English

COBOL85 V2.3

COBOL Compiler

User Guide

Edition July 2014

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Contents

1 Preface

1.1 Summary of contents

This User Guide describes how COBOL source programs produced in a BS2000 environment can be

– prepared for compilation,
– compiled with the COBOL85 compiler,
– linked into executable programs and loaded into main memory, and
– tested for logical errors in debugging sessions.

In addition, it includes details of how COBOL programs

– utilize BS2000 facilities for information exchange,
– process cataloged files,
– sort and merge files,
– take checkpoints and use them for subsequent restarts, and
– communicate with other programs (program linkage).

It also includes a chapter (chapter 13) on how the COBOL85 compiler and the programs it generates can be used within the POSIX subsystem of BS2000/OSD and on how the POSIX file system is accessed.

Familiarity with the COBOL programming language and with simple applications of BS2000 is prerequisite to understanding this manual.
Language elements of the COBOL85 compiler are discussed in detail in the "COBOL85 Language Reference Manual" [1].

Other publications are referred to in the text by their abbreviated titles or by numbers enclosed in square brackets. The full titles are listed with their corresponding numbers under "References".

1.2 Expansion levels of the COBOL85 system

The COBOL85 system V2.3 is supplied in three configurations:

– COBOL85-R (maximum configuration with RISC code generator)

– COBOL85 (maximum configuration without RISC code generator)

– COBOL85-BC (basic configuration)

The BC version of COBOL85 does not include the following control and language facilities:

– AID debugging tool

– Output of a list of all error messages

– Output of object listings

– COBOL-DML language elements for database links

– Report-Writer language module

– COBOL85 Structurizer

– Compiler and program execution in the POSIX subsystem

This User Guide refers to the full-featured configuration. Descriptions of the functions that are not supported by the COBOL85-BC basic configuration are indicated by an appropriate note.

As of Version 2.1A, the COBOL85 compiler does not include the COBOL runtime system. The COBOL85 runtime system is a component of CRTE, the common runtime environment for COBOL85, C and C++ programs.
The COBOL85 runtime system in CRTE provides runtime support for all programs compiled by Version 1.0A and above of the COBOL85 compiler.

1.3 Changes since the last version of the manual

The table below lists the most important technical additions and changes, with reference to the relevant chapter and section numbers.
Changes regarding content and language have been made throughout the manual and are not indicated explicitly in this list.

Chapter / section	**Keyword**	**new**	**changed**	**deleted**
3.3.4	COMPILER-ACTION option: addition of operands for segmentation and RISC-CODE SEGMENTATION = DESTINATION-CODE=	X		
3.3.6	LISTING option: new parameter to allow marking of new keywords in accordance with future standard: MARK-NEW-KEYWORDS parameter to allow year numbers to be processed without century digits: REPORT-2-DIGIT-YEAR	X		
4.2	COMOPT operands for segmentation, RISC-CODE, marking of new keywords in accordance with future standard, generation of faster code when transferring numeric data items (USAGE DISPLAY): ELABORATE-SEGMENTATION GENERATE-RISC-CODE MARK-NEW-KEYWORDS INHIBIT-BAD-SIGN-PROPAGATION	X		
5	Structurizer, addition to the description of the language scope	X		
16	List of compiler modules List of COBOL85 runtime modules		 X	X

1.4 Notational conventions

The following metalinguistic conventions are followed in this user guide:

COMOPT	Uppercase letters denote keywords that must be entered exactly as shown.
name	Lowercase letters denote variables which must be replaced by current values when being entered.
YES <u>NO</u>	Underlining indicates a default value that is automatically used when no value has been specified by the user.
$\left\{\begin{matrix}\text{YES}\\ \\ \underline{\text{NO}}\end{matrix}\right\}$	Braces enclose alternatives, i.e. one of the specified values must be selected. The alternatives are depicted one under the other. If one of the listed values is a default value, no entry need be specified when the default value is desired.
{YES/<u>NO</u>}	A slash separating two adjacent entries also indicates that the entries represent alternatives from which one must be selected. No entry is required if the given default value is desired.
[ ]	Brackets enclose optional entries that may be omitted by the user.
( )	Parentheses must be entered as shown.
␣	This symbol denotes that at least one blank is required for syntactical reasons.
Special characters	Must be entered as given.

Notes

- The usual COBOL conventions apply with regard to the COBOL formats shown in this manual (see “COBOL85 Language Reference Manual” [1]).
- The SDF metasyntax is described separately in chapter 3.2.

1.5 Definitions of terms used in this manual

A number of different terms are frequently used for the same object when describing the process of generating a program. The result obtained from a compiler run, for instance, is called an object module, whereas the same object module in LLM format is referred to as a link-and-load module.

The synonymous use of such terms serves a practical purpose within the context of specific components, but may occasionally be confusing to the user. To prevent any misunderstanding, the most important terms that are used synonymously are defined below for reference.

Object module, prelinked module

The term “object module” refers to object modules as well as “prelinked” modules.

Object modules and prelinked modules have the same structure and are stored in the same format (object module format). Such modules are stored in PLAM libraries as elements of type R.

Object modules are generated by the compiler when source programs are compiled. Prelinked modules are generated by the linkage editor TSOSLNK. A prelinked module is a single module that contains a combination of one or more object modules and/or other prelinked modules.

Object modules can be processed further by the static linkage editor TSOSLNK, the dynamic binder loader DBL, and the linkage editor BINDER.

Module, object module, link-and-load module (LLM)

The term “module” is a generic term for the result obtained by compiling a source program with the COBOL85 compiler. An “object module” is a module in OM format; a “link-and-load module” is a module in LLM format.

Executable program, program, load module, object program

Executable programs are programs that are generated by linkage editors and stored in PLAM libraries as elements of type C. They are often referred to simply as “programs” in this manual. In contrast to object modules, executable programs cannot be processed further by the linkage editor TSOSLNK; they are loaded into memory by a (static) loader.

In some documentation, the term “load module” is also used synonymously for an executable program. Technically speaking, however, a load module is a loadable unit **within** a program. A segmented program, for example, may consist of multiple load modules.

The synonymous use of the term “object program” for a load module could lead to confusion in COBOL terminology. The COBOL Standard uses the term object program for the object generated by the COBOL compiler, without taking any implementation-specific need for a linkage run into account.

Job, task

A job is a sequence of commands, statements, etc., that are specified between the LOGON and LOGOFF commands. A distinction is made between batch jobs (ENTER jobs) and interactive jobs (executed in a dialog).

A job is considered a task if system resources are allocated to it (CPU, memory, devices, etc.). In interactive mode, a job becomes a task as soon as the LOGON command is accepted.

2 Overview

From source code to executable program

Three steps are necessary to convert a COBOL source program into an executable program:

1. Reading in the source program (see section 2.1)
2. Compilation: The source program must be converted into machine language. The compiler generates an object module or a link-and-load module (LLM) and logs the sequence and results of the compilation in listings.
3. Linkage: One or more modules are linked with so-called runtime modules to create an executable program (see chapter 6).

