for another record. You set the return code by a call to PLIRETC.

The sort can be stopped by passing a return code of 16 to Sort. This will result in Sort returning to the calling program with a return code of 16–Sort failed.

The record passed to the routine by Sort is a character string parameter. If you specified the record type as F in the second argument in the call to PLISRT*x*, you should declare the parameter with the length of the record. If you specified the record type as V, you should declare the parameter as adjustable, as in the following example:

```
DCL STRING CHAR(*);
```

Figure 90 on page 369 shows a program that sorts varying length records.

A flowchart for a typical output handling routine is given in Figure 83 on page 362. Skeletal code for a typical output handling routine is shown in Figure 85.

```
E35: PROC(STRING);      /*The procedure must have a character string
                          parameter to receive the record from Sort*/

  DCL STRING CHAR(80);  /*Declaration of parameter*/

 (Your code goes here)

  CALL PLIRETC(4);   /*Pass return code to Sort indicating that the next
                       sorted record is to be passed to this procedure.*/
   END E35;          /*End of procedure returns control to Sort*/
```

Figure 85. Skeletal Code for an Output Handling Procedure

You should note that a call to PLIRETC sets a return code that will be passed by your PL/I program, and will be available to any job steps that follow it. When you have used an output handling routine, it is good practice to reset the return code with a call to PLIRETC after the call to PLISRT*x* to avoid receiving a nonzero completion code. By calling PLIRETC with the return code from Sort as the argument, you can make the PL/I return code reflect the success or failure of the sort. This practice is shown in the examples at the end of this chapter.

Calling PLISRTA Example

After each time that the PL/I input- and output-handling routines communicate the return-code information to the Sort program, the return-code field is reset to zero; therefore, it is not used as a regular return code other than its specific use for the Sort program.

For details on handling conditions, especially those that occur during the input- and output-handling routines, see *Language Environment for MVS & VM Programming Guide*.

```
//OPT14#7  JOB ...
//STEP1 EXEC IEL1CLG
//PLI.SYSIN DD *
 EX106: PROC OPTIONS(MAIN);
     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                   ' RECORD TYPE=F,LENGTH=(80) ',
                     1048576
                     RETURN_CODE);
     SELECT (RETURN_CODE);
       WHEN(0) PUT SKIP EDIT
           ('SORT COMPLETE RETURN_CODE 0') (A);
       WHEN(16) PUT SKIP EDIT
           ('SORT FAILED, RETURN_CODE 16') (A);
       WHEN(20) PUT SKIP EDIT
           ('SORT MESSAGE DATASET MISSING ') (A);
       OTHER    PUT SKIP EDIT (
            'INVALID SORT RETURN_CODE = ', RETURN_CODE) (A,F(2));
       END /* select */;
       CALL PLIRETC(RETURN_CODE);
      /*set PL/I return code to reflect success of sort*/
       END EX106;
//GO.SORTIN DD *
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002886BOOKER R.R. ROTORUA, LINKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SYSPRINT DD SYSOUT=A
//GO.SORTOUT DD SYSOUT=A
//GO.SYSOUT DD SYSOUT=A
//GO.SORTWK01 DD UNIT=SYSDA,SPACE=(CYL,2)
/*
```

Figure 86. PLISRTA—Sorting from Input Data Set to Output Data Set

Calling PLISRTB Example

```
//OPT14#8  JOB ...
//STEP1 EXEC IEL1CLG
//PLI.SYSIN DD *
 EX107:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTB (' SORT FIELDS=(7,74,CH,A) ',
                  ' RECORD TYPE=F,LENGTH=(80) ',
                  1048576
                  RETURN_CODE,
                  E15X);
     SELECT(RETURN_CODE);
       WHEN(0)  PUT SKIP EDIT
           ('SORT COMPLETE RETURN_CODE 0') (A);
       WHEN(16) PUT SKIP EDIT
           ('SORT FAILED, RETURN_CODE 16') (A);
       WHEN(20) PUT SKIP EDIT
           ('SORT MESSAGE DATASET MISSING ') (A);
       OTHER   PUT SKIP EDIT
           ('INVALID RETURN_CODE = ',RETURN_CODE)(A,F(2));
     END /* select */;
     CALL PLIRETC(RETURN_CODE);
      /*set PL/I return code to reflect success of sort*/

 E15X:   /* INPUT HANDLING ROUTINE GETS RECORDS FROM THE INPUT
            STREAM AND PUTS THEM BEFORE THEY ARE SORTED*/
     PROC RETURNS (CHAR(80));
          DCL SYSIN FILE RECORD INPUT,
              INFIELD CHAR(80);

          ON ENDFILE(SYSIN) BEGIN;
             PUT SKIP(3) EDIT ('END OF SORT PROGRAM INPUT')(A);
             CALL PLIRETC(8);  /* signal that last record has
                                 already been sent to sort*/
             GOTO ENDE15;
             END;

           READ FILE (SYSIN) INTO (INFIELD);
           PUT SKIP EDIT (INFIELD)(A(80)); /*PRINT INPUT*/
           CALL PLIRETC(12);  /* request sort to include current
                               record and return for more*/
          RETURN(INFIELD);
    ENDE15:
          END E15X;
  END EX107;
/*
//GO.SYSIN DD *
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002886BOOKER R.R. ROTORUA, LINKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SYSPRINT DD SYSOUT=A
//GO.SORTOUT  DD SYSOUT=A
//GO.SYSOUT DD SYSOUT=A
//*
//GO.SORTCNTL DD *
   OPTION DYNALLOC=(3380,2),SKIPREC=2
/*
```

Figure 87. PLISRTB—Sorting from Input Handling Routine to Output Data Set

Calling PLISRTC Example

```
//OPT14#9  JOB ...
//STEP1 EXEC IEL1CLG
//PLI.SYSIN DD *
 EX108:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTC (' SORT FIELDS=(7,74,CH,A) ',
                  ' RECORD TYPE=F,LENGTH=(80) ',
                  1048576
                  RETURN_CODE,
                  E35X);
        SELECT(RETURN_CODE);
          WHEN(0)  PUT SKIP EDIT
              ('SORT COMPLETE RETURN_CODE 0') (A);
          WHEN(16) PUT SKIP EDIT
              ('SORT FAILED, RETURN_CODE 16') (A);
          WHEN(20) PUT SKIP EDIT
              ('SORT MESSAGE DATASET MISSING ') (A);
          OTHER    PUT SKIP EDIT
              ('INVALID RETURN_CODE = ', RETURN_CODE) (A,F(2));
        END /* select */;
     CALL PLIRETC (RETURN_CODE);
      /*set PL/I return code to reflect success of sort*/

 E35X:   /* output handling routine prints sorted records*/
       PROC (INREC);
          DCL INREC CHAR(80);
          PUT SKIP EDIT (INREC) (A);
          CALL PLIRETC(4); /*request next record from sort*/
       END E35X;
    END EX108;
/*
//GO.STEPLIB DD DSN=SYS1.SORTLINK,DISP=SHR
//GO.SYSPRINT DD SYSOUT=A
//GO.SYSOUT   DD SYSOUT=A
//GO.SORTIN DD *
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059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SORTCNTL DD *
   OPTION DYNALLOC=(3380,2),SKIPREC=2
/*
```

Figure 88. PLISRTC—Sorting from Input Data Set to Output Handling Routine

Calling PLISRTD Example

```
 //OPT14#10  JOB ...
 //STEP1 EXEC IEL1CLG
 //PLI.SYSIN DD *
  EX109:  PROC OPTIONS(MAIN);
      DCL RETURN_CODE FIXED BIN(31,0);
      CALL PLISRTD (' SORT FIELDS=(7,74,CH,A) ',
                   ' RECORD TYPE=F,LENGTH=(80) ',
                   1048576
                   RETURN_CODE,
                   E15X,
                   E35X);

      SELECT(RETURN_CODE);
        WHEN(0)  PUT SKIP EDIT
            ('SORT COMPLETE RETURN_CODE 0') (A);
        WHEN(20) PUT SKIP EDIT
            ('SORT MESSAGE DATASET MISSING ') (A);
        OTHER    PUT SKIP EDIT
            ('INVALID RETURN_CODE = ', RETURN_CODE) (A,F(2));
        END /* select */;

      CALL PLIRETC(RETURN_CODE);
       /*set PL/I return code to reflect success of sort*/

  E15X:   /* Input handling routine prints input before sorting*/
        PROC RETURNS(CHAR(80));
             DCL INFIELD CHAR(80);

             ON ENDFILE(SYSIN) BEGIN;
                PUT SKIP(3) EDIT ('END OF SORT PROGRAM INPUT.  ',
                    'SORTED OUTPUT SHOULD FOLLOW')(A);
                CALL PLIRETC(8);  /* Signal end of input to sort*/
                GOTO ENDE15;
             END;

             GET FILE (SYSIN) EDIT (INFIELD) (A(80));
             PUT SKIP EDIT (INFIELD)(A);
             CALL PLIRETC(12);  /*Input to sort continues*/
            RETURN(INFIELD);
   ENDE15:
             END E15X;

   E35X:   /* Output handling routine prints the sorted records*/
        PROC (INREC);

             DCL INREC CHAR(80);
             PUT SKIP EDIT (INREC) (A);
      NEXT:  CALL PLIRETC(4); /* Request next record from sort*/
             END E35X;
  END EX109;
 /*
//GO.SYSOUT DD SYSOUT=A
//GO.SYSPRINT DD SYSOUT=A
//GO.SORTWK01 DD UNIT=SYSDA,SPACE=(CYL,1)
//GO.SORTWK02 DD UNIT=SYSDA,SPACE=(CYL,1)
//GO.SORTWK03 DD UNIT=SYSDA,SPACE=(CYL,1)
//GO.SYSIN DD *
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003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
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000931FOREST, IVER, BUCKS
/*
```

Figure 89. PLISRTD—Sorting from Input Handling Routine to Output Handling Routine

Sorting Variable-Length Records Example

```
//OPT14#11 JOB ...
//STEP1 EXEC IEL1CLG
//PLI.SYSIN DD *
  /* PL/I EXAMPLE USING PLISRTD TO SORT VARIABLE-LENGTH
     RECORDS */

  EX1306:  PROC OPTIONS(MAIN);
          DCL RETURN_CODE FIXED BIN(31,0);
          CALL PLISRTD (' SORT FIELDS=(11,14,CH,A) ',
                       ' RECORD TYPE=V,LENGTH=(84,,,24,44) ',
                       /*NOTE THAT LENGTH IS MAX AND INCLUDES
                         4 BYTE LENGTH PREFIX*/
                       1048576
                       RETURN_CODE,
                       PUTIN,
                       PUTOUT);

               SELECT(RETURN_CODE);
                 WHEN(0)  PUT SKIP EDIT (
                        'SORT COMPLETE RETURN_CODE 0') (A);
                 WHEN(16) PUT SKIP EDIT (
                        'SORT FAILED, RETURN_CODE 16') (A);
                 WHEN(20) PUT SKIP EDIT (
                        'SORT MESSAGE DATASET MISSING ') (A);
                 OTHER    PUT SKIP EDIT (
                      'INVALID RETURN_CODE = ', RETURN_CODE)
                          (A,F(2));
               END /* SELECT */;

     CALL PLIRETC(RETURN_CODE);
      /*SET PL/I RETURN CODE TO REFLECT SUCCESS OF SORT*/
      PUTIN: PROC RETURNS (CHAR(80) VARYING);
        /*OUTPUT HANDLING ROUTINE*/
        /*NOTE THAT VARYING MUST BE USED ON RETURNS ATTRIBUTE
          WHEN USING VARYING LENGTH RECORDS*/
          DCL STRING CHAR(80) VAR;

          ON ENDFILE(SYSIN) BEGIN;
               PUT SKIP EDIT ('END OF INPUT')(A);
               CALL PLIRETC(8);
               GOTO ENDPUT;
               END;

          GET EDIT(STRING)(A(80));
          I=INDEX(STRING||'  ','  ')-1;/*RESET LENGTH OF THE*/
          STRING = SUBSTR(STRING,1,I); /* STRING FROM 80 TO */
                                       /* LENGTH OF TEXT IN */
                                       /* EACH INPUT RECORD.*/
```

Figure 90 (Part 1 of 2). Sorting Varying-Length Records Using Input and Output Handling Routines

```
          PUT SKIP EDIT(I,STRING) (F(2),X(3),A);
          CALL PLIRETC(12);
          RETURN(STRING);
 ENDPUT:  END;
 PUTOUT:PROC(STRING);
         /*OUTPUT HANDLING ROUTINE OUTPUT SORTED RECORDS*/
          DCL STRING CHAR (*);
           /*NOTE THAT FOR VARYING RECORDS THE STRING
             PARAMETER FOR THE OUTPUT-HANDLING ROUTINE
             SHOULD BE DECLARED ADJUSTABLE BUT CANNOT BE
             DECLARED VARYING*/
          PUT SKIP EDIT(STRING)(A);  /*PRINT THE SORTED DATA*/
          CALL PLIRETC(4);
          END;  /*ENDS PUTOUT*/
         END;
/*
//GO.SYSIN DD *
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002886BOOKER R.R. ROTORUA, LINKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SYSPRINT DD SYSOUT=A
//GO.SORTOUT DD SYSOUT=A
//GO.SYSOUT DD SYSOUT=A
//GO.SORTWK01 DD UNIT=SYSDA,SPACE=(CYL,1)
//GO.SORTWK02 DD UNIT=SYSDA,SPACE=(CYL,1)
//*
```

Figure 90 (Part 2 of 2). Sorting Varying-Length Records Using Input and Output Handling Routines

Part 6. Specialized programming tasks

Chapter 16. Parameter Passing and Data Descriptors

This chapter describes PL/I parameter passing conventions and also special PL/I control blocks that are passed between PL/I routines at run time. The most important of these control blocks, called locators and descriptors, provide lengths, bounds, and sizes of certain types of argument data.

Assembler routines can communicate with PL/I routines by following the parameter passing techniques described in this chapter. This includes assembler routines that call PL/I routines and PL/I routines that call assembler routines.

For additional information about LE/370 run-time environment considerations, other than parameter passing conventions, see the *Language Environment for MVS & VM Programming Guide*. This includes run-time environment conventions and assembler macros supporting these conventions,

PL/I Parameter Passing Conventions

PL/I passes arguments using two methods:

- By passing the address of the arguments in the argument list
- By imbedding the arguments in the argument list

This section discusses the first method. For information on the second method, see “Options BYVALUE” on page 378.

When arguments are passed by address between PL/I routines, register 1 points to a list of addresses that is called an argument list. Each address in the argument list occupies a fullword in storage. The last fullword in the list must have its high-order bit turned on for the last argument address to be recognized. If a function reference is used, the address of the returned value or its control block is passed as an implicit last argument. In this situation, the implicit last argument is marked as the last argument, using the high-order bit flagging.

If no arguments are passed in a CALL statement, register 1 is set to zero.

When arguments are passed between PL/I routines, what is passed varies depending upon the type of data passed. The argument list addresses are the addresses of the data items for scalar arithmetic items. For other items, where the receiving routines might expect information about length or format in addition to the data itself, locators and descriptors are used. For program control information such as files or entries, other control blocks are used.

Table 45 on page 374 shows the argument address that is passed between PL/I routines for different data types. The table also includes the effect of the ASSEMBLER option. This option is recommended. See “Passing Assembler Parameters” on page 374 for additional details.

Table 45. Argument List Addresses

Data type passed	Address passed
Arithmetic items	Arithmetic variable
Array or structure	Array or structure variable, if OPTIONS(ASM) Otherwise, aggregate locator[1]
String or area	String or area variable, if OPTIONS(ASM)[2] Otherwise, locator/descriptor[1]
File constant/variable	File variable[3]
Entry	Entry variable[4]
Label	Label variable[5]
Pointer	Pointer variable
Offset	Offset variable

Notes:

1. Locators and descriptors are described below in “Descriptors and Locators” on page 380.
2. With options ASSEMBLER: When an unaligned bit string is involved, the address passed points to the byte that contains the start of the bit string. For a VARYING length string, the address passed points to the 2-byte field specifying the current length of the string that precedes the string.
3. A file variable is a fullword holding the address of file control data.
4. An entry variable consists of two words. The first word has the address of the entry. The second word has the address of the save area for the immediately statically encompassing block or zero, if none.
5. A label variable consists of two words. The first word has the address of a label constant. The second word has the address of the save area of the block that owns the label at the time of assignment. A label constant consists of two words. The first word has the address of the label in the program. The second word has program control data.

Passing Assembler Parameters

If you call an assembler routine from PL/I, the ASSEMBLER option is recommended in the declaration of the assembler entry name. For example,

```
DCL ASMRTN ENTRY OPTIONS(ASSEMBLER);
DCL C CHAR(80);

CALL ASMRTN(C);
```

When the ASSEMBLER option is specified, the addresses of the data items are passed directly. No PL/I locators or descriptors are involved. In the example above, the address in the argument list is that of the first character in the 80-byte character string.

For details about how argument lists are built, see “PL/I Parameter Passing Conventions” above.

An assembler routine whose entry point has been declared with the ASSEMBLER option can only be invoked by means of a CALL statement. You cannot use it as a function reference. You can avoid the use of function references by passing the returned value field as a formal argument to the assembler routine.

An assembler routine can pass back a return code to a PL/I routine in register 15. If you declare the assembler entry with the option RETCODE, the value passed back in register 15 is saved by the PL/I routine and is accessed when the built-in function PLIRETV is used. If you do not declare the entry with the option RETCODE, any register 15 return code is ignored.

Figure 91 shows the coding for a PL/I routine that invokes an assembler routine with the option RETCODE.

```
 P1: PROC;
     DCL A FIXED BIN(31) INIT(3);
     DCL C CHAR(8) INIT('ASM2 RTN');
     DCL AR(3)   FIXED BIN(15);
     DCL ASM2 ENTRY EXTERNAL OPTIONS(ASM RETCODE);
     DCL PLIRETV BUILTIN;

     /* Invoke entry ASM2.                                     */
     /* The argument list has three pointers.                  */
     /* The first  pointer addresses a copy of variable A.     */
     /* The second pointer addresses the storage for C.        */
     /* The third  pointer addresses the storage for AR.       */
     CALL ASM2((A),C,AR);

     /* Check register 15 return code passed back from assembler  */
     /* routine.                                                  */
     IF PLIRETV¬=0 THEN STOP;

     END P1;
```

Figure 91. A PL/I Routine That Invokes an Assembler Routine with the Option RETCODE

If an assembler routine calls a PL/I procedure, the use of locators and descriptors should be avoided. Although you cannot specify ASSEMBLER as an option in a PROCEDURE statement, locators and descriptors can be avoided if the procedures do not directly receive strings, areas, arrays, or structures as parameters. For example, you can pass a pointer to these items instead. If a length, bound, or size is needed, you can pass these as a separate parameter. If your assembler routine is invoking a PL/I MAIN procedure, see “Passing MAIN Procedure Parameters” on page 376 for additional considerations involving MAIN procedure parameters.

Figure 92 on page 376 shows a PL/I routine that is invoked by an assembler routine, which is assumed to be operating within the Language Environment environment.

```
ASMR     CSECT
         .
         .
*
*        Invoke procedure P2 passing four arguments.
*
         LA    1,ALIST             Register 1 has argument list
         L     15,P2               Set P2 entry address
         BALR  14,15               Invoke procedure P2
         .
         .
*
*        Argument list below contains the addresses of 4 arguments.
*
ALIST    DC    A(A)                1st argument address
         DC    A(P)                2nd argument address
         DC    A(Q)                3rd argument address
         DC    A(R+X'80000000')    4th argument address
*
A        DC    F'3'                Fixed bin(31) argument
P        DC    A(C)                Pointer (to C) argument
Q        DC    A(AR)               Pointer (to AR) argument
R        DC    A(ST)               Pointer (to ST) argument
*
C        DC    CL10'INVOKE P2 '     Character string
AR       DC    4D'0'               Array of 4 elements
ST       DC    F'1'                Structure
         DC    F'2'
         DC    D'0'
P2       DC    V(P2)               Procedure P2 entry address
         END   ASMR

- - - - - - - - - - - - - - - - - -  - - - - - - - - - -  - - - - - -

/* This routine receives four parameters from ASMR.     */
/* The arithmetic item is received directly.            */
/* The character string, array and structure are        */
/* received using a pointer indirection.                */

P2: PROC(A,P,Q,R);

    DCL A FIXED BIN(31);
    DCL (P,Q,R) POINTER;
    DCL C CHAR(10) BASED(P);
    DCL AR(4)   FLOAT DEC(16) BASED(Q);
    DCL 1 ST BASED(R),
          2 ST1 FIXED BIN(31),
          2 ST2 FIXED BIN(31),
          2 ST3 FLOAT DEC(16);
          .
          .
          .
    END P2;
```

Figure 92. A PL/I Routine That Is Invoked by an Assembler Routine

If you choose to code an assembler routine that passes or receives strings, areas, arrays or structures that require a locator or descriptor, see “Descriptors and Locators” on page 380 for their format and construction. Keep in mind, however, that doing so might affect the migration of these assembler routines in the future.

Passing MAIN Procedure Parameters

The format of a PL/I MAIN procedure parameter list is controlled by the SYSTEM compiler option and the NOEXECOPS procedure option. The kind of coding needed also depends upon the type of parameter received by the MAIN procedure.

If the MAIN procedure receives no parameters or a single varying character string:

- It is recommended that the MAIN procedure be compiled with SYSTEM(MVS).

- If the assembler routine needs to pass run-time options for initializing the run-time environment, the NOEXECOPS option should not be specified or defaulted. Otherwise, NOEXECOPS should be specified.
- The MAIN procedure must be coded to have no parameters or a single parameter, consisting of a varying character string. For example:

```
MAIN: PROC(C) OPTIONS(MAIN);
      DCL C CHAR(100) VARYING;
```

- The assembler routine must invoke the MAIN procedure passing a varying length character string, as shown in Figure 93. The string has the same format as that passed in the PARM= option of the MVS EXEC statement, when an Language Environment program is executed. The string consists of optional run-time options, followed by a slash (/), followed by optional characters to be passed to the MAIN procedure.

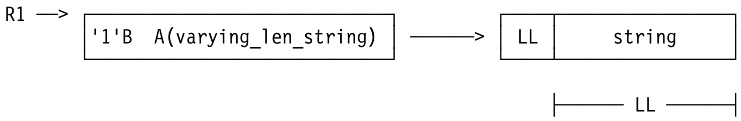


Figure 93. Assembler Routine Invoking a MAIN Procedure

If NOEXECOPS is specified, run-time options and the accompanying slash should be omitted. If run-time options are provided in the string, they will have no effect on environment initialization.

If a MAIN procedure receives no parameters, the argument list should be built as shown in Figure 93 but a null string should be passed by setting the length LL to zero.

If the MAIN procedure receives a character string as a parameter, the locator/descriptor needed for this string is built by PL/I run-time services before the MAIN procedure gains control.

If a MAIN procedure receives more than one parameter or a parameter that is not a single varying character string:

- It is recommended that the MAIN procedure be compiled with SYSTEM(MVS).
- NOEXECOPS is always implied. There is no mechanism to receive and parse run-time options from the assembler routine for initializing the run-time environment.
- The assembler routine should build its argument list so it corresponds to the parameters expected by the MAIN procedure. The assembler argument list is passed through as is to the MAIN procedure. If strings, areas, arrays or structures need to be passed, consider passing pointers to these items instead. This avoids the use of locators and descriptors.

  Figure 94 on page 378 illustrates this technique.

```
ASM0     CSECT
         .
         .
         .
*
*        Invoke MAINP passing two arguments.
*
         LA    1,ALIST             Register 1 has argument list
         LINK  EP=MAINP            Invoke MAINP load module,
*                                  giving control to entry CEESTART
         .
         .
         .
*
*        The argument list below contains the addresses of two
*        arguments, both of which are pointers.
*
ALIST    DC    A(P)                First argument address
         DC    A(Q+X'80000000')    Second argument address
*
P        DC    A(C)                Pointer (to 1st string) argument
Q        DC    A(D)                Pointer (to 2nd string) argument
*
C        DC    C'Character string 1  '
D        DC    C'Character string 2  '
         END   ASM0

- - - - - - - - - - - - - - - - - - -  - - - - - - - - -  - - - - - -

%PROCESS SYSTEM(MVS);

 /* This procedure receives two pointers as its parameters.       */

 MAINP: PROCEDURE(P,Q) OPTIONS(MAIN);
       DCL (P,Q) POINTER;
       DCL C CHAR(20) BASED(P);
       DCL D CHAR(20) BASED(Q);

       /* Display contents of character strings pointed to by     */
       /* pointer parameters.                                     */
       DISPLAY(C);
       DISPLAY(D);

       END MAINP;
```

Figure 94. Assembler Routine That Passes Pointers to Strings

- An assembler routine can choose to pass strings, areas, arrays or structures to a MAIN procedure. If so, locators and descriptors as described in “Descriptors and Locators” on page 380 must be provided by the assembler routine.

Assembler routines should not invoke MAIN procedures compiled by PL/I MVS & VM that specify SYSTEM(IMS) or SYSTEM(CICS). Assembler routines can invoke MAIN procedures compiled with other SYSTEM options. However, these interfaces generally involve specialized usage.

Options BYVALUE

PL/I supports the BYVALUE option for external procedure entries and entry declarations. The BYVALUE option specifies that variables are passed by copying the value of the variables into the argument list. This implies that the invoked routine cannot modify the variables passed by the caller.

BYVALUE arguments and returned values must have a scalar data type of either POINTER or REAL FIXED BINARY(31,0). Consequently, each fullword slot in the argument list consists of either a pointer value or a real fixed binary(31,0) value. If you need to pass a data type that is not POINTER or REAL FIXED BINARY(31,0), consider passing the data type indirectly using the POINTER data type.

Values from function references are returned using register 15.

With the BYVALUE argument passing convention, PL/I does not manipulate the high-order bit of BYVALUE POINTER arguments, even if last in the argument list. Further, the high-order bit is neither turned off for incoming nor set for outgoing BYVALUE arguments.Figure 95 shows an assembler routine ASM1 that invokes a procedure PX passing three arguments BYVALUE, which in turn invokes an assembler routine ASM2 (not shown). The assembler routines are assumed to be operating in the Language Environment for MVS & VM environment.

```
ASM1     CSECT
         .
         .
         .
*
*        Invoke procedure PX passing three arguments BYVALUE.
*
         LA    1,ALIST             Register 1 has argument list
         L     15,PX               Set reg 15 with entry point
         BALR  14,15               Invoke BYVALUE procedure
         LTR   15,15               Checked returned value
         .
         .
*
*        The BYVALUE argument list contains three arguments.
*        The high order bit of the last argument is *not* specially
*        flagged when using the BYVALUE passing convention.
*
ALIST    DC    A(A)                1st arg is pointer value
         DC    A(C)                2nd arg is pointer value
         DC    F'2'                3rd arg is arithmetic value
*
A        DC    2D'0'               Array
C        DC    C'CHARSTRING'       Character string
*
*
PX       DC    V(PX)               Entry point to be invoked
         END   ASM1
```

```
- - - - - - - - - - - - - - - - - - -  - - - - - - - - - -  - - - - - -
```

```
PX:   PROCEDURE(P,Q,M) OPTIONS(BYVALUE) RETURNS(FIXED BIN(31));
      DCL (P,Q) POINTER;
      DCL A(2) FLOAT DEC(16) BASED(P);
      DCL C    CHAR(10)     BASED(Q);
      DCL M FIXED BIN(31);
      DCL  ASM2 ENTRY(FIXED BIN(31,0)) OPTIONS(BYVALUE ASM);

      M=A(1);

      /* ASM2 is passed variable M byvalue, so it can not alter  */
      /* the contents of variable M.                             */
      CALL ASM2(M);

      RETURN(0);

      END PX;
```

Figure 95. Assembler Routine Passing Arguments BYVALUE

Descriptors and Locators

PL/I supports locators and descriptors in order to communicate the lengths, bounds, and sizes of strings, areas, arrays and structures between PL/I routines. For example, the procedure below can receive the parameters shown without explicit knowledge of their lengths, bounds or sizes at compilation time.

```
P:  PROCEDURE(C,D,AR);
    DCL C  CHAR(*),
        D  AREA(*),
        AR(*,*) CHAR(*);
```

The use of locators and descriptors is not recommended for assembler routines, because the migration of these routines might be affected in the future. In addition, portability to other platforms can be adversely affected. See "Passing Assembler Parameters" on page 374 for techniques to avoid the use of these control blocks.

The major control blocks are:

Descriptors These hold the extent of the data item such as string lengths, array bounds, and area sizes.

Locators These hold the address of a data item. If they are not concatenated with the descriptor, they hold the descriptor's address.

Locator/descriptor
This is a control block consisting of a locator concatenated with a descriptor.

When received as parameters or passed as arguments, locators and descriptors are needed for strings, areas, arrays, and structures. For strings and areas, the locator is concatenated with the descriptor and contains only the address of the variable. For structures and arrays, the locator is a separate control block from the descriptor and holds the address of both the variable and the descriptor.

Figure 96 on page 381 gives an example of the way in which data is related to its locator and descriptor.

PL/I Statement: DCL TABLE(10) FLOAT DECIMAL(6);

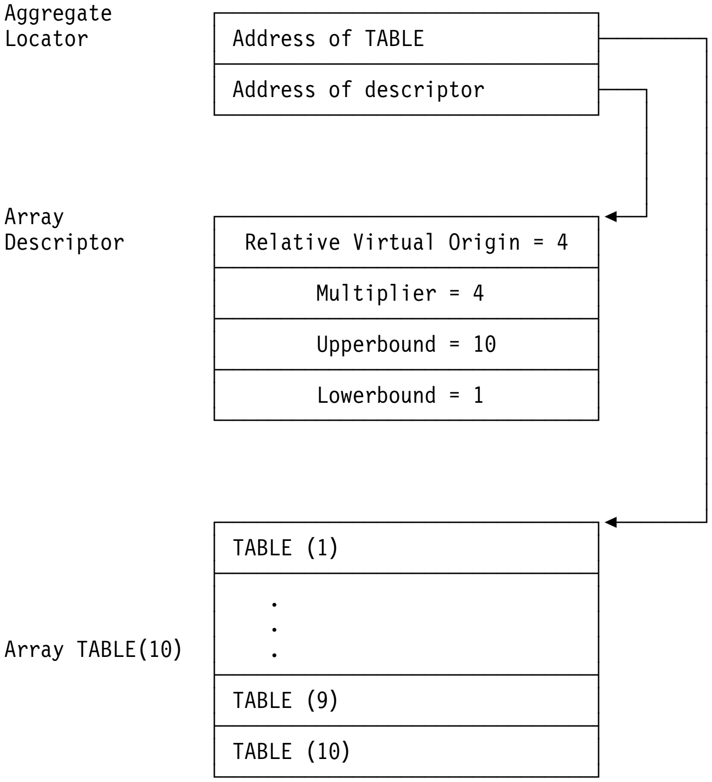


Figure 96. Example of Locator, Descriptor, and Array Storage

Aggregate Locator

The aggregate locator holds this information:

- The address of the start of the array or structure
- The address of the array descriptor or structure descriptor

Figure 97 shows the format of the aggregate locator.

0	Address of the start of the array or structure
4	Address of the array descriptor or structure descriptor

Figure 97. Format of the Aggregate Locator

The array and structure descriptor are described in subsequent sections.

Area Locator/Descriptor

The area locator/descriptor holds this information:

- The address of the start of the area
- The length of the area

Figure 98 on page 382 shows the format of the area locator/descriptor.

0	Address of area variable
4	Length of area variable

Figure 98. Format of the Area Locator/Descriptor

The area variable consists of a 16-byte area variable control block followed by the storage for the area variable.

The area descriptor is the second word of the area locator/descriptor. It is used in structure descriptors when areas appear in structures and also in array descriptors, for arrays of areas.

Array Descriptor

The array descriptor holds this information:

- The relative virtual origin (RVO) of the array
- The multiplier for each dimension
- The high and low bounds for the subscripts in each dimension

When the array is an array of strings or areas, the string or area descriptor is concatenated at the end of the array descriptor to provide the necessary additional information. String and area descriptors are the second word of the locator/descriptor word pair.

The CMPAT(V2) format of the array descriptor differs from the CMPAT(V1) level, but holds the same information. After the first fullword (RVO) of the array descriptor, each array dimension is represented by three words (CMPAT(V2)) or two words (CMPAT(V1)) that contain the multiplier and bounds for each dimension.

Figure 99 shows the format of the CMPAT(V2) array descriptor.

0	RVO (Relative Virtual Origin)
4	Multiplier for this dimension
8	High bound for this dimension
C	Low bound for this dimension
	. . . Three fullwords containing multiplier and high and low bounds are included for each array dimension. . . .

Concatenated string or area descriptor, if this is an array of strings or areas.

Figure 99. Format of the Array Descriptor for a Program Compiled with CMPAT(V2)

Figure 100 on page 383 shows the format of the CMPAT(V1) array descriptor.

```
0   | RVO (Relative Virtual Origin)                                |
4   | Multiplier for this dimension                                |
8   | High bound this dimension  |  Low bound this dimension       |
    |        .                                                     |
    |        .                                                     |
    |        .                                                     |
    | Two fullwords containing multiplier and high and low         |
    | bounds are included for each array dimension.                |
    |        .                                                     |
    |        .                                                     |
    |        .                                                     |

    | Concatenated string or area descriptor, if this is an        |
    | array of strings or areas.                                   |
```

Figure 100. Format of the Array Descriptor for a Program Compiled with CMPAT(V1)

RVO (Relative virtual origin)
This is held as a byte value except for bit string arrays, in which case this is a bit value. For bit string arrays, the bit offset from the byte address is held in the string descriptor.

Multiplier The multiplier is held as a byte value, except for bit string arrays in which case they are bit values.

High bound The high subscript for this dimension

Low bound The low subscript for this dimension.

String Locator/Descriptor

The string locator/descriptor holds this information:

- The byte address of the string
- The (maximum) length of the string
- Whether or not it is a varying string
- For a bit string, the bit offset from the byte address

Figure 101 shows the format of the string locator/descriptor.

```
0   | Byte address of string                                       |
4   | Allocated length         |F1|   Not Used        |  F2        |
```

Figure 101. Format of the String Locator/Descriptor

For VARYING strings, the byte address of the string points to the half-word length prefix, which precedes the string.

Allocated length is held in bits for bit strings and in bytes for character strings. Length is held in number of graphics for graphic strings.

```
F1 = First bit in second halfword:
     '0'B  Fixed length string
     '1'B  VARYING string

F2 = Last 3 bits in second halfword:
     Used for bit strings to hold offset from byte address of
     first bit in bit string.
```

The string descriptor is the second word of the string locator/descriptor. It is used in structure descriptors when strings appear in structures and also in array descriptors, for arrays of strings.

Structure Descriptor

The structure descriptor is a series of fullwords that give the byte offset of the start of each base element from the start of the structure. If a base element has a descriptor, the descriptor is included in the structure descriptor, following the appropriate fullword offset.

Structure descriptor format:

Figure 102 shows the format of the structure descriptor. For each base element in the structure, a fullword field is present in the structure descriptor that contains the byte offset of the base element from the start of the storage for the structure. If the base element is a string, area, or array, this fullword is followed by a descriptor, which is followed by the offset field for the next base element. If the base element is not a string, area, or array, the descriptor field is omitted.

```
 0  ┌─────────────────────────────────────────────────────┐
    │ Base element offset from the start of the structure │
 4  ├─────────────────────────────────────────────────────┤
    │ Base element descriptor (if required)               │
    ├─────────────────────────────────────────────────────┤
    │    .                                                │
    │    .                                                │
    │    .                                                │
    │ For every base element in the structure, an entry is│
    │ made consisting of a fullword offset field and,     │
    │ if the element requires a descriptor, a descriptor. │
    │    .                                                │
    │    .                                                │
    │    .                                                │
    └─────────────────────────────────────────────────────┘
```

Figure 102. Format of the Structure Descriptor

Base element offsets are held in bytes. Any adjustments needed for bit-aligned addresses are held in the respective descriptors.

Major and minor structures themselves, versus the contained base elements, are not represented in the structure descriptor.

Arrays of Structures and Structures of Arrays

When necessary, an aggregate locator and a structure descriptor are generated for both arrays of structures and structures of arrays.

The structure descriptor has the same format for both an array of structures and a structure of arrays. The difference between the two is the values in the field of the array descriptor within the structure descriptor. For example, take the array of structures AR and the structure of arrays ST, declared as follows:

```
Array of structures               Structure of arrays
DCL 1 AR(10),                     DCL 1 ST,
      2 B,                              2 B(10),
      2 C;                              2 C(10);
```

The structure descriptor for both AR and ST contains an offset field and an array descriptor for B and C. However, the values in the descriptors are different, because the array of structures AR consists of elements held in the order:

```
B,C,B,C,B,C,B,C,B,C,B,C,B,C,B,C,B,C,B,C
```

but the elements in the structure of arrays ST are held in the order:

```
B,B,B,B,B,B,B,B,B,B,C,C,C,C,C,C,C,C,C,C.
```

Chapter 17. Using PLIDUMP

This section provides information about dump options and the syntax used to call PLIDUMP, and describes PL/I-specific information included in the dump that can help you debug your routine.

Note: PLIDUMP conforms to National Language Support standards.

Figure 103 shows an example of a PL/I routine calling PLIDUMP to produce an Language Environment for MVS & VM dump. In this example, the main routine PLIDMP calls PLIDMPA, which then calls PLIDMPB. The call to PLIDUMP is made in routine PLIDMPB.

```
%PROCESS MAP GOSTMT SOURCE STG LIST OFFSET LC(101);                     00001000
 PLIDMP: PROC  OPTIONS(MAIN) ;                                          00002000
                                                                        00003000
   Declare   (H,I) Fixed bin(31) Auto;                                  00004000
   Declare   Names Char(17) Static init('Bob Teri Bo Jason');           00005000
   H = 5;  I = 9;                                                       00006000
   Put skip list('PLIDMP Starting');                                    00007000
   Call PLIDMPA;                                                        00008000
                                                                        00009000
     PLIDMPA:  PROC;                                                    00010000
       Declare  (a,b)  Fixed bin(31)   Auto;                            00011000
       a = 1;  b = 3;                                                   00012000
       Put skip list('PLIDMPA Starting');                               00013000
       Call PLIDMPB;                                                    00014000
                                                                        00015000
         PLIDMPB:  PROC;                                                00016000
           Declare  1 Name  auto,                                       00017000
                      2  First   Char(12) Varying,                      00018000
                      2  Last    Char(12) Varying;                      00019000
           First = 'Teri';                                              00020000
           Last  = 'Gillispy';                                          00021000
           Put skip list('PLIDMPB Starting');                           00022000
           Call PLIDUMP('TBFC','PLIDUMP called from procedure PLIDMPB');00023000
           Put Data;                                                    00024000
         End PLIDMPB;                                                   00025000
                                                                        00026000
     End PLIDMPA;                                                       00027000
                                                                        00028000
 End PLIDMP;                                                            00029000
```

Figure 103. Example PL/I Routine Calling PLIDUMP

The syntax and options for PLIDUMP are shown below.

Syntax

```
►►──PLIDUMP──(──character-string-expression 1──,──────────────────►

►──character-string-expression 2──)───────────────────────────────►◄
```

where:

character-string-expression 1
is a dump options character string consisting of one or more of the following:

A Requests information relevant to all tasks in a multitasking program.

B BLOCKS (PL/I hexadecimal dump).

C Continue. The routine continues after the dump.

E Exit from current task of a multitasking program. Program continues to run after requested dump is completed.

F FILES.

H STORAGE.

Note: A ddname of CEESNAP must be specified with the H option to produce a SNAP dump of a PL/I routine.

K BLOCKS (when running under CICS). The Transaction Work Area is included.

NB NOBLOCKS.

NF NOFILES.

NH NOSTORAGE.

NK NOBLOCKS (when running under CICS).

NT NOTRACEBACK.

O Only information relevant to the current task in a multitasking program.

S Stop. The enclave is terminated with a dump.

T TRACEBACK.

T, F, and C are the default options.

character-string-expression 2
is a user-identified character string up to 80 characters long that is printed as the dump header.

PLIDUMP Usage Notes

If you use PLIDUMP, the following considerations apply:

- If a routine calls PLIDUMP a number of times, use a unique user-identifier for each PLIDUMP invocation. This simplifies identifying the beginning of each dump.
- A DD statement with the ddname PLIDUMP, PL1DUMP, or CEEDUMP; a FILEDEF command in VM; or an ALLOCATE command in TSO can be used to define the data set for the dump.
- The data set defined by the PLIDUMP, PL1DUMP, or CEEDUMP DD statement should specify a logical record length (LRECL) of at least 133 to prevent dump records from wrapping.
- When you specify the H option in a call to PLIDUMP, the PL/I library issues an OS SNAP macro to obtain a dump of virtual storage. The first invocation of PLIDUMP results in a SNAP identifier of 0. For each successive invocation, the ID is increased by one to a maximum of 256, after which the ID is reset to 0.
- Support for SNAP dumps using PLIDUMP is only provided under VM and MVS. SNAP dumps are not produced in a CICS environment.

- If the SNAP is not successful, the CEE3DMP DUMP file displays the message:

  ```
  Snap was unsuccessful
  ```

- If the SNAP is successful, CEE3DMP displays the message:

  ```
  Snap was successful; snap ID = nnn
  ```

  where *nnn* corresponds to the SNAP identifier described above. An unsuccessful SNAP does not result in an incrementation of the identifier.

If you want to ensure portability across system platforms, use PLIDUMP to generate a dump of your PL/I routine.

Chapter 18. Retaining the Run-Time Environment for Multiple Invocations

If an assembler routine is to invoke either a number of PL/I routines or the same PL/I routine repeatedly, the creation and termination of the run-time environment for each invocation will be unnecessarily inefficient. The solution is to create the run-time environment only once for use by all invocations of PL/I procedures. This can be achieved by several techniques which include:

- Preinitializing the PL/I program
- Establishing a Language Environment for MVS & VM-enabled assembler routine as the MAIN procedure
- Retaining the run-time environment using Language Environment for MVS & VM-enabled assembler as MAIN

Each of these techniques is discussed below.

Preinitializable Programs

To call a PL/I program multiple times, you can establish the run-time environment and then repeatedly invoke the PL/I program using the already-established run-time environment. You incur the overhead of initializing and terminating the run-time environment only once instead of every time you invoke the PL/I program.

Because PL/I detects preinitializable programs dynamically during initialization, you do not have to recompile or relink-edit a program. However, this facility assumes that the PL/I MAIN procedure is compiled with the OS PL/I Version 2 or the PL/I for MVS & VM compiler.

Note: PL/I-defined preinitialization support does not include support for ILC. The support provided is slightly different from that provided by OS PL/I Version 2. Refer to the *PL/I for MVS & VM Compiler and Run-Time Migration Guide* for information about these differences.

To maintain the run-time environment, invoke the program with the PL/I entry PLISTART if you are using OS PL/I Version 2, or with CEESTART if you are using PL/I for MVS & VM, and pass a special Extended Parameter List (EPLIST) that indicates that the program is to be preinitialized.

parameter list when you pass it:

INIT
Initialize the run-time environment, return two tokens that represent the environment, but do not run the program.

CALL
Run the PL/I program using the environment established by the INIT request, and leave the environment intact when the program completes. CALL uses the two tokens that were returned by the INIT request so that PL/I can recognize the proper environment.

You can also initialize and call a PL/I program by passing the CALL parameter with two zero tokens. PL/I will service this request as an INIT followed by a CALL. You can still call the program repeatedly.

TERM
Terminate the run-time environment but do not run the program.

EXECUTE
Perform INIT, CALL, and TERM in succession.

In order for a program to be preinitialized it must perform the following tasks:

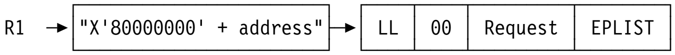
- Explicitly close all files, including SYSPRINT.
- Explicitly free all controlled variables.
- Explicitly release all fetched modules.

Different programs can use the same run-time environment if the programs do not use files, controlled variables, or fetched procedures. stream-oriented output to SYSPRINT, and SYSPRINT must be declared as EXTERNAL FILE.

Note: You cannot preinitialize a PL/I program under CICS or in conjunction with PL/I multitasking.

The Interface for Preinitializable Programs

The interface for preinitializable programs is shown below:



The “LL” field must The following halfword must contain zeros.

The “Request” field is a field of eight characters that can contain

```
'INIT    '
'CALL    '
'TERM    '
'EXECUTE '
```

No other values are allowed.

The “EPLIST” field is a pointer to the extended parameter list, which is described in the following section.