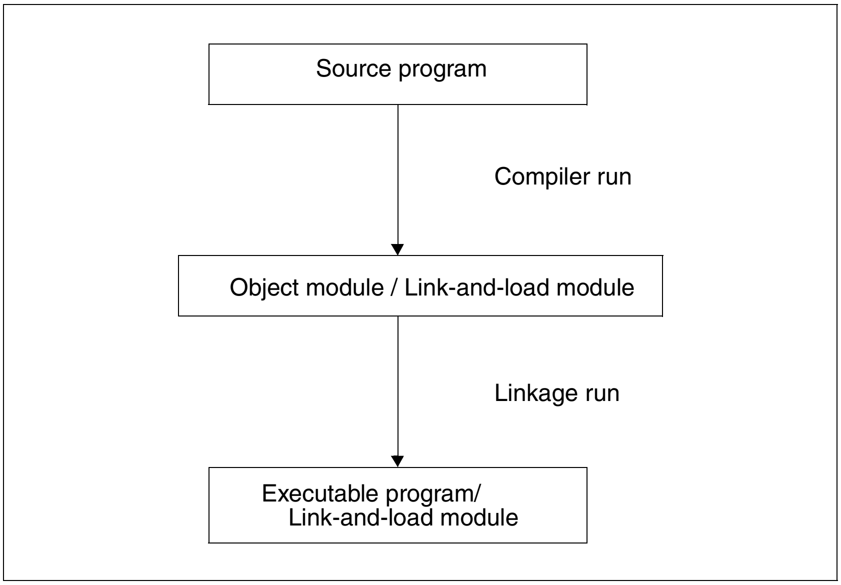


Fig. 2-1 Producing an executable program

Three functions are performed by the compiler during the compilation run:

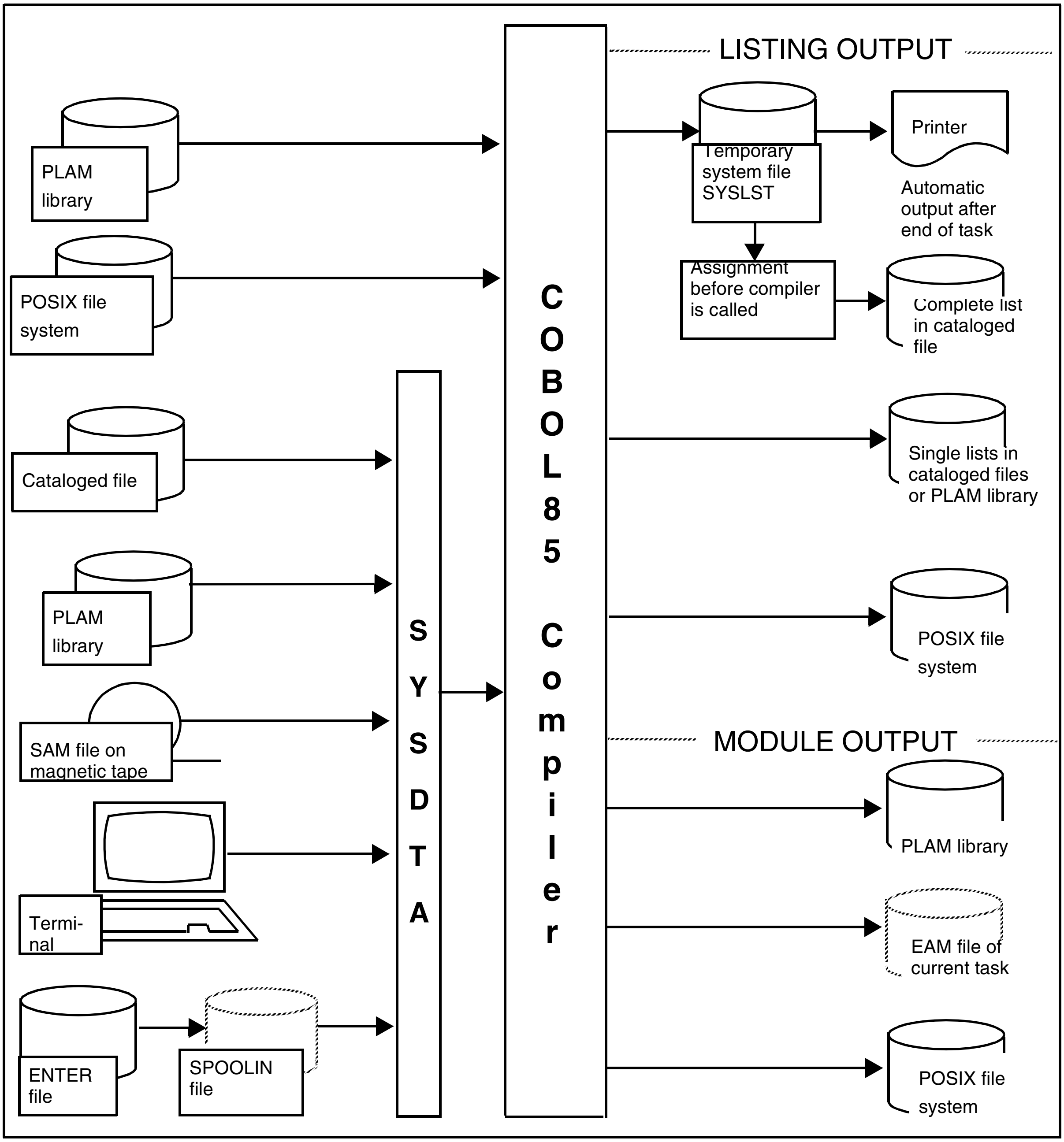
- Checking of the source program for syntax and semantic errors,
- Conversion of COBOL code into machine language,
- Output of messages, listings, and modules.

The user can make use of control statements to

- select COBOL85 functions,
- allocate resources for input and output,
- define characteristics of the modules,
- specify the type and scope of listing output.

The control options provided by COBOL85 and by the operating system are described in detail in chapters 3 and 4.

Possible input sources and output locations for the compiler



2.1 Reading in the source program

After a COBOL source program has been coded, it must be made available to the compiler for compilation.
This can be achieved in several ways, the most common methods being:

– input from a file and

– input from a PLAM library.

The operating system supports the loading of source programs into files or PLAM libraries by means of various commands and utility routines.

2.1.1 Input from cataloged files

This section deals with the various methods that can be used to make a source program available in a cataloged file. The next section discusses PLAM libraries.

COBOL85 can process source programs from SAM or ISAM files. If ISAM files are used, they must be cataloged with KEYPOS=5 and KEYLEN=8. The method used to enter the source program into such a file is contingent on the form in which the program is available:

- If the source program is already stored on an external volume (e.g. magnetic tape), it can be moved to a cataloged file by means of suitable
  - BS2000 commands (see [3]), e.g. the COPY-FILE command (for source programs on magnetic tapes), or
  - utility routines, e.g. ARCHIVE for magnetic tapes.
- If the source program is being entered as it is being written, the file editor EDT (see [21]) can be used. This editor processes both SAM and ISAM files and provides special functions which support the formatted writing and subsequent modification of COBOL source programs. Some of these functions are listed below:
  - The option of setting tabs enables quick and reliable positioning to the starting columns of areas A (column 8) and B (column 12) and thus facilitates compliance with the reference format for COBOL programs (see [1]).
  - Functions for the insertion, deletion, copying, transfer, and modification of single source lines and ranges of lines or columns.
  - Statements for the insertion, deletion, and replacement of character strings in the file.