Using the Extended Parameter List (EPLIST)

You can use the facilities made possible through the extended parameter list to support PL/I programs that run in nonproblem-state environments. These new environments include, but are not limited to:

Supervisor state
Cross-memory mode
System request block (SRB) mode

Warning

The code that uses the preinitialization interface described in this chapter (that is, the preinitialization "director" or "driver" module) is responsible for maintaining MVS integrity. PL/I as shipped does not prevent the operation of nonproblem-state programs in the environment described in this section, nor does it provide any means of manipulating PSW keys. Therefore, your preinitialization director code must ensure that all data areas and addresses passed as parameters to a nonproblem-state PL/I program are accessible for reading and/or writing as needed by that PL/I program in the PSW key under which the program is given control. The director code is also responsible for checking any parameters passed by the problem-state caller to ensure that the caller has the read and/or write authority needed in its PSW protect key.

The "EPLIST" field serves as a means of communication between the caller and the run-time environment. It points to the EPLIST, a vector of fullwords that The items must occur in the following order:

1. The length of the extended parameter list.
2. First token for the run-time environment.
3. Second token for the run-time environment.
4. Pointer to a parameter list Use a fullword of zeros if your code does not expect a parameter.
5. Pointer to a character string of your run-time options.

If you need them, you can optionally include the following additional fullword slots after those listed above:

6. Pointer to an alternative MAIN PL/I routine you wish to invoke. If you do not want to use this slot but wish to specify the seventh slot, use a fullword of zeros.
7. Pointer to a service vector defined by you through which you designate alternative routines to perform certain services, like loading and deleting.

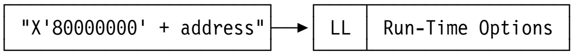
The defined constants area of the assembler module in Figure 104 on page 394 shows an example of how you could set up the extended parameter list.

The use of each field in the extended parameter list is described below.

Length of EPLIST: Includes the four bytes for itself. Valid decimal values are 20, 24, and 28.

First and Second Run-Time Environment Tokens: These tokens are automatically returned during initialization. Or, you can use zeros for them when requesting a preinitialized CALL and the effect is that both an INIT and a CALL are performed.

Pointer to Your Program Parameters: These parameters should be as your object code expects. If your object code expects a character string as its parameter, use the following structure:



where “LL” is a halfword containing the length of the character string.

Use a value of zero as a place holder for this slot if your program does not expect any parameters.

When parameters are passed to a preinitialized program, the parameter list must consist of one address for each parameter. The high-order bit must be turned on for the address of the last parameter.

Without knowledge of PL/I descriptors, the only data types that you can pass to a PL/I preinitialized program are pointers and numeric scalars. Numeric scalars can have any base, mode, scale, or precision.

For example, to pass the REAL FIXED BIN(31) values 5 and 6 to a preinitialized program, the parameter list could be declared as:

```
PARMS     DC  A(BIN_PARM1)
          DC  A(X'80000000'+BIN_PARM2)
BIN_PARM1 DC  F'5'
BIN_PARM2 DC  F'6'
```

To pass the two strings “pre” and “init” to a preinitialized program that receives them as varying strings, you should pass the parameters indirectly via pointers. The parameter list could be declared as:

```
PARMS     DC  A(PTR_PARM1)
          DC  A(X'80000000'+PTR_PARM2)
PTR_PARM1 DC  A(STR_PARM1)
PTR_PARM2 DC  A(STR_PARM2)
STR_PARM1 DC  H'3'
          DC  CL8'pre'
STR_PARM2 DC  H'4'
          DC  CL16'init'
```

The preinitialized PL/I program would declare its incoming parameters as pointers which could be used as locators for varying strings. The actual code might look like the following:

```
 PIPISTR: Proc( String1_base, String2_base) options(main noexecops);

   Declare (String1_base, String2_base) pointer;

   Declare String1   char(08) varying based(String1_base);

   Declare String2   char(16) varying based(String2_base);
```

Pointer to Your Run-Time Options: To point to the character string of run-time options, use the structure shown in the diagram under “Pointer to Your Program Parameters” above. The run-time options provided are merged as the command-level options.

Pointer to an Alternative Main: If you place an address in this field and your request is for a preinitialized CALL, that address is used as the address of the compiled code to be invoked.

Note: When using this function, the alternative mains you invoke cannot use FETCH and RELEASE, cannot use CONTROLLED variables, and cannot use any I/O other than stream-oriented output to SYSPRINT, which must be declared as EXTERNAL FILE.

For an example of how to use this facility, see “Invoking an Alternative MAIN Routine” on page 398.

Pointer to the Service Vector: If you want certain services like load and delete to be carried out by some other code supplied by you (instead of, for example, the Language Environment for MVS & VM LOAD and DELETE services), you must use this field to point to the service vector. For a description of the service vector and interface requirements for user-supplied service routines, see “Using the Service Vector and Associated Routines” on page 402. Sample service routines are shown for some of the services.

Note: Besides interfaces and rules defined here for these services, you also might need to follow additional rules. That is, each service that you provide must follow rules defined here and rules defined for the corresponding service in the Language Environment for MVS & VM preinitialization. For detailed rules for services in Language Environment for MVS & VM-defined preinitialization, see the *Language Environment for MVS & VM Programming Guide*.

Preinitializing a PL/I Program

Figure 104 on page 394 demonstrates how to:

- Establish the run-time environment via an INIT request
- Pass run-time parameters to the PL/I initialization routine
- Set up a parameter to the PL/I program which is different for each invocation of the program
- Repeatedly invoke a PL/I program via the CALL request
- Perform load and delete services using your own service routines instead of Language Environment for MVS & VM-provided services
- List out names of all modules loaded and deleted during the run
- Communicate from the PL/I program to the driving program via PLIRETC
- Terminate the PL/I program via the TERM request

The PL/I program itself is very simple. The parameter it expects is a fullword integer. If the parameter is the integer 3, PLIRETC is set to 555. For an example, see Figure 105 on page 398.

The assembler program which drives the PL/I program establishes the run-time environment, repeatedly invokes the PL/I program passing a parameter of 10, 9, 8, and so on. If the return code set by the PL/I program is nonzero, the assembler program terminates the run-time environment and exits.

Figure 108 on page 404 and Figure 109 on page 407 show the load and delete routines used in place of the usual Language Environment for MVS & VM-provided services. These are examples of user-supplied service routines that comply with the interface conventions discussed in “Using the Service Vector and Associated Routines” on page 402. These particular routines list out the names of all modules loaded and deleted during the run.

Note: This program does not include the logic that would verify the correctness of any of the invocations. This logic is imperative for proper operations.

```
         TITLE 'Preinit Director Module'
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Function:Demonstrate the use of the Preinitializable Program Facility
* Preinit Requests : INIT, CALL, TERM
*
* Parm to Prog : Fixed Bin(31)
* Output       : Return Code set via PLIRETC
*
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NEWPIPI  CSECT
         EXTRN CEESTART
         EXTRN LDMPIPI           User's load routine
         EXTRN DLMPIPI           User's delete routine
*
         DS    0H
         STM   14,12,12(13)      Save registers
         LR    R12,R15           Set module Base
         USING NEWPIPI,R12
*
         LA    R10,SAVAREA
         ST    R10,8(R13)        Forward Chain
         ST    R13,4(R10)        Back Chain
         LR    R13,R10
*
MAINCODE EQU   *
* ===============================================================
*   Setup the Request list specifying 'INIT'.
* ===============================================================
*
         WTO   'Prior to INIT request'
*
         MVC   PRP_REQUEST,INIT   Indicate the INIT request
*
         LA    R1,EXEC_ADDR       Get the parm addr list
         ST    R1,EPL_EXEC_OPTS   Save in EPL
*
*  Setup R1 to point to the Parm list
*
         LA    R1,PARM_EPL        R1 --> Pointer --> Request list
         L     R15,PSTART         PL/I Entry addr
         BALR  R14,R15            Invoke PL/I
*
         WTO   'After INIT request'
*
```

Figure 104 (Part 1 of 4). Director Module for Preinitializing a PL/I Program

```
* ===============================================================
*   The run-time environment is now established.  PL/I object code
*   has not yet been executed.  We will now repeatedly invoke
*   the PL/I object code until the PL/I object code sets
*   a non-zero return code.
* ===============================================================
*   Setup the Request list specifying 'CALL'.
* ===============================================================
*
DO_CALL  EQU   *
*
         WTO   'Prior to CALL request'
*
         MVC   PRP_REQUEST,CALL   Indicate the CALL request
*
         LA    R1,PARMS           Get the parm addr list
         ST    R1,EPL_PROG_PARMS  Save in EPL
*
*  Setup R1 to point to the Parm list
*
         LA    R1,PARM_EPL        R1 --> Pointer --> Request list
         L     R15,PSTART         PL/I Entry addr
         BALR  R14,R15            Invoke PL/I
*
         LTR   R15,R15            Zero PL/I return code?
         BNZ   DO_TERM            No. We are done
*
         L     R5,PARAMETER       Change the parm ...
         BCTR  R5,0               ... passing one less ...
         ST    R5,PARAMETER       ... each time
*
         LTR   R5,R5              Don't loop forever
         BNZ   DO_CALL
*
* ===============================================================
*    The request now is 'TERM'
* ===============================================================
*
DO_TERM  EQU   *
*
         ST    R15,RETCODE        SAVE PL/I RETURN CODE
*
         WTO   'Prior to TERM request'
*
         MVC   PRP_REQUEST,TERM   Indicate a TERM command
*
         LA    R1,0               No parm list is present
         ST    R1,EPL_PROG_PARMS  Save in EPL
*
         LA    R1,PARM_EPL        R1 --> Pointer --> Request list
         L     R15,PSTART         PL/I Entry addr
         BALR  R14,R15            Invoke PL/I
*
         WTO   'After TERM request'
*
```

Figure 104 (Part 2 of 4). Director Module for Preinitializing a PL/I Program

```
*============================================================
*   Return to the System        -        Bye
*============================================================
SYSRET   EQU   *
*
         L     R13,SAVAREA+4
         L     R14,12(R13)
         L     R15,RETCODE
         LM    R0,R12,20(R13)
         BR    R14                Return to your caller
         EJECT
         EJECT
*
*              CONSTANTS AND WORKAREAS
*
SAVAREA  DS    20F
*
RETCODE  DC    F'0'
PARM_EPL DC    A(X'80000000'+IBMBZPRP)      Parameter Addr List
PSTART   DC    A(CEESTART)
* ===============================================================
* Request strings allowed in the Interface
* ===============================================================
INIT     DC    CL8'INIT'          Initialize the program envir
CALL     DC    CL8'CALL'          Invoke the appl - leave envir up
TERM     DC    CL8'TERM'          Terminate Environment
EXEC     DC    CL8'EXECUTE'       INIT, CALL, TERM - all in one
*
* ===============================================================
                     SPACE 1
*      Parameter list passed by a Pre-Initialized Program
*      Addressed by Reg 1 = A(A(IBMBZPRP))
*      See IBMBZEPL DSECT.
                     SPACE 1
IBMBZPRP             DS  0F
PRP_LENGTH           DC  H'16'         Len of this PRP passed (16)
PRP_ZERO             DC  H'0'          Must be zero
PRP_REQUEST          DC  CL8' '        'INIT' - initialize PL/I
*                                      'CALL' - invoke application
*                                      'TERM' - terminate PL/I
*                                      'EXECUTE' - init, call, term
*
PRP_EPL_PTR          DC  A(IBMBZEPL)   A(EPL) - Extended Parm List
* ===============================================================
                     SPACE 1
*      Parameter list for the Pre-Initialized Programs
                     SPACE 1
IBMBZEPL             DS  0F
EPL_LENGTH           DC  A(EPL_SIZE)   Length of this EPL passed
EPL_TOKEN1           DC  F'0'          First env token
EPL_TOKEN2           DC  F'0'          Second env token
EPL_PROG_PARMS       DC  F'0'          A(Parm address List) ...
EPL_EXEC_OPTS        DC  A(EXEC_ADDR)  A(Execution time optns) ...
EPL_ALTMAIN          DC  F'0'          A(Alternate Main)
EPL_SERVICE_VEC      DC  A(IBMBZSRV)   A(Service Routines Vector)
EPL_SIZE             EQU *-IBMBZEPL    The size of this block
*
```

Figure 104 (Part 3 of 4). Director Module for Preinitializing a PL/I Program

```
*---------------------------------------------------------------------
*
*      Service Routine Vector
*
IBMBZSRV            DS  0F
SRV_SLOTS           DC  F'4'          Count of slots defined
SRV_USERWORD        DC  A(SRV_UA)     user word
SRV_WORKAREA        DC  A(SRV_WA)     A(workarea)
SRV_LOAD            DC  A(LDMPIPI)    A(Load routine)
SRV_DELETE          DC  A(DLMPIPI)    A(Delete routine)
SRV_GETSTOR         DC  F'0'          A(Get storage routine)
SRV_FREESTOR        DC  F'0'          A(Free storage routine)
SRV_EXCEP_RTR       DC  F'0'          A(Exception router service)
SRV_ATTN_RTR        DC  F'0'          A(Attention router service)
SRV_MSG_RTR         DC  F'0'          A(Message router service)
SRV_END             DS  0F
*
*
*      Service Routine Userarea
*
SRV_UA              DS  8F
*
*      Service Routine Workarea
*
SRV_WA              DS  0D
                    DC  F'256'        Length of workarea
                    DS  63F           Actual workarea
*
*---------------------------------------------------------------------
*  Setup the parameter to be passed to the PL/I Init and Program
*---------------------------------------------------------------------
*
PARMS     DC    A(X'80000000'+PARAMETER)
PARAMETER DC    F'10'
*
EXEC_ADDR DC    A(X'80000000'+EXEC_LEN)
EXEC_LEN  DC    AL2(EXEC_OLEN)
EXEC_OPTS DC    C'NATLANG(ENU)'
EXEC_OLEN EQU   *-EXEC_OPTS
*
*

     LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END
```

Figure 104 (Part 4 of 4). Director Module for Preinitializing a PL/I Program

The program in Figure 105 shows how to use the preinitializable program.

```
%PROCESS LIST SYSTEM(MVS) TEST;
 /* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
 /* Function : To demonstrate the use of a preinitializable program */
 /* Action   : Passed an argument of 3, it sets the PL/I return     */
 /*            code to 555.                                         */
 /*                                                                 */
 /* Input    : Fullword Integer                                     */
 /* Output   : Return Code set via PLIRETC                          */
 /*                                                                 */
 /* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
 PLIEXAM: Proc (Arg) Options(MAIN);
   Dcl Sysprint File Output;
   Dcl Arg Fixed Bin(31);
   Dcl Pliretc Builtin;

   Open  File(Sysprint);
   Put Skip List ('Hello' || Arg);

   If (Arg = 3) Then
     Do;
      Put Skip List ('Setting a nonzero PL/I return Code.');
      Call Pliretc(555);
     End;

   Close File(Sysprint);

 END PLIEXAM;
```

Figure 105. A Preinitializable Program

Invoking an Alternative MAIN Routine

This section shows a sample director module (see Figure 106 on page 399) much like the one in the “Preinitializing a PL/I Program” on page 393, except that instead of invoking the same PL/I program repeatedly, it invokes the original program only once, and all subsequent invocations go to an alternative MAIN program.

For simplicity, the alternative MAIN (see Figure 107 on page 402) is the same program as the original one except that it has been given another name. It expects a fullword integer as its parameter, and sets PLITREC to 555 if the parameter received is the integer 3.

Note: When using this function, the alternative MAINs you invoke cannot use FETCH and RELEASE, cannot use CONTROLLED variables, and cannot use any I/O other than stream-oriented output to SYSPRINT, which must be declared as EXTERNAL FILE.

The following director module does not include the logic that would verify the correctness of any of the invocations. This logic is imperative for proper operations.

```
         TITLE 'Preinit Director Module'
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Invoke PL/I program using Preinit Xaction.                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
PIALTEPA  CSECT
PIALTEPA  RMODE ANY
PIALTEPA  AMODE ANY
         EXTRN CEESTART
         EXTRN ALTMAIN
*
         DS    0H
         STM   14,12,12(13)       Save registers
         LR    R12,R15            Set module Base
         USING PIALTEPA,R12
*
         LA    R10,SAVAREA
         ST    R10,8(R13)         Forward Chain
         ST    R13,4(R10)         Back Chain
         LR    R13,R10
*
MAINCODE EQU   *
* ===============================================================
*   Setup the Request list specifying 'INIT'.
* ===============================================================
*
         WTO   'Prior to INIT request'
*
         MVC   PRP_REQUEST,INIT   Indicate the INIT request
*
         LA    R1,EXEC_ADDR       Get the parm addr list
         ST    R1,EPL_EXEC_OPTS   Save in EPL
*
*  Setup R1 to point to the Parm list
*
         LA    R1,PARM_EPL        R1 --> Pointer --> Request list
         L     R15,PSTART         PL/I Entry addr
         BALR  R14,R15            Invoke PL/I
*
         WTO   'After INIT request'
*
* ===============================================================
*   Setup the Request list specifying 'CALL'.
* ===============================================================
*
DO_CALL  EQU   *
*
         WTO   'Prior to CALL request'
*
         MVC   PRP_REQUEST,CALL   Indicate the CALL request
*
         LA    R1,PARMS           Get the parm addr list
         ST    R1,EPL_PROG_PARMS  Save in EPL
*
*  Setup R1 to point to the Parm list
*
         LA    R1,PARM_EPL        R1 --> Pointer --> Request list
         L     R15,PSTART         PL/I Entry addr
         BALR  R14,R15            Invoke PL/I
*
         LTR   R15,R15            Zero PL/I return code?
         BNZ   DO_TERM            No. We are done
*
         L     R5,PARAMETER       Change the parm ...
         BCTR  R5,0               ... passing one less ...
         ST    R5,PARAMETER       ... each time
```

Figure 106 (Part 1 of 3). Director Module for Invoking an Alternative MAIN

```
* ---------------------------------------------------------------
*    Following code causes subsequent invocations to go to
*    alternative MAIN
* ---------------------------------------------------------------
         L     R15,PSTART2
         ST    R15,EPL_ALTMAIN
*
         LTR   R5,R5              Don't loop forever
         BNZ   DO_CALL
*
* ===============================================================
*    The request now is 'TERM'
* ===============================================================
*
DO_TERM  EQU   *
*
         ST    R15,RETCODE        SAVE PL/I RETURN CODE
*
         WTO   'Prior to TERM request'
*
         MVC   PRP_REQUEST,TERM   Indicate a TERM command
*
         LA    R1,0               No parm list is present
         ST    R1,EPL_PROG_PARMS  Save in EPL
*
         LA    R1,PARM_EPL        R1 --> Pointer --> Request list
         L     R15,PSTART         PL/I Entry addr
         BALR  R14,R15            Invoke PL/I
*
         WTO   'After TERM request'
*
SYSRET   EQU   *
*
         L     R13,SAVAREA+4
         L     R14,12(R13)
         L     R15,RETCODE
         LM    R0,R12,20(R13)
         BR    R14                Return to your caller
         EJECT
         EJECT
*              CONSTANTS AND WORKAREAS
*
SAVAREA  DS    20F
*
RETCODE  DC    F'0'
PARM_EPL DC    A(X'80000000'+IBMBZPRP)      Parameter Addr List
PSTART   DC    A(CEESTART)
PSTART2  DC    A(ALTMAIN)
* ===============================================================
* Request strings allowed in the Interface
* ===============================================================
INIT     DC    CL8'INIT'          Initialize the program envir
CALL     DC    CL8'CALL'          Invoke the appl - leave envir up
TERM     DC    CL8'TERM'          Terminate Environment
EXEC     DC    CL8'EXECUTE'       INIT, CALL, TERM - all in one
*
* ===============================================================
                     SPACE 1
```

Figure 106 (Part 2 of 3). Director Module for Invoking an Alternative MAIN

```
*      Parameter list passed by a Pre-Initialized Program
*      Addressed by Reg 1 = A(A(IBMBZPRP))
*      See IBMBZEPL DSECT.
                     SPACE 1
IBMBZPRP             DS  0F
PRP_LENGTH           DC  H'16'         Len of this PRP passed (16)
PRP_ZERO             DC  H'0'          Must be zero
PRP_REQUEST          DC  CL8' '        'INIT' - initialize PL/I
*                                      'CALL' - invoke application
*                                      'TERM' - terminate PL/I
*                                      'EXECUTE' - init, call, term
*
PRP_EPL_PTR          DC  A(IBMBZEPL)   A(EPL) - Extended Parm List
* ================================================================
                     SPACE 1
*      Parameter list for the Pre-Initialized Programs
                     SPACE 1
IBMBZEPL             DS  0F
EPL_LENGTH           DC  A(EPL_SIZE)   Length of this EPL passed
EPL_TOKEN_TCA        DC  F'0'          A(TCA)
EPL_TOKEN_PRV        DC  F'0'          A(PRV)
EPL_PROG_PARMS       DC  F'0'          A(Parm address List) ...
EPL_EXEC_OPTS        DC  A(EXEC_ADDR)  A(Execution time optns) ...
EPL_ALTMAIN          DC  A(0)          A(alternate MAIN)
EPL_SERVICE_VEC      DC  A(0)          A(Service Routines Vector)
EPL_SIZE             EQU *-IBMBZEPL    The size of this block
*
*
*---------------------------------------------------------------------
*  Setup the parameter to be passed to the PL/I Init and Program
*---------------------------------------------------------------------
*
PARMS     DC    A(X'80000000'+PARAMETER)
PARAMETER DC    F'10'
*
EXEC_ADDR DC    A(X'80000000'+EXEC_LEN)
EXEC_LEN  DC    AL2(EXEC_OLEN)
EXEC_OPTS DC    C'NATLANG(ENU)'
EXEC_OLEN EQU   *-EXEC_OPTS
*
*
     LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END
```

Figure 106 (Part 3 of 3). Director Module for Invoking an Alternative MAIN

```
%PROCESS A(F) X(F) NIS S  FLAG(I);
%PROCESS TEST(NONE,SYM);
%PROCESS SYSTEM(MVS);
 ALTMAIN: Proc (Arg) options (main);
 Dcl Arg Fixed Bin(31);
 Dcl Pliretc Builtin;
 Dcl Oncode  Builtin;
 Dcl Sysprint File Output Stream;

 On Error Begin;
   On error system;
   Put Skip List ('ALTMAIN - In error On-unit. OnCode = '||Oncode );
 End;

 Put Skip List ('ALTMAIN - Entering Pli');
 Put Skip List ('  Arg = ' || Arg );

 If Arg = 3 Then
   do;
     Put Skip List ('Setting a nonzero PL/I return code');
     Call Pliretc(555);
   end;
 Else;

 Put skip List ('ALTMAIN - Leaving Pli');

 END;
```

Figure 107. Alternative MAIN Routine

Using the Service Vector and Associated Routines

This section describes the service vector, which is a list of addresses of various user-supplied service routines. Also described are the interface requirements for each of the service routines that you can supply, including sample routines for some of the services.

Note: These services must be AMODE(ANY) and RMODE(24). You must also follow further rules defined for services that Language Environment for MVS & VM-defined preinitialization provides.

Using the Service Vector

If you want certain services like load and delete to be carried out by some other code supplied by you (instead of, for example, the Language Environment for MVS & VM LOAD and DELETE services), you must place the address of your service vector in the seventh fullword slot of the extended parameter list (see “Using the Extended Parameter List (EPLIST)” on page 390). You must define the service vector according to the pattern shown in the following example:

```
SRV_COUNT      DS   F            Count of slots defined
SRV_USER_WORD  DS   F            User-defined word
SRV_WORKAREA   DS   A            Addr of work area for dsas etc
SRV_LOAD       DS   A            Addr of load routine
SRV_DELETE     DS   A            Addr of delete routine
SRV_GETSTOR    DS   A            Addr of get-storage routine
SRV_FREESTOR   DS   A            Addr of free-storage routine
SRV_EXCEP_RTR  DS   A            Addr of exception router
SRV_ATTN_RTR   DS   A            Addr of attention router
SRV_MSG_RTR    DS   A            Addr of message router
```

Although you do not need to use labels identical to those above, you must use the order above. That is, the address of your free-storage routine is seventh, the address of your load routine is fourth, and so on.

Some other constraints apply:

- When you define the service vector, you must fill all the slots in the template that precede the last one you specify. You can, however, supply zeros for the slots that you want ignored.
- The slot count does not count itself. The maximum value is therefore 9.
- You must specify an address in the work area slot if you specify addresses in any of the subsequent fields.
- This work area must begin on a doubleword boundary and start with a fullword that specifies its length. The length must be at least 256 bytes.
- For the load and delete routines, you cannot specify one of the pair without the other; if one of these two slots contains a value of zero, the other is automatically ignored.
- For the get-storage and free-storage routines, you cannot specify one of the pair without the other; if one of these two slots contains a value of zero, the other is automatically ignored.
- If you specify the get- and free-storage services, you must also specify the load and delete services.

For an example of a service vector definition, see the defined constants area of the assembler module in Figure 104 on page 394.

You are responsible for supplying any service routines pointed to in your service vector. These service routines, upon invocation, can expect:

- Register 13 to point to a standard 18-fullword save area
- Register 1 to point to a list of addresses of parameters available to the routine
- The third parameter in the list to be the address of the user word you specified in the second slot of the service vector

The parameters available to each routine, and the return and reason codes each routine is expected to use are given in the following sections. The parameter addresses are passed in the same order as the order in which the parameters are listed.

Load Service Routine

The load routine is responsible for loading named modules. This is the service typically obtained via the LOAD macro.

The parameters passed to the load routine are:

Parameter	PL/I attributes	Type
Address of module name	POINTER	Input
Length of name	FIXED BIN(31)	Input
User word	POINTER	Input
(Reserved field)	FIXED BIN(31)	Input
Address of load point	POINTER	Output
Size of module	FIXED BIN(31)	Output
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The name length must not be zero. You can ignore the reserved field: it will contain zeros. For additional rules about the LOAD service, see the *Language Environment for MVS & VM Programming Guide*.

The return/reason codes that the load routine can set are:

0/0	successful
0/4	successful—found as a VM nucleus extension
0/8	successful—loaded as a VM shared segment
0/12	successful—loaded using SVC8
4/4	unsuccessful—module loaded above line when in AMODE(24)
8/4	unsuccessful—load failed
16/4	unsuccessful—uncorrectable error occurred

Figure 108 shows a sample load routine that displays the name of each module as it is loaded.

```
         TITLE 'Preinit Load Service Routine'
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Load service routine to be used by preinit under MVS           *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
LDMPIPI  CSECT
*
         DS    0H
         STM   14,12,12(13)       Save registers
         LR    R3,R15             Set module Base
         USING LDMPIPI,R3
*
         LR    R2,R1                  Save parm register
         USING SRV_LOAD_PLIST,R2
         USING SRV_PARM,R4
```

Figure 108 (Part 1 of 3). User-Defined Load Routine

```
*
         L     R4,SRV_LOAD_A_USERWORD Get a(userword)
         L     R1,SRV_PARM_VALUE      Get userword
         MVC   0(12,R1),WTOCTL        Move in WTO skeleton
         L     R4,SRV_LOAD_A_NAME     Get a(a(module name))
         L     R15,SRV_PARM_VALUE     Get a(module name)
*  the following assumes the name is 8 characters
         MVC   12(8,R1),0(R15)        Move in name
         SVC   35
*
         L     R4,SRV_LOAD_A_NAME     Get a(a(module name))
         L     R0,SRV_PARM_VALUE      Get a(module name)
*
         LOAD  EPLOC=(0)
*
         L     R4,SRV_LOAD_A_LOADPT   Get a(a(loadpt))
         ST    R0,SRV_PARM_VALUE      Set a(module) in parmlist
         L     R4,SRV_LOAD_A_SIZE     Get a(a(size))
         ST    R1,SRV_PARM_VALUE      Set l(module) in parmlist
         SR    R0,R0                  Get zero for codes
         L     R4,SRV_LOAD_A_RETCODE  Get a(retcode)
         ST    R0,SRV_PARM_VALUE      Set retcode = 0
         L     R4,SRV_LOAD_A_RSNCODE  Get a(rsncode)
         ST    R0,SRV_PARM_VALUE      Set rsncode = 0
*
         LM    R14,R12,12(R13)
         BR    R14                Return to your caller
*
*
WTOCTL   DS    0H
WTOWLEN  DC    AL2(WTOEND-WTOCTL)
WTOFLG   DC    X'8000'
WTOAREA  DC    CL8'LOAD'
WTONAME  DS    CL8
WTOEND   DS    0X
WTOLEN   EQU   *-WTOCTL
         EJECT
* ===============================================================
*
*      Declare to de-reference parameter pointers
*
                     SPACE 1
SRV_PARM             DSECT
SRV_PARM_VALUE       DS  A             Parameter value
*
*
```

Figure 108 (Part 2 of 3). User-Defined Load Routine

```
*      Parameter list for LOAD service
*
                     SPACE 1
SRV_LOAD_PLIST       DSECT
SRV_LOAD_A_NAME      DS  A            A(A(module name))
SRV_LOAD_A_NAMELEN   DS  A            A(Length of name)
SRV_LOAD_A_USERWORD  DS  A            A(User word)
SRV_LOAD_A_RSVD      DS  A            A(Reserved - must be 0)
SRV_LOAD_A_LOADPT    DS  A            A(A(module load point))
SRV_LOAD_A_SIZE      DS  A            A(Size of module)
SRV_LOAD_A_RETCODE   DS  A            A(Return code)
SRV_LOAD_A_RSNCODE   DS  A            A(Reason code)
*
*

*
    LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END
```

Figure 108 (Part 3 of 3). User-Defined Load Routine

Delete Service Routine

The delete routine is responsible for deleting named modules. This is the service typically obtained via the DELETE macro.

The parameters passed to the delete routine are:

Parameter	PL/I attributes	Type
Address of module name	POINTER	Input
Length of name	FIXED BIN(31)	Input
User word	POINTER	Input
(Reserved field)	FIXED BIN(31)	Input
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The name length must not be zero. You can ignore the reserved field: it will contain zeros. Every delete must have a corresponding load, and the task that does the load must also do the delete. Counts of deletes and loads performed must be maintained by the service routines themselves.

The return/reason codes that the delete routine can set are:

0/0	successful
8/4	unsuccessful—delete failed
16/4	uncorrectable error occurred

Figure 109 on page 407 shows a sample delete routine that displays the name of each module as it is deleted.

```
         TITLE 'Preinit Delete Service Routine'
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Delete service routine to be used by preinit under MVS        *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
DLMPIPI  CSECT
*
         DS    0H
         STM   14,12,12(13)       Save registers
         LR    R3,R15             Set module Base
         USING DLMPIPI,R3
*
         LR    R2,R1                  Save parm register
         USING SRV_DELE_PLIST,R2
         USING SRV_PARM,R4

*
         L     R4,SRV_DELE_A_USERWORD Get a(userword)
         L     R1,SRV_PARM_VALUE      Get userword
         MVC   0(12,R1),WTOCTL        Move in WTO skeleton
         L     R4,SRV_DELE_A_NAME     Get a(a(module name))
         L     R15,SRV_PARM_VALUE     Get a(module name)
*  the following assumes the name is 8 characters
         MVC   12(8,R1),0(R15)        Move in name
         SVC   35
*
         L     R4,SRV_DELE_A_NAME     Get a(a(module name))
         L     R0,SRV_PARM_VALUE      Get a(module name)
*
         DELETE EPLOC=(0)
*
         SR    R0,R0                  Get zero for codes
         L     R4,SRV_DELE_A_RETCODE  Get a(retcode)
         ST    R0,SRV_PARM_VALUE      Set retcode = 0
         L     R4,SRV_DELE_A_RSNCODE  Get a(rsncode)
         ST    R0,SRV_PARM_VALUE      Set rsncode = 0
*
         LM    R14,R12,12(R13)
         BR    R14                Return to your caller
*

*
WTOCTL   DS    0H
WTOWLEN  DC    AL2(WTOEND-WTOCTL)
WTOFLG   DC    X'8000'
WTOAREA  DC    CL8'DELETE'
WTONAME  DS    CL8
WTOEND   DS    0X
WTOLEN   EQU   *-WTOCTL
         EJECT
* ===============================================================
*
*      Declare to dereference parameter pointers
*
                     SPACE 1
SRV_PARM             DSECT
SRV_PARM_VALUE       DS  A             Parameter value
*
```

Figure 109 (Part 1 of 2). User-Defined Delete Routine

```
*
*      Parameter list for DELETE service
*
                     SPACE 1
SRV_DELE_PLIST       DSECT
SRV_DELE_A_NAME      DS  A             A(A(module name))
SRV_DELE_A_NAMELEN   DS  A             A(Length of name)
SRV_DELE_A_USERWORD  DS  A             A(User word)
SRV_DELE_A_RSVD      DS  A             A(Reserved - must be 0)
SRV_DELE_A_RETCODE   DS  A             A(Return code)
SRV_DELE_A_RSNCODE   DS  A             A(Reason code)
*
*

*
     LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END
```

Figure 109 (Part 2 of 2). User-Defined Delete Routine

Get-Storage Service Routine

The get-storage routine is responsible for obtaining storage. This is the service typically obtained via the GETMAIN, DMSFREE, or CMSSTOR macros.

The parameters passed to the get-storage routine are:

Parameter	PL/I attributes	Type
Amount desired	FIXED BIN(31)	Input
Subpool number	FIXED BIN(31)	input
User word	POINTER	Input
Flags	BIT(32)	Input
Address of gotten storage	POINTER	Output
Amount obtained	FIXED BIN(31)	Output
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The return/reason codes for the get-storage routine are:

0/0	successful
16/4	unsuccessful—uncorrectable error occurred

All storage must be obtained conditionally by the service routine. Bit 0 in the flags is on if storage is wanted below the line. The other bits are reserved and might or might not be zero.

Free-Storage Service Routine

The free-storage routine is responsible for freeing storage. This is the service typically obtained via the FREEMAIN, DMSFRET, or CMSSTOR macros.

The parameters passed to the free-storage routine are:

Parameter	PL/I attributes	Type
Amount to be freed	FIXED BIN(31)	Input
Subpool number	FIXED BIN(31)	Input
User word	POINTER	Input
Address of storage	POINTER	Input
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The return/reason codes for the free-storage service routine are:

0/0	successful
16/0	unsuccessful—uncorrectable error occurred

Exception Router Service Routine

The exception router is responsible for trapping and routing exceptions. These are the services typically obtained via the ESTAE and ESPIE macros.

The parameters passed to the exception router are:

Parameter	PL/I attributes	Type
Address of exception handler	POINTER	Input
Environment token	POINTER	Input
User word	POINTER	Input
Abend flags	BIT(32)	Input
Check flags	BIT(32)	Input
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

During initialization, if the TRAP(ON) option is in effect, the Language Environment for MVS & VM library puts the address of the common library exception handler in the first field of the above parameter list, and sets the environment token field to a value that will be passed on to the exception handler. It also sets abend and check flags as appropriate, and then calls your exception router to establish an exception handler.

The meaning of the bits in the abend flags are given by the following declare:

```
dcl
  1 abendflags,
    2 system,
      3 abends bit(1),  /* control for system abends desired  */
      3 rsrv1  bit(15), /* reserved                           */
    2 user,
      3 abends bit(1),  /* control for user abends desired    */
      3 rsrv2  bit(15); /* reserved                           */
```

The meaning of the bits in the check flags is given by the following declare:

```
1 checkflags,
  2 type,
    3 reserved3             bit(1),
    3 operation             bit(1),
    3 privileged_operation  bit(1),
    3 execute               bit(1),
    3 protection            bit(1),
    3 addressing            bit(1),
    3 specification         bit(1),
    3 data                  bit(1),
    3 fixed_overflow        bit(1),
    3 fixed_divide          bit(1),
    3 decimal_overflow      bit(1),
    3 decimal_divide        bit(1),
    3 exponent_overflow     bit(1),
    3 exponent_underflow    bit(1),
    3 significance          bit(1),
    3 float_divide          bit(1),
  2 reserved4             bit(16);
```

The return/reason codes that the exception router must use are:

0/0	successful
4/4	unsuccessful—the exit could not be (de-)established
16/4	unrecoverable error occurred

When an exception occurs, the exception router must determine if the established exception handler is interested in the exception (by examining abend and check flags). If the exception handler *is not* interested in the exception, the exception router must treat the program as in error, but can assume the environment for the thread to be functional and reusable. If the exception handler *is* interested in the exception, the exception router must invoke the exception handler, passing the following parameters:

Parameter	PL/I attributes	Type
Environment token	POINTER	Input
SDWA	POINTER	Input
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The return/reason codes upon return from the exception handler are as follows:

0/0 Continue with the exception. Percolate the exception taking whatever action would have been taken had it not been handled at all. In this case, your exception router can assume the environment for the thread to be functional and reusable.

0/4 Continue with the exception. Percolate the exception taking whatever action would have been taken had it not been handled at all. In this case, the environment for the thread is probably unreliable and not reusable. A forced termination is suggested.

4/0 Resume execution using the updated SDWA. The invoked exception handler will have already used the SETRP RTM macro to set the SDWA for correct resumption.

During termination, your exception router is invoked with the exception handler address (first parameter) set to zero in order to de-establish the exit—if it was established during initialization.

For certain exceptions, the common library exception handler calls your exception router to establish another exception handler exit, and then makes a call to de-establish it before completing processing of the exception. If an exception occurs while the second exit is active, special processing is performed. Depending on what this second exception is, either the first exception will not be retried, or processing will continue on the first exception by requesting retry for the second exception.

If the common library exception handler determines that execution should resume for an exception, it will set the SDWA with SETRP and return with return/reason codes 4/0. Execution will resume in library code or in user code, depending on what the exception was.

Your exception router must be capable of restoring all the registers from the SDWA when control is given to the retry routine. This is required for PL/I to resume execution at the point where an interrupt occurred for the ZERODIVIDE, OVERFLOW, FIXEDOVERFLOW, and UNDERFLOW conditions, and certain instances of the SIZE condition. The ESPIE and ESTAE services are capable of accomplishing this. The SETFRR service will not restore register 15 to the requested value. If you cannot restore all the registers, unpredictable results can occur for a normal return from an ON-unit for one of these conditions. Unpredictable results can also occur if any of these conditions are disabled by a condition prefix. In addition, unpredictable results can occur for the implicit action for the UNDERFLOW condition.

To avoid unpredictable results in PL/I programs when not all of the registers can be restored, you must code an ON-unit for UNDERFLOW that does not return normally. For the other conditions, the implicit action is to raise the error condition, which is a predictable result. If you use an ON-unit for one of these conditions, you should guarantee that the ON-unit will not return normally.

In using the exception router service, you should also be aware that:

- Your exception router should not invoke the Language Environment for MVS & VM library exception handler if active I/O has been halted and is not restorable.

- You cannot invoke any Language Environment for MVS & VM dump services including PLIDUMP.
- This service requires an ESA* environment.
- This service is not supported under VM.

If an exception occurs while the exception handler is in control before another exception handler exit has been stacked, your exception router should assume that exception could not be handled and that the environment for the program (thread) is damaged. In this case, your exception router should force termination of the preinitialized environment.

Attention Router Service Routine

The attention router is responsible for trapping and routing attention interrupts. These are the services typically obtained via the STAX macro.

The parameters passed to the attention router are:

Parameter	PL/I attributes	Type
Address of attention handler	POINTER	Input
Environment token	POINTER	Input
User word	POINTER	Input
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The return/reason codes upon return from the attention router are as follows:

0/0	successful
4/4	unsuccessful—the exit could not be (de-)established
16/4	unrecoverable error occurred

When an attention interrupt occurs, your attention router must invoke the attention handler using the address in the attention handler field, passing the following parameters:

Parameter	PL/I attributes	Type
Environment token	POINTER	Input
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

The return/reason codes upon return from the attention handler are as follows:

0/0	attention has been (will be) handled

If an attention interrupt occurs while in the attention handler or when an attention handler is not established at all, your attention router should ignore the attention interrupt.

Figure 110 on page 413 shows a sample attention router.

```
         TITLE 'Preinit Attention Router Service Routine'
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Attention service routine to be used by preinit               *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
ATAPIPI  CSECT
*
         DS    0H
         STM   14,12,12(13)           Save registers
         LR    R3,R15                 Set module Base
         USING ATAPIPI,R3
*
         LR    R2,R1                  Save parm register
         USING SRV_ATTN_PLIST,R2
         USING SRV_PARM,R4

*
         L     R4,SRV_ATTN_A_USERWORD Get A(userword)
         L     R11,SRV_PARM_VALUE     Get userword -- storage area
         USING ZSA,R11
         WTO   'In attn router'
*
         L     R4,SRV_ATTN_A_HANDLER  Get a(a(handler))
         ICM   R5,X'F',SRV_PARM_VALUE Get a(handler)
         BZ    CANCEL_STAX            A(0) means cancel
*
         L     R4,SRV_ATTN_A_TOKEN    Get a(a(token))
         L     R6,SRV_PARM_VALUE      Get a(token)
*
         ST    R5,ZHANDLER            Set handler in user parm list
         ST    R6,ZTOKEN              Set token in user parm list
         LA    R5,ZHANDLER            Address user parm list for STAX
*
         LA    R4,RETPOINT            Address attention exit routine
*
         XC    ZSTXLST(STXLTH),ZSTXLST     Clear STAX work area
*
*   Set appropriate SPLEVEL
*
         SPLEVEL SET=2               Get XA or ESA version of macro
         STAX  (R4),REPLACE=YES,                                       C
               USADDR=(R5),MF=(E,ZSTXLST)
*
         B     EXIT_CODE

*
CANCEL_STAX DS  0H
*
         STAX
*
EXIT_CODE   DS  0H
*
         SR    R0,R0                  Get zero for codes
         L     R4,SRV_ATTN_A_RETCODE  Get a(retcode)
         ST    R0,SRV_PARM_VALUE      Set retcode = 0
         L     R4,SRV_ATTN_A_RSNCODE  Get a(rsncode)
         ST    R0,SRV_PARM_VALUE      Set rsncode = 0
*
         LM    R14,R12,12(R13)
         BR    R14                    Return to your caller
         EJECT
```

Figure 110 (Part 1 of 4). User-Defined Attention Router

```
*
RETPOINT DS    0H
*
*   This is the attention exit routine, entered after an
*   attention interrupt.
*
         STM   14,12,12(13)           Save registers
         BALR  R3,0                   Set module base
         USING *,R3
         LR    R2,R1                  Save parm register

*
         WTO   'In stax exit'
*
         USING ZAXP,R2
         L     R11,ZAUSA              Get A(User area) -- our storage
*
         L     R14,ZTOKEN             Get A(token)
         ST    R14,SRV_AHND_TOKEN     Set in its place
         LA    R14,SRV_AHND_TOKEN     Get...
         LA    R15,SRV_AHND_RETCODE    ..addresses...
         LA    R0,SRV_AHND_RSNCODE       ..of parms
         STM   R14,R0,SRV_AHND_A_TOKEN     Set parms for handler
*
         LA    R14,ZSSA               Get A(save area)
         ST    R13,4(,R14)            Set chain
         LR    R13,R14                Set new save area
*
         LA    R1,SRV_AHND_PLIST      Reg 1 to parameter list
         L     R15,ZHANDLER           Get A(handler)
         BALR  R14,R15                Invoke PL/I's handler
*
         L     R13,4(,R13)            Restore save area
*
         LM    R14,R12,12(R13)
         BR    R14                    Return to your caller
*

*
*
ZSA      DSECT
*  user address points to here on STAX invocation
ZHANDLER DS    F                      A(handler)
ZTOKEN   DS    F                      A(token)
*   end of information needed when Attention occurs
ZSSA     DS    18F                    Save area
ZSTXLST  DS    0F                     STAX Plist
         SPLEVEL SET=2                Get XA or ESA version of macro
         STAX  0,MF=L
         DS    0D                     ALIGN
STXLTH   EQU   *-ZSTXLST              LENGTH
*
```

Figure 110 (Part 2 of 4). User-Defined Attention Router

```
*      Parameter list for Attention Handler routine
*
SRV_AHND_PLIST       DS  0F
SRV_AHND_A_TOKEN     DS  A            A(Token)
SRV_AHND_A_RETCODE   DS  A            A(Return code)
SRV_AHND_A_RSNCODE   DS  A            A(Reason code)
*   end of parameter list
SRV_AHND_TOKEN       DS  A            Token
SRV_AHND_RETCODE     DS  A            Return code
SRV_AHND_RSNCODE     DS  A            Reason code
*
* ===============================================================
*
ZAXP     DSECT                        Attention exit Plist
ZATAIE   DS    F                      A(Terminal attention
*                                     interrupt element - TAIE)
ZAIBUF   DS    F                      A(Input buffer)
ZAUSA    DS    F                      A(User area)
*
*      Declare to dereference parameter pointers
*
                     SPACE 1
SRV_PARM             DSECT
SRV_PARM_VALUE       DS  A            Parameter value
*
*
*      Parameter list for Attention Router service
*
                     SPACE 1
SRV_ATTN_PLIST       DSECT
SRV_ATTN_A_HANDLER   DS  A            A(Handler)
SRV_ATTN_A_TOKEN     DS  A            A(Token)
SRV_ATTN_A_USERWORD  DS  A            A(User word)
SRV_ATTN_A_RETCODE   DS  A            A(Return code)
SRV_ATTN_A_RSNCODE   DS  A            A(Reason code)
SRV_ATTN_HANDLER     DS  A            Handler
SRV_ATTN_TOKEN       DS  A            Token
SRV_ATTN_USERWORD    DS  A            User word
SRV_ATTN_RETCODE     DS  A            Return code
SRV_ATTN_RSNCODE     DS  A            Reason code
*
```

Figure 110 (Part 3 of 4). User-Defined Attention Router

```
*
*
     LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END
```

Figure 110 (Part 4 of 4). User-Defined Attention Router

Message Router Service Routine

The message router is responsible for routing messages generated during execution. This is the service typically obtained via the WTO and other macros.

The parameters passed to the message router are:

Parameter	**PL/I attributes**	**Type**
Address of message	POINTER	Input
Message length in bytes	FIXED BIN(31)	Input
User word	POINTER	Input
Line length	FIXED BIN(31)	Output
Return code	FIXED BIN(31)	Output
Reason code	FIXED BIN(31)	Output

If the address of the message is zero, your message router is expected to return the size of the line to which messages are written (in the line length field). This allows messages to be formatted correctly—that is, broken at blanks, etc.

The return/reason codes that the message router must use are as follows:

0/0	successful
16/4	unrecoverable error occurred

Figure 111 on page 417 shows a sample message router.

```
         TITLE 'Preinit Message Service Routine'
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Message service routine to be used by preinit                 *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
MSGPIPI  CSECT
*
         DS    0H
         STM   14,12,12(13)       Save registers
         LR    R3,R15             Set module Base
         USING MSGPIPI,R3
*
         LR    R2,R1                  Save parm register
         USING SRV_MSG_PLIST,R2
         USING SRV_PARM,R4
*
         L     R4,SRV_MSG_A_ADDR      Get a(a(message))
         L     R5,SRV_PARM_VALUE      Get a(message)
*
*   If the address of the message is zero then
*     return the message line length (the maximum
*     length a message should be)
*
         LTR   R5,R5                  a(message) zero?
         BNZ   WRT_MSG                if not, go write msg
*
         LA    R5,72                  buffer length = 72
         L     R4,SRV_MSG_A_LRECL     set message lrecl = 72
         ST    R5,SRV_PARM_VALUE
         B     DONE

*
WRT_MSG  DS    0H
         L     R4,SRV_MSG_A_USERWORD  Get a(userword)
         L     R1,SRV_PARM_VALUE      Get userword
         MVC   0(12,R1),WTOCTL        Move in WTO skeleton
         MVI   13(R1),C' '            Blank out the
         MVC   14(71,R1),13(R1)         message buffer
*
         L     R4,SRV_MSG_A_ADDR      Get a(a(message))
         L     R5,SRV_PARM_VALUE      Get a(message)
         L     R4,SRV_MSG_A_LEN       Get a(message length)
         L     R6,SRV_PARM_VALUE      Get message length
         BCTR  R6,0                   subtract 1 from length for EX
         EX    R6,MOVE                Move in the message
*
         SVC   35                     Use WTO to display message
*
DONE     DS    0H
         SR    R0,R0                  Get zero for codes
         L     R4,SRV_MSG_A_RETCODE   Get a(retcode)
         ST    R0,SRV_PARM_VALUE      Set retcode = 0
         L     R4,SRV_MSG_A_RSNCODE   Get a(rsncode)
         ST    R0,SRV_PARM_VALUE      Set rsncode = 0
*
         LM    R14,R12,12(R13)
         BR    R14                Return to your caller
*
```

Figure 111 (Part 1 of 2). User-Defined Message Router

```
MOVE     MVC   12(0,R1),0(R5)
WTOCTL   DS    0H
WTOWLEN  DC    AL2(WTOEND-WTOCTL)
WTOFLG   DC    X'8000'
WTOAREA  DC    CL8'MESSAGE'
WTOMSG   DS    CL72
WTOEND   DS    0X
WTOLEN   EQU   *-WTOCTL
         EJECT
* ===============================================================
*
*      Declare to dereference parameter pointers
*
                     SPACE 1
SRV_PARM             DSECT
SRV_PARM_VALUE       DS  A                 Parameter value
*
*
*      Parameter list for Message service
*
                     SPACE 1
SRV_MSG_PLIST       DSECT
SRV_MSG_A_ADDR      DS  A             A(A(message))
SRV_MSG_A_LEN       DS  A             A(message length)
SRV_MSG_A_USERWORD  DS  A             A(User word)
SRV_MSG_A_LRECL     DS  A             A(line length)
SRV_MSG_A_RETCODE   DS  A             A(Return code)
SRV_MSG_A_RSNCODE   DS  A             A(Reason code)
*
*
     LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END
```

Figure 111 (Part 2 of 2). User-Defined Message Router

User Exits in Preinitializable Programs

The user exits are invoked when initialization and termination is actually performed according to the user exit invocation rules defined by Language Environment for MVS & VM. That is, the user exit is invoked for initialization during the INIT request or the CALL with the zero token request. Similarly, the user exit is called for termination only during the TERM request.

The SYSTEM Option in Preinitializable Programs

PL/I honors the SYSTEM compile-time option when evaluating the object code's parameter, except for the SYSTEM(CMS) and SYSTEM(CMSTPL) options. To invoke a preinitialized program under VM, the program **must** have been compiled using the SYSTEM(MVS) compile-time option. **Preinitializable programs are not allowed for programs compiled with SYSTEM(CMS) or SYSTEM(CMSTPL)**.

For the remaining SYSTEM options (MVS, CICS, TSO, and IMS), PL/I will interpret the object code's parameter list as dictated by the SYSTEM option.

Note: PL/I-defined preinitialization is not supported under CICS.

To preinitialize programs in the VM environment, you must compile with the SYSTEM(MVS) option and drive the PL/I program via an assembler program.

Calling a Preinitializable Program under VM

The following series of VM commands runs programs shown in Figure 104 on page 394 and Figure 105 on page 398:

```
PLIOPT PLIEXAM ( SYSTEM ( MVS
HASM PREPEXAM
LOAD PREPEXAM PLIEXAM ( RESET PREPEXAM
START *
```

Figure 112. Commands for Calling a Preinitializable PL/I Program under VM

Calling a Preinitializable Program under MVS

Figure 113 on page 420 is a skeleton JCL which runs the example of a preinitializable program in an MVS environment.

```
//PREINIT  JOB
//* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
//*   Assemble the driving assembler program
//* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
//ASM     EXEC PGM=IEV90,PARM='OBJECT,NODECK'
//SYSPRINT  DD SYSOUT=A
//SYSLIB    DD DSN=SYS1.MACLIB,DISP=SHR
//SYSLIN    DD DSN=&&OBJ1,DISP=(,PASS),UNIT=SYSDA,
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),SPACE=(CYL,(2,1))
//SYSUT1    DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSIN     DD *
  ********* ASSEMBLER PROGRAM GOES HERE **********

//* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
//*   Compile the PL/I program
//* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

//PLI      EXEC PGM=IEL1AA,PARM='OBJECT,NODECK',REGION=512K
//STEPLIB  DD  DSN=IEL.V1R1M1.SIELCOMP,DISP=SHR
//         DD  DSN=CEE.V1R2M0.SCEERUN,DISP=SHR
//SYSPRINT DD  SYSOUT=*
//SYSLIN   DD  DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSDA,
//             SPACE=(80,(250,100)),DCB=(BLKSIZE=3120)
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,
//             SPACE=(1024,(200,50),,CONTIG,ROUND),DCB=BLKSIZE=1024
//SYSIN     DD *
  ********* PLIEXAM PLIOPT PROGRAM GOES HERE **********

//***************************************************************
//* Link-edit the program
//***************************************************************
//LKED     EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=512K
//SYSLIB   DD  DSN=CEE.V1R2M0.SCEELKED,DISP=SHR
//SYSPRINT DD  SYSOUT=*
//SYSLIN   DD  DSN=&&OBJ1,DISP=(OLD,DELETE)
//         DD  DSN=&&LOADSET,DISP=(OLD,DELETE)
//         DD  *
  ENTRY    name of preinit csect
//SYSLMOD  DD  DSN=&&GOSET(GOPGM),DISP=(MOD,PASS),UNIT=SYSDA,
//             SPACE=(1024,(50,20,1))
//SYSUT1   DD  DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//             DCB=BLKSIZE=1024
//**************************************************************
//* Execute the preinitializable program
//**************************************************************
//GO       EXEC PGM=*.LKED.SYSLMOD,COND=((9,LT,PLI),(9,LT,LKED)),
//             REGION=2048K
//STEPLIB  DD  DSN=CEE.V1R2M0.SCEERUN,DISP=SHR
//SYSPRINT DD  SYSOUT=*
//CEEDUMP  DD  SYSOUT=*
//SYSUDUMP DD  SYSOUT=*
```

Figure 113. JCL for Running a Preinitializable PL/I Program under MVS

Establishing an Language Environment for MVS & VM-Enabled Assembler Routine as the MAIN Procedure

For information about compatibility of an assembler routine as the MAIN procedure, see the *PL/I for MVS & VM Compiler and Run-Time Migration Guide*.

Retaining the Run-Time Environment Using Language Environment for MVS & VM-Enabled Assembler as MAIN

For information about retaining the environment for better performance, see the *Language Environment for MVS & VM Programming Guide*.

Chapter 19. Multitasking in PL/I

You can use PL/I multitasking to exploit multiprocessors or to synchronize and coordinate tasks in a uniprocessor. Multitasking allows data and files to be shared. This involves task creation, tasking rules, tasking program control data, attributes, options, and built-in functions.

In general, a *task* is a unit of work that competes for the resources of the computing system. A task can be independent of, or dependent on, other tasks in the system. In MVS, a task is associated with a TCB (Task Control Block) which describes the resources of the task.

In MVS you usually have one application task per address space. However, you can create multiple tasks which:

- Complete a piece of work in shorter elapsed time. You could use this in batch applications that process accumulated data.
- Use computing system resources that might be idle. This includes I/O devices as well as the CPUs.
- Effectively utilize multiprocessor complexes such as the 3090*. However, you do not need a multiprocessing system to use multitasking.
- Implement real-time multi-user applications where the response time is critical, and each task can be processed independently as resources become available.
- Isolate independent pieces of work for reliability. This means that you can isolate the failure of a part of a job while still processing other independent parts.

PL/I Multitasking Facilities

PL/I Multitasking facilities are simple extensions to the nontasking language which you can use only when running programs under MVS (excluding the IMS and CICS subsystems) on any 390 processor. The DB2 SQL statements from multiple tasks not under IMS or CICS are supported. You also must have OpenEdition Release 2 installed and activated before you can run your multitasking applications.

The run-time environment uses the POSIX multithreading services to support PL/I multitasking. Because of the differences in this environment, you might experience a different timing in your application. Also, you cannot invoke any POSIX functions while you are using the the PL/I multitasking facility. If you attempt to use the multitasking facility while you are using the POSIX-defined multithreading environment, your program will abend. See the *Language Environment for MVS & VM Debugging Guide and Run-Time Messages* for a description of message IBM0581I.

For details of the run-time environment needed for using the PL/I multitasking facility, see *Language Environment for MVS & VM Programming Guide*.

Creating PL/I Tasks

You must initiate multitasking in your main procedure (initial enclave). If it is found in a nested enclave, your program will be terminated and IBM0576S error message issued. See Language Environment for MVS & VM Debugging Guide and Run-Time Messages for information on this error message.

When you create (attach) a task in PL/I, you must use the CALL statement with at least one of the options TASK, EVENT, or PRIORITY. When you use one of these options, you attach a task and create a subtask. You can attach other tasks to this attached task, creating more subtasks.

Use the WAIT statement to synchronize your tasks. If the subtask synchronously invokes any procedures or functions (that is, without the TASK, EVENT, or PRIORITY options), they become part of that subtask too.

The TASK Option of the CALL Statement

Use the TASK option of the CALL statement to specify a TASK variable. This variable is associated with the attached task and can control the dispatching priority of the attached task. You can use the task variable to interrogate or change the dispatching priority of the current task or any other task.

Example

```
CALL INPUT TASK(T1);
```

This call attaches a task by invoking INPUT. It names the task T1. T1 is the TASK variable.

The EVENT Option of the CALL Statement

You can use the EVENT option to specify an EVENT variable which another task can use to WAIT for the completion of the attached task.

Examples

The following CALL statement creates an unnamed task:

```
CALL INPUT EVENT(E4);
```

The EVENT option indicates that this unnamed task will be finished when EVENT E4 is completed.

The following CALL statement with the TASK option creates task T4:

```
CALL INPUT TASK(T4) EVENT(E5);
```

The EVENT option allows the attaching task (or another task) to wait until event E5 is completed.

Also see the last example under “The PRIORITY Option of the CALL Statement” on page 424.

The PRIORITY Option of the CALL Statement

You can use the PRIORITY option to set the initial dispatching priority of the attached task. This priority is only relative to the attaching task's priority. The attached task can have a priority higher than, lower than, or equal to the priority of the attaching task. The actual priority can range between zero and the MVS-allowed maximum.

If you do not use the PRIORITY option, or you set it to zero, the attached task's initial dispatching priority is the same as the attaching task's.

Examples

The following CALL statement creates an unnamed task:

```
CALL INPUT PRIORITY(2);
```

It runs at a dispatching priority of two more than that of the attaching task.

The following CALL statement with the TASK option creates task T2:

```
CALL INPUT TASK(T2) PRIORITY(-1);
```

The PRIORITY option makes the actual dispatching priority of task T2 to be one less than that of the attaching task, but not less than zero.

The following CALL statement with the TASK option creates task T3:

```
CALL INPUT TASK(T3) PRIORITY(1) EVENT(E3);
```

The PRIORITY option makes the actual dispatching priority of task T3 to be one more than that of the attaching task, but not more than the MVS-allowed maximum. The EVENT option says the status and completion values of event E3 are set when task T3 terminates. This allows synchronization of other tasks with task T3.

Synchronization and Coordination of Tasks

You can synchronize and coordinate the execution of tasks by using the EVENT option. The completion and status values control the EVENT option. The BIT(1) completion value can be '1'B which indicates the EVENT is complete or '0'B which indicates that the EVENT is not complete. The FIXED BIN(15,0) status value can be zero which shows that the EVENT has normal completion or any other number which shows that the EVENT has abnormal completion.

These values can be set by:

- The termination of a task (END, RETURN, EXIT)
- The COMPLETION pseudovariable for the completion value
- The STATUS pseudovariable for the status value
- The assignment of both EVENT variable values simultaneously
- A Statement with the EVENT option.

In addition to these conditions, you can also change the values by using a WAIT statement for an I/O or DISPLAY statement event or a CLOSE statement for a FILE having an active EVENT I/O operation.

However, while you are using these tools, you must be careful not to reset or reuse an EVENT variable already associated with an active task or I/O operation.

If you want to test the value of the EVENT variable, you can use the BUILTIN functions for the completion and status values. You can also reassign the EVENT variables to test both values (completion and status) simultaneously. You can also test using the WAIT statement, which waits for the completion of the event.

Sharing Data between Tasks

If you want data to be shared between tasks you must be sure that the STATIC and current AUTOMATIC variables are known in the attaching block at the time the subtask is attached.

You must use only the latest generation of CONTROLLED variables. Subsequent generations will be known only to the allocating task (attaching or attached). Be sure that a task does not free a CONTROLLED variable shared by more than one task.

Your BASED allocations can be in AREAs shared between multiple tasks but all other BASED allocations are task local. Also, any variable of any storage class can be shared via a BASED reference as long it is allocated and is not freed until none of the tasks are using it.

When you update shared data, be sure that multiple concurrent updates are not lost. In order to do this, you must use EVENTs to coordinate updating.

Sharing Files between Tasks

You can share any file subject to the following rules:

1. An attached task can share any file opened by the attaching task before the attached task is called.
2. The file must not be closed by the attaching task while it is being used by any attached task.

   If the file is closed by the attaching task, results are unpredictable if an attempt is made to reference the file in any attached task, which had previously shared the file.
3. The file must not be closed by a task that did not open it.
4. Sharing must be coordinated between the sharing tasks. Most access methods do not allow simultaneous use of a file by multiple tasks. Therefore you must provide some form of interlocking. You can use WAIT and COMPLETION for interlocking in the PL/I environment.

   In order to avoid the error condition associated with concurrent access, interlocking is required for files with a limit of one I/O operation. VSAM files and both SEQUENTIAL and DIRECT UNBUFFERED files not using the ISAM compatibility interface, have a limitation of one I/O operation.

   To avoid competition between tasks using SYSPRINT, PL/I provides serialization for STREAM PUT statements for the STREAM file SYSPRINT only.
5. Use the EXCLUSIVE attribute to guarantee multiple updates of the same record for DIRECT UPDATE files.

You cannot share files if they are opened by the attaching task after an attached task is called. Also, attached task files are not shared by the attaching task. If you use several files to access one data set, see “Associating Several Files with One Data Set” on page 101.

Producing More Reliable Tasking Programs

You will be able to produce more reliable tasking programs if you take note of the following:

- Use PROC OPTIONS(REENTRANT) on all external procedures.
- Do not modify STATIC (INTERNAL and EXTERNAL) storage.
- If the MSGFILE(SYSPRINT) run-time option is specified, the standard SYSPRINT file must be opened before any subtasks are created. Output lines from STREAM PUT statements might be interwoven with run-time messages.
- Be sure to avoid task interlocks, such as Task A waiting for Task B and Task B waiting for Task A. For more information on this, see the *PL/I for MVS & VM Language Reference*
- If you use COBOL ILC, only one task at a time can use it.
- You might not need to explicitly include certain Library routines in the PL/I Main load module if a FETCHed procedure is attached as a task (see Language Environment for MVS & VM Programming Guide for detailed information).

Terminating PL/I Tasks

Termination is normal when the initial procedure of the task reaches an END or a RETURN statement. Abnormal terminations can occur:

- When control in the attached task reaches an EXIT statement.
- When control in any task reaches a STOP statement.
- When the attaching task or attaching block (calling PROCEDURE or BEGIN) terminates.
- As a result of implicit action or action on normal return for ERROR.

When a task terminates normally or abnormally, PL/I will:

- Set all incomplete I/O EVENTs to abnormal status so the results of I/O operations are undefined.
- Close all files opened by the task, disabling all I/O conditions so no I/O conditions are raised.
- Free all CONTROLLED allocations and BASED allocations (except in AREAs owned by other tasks) done by the task.
- Terminate all active blocks and subtasks.
- Post the EVENT variable on the attaching CALL statement complete.
- Unlock all records locked by the task.

Dispatching Priority of Tasks

You can determine the dispatching priority of tasks in two ways while MVS can determine them in several ways. You can use the PRIORITY option to set the initial dispatching priority, as shown in the above examples. Or you can explicitly declare the actual priority as in:

```
DCL T1 TASK
```

In MVS, a task can change its own or any other task's priority. A TASK's priority value can be set or changed by:

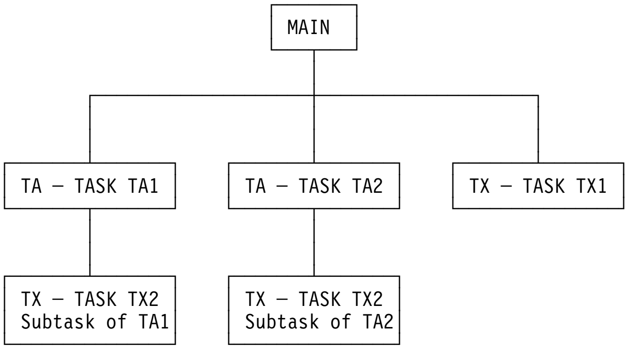
- The PRIORITY option of CALL
- The PRIORITY pseudovariable
- TASK variable assignment to an inactive TASK variable.

You can test a TASK's priority value by using the PRIORITY built-in function. However, the PRIORITY built-in function might not return the same value as was set by the PRIORITY pseudovariable. For more information, see the *PL/I for MVS & VM Language Reference*

A task hierarchy example is shown in the following program:

```
MAIN: PROC OPTIONS(MAIN REENTRANT);
   CALL TA TASK(TA1);
   CALL TA TASK(TA2);
   CALL TX TASK(TX1);
   TA: PROC;
      CALL TX TASK(TX2);
   END;
END;
```

where the hierarchy is:



Running Tasking Programs

When you run your tasking programs, first compile external procedures and link edit the object code, being sure to place SIBMTASK ahead of SCEELKED in SYSLIB DD statement. This rule applies to the main load module, but not to a FETCHed subroutine load module.

Note: Linking the main load module of an application that does not use the multitasking facility, with SIBMTASK or PLITASK, causes a loss in performance during initialization and termination.

Language Environment provides HEAP, THREADHEAP, NONIPSTACK, and PLITASKCOUNT run-time options to support PL/I multitasking. For a description of these options, see *Language Environment for MVS & VM Programming Guide*. You can also use PLIDUMP's multitasking options which are described in Chapter 17, “Using PLIDUMP” on page 386.

Sample Program 1: Multiple Independent Processes

Figure 114 on page 429 is a nontasking version of a program that processes an input file consisting of transactions that can be processed independent of one another. Following that is Figure 115 on page 430, which is a tasking version of the same program.

Multiple Independent Processes: Nontasking Version

```
/* PROC - MULTIPLE INDEPENDENT PROCESSES (NONTASKING VERSION)        */
PROC: PROC OPTIONS(MAIN REENTRANT) REORDER;
   DCL INPUT FILE;
   DCL RECORD CHAR(80),
       REQUEST CHAR(8) DEF(RECORD);
   DCL EOF BIT INIT('0'B);
   ON ENDFILE(INPUT) EOF='1'B;
   READ FILE(INPUT) INTO(RECORD);
   DO WHILE(¬EOF);
     SELECT(REQUEST);
       WHEN('REPORT') CALL REPORT; /* PRODUCE A REPORT              */
       WHEN('COPY') CALL COPY;     /* COPY RECORDS TO "OUTPUT" FILE */
       OTHERWISE CALL ERROR;       /* INVALID                       */
     END;
     READ FILE(INPUT) INTO(RECORD);
   END;

REPORT: PROC REORDER;
     /***************************************************************/
     /* PROCESS EACH RECORD TO PRODUCE A REPORT                     */
     /***************************************************************/
   DCL FREPORT FILE OUTPUT;
   WRITE FILE(FREPORT) FROM(RECORD);
 END;

COPY: PROC REORDER;
     /***************************************************************/
     /* COPY RECORDS TO "OUTPUT" FILE                               */
     /***************************************************************/
   DCL FCOPY FILE OUTPUT;
   WRITE FILE(FCOPY) FROM(RECORD);
 END;

ERROR: PROC REORDER;
     /***************************************************************/
     /* INVALID REQUEST - WRITE RECORD TO THE ERROR FILE            */
     /***************************************************************/
   DCL FERROR FILE OUTPUT;
   WRITE FILE(FERROR) FROM(RECORD);
 END;
 END;                              /* MAIN                          */
```

Figure 114. Nontasking Version of Multiple Independent Processes

Multiple Independent Processes: Tasking Version

```
/* PROCT - MULTIPLE INDEPENDENT PROCESSES (TASKING VERSION)         */
PROCT: PROC OPTIONS(MAIN REENTRANT) REORDER;
   DCL INPUT FILE INPUT;
   DCL RECORD CHAR(80),
       REQUEST CHAR(8) DEF(RECORD);
   DCL EOF BIT(1) INIT('0'B);
   DCL (TASK_ENDED, WORK_READY, WORK_DONE)(3) EVENT;
   DCL REC_PTR(3,                  /* A LIST OF RECORDS ...         */
                  10)              /* FOR EACH TASK                 */
         PTR INIT((30) NULL());
   DCL
       REC_AREA(3,                 /* RECORD AREA (FOR EACH REC_PTR)*/
                   10) CHAR(80);   /* FOR EACH TASK                 */
   DCL
     TASK_REC_PTR#(3) FIXED BIN INIT((3)0);/* INDEX INTO REC_PTR AND
                                      REC_AREA WHERE THE LAST RECORD
                                      WAS PLACED FOR EACH OF THE
                                      TASKS                         */
   DCL REC_PTR# FIXED BIN;
   DCL TASKS(3) ENTRY INIT(REPORT,COPY,ERROR);
   DCL (FREPORT,FCOPY,FERROR) FILE OUTPUT;
   DCL OUT_FILE(3) FILE INIT(FREPORT,FCOPY,FERROR);
   DCL REC_TYPE FIXED BIN INIT(0);
   DCL LIST_SEARCHED BIT(1);
   /*****************************************************************/
   /* START ALL TASKS AND LET THEM INITIALIZE                       */
   /*****************************************************************/
   STATUS(WORK_READY)=0;           /* DO WORK - DON'T TERMINATE     */
   DO I=LBOUND(TASKS,1) TO HBOUND(TASKS,1);
     CALL TASKS(I)(OUT_FILE(I),WORK_READY(I),WORK_DONE(I),(I))/*
                                      MUST HAVE A TEMPORARY FOR "I" */
         EVENT(TASK_ENDED(I));
   END;
   /*****************************************************************/
   /* PROCESS RECORDS                                               */
   /*****************************************************************/
   ON ENDFILE(INPUT) EOF='1'B;
   READ FILE(INPUT) INTO(RECORD);
   I=LBOUND(REC_PTR,1);
   DO WHILE(¬EOF);
     I=REC_TYPE;                   /* JUST PROCESSED REC TYPE IF ANY*/
     SELECT(REQUEST);
       WHEN('REPORT') REC_TYPE=1;
       WHEN('COPY') REC_TYPE=2;
       OTHERWISE REC_TYPE=3;
     END;
     IF REC_TYPE¬=I                /* CURRENT TYPE NOT SAME & WE'RE */
        &I¬=0 THEN                 /* NOT HERE FOR FIRST TIME       */
       COMPLETION(WORK_READY(I))='1'B;/* GET THAT TASK
                                      GOING IN CASE IT'S WAITING    */
     LIST_SEARCHED='0'B;
```

Figure 115 (Part 1 of 3). Tasking Version of Multiple Independent Processes

```
PLACE_REC:
     DO REC_PTR#=TASK_REC_PTR#(REC_TYPE)+1 REPEAT REC_PTR#+1;
       /*************************************************************/
       /* IF LIST IS ALL FULL, WAIT FOR APPROPRIATE TASK TO BE      */
       /* READY FOR WORK. OTHERWISE PLACE RECORD JUST READ IN AN    */
       /* AVAILABLE SLOT ON THE APPROPRIATE LIST.                   */
       /*************************************************************/
       IF REC_PTR#>HBOUND(REC_PTR,2) THEN
         DO;
           REC_PTR#=LBOUND(REC_PTR,2);  /* RESET LOOP COUNTER       */
           IF LIST_SEARCHED THEN
             DO;
               /*****************************************************/
               /* ALL REC_PTR LIST IS EMPTY (FOR THIS REC TYPE).    */
               /* WAIT FOR APPROPRIATE TASK TO GET READY FOR WORK   */
               /*****************************************************/
               WAIT(WORK_DONE(REC_TYPE));
               COMPLETION(WORK_DONE(REC_TYPE))='0'B;
               COMPLETION(WORK_READY(REC_TYPE))='1'B;/* GET THAT TASK
                                      GOING IN CASE IT'S WAITING    */
             END;
           ELSE
             LIST_SEARCHED='1'B;   /* WE'LL DO AT LEAST ONE COMPLETE
                                      SCAN OF LIST                  */
         END;
       IF REC_PTR(REC_TYPE,REC_PTR#)=NULL() THEN
         DO;
           REC_AREA(REC_TYPE,REC_PTR#)=RECORD;/* PUT RECORD IN
                                      RECORD AREA LIST              */
           REC_PTR(REC_TYPE,REC_PTR#)=ADDR(REC_AREA(REC_TYPE,REC_PTR#)
               );                  /* SET PTR                       */
           TASK_REC_PTR#(REC_TYPE)=REC_PTR#;/* REMEMBER THIS INDEX  */
           LEAVE PLACE_REC;
         END;
     END;
     READ FILE(INPUT) INTO(RECORD);
   END;
   /*****************************************************************/
   /* AT END OF JOB (END OF FILE), TELL ALL TASKS TO FINISH AND WAIT*/
   /* FOR THEM ALL TO FINISH                                        */
   /*****************************************************************/
   STATUS(WORK_READY)=4;           /* FINISH REMAINING WORK & QUIT  */
   COMPLETION(WORK_READY)='1'B;
   WAIT(TASK_ENDED);
```

Figure 115 (Part 2 of 3). Tasking Version of Multiple Independent Processes

```
   /******************************************************************/
   /* REPORT/COPY/ERROR TASKS                                        */
   /******************************************************************/
REPORT: COPY: ERROR:
   PROC(OUT_FILE,WORK_READY,WORK_DONE,MY_LIST) REORDER;
   /******************************************************************/
   /* PROCESS "INPUT FILE" AND PRODUCE A REPORT FOR EVERY REQUEST   */
   /******************************************************************/
   DCL OUT_FILE FILE;
   DCL (WORK_READY, WORK_DONE) EVENT;
   DCL MY_LIST FIXED BIN;
   DCL RECORD CHAR(80) BASED;
   DCL LIST_SEARCHED BIT(1) INIT('0'B);
   DCL J FIXED BIN;
   /******************************************************************/
   /* DO INIT, OPEN FILES, ETC.                                      */
   /******************************************************************/
   ;
   DO J=1 REPEAT J+1;
     /****************************************************************/
     /* PROCESS NEXT AVAILABLE RECORD                                */
     /****************************************************************/
     IF REC_PTR(MY_LIST,J)¬=NULL() THEN
       DO;
         /************************************************************/
         /* PROCESS RECORD ...                                       */
         /************************************************************/
         WRITE FILE(OUT_FILE) FROM(REC_PTR(MY_LIST,J)->RECORD);
         REC_PTR(MY_LIST,J)=NULL();/* RECORD PROCESSED               */
       END;
     IF J=HBOUND(REC_PTR,2) THEN
       DO;
         J=LBOUND(REC_PTR,2)-1;    /* RESET LOOP                     */
         IF LIST_SEARCHED THEN
           DO;
             /********************************************************/
             /* ALL REC_PTR LIST IS EMPTY (FOR THIS REC TYPE). WAIT */
             /* FOR MORE WORK OR REQUEST TO TERMINATE IF NOT ALREADY*/
             /* ASKED TO TERMINATE                                   */
             /********************************************************/
             IF STATUS(WORK_READY) = 4 THEN RETURN;
             COMPLETION(WORK_DONE)='1'B;/* FINISHED WITH
                                      WHAT I HAVE                    */
             WAIT(WORK_READY);           /* WAIT FOR MORE WORK OR
                                      FOR REQUEST TO FINISH          */
             COMPLETION(WORK_READY)='0'B;
             LIST_SEARCHED='0'B;
           END;
         ELSE
           LIST_SEARCHED='1'B;     /* WE'LL DO AT LEAST ONE COMPLETE
                                      SCAN OF LIST LIST              */
       END;
   END;
 END;                              /* REPORT ...                     */
 END;                              /* MAIN                           */
```

Figure 115 (Part 3 of 3). Tasking Version of Multiple Independent Processes

Sample Program 2: Multiple Independent Computations

Figure 116 on page 433 is a nontasking version of a program that processes an input file and performs independent computations. Figure 117 on page 434 follows that. It is the tasking version of the same program.

Multiple Independent Computations: Nontasking Version

```
/* COMP - INDEPENDENT COMPUTATIONS (NONTASKING VERSION)             */
COMP: PROC OPTIONS(MAIN REENTRANT) REORDER;
   DCL (AR1, AR2, AR3, A)(100,100,100) FLOAT BIN;
   DCL (BR1, BR2, BR3, X)(100,100,100) FLOAT BIN;
   DCL EOF BIT(1) INIT('0'B),
      (B, Y) FLOAT BIN;
   DO WHILE(¬EOF);
     /***************************************************************/
     /* READ FILE ...                                               */
     /***************************************************************/

     /***************************************************************/
     /* 2 INDEPENDENT COMPUTATIONS FOLLOW                           */
     /***************************************************************/

     /***************************************************************/
     /* INDEPENDENT COMPUTATION NUMBER 1                            */
     /***************************************************************/
     DO I=LBOUND(AR1,1)+3 TO HBOUND(AR1,1);
       DO J=LBOUND(AR1,2)+2 TO HBOUND(AR1,2);
         DO K=LBOUND(AR1,3)+1 TO HBOUND(AR1,3);
           AR1(I,J,K)=A(I,J,K)+B;
           AR2(I,J,K)=AR1(I,J,K)+AR3(I-3,J-2,K-1);
         END;
       END;
     END;

     /***************************************************************/
     /* INDEPENDENT COMPUTATION NUMBER 1                            */
     /***************************************************************/
     DO I=LBOUND(BR1,1)+3 TO HBOUND(BR1,1);
       DO J=LBOUND(BR1,2)+2 TO HBOUND(BR1,2);
         DO K=LBOUND(BR1,3)+1 TO HBOUND(BR1,3);
           BR1(I,J,K)=X(I,J,K)+Y;
           BR2(I,J,K)=BR1(I,J,K)+BR3(I-3,J-2,K-1);
         END;
       END;
     END;
   END;
 END;
```

Figure 116. Nontasking Version of Multiple Independent Computations

Multiple Independent Computations: Tasking Version

```
/* COMPT - INDEPENDENT COMPUTATIONS (TASKING VERSION)               */
COMPT: PROC OPTIONS(MAIN REENTRANT) REORDER;
   DCL (AR1, AR2, AR3, A)(100,100,100) FLOAT BIN;
   DCL (BR1, BR2, BR3, X)(100,100,100) FLOAT BIN;
   DCL EOF BIT(1) INIT('0'B),
       (B,Y) FLOAT BIN;
   DCL (AR_WORK_READY, AR_WORK_DONE) EVENT;
   DCL (BR_WORK_READY, BR_WORK_DONE) EVENT;
   DCL (AR_TASK, BR_TASK) EVENT;
   STATUS(AR_WORK_READY),
   STATUS(BR_WORK_READY)=0;        /* DO WORK - DON'T TERMINATE     */
   CALL AR EVENT(AR_TASK);         /* ATTACH PARALLEL               */
   CALL BR EVENT(BR_TASK);         /* TASKS                         */
   DO WHILE(¬EOF);
     /***************************************************************/
     /*                                                             */
     /* READ FILE ...                                               */
     /*                                                             */
     /***************************************************************/
     COMPLETION(AR_WORK_READY),
     COMPLETION(BR_WORK_READY)='1'B;/* GO DO IT                     */
     WAIT(AR_WORK_DONE,BR_WORK_DONE);/* WAIT FOR BOTH TASKS TO BE
                                      READY AGAIN                   */
     COMPLETION(AR_WORK_DONE),
     COMPLETION(BR_WORK_DONE)='0'B;
   END;
   /*****************************************************************/
   /* AT END OF JOB (END OF FILE)                                   */
   /*****************************************************************/
   STATUS(AR_WORK_READY),
   STATUS(BR_WORK_READY)=4;        /* NO MORE WORK - JUST TERMINATE */
   COMPLETION(AR_WORK_READY),
   COMPLETION(BR_WORK_READY)='1'B; /* TERMINATE                    */
   WAIT(AR_TASK,BR_TASK);          /* WAIT FOR BOTH TO TERMINATE    */
```

Figure 117 (Part 1 of 2). Tasking Version of Multiple Independent Computations

```
    /*****************************************************************/
    /* INDEPENDENT TASK FOR COMPUTATION 1                            */
    /*****************************************************************/
 AR: PROC REORDER;
    DO WHILE('1'B);                 /* DO FOREVER                    */
      WAIT(AR_WORK_READY);
      COMPLETION(AR_WORK_READY)='0'B;
      IF STATUS(AR_WORK_READY)=4 THEN
        RETURN;
      DO I=LBOUND(AR1,1)+3 TO HBOUND(AR1,1);
        DO J=LBOUND(AR1,2)+2 TO HBOUND(AR1,2);
          DO K=LBOUND(AR1,3)+1 TO HBOUND(AR1,3);
            AR1(I,J,K)=A(I,J,K)+B;
            AR2(I,J,K)=AR1(I,J,K)+AR3(I-3,J-2,K-1);
          END;
        END;
      END;
      COMPLETION(AR_WORK_DONE)='1'B;/* READY FOR MORE WORK           */
    END;
    END;                            /* AR                            */

    /*****************************************************************/
    /* INDEPENDENT TASK FOR COMPUTATION 2                            */
    /*****************************************************************/
 BR: PROC REORDER;
    DO WHILE('1'B);                 /* DO FOREVER                    */
      WAIT(BR_WORK_READY);
      COMPLETION(BR_WORK_READY)='0'B;
      IF STATUS(BR_WORK_READY)=4 THEN
        RETURN;
      DO I=LBOUND(BR1,1)+3 TO HBOUND(BR1,1);
        DO J=LBOUND(BR1,2)+2 TO HBOUND(BR1,2);
          DO K=LBOUND(BR1,3)+1 TO HBOUND(BR1,3);
            BR1(I,J,K)=X(I,J,K)+Y;
            BR2(I,J,K)=BR1(I,J,K)+BR3(I-3,J-2,K-1);
          END;
        END;
      END;
      COMPLETION(AR_WORK_DONE)='1'B;/* READY FOR MORE WORK           */
    END;
    END;                            /* BR                            */
  END;                              /* MAIN                          */
```

Figure 117 (Part 2 of 2). Tasking Version of Multiple Independent Computations

Chapter 20. Interrupts and Attention Processing

To enable a PL/I program to recognize attention interrupts, two operations must be possible:

- You must be able to create an interrupt. This is done in different ways depending upon both the terminal you use and the operating system (such as VM or TSO).
- Your program must be prepared to respond to the interrupt. You can write an ON ATTENTION statement in your program so that the program receives control when the ATTENTION condition is raised.

  Note: If the program has an ATTENTION ON-unit that you want invoked, you must compile the program with either of the following:

  – The INTERRUPT option.
  – A TEST option other than NOTEST or TEST(NONE,NOSYM).

  Compiling this way causes INTERRUPT(ON) to be in effect, unless you explicitly specify INTERRUPT(OFF) in PLIXOPT.

You can find the procedure used to create an interrupt in the IBM instruction manual for the operating system and terminal that you are using. For TSO, see the information on the TERMINAL command and its INPUT subparameter in the *OS/VS2 TSO Command Language Reference*. For VM, see the information on the ATTN command and the discussion of external interrupts in the *VM/SP CMS Command Reference*.

There is a difference between the interrupt (the operating system recognized your request) and the raising of the ATTENTION condition.

An *interrupt* is your request that the operating system notify the running program. If a PL/I program was compiled with the INTERRUPT compile-time option, instructions are included that test an internal interrupt switch at discrete points in the program. The internal interrupt switch can be set if any program in the load module was compiled with the INTERRUPT compile-time option.

The internal switch is set when the operating system recognizes that an interrupt request was made. The execution of the special testing instructions (polling) raises the ATTENTION condition. If a debugging tool hook (or a CALL PLITEST) is encountered before the polling occurs, the debugging tool can be given control before the ATTENTION condition processing starts.

If ***any*** program in the load module was compiled with the INTERRUPT option, polling also takes place in all stream I/O statements to and from the terminal. Polling ensures that the ATTENTION condition is raised between PL/I statements, rather than within the statements.

Figure 118 shows a skeleton program, an ATTENTION ON-unit, and several situations where polling instructions will be generated. In the program polling will occur at:

- LABEL1
- Each iteration of the DO
- The ELSE PUT SKIP ... statement
- Block END statements

```
%PROCESS INTERRUPT;
     .
     .
     .
 ON ATTENTION
   BEGIN;
     DCL X FIXED BINARY(15);
     PUT SKIP LIST ('Enter 1 to terminate, 0 to continue.');
     GET SKIP LIST (X);
     IF X = 1 THEN
       STOP;
     ELSE
       PUT SKIP LIST ('Attention was ignored');
   END;
     .
     .
     .
  LABEL1:
   IF EMPNO ...
     .
     .
     .
   DO I = 1 TO 10;
     .
     .
     .
   END;
     .
     .
     .
```

Figure 118. Using an ATTENTION ON-Unit

Using ATTENTION ON-Units

You can use processing within the ATTENTION ON-unit to terminate potentially endless looping in a program.

Control is given to an ATTENTION ON-unit when polling instructions recognize that an interrupt has occurred. Normal return from the ON-unit is to the statement following the polling code.

Interaction with a Debugging Tool

If the program has the TEST(ALL) or TEST(ERROR) run-time option in effect, then an interrupt causes the debugging tool to receive control the next time a hook is encountered. This might be before the program's polling code recognizes that the interrupt occurred.

Later, when the ATTENTION condition is raised, the debugging tool receives control again for condition processing.

Chapter 21. Using the Checkpoint/Restart Facility

This chapter describes the PL/I Checkpoint/Restart feature which provides a convenient method of taking checkpoints during the execution of a long-running program in a batch environment.

Note: You cannot use Checkpoint/Restart in a TSO or VM environment.

At points specified in the program, information about the current status of the program is written as a record on a data set. If the program terminates due to a system failure, you can use this information to restart the program close to the point where the failure occurred, avoiding the need to rerun the program completely.

This restart can be either automatic or deferred. An automatic restart is one that takes place immediately (provided the operator authorizes it when requested by a system message). A deferred restart is one that is performed later as a new job.

You can request an automatic restart from within your program without a system failure having occurred.

PL/I Checkpoint/Restart uses the Advanced Checkpoint/Restart Facility of the operating system. This facility is described in the books listed in “Bibliography” on page 500.

To use checkpoint/restart you must do the following:

- Request, at suitable points in your program, that a checkpoint record is written. This is done with the built-in subroutine PLICKPT.
- Provide a data set on which the checkpoint record can be written.
- Also, to ensure the desired restart activity, you might need to specify the RD parameter in the EXEC or JOB statement (see the publication *MVS/ESA JCL Reference*).

Note: You should be aware of the restrictions affecting data sets used by your program. These are detailed in the “Bibliography” on page 500.

Requesting a Checkpoint Record

Each time you want a checkpoint record to be written, you must invoke, from your PL/I program, the built-in subroutine PLICKPT.

```
►►──CALL──PLICKPT──┬──────────────────────────────────────────────────┬──►◄
                   └─(──ddname──┬──────────────────────────────────┬─)─┘
                                └─,──check-id──┬─────────────────┬─┘
                                               └─,──org──┬─────────┬┘
                                                         └─,──code─┘
```

The four arguments are all optional. If you do not use an argument, you need not specify it unless you specify another argument that follows it in the given order. In this case, you must specify the unused argument as a null string (`''`). The following paragraphs describe the arguments.

ddname
is a character string constant or variable specifying the name of the DD statement defining the data set that is to be used for checkpoint records. If you omit this argument, the system will use the default ddname SYSCHK.

check-id
is a character string constant or variable specifying the name that you want to assign to the checkpoint record so that you can identify it later. If you omit this argument, the system will supply a unique identification and print it at the operator's console.

org
is a character string constant or variable with the attributes CHARACTER(2) whose value indicates, in operating system terms, the organization of the checkpoint data set. PS indicates sequential (that is, CONSECUTIVE) organization; PO represents partitioned organization. If you omit this argument, PS is assumed.

code
is a variable with the attributes FIXED BINARY (31), which can receive a return code from PLICKPT. The return code has the following values:

0 A checkpoint has been successfully taken.

4 A restart has been successfully made.

8 A checkpoint has not been taken. The PLICKPT statement should be checked.

12 A checkpoint has not been taken. Check for a missing DD statement, a hardware error, or insufficient space in the data set. A checkpoint will fail if taken while a DISPLAY statement with the REPLY option is still incomplete.

16 A checkpoint has been taken, but ENQ macro calls are outstanding and will not be restored on restart. This situation will not normally arise for a PL/I program.

Defining the Checkpoint Data Set

You must include a DD statement in the job control procedure to define the data set in which the checkpoint records are to be placed. This data set can have either CONSECUTIVE or partitioned organization. You can use any valid ddname. If you use the ddname SYSCHK, you do not need to specify the ddname when invoking PLICKPT.

You must specify a data set name only if you want to keep the data set for a deferred restart. The I/O device can be any magnetic-tape or direct-access device.

To obtain only the last checkpoint record, then specify status as NEW (or OLD if the data set already exists). This will cause each checkpoint record to overwrite the previous one.

To retain more than one checkpoint record, specify status as MOD. This will cause each checkpoint record to be added after the previous one.

If the checkpoint data set is a library, “check-id” is used as the member-name. Thus a checkpoint will delete any previously taken checkpoint with the same name.

For direct-access storage, you should allocate enough primary space to store as many checkpoint records as you will retain. You can specify an incremental space allocation, but it will not be used. A checkpoint record is approximately 5000 bytes longer than the area of main storage allocated to the step.