2.1.2 Input from PLAM libraries

Apart from SAM or ISAM files, PLAM libraries represent another important input source for the COBOL85 compiler.

Characteristics of PLAM libraries

PLAM libraries are PAM files that are processed by using the PLAM (**P**rimary **L**ibrary **A**ccess **M**ethod) access method (see [24]). These libraries can be created and maintained with the help of the LMS utility routine (see [10]).

The elements of a PLAM library typically include source programs or source program segments (COPY elements) as well as modules and executable programs. The individual element types are distinguished by means of specific type designations. Among others, elements of the following types may be stored in a PLAM library:

Type designation	Content of the library elements
S	Source programs, COPY elements
R	Object modules or prelinked modules
C	Executable programs
J	Procedures
L	Link-and-load modules (LLMs)
P	Print-edited data (lists)

Table 2-1: PLAM element types

A PLAM library can also contain elements that have the same name, provided they can be distinguished by version or type designation.

The advantages of maintaining data in PLAM libraries are listed below:

– Up to 30% storage space can be saved by combining different types of elements and by using additional compression techniques.

– Access times are shorter for the various types of elements in the same program library as opposed to access times for conventional data maintenance.

– The burden on EAM storage space is reduced when link-and-load modules are directly stored as PLAM library elements.

Input into PLAM libraries

PLAM libraries can accept source programs
- from files
- from other libraries
- via SYSDTA or SYSIPT, i.e. from a terminal or a temporary spoolin file.

The method used to enter a source program into the PLAM library is contingent on the form in which the program is available:

- If the source program is available in a cataloged file or as a element of a library, it can be transferred to a PLAM library via the LMS utility routine (see example 2-1).
  When transferring a source program from an ISAM file with LMS, it must be noted that the ISAM key is not also transferred with PAR KEY=YES or SOURCE-ATTRIBUTES=KEEP. COBOL85 will not be able to process a source program with ISAM key.
- If the source program is being entered for the first time, it can also be directly written into a PLAM library (as an element) by using the EDT file editor.

Example 2-1: Transfer of a source program from a cataloged file to a PLAM library

```
/START-LMS─────────────────────────────────────────────────────────────────── (1)
%  LMS0310 LMS VERSION  V03.4B10 STARTED
                                                         PRT=(OUT)
//OPEN-LIBRARY LIB=PLAM.LIB,MODE=UPDATE(STATE=NEW)──────────────────────────── (2)
//ADD-ELEM FROM-FILE=SOURCE.EINXEINS,TO-E=LIB-ELEM(ELEM=EINXEINS,TYPE=S) (3)
//END──────────────────────────────────────────────────────────────────────── (4)
%  LMS0311 LMS V03.4B10   TERMINATED NORMALLY
```

(1) The LMS utility routine is invoked.

(2) PLAM.LIB is defined as the new (STATE=NEW) output library (USAGE=OUT). By default, it is created as a PLAM library by LMS.

(3) The source program is transferred from the cataloged file SOURCE.MULTABLE and is included under the name MULTABLE as an S-type element in the PLAM library.

(4) The LMS run is terminated; all open files are closed.

2.2 Source data input

Input to the compiler may consist of the following source data:
- Source programs (individual source programs or source program sequences)

– Source program segments (COPY elements)
– Compiler control statements (COMOPT statements or SDF options)

The compiler can process source programs from cataloged SAM or ISAM files and from elements of PLAM libraries. Input from source programs is described in section 2.1; control statements for the input are detailed in chapters 3 (control statements in SDF format) and 4 (COMOPT statements). The required assignment of the system file SYSDTA, which is common to both control modes, is described below.

2.2.1 Assigning the source program with the ASSIGN-SYSDTA command

By default, the compiler expects source data input from the system file SYSDTA. SYSDTA can be assigned to a cataloged file or library element before the compiler is called. The command for this is:

```
                                  ⎧ filename                              ⎫
/ASSIGN-SYSDTA [TO-FILE =]       ⎨                                       ⎬
                                  ⎩ *LIB-ELEM(LIB=library,ELEM=element)   ⎭
```

Detailed information on the ASSIGN-SYSDTA command is given in the manual "Commands" [3].

Example 2-2: Reading a source program from a cataloged file

```
/ASSIGN-SYSDTA QUELL.MULTABLE  ---------------------------------------- (1)

Call to compiler ------------------------------------------------------- (2)
Compilation

/ASSIGN-SYSDTA *PRIMARY  ---------------------------------------------- (3)
```

(1) The cataloged file SOURCE.MULTABLE, which contains the source program to be compiled, is assigned to the SYSDTA system file.

(2) The compiler is loaded and started. It processes the data that is received from SYSDTA. This applies only if the compiler has not been called via SDF interface or source = ... was not specified here.

(3) The SYSDTA system file is reset to its primary assignment for subsequent tasks.

Example 2-3: Reading a source program from a library

```
/ASSIGN-SYSDTA *LIBRARY-ELEMENT(LIB=PLAM.LIB,ELEM=EXAMP3) ────────────── (1)

Call to compiler ─────────────────────────────────────────────────────── (2)
Compilation

/ASSIGN-SYSDTA *PRIMARY ──────────────────────────────────────────────── (3)
```

(1) The system file SYSDTA is assigned to the element EXAMP3 in the PLAM library PLAM.LIB.

(2) The compiler is invoked. It accesses the assigned library element via SYSDTA. See the example above.

(3) SYSDTA is reset to its primary assignment.

Other methods for the input of source data are related to controlling the compiler with COMPOPT statements and are described in chapter 4.

2.2.2 Input of source program segments

Source program segments (COPY elements) can be stored in libraries as distinct entities independent of the source program in which they are used. This is especially recommended when identical program segments are used in different source programs.
In the source program itself, such program segments are represented by a COPY statement. COPY statements may be located at any position in the source program (except for comment lines and non-numeric literals).
When the compiler encounters a COPY statement in the source program being compiled, it inserts the element specified in the COPY statement from the appropriate library. The COPY element is then compiled as if it were a part of the source program itself.
The COPY statement format is shown and explained in chapter 11 of the COBOL85 Language Reference Manual [1].

Input of COPY elements from PLAM libraries

Before invoking the compiler, the library that contains the COPY element must be assigned to the compiler and linked to the file link name specified below using the SET-FILE-LINK command.
If a library name is specified in the COPY statement, the link name is formed from the first 8 characters of the library name.
If no library name has been declared in the COPY statement, up to ten libraries can be linked using the standard link names COBLIB, and COBLIB1 through COBLIB9. The compiler then searches the assigned libraries in hierarchical order until the required COPY element is found.

Depending on how the COPY statement is formulated in the source program, the following assignments are required in the SET-FILE-LINK command:

COPY statement	**SET-FILE-LINK command**

`COPY textname`
 	
textname: element name (max. 30 characters long)
	`SET-FILE-LINK [LINK-NAME=]standard-linkname,`
	`[FILE-NAME=]libname`
	
	standard-linkname: COBLIB
	COBLIB1..COBLIB9
	libname: Name of the cataloged library in which the COPY element is stored

`COPY textname OF library`
 	
library: library name (max. 30 characters long)
	`SET-FILE-LINK [LINK-NAME=] linkname,`
	`[FILE-NAME=] libname`
	
	linkname: The first eight characters of the name of the library specified in the COPY statement
	libname: Name of the cataloged library in which the COPY element is stored

Input of COPY elements from the POSIX file system

If the POSIX subsystem is available, you can also pass COPY elements from the POSIX file system to the compiler. To do this you use an SDF-P variable with the default name of SYSIOL-COBLIB or SYSIOL-libname. The formulation of the COPY statement in the source program influences the SDF-P variable as follows (see also example 2-6, p.18); this does not apply to BC (basic configuration):

COPY statement	**SDF-P variable**

`COPY textname`
 	
textname: name of POSIX file (max. 30 characters long) containing the COPY text. textname must not contain lowercase letters.
	`DECL-VAR SYSIOL-COBLIB,INIT=‘*POSIX(pfad)‘,`
	`SCOPE=*TASK`
	
	pathname: Absolute pathname (beginning with /) of the directory in which a search is made for the file textname

`COPY textname OF library`
 	
library: name (max. 30 characters long) for forming the SDF-P variable with the name SYSIOL-libname. library must not contain lowercase letters.
	`DECL-VAR SYSIOL-bibliothek=‘*POSIX(pfad)‘,`
	`SCOPE=*TASK`
	
	pathname: Absolute pathname (beginning with /) of the directory in which a search is made for the file textname

Example 2-4: Input of two COPY elements

The source program in the file EXAMPLE1 includes the following COPY statements:

```
IDENTIFICATION DIVISION.
PROGRAM-ID. PROG.
...
    COPY XYZ.──────────────────────────────────────────────────────────── (1)
    COPY ABC OF LIBRARY.───────────────────────────────────────────────── (2)
...
```

Assignment and linkage:

```
/ASSIGN-SYSDTA EXAMPLE1 ───────────────────────────────────────────────── (3)
/SET-FILE-LINK COBLIB,LIB1 ────────────────────────────────────────────── (4)
/SET-FILE-LINK LIBRARY,LIB2 ───────────────────────────────────────────── (5)
```

Call to compiler

(1) XYZ is the name of the element under which the COPY element is stored in the PLAM library LIB1.

(2) ABC is the name of the element under which the COPY element is stored in the PLAM library LIB2 with the link name LIBRARY.

(3) SYSDTA is assigned to the file EXAMPLE1. From this file, the compiler receives a source program in which two COPY statements are written.

(4) The first SET-FILE-LINK command assigns the PLAM library LIB1 and links it to the standard link name COBLIB.

(5) The second SET-FILE-LINK command assigns the PLAM library LIB2 and links it to the library name LIBRARY specified in the COPY statement.

Example 2-5: Input of several COPY elements from different libraries

```
IDENTIFICATION DIVISION.
PROGRAM-ID. PROG1.
...
    COPY A1.  }
    COPY B1.  }  ------------------------------------------- (1)
    COPY D1.  }
...
```
Assignment and linkage:
```
/ASSIGN-SYSDTA EXAMPLE2  --------------------------------- (2)

/SET-FILE-LINK COBLIB,A   }
/SET-FILE-LINK COBLIB1,B  }  ----------------------------- (3)
/SET-FILE-LINK COBLIB3,D  }

Call to compiler  ---------------------------------------- (4)
```

The source program EXAMPLE2 includes the following COPY statements:

(1) A1, B1 and D1 are the names under which the COPY elements have been stored in the cataloged libraries A, B and D.

(2) SYSDTA is assigned to the cataloged file EXAMPLE.2. From this file, the compiler receives a source program in which three COPY statements are written.

(3) Libraries A, B and D are assigned and linked to standard link names. Whereas the standard link name COBLIB must always be assigned, the number and sequence of links to COBLIB1 through COBLIB9 are freely selectable.

(4) After invocation, the compiler searches COBLIB, COBLIB1, and COBLIB3 in the given order for the elements specified in the COPY statements and copies the program lines into the source program file EXAMPLE2.

Example 2-6: Input of a COPY element from the POSIX file system

```
IDENTIFICATION DIVISION.
PROGRAM-ID. PROG1.
...
COPY ATEXT. ──────────────────────────────────────────────────────────── (1)
...
```

Assigning the POSIX file system by declaring and setting an SDF-P variable:

```
/DECL-VAR SYSIOL-COBLIB ,INIT=‘*POSIX(/usr/dir1),*POSIX(/usr/dir2)‘,
                              SCOPE=*TASK ─────────────────────────── (2)
/START-COBOL85-COMPILER? ─────────────────────────────────────────────── (3)
```

(1) The COPY element ATEXT is a file in the POSIX file system.

(2) The SDF-P command DECL-VARIABLE sets the variable to the paths of the POSIX directories dir1 and dir2 which are to be searched for ATEXT.

(3) Access to the POSIX file system is only possible when the compiler is invoked under SDF control. By means of the “?” appended to the call command, the user is placed in SDF menu mode (see section 3.1.2, p.27) in which further entries on controlling the compiler run can be made.

(4) The compiler accepts COPY elements from the POSIX file system only if their file names consist only of upper-case letters.

2.3 Output from the compiler

2.3.1 Output of object modules

The compiler translates the source data input into machine language, generating one or more object modules (OM format) or link-and-load modules (LLM format) in the process. Each such module can be assigned an **I**nternal **S**ymbol **D**ictionary (ISD) or a **L**ist for **S**ymbolic **D**ebugging (LSD) containing the symbolic addresses of the source program.

By default, the compiler outputs object modules to the temporary EAM file of the current task. The object modules are simply added to the library, i.e. stored without defining any relationship between them.

The EAM file belongs to the task under which the compilation is performed. It is created for this task during the first compilation run and is automatically deleted at task end (LOGOFF). If the results of the compilation are to be used later, it is up to the user to store the contents of the EAM file in a backup file for further processing. The LMS utility routine (see [10]) is available to the user for backup of object modules from the EAM file in PLAM libraries.

If the compiled object modules are no longer needed in the EAM file, e.g. because the source program still contains errors that need to be corrected, it is advisable to delete the EAM file - at the latest, before the next compiler run - by means of the command:

```
DELETE-SYSTEM-FILE [SYSTEM-FILE=] OMF
```

Link-and-load modules (LLMs) are always written to a PLAM library by the compiler as elements of type L.

If the POSIX subsystem is available, modules can be output to the POSIX file system. This option is described in section 3.3.5, MODULE-OUTPUT option (p.42).

Formation of element names when modules are output to libraries

	Module format OM	Module format LLM
Source program	Standard name derived from	
Code that is not shareable [1)]		
not segmented	PROGRAM-ID-name 1..8[2)]	PROGRAM-ID-name 1..30[3)]
segmented	PROGRAM-ID-name 1..6 + segment number (for each segment)	PROGRAM-ID-name 1..30[3)] (segmentation ignored)
Shareable code [4)]	PROGRAM-ID-name 1..7@ (code module) PROGRAM-ID-name 1..7 (data module)	PROGRAM-ID-name 1..30[3)]

Table 2-2 Formation of element names at module generation and output

1) Module generated with
COMPILER-ACTION=MODULE-GENERATION(SHAREABLE-CODE=NO) or
COMOPT GENERATE-SHARED-CODE=NO

2) The name should be unique in the first 7 characters.