No DCB information is required, but you can include any of the following, where applicable:

```
OPTCD=W, OPTCD=C, RECFM=UT, NCP=2, TRTCH=C
```

These subparameters are described in the *MVS/ESA JCL User's Guide*.

Requesting a Restart

A restart can be automatic or deferred. You can make automatic restarts after a system failure or from within the program itself. The system operator must authorize all automatic restarts when requested by the system.

Automatic Restart after a System Failure

If a system failure occurs after a checkpoint has been taken, the automatic restart will occur at the last checkpoint if you have specified RD=R (or omitted the RD parameter) in the EXEC or JOB statement.

If a system failure occurs before any checkpoint has been taken, an automatic restart, from the beginning of the job step, can still occur if you have specified RD=R in the EXEC or JOB statement.

After a system failure occurs, you can still force automatic restart from the beginning of the job step by specifying RD=RNC in the EXEC or JOB statement. By specifying RD=RNC, you are requesting an automatic step restart without checkpoint processing if another system failure occurs.

Automatic Restart within a Program

You can request a restart at any point in your program. The rules for the restart are the same as for a restart after a system failure. To request the restart, you must execute the statement:

```
CALL PLIREST;
```

To effect the restart, the compiler terminates the program abnormally, with a system completion code of 4092. Therefore, to use this facility, the system completion code 4092 must not have been deleted from the table of eligible codes at system generation.

Getting a Deferred Restart

To ensure that automatic restart activity is canceled, but that the checkpoints are still available for a deferred restart, specify RD=NR in the EXEC or JOB statement when the program is first executed.

```
►►──RESTART──=──(──stepname──┬────────────┬──)───────────────────────────────►◄
                             └─,──────────┤
                             └─check-id───┘
```

If you subsequently require a deferred restart, you must submit the program as a new job, with the RESTART parameter in the JOB statement. Use the RESTART parameter to specify the job step at which the restart is to be made and, if you want to restart at a checkpoint, the name of the checkpoint record.

For a restart from a checkpoint, you must also provide a DD statement that defines the data set containing the checkpoint record. The DD statement must be named SYSCHK. The DD statement must occur immediately before the EXEC statement for the job step.

Modifying Checkpoint/Restart Activity

You can cancel automatic restart activity from any checkpoints taken in your program by executing the statement:

```
CALL PLICANC;
```

However, if you specified RD=R or RD=RNC in the JOB or EXEC statement, automatic restart can still take place from the beginning of the job step.

Also, any checkpoints already taken are still available for a deferred restart.

You can cancel any automatic restart and the taking of checkpoints, even if they were requested in your program, by specifying RD=NC in the JOB or EXEC statement.

Part 7. Appendix

Appendix. Sample Program IBMLSO1

This appendix is a PL/I program that illustrates all the components of the listings produced by the compiler and the linkage editor. You can use this sample program to verify that PL/I has been installed correctly on your system.

The listings themselves are described in the chapters on compiling.

The program has comments to document both the preprocessor input and the source listing. These comments are the lines of text preceded by /* and followed by */. Note that the /* does not appear in columns 1 and 2 of the input record, because /* in those columns is understood as a job control end-of-file statement.

In addition to the /* comments lines, most pages of the listing contain brief notes explaining the contents of the pages.

```
5688-235 IBM PL/I for MVS & VM Ver 1 Rel 1 Mod 1                         29 JAN 95   10:03:24  PAGE  1
OPTIONS SPECIFIED


%PROCESS OPTIONS INSOURCE SOURCE NEST MACRO MAP STORAGE;                        00010000
%PROCESS AGGREGATE, ESD, OFFSET;                                      1         00015000
%PROCESS LIST(40,45) FLAG(I) MARGINS(2,72,1) MARGINI('|');                      00020000
%PROCESS OPT(2) TEST(ALL,SYM) ATTRIBUTES(FULL) XREF(SHORT);                     00030000

OPTIONS USED

AGGREGATE      NODECK         ATTRIBUTES(SHORT)
ESD            NOGOSTMT       NOCOMPILE(S)
GONUMBER       NOGRAPHIC      CMPAT(V2)
INSOURCE       NOIMPRECISE    FLAG(I)
LMESSAGE       NOINCLUDE      LANGLVL(OS,SPROG)
MACRO          NOINTERRUPT    LINECOUNT(55)
MAP            NOMDECK        LIST(40,45)
NEST           NOSTMT         MARGINI('|')                 2
NUMBER                        MARGINS(2,72,1)
OBJECT                        OPTIMIZE(TIME)
OFFSET                        SEQUENCE(73,80)
OPTIONS                       SIZE(2054856)
SOURCE                        NOSYNTAX(S)
STORAGE                       SYSTEM(CMS)
                              TEST(ALL,SYM)
                              XREF(SHORT)
                              TERMINAL(NOAGRAGATE,
                                       NOATTRIBUTES,
                                       NOESD,
                                       NOINSOURCE,
                                       NOLIST,
                                       NOMAP,
                                       NOOFFSET,
                                       NOOPTIONS,
                                       NOSOURCE,
                                       NOSTORAGE,
                                       NOXREF)
```

```
Start of the compiler listing

1  List of options specified in
   %PROCESS statements.

2  List of options used, whether
   obtained by default or by being
   specified explicitly.
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE  2
                        PREPROCESSOR INPUT
 2
LINE                                                                                     3
   1       |/* PL/I Sample Program: Used to verify product installation  1      */|00040000

   3       |/*=== SAMPLE ==========================================================*/|00060000
   4       |/*=====================================================================*/|00070000
   5       |/*===                                                               ==*/|00080000
   6       |/*===  This is the PL/I sample program that is intended to be       ==*/|00090000
   7       |/*===  used to verify the product's complete installation.          ==*/|00100000
   8       |/*===  It is expected to execute and to provide some output.        ==*/|00110000
   9       |/*===  Although “results” are created by the program it is only     ==*/|00120000
  10       |/*===  to verify that representative I/O services are operable --   ==*/|00130000
  11       |/*===  the results are verified (internally) by the program.        ==*/|00140000
  12       |/*===                                                               ==*/|00150000
  13       |/*===  The program is intended to read a data file and count        ==*/|00160000
  14       |/*===  the number of occurrences of each PL/I statement type.       ==*/|00170000
  15       |/*===  The results are displayed at the end of execution.           ==*/|00180000
  16       |/*===  If any count does not match the value that is expected       ==*/|00190000
  17       |/*===  a warning message is displayed.                              ==*/|00200000
  18       |/*===                                                               ==*/|00210000
  19       |/*===  When the program is executed this source program file will   ==*/|00220000
  20       |/*===  be used as the input file.  The filename or DDNAME is        ==*/|00230000
  21       |/*===  SOURCE.                                                      ==*/|00240000
  22       |/*===                                                               ==*/|00250000
  23       |/*===  NOTE: Compilation of this program should cause preprocessor  ==*/|00260000
  24       |/*===        message:                                               ==*/|00270000
  25       |/*===                                                               ==*/|00280000
  26       |/*===   IEL2250I I 140 The WORD_TABLE was successfully declared.    ==*/|00281000
  27       |/*===                                                               ==*/|00282000
  28       |/*===        Two compiler messages will be produced as well:        ==*/|00283000
  29       |/*===                                                               ==*/|00284000
  30       |/*===   IEL0533I I     NO 'DECLARE' STATEMENT(S) FOR 'INDEX'.       ==*/|00285000
  31       |/*===   IEL0871I I  62 RESULT OF BUILTIN FUNCTION 'SUM' WILL BE     ==*/|00286000
  32       |/*===                  EVALUATED USING FIXED POINT ARITHMETIC       ==*/|00287000
  33       |/*===                  OPERATIONS.                                  ==*/|00288000
  34       |/*===                                                               ==*/|00289000
  35       |/*=====================================================================*/|00290000
  36       |/*=====================================================================*/|00300000

  38       |SAMPLE: PROCEDURE OPTIONS(MAIN) REORDER;                                 |00320000
```

Source statements for the sample program as they appear in the input stream. These statements form the input data for the preprocessor. Preprocessor statements are identified by the % symbol.

1 The first line of the input is included as part of the heading for all the pages of the preprocessor and compiler listing.

2 Each input record is numbered sequentially.

3 If an input record has a sequence number, this number is printed.

```
5688-235 IBM PL/I for MVS & VM           /* PL/I Sample Program: Used to verify product installation      */PAGE  3
 LINE
   40       |  %/*---------------------------------------------------------------*/;|00340000
   41       |  %/*   The services of the PL/I Preprocessor will be used by this  */;|00350000
   42       |  %/* program.  Since some of its variables are global (their use   */;|00360000
   43       |  %/* crosses macros) they must be defined early in the source     */;|00370000
   44       |  %/* program.                                                      */;|00380000
   45       |  %/*   Notice that these lines start with a percent sign and       */;|00390000
   46       |  %/* end with a semicolon.  Notice also that they do not appear    */;|00400000
   47       |  %/* on the program SOURCE listing.                                */;|00410000
   48       |  %/*---------------------------------------------------------------*/;|00420000
   49       |  %DCL BIG_LIST CHAR;                                                  |00430000
   50       |  %BIG_LIST = '';                                                      |00440000
   51       |  %;                                                                   |00450000
   52       |  %DCL SIZE_WORD_LIST FIXED;                                           |00460000
   53       |  %SIZE_WORD_LIST = 0;                                                 |00470000
   54       |  %;                                                                   |00480000
   55       |  %DCL MAX_WORD_LENGTH FIXED;                                          |00490000
   56       |  %MAX_WORD_LENGTH = 0;                                                |00500000
   57       |  %;                                                                   |00510000
   58       |  %DCL CURRENT_POSITION FIXED;                                         |00520000
   59       |  %CURRENT_POSITION = 0;                                               |00530000
   60       |  %;                                                                   |00540000
   61       |  %DCL FIRST_WORD_INDICES CHAR;                                        |00550000
   62       |  %FIRST_WORD_INDICES = '';                                            |00560000
   63       |  %DCL LAST_INDEX         FIXED;                                       |00570000
   64       |  %LAST_INDEX = 0;                                                     |00580000
   65       |  %;                                                                   |00590000
   66       |  %ACTIVATE ADD_TO_LIST, END_OF_LIST;                                  |00600000
   67       |  %/*---------------------------------------------------------------*/;|00610000
   68       |  %/* End of the global Preprocessor variable declarations          */;|00620000
   69       |  %/*---------------------------------------------------------------*/;|00630000
   70       |  /*=================================================================*/|00640000
   71       |  /* Non-Preprocessor data variables are declared here.  Only the   */|00650000
   72       |  /* variables that are used in the main block (or in more than one  */|00660000
   73       |  /* of the contained blocks) are defined here.                      */|00670000
   74       |  /*=================================================================*/|00680000
   75       |                                                                       |00690000
   76       |  /*-----------------------------------------------------------------*/|00700000
   77       |  /* Declare the source program input file and its accoutrements.    */|00710000
   78       |  /*-----------------------------------------------------------------*/|00720000
   79       |  DECLARE SOURCE         FILE RECORD;                                  |00730000
   80       |  DECLARE RECORD         CHARACTER(121) VARYING;                       |00740000
   81       |  DECLARE RECORD_READ    BIT(1) INIT(FALSE);                           |00750000
   82       |  DECLARE LAST_CHAR_POSN FIXED BINARY(15);                             |00760000
   83       |  DECLARE DISCREPANCY_OCCURRED  BIT(1) INIT(FALSE);                    |00770000
   84       |                                                                       |00780000
   85       |  /*-----------------------------------------------------------------*/|00790000
   86       |  /* Declare the left- and right-margins of the input dataset.      */|00800000
   87       |  /*-----------------------------------------------------------------*/|00810000
   88       |  DECLARE LEFT_MARGIN    FIXED BINARY(15) INIT('2');                   |00820000
   89       |  DECLARE RIGHT_MARGIN   FIXED BINARY(15) INIT('72');                  |00830000
   90       |                                                                       |00840000
```

```
5688-235 IBM PL/I for MVS & VM           /* PL/I Sample Program: Used to verify product installation       */PAGE  4
| /*-----------------------------------------------------------------*/|00850000
| /* Declare '1'B as TRUE and '0'B as FALSE.                         */|00860000
| /*-----------------------------------------------------------------*/|00870000
| DECLARE TRUE           BIT(1) INIT('1'B);                            |00880000
| DECLARE FALSE          BIT(1) INIT('0'B);                            |00890000
|                                                                      |00900000
| /*-----------------------------------------------------------------*/|00910000
| /* Declare which characters are acceptable as the first character  */|00920000
| /* of a word -- then declare acceptable succeeding characters.     */|00930000
| /*-----------------------------------------------------------------*/|00940000
| DECLARE WORD_FIRST_CHARACTERS CHAR(29) STATIC                        |00950000
|               INIT('ABCDEFGHIJKLMNOPQRSTUVWXYZ@#$');                 |00960000
| DECLARE WORD_NEXT_CHARACTERS  CHAR(30) STATIC                        |00970000
|               INIT('ABCDEFGHIJKLMNOPQRSTUVWXYZ_@#$');                |00980000
|                                                                      |00990000
| /*-----------------------------------------------------------------*/|01000000
| /* Declare a place to hold words extracted from program text.      */|01010000
| /*-----------------------------------------------------------------*/|01020000
| DECLARE WORD  CHAR(31) VARYING;                                      |01030000
| DECLARE WORD_INDEX     FIXED BINARY(15);                             |01040000
|                                                                      |01050000
| /*-----------------------------------------------------------------*/|01060000
| /* Declare the use of SYSPRINT and all of the builtin functions.   */|01070000
| /*-----------------------------------------------------------------*/|01080000
| DECLARE SYSPRINT       FILE STREAM,                                  |01090000
|         PLIXOPT CHAR(100) VAR STATIC EXT INIT('MSGFILE(SYSPRINT)');  |01095000
| DECLARE (HIGH, SUBSTR, SUM, UNSPEC, VERIFY) BUILTIN;                 |01100000
| DECLARE ONCODE         BUILTIN;                                      |01110000
5688-235 IBM PL/I for MVS & VM           /* PL/I Sample Program: Used to verify product installation       */PAGE  5
| /*=================================================================*/|01120000
| /* PL/I statement keywords are collected using the ADD_TO_LIST     */|01130000
| /* macro.  They are put into a table, WORD_TABLE, by the           */|01140000
| /* END_OF_LIST macro.  That macro also creates an index,           */|01150000
| /* WORD_TABLE_INDEX, into the WORD_TABLE.                          */|01160000
| /*                                                                 */|01170000
| /* Finally, a table, WORD_COUNT, is created that has a counter     */|01180000
| /* that corresponds to each word.  Whenever that word is           */|01190000
| /* encountered in the input stream the appropriate WORD_COUNT      */|01200000
| /* element is incremented.                                         */|01210000
| /*                                                                 */|01220000
| /* Notice that there are no semicolons in the macro statements.    */|01230000
| /*=================================================================*/|01240000
| ADD_TO_LIST ('ALLOCATE,BEGIN')                                       |01260000
| ADD_TO_LIST ('CALL,CLOSE,DCL,DECLARE,DEFAULT,DISPLAY')               |01270000
| ADD_TO_LIST ('DO')                                                   |01280000
| ADD_TO_LIST ('ELSE,END,ENTRY,FREE,GENERIC,GET,GO,GOTO,IF')           |01290000
| ADD_TO_LIST ('LEAVE,LIST,LOCATE,ON,OPEN')                            |01300000
| ADD_TO_LIST ('PROC,PROCEDURE')                                       |01310000
| ADD_TO_LIST ('READ,RETURN,REVERT,REWRITE,SELECT,SIGNAL')             |01320000
| ADD_TO_LIST ('STOP,THEN,WAIT,WHEN,WRITE')                            |01330000
| END_OF_LIST                                                          |01340000
|                                                                      |01350000
| /*-----------------------------------------------------------------*/|01360000
| /* This is the table containing the results when THIS program      */|01370000
| /* is the input dataset.  There is an intentional error on the     */|01380000
| /* IF count so that an error message can be produced.              */|01390000
| /*-----------------------------------------------------------------*/|01400000
| DECLARE CONTROLLED_SET(SIZE_WORD_LIST) FIXED BINARY(15)              |01410000
|                            INIT( 0, 3,                               |01420000
|                                  0, 1, 13, 24, 0, 2,                 |01430000
|                                  14,                                 |01440000
|                                  13, 23, 0, 0, 0, 0, 1, 0, 14,       |01450000
|                                  0, 7, 0, 4, 1,                      |01460000
|                                  2, 3,                               |01470000
|                                  2, 4, 0, 0, 1, 0,                   |01480000
|                                  2, 13, 0, 2, 0);                    |01490000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE  6
/*=================================================================*/ 01510000
/*= SAMPLE will perform the following tasks:                      =*/ 01520000
/*= 1) OPEN the input dataset                                     =*/ 01530000
/*= 2) READ each record and, for each record,                     =*/ 01540000
/*=    a) Extract a character string that meets the PL/I          =*/ 01550000
/*=       definition of a word.                                   =*/ 01560000
/*=    b) If the word also appears in the list of interesting     =*/ 01570000
/*=       words, record its presence by incrementing a counter.   =*/ 01580000
/*= 3) Report on the number of appearances of the words that      =*/ 01590000
/*=    actually appeared in the dataset.                          =*/ 01600000
/*= 4) DISPLAY a message if the count does not match the count    =*/ 01610000
/*=    of PL/I statement keywords in this program.                =*/ 01620000
/*=================================================================*/ 01630000
                                                                      01640000
/*-----------------------------------------------------------------*/ 01650000
/* Describe the action to take on selected exceptional conditions. */ 01660000
/*-----------------------------------------------------------------*/ 01670000
                                                                      01680000
/*-----------------------------------------------------------------*/ 01690000
/* If the file has not been properly defined, tell them about it.  */ 01700000
/*-----------------------------------------------------------------*/ 01710000
ON UNDEFINEDFILE(SOURCE)                                              01720000
  BEGIN;                                                              01730000
    DISPLAY ('The input data set has not been defined.');             01740000
    STOP;                                                             01750000
  END;                                                                01760000
                                                                      01770000
/*-----------------------------------------------------------------*/ 01780000
/* When the file has been processed indicate “no record read”      */ 01790000
/*-----------------------------------------------------------------*/ 01800000
ON ENDFILE(SOURCE)                                                    01810000
  BEGIN;                                                              01820000
    RECORD_READ = FALSE;                                              01830000
  END;                                                                01840000
                                                                      01850000
/*-----------------------------------------------------------------*/ 01860000
/* If any other errors occur, write a message and terminate.       */ 01870000
/*-----------------------------------------------------------------*/ 01880000
ON ERROR                                                              01890000
  BEGIN;                                                              01900000
    ON ERROR SYSTEM;                                                  01910000
    DISPLAY ('Unspecified error occurred.  ONCODE=' || ONCODE );      01920000
    STOP;                                                             01930000
  END;                                                                01940000
                                                                      01950000
/*-----------------------------------------------------------------*/ 01960000
/* Prepare the input dataset for processing -- mark it as open.    */ 01970000
/*-----------------------------------------------------------------*/ 01980000
OPEN FILE(SOURCE) INPUT;                                              01990000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE  7
 LINE
  206        |  /*=================================================================*/|02000000
  207        |  /* Count the use of PL/I statements in each record of the          */|02010000
  208        |  /* input data set.                                                 */|02020000
  209        |  /*=================================================================*/|02030000
  210        |                                                                       |02040000
  211        |  /*-----------------------------------------------------------------*/|02050000
  212        |  /* Read the first record of the input dataset.                     */|02060000
  213        |  /*-----------------------------------------------------------------*/|02070000
  214        |  RECORD_READ = TRUE;                                                  |02080000
  215        |  READ FILE(SOURCE) INTO (RECORD);                                     |02090000
  216        |                                                                       |02100000
  217        |  /*-----------------------------------------------------------------*/|02110000
  218        |  /* Process the first and all succeeding records.                   */|02120000
  219        |  /*-----------------------------------------------------------------*/|02130000
  220        |  DO WHILE (RECORD_READ);                                              |02140000
  221        |                                                                       |02150000
  222        |    /* Set the “last character” position to the left margin          */|02160000
  223        |    LAST_CHAR_POSN = LEFT_MARGIN;                                      |02170000
  224        |    /* Use NEXT_WORD to extract the first word from this record.     */|02180000
  225        |    WORD = NEXT_WORD(RECORD);                                          |02190000
  226        |                                                                       |02200000
  227        |    /*---------------------------------------------------------------*/|02210000
  228        |    /* Extract words from this record until no more remain.          */|02220000
  229        |    /*---------------------------------------------------------------*/|02230000
  230        |    DO WHILE (WORD ¬= '');                                             |02240000
  231        |      /* Use LOOKUP_WORD to find its position in the table.          */|02250000
  232        |      WORD_INDEX = LOOKUP_WORD(WORD);                                  |02260000
  233        |                                                                       |02270000
  234        |      /*-------------------------------------------------------------*/|02280000
  235        |      /* If the word is in the list, count it.                       */|02290000
  236        |      /*-------------------------------------------------------------*/|02300000
  237        |      IF WORD_INDEX ¬= 0 THEN                                          |02310000
  238        |        WORD_COUNT(WORD_INDEX) = WORD_COUNT(WORD_INDEX) + 1;           |02320000
  239        |      ELSE;                                                            |02330000
  240        |      /* Get the next word from the record.                          */|02340000
  241        |      WORD = NEXT_WORD(RECORD);                                        |02350000
  242        |    END;                                                               |02360000
  243        |                                                                       |02370000
  244        |    /*---------------------------------------------------------------*/|02380000
  245        |    /* Read the next record from the input data set.                 */|02390000
  246        |    /*---------------------------------------------------------------*/|02400000
  247        |    READ FILE(SOURCE) INTO (RECORD);                                   |02410000
  248        |  END;                                                                 |02420000
  249        |                                                                       |02430000
  250        |  /*-----------------------------------------------------------------*/|02440000
  251        |  /* Input from the data set is exhausted. CLOSE it.                 */|02450000
  252        |  /*-----------------------------------------------------------------*/|02460000
  253        |  CLOSE FILE(SOURCE);                                                  |02470000
```

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5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE  8
 LINE
            |  /*=================================================================*/|02490000
            |  /*= The report that details and summarizes the use of word in the =*/|02500000
            |  /*= WORD_TABLE is prepared in this section.                       =*/|02510000
            |  /*=================================================================*/|02520000
            |                                                                       |02530000
            |  PUT SKIP LIST (' *********************** ');                         |02540000
            |  PUT SKIP LIST (' *** Word-use Report *** ');                         |02550000
            |  PUT SKIP LIST (' *********************** ');                         |02560000
            |  PUT SKIP LIST (' -count-   --word-- ');                              |02570000
            |                                                                       |02580000
            |  /*-----------------------------------------------------------------*/|02590000
            |  /* Review the activity for each word in the list.                  */|02600000
            |  /*-----------------------------------------------------------------*/|02610000
            |  DO WORD_INDEX = 1 TO SIZE_WORD_LIST;                                 |02620000
            |                                                                       |02630000
            |    /*---------------------------------------------------------------*/|02640000
            |    /* If the word was used then display the word and its use-count. */|02650000
            |    /*---------------------------------------------------------------*/|02660000
            |    IF WORD_COUNT(WORD_INDEX) > 0 THEN                                 |02670000
            |      PUT SKIP EDIT (WORD_COUNT(WORD_INDEX),                           |02680000
            |                     WORD_TABLE(WORD_INDEX))                           |02690000
            |                     (F(6), X(6),A);                                   |02700000
            |    ELSE;                                                              |02710000
            |                                                                       |02720000
            |    /*---------------------------------------------------------------*/|02730000
            |    /* If there was a discrepancy between what was counted and what  */|02740000
            |    /* was expected then display a warning message and remember that */|02750000
            |    /* it had occurred.                                              */|02760000
            |    /*---------------------------------------------------------------*/|02770000
            |    IF WORD_COUNT(WORD_INDEX) ¬= CONTROLLED_SET(WORD_INDEX) THEN       |02780000
            |      DO;                                                              |02790000
            |        PUT SKIP EDIT ((12)'-',                                        |02800000
            |                       'The previous value should have been',          |02810000
            |                       CONTROLLED_SET(WORD_INDEX))                     |02820000
            |                       (A, A, F(6));                                   |02830000
            |        DISCREPANCY_OCCURRED = TRUE;                                   |02840000
            |      END;                                                             |02850000
            |    ELSE;                                                              |02860000
            |  END;                                                                 |02870000
            |                                                                       |02880000
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE  9
 LINE
            |  /*=================================================================*/|02890000
            |  /* Summarize word activity on this input dataset.                  */|02900000
            |  /*=================================================================*/|02910000
            |                                                                       |02920000
            |  PUT SKIP(2) LIST ('There were ' || SUM(WORD_COUNT)                   |02930000
            |                 || ' references to ' || SIZE_WORD_LIST                |02940000
            |                 || ' words.');                                        |02950000
            |                                                                       |02960000
            |  /*-----------------------------------------------------------------*/|02970000
            |  /* If a discrepency between one of the counts and the expected     */|02980000
            |  /* counts occured then display a warning message.                  */|02990000
            |  /*-----------------------------------------------------------------*/|03000000
            |  IF DISCREPANCY_OCCURRED THEN                                         |03010000
            |    PUT SKIP(2) LIST ('There was a discrepancy in at least one of'     |03020000
            |                 || ' the word-counts.');                              |03030000
            |  ELSE;                                                                |03040000
```

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5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 10
|  /*=== NEXT_WORD ====================================================*/|03050000
|  /*==================================================================*/|03060000
|  /*==                                                              ==*/|03070000
|  /*==  Extract a word from the argument string that is passed.     ==*/|03080000
|  /*==  Return it as CHAR(31) VARYING.                              ==*/|03090000
|  /*==                                                              ==*/|03100000
|  /*==  Ignore PL/I comments and constants (strings surrounded by   ==*/|03110000
|  /*==  single quotes (').  Comments and constants can not be       ==*/|03120000
|  /*==  continued but must be complete in the argument string.     ==*/|03130000
|  /*==                                                              ==*/|03140000
|  /*==  If no more words exist then a null character string will  ==*/|03150000
|  /*==  be returned.                                                ==*/|03160000
|  /*==                                                              ==*/|03170000
|  /*==================================================================*/|03180000
|  /*==================================================================*/|03190000
|                                                                        |03200000
|  NEXT_WORD: PROCEDURE(DATA_RECORD) RETURNS(CHAR(31) VARYING);          |03210000
|                                                                        |03220000
|    DECLARE DATA_RECORD        CHAR(*)  VARYING;                        |03230000
|    DECLARE DATA_WORD          CHAR(31) VARYING;                        |03240000
|    DECLARE NEXT_CHARACTER     CHAR(1);                                 |03250000
|    DECLARE LENGTH_OF_STRING   FIXED BINARY(15);                        |03260000
|                                                                        |03270000
|    DECLARE NEXT_CHAR_POSN     FIXED BINARY(15);                        |03280000
|                                                                        |03290000
|    /*================================================================*/|03300000
|    /*= LAST_CHAR_POSN remembers, from call to call, the point where=*/ |03310000
|    /*= the search for additional words will start.  Management of  =*/|03320000
|    /*= its value is a key concern to this function.                 =*/|03330000
|    /*=                                                              =*/|03340000
|    /*= Comments and constants in the argument string will be        =*/|03350000
|    /*= ignored.  If a character is found that is a legitimate PL/I  =*/|03360000
|    /*= “first-character” then a word is assumed to follow.  It      =*/|03370000
|    /*= will be built by concatenating (suffixing) additional,       =*/|03380000
|    /*= legitimate “next-characters.”                                =*/|03390000
|    /*================================================================*/|03400000

5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 11
|    /*================================================================*/|03410000
|    /*= Scan each character in the record.  Start at the position    =*/|03420000
|    /*= where scanning last terminated (LAST_CHAR_POSN) and          =*/|03430000
|    /*= continue until the end of a word or the end of the record   =*/|03440000
|    /*= is reached.                                                  =*/|03450000
|    /*================================================================*/|03460000
|                                                                        |03470000
|    DATA_WORD = '';                                                     |03480000
|    DO NEXT_CHAR_POSN = LAST_CHAR_POSN TO RIGHT_MARGIN                  |03490000
|     WHILE (DATA_WORD = '');                                            |03500000
|      NEXT_CHARACTER = SUBSTR(DATA_RECORD, NEXT_CHAR_POSN, 1);          |03510000
|      SELECT (NEXT_CHARACTER);                                          |03520000
|                                                                        |03530000
|        WHEN ('/')                                                      |03540000
|                                                                        |03550000
|          /*----------------------------------------------------------*/|03560000
|          /* If this turns out to be a comment then skip over it.     */|03570000
|          /*----------------------------------------------------------*/|03580000
|          DO;                                                           |03590000
|            IF SUBSTR(DATA_RECORD, NEXT_CHAR_POSN, 2) = '/*' THEN       |03600000
|              NEXT_CHAR_POSN = NEXT_CHAR_POSN + 3                       |03610000
|                   + INDEX(SUBSTR(DATA_RECORD,NEXT_CHAR_POSN+2),'*/');  |03620000
|            ELSE;                                                       |03630000
|          END;                                                          |03640000
|                                                                        |03650000
|        WHEN ('''')                                                     |03660000
|                                                                        |03670000
|          /*----------------------------------------------------------*/|03680000
|          /* Skip over the constant.                                  */|03690000
|          /*----------------------------------------------------------*/|03700000
|          NEXT_CHAR_POSN = NEXT_CHAR_POSN                               |03710000
|                    + INDEX(SUBSTR(DATA_RECORD,NEXT_CHAR_POSN+1),''''); |03720000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 12
      /*===========================================================*/|03730000
      /*= This may be the start of a word.  Extract it if so.     =*/|03740000
      /*===========================================================*/|03750000
                                                                     |03760000
      OTHERWISE                                                      |03770000
                                                                     |03780000
        /*---------------------------------------------------------*/|03790000
        /* This may be the start of a word.                        */|03800000
        /*---------------------------------------------------------*/|03810000
        DO;                                                          |03820000
                                                                     |03830000
          /*-------------------------------------------------------*/|03840000
          /* If the next character is not acceptable as the first  */|03850000
          /* character of a word then do nothing further -- our    */|03860000
          /* enclosing DO will step to the next character for      */|03870000
          /* further checking.                                     */|03880000
          /*-------------------------------------------------------*/|03890000
          IF INDEX(WORD_FIRST_CHARACTERS, NEXT_CHARACTER) = 0 THEN;  |03900000
          ELSE                                                       |03910000
                                                                     |03920000
            /*-----------------------------------------------------*/|03930000
            /* This is the start of a word.  Collect the rest of it*/|03940000
            /*-----------------------------------------------------*/|03950000
                                                                     |03960000
            DO;                                                      |03970000
              DATA_WORD = NEXT_CHARACTER;                            |03980000
                                                                     |03990000
              /*---------------------------------------------------*/|04000000
              /* Build up DATA_WORD by iteratively appending       */|04010000
              /* characters from the input argument string.  Do it */|04020000
              /* as long as the characters are acceptable PL/I     */|04030000
              /* “next=characters.”                                */|04040000
              /*---------------------------------------------------*/|04050000
                                                                     |04060000
              DO NEXT_CHAR_POSN = NEXT_CHAR_POSN+1 TO RIGHT_MARGIN   |04070000
               WHILE (INDEX(WORD_NEXT_CHARACTERS,                    |04080000
                       SUBSTR(DATA_RECORD, NEXT_CHAR_POSN,1)) ¬= 0); |04090000
                DATA_WORD = DATA_WORD                                |04100000
                            || SUBSTR(DATA_RECORD, NEXT_CHAR_POSN,1);|04110000
              END;                                                   |04120000
              LAST_CHAR_POSN = NEXT_CHAR_POSN + 1;                   |04130000
            END;                                                     |04140000
        END;                                                         |04150000
    END;   /* End of the SELECT (NEXT_CHARACTER) statement         */|04160000
  END;     /* End of the DO that tries to find a word              */|04170000
                                                                     |04180000
  RETURN (DATA_WORD);                                                |04190000
END;                                                                 |04200000
```

```
/*=== LOOKUP_WORD ==================================================*/ |04210000
/*==================================================================*/ |04220000
/*==                                                              ==*/ |04230000
/*==  Find the word in the WORD_TABLE that matches the            ==*/ |04240000
/*==  argument string (CHAR(*) VARYING) and return the            ==*/ |04250000
/*==  position of that word (its subscript) to the                ==*/ |04260000
/*==  invoker (FIXED BINARY(15)).                                 ==*/ |04270000
/*==                                                              ==*/ |04280000
/*==  If the word does not exist in the list a 0 will be          ==*/ |04290000
/*==  returned.                                                   ==*/ |04300000
/*==                                                              ==*/ |04310000
/*==================================================================*/ |04320000
/*==================================================================*/ |04330000
                                                                       |04340000
LOOKUP_WORD: PROCEDURE(DATA_WORD) RETURNS(FIXED BINARY(15));           |04350000
                                                                       |04360000
  DECLARE DATA_WORD   CHAR(*) VARYING;                                 |04370000
  DECLARE WORD_NUMBER FIXED BINARY(15);                                |04380000
                                                                       |04390000
  /*================================================================*/ |04400000
  /*= A sequential search is used to locate the required word.     =*/ |04410000
  /*= WORD_INDEX_TABLE is used to start the search at the first    =*/ |04420000
  /*= word in the list that has the same first character.          =*/ |04430000
  /*================================================================*/ |04440000
  WORD_NUMBER = WORD_INDEX_TABLE   /* Subscript is on next line */     |04450000
              (INDEX (WORD_FIRST_CHARACTERS, SUBSTR(DATA_WORD,1,1)));  |04460000
                                                                       |04470000
  /*----------------------------------------------------------------*/ |04480000
  /* Search words in the WORD_TABLE until the word is found or is   */ |04490000
  /* determined to be not a part of the list -- its index number    */ |04500000
  /* (WORD_NUMBER) is zero.                                         */ |04510000
  /*----------------------------------------------------------------*/ |04520000
  DO WORD_NUMBER = WORD_NUMBER BY 1                                    |04530000
     UNTIL (  WORD_TABLE(WORD_NUMBER) = DATA_WORD                      |04540000
            | WORD_NUMBER = 0);                                        |04550000
                                                                       |04560000
    /*--------------------------------------------------------------*/ |04570000
    /* If the word in the WORD_TABLE is alphabetically greater      */ |04580000
    /* than the argument word then a match cannot be found.  Set    */ |04590000
    /* the WORD_NUMBER to 0 to indicate a non=match situation.      */ |04600000
    /*--------------------------------------------------------------*/ |04610000
    IF WORD_TABLE(WORD_NUMBER) > DATA_WORD THEN                        |04620000
      WORD_NUMBER = 0;                                                 |04630000
    ELSE;                                                              |04640000
  END;                                                                 |04650000
                                                                       |04660000
  RETURN (WORD_NUMBER);                                                |04670000
END;                                                                   |04680000
%;                                                                     |04690000
%/*================================================================*/; |04700000
%/*================================================================*/; |04710000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 14
%/*=                                                             =*/;|04720000
%/*= Submit a list of words that are to be included in the       =*/;|04730000
%/*= WORD_TABLE.  They must be in alphabetic order.  The list    =*/;|04740000
%/*= must be within parentheses and cannot contain any blanks    =*/;|04750000
%/*=                                                             =*/;|04760000
%/*===============================================================*/;|04770000
%/*===============================================================*/;|04780000
%ADD_TO_LIST: PROC(WORD_LIST) RETURNS(CHAR);                         |04790000
  DCL WORD_LIST       CHAR;                                          |04800000
  DCL EXTRACTED_WORD  CHAR;                                          |04810000
  DCL THIS_INDEX_CHAR CHAR;                                          |04820000
  DCL THIS_INDEX      FIXED;                                         |04830000
  DCL COMMA           FIXED;                                         |04840000
  DCL (INDEX, LENGTH, SUBSTR) BUILTIN;                               |04850000
                                                                     |04860000
  /* Remove the leading and trailing apostrophes                   */|04870000
  WORD_LIST = SUBSTR(WORD_LIST,2,LENGTH(WORD_LIST)-2);               |04880000
                                                                     |04890000
  /*---------------------------------------------------------------*/|04900000
  /* Extract each word from the argument data string.  Put each    */|04910000
  /* word onto the end of a growing string that will eventually    */|04920000
  /* be used in the INITIAL clause of the declaration of           */|04930000
  /* the WORD_TABLE.                                               */|04940000
  /*---------------------------------------------------------------*/|04950000
PARSE_LOOP:                                                          |04960000
  /* Keep track of the size of the word list.                      */|04970000
  SIZE_WORD_LIST = SIZE_WORD_LIST + 1;                               |04980000
  THIS_INDEX = INDEX('ABCDEFGHIJKLMNOPQRSTUVWXYZ',                   |04990000
                      SUBSTR(WORD_LIST,1,1));                        |05000000
                                                                     |05010000
  /*---------------------------------------------------------------*/|05020000
  /* Is this is the first time that this initial character has     */|05030000
  /* been encountered?  If so, the table of indices into           */|05040000
  /* WORD_TABLE must be updated.                                   */|05050000
  /*---------------------------------------------------------------*/|05060000
  IF THIS_INDEX ¬= LAST_INDEX THEN                                   |05070000
    DO;                                                              |05080000
                                                                     |05090000
      /*-----------------------------------------------------------*/|05100000
      /* Update the “initial character index” for all characters   */|05110000
      /* between the last one and this one.                        */|05120000
      /*-----------------------------------------------------------*/|05130000
                                                                     |05140000
      DO LAST_INDEX = LAST_INDEX+1 TO THIS_INDEX;                    |05150000
        /*---------------------------------------------------------*/|05160000
        /* If the last character processed and this character are  */|05170000
        /* are not alphabetically adjacent then a zero (no word    */|05180000
        /* having such a first character is acceptable) must be    */|05190000
        /* appended to the list of indices.  The list will be      */|05200000
        /* used later in the INITIAL clause of the declaration     */|05210000
        /* of WORD_TABLE_INDEX.                                    */|05220000
```

```
|          /*----------------------------------------------------------*/|05230000
|          IF LAST_INDEX < THIS_INDEX THEN                               |05240000
|            FIRST_WORD_INDICES = FIRST_WORD_INDICES || ', 0';           |05250000
|          ELSE                                                          |05260000
|          FIRST_WORD_INDICES = FIRST_WORD_INDICES||','||SIZE_WORD_LIST;|05270000
|        END;                                                            |05280000
|        LAST_INDEX = LAST_INDEX - 1;                                    |05290000
|      END;                                                              |05300000
|    ELSE;                                                               |05310000
|                                                                        |05320000
|    COMMA = INDEX(WORD_LIST,',');                                       |05330000
|                                                                        |05340000
|    /*----------------------------------------------------------------*/|05350000
|    /* Is there a comma after this word?                              */|05360000
|    /*----------------------------------------------------------------*/|05370000
|    IF COMMA = 0 THEN                                                   |05380000
|      DO;                                                               |05390000
|                                                                        |05400000
|        /*------------------------------------------------------------*/|05410000
|        /* Since this word is not followed by a comma it is the       */|05420000
|        /* last one in the list.                                      */|05430000
|        /*------------------------------------------------------------*/|05440000
|        BIG_LIST = BIG_LIST || '''' || WORD_LIST || ''', ';             |05450000
|                                                                        |05460000
|        /*------------------------------------------------------------*/|05470000
|        /* Keep track of the longest word in the list.                */|05480000
|        /*------------------------------------------------------------*/|05490000
|        IF LENGTH(WORD_LIST) > MAX_WORD_LENGTH THEN                     |05500000
|          MAX_WORD_LENGTH = LENGTH(WORD_LIST);                          |05510000
|        ELSE;                                                           |05520000
|        RETURN('');                                                     |05530000
|      END;                                                              |05540000
|    ELSE                                                                |05550000
|      DO;                                                               |05560000
|                                                                        |05570000
|        /*------------------------------------------------------------*/|05580000
|        /* Extract the next word and remove it from the input.        */|05590000
|        /*------------------------------------------------------------*/|05600000
|        EXTRACTED_WORD = SUBSTR(WORD_LIST,1,COMMA-1);                   |05610000
|        BIG_LIST = BIG_LIST || ''''                                     |05620000
|                            || EXTRACTED_WORD || ''', ';                |05630000
|                                                                        |05640000
|        /*------------------------------------------------------------*/|05650000
|        /* Keep track of the longest word in the list.                */|05660000
|        /*------------------------------------------------------------*/|05670000
|        IF LENGTH(EXTRACTED_WORD) > MAX_WORD_LENGTH THEN                |05680000
|          MAX_WORD_LENGTH = LENGTH(EXTRACTED_WORD);                     |05690000
|        ELSE;                                                           |05700000
|        /* Remove this word and the comma from the input string.      */|05710000
|        WORD_LIST = SUBSTR(WORD_LIST,COMMA+1);                          |05720000
|      END;                                                              |05730000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 16
 LINE
  580       |    GO TO PARSE_LOOP;                                                   |05740000
  581       |  %END;                                                                 |05750000
  582       |  %;                                                                    |05760000
  583       |  %/*================================================================*/;|05770000
  584       |  %/*================================================================*/;|05780000
  585       |  %/*=                                                              =*/;|05790000
  586       |  %/*= All words contained in the search list have been submitted. =*/;|05800000
  587       |  %/*= Create the DECLAREs for the WORD_TABLE, WORD_COUNT vector   =*/;|05810000
  588       |  %/*= and the WORD_INDEX_TABLE.                                    =*/;|05820000
  589       |  %/*=                                                              =*/;|05830000
  590       |  %/*================================================================*/;|05840000
  591       |  %/*================================================================*/;|05850000
  592       |  %END_OF_LIST: PROC RETURNS(CHAR);                                     |05860000
  593       |    DCL TABLE_DCL CHAR;                                                 |05870000
  594       |                                                                        |05880000
  595       |    /*----------------------------------------------------------------*/|05890000
  596       |    /* Create the DECLARE for the WORD_TABLE                          */|05900000
  597       |    /*----------------------------------------------------------------*/|05910000
  598       |    TABLE_DCL = 'DECLARE '                                              |05920000
  599       |                  || 'WORD_TABLE(' || (SIZE_WORD_LIST+1) || ') '        |05930000
  600       |                  || 'CHAR(' || MAX_WORD_LENGTH || ')'                  |05940000
  601       |                  || 'INIT(' || BIG_LIST                                |05950000
  602       |                             || 'HIGH(' || MAX_WORD_LENGTH || '));' ;   |05960000
  603       |                                                                        |05970000
  604       |    /*----------------------------------------------------------------*/|05980000
  605       |    /* Append the DECLARE for the WORD_COUNT array.                   */|05990000
  606       |    /*----------------------------------------------------------------*/|06000000
  607       |    TABLE_DCL = TABLE_DCL                                               |06010000
  608       |             || 'DECLARE WORD_COUNT(' || SIZE_WORD_LIST || ') '         |06020000
  609       |             || 'FIXED BINARY(15) INIT((' || SIZE_WORD_LIST || ')0);' ; |06030000
  610       |                                                                        |06040000
  611       |    /*----------------------------------------------------------------*/|06050000
  612       |    /* Append the DECLARE for the WORD_INDEX_TABLE array.             */|06060000
  613       |    /*----------------------------------------------------------------*/|06070000
  614       |    TABLE_DCL = TABLE_DCL                                               |06080000
  615       |             || 'DECLARE WORD_INDEX_TABLE(26) FIXED BINARY(15) INIT(' ; |06090000
  616       |    TABLE_DCL = TABLE_DCL || SUBSTR(FIRST_WORD_INDICES,5);              |06100000
  617       |                                                                        |06110000
  618       |    /*----------------------------------------------------------------*/|06120000
  619       |    /* If the last word started with a Z then the initial values      */|06130000
  620       |    /* for the index table is complete.  If not then some zeroes      */|06140000
  621       |    /* have to be added to account for all 26 array items.            */|06150000
  622       |    /*----------------------------------------------------------------*/|06160000
  623       |    IF SIZE_WORD_LIST = 26 THEN                                         |06170000
  624       |      TABLE_DCL = TABLE_DCL || ')' ;                                    |06180000
  625       |    ELSE                                                                |06190000
  626       |      TABLE_DCL = TABLE_DCL || ',(' || 26-LAST_INDEX || ')0);';         |06200000
  627       |    NOTE ('The WORD_TABLE was successfully declared.',0);               |06205000
  628       |    RETURN(TABLE_DCL);                                                  |06210000
  629       |  %END;                                                                 |06220000
  630       |END;                                                                    |06230000

5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 17
PREPROCESSOR DIAGNOSTIC MESSAGES
   1      2      3
ERROR ID L   LINE    MESSAGE DESCRIPTION



PREPROCESSOR INFORMATORY MESSAGES

IEL2250I I   140     The WORD_TABLE was successfully declared.

END OF PREPROCESSOR DIAGNOSTIC MESSAGES
```

Diagnostic messages generated by the preprocessor. All messages generated by the compiler (including the preprocessor) are documented in the publication *PL/I MVS & VM Compile-Time Messages and Codes*.

1 ERROR ID identifies the message originating from the compiler (IEL) and gives the message number.

2 L indicates the severity level of the message.

3 LINE lists the number of the line in which the error occurred.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 18


                SOURCE LISTING                                                                      4
    STMT LEV NT                                                                                     R

               |/* PL/I Sample Program: Used to verify product installation         */|00040000

               |/*=== SAMPLE ========================================================*/|00060000
               |/*===================================================================*/|00070000
               |/*==                                                               ==*/|00080000
               |/*==  This is the PL/I sample program that is intended to be       ==*/|00090000
               |/*==  used to verify the product's complete installation.          ==*/|00100000
               |/*==  It is expected to execute and to provide some output.        ==*/|00110000
               |/*==  Although “results” are created by the program it is only     ==*/|00120000
               |/*==  to verify that representative I/O services are operable --   ==*/|00130000
               |/*==  the results are verified (internally) by the program.        ==*/|00140000
               |/*==                                                               ==*/|00150000
               |/*==  The program is intended to read a data file and count        ==*/|00160000
               |/*==  the number of occurrences of each PL/I statement type.       ==*/|00170000
               |/*==  The results are displayed at the end of execution.           ==*/|00180000
               |/*==  If any count does not match the value that is expected       ==*/|00190000
               |/*==  a warning message is displayed.                              ==*/|00200000
               |/*==                                                               ==*/|00210000
               |/*==  When the program is executed this source program file will   ==*/|00220000
               |/*==  be used as the input file.  The filename or DDNAME is        ==*/|00230000
               |/*==  SOURCE.                                                      ==*/|00240000
               |/*==                                                               ==*/|00250000
               |/*==  NOTE: Compilation of this program should cause preprocessor  ==*/|00260000
               |/*==        message:                                               ==*/|00270000
               |/*==                                                               ==*/|00280000
               |/*==   IEL2250I I 140 The WORD_TABLE was successfully declared.    ==*/|00281000
               |/*==                                                               ==*/|00282000
               |/*==        Two compiler messages will be produced as well:        ==*/|00283000
               |/*==                                                               ==*/|00284000
               |/*==   IEL0533I I     NO 'DECLARE' STATEMENT(S) FOR 'INDEX'.       ==*/|00285000
               |/*==   IEL0871I I  62 RESULT OF BUILTIN FUNCTION 'SUM' WILL BE     ==*/|00286000
               |/*==                  EVALUATED USING FIXED POINT ARITHMETIC       ==*/|00287000
               |/*==                  OPERATIONS.                                  ==*/|00288000
               |/*==                                                               ==*/|00289000
               |/*===================================================================*/|00290000
               |/*===================================================================*/|00300000

       1      0|SAMPLE: PROCEDURE OPTIONS(MAIN) REORDER;                               |00320000
```

Source listing. This is the output from the preprocessor and the input to the compiler. All the preprocessor statements have been executed and all preprocessor comments have been deleted.

4 Numbers in this column of the listing indicate the maximum depth of replacement of preprocessor statements.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 19
    STMT LEV NT                                                                                  R

               | /*==================================================================*/|00640000
               | /* Non-Preprocessor data variables are declared here.  Only the     */|00650000
               | /* variables that are used in the main block (or in more than one   */|00660000
               | /* of the contained blocks) are defined here.                       */|00670000
               | /*==================================================================*/|00680000
               |                                                                       |00690000
               | /*------------------------------------------------------------------*/|00700000
               | /* Declare the source program input file and its accoutrements.     */|00710000
               | /*------------------------------------------------------------------*/|00720000
     2   1  0  | DECLARE SOURCE         FILE RECORD;                                   |00730000
     3   1  0  | DECLARE RECORD         CHARACTER(121) VARYING;                        |00740000
     4   1  0  | DECLARE RECORD_READ    BIT(1) INIT(FALSE);                            |00750000
     5   1  0  | DECLARE LAST_CHAR_POSN FIXED BINARY(15);                              |00760000
     6   1  0  | DECLARE DISCREPANCY_OCCURRED  BIT(1) INIT(FALSE);                     |00770000
               |                                                                       |00780000
               | /*------------------------------------------------------------------*/|00790000
               | /* Declare the left- and right-margins of the input dataset.        */|00800000
               | /*------------------------------------------------------------------*/|00810000
     7   1  0  | DECLARE LEFT_MARGIN    FIXED BINARY(15) INIT('2');                    |00820000
     8   1  0  | DECLARE RIGHT_MARGIN   FIXED BINARY(15) INIT('72');                   |00830000
               |                                                                       |00840000
               | /*------------------------------------------------------------------*/|00850000
               | /* Declare '1'B as TRUE and '0'B as FALSE.                          */|00860000
               | /*------------------------------------------------------------------*/|00870000
     9   1  0  | DECLARE TRUE           BIT(1) INIT('1'B);                             |00880000
    10   1  0  | DECLARE FALSE          BIT(1) INIT('0'B);                             |00890000
               |                                                                       |00900000
               | /*------------------------------------------------------------------*/|00910000
               | /* Declare which characters are acceptable as the first character   */|00920000
               | /* of a word -- then declare acceptable succeeding characters.      */|00930000
               | /*------------------------------------------------------------------*/|00940000
    11   1  0  | DECLARE WORD_FIRST_CHARACTERS CHAR(29) STATIC                         |00950000
               |               INIT('ABCDEFGHIJKLMNOPQRSTUVWXYZ@#$');                  |00960000
    12   1  0  | DECLARE WORD_NEXT_CHARACTERS  CHAR(30) STATIC                         |00970000
               |               INIT('ABCDEFGHIJKLMNOPQRSTUVWXYZ_@#$');                 |00980000
               |                                                                       |00990000
               | /*------------------------------------------------------------------*/|01000000
               | /* Declare a place to hold words extracted from program text.       */|01010000
               | /*------------------------------------------------------------------*/|01020000
    13   1  0  | DECLARE WORD  CHAR(31) VARYING;                                       |01030000
    14   1  0  | DECLARE WORD_INDEX     FIXED BINARY(15);                              |01040000
               |                                                                       |01050000
               | /*------------------------------------------------------------------*/|01060000
               | /* Declare the use of SYSPRINT and all of the builtin functions.    */|01070000
               | /*------------------------------------------------------------------*/|01080000
    15   1  0  | DECLARE SYSPRINT       FILE STREAM,                                   |01090000
               |         PLIXOPT CHAR(100) VAR STATIC EXT INIT('MSGFILE(SYSPRINT)');   |01095000
    16   1  0  | DECLARE (HIGH, SUBSTR, SUM, UNSPEC, VERIFY) BUILTIN;                  |01100000
    17   1  0  | DECLARE ONCODE         BUILTIN;                                       |01110000
    STMT LEV NT                                                                                R
                 |  /*=================================================================*/|01120000
                 |  /* PL/I statement keywords are collected using the ADD_TO_LIST     */|01130000
                 |  /* macro.  They are put into a table, WORD_TABLE, by the           */|01140000
                 |  /* END_OF_LIST macro.  That macro also creates an index,           */|01150000
                 |  /* WORD_TABLE_INDEX, into the WORD_TABLE.                          */|01160000
                 |  /*                                                                 */|01170000
                 |  /* Finally, a table, WORD_COUNT, is created that has a counter     */|01180000
                 |  /* that corresponds to each word.  Whenever that word is           */|01190000
                 |  /* encountered in the input stream the appropriate WORD_COUNT      */|01200000
                 |  /* element is incremented.                                         */|01210000
                 |  /*                                                                 */|01220000
                 |  /* Notice that there are no semicolons in the macro statements.    */|01230000
                 |  /*=================================================================*/|01240000
                 |                                                                       |01260000  1
                 |                                                                       |01270000  1
                 |                                                                       |01280000  1
                 |                                                                       |01290000  1
                 |                                                                       |01300000  1
                 |                                                                       |01310000  1
                 |                                                                       |01320000  1
                 |                                                                       |01330000  1
      18   1  0  |  DECLARE WORD_TABLE(      37) CHAR(       9)INIT('ALLOCATE', 'BEGIN', |01340000  1
                 |'CALL', 'CLOSE', 'DCL', 'DECLARE', 'DEFAULT', 'DISPLAY', 'DO', 'ELSE', |01340000  1
                 |'END', 'ENTRY', 'FREE', 'GENERIC', 'GET', 'GO', 'GOTO', 'IF', 'LEAVE', |01340000  1
                 |'LIST', 'LOCATE', 'ON', 'OPEN', 'PROC', 'PROCEDURE', 'READ', 'RETURN', |01340000  1
                 |'REVERT', 'REWRITE', 'SELECT', 'SIGNAL', 'STOP', 'THEN', 'WAIT', 'WHEN'|01340000  1
      19   1  0  |, 'WRITE', HIGH(       9));DECLARE WORD_COUNT(      36) FIXED BINARY(15|01340000  1
      20   1  0  |) INIT((      36)0);DECLARE WORD_INDEX_TABLE(26) FIXED BINARY(15) INIT(|01340000  1
                 |    1,       2,       3,       5,      10,      13,      14, 0,      18|01340000  1
                 |, 0, 0,      19, 0, 0,      22,      24, 0,      26,      30,      33, |01340000  1
                 |0, 0,      34,(       3)0);                                            |01340000  1
                 |                                                                       |01350000
                 |  /*-----------------------------------------------------------------*/|01360000
                 |  /* This is the table containing the results when THIS program      */|01370000
                 |  /* is the input dataset.  There is an intentional error on the     */|01380000
                 |  /* IF count so that an error message can be produced.              */|01390000
                 |  /*-----------------------------------------------------------------*/|01400000
      21   1  0  |  DECLARE CONTROLLED_SET(      36) FIXED BINARY(15)                    |01410000  1
                 |                             INIT( 0, 3,                               |01420000
                 |                                   0, 1, 13, 24, 0, 2,                 |01430000
                 |                                   14,                                 |01440000
                 |                                   13, 23, 0, 0, 0, 0, 1, 0, 14,       |01450000
                 |                                   0, 7, 0, 4, 1,                      |01460000
                 |                                   2, 3,                               |01470000
                 |                                   2, 4, 0, 0, 1, 0,                   |01480000
                 |                                   2, 13, 0, 2, 0);                    |01490000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 21
    STMT LEV NT                                                                                      R

               | /*==================================================================*/| 01510000
               | /*= SAMPLE will perform the following tasks:                       =*/| 01520000
               | /*= 1) OPEN the input dataset                                      =*/| 01530000
               | /*= 2) READ each record and, for each record,                      =*/| 01540000
               | /*=    a) Extract a character string that meets the PL/I           =*/| 01550000
               | /*=       definition of a word.                                    =*/| 01560000
               | /*=    b) If the word also appears in the list of interesting      =*/| 01570000
               | /*=       words, record its presence by incrementing a counter.   =*/| 01580000
               | /*= 3) Report on the number of appearances of the words that       =*/| 01590000
               | /*=    actually appeared in the dataset.                           =*/| 01600000
               | /*= 4) DISPLAY a message if the count does not match the count     =*/| 01610000
               | /*=    of PL/I statement keywords in this program.                 =*/| 01620000
               | /*==================================================================*/| 01630000
               |                                                                       | 01640000
               | /*------------------------------------------------------------------*/| 01650000
               | /* Describe the action to take on selected exceptional conditions. */| 01660000
               | /*------------------------------------------------------------------*/| 01670000
               |                                                                       | 01680000
               | /*------------------------------------------------------------------*/| 01690000
               | /* If the file has not been properly defined, tell them about it.  */| 01700000
               | /*------------------------------------------------------------------*/| 01710000
    22   1  0  | ON UNDEFINEDFILE(SOURCE)                                              | 01720000
               |   BEGIN;                                                              | 01730000
    23   2  0  |     DISPLAY ('The input data set has not been defined.');            | 01740000
    24   2  0  |     STOP;                                                             | 01750000
    25   2  0  |   END;                                                                | 01760000
               |                                                                       | 01770000
               | /*------------------------------------------------------------------*/| 01780000
               | /* When the file has been processed indicate “no record read.”     */| 01790000
               | /*------------------------------------------------------------------*/| 01800000
    26   1  0  | ON ENDFILE(SOURCE)                                                    | 01810000
               |   BEGIN;                                                              | 01820000
    27   2  0  |     RECORD_READ = FALSE;                                              | 01830000
    28   2  0  |   END;                                                                | 01840000
               |                                                                       | 01850000
               | /*------------------------------------------------------------------*/| 01860000
               | /* If any other errors occur, write a message and terminate.       */| 01870000
               | /*------------------------------------------------------------------*/| 01880000
    29   1  0  | ON ERROR                                                              | 01890000
               |   BEGIN;                                                              | 01900000
    30   2  0  |     ON ERROR SYSTEM;                                                  | 01910000
    31   2  0  |     DISPLAY ('Unspecified error occurred.  ONCODE=' || ONCODE );      | 01920000
    32   2  0  |     STOP;                                                             | 01930000
    33   2  0  |   END;                                                                | 01940000
               |                                                                       | 01950000
               | /*------------------------------------------------------------------*/| 01960000
               | /* Prepare the input dataset for processing -- mark it as open.    */| 01970000
               | /*------------------------------------------------------------------*/| 01980000
    34   1  0  | OPEN FILE(SOURCE) INPUT;                                              | 01990000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 22
    STMT LEV NT                                                                                         R
                 |  /*=================================================================*/|02000000
                 |  /* Count the use of PL/I statements in each record of the          */|02010000
                 |  /* input data set.                                                 */|02020000
                 |  /*=================================================================*/|02030000
                 |                                                                     |02040000
                 |  /*-----------------------------------------------------------------*/|02050000
                 |  /* Read the first record of the input dataset.                     */|02060000
                 |  /*-----------------------------------------------------------------*/|02070000
      35   1  0  |  RECORD_READ = TRUE;                                                  |02080000
      36   1  0  |  READ FILE(SOURCE) INTO (RECORD);                                     |02090000
                 |                                                                     |02100000
                 |  /*-----------------------------------------------------------------*/|02110000
                 |  /* Process the first and all succeeding records.                   */|02120000
                 |  /*-----------------------------------------------------------------*/|02130000
      37   1  0  |  DO WHILE (RECORD_READ);                                              |02140000
                 |                                                                     |02150000
                 |    /* Set the “last character” position to the left margin          */|02160000
      38   1  1  |    LAST_CHAR_POSN = LEFT_MARGIN;                                      |02170000
                 |    /* Use NEXT_WORD to extract the first word from this record.     */|02180000
      39   1  1  |    WORD = NEXT_WORD(RECORD);                                          |02190000
                 |                                                                     |02200000
                 |    /*---------------------------------------------------------------*/|02210000
                 |    /* Extract words from this record until no more remain.          */|02220000
                 |    /*---------------------------------------------------------------*/|02230000
      40   1  1  |    DO WHILE (WORD ¬= '');                                             |02240000
                 |      /* Use LOOKUP_WORD to find its position in the table.          */|02250000
      41   1  2  |      WORD_INDEX = LOOKUP_WORD(WORD);                                  |02260000
                 |                                                                     |02270000
                 |      /*-------------------------------------------------------------*/|02280000
                 |      /* If the word is in the list, count it.                       */|02290000
                 |      /*-------------------------------------------------------------*/|02300000
      42   1  2  |      IF WORD_INDEX ¬= 0 THEN                                          |02310000
                 |        WORD_COUNT(WORD_INDEX) = WORD_COUNT(WORD_INDEX) + 1;           |02320000
      43   1  2  |      ELSE;                                                            |02330000
                 |      /* Get the next word from the record.                          */|02340000
      44   1  2  |      WORD = NEXT_WORD(RECORD);                                        |02350000
      45   1  2  |    END;                                                               |02360000
                 |                                                                     |02370000
                 |    /*---------------------------------------------------------------*/|02380000
                 |    /* Read the next record from the input data set.                 */|02390000
                 |    /*---------------------------------------------------------------*/|02400000
      46   1  1  |    READ FILE(SOURCE) INTO (RECORD);                                   |02410000
      47   1  1  |  END;                                                                 |02420000
                 |                                                                     |02430000
                 |  /*-----------------------------------------------------------------*/|02440000
                 |  /* Input from the data set is exhausted. CLOSE it.                 */|02450000
                 |  /*-----------------------------------------------------------------*/|02460000
      48   1  0  |  CLOSE FILE(SOURCE);                                                  |02470000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 23
    STMT LEV NT                                                                                        R

                |  /*=================================================================*/|02490000
                |  /*= The report that details and summarizes the use of word in the =*/|02500000
                |  /*= WORD_TABLE is prepared in this section.                       =*/|02510000
                |  /*=================================================================*/|02520000
                |                                                                        |02530000
      49   1  0 |  PUT SKIP LIST (' *********************** ');                          |02540000
      50   1  0 |  PUT SKIP LIST (' *** Word-use Report *** ');                          |02550000
      51   1  0 |  PUT SKIP LIST (' *********************** ');                          |02560000
      52   1  0 |  PUT SKIP LIST (' -count-   --word-- ');                               |02570000
                |                                                                        |02580000
                |  /*-----------------------------------------------------------------*/|02590000
                |  /* Review the activity for each word in the list.                  */|02600000
                |  /*-----------------------------------------------------------------*/|02610000
      53   1  0 |  DO WORD_INDEX = 1 TO       36;                                        |02620000  1
                |                                                                        |02630000
                |    /*---------------------------------------------------------------*/|02640000
                |    /* If the word was used then display the word and its use-count. */|02650000
                |    /*---------------------------------------------------------------*/|02660000
      54   1  1 |    IF WORD_COUNT(WORD_INDEX) > 0 THEN                                  |02670000
                |      PUT SKIP EDIT (WORD_COUNT(WORD_INDEX),                            |02680000
                |                     WORD_TABLE(WORD_INDEX))                            |02690000
                |                     (F(6), X(6),A);                                    |02700000
      55   1  1 |    ELSE;                                                               |02710000
                |                                                                        |02720000
                |    /*---------------------------------------------------------------*/|02730000
                |    /* If there was a discrepancy between what was counted and what  */|02740000
                |    /* was expected then display a warning message and remember that */|02750000
                |    /* it had occurred.                                              */|02760000
                |    /*---------------------------------------------------------------*/|02770000
      56   1  1 |    IF WORD_COUNT(WORD_INDEX) ¬= CONTROLLED_SET(WORD_INDEX) THEN        |02780000
                |      DO;                                                               |02790000
      57   1  2 |        PUT SKIP EDIT ((12)'-',                                         |02800000
                |                       'The previous value should have been',           |02810000
                |                       CONTROLLED_SET(WORD_INDEX))                      |02820000
                |                       (A, A, F(6));                                    |02830000
      58   1  2 |        DISCREPANCY_OCCURRED = TRUE;                                    |02840000
      59   1  2 |      END;                                                              |02850000
      60   1  1 |    ELSE;                                                               |02860000
      61   1  1 |  END;                                                                  |02870000
                |                                                                        |02880000
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 24
    STMT LEV NT                                                                                        R
                |  /*=================================================================*/|02890000
                |  /* Summarize word activity on this input dataset.                  */|02900000
                |  /*=================================================================*/|02910000
                |                                                                        |02920000
      62   1  0 |  PUT SKIP(2) LIST ('There were ' || SUM(WORD_COUNT)                    |02930000
                |                 || ' references to ' ||       36                       |02940000  1
                |                 || ' words.');                                         |02950000
                |                                                                        |02960000
                |  /*-----------------------------------------------------------------*/|02970000
                |  /* If a discrepency between one of the counts and the expected     */|02980000
                |  /* counts occured then display a warning message.                  */|02990000
                |  /*-----------------------------------------------------------------*/|03000000
      63   1  0 |  IF DISCREPANCY_OCCURRED THEN                                          |03010000
                |    PUT SKIP(2) LIST ('There was a discrepancy in at least one of'      |03020000
                |                 || ' the word-counts.');                               |03030000
      64   1  0 |  ELSE;                                                                 |03040000
```

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 25
    STMT LEV NT                                                                                          R
                | /*=== NEXT_WORD ===================================================*/| 03050000
                | /*=================================================================*/| 03060000
                | /*===                                                            ==*/| 03070000
                | /*===  Extract a word from the argument string that is passed.    ==*/| 03080000
                | /*===  Return it as CHAR(31) VARYING.                             ==*/| 03090000
                | /*===                                                            ==*/| 03100000
                | /*===  Ignore PL/I comments and constants (strings surrounded by  ==*/| 03110000
                | /*===  single quotes (').  Comments and constants can not be      ==*/| 03120000
                | /*===  continued but must be complete in the argument string.     ==*/| 03130000
                | /*===                                                            ==*/| 03140000
                | /*===  If no more words exist then a null character string will   ==*/| 03150000
                | /*===  be returned.                                               ==*/| 03160000
                | /*===                                                            ==*/| 03170000
                | /*=================================================================*/| 03180000
                | /*=================================================================*/| 03190000
                |                                                                      | 03200000
      65   1  0 | NEXT_WORD: PROCEDURE(DATA_RECORD) RETURNS(CHAR(31) VARYING);         | 03210000
                |                                                                      | 03220000
      66   2  0 |   DECLARE DATA_RECORD        CHAR(*)  VARYING;                       | 03230000
      67   2  0 |   DECLARE DATA_WORD          CHAR(31) VARYING;                       | 03240000
      68   2  0 |   DECLARE NEXT_CHARACTER     CHAR(1);                                | 03250000
      69   2  0 |   DECLARE LENGTH_OF_STRING   FIXED BINARY(15);                       | 03260000
                |                                                                      | 03270000
      70   2  0 |   DECLARE NEXT_CHAR_POSN     FIXED BINARY(15);                       | 03280000
                |                                                                      | 03290000
                |   /*===============================================================*/| 03300000
                |   /*= LAST_CHAR_POSN remembers, from call to call, the point where=*/| 03310000
                |   /*= the search for additional words will start.  Management of  =*/| 03320000
                |   /*= its value is a key concern to this function.                =*/| 03330000
                |   /*=                                                             =*/| 03340000
                |   /*= Comments and constants in the argument string will be       =*/| 03350000
                |   /*= ignored.  If a character is found that is a legitimate PL/I =*/| 03360000
                |   /*= “first-character” then a word is assumed to follow.  It     =*/| 03370000
                |   /*= will be built by concatenating (suffixing) additional,      =*/| 03380000
                |   /*= legitimate “next-characters.”                               =*/| 03390000
                |   /*===============================================================*/| 03400000
```

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 26
    STMT LEV NT                                                                                          R
                |   /*===============================================================*/| 03410000
                |   /*= Scan each character in the record.  Start at the position   =*/| 03420000
                |   /*= where scanning last terminated (LAST_CHAR_POSN) and         =*/| 03430000
                |   /*= continue until the end of a word or the end of the record   =*/| 03440000
                |   /*= is reached.                                                 =*/| 03450000
                |   /*===============================================================*/| 03460000
                |                                                                      | 03470000
      71   2  0 |   DATA_WORD = '';                                                    | 03480000
      72   2  0 |   DO NEXT_CHAR_POSN = LAST_CHAR_POSN TO RIGHT_MARGIN                 | 03490000
                |    WHILE (DATA_WORD = '');                                           | 03500000
      73   2  1 |     NEXT_CHARACTER = SUBSTR(DATA_RECORD, NEXT_CHAR_POSN, 1);         | 03510000
      74   2  1 |     SELECT (NEXT_CHARACTER);                                         | 03520000
                |                                                                      | 03530000
      75   2  2 |       WHEN ('/')                                                     | 03540000
                |                                                                      | 03550000
                |         /*---------------------------------------------------------*/| 03560000
                |         /* If this turns out to be a comment then skip over it.    */| 03570000
                |         /*---------------------------------------------------------*/| 03580000
                |         DO;                                                          | 03590000
      76   2  3 |           IF SUBSTR(DATA_RECORD, NEXT_CHAR_POSN, 2) = '/*' THEN      | 03600000
                |             NEXT_CHAR_POSN = NEXT_CHAR_POSN + 3                      | 03610000
                |                  + INDEX(SUBSTR(DATA_RECORD,NEXT_CHAR_POSN+2),'*/'); | 03620000
      77   2  3 |           ELSE;                                                      | 03630000
      78   2  3 |         END;                                                         | 03640000
                |                                                                      | 03650000
      79   2  2 |       WHEN ('''')                                                    | 03660000
                |                                                                      | 03670000
                |         /*---------------------------------------------------------*/| 03680000
                |         /* Skip over the constant.                                 */| 03690000
                |         /*---------------------------------------------------------*/| 03700000
                |         NEXT_CHAR_POSN = NEXT_CHAR_POSN                              | 03710000
                |                   + INDEX(SUBSTR(DATA_RECORD,NEXT_CHAR_POSN+1),'''');| 03720000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 27
    STMT LEV NT                                                                                         R
                 |        /*============================================================*/|03730000
                 |        /*= This may be the start of a word.  Extract it if so.     =*/|03740000
                 |        /*============================================================*/|03750000
                 |                                                                        |03760000
      80   2  2  |        OTHERWISE                                                       |03770000
                 |                                                                        |03780000
                 |          /*----------------------------------------------------------*/|03790000
                 |          /* This may be the start of a word.                         */|03800000
                 |          /*----------------------------------------------------------*/|03810000
                 |          DO;                                                           |03820000
                 |                                                                        |03830000
                 |            /*--------------------------------------------------------*/|03840000
                 |            /* If the next character is not acceptable as the first   */|03850000
                 |            /* character of a word then do nothing further -- our     */|03860000
                 |            /* enclosing DO will step to the next character for       */|03870000
                 |            /* further checking.                                      */|03880000
                 |            /*--------------------------------------------------------*/|03890000
      81   2  3  |            IF INDEX(WORD_FIRST_CHARACTERS, NEXT_CHARACTER) = 0 THEN;   |03900000
      82   2  3  |            ELSE                                                        |03910000
                 |                                                                        |03920000
                 |              /*------------------------------------------------------*/|03930000
                 |               /* This is the start of a word.  Collect the rest of it*/|03940000
                 |              /*------------------------------------------------------*/|03950000
                 |                                                                        |03960000
                 |              DO;                                                       |03970000
      83   2  4  |                DATA_WORD = NEXT_CHARACTER;                             |03980000
                 |                                                                        |03990000
                 |                /*----------------------------------------------------*/|04000000
                 |                /* Build up DATA_WORD by iteratively appending        */|04010000
                 |                /* characters from the input argument string.  Do it  */|04020000
                 |                /* as long as the characters are acceptable PL/I      */|04030000
                 |                /* “next=characters.”                                 */|04040000
                 |                /*----------------------------------------------------*/|04050000
                 |                                                                        |04060000
      84   2  4  |                DO NEXT_CHAR_POSN = NEXT_CHAR_POSN+1 TO RIGHT_MARGIN    |04070000
                 |                 WHILE (INDEX(WORD_NEXT_CHARACTERS,                     |04080000
                 |                         SUBSTR(DATA_RECORD, NEXT_CHAR_POSN,1)) ¬= 0);  |04090000
      85   2  5  |                  DATA_WORD = DATA_WORD                                 |04100000
                 |                               || SUBSTR(DATA_RECORD, NEXT_CHAR_POSN,1);|04110000
      86   2  5  |                END;                                                    |04120000
      87   2  4  |                LAST_CHAR_POSN = NEXT_CHAR_POSN + 1;                    |04130000
      88   2  4  |              END;                                                      |04140000
      89   2  3  |          END;                                                          |04150000
      90   2  2  |      END;   /* End of the SELECT (NEXT_CHARACTER) statement          */|04160000
      91   2  1  |    END;     /* End of the DO that tries to find a word               */|04170000
                 |                                                                        |04180000
      92   2  0  |    RETURN (DATA_WORD);                                                 |04190000
      93   2  0  |  END;                                                                  |04200000
```

```
 STMT LEV NT                                                                      R
             |  /*=== LOOKUP_WORD =================================================*/| 04210000
             |  /*=================================================================*/| 04220000
             |  /*==                                                             ==*/| 04230000
             |  /*==  Find the word in the WORD_TABLE that matches the           ==*/| 04240000
             |  /*==  argument string (CHAR(*) VARYING) and return the           ==*/| 04250000
             |  /*==  position of that word (its subscript) to the               ==*/| 04260000
             |  /*==  invoker (FIXED BINARY(15)).                                ==*/| 04270000
             |  /*==                                                             ==*/| 04280000
             |  /*==  If the word does not exist in the list a 0 will be         ==*/| 04290000
             |  /*==  returned.                                                  ==*/| 04300000
             |  /*==                                                             ==*/| 04310000
             |  /*=================================================================*/| 04320000
             |  /*=================================================================*/| 04330000
             |                                                                       | 04340000
   94   1  0 |  LOOKUP_WORD: PROCEDURE(DATA_WORD) RETURNS(FIXED BINARY(15));         | 04350000
             |                                                                       | 04360000
   95   2  0 |    DECLARE DATA_WORD   CHAR(*) VARYING;                               | 04370000
   96   2  0 |    DECLARE WORD_NUMBER FIXED BINARY(15);                              | 04380000
             |                                                                       | 04390000
             |    /*===============================================================*/| 04400000
             |    /*= A sequential search is used to locate the required word.    =*/| 04410000
             |    /*= WORD_INDEX_TABLE is used to start the search at the first   =*/| 04420000
             |    /*= word in the list that has the same first character.         =*/| 04430000
             |    /*===============================================================*/| 04440000
   97   2  0 |    WORD_NUMBER = WORD_INDEX_TABLE   /* Subscript is on next line */   | 04450000
             |                (INDEX (WORD_FIRST_CHARACTERS, SUBSTR(DATA_WORD,1,1)));| 04460000
             |                                                                       | 04470000
             |    /*---------------------------------------------------------------*/| 04480000
             |    /* Search words in the WORD_TABLE until the word is found or is  */| 04490000
             |    /* determined to be not a part of the list -- its index number   */| 04500000
             |    /* (WORD_NUMBER) is zero.                                        */| 04510000
             |    /*---------------------------------------------------------------*/| 04520000
   98   2  0 |    DO WORD_NUMBER = WORD_NUMBER BY 1                                  | 04530000
             |       UNTIL (  WORD_TABLE(WORD_NUMBER) = DATA_WORD                    | 04540000
             |              | WORD_NUMBER = 0);                                      | 04550000
             |                                                                       | 04560000
             |      /*-------------------------------------------------------------*/| 04570000
             |      /* If the word in the WORD_TABLE is alphabetically greater     */| 04580000
             |      /* than the argument word then a match cannot be found.  Set   */| 04590000
             |      /* the WORD_NUMBER to 0 to indicate a non=match situation.     */| 04600000
             |      /*-------------------------------------------------------------*/| 04610000
   99   2  1 |      IF WORD_TABLE(WORD_NUMBER) > DATA_WORD THEN                      | 04620000
             |        WORD_NUMBER = 0;                                               | 04630000
  100   2  1 |      ELSE;                                                            | 04640000
  101   2  1 |    END;                                                               | 04650000
             |                                                                       | 04660000
  102   2  0 |    RETURN (WORD_NUMBER);                                              | 04670000
  103   2  0 |  END;                                                                 | 04680000
  104   1  0 |END;                                                                   | 06230000
 1           3                           ATTRIBUTE AND CROSS-REFERENCE TABLE (SHORT)
DCL NO.     IDENTIFIER                  ATTRIBUTES AND REFERENCES

21          CONTROLLED_SET           4  (36) AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)

                                     5  320000,320000,320000,320000,320000,320000,320000,320000,320000,320000,
                                        320000,320000,320000,320000,320000,320000,320000,320000,320000,320000,
                                        320000,320000,320000,320000,320000,320000,320000,320000,320000,320000,
                                        320000,320000,320000,320000,320000,320000,3380000,3400000

66          DATA_RECORD                 /* PARAMETER */ UNALIGNED CHARACTER(*) VARYING
                                        4110000,4200000,4200000,4260000,4670000,4700000
95          DATA_WORD                   /* PARAMETER */ UNALIGNED CHARACTER(*) VARYING
                                        5050000,5130000,5220000
67          DATA_WORD                   AUTOMATIC UNALIGNED CHARACTER (31) VARYING
                                        4080000,4090000,4580000,4700000,4700000,4790000
6           DISCREPANCY_OCCURRED        AUTOMATIC UNALIGNED INITIAL BIT (1)
                                        320000,3440000,3610000
10          FALSE                       AUTOMATIC UNALIGNED INITIAL BIT (1)
                                        320000,320000,320000,2430000
16          HIGH                        BUILTIN
   2                                    1040000
********    INDEX                       BUILTIN
                                        4200000,4260000,4500000,4670000,5050000
5           LAST_CHAR_POSN              AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                        2770000,4090000,4730000
7           LEFT_MARGIN                 AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                        320000,2770000
94          LOOKUP_WORD                 ENTRY RETURNS(BINARY FIXED (15,0))
                                        2860000
70          NEXT_CHAR_POSN              AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                        4090000,4090000,4110000,4200000,4200000,4200000,4200000,4260000,42600  00,
                                        4260000,4670000,4670000,4670000,4670000,4700000,4730000
68          NEXT_CHARACTER              AUTOMATIC UNALIGNED CHARACTER (1)
                                        4110000,4120000,4500000,4580000
65          NEXT_WORD                   ENTRY RETURNS(CHARACTER (31) VARYING )
                                        2790000,2950000
```

Attribute and cross-reference table

1 Number of the statement in the source listing in which the identifier is explicitly declared.

2 Asterisks indicate an undeclared identifier: all of its attributes are implied or supplied by default.

3 All identifiers used in the program are listed in ascending order according to their binary value.

4 Declared and default attributes are listed. This list also includes descriptive comments.

5 Cross references: these are the numbers of all other statements in which the identifier appears.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 30
DCL NO.    IDENTIFIER                      ATTRIBUTES AND REFERENCES
17         ONCODE                          BUILTIN
                                           31
3          RECORD                          AUTOMATIC UNALIGNED CHARACTER (121) VARYING
                                           36,39,44,46
4          RECORD_READ                     AUTOMATIC UNALIGNED INITIAL BIT (1)
                                           1,35,37
                                           27
8          RIGHT_MARGIN                    AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                           1,72,84
2          SOURCE                          EXTERNAL FILE RECORD
                                           22,26,34,36,46,48
16         SUBSTR                          BUILTIN
                                           73,76,76,79,84,85,97
16         SUM                             BUILTIN
                                           62
15         SYSPRINT                        EXTERNAL FILE STREAM
                                           49,50,51,52,54,57,62,63
9          TRUE                            AUTOMATIC UNALIGNED INITIAL BIT (1)
                                           1,35,58
13         WORD                            AUTOMATIC UNALIGNED CHARACTER (31) VARYING
                                           39,40,41,44
19         WORD_COUNT                      (36) AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                           1,42,42,54,54,56,62
11         WORD_FIRST_CHARACTERS           STATIC UNALIGNED INITIAL CHARACTER (29)
                                           81,97
14         WORD_INDEX                      AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                           41,42,42,42,53,53,54,54,54,56,56,57
20         WORD_INDEX_TABLE                (26) AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                           1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,97
12         WORD_NEXT_CHARACTERS            STATIC UNALIGNED INITIAL CHARACTER (30)
                                           84
96         WORD_NUMBER                     AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                           97,98,98,98,98,98,99,99,102

5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 31
DCL NO.    IDENTIFIER                      ATTRIBUTES AND REFERENCES
18         WORD_TABLE                      (37) AUTOMATIC UNALIGNED INITIAL CHARACTER (9)
                                           1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,
                                           54,98,99

5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 32


                                       AGGREGATE LENGTH TABLE
 1            2                                                                     3
DCL NO.   IDENTIFIER                          LVL     DIMS        OFFSET       ELEMENT         TOTAL
                                                                                LENGTH        LENGTH

21        CONTROLLED_SET                                 1                            2            72
19        WORD_COUNT                                     1                            2            72
20        WORD_INDEX_TABLE                               1                            2            52
18        WORD_TABLE                                     1                            9           333
                                                        4   SUM OF CONSTANT LENGTHS             529
```

Aggregate length table

1 Number of the statement in which the aggregate is declared, or, for a controlled aggregate, the number of the associated ALLOCATE statement.

2 The elements of the aggregate as declared.

3 Length of each element of the aggregate.

4 Sum of the lengths of aggregates whose lengths are constant.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 33

                    STORAGE REQUIREMENTS
  5                               6                      7                       8
BLOCK, SECTION OR STATEMENT     TYPE                   LENGTH   (HEX)    DSA SIZE   (HEX)
*SAMPLE1                        PROGRAM CSECT            4444    115C
*SAMPLE2                        STATIC CSECT             2880     B40
SAMPLE                          PROCEDURE BLOCK          2298     8FA        1208     4B8
BLOCK 2      STMT 22            ON UNIT                   170      AA         208      D0
BLOCK 3      STMT 26            ON UNIT                   162      A2         216      D8
BLOCK 4      STMT 29            ON UNIT                   304     130         288     120
NEXT_WORD                       PROCEDURE BLOCK          1056     420         368     170
LOOKUP_WORD                     PROCEDURE BLOCK           448     1C0         256     100
```

Storage requirements. This table gives the main storage requirements for the program. These quantities do not include the main storage required by the library subroutines that will be included by the linkage editor or loaded dynamically during execution.

5 Name of the block, section, or number of the statement in the program.

6 Description of the block, section, or statement.

7 Length in bytes of the storage areas in both decimal and hexadecimal notation.

8 Length in bytes of the dynamic storage area (DSA) in both decimal and hexadecimal notation.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation       */PAGE 34

                    EXTERNAL SYMBOL DICTIONARY

              1              2        3        4         5
            SYMBOL          TYPE      ID      ADDR     LENGTH

           CEESTART          SD      0001    000000    000080
           *SAMPLE1          SD      0002    000000    00115C
           *SAMPLE2          SD      0003    000000    000B40
           CEEMAIN           WX      0004    000000
           CEEMAIN           SD      0005    000000    000010
           IBMRINP1          ER      0006    000000
           CEEFMAIN          WX      0007    000000
           CEEBETBL          ER      0008    000000
           CEEROOTA          ER      0009    000000
           CEEOPIPI          ER      000A    000000
           CEESG010          ER      000B    000000
           IBMSEATA          ER      000C    000000
           IELCGOG           SD      000D    000000    0000AE
           IELCGOH           SD      000E    000000    0000A0
           IELCGOC           SD      000F    000000    00007C
           IELCGMY           SD      0010    000000    0000A4
           IELCGCY           SD      0011    000000    00007E
           IBMSSIOA          ER      0012    000000
           IBMSASCA          ER      0013    000000
           IBMSCEDB          ER      0014    000000
           IBMSCHFD          ER      0015    000000
           IBMSCHXH          WX      0016    000000
           IBMSCWDH          ER      0017    000000
           IBMSEOCA          ER      0018    000000
           IBMSJDSA          ER      0019    000000
           IBMSOCLA          ER      001A    000000
           IBMSOCLC          WX      001B    000000
           IBMSRIOA          ER      001C    000000
           IBMSSEOA          ER      001D    000000
           IBMSSIOE          WX      001E    000000
           IBMSSIOT          WX      001F    000000
           IBMSSLOA          ER      0020    000000
           IBMSSPLA          ER      0021    000000
           IBMSSXCA          ER      0022    000000
           IBMSSXCB          WX      0023    000000
           IBMSSIST          WX      0024    000000
           CEEUOPT           SD      0025    000000    0004D0
           PLIXOPT           SD      0026    000000    000066
           PLIXOPT*          SD      0027    000000    00002C
           PLIXOPT+          LD              000004
           PLIXOPT-          LD              000020
           PLIXOPT-          ER      0028    000000
           SAMPLE            LD              000008
           SAMPLE            ER      0029    000000
           SAMPLE*           SD      002A    000000    000020
           SAMPLE+           LD              000000
           SOURCE            SD      002B    000000    00001C
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation       */PAGE 35
           SOURCE            PR      002C    000000    000004
           SOURCE*           SD      002D    000000    000020
           SOURCE+           LD              000000
           SYSPINT           SD      002E    000000    000020
           SYSPINT*          SD      002F    000000    000020
           SYSPINT+          LD              000000
```

External symbol dictionary

1 List of all the external symbols that make up the object module.

2 Type of external symbol, as follows:

CM Common area
ER External reference
LD Label definition
PR Pseudo-register
SD Section definition
WX Weak external reference

Full definitions of all these terms are given in “External symbol dictionary” in the main text.

3 All entries, except LD type entries, are identified by a hexadecimal number.

4 Address (in hexadecimal) of LD type entries.

5 Length in bytes (in hexadecimal) of SD, CM, and PR type entries.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation       */PAGE 36

                           STATIC INTERNAL STORAGE MAP
  1       2                    3
000000  E0000B38              PROGRAM ADCON
000004  00000008              PROGRAM ADCON
000008  000000FC              PROGRAM ADCON
00000C  0000034C              PROGRAM ADCON
000010  000008FC              PROGRAM ADCON
000014  0000096E              PROGRAM ADCON
000018  000009A8              PROGRAM ADCON
00001C  00000A1A              PROGRAM ADCON
000020  00000A24              PROGRAM ADCON
000024  00000A4C              PROGRAM ADCON
000028  00000AD8              PROGRAM ADCON
00002C  00000B88              PROGRAM ADCON
000030  00000C1A              PROGRAM ADCON
000034  00000C40              PROGRAM ADCON
000038  00000FA8              PROGRAM ADCON
00003C  00001032              PROGRAM ADCON
000040  0000103C              PROGRAM ADCON
000044  0000103C              PROGRAM ADCON
000048  0000103C              PROGRAM ADCON
00004C  0000103C              PROGRAM ADCON
000050  0000103C              PROGRAM ADCON
000054  0000103C              PROGRAM ADCON
000058  0000103C              PROGRAM ADCON
00005C  00000000              A..IELCGOG
000060  00000000              A..IELCGOH
000064  00000000              A..IELCGOC
000068  00000000              A..IELCGMY
00006C  00000000              A..IELCGCY
000070  00000000              A..IBMSASCA
000074  00000000              A..IBMSCEDB
000078  00000000              A..IBMSCHFD
00007C  00000000              A..IBMSCHXH
000080  00000000              A..IBMSCWDH
000084  00000000              A..IBMSEOCA
000088  00000000              A..IBMSJDSA
00008C  00000000              A..IBMSOCLA
000090  00000000              A..IBMSOCLC
000094  00000000              A..IBMSRIOA
000098  00000000              A..IBMSSEOA
00009C  00000000              A..IBMSSIOE
0000A0  00000000              A..IBMSSIOT
0000A4  00000000              A..IBMSSLOA
0000A8  00000000              A..IBMSSPLA
0000AC  00000000              A..IBMSSXCA
0000B0  00000000              A..IBMSSXCB
0000B4  00000000              A..STATIC
0000B8  B4000A00              DED..NEXT_WORD
0000BC  2000                  DED
0000BE  00000F80              DED..WORD_COUNT
0000C2  500000060080          FED
```

```
  1       2                    3
0000C8  60000006              FED
0000CC  58000009              FED
0000D0  5800000C              FED
0000D4  58000023              FED
0000D8  2800                  DED..WORD
0000DA  2401                  DED..FALSE
0000DC  0002                  CONSTANT
0000DE  0048                  CONSTANT
0000E0  0000                  CONSTANT
0000E2  0001                  CONSTANT
0000E4  0003                  CONSTANT
0000E6  0005                  CONSTANT
0000E8  000A                  CONSTANT
0000EA  000D                  CONSTANT
0000EC  000E                  CONSTANT
0000EE  0012                  CONSTANT
0000F0  0013                  CONSTANT
0000F2  0016                  CONSTANT
0000F4  0018                  CONSTANT
0000F6  001A                  CONSTANT
0000F8  001E                  CONSTANT
0000FA  0021                  CONSTANT
0000FC  0022                  CONSTANT
0000FE  0017                  CONSTANT
000100  0007                  CONSTANT
000102  0004                  CONSTANT
000104  0024                  CONSTANT
000106  0009                  CONSTANT
000108  4040402020202020      CONSTANT
        202020202120
000116  001C                  CONSTANT
000118  001D                  CONSTANT
00011A
000120  00000000000001B4      LOCATOR..CONTROLLED_SET
000128  00000000000001C4      LOCATOR..WORD_INDEX_TABLE
000130  00000000000001D4      LOCATOR..WORD_TABLE
000138  00000000001F8000      LOCATOR..WORD
000140  00000535001E0000      LOCATOR..WORD_NEXT_CHARACTERS
000148  00000518001D0000      LOCATOR..WORD_FIRST_CHARACTERS
000150  0000000000010000      LOCATOR..FALSE
000158  0000000000798000      LOCATOR..RECORD
000160  0000000000008000      LOCATOR..DATA_RECORD
000168  0080000091102000      CONSTANT
000170  000000000200007B      RECORD DESCRIPTOR
000178  000003D800190000      LOCATOR
000180  000003F100190000      LOCATOR
000188  0000040A00140000      LOCATOR
000190  0000000000340000      LOCATOR
000198  00000000003B0000      LOCATOR
0001A0  000004AE00280000      LOCATOR
0001A8  00000000002D0000      LOCATOR
0001B0  91E091E0              CONSTANT
```

Static internal storage map.
This is a storage map of the static control section for the program. This control section is the third standard entry in the external symbol dictionary.