3) A separate element name may be selected instead of the standard name by specifying
MODULE-LIBRARY=<filename>(ELEMENT=<composed-name>) or
COMOPT MODULE-ELEMENT=element-name.
It should be noted, however, that this option has no effect on the name of the entry point, i.e. the name that is specified in the CALL statement.

4) Module generated with
COMPILER-ACTION=MODULE-GENERATION(SHAREABLE-CODE=YES) or
COMOPT GENERATE-SHARED-CODE=YES

2.3.2 Output of listings and messages

Output of listings

The compiler can generate the following listings during the compilation run:

Control statement listing	OPTION LISTING
Source program listing	SOURCE LISTING
Library listing	LIBRARY LISTING
Object listing	OBJECT PROGRAM LISTING
Locator map Cross-reference listing	LOCATOR MAP LISTING
Error message listing	DIAGNOSTIC LISTING

The compiler writes each requested listing to a separate cataloged file by default. The listings stored in cataloged files can then be printed at any time by using the PRINT-FILE command (see [3]).

Instead of being written to cataloged files, the requested listings can also be written as elements in a PLAM library.

If desired, the user can have the requested listings output to the system file SYSLST by means of an appropriate control statement. The system automatically sends the temporary file created for this purpose to the printer.

The generation and output of listings can be controlled by the user via

– the SDF option LISTING (see chapter 3) or

– the COMOPT statements LISTFILES, LIBFILES or SYSLIST (see chapter 4).

If the POSIX subsystem is available, listings (with the exception of the object listing) can be output to the POSIX file system. This option is described in section 3.3.6, LISTING option p.45.

Output of messages

All compiler messages related to the execution of the compilation run (COB90xx) are output to the terminal via the system file SYSOUT by default.
The texts of all the COB90xx messages that can be issued by the compiler are listed, together with comments, in chapter 14.

2.4 Compiler control options

The method used for the input of source data, the attributes of the generated module, the output of messages and listings, as well as the output of the object module itself can be controlled by means of statements issued to COBOL85.
The COBOL85 compiler can be controlled in two ways:

- by means of options in the SDF syntax format

  or

- by means of COMOPT statements.

The user chooses one of the two control options through the type of command used to call the compiler:

Compiler invocation command	**Control mode**
/START-COBOL85-COMPILER options	SDF control, expert mode
/?	SDF control, menu mode
/START-COBOL85-COMPILER?	SDF control, menu mode
/START-PROGRAM $COBOL85	COMOPT control
/START-COBOL85-COMPILER	None; input of source program from SYSDTA

Table 2-3: Compiler invocation commands and control modes

SDF control options are described in chapter 3, COMOPT control options in chapter 4.

Compiler control in the POSIX subsystem is described in chapter 13.

2.5 Terminating the COBOL85 compiler run

The termination behavior of the COBOL85 compiler depends on

– the class of any errors detected in the source program and

– whether the compiler itself executes without error.

This behavior is particularly significant when the COBOL85 compiler is called from within a procedure or is monitored by monitoring job variables.
The following table provides an overview of the possible events, their impact on the further course of the procedure, and the contents of the return code indicator of the monitoring job variable:

Error	Termination	Dump	Return code indicator in monitoring job variable	Behavior in procedures
No error	Normal	No	0000	No branch
Error class F	Normal	No	0001	
Error class I	Normal	No	0001	
Error class 0	Normal	No	1002	
Error class 1	Normal	No	1003	
Error class 2	Normal	No	2004	No branch except in the event of explicit suppression of listing or module generation
Error class 3	Norma	No	2005	Branch to the next STEP, ABEND ABORT, ENDP or LOGOFF command
Compiler error	Abnormal	Yes	3006	

Table 2-4: Termination behavior of the compiler

2.6 Compiling a sequence of source programs

The special aspects to be noted when compiling a sequence of source programs are discussed below.

Control statements:
Control statements that are specified before the compiler is called apply to all source programs in the sequence.
No control statements must come between the programs in a sequence.

Output of listings via SYSLST:
Requested listings are output sequentially in a single SPOOL file in program-specific order.

Output of listings to cataloged files:
If standard names are used, the same number of files is created for each source program in the sequence as the number of requested listings.
If standard link names are used, the creation of files is based on the type of listing: the file linked to SRCLINK contains the source listings of all programs in the sequence; the file linked to ERRLINK contains all diagnostic listings, and the file linked to LOCLINK contains all locator map and cross-reference listings.

Output of listings to a PLAM library:
For each program in the source program sequence, the number of elements created is equal to the number of listings requested.

Values indicated in monitoring job variables:
The return code of the source program containing the error with the highest error weight is always indicated in the monitoring job variable.

Compiler termination:
If a program in the sequence contains an error that aborts compilation of that program, the entire compiler run is terminated, i.e. none of the following programs are compiled.

Module output:
A separate module is generated for each source program in the sequence. These modules are entered into the EAM file sequentially, or stored as individual elements in a PLAM library.

3 Controlling the compiler via SDF

The COBOL85 compiler can be controlled via SDF (**S**ystem **D**ialog **F**acility).

The principal ways of working with SDF are described in the following sections. For a detailed description of the SDF dialog interface, refer to the manuals “SDF Dialog Interface” [5] and “Commands” [3].

3.1 Calling the compiler and entering options

In interactive mode SDF offers the following ways of entering options:

- input from the display terminal without user guidance, referred to below as “expert mode”.
- input from the display terminal with three different levels of user guidance, referred to below as “menu mode”.

3.1.1 SDF expert mode

SDF expert mode is preset as the default mode following the LOGON command. In this mode the user starts the compilation run as follows:

```
/START-COBOL85-COMPILER options

Abbreviation: S-COB-C options
```

The compilation is started immediately after input of the command.

If no options are specified, the compiler will read the source program from SYSDTA, so the file or library element containing the source program (see section 2.2.1) must be assigned to SYSDTA before the compiler is called.

The following general rules apply for option input in expert mode:

- All options, parameters and operand values must be separated from one another by commas.
- If there is not enough room to enter all the options in one line
  - continuation lines can be generated by keying a hyphen (“-”) after the last character entered in the line,
  - or all the options can be written continuously (i.e. without regard for the end of the line).

Options may be specified as keyword operands or as positional operands.

- Keyword operands

  The keywords must be specified in the correct format; they can, however, be abbreviated as desired provided they remain unique within their respective SDF environment. Illegal abbreviations and typing errors are reported as syntax errors and can be corrected immediately.

Example 3-1

```
/START-COBOL85-COMPILER SOURCE=XMP,-
/COMPILER-ACTION=MODULE-GENERATION(SHAREABLE-CODE=YES),-
/ACTIVATE-FLAGGING=ANS85,-
/TEST-SUPPORT=AID
```

The maximum possible abbreviation in the example environment is:

```
/S-COB-C S=XMP,C-A=MOD(SH=Y),A-F=ANS85,T=A
```

- Positional operands

  The operand keywords (i.e. the keywords to the left of the equal sign in the format) and the equal sign itself can be omitted provided the predetermined order of the operands, and their values, are strictly adhered to. All operands that are not specified because their default value is to be used must be indicated by the comma separator “,”.
  If there are further possible options after the last option to be specified explicitly, their position does not have to be indicated by separators.

  Options should not be specified as positional operands in procedures.