1 Six-digit offset (in hexadecimal)

2 Text (in hexadecimal)

3 Comment indicating type of item to which the text refers. A comment appears only against the first line of the text for an item.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 37
0001B4  0000000200000002      DESCRIPTOR                            40
        0000002400000001                                    0002A6  C3C1D3D340404040      CONSTANT
0001C4  0000000200000002      DESCRIPTOR                            40
        0000001A00000001                                    0002AF  C3D3D6E2C5404040      CONSTANT
0001D4  0000000900000009      DESCRIPTOR                            40
        0000002500000001                                    0002B8  C4C3D34040404040      CONSTANT
        00090000                                                    40
0001E8  00000001              CONSTANT                      0002C1  C4C5C3D3C1D9C540      CONSTANT
0001EC  0010000000601800      CONSTANT                              40
        00000000                                            0002CA  C4C5C6C1E4D3E340      CONSTANT
0001F8  00000002              CONSTANT                              40
0001FC  00000003              CONSTANT                      0002D3  C4C9E2D7D3C1E840      CONSTANT
000200  0000001F              CONSTANT                              40
000204  00000000              A..PLIXOPT                    0002DC  C4D6404040404040      CONSTANT
000208  00000000              A..DCLCB                              40
00020C  00000000              A..DCLCB                      0002E5  C5D3E2C540404040      CONSTANT
000210  000001E8              A..CONSTANT                           40
000214  00000000              A..DCLCB                      0002EE  C5D5C44040404040      CONSTANT
000218  000001EC              A..CONSTANT                           40
00021C  00000000              OMITTED ARGUMENT              0002F7  C5D5E3D9E8404040      CONSTANT
000220  00000000              OMITTED ARGUMENT                      40
000224  80000000              OMITTED ARGUMENT              000300  C6D9C5C540404040      CONSTANT
000228  00000000              A..DCLCB                              40
00022C  00000168              A..CONSTANT                   000309  C7C5D5C5D9C9C340      CONSTANT
000230  00000000              A..RD                                 40
000234  00000000              OMITTED ARGUMENT              000312  C7C5E34040404040      CONSTANT
000238  00000000              OMITTED ARGUMENT                      40
00023C  80000000              OMITTED ARGUMENT              00031B  C7D6404040404040      CONSTANT
000240  00000000              A..LOCATOR                            40
000244  80000000              A..TEMP                       000324  C7D6E3D640404040      CONSTANT
000248  00000000              A..LOCATOR                            40
00024C  80000000              A..WORD_INDEX                 00032D  C9C6404040404040      CONSTANT
000250  000001E8              A..CONSTANT                           40
000254  00000000              A..DCLCB                      000336  D3C5C1E5C5404040      CONSTANT
000258  80000000              OMITTED ARGUMENT                      40
00025C  00000000              A..DCLCB                      00033F  D3C9E2E340404040      CONSTANT
000260  00000000              A..TEMP                               40
000264  800001E8              A..CONSTANT                   000348  D3D6C3C1E3C54040      CONSTANT
000268  00000000              A..DCLCB                              40
00026C  00000000              A..TEMP                       000351  D6D5404040404040      CONSTANT
000270  800001F8              A..CONSTANT                           40
000274  00000000              A..LOCATOR                    00035A  D6D7C5D540404040      CONSTANT
000278  000000E2              A..CONSTANT                           40
00027C  000000BE              A..DED..WORD_COUNT            000363  D7D9D6C340404040      CONSTANT
000280  00000000              A..TEMP                               40
000284  800000E0              A..CONSTANT                   00036C  D7D9D6C3C5C4E4D9      CONSTANT
000288  800001A0              A..CONSTANT                           C5
00028C  0D800000              CONSTANT                      000375  D9C5C1C440404040      CONSTANT
000290  80000000              A..TEMP                               40
000294  C1D3D3D6C3C1E3C5      CONSTANT                      00037E  D9C5E3E4D9D54040      CONSTANT
        40                                                          40
00029D  C2C5C7C9D5404040      CONSTANT                      000387  D9C5E5C5D9E34040      CONSTANT
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 38
        40                                                          96A3408285859540
000390  D9C5E6D9C9E3C540      CONSTANT                              848586899585844B
        40                                                  0004D6  4040202020202021      CONSTANT
000399  E2C5D3C5C3E34040      CONSTANT                              20
        40                                                  0004DF  E495A29785838986      CONSTANT
0003A2  E2C9C7D5C1D34040      CONSTANT                              8985844085999996
        40                                                          9940968383A49999
0003AB  E2E3D6D740404040      CONSTANT                              85844B4040D6D5C3
        40                                                          D6C4C57E
0003B4  E3C8C5D540404040      CONSTANT                      000503  615C                  CONSTANT
        40                                                  000505  5C61                  CONSTANT
0003BD  E6C1C9E340404040      CONSTANT                      000507  7D                    CONSTANT
        40                                                  000508  0C16000000000A4C      STATIC ONCB
0003C6  E6C8C5D540404040      CONSTANT                      000510  0C96000000000000      STATIC ONCB
        40                                                  000518  C1C2C3C4C5C6C7C8      INITIAL VALUE..WORD_FIRST_CHAR
0003CF  E6D9C9E3C5404040      CONSTANT                              C9D1D2D3D4D5D6D7
        40                                                          D8D9E2E3E4E5E6E7
0003D8  405C5C5C5C5C5C5C      CONSTANT                              E8E97C7B5B
        5C5C5C5C5C5C5C5C                                    000535  C1C2C3C4C5C6C7C8      INITIAL VALUE..WORD_NEXT_CHARA
        5C5C5C5C5C5C5C5C                                            C9D1D2D3D4D5D6D7
        40                                                          D8D9E2E3E4E5E6E7
0003F1  405C5C5C40E69699      CONSTANT                              E8E96D7C7B5B
        8460A4A28540D985                                    000558  00000000              SYMBOL TABLE ELEMENT
        979699A3405C5C5C                                    00055C  00000000              CONSTANT
        40                                                  000560  00000000              SYMBOL TABLE ELEMENT
00040A  40608396A495A360      CONSTANT                      000564  00000604              SYMBOL TABLE ELEMENT
        4040406060A69699                                    000568  00000624              SYMBOL TABLE ELEMENT
        84606040                                            00056C  00000648              SYMBOL TABLE ELEMENT
00041E  6060606060606060      CONSTANT                      000570  00000664              SYMBOL TABLE ELEMENT
        60606060                                            000574  80000000              SYMBOL TABLE ELEMENT
00042A  E3888540979985A5      CONSTANT                      000578  00000680              SYMBOL TABLE ELEMENT
        8996A4A240A58193                                    00057C  0000069C              SYMBOL TABLE ELEMENT
        A48540A28896A493                                    000580  000006B4              SYMBOL TABLE ELEMENT
        84408881A5854082                                    000584  000006DC              SYMBOL TABLE ELEMENT
        858595                                              000588  00000704              SYMBOL TABLE ELEMENT
00044D  E38885998540A685      CONSTANT                      00058C  0000071C              SYMBOL TABLE ELEMENT
        998540                                              000590  00000734              SYMBOL TABLE ELEMENT
000458  4099858685998595      CONSTANT                      000594  00000754              SYMBOL TABLE ELEMENT
        8385A240A39640                                      000598  00000774              SYMBOL TABLE ELEMENT
000467  404040F3F6            CONSTANT                      00059C  0000079C              SYMBOL TABLE ELEMENT
00046C  40A6969984A24B        CONSTANT                      0005A0  000007BC              SYMBOL TABLE ELEMENT
000473  E38885998540A681      CONSTANT                      0005A4  000007DC              SYMBOL TABLE ELEMENT
        A24081408489A283                                    0005A8  000008D0              SYMBOL TABLE ELEMENT
        998597819583A840                                    0005AC  000008EC              SYMBOL TABLE ELEMENT
        89954081A3409385                                    0005B0  00000000              SYMBOL TABLE ELEMENT
        81A2A34096958540                                    0005B4  00000000              SYMBOL TABLE ELEMENT
        968640A3888540A6                                    0005B8  00000000              CONSTANT
        969984608396A495                                    0005BC  00000558              SYMBOL TABLE ELEMENT
        A3A24B                                              0005C0  00000000              CONSTANT
0004AE  E3888540899597A4      CONSTANT                      0005C4  00000564              SYMBOL TABLE ELEMENT
        A3408481A38140A2                                    0005C8  00000000              CONSTANT
        85A3408881A24095                                    0005CC  00000564              SYMBOL TABLE ELEMENT
```

```
0005D0  00000000              CONSTANT                              0004E3D9E4C50000
0005D4  00000564              SYMBOL TABLE ELEMENT          000734  85000001000000BE      SYMBOL TABLE..RIGHT_MARGIN
0005D8  000007F4              SYMBOL TABLE ELEMENT                  0000011A00000000
0005DC  00000814              SYMBOL TABLE ELEMENT                  000CD9C9C7C8E36D
0005E0  00000838              SYMBOL TABLE ELEMENT                  D4C1D9C7C9D50000
0005E4  00000858              SYMBOL TABLE ELEMENT          000754  85000001000000BE      SYMBOL TABLE..LEFT_MARGIN
0005E8  00000874              SYMBOL TABLE ELEMENT                  0000011C00000000
0005EC  00000000              CONSTANT                              000BD3C5C6E36DD4
0005F0  00000564              SYMBOL TABLE ELEMENT                  C1D9C7C9D5000000
0005F4  00000894              SYMBOL TABLE ELEMENT          000774  81000001000000DA      SYMBOL TABLE..DISCREPANCY_OCCU
0005F8  000008B4              SYMBOL TABLE ELEMENT                  000000F800000000
0005FC  00000000              CONSTANT                              0014C4C9E2C3D9C5
000600  00000564              SYMBOL TABLE ELEMENT                  D7C1D5C3E86DD6C3
000604  81000101000000BE      SYMBOL TABLE..CONTROLLED_SET          C3E4D9D9C5C40000
        000000C000000000                                    00079C  85000001000000BE      SYMBOL TABLE..LAST_CHAR_POSN
        000EC3D6D5E3D9D6                                            0000011E00000000
        D3D3C5C46DE2C5E3                                            000ED3C1E2E36DC3
000624  81000101000000BE      SYMBOL TABLE..WORD_INDEX_TABLE        C8C1D96DD7D6E2D5
        000000C800000000                                    0007BC  81000001000000DA      SYMBOL TABLE..RECORD_READ
        0010E6D6D9C46DC9                                            0000010000000000
        D5C4C5E76DE3C1C2                                            000BD9C5C3D6D9C4
        D3C50000                                                    6DD9C5C1C4000000
000648  81000101000000BE      SYMBOL TABLE..WORD_COUNT      0007DC  81000001000000D8      SYMBOL TABLE..RECORD
        000000D000000000                                            0000010800000000
        000AE6D6D9C46DC3                                            0006D9C5C3D6D9C4
        D6E4D5E3                                            0007F4  85000002000000BE      SYMBOL TABLE..NEXT_CHAR_POSN
000664  81000101000000BC      SYMBOL TABLE..WORD_TABLE              000000D000000000
        000000D800000000                                            000ED5C5E7E36DC3
        000AE6D6D9C46DE3                                            C8C1D96DD7D6E2D5
        C1C2D3C5                                            000814  85000002000000BE      SYMBOL TABLE..LENGTH_OF_STRING
000680  85000001000000BE      SYMBOL TABLE..WORD_INDEX              000000D200000000
        0000011800000000                                            0010D3C5D5C7E3C8
        000AE6D6D9C46DC9                                            6DD6C66DE2E3D9C9
        D5C4C5E7                                                    D5C70000
00069C  81000001000000D8      SYMBOL TABLE..WORD            000838  81000002000000BC      SYMBOL TABLE..NEXT_CHARACTER
        000000E000000000                                            000000B800000000
        0004E6D6D9C40000                                            000ED5C5E7E36DC3
0006B4  01000000000000BC      SYMBOL TABLE..WORD_NEXT_CHARAC        C8C1D9C1C3E3C5D9
        0000014000000000                                    000858  81000002000000D8      SYMBOL TABLE..DATA_WORD
        0014E6D6D9C46DD5                                            000000C000000000
        C5E7E36DC3C8C1D9                                            0009C4C1E3C16DE6
        C1C3E3C5D9E20000                                            D6D9C400
0006DC  01000000000000BC      SYMBOL TABLE..WORD_FIRST_CHARA000874  A1000002000000D8      SYMBOL TABLE..DATA_RECORD
        0000014800000000                                            0000010000000000
        0015E6D6D9C46DC6                                            000BC4C1E3C16DD9
        C9D9E2E36DC3C8C1                                            C5C3D6D9C4000000
        D9C1C3E3C5D9E200                                    000894  85000002000000BE      SYMBOL TABLE..WORD_NUMBER
000704  81000001000000DA      SYMBOL TABLE..FALSE                   000000C000000000
        000000E800000000                                            000BE6D6D9C46DD5
        0005C6C1D3E2C500                                            E4D4C2C5D9000000
00071C  81000001000000DA      SYMBOL TABLE..TRUE            0008B4  A1000002000000D8      SYMBOL TABLE..DATA_WORD
        000000F000000000                                            000000D000000000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 40
        0009C4C1E3C16DE6
        D6D9C400                                    000000  1D02000000000018      SYMBOL TABLE..SAMPLE
0008D0  0D020001000000B8      SYMBOL TABLE..NEXT_WORD               0000000000000000
        00000B8800000000                                            0006E2C1D4D7D3C5
        0009D5C5E7E36DE6                            000018  B4000A00              SYMTAB DED..SAMPLE
        D6D9C400
0008EC  0D020001000000B8      SYMBOL TABLE..LOOKUP_WORD     000000  1D00000100000018      SYMBOL TABLE..SOURCE
        00000FA800000000                                            0000000000000000
        000BD3D6D6D2E4D7                                            0006E2D6E4D9C3C5
        6DE6D6D9C4000000                            000018  B800                  SYMTAB DED..SOURCE

                                                            000000  1D0000010000001C      SYMBOL TABLE..SYSPRINT
                                                                    0000000000000000
                                                                    0008E2E8E2D7D9C9
                          STATIC EXTERNAL CSECTS                    D5E30000
                                                            00001C  B800                  SYMTAB DED..SYSPRINT


000000  FFFFFFFC41000000      DCLCB
        02C70F0000000000
        000000140008E2E8
        E2D7D9C9D5E30000


000000  0000000002000000      DCLCB
        0100100000000000
        000000140006E2D6
        E4D9C3C5


000000  0011D4E2C7C6C9D3      CSECT FOR EXTERNAL VARIABLE
        C54DE2E8E2D7D9C9
        D5E35D0000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        000000000000

000000  2800                  SYMTAB DED..PLIXOPT
000002  0000
000004  1900000000000000      SYMBOL TABLE..PLIXOPT
        0000002400000000
        0007D7D3C9E7D6D7
        E3000000
000020  80000004              SYMBOL TABLE ELEMENT
000024  0000000000648000      LOCATOR..PLIXOPT
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 41
                                  VARIABLE STORAGE MAP
IDENTIFIER                        LEVEL         OFFSET       (HEX)   CLASS     BLOCK

CONTROLLED_SET                        1            296         128   AUTO      SAMPLE
WORD_INDEX_TABLE                      1            368         170   AUTO      SAMPLE
WORD_COUNT                            1            420         1A4   AUTO      SAMPLE
WORD_TABLE                            1            650         28A   AUTO      SAMPLE
WORD_INDEX                            1            280         118   AUTO      SAMPLE
WORD                                  1            492         1EC   AUTO      SAMPLE
WORD_NEXT_CHARACTERS                  1           1333         535   STATIC    SAMPLE
WORD_FIRST_CHARACTERS                 1           1304         518   STATIC    SAMPLE
FALSE                                 1            288         120   AUTO      SAMPLE
TRUE                                  1            289         121   AUTO      SAMPLE
RIGHT_MARGIN                          1            282         11A   AUTO      SAMPLE
LEFT_MARGIN                           1            284         11C   AUTO      SAMPLE
DISCREPANCY_OCCURRED                  1            290         122   AUTO      SAMPLE
LAST_CHAR_POSN                        1            286         11E   AUTO      SAMPLE
RECORD_READ                           1            291         123   AUTO      SAMPLE
RECORD                                1            526         20E   AUTO      SAMPLE
NEXT_CHAR_POSN                        2            208          D0   AUTO      NEXT_WORD
LENGTH_OF_STRING                      2            210          D2   AUTO      NEXT_WORD
NEXT_CHARACTER                        2            212          D4   AUTO      NEXT_WORD
DATA_WORD                             2            216          D8   AUTO      NEXT_WORD
WORD_NUMBER                           2            192          C0   AUTO      LOOKUP_WORD
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 42
              TABLES OF OFFSETS AND STATEMENT NUMBERS

              WITHIN PROCEDURE SAMPLE
OFFSET (HEX)        0    348    358    368    370    37E    388    39E    3AE    3BA    410    432    462    48A    492
STATEMENT NO.       1     22     26     29     34     35     36     37     38     39     40     41     42     43     44
OFFSET (HEX)      4E8    4F0    506    50E    51C    55C    59C    5DC    61C    62E    63A    642    6DA    6E2    6FA
STATEMENT NO.      45     46     47     48     49     50     51     52     53     54     53     54     55     56     57
OFFSET (HEX)      78A    794    79C    7A4    7A8    7B4    7CC    7CC    86E    8D2    8DA
STATEMENT NO.      58     59     60     61     54     61     53     62     63     64    104
              WITHIN ON UNIT BLOCK 2
OFFSET (HEX)        0     76     84     92
STATEMENT NO.      22     23     24     25
              WITHIN ON UNIT BLOCK 3
OFFSET (HEX)        0     80     8A
STATEMENT NO.      26     27     28
              WITHIN ON UNIT BLOCK 4
OFFSET (HEX)        0     90     98    10A    118
STATEMENT NO.      29     30     31     32     33
              WITHIN PROCEDURE NEXT_WORD
OFFSET (HEX)        0     BC     C8    100    11A    124    134    1C0    1C8    1D0    24C    254    292    29A    2AC
STATEMENT NO.      65     71     72     73     74     75     76     77     78     79     80     81     82     83     84
OFFSET (HEX)      328    386    38A    38E    3A4    3B8    3BC    3C0    3C0    3C4    3DC    414
STATEMENT NO.      85     86     84     86     87     88     89     90     90     91     92     93
              WITHIN PROCEDURE LOOKUP_WORD
OFFSET (HEX)        0     98     DA     E2    132    13A    13E    146    148    15E    176    182    184    18C    190
STATEMENT NO.      94     97     98     99    100    101     98    101     98    101     98    101     98    101    102
OFFSET (HEX)      1B4
STATEMENT NO.     103
```

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 43
  OBJECT LISTING
```

```
       1
* STATEMENT NUMBER  40                              2
000418  44 00 C 1AC                3  EX    0,HOOK..STMT
00041C                    CL.48       EQU   *
00041C  48 90 3 0E0                   LH    9,224(0,3)
000420  48 70 D 1EC                   LH    7,WORD
000424  41 80 3 294                   LA    8,660(0,3)
000428  41 60 D 1EE                   LA    6,WORD+2
00042C  58 F0 3 06C                   L     15,A..IELCGCY
000430  05 EF                         BALR  14,15
000432  47 80 2 1AC                   BE    CL.15
000436  44 00 C 1C8                   EX    0,HOOK..DO


* STATEMENT NUMBER  41
00043A  44 00 C 1AC                   EX    0,HOOK..STMT
00043E  41 70 D 0E0                   LA    7,224(0,13)
000442  50 70 3 248                   ST    7,584(0,3)
000446  41 70 D 118                   LA    7,WORD_INDEX
00044A  50 70 3 24C                   ST    7,588(0,3)
00044E  96 80 3 24C                   OI    588(3),X'80'
000452  18 5D                         LR    5,13
000454  41 10 3 248                   LA    1,584(0,3)
000458  58 F0 3 038                   L     15,A..LOOKUP_WORD
00045C  44 00 C 1C0                3  EX    0,HOOK..PRE-CALL
000460  47 01 4 00A                   NOP   HOOK..INFO
000464  05 EF                         BALR  14,15
000466  44 00 C 1C4                3  EX    0,HOOK..POST-CALL


* STATEMENT NUMBER  42
00046A  44 00 C 1AC                   EX    0,HOOK..STMT
00046E  48 90 D 118                   LH    9,WORD_INDEX
000472  49 90 3 0E0                   CH    9,224(0,3)
000476  47 80 2 146                   BE    CL.16
00047A  44 00 C 1CC                   EX    0,HOOK..IF-TRUE
00047E  89 90 0 001                   SLL   9,1
000482  48 69 D 1A2                   LH    6,VO..WORD_COUNT(9
                                            )
000486  4A 60 3 0E2                   AH    6,226(0,3)
00048A  40 69 D 1A2                   STH   6,VO..WORD_COUNT(9
                                            )
00048E  47 F0 2 14E                   B     CL.17


* STATEMENT NUMBER  43
000492                    CL.16       EQU   *
000492  44 00 C 1AC                   EX    0,HOOK..STMT
000496  44 00 C 1D0                   EX    0,HOOK..IF-FALSE
```

```
* STATEMENT NUMBER  44
00049A             CL.17   EQU   *
00049A  44 00 C 1AC                    EX    0,HOOK..STMT
00049E  41 70 D 108      LA    7,264(0,13)
0004A2  50 70 3 240               ST    7,576(0,3)
0004A6  D2 07 D 484 3 138         MVC   1156(8,13),312(3)
0004AC  41 80 D 462               LA    8,1122(0,13)
0004B0  50 80 D 484               ST    8,1156(0,13)
0004B4  41 70 D 484               LA    7,1156(0,13)
0004B8  50 70 3 244               ST    7,580(0,3)
0004BC  96 80 3 244               OI    580(3),X'80'
0004C0  18 5D                     LR    5,13
0004C2  41 10 3 240               LA    1,576(0,3)
0004C6  58 F0 3 02C               L     15,A..NEXT_WORD
0004CA  44 00 C 1C0               EX    0,HOOK..PRE-CALL
0004CE  47 01 4 00A               NOP   HOOK..INFO
0004D2  05 EF                     BALR  14,15
0004D4  44 00 C 1C4               EX    0,HOOK..POST-CALL
0004D8  D2 00 D 1EC D 462         MVC   WORD(1),1122(13)
0004DE  48 F0 D 462               LH    15,1122(0,13)
0004E2  44 F0 2 19E               EX    15,CL.72
0004E6  47 F0 2 1A4               B     CL.73
0004EA                    CL.72   EQU   *
0004EA  D2 00 D 1ED D 463         MVC   WORD+1(1),1123(13)
0004F0                    CL.73   EQU   *


* STATEMENT NUMBER  45
0004F0  44 00 C 1AC     EX    0,HOOK..STMT
0004F4  47 F0 2 0D0               B     CL.48
0004F8                    CL.15   EQU   *
```

Object listing. This is a partial listing of the machine instructions generated by the compiler from the PL/I source program.

1 Machine instructions (in hexadecimal)

2 Assembler-language form of the machine instruction

3 HOOK indicates a location where the debugging tool could get control.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 44
COMPILER DIAGNOSTIC MESSAGES

  1      2     3
ERROR ID L   STMT    MESSAGE DESCRIPTION

COMPILER INFORMATORY MESSAGES

IEL0533I I           NO 'DECLARE' STATEMENT(S) FOR 'INDEX'.
IEL0871I I   62      RESULT OF BUILTIN FUNCTION 'SUM' WILL BE EVALUATED USING FIXED POINT ARITHMETIC OPERATIONS.

END OF COMPILER DIAGNOSTIC MESSAGES

   4                                    5
COMPILE TIME    0.01 MINS        SPILL FILE:     0 RECORDS, SIZE  4051
END OF COMPILATION OF SAMPLE
```

Diagnostic messages and an end-of-compile-step message generated by the compiler. All diagnostic messages generated by the compiler are documented in the publication *PL/I MVS & VM Compile-Time Messages and Codes.*

1 ERROR ID identifies the message as originating from the PL/I compiler (IEL), and gives the message number.

2 L indicates the severity level of the message.

3 STMT gives the number of the statement in which the error occurred.

4 Compile time in minutes. This time includes the preprocessor.

5 Number of records “spilled” into auxiliary storage and the size in bytes of the spill file records.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 45

 MVS/DFP VERSION 3 RELEASE 3 LINKAGE EDITOR     10:03:27  FRI  JAN 29, 1993
 JOB IEL11IVP   STEP IVP        PROCEDURE LKED
 INVOCATION PARAMETERS - XREF,LIST  1
 ACTUAL SIZE=(317440,79872)
 OUTPUT DATA SET SYS93029.T100323.RA000.IEL11IVP.GOSET IS ON VOLUME PUB002

                                          2        CROSS REFERENCE TABLE
     3
  CONTROL SECTION                       ENTRY
    NAME    ORIGIN  LENGTH                NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
  CEESTART      00      80
  CEEMAIN       80      10
  SYSPINT       90      20
  SOURCE        B0      1C
  CEEUOPT       D0     4D0
  PLIXOPT      5A0      66
  PLIXOPT*     608      2C
                                        PLIXOPT+     60C    PLIXOPT-     628
  SAMPLE*      638      20
                                        SAMPLE+      638
  SOURCE*      658      20
                                        SOURCE+      658
  SYSPINT*     678      20
                                        SYSPINT+     678
```

Linkage editor listing.

1 Statement identifying the version and level of the linkage editor and giving the options as specified in the PARM parameter of the EXEC statement that invokes the linkage editor

2 Cross reference table, consisting of a module map and the cross reference table

3 The module map shows each control section and its associated entry points, if any, listed across the page. An asterisk in column 9 after a name beginning with “IBM” indicates a library subroutine obtained by automatic library call.

4 The cross reference table gives all the locations in a control section at which a symbol is reference. UNRESOLVED(W) identifies a weak external reference that has not been resolved.

```
  *SAMPLE2     698     B40
  IELCGOG     11D8      AE
  IELCGOH     1288      A0
  IELCGOC     1328      7C
  IELCGMY     13A8      A4
  IELCGCY     1450      7E
  *SAMPLE1    14D0    115C
                                        SAMPLE      14D8
  CEEBETBL*   2630      1C
  CEEOPIPI*   2650     208
  CEEROOTA*   2858     268
  CEESG010*   2AC0      64
  IBMRINP1*   2B28      24
  IBMSASCA*   2B50      14
                                        IBMBASCA    2B50
  IBMSCEDB*   2B68      14
                                        IBMBCEDB    2B68
  IBMSCHFD*   2B80      14
                                        IBMBCHFD    2B80
  IBMSEATA*   2B98      14
```

```
                                      IBMBEATA    2B98
IBMSSIOA*   2BB0      14
                                      IBMBSIOA    2BB0
IBMSCHXH*   2BC8      14
                                      IBMBCHXH    2BC8
IBMSCWDH*   2BE0      14
                                      IBMBCWDH    2BE0

  NAME    ORIGIN  LENGTH                NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
IBMSEOCA*   2BF8      14
                                      IBMBEOCA    2BF8
IBMSJDSA*   2C10      14
                                      IBMBJDSA    2C10
IBMSOCLA*   2C28      14
                                      IBMBOCLA    2C28
IBMSRIOA*   2C40      14
                                      IBMBRIOA    2C40

IBMSSEOA*   2C58      14
                                      IBMBSEOA    2C58
IBMSSIOE*   2C70      14
                                      IBMBSIOE    2C70
IBMSSIOT*   2C88      14
                                      IBMBSIOT    2C88
IBMSSLOA*   2CA0      14
                                      IBMBSLOA    2CA0
CEEARLU *   2CB8     140
CEEBINT *   2DF8       8
CEEBLLST*   2E00      5C
                                      CEELLIST    2E10
CEEBTRM *   2E60     180
CEEP#CAL*   2FE0     120
CEEP#INT*   3100     340
CEEP#TRM*   3440     210
IBMSOCLC*   3650      14
                                      IBMBOCLC    3650

IBMSSPLA*   3668      14
                                      IBMBSPLA    3668
IBMSSXCA*   3680      14
                                      IBMBSXCA    3680
CEEBPIRA*   3698     2E0
                                      CEEINT      3698    CEEBPIRB    3698    CEEBPIRC    3698
IBMSCEDF*   3978      14
                                      IBMBCEDF    3978
IBMSCEDX*   3990      14
                                      IBMBCEDX    3990
IBMSCEFX*   39A8      14
                                      IBMBCEFX    39A8
IBMSCEZB*   39C0      14
                                      IBMBCEZB    39C0
IBMSCEZF*   39D8      14
                                      IBMBCEZF    39D8
IBMSCEZX*   39F0      14
                                      IBMBCEZX    39F0
IBMSCHFE*   3A08      14
                                      IBMBCHFE    3A08
CEEPMATH*   3A20      18
                                      IBMSMATH    3A20
IBMSSXCB*   3A38      14
                                      IBMBSXCB    3A38
IBMSCHFH*   3A50      14
                                      IBMBCHFH    3A50
  NAME    ORIGIN  LENGTH             NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
IBMSCHFP*   3A68      14
                                   IBMBCHFP    3A68
IBMSCHFY*   3A80      14
                                   IBMBCHFY    3A80
IBMSCHXD*   3A98      14
                                   IBMBCHXD    3A98
IBMSCHXE*   3AB0      14
                                   IBMBCHXE    3AB0
IBMSCHXF*   3AC8      14
                                   IBMBCHXF    3AC8
IBMSCHXP*   3AE0      14
                                   IBMBCHXP    3AE0
IBMSCHXY*   3AF8      14
                                   IBMBCHXY    3AF8
IBMSSIOB*   3B10      14
                                   IBMBSIOB    3B10
IBMSSIOC*   3B28      14
                                   IBMBSIOC    3B28
IBMSCWZH*   3B40      14
                                   IBMBCWZH    3B40
IBMSJDSB*   3B58      14
                                   IBMBJDSB    3B58
IBMSOCLB*   3B70      14
                                   IBMBOCLB    3B70
IBMSOCLD*   3B88      14
                                   IBMBOCLD    3B88
IBMSRIOB*   3BA0      14
                                   IBMBRIOB    3BA0
IBMSRIOC*   3BB8      14
                                   IBMBRIOC    3BB8
IBMSRIOD*   3BD0      14
                                   IBMBRIOD    3BD0
IBMSSIOD*   3BE8      14
                                   IBMBSIOD    3BE8
IBMSSLOB*   3C00      14
                                   IBMBSLOB    3C00
IBMSSPLB*   3C18      14
                                   IBMBSPLB    3C18
IBMSSPLC*   3C30      14
                                   IBMBSPLC    3C30
IBMSSXCC*   3C48      14
                                   IBMBSXCC    3C48
IBMSSXCD*   3C60      14
                                   IBMBSXCD    3C60

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION            LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
     2C            CEEMAIN         CEEMAIN                       68            CEEFMAIN  4  $UNRESOLVED(W)
     74            CEEBETBL        CEEBETBL                      78            CEEROOTA        CEEROOTA
     84            *SAMPLE1        *SAMPLE1                      88            IBMRINP1        IBMRINP1
    62C            PLIXOPT         PLIXOPT                      640            SAMPLE          *SAMPLE1

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION            LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
    660            SOURCE          SOURCE                       680            SYSPINT         SYSPINT
    69C            *SAMPLE1        *SAMPLE1                     6A0            *SAMPLE1        *SAMPLE1
    6A4            *SAMPLE1        *SAMPLE1                     6A8            *SAMPLE1        *SAMPLE1
    6AC            *SAMPLE1        *SAMPLE1                     6B0            *SAMPLE1        *SAMPLE1
    6B4            *SAMPLE1        *SAMPLE1                     6B8            *SAMPLE1        *SAMPLE1
    6BC            *SAMPLE1        *SAMPLE1                     6C0            *SAMPLE1        *SAMPLE1
    6C4            *SAMPLE1        *SAMPLE1                     6C8            *SAMPLE1        *SAMPLE1
    6CC            *SAMPLE1        *SAMPLE1                     6D0            *SAMPLE1        *SAMPLE1
    6D4            *SAMPLE1        *SAMPLE1                     6D8            *SAMPLE1        *SAMPLE1
    6DC            *SAMPLE1        *SAMPLE1                     6E0            *SAMPLE1        *SAMPLE1
    6E4            *SAMPLE1        *SAMPLE1                     6E8            *SAMPLE1        *SAMPLE1
    6EC            *SAMPLE1        *SAMPLE1                     6F0            *SAMPLE1        *SAMPLE1
    6F4            IELCGOG         IELCGOG                      6F8            IELCGOH         IELCGOH
    6FC            IELCGOC         IELCGOC                      700            IELCGMY         IELCGMY
    704            IELCGCY         IELCGCY                      708            IBMSASCA        IBMSASCA
    70C            IBMSCEDB        IBMSCEDB                     710            IBMSCHFD        IBMSCHFD
    714            IBMSCHXH        IBMSCHXH                     718            IBMSCWDH        IBMSCWDH
    71C            IBMSEOCA        IBMSEOCA                     720            IBMSJDSA        IBMSJDSA
    724            IBMSOCLA        IBMSOCLA                     728            IBMSOCLC        IBMSOCLC
    72C            IBMSRIOA        IBMSRIOA                     730            IBMSSEOA        IBMSSEOA
    734            IBMSSIOE        IBMSSIOE                     738            IBMSSIOT        IBMSSIOT
    73C            IBMSSLOA        IBMSSLOA                     740            IBMSSPLA        IBMSSPLA
    744            IBMSSXCA        IBMSSXCA                     748            IBMSSXCB        IBMSSXCB
    89C            PLIXOPT         PLIXOPT                      8A0            SYSPINT         SYSPINT
    8A4            SOURCE          SOURCE                       8AC            SOURCE          SOURCE
    8C0            SOURCE          SOURCE                       8EC            SOURCE          SOURCE
    8F4            SYSPINT         SYSPINT                      900            SYSPINT         SYSPINT
    BA4            *SAMPLE1        *SAMPLE1                     BF0            SAMPLE*         SAMPLE*
    C0C            PLIXOPT-        PLIXOPT*                     C48            SOURCE*         SOURCE*
    C4C            SYSPINT*        SYSPINT*                     F70            *SAMPLE1        *SAMPLE1
    F8C            *SAMPLE1        *SAMPLE1                     FA8            *SAMPLE1        *SAMPLE1
   106C            *SAMPLE1        *SAMPLE1                    108C            *SAMPLE1        *SAMPLE1
   10A8            *SAMPLE1        *SAMPLE1                    10CC            *SAMPLE1        *SAMPLE1
   1164            *SAMPLE1        *SAMPLE1                    11D4            CEESTART        CEESTART
   1320            IBMSSIST       $UNRESOLVED(W)               1324            IBMSSEOA        IBMSSEOA
   139C            IBMSSXCB        IBMSSXCB                    13A0            IBMSSIST       $UNRESOLVED(W)
   14E0            *SAMPLE2        *SAMPLE2                    14E8            *SAMPLE2        *SAMPLE2
   14EC            *SAMPLE2        *SAMPLE2                    1510            *SAMPLE2        *SAMPLE2
   1DD4            *SAMPLE2        *SAMPLE2                    1DDC            *SAMPLE2        *SAMPLE2
   1DE0            *SAMPLE2        *SAMPLE2                    1E80            *SAMPLE2        *SAMPLE2
   1E88            *SAMPLE2        *SAMPLE2                    1E8C            *SAMPLE2        *SAMPLE2
   1F24            *SAMPLE2        *SAMPLE2                    1F2C            *SAMPLE2        *SAMPLE2
   1F30            *SAMPLE2        *SAMPLE2                    2060            *SAMPLE2        *SAMPLE2
   2068            *SAMPLE2        *SAMPLE2                    206C            *SAMPLE2        *SAMPLE2
   2480            *SAMPLE2        *SAMPLE2                    2488            *SAMPLE2        *SAMPLE2
   248C            *SAMPLE2        *SAMPLE2                    2640            CEEUOPT         CEEUOPT
   2634            CEEBXITA       $UNRESOLVED(W)               2638            CEEBINT         CEEBINT
   263C            CEEBLLST        CEEBLLST                    2644            CEEBTRM         CEEBTRM
   26F4            CEEP#INT        CEEP#INT                    275C            CEEP#INT        CEEP#INT
   2798            CEEP#INT        CEEP#INT                    2740            CEEP#CAL        CEEP#CAL
   276C            CEEP#CAL        CEEP#CAL                    277C            CEEP#TRM        CEEP#TRM
   27F4            CEEP#TRM        CEEP#TRM                    29F8            CEEARLU         CEEARLU

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION             LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
   2A04            CEEINT          CEEBPIRA                    29E8            CEEFMAIN       $UNRESOLVED(W)
   29EC            CEEMAIN         CEEMAIN                     29F0            PLIMAIN        $UNRESOLVED(W)
   29F4            IBMSEMNA       $UNRESOLVED(W)               29FC            CEESG010        CEESG010
   2A00            CEEOPIPI        CEEOPIPI                    2A08            CEEROOTB       $UNRESOLVED(W)
   2B1C            CEEBETBL        CEEBETBL                    2B20            IBMSMATH        CEEPMATH
   2AD4            CEEMAIN         CEEMAIN                     2B10            CEEFMAIN       $UNRESOLVED(W)
   2B0C            PLISTART       $UNRESOLVED(W)               2AF4            PLIXOPT         PLIXOPT
   2AF8            IBMBPOPT       $UNRESOLVED(W)               2AD8            SYSPINT         SYSPINT
   2AE0            PLITABS        $UNRESOLVED(W)               2B00            IBMBEATA        IBMSEATA
   2AD0            PLIMAIN        $UNRESOLVED(W)               2B38            CEESTART        CEESTART
   2B3C            CEEBETBL        CEEBETBL                    2B28            CEEMAIN         CEEMAIN
   2B34            CEEMAIN         CEEMAIN                     2E10            CEESG000       $UNRESOLVED(W)
   2E14            CEESG001       $UNRESOLVED(W)               2E18            CEESG002       $UNRESOLVED(W)
   2E1C            CEESG003       $UNRESOLVED(W)               2E20            CEESG004       $UNRESOLVED(W)
   2E24            CEESG005       $UNRESOLVED(W)               2E28            CEESG006       $UNRESOLVED(W)
   2E2C            CEESG007       $UNRESOLVED(W)               2E30            CEESG008       $UNRESOLVED(W)
   2E34            CEESG009       $UNRESOLVED(W)               2E38            CEESG010        CEESG010
   2E3C            CEESG011       $UNRESOLVED(W)               2E40            CEESG012       $UNRESOLVED(W)
   2E44            CEESG013       $UNRESOLVED(W)               2E48            CEESG014       $UNRESOLVED(W)
   2E4C            CEESG015       $UNRESOLVED(W)               2E50            CEESG016       $UNRESOLVED(W)
```

```
  LOCATION     3C REQUESTS CUMULATIVE PSEUDO REGISTER LENGTH
 PSEUDO REGISTERS
    NAME    ORIGIN  LENGTH        NAME    ORIGIN  LENGTH        NAME    ORIGIN  LENGTH        NAME    ORIGIN  LENGTH
  SOURCE       00      4
 TOTAL LENGTH OF PSEUDO REGISTERS       4
 ENTRY ADDRESS       00
 TOTAL LENGTH      3C78
 ** GO       DID NOT PREVIOUSLY EXIST BUT WAS ADDED AND HAS AMODE 31
 ** LOAD MODULE HAS RMODE ANY
 ** AUTHORIZATION CODE IS         0.

 ***********************
 *** Word-use Report ***  1
 ***********************
 -count-   --word--
     3      BEGIN
     1      CLOSE
    13      DCL
    24      DECLARE
     2      DISPLAY
    14      DO
    13      ELSE
    23      END
     1      GO
    13      IF
------------The previous value should have been    14  2
     7      LIST
     4      ON
     1      OPEN
     2      PROC
     3      PROCEDURE
     2      READ
     4      RETURN
     1      SELECT
     2      STOP
    13      THEN
     2      WHEN
There were           148 references to    36 words.
There was a discrepancy in at least one of the word-counts.  2
```

Sample program output.

1 Program output header

2 The apparent error is intentional

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation       */PAGE 29

 1          3                                ATTRIBUTE AND CROSS-REFERENCE TABLE (SHORT)
DCL NO.     IDENTIFIER                    ATTRIBUTES AND REFERENCES

21          CONTROLLED_SET              4 (36) AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)

                                        5 320000,320000,320000,320000,320000,320000,320000,320000,320000,320000,
                                          320000,320000,320000,320000,320000,320000,320000,320000,320000,320000,
                                          320000,320000,320000,320000,320000,320000,320000,320000,320000,320000,
                                          320000,320000,320000,320000,320000,320000,3380000,3400000

66          DATA_RECORD                   /* PARAMETER */ UNALIGNED CHARACTER(*) VARYING
                                          4110000,4200000,4200000,4260000,4670000,4700000
95          DATA_WORD                     /* PARAMETER */ UNALIGNED CHARACTER(*) VARYING
                                          5050000,5130000,5220000
67          DATA_WORD                     AUTOMATIC UNALIGNED CHARACTER (31) VARYING
                                          4080000,4090000,4580000,4700000,4700000,4790000
6           DISCREPANCY_OCCURRED          AUTOMATIC UNALIGNED INITIAL BIT (1)
                                          320000,3440000,3610000
10          FALSE                         AUTOMATIC UNALIGNED INITIAL BIT (1)
                                          320000,320000,320000,2430000
16          HIGH                          BUILTIN
   2                                      1040000
********    INDEX                         BUILTIN
                                          4200000,4260000,4500000,4670000,5050000
5           LAST_CHAR_POSN                AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                          2770000,4090000,4730000
7           LEFT_MARGIN                   AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                          320000,2770000
94          LOOKUP_WORD                   ENTRY RETURNS(BINARY FIXED (15,0))
                                          2860000
70          NEXT_CHAR_POSN                AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                          4090000,4090000,4110000,4200000,4200000,4200000,4200000,4260000,42600  00,
                                          4260000,4670000,4670000,4670000,4670000,4700000,4730000
68          NEXT_CHARACTER                AUTOMATIC UNALIGNED CHARACTER (1)
                                          4110000,4120000,4500000,4580000
65          NEXT_WORD                     ENTRY RETURNS(CHARACTER (31) VARYING )
                                          2790000,2950000
```

Attribute and cross-reference table

1 Number of the statement in the source listing in which the identifier is explicitly declared.

2 Asterisks indicate an undeclared identifier: all of its attributes are implied or supplied by default.

3 All identifiers used in the program are listed in ascending order according to their binary value.

4 Declared and default attributes are listed. This list also includes descriptive comments.

5 Cross references: these are the numbers of all other statements in which the identifier appears.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 30
DCL NO.    IDENTIFIER                     ATTRIBUTES AND REFERENCES
17         ONCODE                         BUILTIN
                                          31
3          RECORD                         AUTOMATIC UNALIGNED CHARACTER (121) VARYING
                                          36,39,44,46
4          RECORD_READ                    AUTOMATIC UNALIGNED INITIAL BIT (1)
                                          1,35,37
                                          27
8          RIGHT_MARGIN                   AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                          1,72,84
2          SOURCE                         EXTERNAL FILE RECORD
                                          22,26,34,36,46,48
16         SUBSTR                         BUILTIN
                                          73,76,76,79,84,85,97
16         SUM                            BUILTIN
                                          62
15         SYSPRINT                       EXTERNAL FILE STREAM
                                          49,50,51,52,54,57,62,63
9          TRUE                           AUTOMATIC UNALIGNED INITIAL BIT (1)
                                          1,35,58
13         WORD                           AUTOMATIC UNALIGNED CHARACTER (31) VARYING
                                          39,40,41,44
19         WORD_COUNT                     (36) AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                          1,42,42,54,54,56,62
11         WORD_FIRST_CHARACTERS          STATIC UNALIGNED INITIAL CHARACTER (29)
                                          81,97
14         WORD_INDEX                     AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                          41,42,42,42,53,53,54,54,54,56,56,57
20         WORD_INDEX_TABLE               (26) AUTOMATIC ALIGNED INITIAL BINARY FIXED (15,0)
                                          1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,97
12         WORD_NEXT_CHARACTERS           STATIC UNALIGNED INITIAL CHARACTER (30)
                                          84
96         WORD_NUMBER                    AUTOMATIC ALIGNED BINARY FIXED (15,0)
                                          97,98,98,98,98,98,99,99,102

5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 31
DCL NO.    IDENTIFIER                     ATTRIBUTES AND REFERENCES
18         WORD_TABLE                     (37) AUTOMATIC UNALIGNED INITIAL CHARACTER (9)
                                          1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,
                                          54,98,99

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                                         AGGREGATE LENGTH TABLE
1            2                                                                       3
DCL NO.   IDENTIFIER                           LVL    DIMS      OFFSET      ELEMENT        TOTAL
                                                                              LENGTH       LENGTH

21        CONTROLLED_SET                                  1                        2           72
19        WORD_COUNT                                      1                        2           72
20        WORD_INDEX_TABLE                                1                        2           52
18        WORD_TABLE                                      1                        9          333
                                                        4  SUM OF CONSTANT LENGTHS            529
```

Aggregate length table

1 Number of the statement in which the aggregate is declared, or, for a controlled aggregate, the number of the associated ALLOCATE statement.

2 The elements of the aggregate as declared.

3 Length of each element of the aggregate.

4 Sum of the lengths of aggregates whose lengths are constant.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 33

                    STORAGE REQUIREMENTS
 5                                6                      7                        8
BLOCK, SECTION OR STATEMENT     TYPE                  LENGTH   (HEX)    DSA SIZE   (HEX)
*SAMPLE1                        PROGRAM CSECT           4444    115C
*SAMPLE2                        STATIC CSECT            2880     B40
SAMPLE                          PROCEDURE BLOCK         2298     8FA       1208     4B8
BLOCK 2      STMT 22            ON UNIT                  170      AA        208      D0
BLOCK 3      STMT 26            ON UNIT                  162      A2        216      D8
BLOCK 4      STMT 29            ON UNIT                  304     130        288     120
NEXT_WORD                       PROCEDURE BLOCK         1056     420        368     170
LOOKUP_WORD                     PROCEDURE BLOCK          448     1C0        256     100
```

Storage requirements. This table gives the main storage requirements for the program. These quantities do not include the main storage required by the library subroutines that will be included by the linkage editor or loaded dynamically during execution.

5 Name of the block, section, or number of the statement in the program.

6 Description of the block, section, or statement.

7 Length in bytes of the storage areas in both decimal and hexadecimal notation.

8 Length in bytes of the dynamic storage area (DSA) in both decimal and hexadecimal notation.

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation       */PAGE 34

                   EXTERNAL SYMBOL DICTIONARY

            1             2        3         4         5
           SYMBOL        TYPE     ID       ADDR     LENGTH

          CEESTART        SD     0001     000000    000080
          *SAMPLE1        SD     0002     000000    00115C
          *SAMPLE2        SD     0003     000000    000B40
          CEEMAIN         WX     0004     000000
          CEEMAIN         SD     0005     000000    000010
          IBMRINP1        ER     0006     000000
          CEEFMAIN        WX     0007     000000
          CEEBETBL        ER     0008     000000
          CEEROOTA        ER     0009     000000
          CEEOPIPI        ER     000A     000000
          CEESG010        ER     000B     000000
          IBMSEATA        ER     000C     000000
          IELCGOG         SD     000D     000000    0000AE
          IELCGOH         SD     000E     000000    0000A0
          IELCGOC         SD     000F     000000    00007C
          IELCGMY         SD     0010     000000    0000A4
          IELCGCY         SD     0011     000000    00007E
          IBMSSIOA        ER     0012     000000
          IBMSASCA        ER     0013     000000
          IBMSCEDB        ER     0014     000000
          IBMSCHFD        ER     0015     000000
          IBMSCHXH        WX     0016     000000
          IBMSCWDH        ER     0017     000000
          IBMSEOCA        ER     0018     000000
          IBMSJDSA        ER     0019     000000
          IBMSOCLA        ER     001A     000000
          IBMSOCLC        WX     001B     000000
          IBMSRIOA        ER     001C     000000
          IBMSSEOA        ER     001D     000000
          IBMSSIOE        WX     001E     000000
          IBMSSIOT        WX     001F     000000
          IBMSSLOA        ER     0020     000000
          IBMSSPLA        ER     0021     000000
          IBMSSXCA        ER     0022     000000
          IBMSSXCB        WX     0023     000000
          IBMSSIST        WX     0024     000000
          CEEUOPT         SD     0025     000000    0004D0
          PLIXOPT         SD     0026     000000    000066
          PLIXOPT*        SD     0027     000000    00002C
          PLIXOPT+        LD              000004
          PLIXOPT-        LD              000020
          PLIXOPT-        ER     0028     000000
          SAMPLE          LD              000008
          SAMPLE          ER     0029     000000
          SAMPLE*         SD     002A     000000    000020
          SAMPLE+         LD              000000
          SOURCE          SD     002B     000000    00001C
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation       */PAGE 35
          SOURCE          PR     002C     000000    000004
          SOURCE*         SD     002D     000000    000020
          SOURCE+         LD              000000
          SYSPINT         SD     002E     000000    000020
          SYSPINT*        SD     002F     000000    000020
          SYSPINT+        LD              000000
```

External symbol dictionary

1 List of all the external symbols that make up the object module.

2 Type of external symbol, as follows:

```
CM  Common area
ER  External reference
LD  Label definition
PR  Pseudo-register
SD  Section definition
WX  Weak external reference
```

Full definitions of all these terms are given in “External symbol dictionary” in the main text.

3 All entries, except LD type entries, are identified by a hexadecimal number.

4 Address (in hexadecimal) of LD type entries.

5 Length in bytes (in hexadecimal) of SD, CM, and PR type entries.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation       */PAGE 36

                                                              1         2                    3
                          STATIC INTERNAL STORAGE MAP       0000C8  60000006              FED
  1        2                      3                         0000CC  58000009              FED
000000  E0000B38              PROGRAM ADCON                 0000D0  5800000C              FED
000004  00000008              PROGRAM ADCON                 0000D4  58000023              FED
000008  000000FC              PROGRAM ADCON                 0000D8  2800                  DED..WORD
00000C  0000034C              PROGRAM ADCON                 0000DA  2401                  DED..FALSE
000010  000008FC              PROGRAM ADCON                 0000DC  0002                  CONSTANT
000014  0000096E              PROGRAM ADCON                 0000DE  0048                  CONSTANT
000018  000009A8              PROGRAM ADCON                 0000E0  0000                  CONSTANT
00001C  00000A1A              PROGRAM ADCON                 0000E2  0001                  CONSTANT
000020  00000A24              PROGRAM ADCON                 0000E4  0003                  CONSTANT
000024  00000A4C              PROGRAM ADCON                 0000E6  0005                  CONSTANT
000028  00000AD8              PROGRAM ADCON                 0000E8  000A                  CONSTANT
00002C  00000B88              PROGRAM ADCON                 0000EA  000D                  CONSTANT
000030  00000C1A              PROGRAM ADCON                 0000EC  000E                  CONSTANT
000034  00000C40              PROGRAM ADCON                 0000EE  0012                  CONSTANT
000038  00000FA8              PROGRAM ADCON                 0000F0  0013                  CONSTANT
00003C  00001032              PROGRAM ADCON                 0000F2  0016                  CONSTANT
000040  0000103C              PROGRAM ADCON                 0000F4  0018                  CONSTANT
000044  0000103C              PROGRAM ADCON                 0000F6  001A                  CONSTANT
000048  0000103C              PROGRAM ADCON                 0000F8  001E                  CONSTANT
00004C  0000103C              PROGRAM ADCON                 0000FA  0021                  CONSTANT
000050  0000103C              PROGRAM ADCON                 0000FC  0022                  CONSTANT
000054  0000103C              PROGRAM ADCON                 0000FE  0017                  CONSTANT
000058  0000103C              PROGRAM ADCON                 000100  0007                  CONSTANT
00005C  00000000              A..IELCGOG                    000102  0004                  CONSTANT
000060  00000000              A..IELCGOH                    000104  0024                  CONSTANT
000064  00000000              A..IELCGOC                    000106  0009                  CONSTANT
000068  00000000              A..IELCGMY                    000108  4040402020202020      CONSTANT
00006C  00000000              A..IELCGCY                            202020202120
000070  00000000              A..IBMSASCA                   000116  001C                  CONSTANT
000074  00000000              A..IBMSCEDB                   000118  001D                  CONSTANT
000078  00000000              A..IBMSCHFD                   00011A
00007C  00000000              A..IBMSCHXH                   000120  00000000000001B4      LOCATOR..CONTROLLED_SET
000080  00000000              A..IBMSCWDH                   000128  00000000000001C4      LOCATOR..WORD_INDEX_TABLE
000084  00000000              A..IBMSEOCA                   000130  00000000000001D4      LOCATOR..WORD_TABLE
000088  00000000              A..IBMSJDSA                   000138  00000000001F8000      LOCATOR..WORD
00008C  00000000              A..IBMSOCLA                   000140  00000535001E0000      LOCATOR..WORD_NEXT_CHARACTERS
000090  00000000              A..IBMSOCLC                   000148  00000518001D0000      LOCATOR..WORD_FIRST_CHARACTERS
000094  00000000              A..IBMSRIOA                   000150  0000000000010000      LOCATOR..FALSE
000098  00000000              A..IBMSSEOA                   000158  0000000000798000      LOCATOR..RECORD
00009C  00000000              A..IBMSSIOE                   000160  0000000000008000      LOCATOR..DATA_RECORD
0000A0  00000000              A..IBMSSIOT                   000168  0080000091102000      CONSTANT
0000A4  00000000              A..IBMSSLOA                   000170  000000000200007B      RECORD DESCRIPTOR
0000A8  00000000              A..IBMSSPLA                   000178  000003D800190000      LOCATOR
0000AC  00000000              A..IBMSSXCA                   000180  000003F100190000      LOCATOR
0000B0  00000000              A..IBMSSXCB                   000188  0000040A00140000      LOCATOR
0000B4  00000000              A..STATIC                     000190  0000000000340000      LOCATOR
0000B8  B4000A00              DED..NEXT_WORD                000198  00000000003B0000      LOCATOR
0000BC  2000                  DED                           0001A0  000004AE00280000      LOCATOR
0000BE  00000F80              DED..WORD_COUNT               0001A8  00000000002D0000      LOCATOR
0000C2  500000060080          FED                           0001B0  91E091E0              CONSTANT
```

Static internal storage map.
This is a storage map of the static control section for the program. This control section is the third standard entry in the external symbol dictionary.

1 Six-digit offset (in hexadecimal)

2 Text (in hexadecimal)

3 Comment indicating type of item to which the text refers. A comment appears only against the first line of the text for an item.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 37
0001B4  0000000200000002      DESCRIPTOR                            40
        0000002400000001                                    0002A6  C3C1D3D340404040      CONSTANT
0001C4  0000000200000002      DESCRIPTOR                            40
        0000001A00000001                                    0002AF  C3D3D6E2C5404040      CONSTANT
0001D4  0000000900000009      DESCRIPTOR                            40
        0000002500000001                                    0002B8  C4C3D34040404040      CONSTANT
        00090000                                                    40
0001E8  00000001              CONSTANT                      0002C1  C4C5C3D3C1D9C540      CONSTANT
0001EC  0010000000601800      CONSTANT                              40
        00000000                                            0002CA  C4C5C6C1E4D3E340      CONSTANT
0001F8  00000002              CONSTANT                              40
0001FC  00000003              CONSTANT                      0002D3  C4C9E2D7D3C1E840      CONSTANT
000200  0000001F              CONSTANT                              40
000204  00000000              A..PLIXOPT                    0002DC  C4D6404040404040      CONSTANT
000208  00000000              A..DCLCB                              40
00020C  00000000              A..DCLCB                      0002E5  C5D3E2C540404040      CONSTANT
000210  000001E8              A..CONSTANT                           40
000214  00000000              A..DCLCB                      0002EE  C5D5C44040404040      CONSTANT
000218  000001EC              A..CONSTANT                           40
00021C  00000000              OMITTED ARGUMENT              0002F7  C5D5E3D9E8404040      CONSTANT
000220  00000000              OMITTED ARGUMENT                      40
000224  80000000              OMITTED ARGUMENT              000300  C6D9C5C540404040      CONSTANT
000228  00000000              A..DCLCB                              40
00022C  00000168              A..CONSTANT                   000309  C7C5D5C5D9C9C340      CONSTANT
000230  00000000              A..RD                                 40
000234  00000000              OMITTED ARGUMENT              000312  C7C5E34040404040      CONSTANT
000238  00000000              OMITTED ARGUMENT                      40
00023C  80000000              OMITTED ARGUMENT              00031B  C7D6404040404040      CONSTANT
000240  00000000              A..LOCATOR                            40
000244  80000000              A..TEMP                       000324  C7D6E3D640404040      CONSTANT
000248  00000000              A..LOCATOR                            40
00024C  80000000              A..WORD_INDEX                 00032D  C9C6404040404040      CONSTANT
000250  000001E8              A..CONSTANT                           40
000254  00000000              A..DCLCB                      000336  D3C5C1E5C5404040      CONSTANT
000258  80000000              OMITTED ARGUMENT                      40
00025C  00000000              A..DCLCB                      00033F  D3C9E2E340404040      CONSTANT
000260  00000000              A..TEMP                               40
000264  800001E8              A..CONSTANT                   000348  D3D6C3C1E3C54040      CONSTANT
000268  00000000              A..DCLCB                              40
00026C  00000000              A..TEMP                       000351  D6D5404040404040      CONSTANT
000270  800001F8              A..CONSTANT                           40
000274  00000000              A..LOCATOR                    00035A  D6D7C5D540404040      CONSTANT
000278  000000E2              A..CONSTANT                           40
00027C  000000BE              A..DED..WORD_COUNT            000363  D7D9D6C340404040      CONSTANT
000280  00000000              A..TEMP                               40
000284  800000E0              A..CONSTANT                   00036C  D7D9D6C3C5C4E4D9      CONSTANT
000288  800001A0              A..CONSTANT                           C5
00028C  0D800000              CONSTANT                      000375  D9C5C1C440404040      CONSTANT
000290  80000000              A..TEMP                               40
000294  C1D3D3D6C3C1E3C5      CONSTANT                      00037E  D9C5E3E4D9D54040      CONSTANT
        40                                                          40
00029D  C2C5C7C9D5404040      CONSTANT                      000387  D9C5E5C5D9E34040      CONSTANT
```

```
        40
000390  D9C5E6D9C9E3C540      CONSTANT
        40
000399  E2C5D3C5C3E34040      CONSTANT
        40
0003A2  E2C9C7D5C1D34040      CONSTANT
        40
0003AB  E2E3D6D740404040      CONSTANT
        40
0003B4  E3C8C5D540404040      CONSTANT
        40
0003BD  E6C1C9E340404040      CONSTANT
        40
0003C6  E6C8C5D540404040      CONSTANT
        40
0003CF  E6D9C9E3C5404040      CONSTANT
        40
0003D8  405C5C5C5C5C5C5C      CONSTANT
        5C5C5C5C5C5C5C5C
        5C5C5C5C5C5C5C5C
        40
0003F1  405C5C5C40E69699      CONSTANT
        8460A4A28540D985
        979699A3405C5C5C
        40
00040A  40608396A495A360      CONSTANT
        4040406060A69699
        84606040
00041E  6060606060606060      CONSTANT
        60606060
00042A  E3888540979985A5      CONSTANT
        8996A4A240A58193
        A48540A28896A493
        84408881A5854082
        858595
00044D  E38885998540A685      CONSTANT
        998540
000458  4099858685998595      CONSTANT
        8385A240A39640
000467  404040F3F6            CONSTANT
00046C  40A6969984A24B        CONSTANT
000473  E38885998540A681      CONSTANT
        A24081408489A283
        998597819583A840
        89954081A3409385
        81A2A34096958540
        968640A3888540A6
        969984608396A495
        A3A24B
0004AE  E3888540899597A4      CONSTANT
        A3408481A38140A2
        85A3408881A24095
        96A3408285859540
        848586899585844B
0004D6  4040202020202021      CONSTANT
        20
0004DF  E495A29785838986      CONSTANT
        8985844085999996
        9940968383A49999
        85844B4040D6D5C3
        D6C4C57E
000503  615C                  CONSTANT
000505  5C61                  CONSTANT
000507  7D                    CONSTANT
000508  0C16000000000A4C      STATIC ONCB
000510  0C96000000000000      STATIC ONCB
000518  C1C2C3C4C5C6C7C8      INITIAL VALUE..WORD_FIRST_CHAR
        C9D1D2D3D4D5D6D7
        D8D9E2E3E4E5E6E7
        E8E97C7B5B
000535  C1C2C3C4C5C6C7C8      INITIAL VALUE..WORD_NEXT_CHARA
        C9D1D2D3D4D5D6D7
        D8D9E2E3E4E5E6E7
        E8E96D7C7B5B
000558  00000000              SYMBOL TABLE ELEMENT
00055C  00000000              CONSTANT
000560  00000000              SYMBOL TABLE ELEMENT
000564  00000604              SYMBOL TABLE ELEMENT
000568  00000624              SYMBOL TABLE ELEMENT
00056C  00000648              SYMBOL TABLE ELEMENT
000570  00000664              SYMBOL TABLE ELEMENT
000574  80000000              SYMBOL TABLE ELEMENT
000578  00000680              SYMBOL TABLE ELEMENT
00057C  0000069C              SYMBOL TABLE ELEMENT
000580  000006B4              SYMBOL TABLE ELEMENT
000584  000006DC              SYMBOL TABLE ELEMENT
000588  00000704              SYMBOL TABLE ELEMENT
00058C  0000071C              SYMBOL TABLE ELEMENT
000590  00000734              SYMBOL TABLE ELEMENT
000594  00000754              SYMBOL TABLE ELEMENT
000598  00000774              SYMBOL TABLE ELEMENT
00059C  0000079C              SYMBOL TABLE ELEMENT
0005A0  000007BC              SYMBOL TABLE ELEMENT
0005A4  000007DC              SYMBOL TABLE ELEMENT
0005A8  000008D0              SYMBOL TABLE ELEMENT
0005AC  000008EC              SYMBOL TABLE ELEMENT
0005B0  00000000              SYMBOL TABLE ELEMENT
0005B4  00000000              SYMBOL TABLE ELEMENT
0005B8  00000000              CONSTANT
0005BC  00000558              SYMBOL TABLE ELEMENT
0005C0  00000000              CONSTANT
0005C4  00000564              SYMBOL TABLE ELEMENT
0005C8  00000000              CONSTANT
0005CC  00000564              SYMBOL TABLE ELEMENT
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 39
0005D0  00000000              CONSTANT                              0004E3D9E4C50000
0005D4  00000564              SYMBOL TABLE ELEMENT          000734  85000001000000BE      SYMBOL TABLE..RIGHT_MARGIN
0005D8  000007F4              SYMBOL TABLE ELEMENT                  0000011A00000000
0005DC  00000814              SYMBOL TABLE ELEMENT                  000CD9C9C7C8E36D
0005E0  00000838              SYMBOL TABLE ELEMENT                  D4C1D9C7C9D50000
0005E4  00000858              SYMBOL TABLE ELEMENT          000754  85000001000000BE      SYMBOL TABLE..LEFT_MARGIN
0005E8  00000874              SYMBOL TABLE ELEMENT                  0000011C00000000
0005EC  00000000              CONSTANT                              000BD3C5C6E36DD4
0005F0  00000564              SYMBOL TABLE ELEMENT                  C1D9C7C9D5000000
0005F4  00000894              SYMBOL TABLE ELEMENT          000774  81000001000000DA      SYMBOL TABLE..DISCREPANCY_OCCU
0005F8  000008B4              SYMBOL TABLE ELEMENT                  000000F800000000
0005FC  00000000              CONSTANT                              0014C4C9E2C3D9C5
000600  00000564              SYMBOL TABLE ELEMENT                  D7C1D5C3E86DD6C3
000604  81000101000000BE      SYMBOL TABLE..CONTROLLED_SET          C3E4D9D9C5C40000
        000000C000000000                                    00079C  85000001000000BE      SYMBOL TABLE..LAST_CHAR_POSN
        000EC3D6D5E3D9D6                                            0000011E00000000
        D3D3C5C46DE2C5E3                                            000ED3C1E2E36DC3
000624  81000101000000BE      SYMBOL TABLE..WORD_INDEX_TABLE        C8C1D96DD7D6E2D5
        000000C800000000                                    0007BC  81000001000000DA      SYMBOL TABLE..RECORD_READ
        0010E6D6D9C46DC9                                            0000010000000000
        D5C4C5E76DE3C1C2                                            000BD9C5C3D6D9C4
        D3C50000                                                    6DD9C5C1C4000000
000648  81000101000000BE      SYMBOL TABLE..WORD_COUNT      0007DC  81000001000000D8      SYMBOL TABLE..RECORD
        000000D000000000                                            0000010800000000
        000AE6D6D9C46DC3                                            0006D9C5C3D6D9C4
        D6E4D5E3                                            0007F4  85000002000000BE      SYMBOL TABLE..NEXT_CHAR_POSN
000664  81000101000000BC      SYMBOL TABLE..WORD_TABLE              000000D000000000
        000000D800000000                                            000ED5C5E7E36DC3
        000AE6D6D9C46DE3                                            C8C1D96DD7D6E2D5
        C1C2D3C5                                            000814  85000002000000BE      SYMBOL TABLE..LENGTH_OF_STRING
000680  85000001000000BE      SYMBOL TABLE..WORD_INDEX              000000D200000000
        0000011800000000                                            0010D3C5D5C7E3C8
        000AE6D6D9C46DC9                                            6DD6C66DE2E3D9C9
        D5C4C5E7                                                    D5C70000
00069C  81000001000000D8      SYMBOL TABLE..WORD            000838  81000002000000BC      SYMBOL TABLE..NEXT_CHARACTER
        000000E000000000                                            000000B800000000
        0004E6D6D9C40000                                            000ED5C5E7E36DC3
0006B4  01000000000000BC      SYMBOL TABLE..WORD_NEXT_CHARAC        C8C1D9C1C3E3C5D9
        0000014000000000                                    000858  81000002000000D8      SYMBOL TABLE..DATA_WORD
        0014E6D6D9C46DD5                                            000000C000000000
        C5E7E36DC3C8C1D9                                            0009C4C1E3C16DE6
        C1C3E3C5D9E20000                                            D6D9C400
0006DC  01000000000000BC      SYMBOL TABLE..WORD_FIRST_CHARA000874  A1000002000000D8      SYMBOL TABLE..DATA_RECORD
        0000014800000000                                            0000010000000000
        0015E6D6D9C46DC6                                            000BC4C1E3C16DD9
        C9D9E2E36DC3C8C1                                            C5C3D6D9C4000000
        D9C1C3E3C5D9E200                                    000894  85000002000000BE      SYMBOL TABLE..WORD_NUMBER
000704  81000001000000DA      SYMBOL TABLE..FALSE                   000000C000000000
        000000E800000000                                            000BE6D6D9C46DD5
        0005C6C1D3E2C500                                            E4D4C2C5D9000000
00071C  81000001000000DA      SYMBOL TABLE..TRUE            0008B4  A1000002000000D8      SYMBOL TABLE..DATA_WORD
        000000F000000000                                            000000D000000000
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 40
        0009C4C1E3C16DE6
        D6D9C400                                            000000  1D02000000000018      SYMBOL TABLE..SAMPLE
0008D0  0D020001000000B8      SYMBOL TABLE..NEXT_WORD               0000000000000000
        00000B8800000000                                            0006E2C1D4D7D3C5
        0009D5C5E7E36DE6                                    000018  B4000A00              SYMTAB DED..SAMPLE
        D6D9C400
0008EC  0D020001000000B8      SYMBOL TABLE..LOOKUP_WORD     000000  1D00000100000018      SYMBOL TABLE..SOURCE
        00000FA800000000                                            0000000000000000
        000BD3D6D6D2E4D7                                            0006E2D6E4D9C3C5
        6DE6D6D9C4000000                                    000018  B800                  SYMTAB DED..SOURCE

                                                            000000  1D0000010000001C      SYMBOL TABLE..SYSPRINT
                                                                    0000000000000000
                                                                    0008E2E8E2D7D9C9
                          STATIC EXTERNAL CSECTS                    D5E30000
                                                            00001C  B800                  SYMTAB DED..SYSPRINT


000000  FFFFFFFC41000000      DCLCB
        02C70F0000000000
        000000140008E2E8
        E2D7D9C9D5E30000


000000  0000000002000000      DCLCB
        0100100000000000
        000000140006E2D6
        E4D9C3C5


000000  0011D4E2C7C6C9D3      CSECT FOR EXTERNAL VARIABLE
        C54DE2E8E2D7D9C9
        D5E35D0000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        0000000000000000
        000000000000

000000  2800                  SYMTAB DED..PLIXOPT
000002  0000
000004  1900000000000000      SYMBOL TABLE..PLIXOPT
        0000002400000000
        0007D7D3C9E7D6D7
        E3000000
000020  80000004              SYMBOL TABLE ELEMENT
000024  0000000000648000      LOCATOR..PLIXOPT
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 41
                                  VARIABLE STORAGE MAP
IDENTIFIER                        LEVEL          OFFSET      (HEX)   CLASS     BLOCK

CONTROLLED_SET                        1             296        128   AUTO      SAMPLE
WORD_INDEX_TABLE                      1             368        170   AUTO      SAMPLE
WORD_COUNT                            1             420        1A4   AUTO      SAMPLE
WORD_TABLE                            1             650        28A   AUTO      SAMPLE
WORD_INDEX                            1             280        118   AUTO      SAMPLE
WORD                                  1             492        1EC   AUTO      SAMPLE
WORD_NEXT_CHARACTERS                  1            1333        535   STATIC    SAMPLE
WORD_FIRST_CHARACTERS                 1            1304        518   STATIC    SAMPLE
FALSE                                 1             288        120   AUTO      SAMPLE
TRUE                                  1             289        121   AUTO      SAMPLE
RIGHT_MARGIN                          1             282        11A   AUTO      SAMPLE
LEFT_MARGIN                           1             284        11C   AUTO      SAMPLE
DISCREPANCY_OCCURRED                  1             290        122   AUTO      SAMPLE
LAST_CHAR_POSN                        1             286        11E   AUTO      SAMPLE
RECORD_READ                           1             291        123   AUTO      SAMPLE
RECORD                                1             526        20E   AUTO      SAMPLE
NEXT_CHAR_POSN                        2             208         D0   AUTO      NEXT_WORD
LENGTH_OF_STRING                      2             210         D2   AUTO      NEXT_WORD
NEXT_CHARACTER                        2             212         D4   AUTO      NEXT_WORD
DATA_WORD                             2             216         D8   AUTO      NEXT_WORD
WORD_NUMBER                           2             192         C0   AUTO      LOOKUP_WORD
```

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 42
              TABLES OF OFFSETS AND STATEMENT NUMBERS

              WITHIN PROCEDURE SAMPLE
OFFSET (HEX)       0    348    358    368    370    37E    388    39E    3AE    3BA    410    432    462    48A    492
STATEMENT NO.      1     22     26     29     34     35     36     37     38     39     40     41     42     43     44
OFFSET (HEX)     4E8    4F0    506    50E    51C    55C    59C    5DC    61C    62E    63A    642    6DA    6E2    6FA
STATEMENT NO.     45     46     47     48     49     50     51     52     53     54     53     54     55     56     57
OFFSET (HEX)     78A    794    79C    7A4    7A8    7B4    7CC    7CC    86E    8D2    8DA
STATEMENT NO.     58     59     60     61     54     61     53     62     63     64    104
              WITHIN ON UNIT BLOCK 2
OFFSET (HEX)       0     76     84     92
STATEMENT NO.     22     23     24     25
              WITHIN ON UNIT BLOCK 3
OFFSET (HEX)       0     80     8A
STATEMENT NO.     26     27     28
              WITHIN ON UNIT BLOCK 4
OFFSET (HEX)       0     90     98    10A    118
STATEMENT NO.     29     30     31     32     33
              WITHIN PROCEDURE NEXT_WORD
OFFSET (HEX)       0     BC     C8    100    11A    124    134    1C0    1C8    1D0    24C    254    292    29A    2AC
STATEMENT NO.     65     71     72     73     74     75     76     77     78     79     80     81     82     83     84
OFFSET (HEX)     328    386    38A    38E    3A4    3B8    3BC    3C0    3C0    3C4    3DC    414
STATEMENT NO.     85     86     84     86     87     88     89     90     90     91     92     93
              WITHIN PROCEDURE LOOKUP_WORD
OFFSET (HEX)       0     98     DA     E2    132    13A    13E    146    148    15E    176    182    184    18C    190
STATEMENT NO.     94     97     98     99    100    101     98    101     98    101     98    101     98    101    102
OFFSET (HEX)     1B4
STATEMENT NO.    103
```

```
5688-235 IBM PL/I for MVS & VM         /* PL/I Sample Program: Used to verify product installation        */PAGE 43
  OBJECT LISTING
```

```
       1
* STATEMENT NUMBER  40                            2
000418  44 00 C 1AC                 3  EX    0,HOOK..STMT
00041C                     CL.48    EQU   *
00041C  48 90 3 0E0                    LH    9,224(0,3)
000420  48 70 D 1EC                    LH    7,WORD
000424  41 80 3 294                    LA    8,660(0,3)
000428  41 60 D 1EE                    LA    6,WORD+2
00042C  58 F0 3 06C                    L     15,A..IELCGCY
000430  05 EF                          BALR  14,15
000432  47 80 2 1AC                    BE    CL.15
000436  44 00 C 1C8                    EX    0,HOOK..DO


* STATEMENT NUMBER  41
00043A  44 00 C 1AC                    EX    0,HOOK..STMT
00043E  41 70 D 0E0                    LA    7,224(0,13)
000442  50 70 3 248                    ST    7,584(0,3)
000446  41 70 D 118                    LA    7,WORD_INDEX
00044A  50 70 3 24C                    ST    7,588(0,3)
00044E  96 80 3 24C                    OI    588(3),X'80'
000452  18 5D                          LR    5,13
000454  41 10 3 248                    LA    1,584(0,3)
000458  58 F0 3 038                    L     15,A..LOOKUP_WORD
00045C  44 00 C 1C0                 3  EX    0,HOOK..PRE-CALL
000460  47 01 4 00A                    NOP   HOOK..INFO
000464  05 EF                          BALR  14,15
000466  44 00 C 1C4                 3  EX    0,HOOK..POST-CALL


* STATEMENT NUMBER  42
00046A  44 00 C 1AC                    EX    0,HOOK..STMT
00046E  48 90 D 118                    LH    9,WORD_INDEX
000472  49 90 3 0E0                    CH    9,224(0,3)
000476  47 80 2 146                    BE    CL.16
00047A  44 00 C 1CC                    EX    0,HOOK..IF-TRUE
00047E  89 90 0 001                    SLL   9,1
000482  48 69 D 1A2                    LH    6,VO..WORD_COUNT(9
                                             )
000486  4A 60 3 0E2                    AH    6,226(0,3)
00048A  40 69 D 1A2                    STH   6,VO..WORD_COUNT(9
                                             )
00048E  47 F0 2 14E                    B     CL.17


* STATEMENT NUMBER  43
000492                     CL.16       EQU   *
000492  44 00 C 1AC                    EX    0,HOOK..STMT
000496  44 00 C 1D0                    EX    0,HOOK..IF-FALSE
```

```
* STATEMENT NUMBER  44
00049A            CL.17   EQU   *
00049A  44 00 C 1AC                    EX    0,HOOK..STMT
00049E  41 70 D 108      LA    7,264(0,13)
0004A2  50 70 3 240               ST    7,576(0,3)
0004A6  D2 07 D 484 3 138         MVC   1156(8,13),312(3)
0004AC  41 80 D 462               LA    8,1122(0,13)
0004B0  50 80 D 484               ST    8,1156(0,13)
0004B4  41 70 D 484               LA    7,1156(0,13)
0004B8  50 70 3 244               ST    7,580(0,3)
0004BC  96 80 3 244               OI    580(3),X'80'
0004C0  18 5D                     LR    5,13
0004C2  41 10 3 240               LA    1,576(0,3)
0004C6  58 F0 3 02C               L     15,A..NEXT_WORD
0004CA  44 00 C 1C0               EX    0,HOOK..PRE-CALL
0004CE  47 01 4 00A               NOP   HOOK..INFO
0004D2  05 EF                     BALR  14,15
0004D4  44 00 C 1C4               EX    0,HOOK..POST-CALL
0004D8  D2 00 D 1EC D 462         MVC   WORD(1),1122(13)
0004DE  48 F0 D 462               LH    15,1122(0,13)
0004E2  44 F0 2 19E               EX    15,CL.72
0004E6  47 F0 2 1A4               B     CL.73
0004EA                    CL.72   EQU   *
0004EA  D2 00 D 1ED D 463         MVC   WORD+1(1),1123(13)
0004F0                    CL.73   EQU   *


* STATEMENT NUMBER  45
0004F0  44 00 C 1AC     EX    0,HOOK..STMT
0004F4  47 F0 2 0D0               B     CL.48
0004F8                    CL.15   EQU   *
```

Object listing. This is a partial listing of the machine instructions generated by the compiler from the PL/I source program.

1 Machine instructions (in hexadecimal)

2 Assembler-language form of the machine instruction

3 HOOK indicates a location where the debugging tool could get control.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 44
COMPILER DIAGNOSTIC MESSAGES

 1      2     3
ERROR ID L   STMT    MESSAGE DESCRIPTION

COMPILER INFORMATORY MESSAGES

IEL0533I I           NO 'DECLARE' STATEMENT(S) FOR 'INDEX'.
IEL0871I I   62      RESULT OF BUILTIN FUNCTION 'SUM' WILL BE EVALUATED USING FIXED POINT ARITHMETIC OPERATIONS.

END OF COMPILER DIAGNOSTIC MESSAGES

  4                                     5
COMPILE TIME    0.01 MINS        SPILL FILE:     0 RECORDS, SIZE  4051
END OF COMPILATION OF SAMPLE
```

Diagnostic messages and an end-of-compile-step message generated by the compiler. All diagnostic messages generated by the compiler are documented in the publication *PL/I MVS & VM Compile-Time Messages and Codes.*

1 ERROR ID identifies the message as originating from the PL/I compiler (IEL), and gives the message number.

2 L indicates the severity level of the message.

3 STMT gives the number of the statement in which the error occurred.

4 Compile time in minutes. This time includes the preprocessor.

5 Number of records “spilled” into auxiliary storage and the size in bytes of the spill file records.

```
5688-235 IBM PL/I for MVS & VM          /* PL/I Sample Program: Used to verify product installation        */PAGE 45

 MVS/DFP VERSION 3 RELEASE 3 LINKAGE EDITOR     10:03:27  FRI  JAN 29, 1993
 JOB IEL11IVP   STEP IVP        PROCEDURE LKED
 INVOCATION PARAMETERS - XREF,LIST   1
 ACTUAL SIZE=(317440,79872)
 OUTPUT DATA SET SYS93029.T100323.RA000.IEL11IVP.GOSET IS ON VOLUME PUB002

                                          2        CROSS REFERENCE TABLE
     3
  CONTROL SECTION                       ENTRY
    NAME    ORIGIN  LENGTH                NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
  CEESTART      00      80
  CEEMAIN       80      10
  SYSPINT       90      20
  SOURCE        B0      1C
  CEEUOPT       D0     4D0
  PLIXOPT      5A0      66
  PLIXOPT*     608      2C
                                        PLIXOPT+     60C    PLIXOPT-     628
  SAMPLE*      638      20
                                        SAMPLE+      638
  SOURCE*      658      20
                                        SOURCE+      658
  SYSPINT*     678      20
                                        SYSPINT+     678
```

Linkage editor listing.

1 Statement identifying the version and level of the linkage editor and giving the options as specified in the PARM parameter of the EXEC statement that invokes the linkage editor

2 Cross reference table, consisting of a module map and the cross reference table

3 The module map shows each control section and its associated entry points, if any, listed across the page. An asterisk in column 9 after a name beginning with “IBM” indicates a library subroutine obtained by automatic library call.

4 The cross reference table gives all the locations in a control section at which a symbol is reference. UNRESOLVED(W) identifies a weak external reference that has not been resolved.

```
  *SAMPLE2     698     B40
  IELCGOG     11D8      AE
  IELCGOH     1288      A0
  IELCGOC     1328      7C
  IELCGMY     13A8      A4
  IELCGCY     1450      7E
  *SAMPLE1    14D0    115C
                                        SAMPLE      14D8
  CEEBETBL*   2630      1C
  CEEOPIPI*   2650     208
  CEEROOTA*   2858     268
  CEESG010*   2AC0      64
  IBMRINP1*   2B28      24
  IBMSASCA*   2B50      14
                                        IBMBASCA    2B50
  IBMSCEDB*   2B68      14
                                        IBMBCEDB    2B68
  IBMSCHFD*   2B80      14
                                        IBMBCHFD    2B80
  IBMSEATA*   2B98      14
```

```
                                      IBMBEATA    2B98
IBMSSIOA*   2BB0      14
                                      IBMBSIOA    2BB0
IBMSCHXH*   2BC8      14
                                      IBMBCHXH    2BC8
IBMSCWDH*   2BE0      14
                                      IBMBCWDH    2BE0

  NAME    ORIGIN  LENGTH                NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
IBMSEOCA*   2BF8      14
                                      IBMBEOCA    2BF8
IBMSJDSA*   2C10      14
                                      IBMBJDSA    2C10
IBMSOCLA*   2C28      14
                                      IBMBOCLA    2C28
IBMSRIOA*   2C40      14
                                      IBMBRIOA    2C40

IBMSSEOA*   2C58      14
                                      IBMBSEOA    2C58
IBMSSIOE*   2C70      14
                                      IBMBSIOE    2C70
IBMSSIOT*   2C88      14
                                      IBMBSIOT    2C88
IBMSSLOA*   2CA0      14
                                      IBMBSLOA    2CA0
CEEARLU *   2CB8     140
CEEBINT *   2DF8       8
CEEBLLST*   2E00      5C
                                      CEELLIST    2E10
CEEBTRM *   2E60     180
CEEP#CAL*   2FE0     120
CEEP#INT*   3100     340
CEEP#TRM*   3440     210
IBMSOCLC*   3650      14
                                      IBMBOCLC    3650

IBMSSPLA*   3668      14
                                      IBMBSPLA    3668
IBMSSXCA*   3680      14
                                      IBMBSXCA    3680
CEEBPIRA*   3698     2E0
                                      CEEINT      3698    CEEBPIRB    3698    CEEBPIRC    3698
IBMSCEDF*   3978      14
                                      IBMBCEDF    3978
IBMSCEDX*   3990      14
                                      IBMBCEDX    3990
IBMSCEFX*   39A8      14
                                      IBMBCEFX    39A8
IBMSCEZB*   39C0      14
                                      IBMBCEZB    39C0
IBMSCEZF*   39D8      14
                                      IBMBCEZF    39D8
IBMSCEZX*   39F0      14
                                      IBMBCEZX    39F0
IBMSCHFE*   3A08      14
                                      IBMBCHFE    3A08
CEEPMATH*   3A20      18
                                      IBMSMATH    3A20
IBMSSXCB*   3A38      14
                                      IBMBSXCB    3A38
IBMSCHFH*   3A50      14
                                      IBMBCHFH    3A50
  NAME    ORIGIN  LENGTH                NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
IBMSCHFP*   3A68      14
                                      IBMBCHFP    3A68
IBMSCHFY*   3A80      14
                                      IBMBCHFY    3A80
IBMSCHXD*   3A98      14
                                      IBMBCHXD    3A98
IBMSCHXE*   3AB0      14
                                      IBMBCHXE    3AB0
IBMSCHXF*   3AC8      14
                                      IBMBCHXF    3AC8
IBMSCHXP*   3AE0      14
                                      IBMBCHXP    3AE0
IBMSCHXY*   3AF8      14
                                      IBMBCHXY    3AF8
IBMSSIOB*   3B10      14
                                      IBMBSIOB    3B10
IBMSSIOC*   3B28      14
                                      IBMBSIOC    3B28
IBMSCWZH*   3B40      14
                                      IBMBCWZH    3B40
IBMSJDSB*   3B58      14
                                      IBMBJDSB    3B58
IBMSOCLB*   3B70      14
                                      IBMBOCLB    3B70
IBMSOCLD*   3B88      14
                                      IBMBOCLD    3B88
IBMSRIOB*   3BA0      14
                                      IBMBRIOB    3BA0
IBMSRIOC*   3BB8      14
                                      IBMBRIOC    3BB8
IBMSRIOD*   3BD0      14
                                      IBMBRIOD    3BD0
IBMSSIOD*   3BE8      14
                                      IBMBSIOD    3BE8
IBMSSLOB*   3C00      14
                                      IBMBSLOB    3C00
IBMSSPLB*   3C18      14
                                      IBMBSPLB    3C18
IBMSSPLC*   3C30      14
                                      IBMBSPLC    3C30
IBMSSXCC*   3C48      14
                                      IBMBSXCC    3C48
IBMSSXCD*   3C60      14
                                      IBMBSXCD    3C60

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION             LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
     2C            CEEMAIN         CEEMAIN                       68            CEEFMAIN   4   $UNRESOLVED(W)
     74            CEEBETBL        CEEBETBL                      78            CEEROOTA        CEEROOTA
     84            *SAMPLE1        *SAMPLE1                      88            IBMRINP1        IBMRINP1
    62C            PLIXOPT         PLIXOPT                      640            SAMPLE          *SAMPLE1

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION             LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
    660            SOURCE          SOURCE                       680            SYSPINT         SYSPINT
    69C            *SAMPLE1        *SAMPLE1                     6A0            *SAMPLE1        *SAMPLE1
    6A4            *SAMPLE1        *SAMPLE1                     6A8            *SAMPLE1        *SAMPLE1
    6AC            *SAMPLE1        *SAMPLE1                     6B0            *SAMPLE1        *SAMPLE1
    6B4            *SAMPLE1        *SAMPLE1                     6B8            *SAMPLE1        *SAMPLE1
    6BC            *SAMPLE1        *SAMPLE1                     6C0            *SAMPLE1        *SAMPLE1
    6C4            *SAMPLE1        *SAMPLE1                     6C8            *SAMPLE1        *SAMPLE1
    6CC            *SAMPLE1        *SAMPLE1                     6D0            *SAMPLE1        *SAMPLE1
    6D4            *SAMPLE1        *SAMPLE1                     6D8            *SAMPLE1        *SAMPLE1
    6DC            *SAMPLE1        *SAMPLE1                     6E0            *SAMPLE1        *SAMPLE1
    6E4            *SAMPLE1        *SAMPLE1                     6E8            *SAMPLE1        *SAMPLE1
    6EC            *SAMPLE1        *SAMPLE1                     6F0            *SAMPLE1        *SAMPLE1
    6F4            IELCGOG         IELCGOG                      6F8            IELCGOH         IELCGOH
    6FC            IELCGOC         IELCGOC                      700            IELCGMY         IELCGMY
    704            IELCGCY         IELCGCY                      708            IBMSASCA        IBMSASCA
    70C            IBMSCEDB        IBMSCEDB                     710            IBMSCHFD        IBMSCHFD
    714            IBMSCHXH        IBMSCHXH                     718            IBMSCWDH        IBMSCWDH
    71C            IBMSEOCA        IBMSEOCA                     720            IBMSJDSA        IBMSJDSA
    724            IBMSOCLA        IBMSOCLA                     728            IBMSOCLC        IBMSOCLC
    72C            IBMSRIOA        IBMSRIOA                     730            IBMSSEOA        IBMSSEOA
    734            IBMSSIOE        IBMSSIOE                     738            IBMSSIOT        IBMSSIOT
    73C            IBMSSLOA        IBMSSLOA                     740            IBMSSPLA        IBMSSPLA
    744            IBMSSXCA        IBMSSXCA                     748            IBMSSXCB        IBMSSXCB
    89C            PLIXOPT         PLIXOPT                      8A0            SYSPINT         SYSPINT
    8A4            SOURCE          SOURCE                       8AC            SOURCE          SOURCE
    8C0            SOURCE          SOURCE                       8EC            SOURCE          SOURCE
    8F4            SYSPINT         SYSPINT                      900            SYSPINT         SYSPINT
    BA4            *SAMPLE1        *SAMPLE1                     BF0            SAMPLE*         SAMPLE*
    C0C            PLIXOPT-        PLIXOPT*                     C48            SOURCE*         SOURCE*
    C4C            SYSPINT*        SYSPINT*                     F70            *SAMPLE1        *SAMPLE1
    F8C            *SAMPLE1        *SAMPLE1                     FA8            *SAMPLE1        *SAMPLE1
   106C            *SAMPLE1        *SAMPLE1                    108C            *SAMPLE1        *SAMPLE1
   10A8            *SAMPLE1        *SAMPLE1                    10CC            *SAMPLE1        *SAMPLE1
   1164            *SAMPLE1        *SAMPLE1                    11D4            CEESTART        CEESTART
   1320            IBMSSIST       $UNRESOLVED(W)               1324            IBMSSEOA        IBMSSEOA
   139C            IBMSSXCB        IBMSSXCB                    13A0            IBMSSIST       $UNRESOLVED(W)
   14E0            *SAMPLE2        *SAMPLE2                    14E8            *SAMPLE2        *SAMPLE2
   14EC            *SAMPLE2        *SAMPLE2                    1510            *SAMPLE2        *SAMPLE2
   1DD4            *SAMPLE2        *SAMPLE2                    1DDC            *SAMPLE2        *SAMPLE2
   1DE0            *SAMPLE2        *SAMPLE2                    1E80            *SAMPLE2        *SAMPLE2
   1E88            *SAMPLE2        *SAMPLE2                    1E8C            *SAMPLE2        *SAMPLE2
   1F24            *SAMPLE2        *SAMPLE2                    1F2C            *SAMPLE2        *SAMPLE2
   1F30            *SAMPLE2        *SAMPLE2                    2060            *SAMPLE2        *SAMPLE2
   2068            *SAMPLE2        *SAMPLE2                    206C            *SAMPLE2        *SAMPLE2
   2480            *SAMPLE2        *SAMPLE2                    2488            *SAMPLE2        *SAMPLE2
   248C            *SAMPLE2        *SAMPLE2                    2640            CEEUOPT         CEEUOPT
   2634            CEEBXITA       $UNRESOLVED(W)               2638            CEEBINT         CEEBINT
   263C            CEEBLLST        CEEBLLST                    2644            CEEBTRM         CEEBTRM
   26F4            CEEP#INT        CEEP#INT                    275C            CEEP#INT        CEEP#INT
   2798            CEEP#INT        CEEP#INT                    2740            CEEP#CAL        CEEP#CAL
   276C            CEEP#CAL        CEEP#CAL                    277C            CEEP#TRM        CEEP#TRM
   27F4            CEEP#TRM        CEEP#TRM                    29F8            CEEARLU         CEEARLU

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION             LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
   2A04            CEEINT          CEEBPIRA                    29E8            CEEFMAIN       $UNRESOLVED(W)
   29EC            CEEMAIN         CEEMAIN                     29F0            PLIMAIN        $UNRESOLVED(W)
   29F4            IBMSEMNA       $UNRESOLVED(W)               29FC            CEESG010        CEESG010
   2A00            CEEOPIPI        CEEOPIPI                    2A08            CEEROOTB       $UNRESOLVED(W)
   2B1C            CEEBETBL        CEEBETBL                    2B20            IBMSMATH        CEEPMATH
   2AD4            CEEMAIN         CEEMAIN                     2B10            CEEFMAIN       $UNRESOLVED(W)
   2B0C            PLISTART       $UNRESOLVED(W)               2AF4            PLIXOPT         PLIXOPT
   2AF8            IBMBPOPT       $UNRESOLVED(W)               2AD8            SYSPINT         SYSPINT
   2AE0            PLITABS        $UNRESOLVED(W)               2B00            IBMBEATA        IBMSEATA
   2AD0            PLIMAIN        $UNRESOLVED(W)               2B38            CEESTART        CEESTART
   2B3C            CEEBETBL        CEEBETBL                    2B28            CEEMAIN         CEEMAIN
   2B34            CEEMAIN         CEEMAIN                     2E10            CEESG000       $UNRESOLVED(W)
   2E14            CEESG001       $UNRESOLVED(W)               2E18            CEESG002       $UNRESOLVED(W)
   2E1C            CEESG003       $UNRESOLVED(W)               2E20            CEESG004       $UNRESOLVED(W)
   2E24            CEESG005       $UNRESOLVED(W)               2E28            CEESG006       $UNRESOLVED(W)
   2E2C            CEESG007       $UNRESOLVED(W)               2E30            CEESG008       $UNRESOLVED(W)
   2E34            CEESG009       $UNRESOLVED(W)               2E38            CEESG010        CEESG010
   2E3C            CEESG011       $UNRESOLVED(W)               2E40            CEESG012       $UNRESOLVED(W)
   2E44            CEESG013       $UNRESOLVED(W)               2E48            CEESG014       $UNRESOLVED(W)
   2E4C            CEESG015       $UNRESOLVED(W)               2E50            CEESG016       $UNRESOLVED(W)
```

```
  LOCATION     3C REQUESTS CUMULATIVE PSEUDO REGISTER LENGTH
 PSEUDO REGISTERS
    NAME    ORIGIN  LENGTH        NAME    ORIGIN  LENGTH        NAME    ORIGIN  LENGTH        NAME    ORIGIN  LENGTH
  SOURCE        00       4
 TOTAL LENGTH OF PSEUDO REGISTERS       4
 ENTRY ADDRESS       00
 TOTAL LENGTH      3C78
 ** GO       DID NOT PREVIOUSLY EXIST BUT WAS ADDED AND HAS AMODE 31
 ** LOAD MODULE HAS RMODE ANY
 ** AUTHORIZATION CODE IS         0.

 ***********************
 *** Word-use Report ***  1
 ***********************
 -count-   --word--
     3      BEGIN
     1      CLOSE
    13      DCL
    24      DECLARE
     2      DISPLAY
    14      DO
    13      ELSE
    23      END
     1      GO
    13      IF
------------The previous value should have been    14  2
     7      LIST
     4      ON
     1      OPEN
     2      PROC
     3      PROCEDURE
     2      READ
     4      RETURN
     1      SELECT
     2      STOP
    13      THEN
     2      WHEN
There were            148 references to    36 words.
There was a discrepancy in at least one of the word-counts.  2
```

Sample program output.