3.1.2 SDF menu mode

There are two ways of using the SDF menu mode to control the compiler:

Permanent menu mode

The user switches to the SDF main menu by entering the SDF command:
/MODIFY-SDF-OPTIONS GUIDANCE = MAXIMUM / MEDIUM / MINIMUM
The available commands for calling the compiler are given there under the entry “PROGRAMMING-SUPPORT”. Specifying the associated number in the input line calls up the PROGRAMMING-SUPPORT menu. The compiler can then be called from this menu by entering the command number.

The values of the MODIFY-SDF-OPTIONS commands have the following meanings:

MAXIMUM	Maximum help level, i.e. all operand values with options, help texts for commands and operands.
MEDIUM	All operand values without options; help texts for commands only.
MINIMUM	Minimum help level, i.e. only default values for the operands; no options, no help texts.

The permanent menu mode remains active until the user explicitly switches back to expert mode by entering the command:
MODIFY-SDF-OPTION GUIDANCE=EXPERT

Temporary menu mode

There are two ways of controlling the compiler in the temporary menu mode:

1. By moving from the SDF menu to the operand form in steps

   When the user enters a question mark at the system level, the SDF main menu is displayed.

```
/?
     The SDF main menu appears
   User specifies the number of the PROGRAMMING-SUPPORT menu
       The PROGRAMMING-SUPPORT menu appears
   User specifies the number of the command to call the compiler
       The operand form appears
```

2. By directly switching to the operand form

   A question mark is appended immediately after START-COBOL85-COMPILER.

```
/START-COBOL85-COMPILER? [options]

        Switch to operand form
```

   Entering START-COBOL85-COMPILER? causes control to switch to menu mode, and the first page of the operand form is opened.
   The form may contain the operand values of options that were specified immediately after START-COBOL85-COMPILER?.

   The user can immediately return to expert mode from any menu by specifying *CANCEL in the NEXT line or by pressing the K1 key.

   After the compilation has terminated, the user is back in expert mode (indicated by /).

Notes on processing the operand form

The operand form is largely self-explanatory. During processing the main thing to note is that only the entry in the input line (“NEXT:...”) determines which operation will be executed. The permitted inputs are listed below this line.

The most important control characters for processing the operand form are summarized below.
A detailed description of the best way to use SDF is given in the manual “Introductory Guide to the SDF Dialog Interface” [5].

Control characters for processing the operand form

?	as an operand value provides a help text and indicates the value range for this operand. If SDF produced the message “CORRECT INCORRECT OPERANDS” after a previous invalid input, the question mark supplies additional detailed error messages. The remainder of the line does not have to be deleted.
!	as an operand value reinserts the default value for this operand if the displayed default value was previously overwritten. The remainder of the line does not have to be deleted.
<operand>(	An open parenthesis after a structure-initiating operand produces the sub-form for the associated structure. Operands specified after the open parenthesis are displayed in the sub-form.
–	as the last character in an input line causes a continuation line to be output (up to 9 continuation lines are possible per operand).
Line (LZF) key	deletes all characters in the input line from the cursor position.

3.2 SDF syntax description

The metasyntax used in the option formats is explained in the following tables.

Table 3-1: Metacharacters

The option formats make use of certain symbols and notational conventions whose meaning is explained in the following table.

Symbol	Meaning	Example

UPPERCASE LETTERS	Uppercase letters indicate keywords. Some keywords are prefixed with *	LISTING = STD
		
		SOURCE = *SYSDTA

=	The equal sign links an operand name with its associated operand values.	LINE-SIZE = 132
< >	Angle brackets indicate variables whose range of values is described by data types and suffixes (see tables 2 and 3).	... = <integer 1..100>
underscoring	Underscoring is used to indicate the default value of an operand.	MODULE-LIBRARY = *OMF
/	A slash separates alternative operand values.	SHAREABLE-CODE = NO / YES
(...)	Parentheses indicate operand values which introduce a structure.	TEST-SUPPORT = AID(...)
indentation |	Indentation indicates dependence on a higher-ranking operand. The vertical bar indicates related operands belonging to the same structure. It extends from the start to the end of the structure. A structure may contain additional structures within itself. The number of vertical bars preceding an operand corresponds to the structure depth.	LISTING = PARAMETERS(...) PARAMETERS(...) | SOURCE = YES(...) | YES(...) | | COPY-EXP... | | . | | .
,	A comma precedes further operands on the same structure level.	,SHAREABLE-CODE = ,PREPARE-CANCEL-STMT =

Table 3-2: Data types

Variable operand values are represented in SDF by data types. Each data type represents a specific set of values. The number of data types is limited to those described in table 3-2.

The description of the data types is valid for all options. Therefore only deviations from table 3-2 are described in the relevant operand descriptions.

Data type	**Character set**	**Special rules**
alphanum-name	A...Z 0...9 $,#,@	
composed-name	A...Z 0...9 $,#,@ hyphen period	Alphanumeric string that may be delimited by periods or commas into several substrings
c-string	EBCDIC characters	A string of EBCDIC characters in single quotes, optionally with the letter C prefixed.
filename	A...Z 0...9 $,#,@ hyphen period	Input format: $\text{:cat:\$user.}\left\{\begin{array}{l}\text{file}\\ \text{file(no)}\\ \text{group}\\ \\ \text{group}\left\{\begin{array}{l}\text{(*abs)}\\ \text{(+rel)}\\ \text{(-rel)}\end{array}\right\}\end{array}\right\}$:cat: optional entry of the catalog identifier; character set limited to A....Z and 0....9; maximum of 4 characters; must be enclosed in colons; default value is the catalog identifier assigned to the user ID, as specified in the JOIN entry. $user. optional entry of the user ID; character set restricted to A...Z and 0...9; maximum of 8 characters; $ and period are mandatory; default value is the user' s own ID.

Data type	**Character set**	**Special rules**
		$. (special case) system default ID
filename (continued)		file file or job variable name; last character must not be a hyphen or period; a maximum of 41 characters; must contain at least A...Z. #file (special case) @file (special case) # or @ used as the first character identifies temporary files or job variables, depending on system generation. file(no) tape file name no: version number; character set is A...Z, 0...9, $, #, @. Parentheses must be specified. group name of a file generation group (character set: as for “file”) $\text{group} \left\{ \begin{matrix} \text{(*abs)} \\ \text{(+rel)} \\ \text{(−rel)} \end{matrix} \right\}$ (*abs) relative generation number (0-99); positive or negative signs and parentheses must be specified. (+rel) (−rel) relative generation number (0-99); positive or negative signs and parentheses must be specified.
integer	0...9,+,-	+ or −, if specified, must be the first character.

Table 3-3: Suffixes for data types

Data-type suffixes define additional rules for data-type input. They can be used to limit or extend the set of values. This manual makes use of the following short codes to represent data-type suffixes:

generation	gen
cat-id	cat
user-id	user
version	vers

The description of the data-type suffixes is valid for all options and operands. Therefore only deviations from table 3-3 are described in the relevant operand descriptions.

Suffix	**Meaning**
x..y	Length specification x Minimum length for the operand value; x is an integer. y Maximum length for the operand value; y is an integer. x=y The length of the operand value must be x exactly.
with-low	Lowercase letters accepted
without	Restricts the specification options for a data type.
-gen	A file generation or file generation group may not be specified.
-vers	The version (see file(no)) may not be specified for tap files.
-cat	A catalog ID may not be specified.
-user	A user ID may not be specified.

3.3 SDF options for controlling the compiler run

Name of the option	**Purpose**
SOURCE	Defines the input source of the source program
SOURCE-PROPERTIES	Defines certain properties of the source program
ACTIVATE-FLAGGING	Flags specific language elements in the error listing with a message of class F
COMPILER-ACTION	Partial execution of the compiler run; determines some attributes of the generated code and the module format (object module, LLM)
MODULE-OUTPUT	Specifies the name and output destination for object modules or LLMs
LISTING	Specifies the type of listings to be output, the layout of these listings, and where they are to be written
TEST-SUPPORT*	Determines if information for debugging with AID is generated
OPTIMIZATION	Activates/deactivates optimization for the compiler
RUNTIME-CHECKS	Activates check routines of the runtime system
COMPILER-TERMINATION	Defines the number of errors at which the compiler run is to be terminated
MONJV	Initializes a job variable to monitor the compiler run
RUNTIME-OPTIONS	Defines some of the runtime characteristics of the program

Overview: Options to control the compiler

* This option is not available in COBOL85-BC

3.3.1 SOURCE option

The parameters for this option determine whether the source program will be read from SYSDTA, from a cataloged BS2000 file, from a PLAM library or from a POSIX file.

Format

```
SOURCE = *SYSDTA / <filename 1..54> / <c-string 1..1024 with-low> / *LIBRARY-ELEMENT(...)

  *LIBRARY-ELEMENT(...)
    |  LIBRARY = <filename 1..54>
    | ,ELEMENT = <composed-name 1..40>(...)
    |    <composed-name>(...)
    |       |  VERSION = *HIGHEST-EXISTING / *UPPER-LIMIT / <alphanum-name 1..24>
```

SOURCE = *SYSDTA
The source program will be read from the SYSDTA system file. In interactive mode this is assigned by default to the terminal. If SYSDTA was assigned to the source program file by means of the ASSIGN-SYSDTA command before the start of the compilation run, there is no need to specify the SOURCE option.

SOURCE = <filename 1..54>
The <filename> parameter is used to assign a cataloged file. After compilation there is a TFT entry for the link name SRCFILE, which is linked with the file name <filename>.

SOURCE = <c-string 1..1024 with-low>
If the POSIX subsystem is available, this parameter can be used to request a source file from the POSIX file system. <c-string> defines the name of the POSIX file. If <c-string> does not include a directory name, the compiler will look for the source file under the specified file name in the home directory of the current BS2000 user ID. If the file is in any other directory, <c-string> must include the absolute path name.

This operand is not available in COBOL-BC.

SOURCE = *LIBRARY-ELEMENT(...)
This parameter specifies a PLAM library and an element (member) held in that library.

> **LIBRARY = <filename 1..54>**
> Name of the PLAM library in which the source program is stored as an element. After compilation there is a TFT entry for the link name SRCLIB, which is linked with the file name <filename> of the PLAM library.
>
> **ELEMENT = <composed-name 1..40>(...)**
> Name of the library element in which the source program is stored.

VERSION = *HIGHEST-EXISTING / *UPPER-LIMIT /
<alphanum-name 1..24>

Version designation of the library element. If no version or *HIGHEST-EXISTING is specified, the compiler reads the version of the element with the highest version designation present in the library. If *UPPER-LIMIT is specified, the compiler reads the version of the element with the highest possible version number (indicated by LMS with "@").

3.3.2 SOURCE-PROPERTIES option

This option defines certain properties of the source program.

Format

```
SOURCE-PROPERTIES = STD / PARAMETERS(...)

   PARAMETERS(...)
     |  RETURN-CODE = FROM-COBOL-SUBPROGRAMS / FROM-ALL-SUBPROGRAMS
```

SOURCE-PROPERTIES = STD
The default value of the following PARAMETERS structure is accepted.

SOURCE-PROPERTIES = PARAMETERS(...)

RETURN-CODE = FROM-COBOL-SUBPROGRAMS
The special register RETURN-CODE is used for information exchange between the COBOL programs in a compilation unit.

RETURN-CODE = FROM-ALL-SUBPROGRAMS
The special register RETURN-CODE is also to serve for accepting function values from C subprograms.

3.3.3 ACTIVATE-FLAGGING option

This option causes the compiler to flag certain language elements according to ANS85 or according to the “Federal Information Processing Standard” (FIPS) with a class F message in the diagnostic listing.

Format

```
ACTIVATE-FLAGGING = NO / ANS85 / FIPS(...)

   FIPS(...)

      | OBSOLETE-FEATURES = NO / YES
      |,NONSTANDARD-LANGUAGE = NO / YES
      |,ABOVEMIN-SUBSET = NO / YES
      |,ABOVEINTERMED-SUBSET = NO / YES
      |,REPORT-WRITER = NO / YES
      |,ALL-SEGMENTATION = NO / YES
      |,SEGMENTATION-ABOVE1 = NO / YES
      |,INTRINSIC-FUNCTIONS = NO / YES
```

ACTIVATE-FLAGGING = NO
No language elements are flagged in the diagnostic listing.

ACTIVATE-FLAGGING = ANS85
When ANS85 is specified, obsolete language elements and also any non-standard language extensions are flagged with a class F message (severity code F) in the diagnostic listing.

ACTIVATE-FLAGGING = FIPS(...)
When FIPS(...) is specified, language elements according to the “Federal Information Processing Standard” can be flagged with a class F message (severity code F) in the diagnostic listing.

OBSOLETE-FEATURES = NO / YES
Flagging of obsolete language elements

NONSTANDARD-LANGUAGE = NO / YES
Flagging of language extensions (with respect to ANS85)

ABOVEMIN-SUBSET = NO / YES
Flagging of all language elements that lie beyond the minimum subset of ANS85, i.e. that belong to the intermediate or high subset

ABOVEINTERMED-SUBSET = NO / YES
Flagging of all language elements that lie beyond the intermediate subset of ANS85, i.e. that belong to the high subset

REPORT-WRITER = NO / YES
Flagging of all language elements of the Report Writer

ALL-SEGMENTATION = NO / YES
Flagging of all language elements belonging to the segmentation module

SEGMENTATION-ABOVE1 = NO / YES
Flagging of all language elements belonging to segmentation level 2

INTRINSIC-FUNCTIONS = NO / YES
Flagging of all language elements belonging to the intrinsic functions module

The following flags are used in the message texts:

“obsolete”	for obsolete language elements
“nonconforming nonstandard”	for all language extensions (additions to ANS85)
“nonconforming standard”	for all ANS85 language elements that are not part of the configured subset

3.3.4 COMPILER-ACTION option

This option specifies a point in the compilation after which the compiler run is to be terminated. If a module is to be generated, this option can also be used to define its format and attributes.

Format

```
COMPILER-ACTION = PRINT-MESSAGE-LIST / SYNTAX-CHECK / SEMANTIC-CHECK /
                  MODULE-GENERATION(...)

   MODULE-GENERATION(...)
     |  ,SHAREABLE-CODE = NO / YES
     |  ,PREPARE-CANCEL-STMT = NO / YES
     |  ,MODULE-FORMAT = OM / LLM
     |  ,SUPPRESS-GENERATION = NO / AT-SEVERE-ERROR
     |  ,DESTINATION-CODE = STD / RISC-4000
     |  ,SEGMENTATION = ELABORATE / IGNORE
```

COMPILER-ACTION = PRINT-MESSAGE-LIST
The compiler prints a list of all possible error messages. No compilation takes place.
This operand is not available in COBOL-BC.