1 Program output header

2 The apparent error is intentional

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- *Self-Study Guide*, SC09-2047

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- *User's Guide and Reference*, SC09-2137

Softcopy Publications

Online publications are distributed on CD-ROMs and can be ordered from Mechanicsburg through your IBM representative. PL/I books are distributed on the following collection kit:

- *Application Development Collection Kit*, SK2T-1237

Other Books You Might Need

CICS/ESA

- *Application Programming Reference*, SC33-0676

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Glossary

This glossary defines terms for all platforms and releases of PL/I. It might contain terms that this manual does not use. If you do not find the terms for which you are looking, see the index in this manual or *IBM Dictionary of Computing*, SC20-1699.

A

access. To reference or retrieve data.

action specification. In an ON statement, the ON-unit or the single keyword SYSTEM, either of which specifies the action to be taken whenever the appropriate condition is raised.

activate (a block). To initiate the execution of a block. A procedure block is activated when it is invoked. A begin-block is activated when it is encountered in the normal flow of control, including a branch. A package cannot be activated.

activate (a preprocessor variable or preprocessor entry point). To make a macro facility identifier eligible for replacement in subsequent source code. The %ACTIVATE statement activates preprocessor variables or preprocessor entry points.

active. (1) The state of a block after activation and before termination. (2) The state in which a preprocessor variable or preprocessor entry name is said to be when its value can replace the corresponding identifier in source program text. (3) The state in which an event variable is said to be during the time it is associated with an asynchronous operation. (4) The state in which a task variable is said to be when its associated task is attached. (5) The state in which a task is said to be before it has been terminated.

actual origin (AO). The location of the first item in the array or structure.

additive attribute. A file description attribute for which there are no defaults, and which, if required, must be stated explicitly or implied by another explicitly stated attribute. Contrast with *alternative attribute*.

adjustable extent. The bound (of an array), the length (of a string), or the size (of an area) that might be different for different generations of the associated variable. Adjustable extents are specified as expressions or asterisks (or by REFER options for based variables), which are evaluated separately for each generation. They cannot be used for static variables.

aggregate. See *data aggregate*.

aggregate expression. An array, structure, or union expression.

aggregate type. For any item of data, the specification whether it is structure, union, or array.

allocated variable. A variable with which main storage is associated and not freed.

allocation. (1) The reservation of main storage for a variable. (2) A generation of an allocated variable. (3) The association of a PL/I file with a system data set, device, or file.

alignment. The storing of data items in relation to certain machine-dependent boundaries (for example, a fullword or halfword boundary).

alphabetic character. Any of the characters A through Z of the English alphabet and the alphabetic extenders #, $, and @ (which can have a different graphic representation in different countries).

alphameric character. An alphabetic character or a digit.

alternative attribute. A file description attribute that is chosen from a group of attributes. If none is specified, a default is assumed. Contrast with *additive attribute*.

ambiguous reference. A reference that is not sufficiently qualified to identify one and only one name known at the point of reference.

area. A portion of storage within which based variables can be allocated.

argument. An expression in an argument list as part of an invocation of a subroutine or function.

argument list. A parenthesized list of zero or more arguments, separated by commas, following an entry name constant, an entry name variable, a generic name, or a built-in function name. The list becomes the parameter list of the entry point.

arithmetic comparison. A comparison of numeric values. See also *bit comparison, character comparison*.

arithmetic constant. A fixed-point constant or a floating-point constant. Although most arithmetic constants can be signed, the sign is not part of the constant.

arithmetic conversion. The transformation of a value from one arithmetic representation to another.

arithmetic data. Data that has the characteristics of base, scale, mode, and precision. Coded arithmetic data and pictured numeric character data are included.

arithmetic operators. Either of the prefix operators + and −, or any of the following infix operators: + − * / **

array. A named, ordered collection of one or more data elements with identical attributes, grouped into one or more dimensions.

array expression. An expression whose evaluation yields an array of values.

array of structures. An ordered collection of identical structures specified by giving the dimension attribute to a structure name.

array variable. A variable that represents an aggregate of data items that must have identical attributes. Contrast with *structure variable*.

ASCII. American National Standard Code for Information Interchange.

assignment. The process of giving a value to a variable.

asynchronous operation. (1) The overlap of an input/output operation with the execution of statements. (2) The concurrent execution of procedures using multiple flows of control for different tasks.

attachment of a task. The invocation of a procedure and the establishment of a separate flow of control to execute the invoked procedure (and procedures it invokes) asynchronously, with execution of the invoking procedure.

attention. An occurrence, external to a task, that could cause a task to be interrupted.

attribute. (1) A descriptive property associated with a name to describe a characteristic represented. (2) A descriptive property used to describe a characteristic of the result of evaluation of an expression.

automatic storage allocation. The allocation of storage for automatic variables.

automatic variable. A variable whose storage is allocated automatically at the activation of a block and released automatically at the termination of that block.

B

base. The number system in which an arithmetic value is represented.

base element. A member of a structure or a union that is itself not another structure or union.

base item. The automatic, controlled, or static variable or the parameter upon which a defined variable is defined.

based reference. A reference that has the based storage class.

based storage allocation. The allocation of storage for based variables.

based variable. A variable whose storage address is provided by a locator. Multiple generations of the same variable are accessible. It does not identify a fixed location in storage.

begin-block. A collection of statements delimited by BEGIN and END statements, forming a name scope. A begin-block is activated either by the raising of a condition (if the begin-block is the action specification for an ON-unit) or through the normal flow of control, including any branch resulting from a GOTO statement.

binary. A number system whose only numerals are 0 and 1.

binary digit. See *bit*.

binary fixed-point value. An integer consisting of binary digits and having an optional binary point and optional sign. Contrast with *decimal fixed-point value*.

binary floating-point value. An approximation of a real number in the form of a significand, which can be considered as a binary fraction, and an exponent, which can be considered as an integer exponent to the base of 2. Contrast with *decimal floating-point value*.

bit. (1) A 0 or a 1. (2) The smallest amount of space of computer storage.

bit comparison. A left-to-right, bit-by-bit comparison of binary digits. See also *arithmetic comparison, character comparison*.

bit string constant. (1) A series of binary digits enclosed in and followed immediately by the suffix B. Contrast with *character constant*. (2) A series of hexadecimal digits enclosed in single quotes and followed by the suffix B4.

bit string. A string composed of zero or more bits.

bit string operators. The logical operators not and exclusive-or (¬), and (&), and or (|).

bit value. A value that represents a bit type.

block. A sequence of statements, processed as a unit, that specifies the scope of names and the allocation of storage for names declared within it. A block can be a package, procedure, or a begin-block.

bounds. The upper and lower limits of an array dimension.

break character. The underscore symbol (_). It can be used to improve the readability of identifiers. For instance, a variable could be called OLD_INVENTORY_TOTAL instead of OLDINVENTORYTOTAL.

built-in function. A predefined function supplied by the language, such as SQRT (square root).

built-in function reference. A built-in function name, which has an optional argument list.

built-in name. The entry name of a built-in subroutine.

built-in subroutine. Subroutine that has an entry name that is defined at compile-time and is invoked by a CALL statement.

buffer. Intermediate storage, used in input/output operations, into which a record is read during input and from which a record is written during output.

C

call. To invoke a subroutine by using the CALL statement or CALL option.

character comparison. A left-to-right, character-by-character comparison according to the collating sequence. See also *arithmetic comparison, bit comparison*.

character string constant. A sequence of characters enclosed in single quotes; for example, `'Shakespeare''s` “Hamlet”`'`.

character set. A defined collection of characters. See *language character set* and *data character set*. See also *ASCII* and *EBCDIC*.

character string picture data. Picture data that has only a character value. This type of picture data must have at least one A or X picture specification character. Contrast with *numeric picture data*.

closing (of a file). The dissociation of a file from a data set or device.

coded arithmetic data. Data items that represent numeric values and are characterized by their base (decimal or binary), scale (fixed-point or floating-point), and precision (the number of digits each can have). This data is stored in a form that is acceptable, without conversion, for arithmetic calculations.

combined nesting depth. The deepest level of nesting, determined by counting the levels of PROCEDURE/BEGIN/ON, DO, SELECT, and IF...THEN...ELSE nestings in the program.

comment. A string of zero or more characters used for documentation that are delimited by /* and */.

commercial character.

- CR (credit) picture specification character
- DB (debit) picture specification character

comparison operator. An operator that can be used in an arithmetic, string locator, or logical relation to indicate the comparison to be done between the terms in the relation. The comparison operators are:

= (equal to)
> (greater than)
< (less than)
>= (greater than or equal to)
<= (less than or equal to)
¬= (not equal to)
¬> (not greater than)
¬< (not less than).

compile time. In general, the time during which a source program is translated into an object module. In PL/I, it is the time during which a source program can be altered, if desired, and then translated into an object program.

compiler options. Keywords that are specified to control certain aspects of a compilation, such as: the nature of the object module generated, the types of printed output produced, and so forth.

complex data. Arithmetic data, each item of which consists of a real part and an imaginary part.

composite operator. An operator that consists of more than one special character, such as <=, **, and /*.

compound statement. A statement that contains other statements. In PL/I, IF, ON, OTHERWISE, and WHEN are the only compound statements. See *statement body*.

concatenation. The operation that joins two strings in the order specified, forming one string whose length is equal to the sum of the lengths of the two original strings. It is specified by the operator ||.

condition. An exceptional situation, either an error (such as an overflow), or an expected situation (such as the end of an input file). When a condition is raised (detected), the action established for it is processed. See also *established action* and *implicit action*.

condition name. Name of a PL/I-defined or programmer-defined condition.

condition prefix. A parenthesized list of one or more condition names prefixed to a statement. It specifies whether the named conditions are to be enabled or disabled.

connected aggregate. An array or structure whose elements occupy contiguous storage without any intervening data items. Contrast with *nonconnected aggregate*.

connected reference. A reference to connected storage. It must be apparent, prior to execution of the program, that the storage is connected.

connected storage. Main storage of an uninterrupted linear sequence of items that can be referred to by a single name.

constant. (1) An arithmetic or string data item that does not have a name and whose value cannot change. (2) An identifier declared with the VALUE attribute. (3) An identifier declared with the FILE or the ENTRY attribute but without the VARIABLE attribute.

constant reference. A value reference which has a constant as its object

contained block, declaration, or source text. All blocks, procedures, statements, declarations, or source text inside a begin, procedure, or a package block. The entire package, procedure, and the BEGIN statement and its corresponding END statements are not contained in the block.

containing block. The package, procedure, or begin-block that contains the declaration, statement, procedure, or other source text in question.

contextual declaration. The appearance of an identifier that has not been explicitly declared in a DECLARE statement, but whose context of use allows the association of specific attributes with the identifier.

control character. A character in a character set whose occurrence in a particular context specifies a control function. One example is the end-of-file (EOF) marker.

control format item. A specification used in edit-directed transmission to specify positioning of a data item within the stream or printed page.

control variable. A variable that is used to control the iterative execution of a DO statement.

controlled parameter. A parameter for which the CONTROLLED attribute is specified in a DECLARE statement. It can be associated only with arguments that have the CONTROLLED attribute.

controlled storage allocation. The allocation of storage for controlled variables.

controlled variable. A variable whose allocation and release are controlled by the ALLOCATE and FREE statements, with access to the current generation only.

conversion. The transformation of a value from one representation to another to conform to a given set of attributes. For example, converting a character string to an arithmetic value such as FIXED BINARY (15,0).

cross section of an array. The elements represented by the extent of at least one dimension of an array. An asterisk in the place of a subscript in an array reference indicates the entire extent of that dimension.

current generation. The generation of an automatic or controlled variable that is currently available by referring to the name of the variable.

D

DDM file. A &system. file that is associated with a remote file that is accessed using DDM. The DDM file provides the information needed for a local (source) system to locate a remote (target) system and to access the file at the target system where the requested data is stored.

data. Representation of information or of value in a form suitable for processing.

data aggregate. A data item that is a collection of other data items.

data attribute. A keyword that specifies the type of data that the data item represents, such as FIXED BINARY.

data-directed transmission. The type of stream-oriented transmission in which data is transmitted. It resembles an assignment statement and is of the form:

```
name = constant
```

data item. A single named unit of data.

data list. In stream-oriented transmission, a parenthesized list of the data items used in GET and PUT statements. Contrast with *format list*.

data set. (1) A collection of data external to the program that can be accessed by reference to a single file name. (2) A device that can be referenced.

data specification. The portion of a stream-oriented transmission statement that specifies the mode of transmission (DATA, LIST, or EDIT) and includes the data list(s) and, for edit-directed mode, the format list(s).

data stream. Data being transferred from or to a data set by stream-oriented transmission, as a continuous stream of data elements in character form.

data transmission. The transfer of data from a data set to the program or vice versa.

data type. A set of data attributes.

DBCS. In the character set, each character is represented by two consecutive bytes.

deactivated. The state in which an identifier is said to be when its value cannot replace a preprocessor identifier in source program text. Contrast with *active*.

debugging. Process of removing bugs from a program.

decimal. The number system whose numerals are 0 through 9.

decimal digit. One of the digits 0 through 9.

decimal digit picture character. The picture specification character 9.

decimal fixed-point constant. A constant consisting of one or more decimal digits with an optional decimal point.

decimal fixed-point value. A rational number consisting of a sequence of decimal digits with an assumed position of the decimal point. Contrast with *binary fixed-point value*.

decimal floating-point constant. A value made up of a significand that consists of a decimal fixed-point constant, and an exponent that consists of the letter E followed by an optionally signed integer constant not exceeding three digits.

decimal floating-point value. An approximation of a real number, in the form of a significand, which can be considered as a decimal fraction, and an exponent, which can be considered as an integer exponent to the base of 10. Contrast with *binary floating-point value*.

decimal picture data. See *numeric picture data.*

declaration. (1) The establishment of an identifier as a name and the specification of a set of attributes (partial or complete) for it. (2) A source of attributes of a particular name.

default. Describes a value, attribute, or option that is assumed when none has been specified.

defined variable. A variable that is associated with some or all of the storage of the designated base variable.

delimit. To enclose one or more items or statements with preceding and following characters or keywords.

delimiter. All comments and the following characters: percent, parentheses, comma, period, semicolon, colon, assignment symbol, blank, pointer, asterisk, and single quote. They define the limits of identifiers, constants, picture specifications, iSUBs, and keywords.

descriptor. A control block that holds information about a variable, such as area size, array bounds, or string length.

digit. One of the characters 0 through 9.

dimension attribute. An attribute that specifies the number of dimensions of an array and indicates the bounds of each dimension.

disabled. The state of a condition in which no interrupt occurs and no established action will take place.

do-group. A sequence of statements delimited by a DO statement and ended by its corresponding END statement, used for control purposes. Contrast with *block*.

do-loop. See *iterative do-group*.

dummy argument. Temporary storage that is created automatically to hold the value of an argument that cannot be passed by reference.

dump. Printout of all or part of the storage used by a program as well as other program information, such as a trace of an error's origin.

E

EBCDIC. (Extended Binary-Coded Decimal Interchange Code). A coded character set consisting of 8-bit coded characters.

edit-directed transmission. The type of stream-oriented transmission in which data appears as a continuous stream of characters and for which a format list is required to specify the editing desired for the associated data list.

element. A single item of data as opposed to a collection of data items such as an array; a scalar item.

element expression. An expression whose evaluation yields an element value.

element variable. A variable that represents an element; a scalar variable.

elementary name. See *base element*.

enabled. The state of a condition in which the condition can cause an interrupt and then invocation of the appropriate established ON-unit.

entry constant. (1) The label prefix of a PROCEDURE statement (an entry name). (2) The declaration of a name with the ENTRY attribute but without the VARIABLE attribute.

entry data. A data item that represents an entry point to a procedure.

entry expression. An expression whose evaluation yields an entry name.

entry name. (1) An identifier that is explicitly or contextually declared to have the ENTRY attribute (unless the VARIABLE attribute is given) or (2) An identifier that has the value of an entry variable with the ENTRY attribute implied.

entry point. A point in a procedure at which it can be invoked. *primary entry point* and *secondary entry point*.

entry reference. An entry constant, an entry variable reference, or a function reference that returns an entry value.

entry variable. A variable to which an entry value can be assigned. It must have both the ENTRY and VARIABLE attributes.

entry value. The entry point represented by an entry constant or variable; the value includes the environment of the activation that is associated with the entry constant.

environment (of an activation). Information associated with and used in the invoked block regarding data declared in containing blocks.

environment (of a label constant). Identity of the particular activation of a block to which a reference to a statement-label constant applies. This information is determined at the time a statement-label constant is passed as an argument or is assigned to a statement-label variable, and it is passed or assigned along with the constant.

established action. The action taken when a condition is raised. See also *implicit action* and *ON-statement action*.

epilogue. Those processes that occur automatically at the termination of a block or task.

evaluation. The reduction of an expression to a single value, an array of values, or a structured set of values.

event. An activity in a program whose status and completion can be determined from an associated event variable.

event variable. A variable with the EVENT attribute that can be associated with an event. Its value indicates whether the action has been completed and the status of the completion.

explicit declaration. The appearance of an identifier (a name) in a DECLARE statement, as a label prefix, or in a parameter list. Contrast with *implicit declaration*.

exponent characters. The following picture specification characters:

1. K and E, which are used in floating-point picture specifications to indicate the beginning of the exponent field.
2. F, the scaling factor character, specified with an integer constant that indicates the number of decimal positions the decimal point is to be moved from its assumed position to the right (if the constant is positive) or to the left (if the constant is negative).

expression. (1) A notation, within a program, that represents a value, an array of values, or a structured set of values; (2) A constant or a reference appearing alone, or a combination of constants and/or references with operators.

extended alphabet. The upper and lower case alphabetic characters A through Z, $, @ and #, or those specified in the NAMES compiler option.

extent. (1) The range indicated by the bounds of an array dimension, by the length of a string, or by the size of an area (2) The size of the target area if this area were to be assigned to a target area.

external name. A name (with the EXTERNAL attribute) whose scope is not necessarily confined only to one block and its contained blocks.

external procedure. (1) A procedure that is not contained in any other procedure. (2) A level-2 procedure contained in a package that is also exported.

extralingual character. Characters (such as $, @, and #) that are not classified as alphanumeric or special. This group includes characters that are determined with the NAMES compiler option.

F

factoring. The application of one or more attributes to a parenthesized list of names in a DECLARE statement, eliminating the repetition of identical attributes for multiple names

field (in the data stream). That portion of the data stream whose width, in number of characters, is defined by a single data or spacing format item.

field (of a picture specification). Any character-string picture specification or that portion (or all) of a numeric character picture specification that describes a fixed-point number.

file. A named representation, within a program, of a data set or data sets. A file is associated with the data set(s) for each opening.

file constant. A name declared with the FILE attribute but not the VARIABLE attribute.

file description attributes. Keywords that describe the individual characteristics of each file constant. See also *alternative attribute* and *additive attribute*.

file expression. An expression whose evaluation yields a value of the type file.

file name. A name declared for a file.

file variable. A variable to which file constants can be assigned. It has the attributes FILE and VARIABLE and cannot have any of the file description attributes.

fixed-point constant. See *arithmetic constant*.

floating-point constant. See *arithmetic constant*.

flow of control. Sequence of execution.

format. A specification used in edit-directed data transmission to describe the representation of a data item in the stream (data format item) or the specific positioning of a data item within the stream (control format item).

format constant. The label prefix on a FORMAT statement.

format data. A variable with the FORMAT attribute.

format label. The label prefix on a FORMAT statement.

format list. In stream-oriented transmission, a list specifying the format of the data item on the external medium. Contrast with *data list*.

fully qualified name. A name that includes all the names in the hierarchical sequence above the member to which the name refers, as well as the name of the member itself.

function (procedure). (1) A procedure that has a RETURNS option in the PROCEDURE statement. (2) A name declared with the RETURNS attribute. It is invoked by the appearance of one of its entry names in a function reference and it returns a scalar value to the point of reference. Contrast with *subroutine*.

function reference. An entry constant or an entry variable, either of which must represent a function, followed by a possibly empty argument list. Contrast with *subroutine call*.

G

generation (of a variable). The allocation of a static variable, a particular allocation of a controlled or automatic variable, or the storage indicated by a particular locator qualification of a based variable or by a defined variable or parameter.

generic descriptor. A descriptor used in a GENERIC attribute.

generic key. A character string that identifies a class of keys. All keys that begin with the string are members of that class. For example, the recorded keys “ABCD,” “ABCE,” and “ABDF,” are all members of the classes identified by the generic keys “A” and “AB,” and the first two are also members of the class “ABC”; and the three recorded keys can be considered to be unique members of the classes “ABCD,” “ABCE,” “ABDF,” respectively.

generic name. The name of a family of entry names. A reference to the generic name is replaced by the entry name whose parameter descriptors match the attributes of the arguments in the argument list at the point of invocation.

group. A collection of statements contained within larger program units. A group is either a do-group or a select-group and it can be used wherever a single statement can appear, except as an on-unit.

H

hex. See *hexadecimal digit*.

hexadecimal. Pertaining to a numbering system with a base of sixteen; valid numbers use the digits 0 through 9 and the characters A through F, where A represents 10 and F represents 15.

hexadecimal digit. One of the digits 0 through 9 and A through F. A through F represent the decimal values 10 through 15, respectively.

I

identifier. A string of characters, not contained in a comment or constant, and preceded and followed by a delimiter. The first character of the identifier must be one of the 26 alphabetic characters and extralingual characters, if any. The other characters, if any, can additionally include extended alphabetic, digit, or the break character.

IEEE. Institute of Electrical and Electronics Engineers.

implicit. The action taken in the absence of an explicit specification.

implicit action. The action taken when an enabled condition is raised and no ON-unit is currently established for the condition. Contrast with *ON-statement action*.

implicit declaration. A name not explicitly declared in a DECLARE statement or contextually declared.

implicit opening. The opening of a file as the result of an input or output statement other than the OPEN statement.

infix operator. An operator that appears between two operands.

inherited dimensions. For a structure, union, or element, those dimensions that are derived from the containing structures. If the name is an element that is not an array, the dimensions consist entirely of its inherited dimensions. If the name is an element that is an array, its dimensions consist of its inherited dimensions plus its explicitly declared dimensions. A structure with one or more inherited dimensions is called a nonconnected aggregate. Contrast with *connected aggregate*.

input/output. The transfer of data between auxiliary medium and main storage.

insertion point character. A picture specification character that is, on assignment of the associated data to a character string, inserted in the indicated position. When used in a P-format item for input, the insertion character is used for checking purposes.

integer. (1) An optionally signed sequence of digits or a sequence of bits without a decimal or binary point. (2) An optionally signed whole number, commonly described as FIXED BINARY (p,0) or FIXED DECIMAL (p,0).

integral boundary. A byte multiple address of any 8-bit unit on which data can be aligned. It usually is a half-word, full-word, or double-word (2-, 4-, or 8-byte multiple respectively) boundary.

interleaved array. An array that refers to nonconnected storage.

interleaved subscripts. Subscripts that exist in levels other than the lowest level of a subscripted qualified reference.

internal block. A block that is contained in another block.

internal name. A name that is known only within the block in which it is declared, and possibly within any contained blocks.

internal procedure. A procedure that is contained in another block. Contrast with *external procedure*.

interrupt. The redirection of the program's flow of control as the result of raising a condition or attention.

invocation. The activation of a procedure.

invoke. To activate a procedure.

invoked procedure. A procedure that has been activated.

invoking block. A block that activates a procedure.

iteration factor. (1) In an INITIAL attribute specification, an expression that specifies the number of consecutive elements of an array that are to be initialized with the given value. (2) In a format list, an expression that specifies the number of times a given format item or list of format items is to be used in succession.

iterative do-group. A do-group whose DO statement specifies a control variable and/or a WHILE or UNTIL option.

K

key. Data that identifies a record within a direct-access data set. See *source key* and *recorded key*.

keyword. An identifier that has a specific meaning in PL/I when used in a defined context.

keyword statement. A simple statement that begins with a keyword, indicating the function of the statement.

known (applied to a name). Recognized with its declared meaning. A name is known throughout its scope.

L

label. (1) A name prefixed to a statement. A name on a PROCEDURE statement is called an entry constant; a name on a FORMAT statement is called a format constant; a name on other kinds of statements is called a label constant. (2) A data item that has the LABEL attribute.

label constant. A name written as the label prefix of a statement (other than PROCEDURE, ENTRY, FORMAT, or PACKAGE) so that, during execution, program control can be transferred to that statement through a reference to its label prefix.

label data. A label constant or the value of a label variable.

label prefix. A label prefixed to a statement.

label variable. A variable declared with the LABEL attribute. Its value is a label constant in the program.

leading zeroes. Zeros that have no significance in an arithmetic value. All zeros to the left of the first nonzero in a number.

level number. A number that precedes a name in a DECLARE statement and specifies its relative position in the hierarchy of structure names.

level-one variable. (1) A major structure or union name. (2) Any unsubscripted variable not contained within a structure or union.

lexically. Relating to the left-to-right order of units.

list-directed. The type of stream-oriented transmission in which data in the stream appears as constants separated by blanks or commas and for which formatting is provided automatically.

locator. A control block that holds the address of a variable or its descriptor.

locator/descriptor. A locator followed by a descriptor. The locator holds the address of the variable, not the address of the descriptor.

locator qualification. In a reference to a based variable, either a locator variable or function reference connected by an arrow to the left of a based variable to specify the generation of the based variable to which the reference refers. It might be an implicit reference.

locator value. A value that identifies or can be used to identify the storage address.

locator variable. A variable whose value identifies the location in main storage of a variable or a buffer. It has the POINTER or OFFSET attribute.

locked record. A record in an EXCLUSIVE DIRECT UPDATE file that has been made available to one task only and cannot be accessed by other tasks until the task using it relinquishes it.

logical level (of a structure or union member). The depth indicated by a level number when all level numbers are in direct sequence (when the increment between successive level numbers is one).

logical operators. The bit-string operators not and exclusive-or (¬), and (&), and or (|).

loop. A sequence of instructions that is executed iteratively.

lower bound. The lower limit of an array dimension.

M

main procedure. An external procedure whose PROCEDURE statement has the OPTIONS (MAIN) attribute. This procedure is invoked automatically as the first step in the execution of a program.

major structure. A structure whose name is declared with level number 1.

member. A structure, union, or element name, possibly dimensioned, in a structure or union.

minor structure. A structure that is contained within another structure or union. The name of a minor structure is declared with a level number greater than one and greater than its parent structure or union.

mode (of arithmetic data). An attribute of arithmetic data. It is either *real* or *complex*.

multiple declaration. (1) Two or more declarations of the same identifier internal to the same block without different qualifications. (2) Two or more external declarations of the same identifier.

multiprocessing. The use of a computing system with two or more processing units to execute two or more programs simultaneously.

multiprogramming. The use of a computing system to execute more than one program concurrently, using a single processing unit.

multitasking. A facility that allows a program to execute more than one PL/I procedure simultaneously.

N

name. Any identifier that the user gives to a variable or to a constant. An identifier appearing in a context where it is not a keyword. Sometimes called a user-defined name.

nesting. The occurrence of:

- A block within another block
- A group within another group
- An IF statement in a THEN clause or in an ELSE clause
- A function reference as an argument of a function reference
- A remote format item in the format list of a FORMAT statement
- A parameter descriptor list in another parameter descriptor list
- An attribute specification within a parenthesized name list for which one or more attributes are being factored.

nonconnected storage. Storage occupied by nonconnected data items. For example, interleaved arrays and structures with inherited dimensions are in nonconnected storage.

null locator value. A special locator value that cannot identify any location in internal storage. It gives a positive indication that a locator variable does not currently identify any generation of data.

null statement. A statement that contains only the semicolon symbol (;). It indicates that no action is to be taken.

null string. A character, graphic, or bit string with a length of zero.

numeric-character data. See *decimal picture data*.

numeric picture data. Picture data that has an arithmetic value as well as a character value. This type of picture data cannot contain the characters “A” or “X.”

O

object. A collection of data referred to by a single name.

offset variable. A locator variable with the OFFSET attribute, whose value identifies a location in storage relative to the beginning of an area.

ON-condition. An occurrence, within a PL/I program, that could cause a program interrupt. It can be the detection of an unexpected error or of an occurrence that is expected, but at an unpredictable time.

ON-statement action. The action explicitly established for a condition that is executed when the condition is raised. When the ON-statement is encountered in the flow of control for the program, it executes, establishing the action for the condition. The action executes when the condition is raised if the ON-unit is still established or a RESIGNAL statement re-establishes it. Contrast with *implicit action*.

ON-unit. The specified action to be executed when the appropriate condition is raised.

opening (of a file). The association of a file with a data set.

operand. The value of an identifier, constant, or an expression to which an operator is applied, possibly in conjunction with another operand.

operational expression. An expression that consists of one or more operators.

operator. A symbol specifying an operation to be performed.

option. A specification in a statement that can be used to influence the execution or interpretation of the statement.

P

package constant. The label prefix on a PACKAGE statement.

packed decimal. The internal representation of a fixed-point decimal data item.

padding. (1) One or more characters, graphics, or bits concatenated to the right of a string to extend the string to a required length. (2) One or more bytes or bits inserted in a structure or union so that the following element within the structure or union is aligned on the appropriate integral boundary.

parameter. A name in the parameter list following the PROCEDURE statement, specifying an argument that will be passed when the procedure is invoked.

parameter descriptor. The set of attributes specified for a parameter in an ENTRY attribute specification.

parameter descriptor list. The list of all parameter descriptors in an ENTRY attribute specification.

parameter list. A parenthesized list of one or more parameters, separated by commas and following either the keyword PROCEDURE in a procedure statement or the keyword ENTRY in an ENTRY statement. The list corresponds to a list of arguments passed at invocation.

partially qualified name. A qualified name that is incomplete. It includes one or more, but not all, of the names in the hierarchical sequence above the structure or union member to which the name refers, as well as the name of the member itself.

picture data. Numeric data, character data, or a mix of both types, represented in character form.

picture specification. A data item that is described using the picture characters in a declaration with the PICTURE attribute or in a P-format item.

picture specification character. Any of the characters that can be used in a picture specification.

PL/I character set. A set of characters that has been defined to represent program elements in PL/I.

point of invocation. The point in the invoking block at which the reference to the invoked procedure appears.

pointer. A type of variable that identifies a location in storage.

pointer value. A value that identifies the pointer type.

pointer variable. A locator variable with the POINTER attribute that contains a pointer value.

precision. The number of digits or bits contained in a fixed-point data item, or the minimum number of significant digits (excluding the exponent) maintained for a floating-point data item.

prefix. A label or a parenthesized list of one or more condition names included at the beginning of a statement.

prefix operator. An operator that precedes an operand and applies only to that operand. The prefix operators are plus (+), minus (–), and not (¬).

preprocessor. A program that examines the source program before the compilation takes place.

preprocessor statement. A special statement appearing in the source program that specifies the actions to be performed by the preprocessor. It is executed as it is encountered by the preprocessor.

primary entry point. The entry point identified by any of the names in the label list of the PROCEDURE statement.

priority. A value associated with a task, that specifies the precedence of the task relative to other tasks.

problem data. Coded arithmetic, bit, character, graphic, and picture data.

problem-state program. A program that operates in the problem state of the operating system. It does not contain input/output instructions or other privileged instructions.

procedure. A collection of statements, delimited by PROCEDURE and END statements. A procedure is a program or a part of a program, delimits the scope of names, and is activated by a reference to the procedure or one of its entry names. See also *external procedure* and *internal procedure*.

procedure reference. An entry constant or variable. It can be followed by an argument list. It can appear in a CALL statement or the CALL option, or as a function reference.

program. A set of one or more external procedures or packages. One of the external procedures must have the OPTIONS(MAIN) specification in its procedure statement.

program control data. Area, locator, label, format, entry, and file data that is used to control the processing of a PL/I program.

prologue. The processes that occur automatically on block activation.

pseudovariable. Any of the built-in function names that can be used to specify a target variable. It is usually on the left-hand side of an assignment statement.

Q

qualified name. A hierarchical sequence of names of structure or union members, connected by periods, used to identify a name within a structure. Any of the names can be subscripted.

R

range (of a default specification). A set of identifiers and/or parameter descriptors to which the attributes in a DEFAULT statement apply.

record. (1) The logical unit of transmission in a record-oriented input or output operation. (2) A collection of one or more related data items. The items usually have different data attributes and usually are described by a structure or union declaration.

recorded key. A character string identifying a record in a direct-access data set where the character string itself is also recorded as part of the data.

record-oriented data transmission. The transmission of data in the form of separate records. Contrast with *stream data transmission*.

recursive procedure. A procedure that can be called from within itself or from within another active procedure.

reentrant procedure. A procedure that can be activated by multiple tasks, threads, or processes simultaneously without causing any interference between these tasks, threads, and processes.

REFER expression. The expression preceding the keyword REFER, which is used as the bound, length, or size when the based variable containing a REFER option is allocated, either by an ALLOCATE or LOCATE statement.

REFER object. The variable in a REFER option that holds or will hold the current bound, length, or size for the member. The REFER object must be a member of the same structure or union. It must not be locator-qualified or subscripted, and it must precede the member with the REFER option.

reference. The appearance of a name, except in a context that causes explicit declaration.

relative virtual origin (RVO). The actual origin of an array minus the virtual origin of an array.

remote format item. The letter R followed by the label (enclosed in parentheses) of a FORMAT statement. The format statement is used by edit-directed data transmission statements to control the format of data being transmitted.

repetition factor. A parenthesized unsigned integer constant that specifies:

1. The number of times the string constant that follows is to be repeated.
2. The number of times the picture character that follows is to be repeated.

repetitive specification. An element of a data list that specifies controlled iteration to transmit one or more data items, generally used in conjunction with arrays.

restricted expression. An expression that can be evaluated by the compiler during compilation, resulting in a constant. Operands of such an expression are constants, named constants, and restricted expressions.

returned value. The value returned by a function procedure.

RETURNS descriptor. A descriptor used in a RETURNS attribute, and in the RETURNS option of the PROCEDURE and ENTRY statements.

S

scalar variable. A variable that is not a structure, union, or array.

scale. A system of mathematical notation whose representation of an arithmetic value is either fixed-point or floating-point.

scale factor. A specification of the number of fractional digits in a fixed-point number.

scaling factor. See *scale factor*.

scope (of a condition prefix). The portion of a program throughout which a particular condition prefix applies.

scope (of a declaration or name). The portion of a program throughout which a particular name is known.

secondary entry point. An entry point identified by any of the names in the label list of an entry statement.

select-group. A sequence of statements delimited by SELECT and END statements.

selection clause. A WHEN or OTHERWISE clause of a select-group.

self-defining data. An aggregate that contains data items whose bounds, lengths, and sizes are determined at program execution time and are stored in a member of the aggregate.

separator. See *delimiter*.

shift. Change of data in storage to the left or to the right of original position.

shift-in. Symbol used to signal the compiler at the end of a double-byte string.

shift-out. Symbol used to signal the compiler at the beginning of a double-byte string.

sign and currency symbol characters. The picture specification characters. S, +, –, and $ (or other national currency symbols enclosed in < and >).

simple parameter. A parameter for which no storage class attribute is specified. It can represent an argument of any storage class, but only the current generation of a controlled argument.

simple statement. A statement other than IF, ON, WHEN, and OTHERWISE.

source. Data item to be converted for problem data.

source key. A key referred to in a record-oriented transmission statement that identifies a particular record within a direct-access data set.

source program. A program that serves as input to the source program processors and the compiler.

source variable. A variable whose value participates in some other operation, but is not modified by the operation. Contrast with *target variable*.

standard default. The alternative attribute or option assumed when none has been specified and there is no applicable DEFAULT statement.

standard file. A file assumed by PL/I in the absence of a FILE or STRING option in a GET or PUT statement. SYSIN is the standard input file and SYSPRINT is the standard output file.

standard system action. Action specified by the language to be taken for an enabled condition in the absence of an on-unit for that condition.

statement. A PL/I statement, composed of keywords, delimiters, identifiers, operators, and constants, and terminated by a semicolon (;). Optionally, it can have a condition prefix list and a list of labels. See also *keyword statement, assignment statement*, and *null statement*.

statement body. A statement body can be either a simple or a compound statement.

statement label. See *label constant*.

static storage allocation. The allocation of storage for static variables.

static variable. A variable that is allocated before execution of the program begins and that remains allocated for the duration of execution.

stream-oriented data transmission. The transmission of data in which the data is treated as though it were a continuous stream of individual data values in character form. Contrast with *record-oriented data transmission*.

string. A contiguous sequence of characters, graphics, or bits that is treated as a single data item.

string variable. A variable declared with the BIT, CHARACTER, or GRAPHIC attribute, whose values can be either bit, character, or graphic strings.

structure. A collection of data items that need not have identical attributes. Contrast with *array*.

structure expression. An expression whose evaluation yields a structure set of values.

structure of arrays. A structure that has the dimension attribute.

structure member. See *member*.

structuring. The hierarchy of a structure, in terms of the number of members, the order in which they appear, their attributes, and their logical level.

subroutine. A procedure that has no RETURNS option in the PROCEDURE statement. Contrast with *function*.

subroutine call. An entry reference that must represent a subroutine, followed by an optional argument list that appears in a CALL statement. Contrast with *function reference*.

subscript. An element expression that specifies a position within a dimension of an array. If the subscript is an asterisk, it specifies all of the elements of the dimension.

subscript list. A parenthesized list of one or more subscripts, one for each dimension of the array, which together uniquely identify either a single element or cross section of the array.

subtask. A task that is attached by the given task or any of the tasks in a direct line from the given task to the last attached task.

synchronous. A single flow of control for serial execution of a program.

T

target. Attributes to which a data item (source) is converted.

target reference. A reference that designates a receiving variable (or a portion of a receiving variable).

target variable. A variable to which a value is assigned.

task. The execution of one or more procedures by a single flow of control .

task name. An identifier used to refer to a task variable.

task variable. A variable with the TASK attribute whose value gives the relative priority of a task.

termination (of a block). Cessation of execution of a block, and the return of control to the activating block by means of a RETURN or END statement, or the transfer of control to the activating block or to some other active block by means of a GO TO statement.

termination (of a task). Cessation of the flow of control for a task.

truncation. The removal of one or more digits, characters, graphics, or bits from one end of an item of data when a string length or precision of a target variable has been exceeded.

type. The set of data attributes and storage attributes that apply to a generation, a value, or an item of data.

U

undefined. Indicates something that a user must not do. Use of a undefined feature is likely to produce different results on different implementations of a PL/I product. In that case, the application program is considered to be in error.

union. A collection of data elements that overlay each other, occupying the same storage. The members can be structures, unions, elementary variables, or arrays. They need not have identical attributes.

union of arrays. A union that has the DIMENSION attribute.

upper bound. The upper limit of an array dimension.

V

value reference. A reference used to obtain the value of an item of data.

variable. A named entity used to refer to data and to which values can be assigned. Its attributes remain constant, but it can refer to different values at different times.

variable reference. A reference that designates all or part of a variable.

virtual origin (VO). The location where the element of the array whose subscripts are all zero are held. If such an element does not appear in the array, the virtual origin is where it would be held.

Z

zero-suppression characters. The picture specification characters Z and *, which are used to suppress zeros in the corresponding digit positions and replace them with blanks or asterisks respectively.

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