COMPILER-ACTION = SYNTAX-CHECK
The compiler merely checks the source program for syntax errors.

COMPILER-ACTION = SEMANTIC-CHECK
The compiler runs a syntax check on the source program and additionally checks that it complies with the semantic rules. Since no module is to be generated, only a source listing and diagnostic listing can be requested.

COMPILER-ACTION = MODULE-GENERATION(...)
A complete compilation run is to be performed and - unless explicitly suppressed - object modules are to be generated.

SHAREABLE-CODE = NO / YES
If YES is specified, the compiler writes the code of the PROCEDURE DIVISION (without DECLARATIVES) into a shareable code module (see section 6.7).
The name of the code module consists of the PROGRAM-ID name, truncated to 7 characters if necessary, followed by the character “@”. Any segmentation of the PROCEDURE DIVISION is ignored.

PREPARE-CANCEL-STMT = NO / YES
If YES is specified, the compiler sets up areas for initialization. Any program that is referred to by a CANCEL statement or that contains the INITIAL clause should be compiled with PREPARE-CANCEL-STMT = YES for standard conforming run.

MODULE-FORMAT = OM / LLM
The following specifications are ignored if the module is written to the POSIX file system (see MODULE-OUTPUT = <c-string...>).
OM: To enable further processing with BINDER, TSOSLNK, or DBL, the module is to be generated in OM format (object module format).
Maximum length for external names: 8 characters.
LLM: To enable further processing with BINDER or DBL, the module is to be generated in LLM format (link-and-load module format).
Maximum length for external names: 30 characters.

SUPPRESS-GENERATION = NO / AT-SEVERE-ERROR
AT-SEVERE-ERROR can be specified to suppress the generation of the module if an error with a severity code >= 2 occurs during compilation.

DESTINATION-CODE=STD / RISC-4000
If STD is specified, /390 code is generated.
If RISC-4000 is specified, RISC code is generated for the RISC systems under OSD-SVP.
If `DESTINATION-CODE=RISC-4000` is specified, only the LLM module format is permitted.

SEGMENTATION=ELABORATE / IGNORE
ELABORATE: permits segmentation. If the program contains nested source programs and non-fixed segments (segment number greater than or equal to segment limit), the compilation is aborted and a message is output. Otherwise, only segmentation-related language elements are rejected with appropriate warnings. If `SEGMENTATION = ELABORATE` is specified together with `SHAREABLE-CODE = YES` or `MODULE-FORMAT = LLM`, it is rejected with an error message.
IGNORE: ignores segmentation-related language elements (`SEGMENT-LIMIT` clause, segment numbers in section header). When they occur, they are indicated with appropriate warnings.

3.3.5 MODULE-OUTPUT option

This option enables the user to control the library the object module is to be stored in and the name it is to be stored under.

Format

```
MODULE-OUTPUT = *STD / *OMF / <c-string 1..1024 with-low> / *LIBRARY-ELEMENT(...)

   *LIBRARY-ELEMENT(...)

      |  LIBRARY=<filename 1..54>
      | ,ELEMENT = *STD (...) / <composed-name 1..32>(...)
      |     *STD (...)
      |        |  VERSION = *UPPER-LIMIT / *INCREMENT / *HIGHEST-EXISTING /
      |        |                <alphanum-name 1..24>
      |     <composed-name>(...)
      |        |  VERSION = *UPPER-LIMIT / *INCREMENT / *HIGHEST-EXISTING /
      |        |                <alphanum-name 1..24>
```

MODULE-OUTPUT = *STD
An object module is placed in the temporary EAM file of the current task.
A link-and-load module (LLM) is placed in a PLAM library with the standard name PLIB.COB85.<prog-id-name>, using the program name as the element name, and *UPPER-LIMIT (i.e. the highest possible version number) as the version designation.

MODULE-OUTPUT = *OMF
An object module is written to the temporary EAM file. If *OMF is specified for a link-and-load module (LLM), the compiler issues a class I (information) message, and the module is placed in the PLAM library PLIB.COB85.<prog-id-name>.

MODULE-OUTPUT = <c-string 1..1024 with-low>
If the POSIX subsystem is available, you can use this parameter to output a module (LLMs only) to the POSIX file system as an object file.
If <c-string> does not include a directory name, the object file will be stored under the specified file name in the home directory of the current BS2000 user ID. If the object file is to be written to any other directory, <c-string> must include the absolute path name.
When selecting a file name, note that object files cannot be further processed, i.e. linked, in the POSIX subsystem unless they have a name ending with the extension “.o”. The compiler does not do any name checking.

This operand is not available in COBOL-BC.

MODULE-OUTPUT = LIBRARY-ELEMENT(...)
This parameter specifies the PLAM library (LIBRARY=) the module is to be stored in and the element name (ELEMENT=) it is to be stored under.

LIBRARY = <filename 1..54>(...)
Name of the PLAM library in which the module is to be placed. If the PLAM library does not exist, it is created automatically.

ELEMENT = *STD
The element name of the module is derived from the PROGRAM-ID name. The formation of standard element names is described in section 2.3.1 and table 2-3.

VERSION =
Specifies the version designation

VERSION = *UPPER-LIMIT
If no version designation or *UPPER-LIMIT is specified, the element receives the highest possible version number (indicated by LMS with “@”).

VERSION = *INCREMENT
The element receives the version number of the highest existing version incremented by 1, provided that the highest existing version designation ends with a digit that can be incremented. Otherwise, the version designation cannot be incremented. In this case, *UPPER-LIMIT is assumed and an appropriate error message is output.

Example:

Highest existing version	Version generated by *INCREMENT
ABC1	ABC2
ABC	@ and error message
ABC9	@ and error message
ABC09	ABC10
003	004
none	001

VERSION = *HIGHEST-EXISTING
The highest existing version in the library is overwritten.

VERSION = <alphanum-name 1..24>
The element receives the specified version designation. If the version designation is to be incrementable, at least the last character must be an incrementable digit (see example above).

ELEMENT = <composed-name 1..32>
The user may optionally specify a freely-selected name for link-and-load modules (LLMs).
If a sequence of source programs is being compiled, this operand is ignored, and the element names of LLMs are derived from the respective PROGRAM-ID name (see section 2.3.1, table 2-3) instead.

VERSION = <u>*UPPER-LIMIT</u> / *INCREMENT / *HIGHEST-EXISTING /
<alphanum-name 1..24>
Version designation (see the above description of the VERSION operand for object modules).
When a sequence of source programs is compiled, each element is assigned the same version designation.

3.3.6 LISTING option

The parameters of this option control which listings the compiler is to generate, their layout, and where they are to be output.

Format

```
LISTING = NONE / STD / PARAMETERS(...)

  PARAMETERS(...)
    |  OPTIONS = NO / YES
    | ,SOURCE = NO / YES(...)
    |     YES(...)
    |       |  COPY-EXPANSION = NO / VISIBLE-COPIES / ALL-COPIES
    |       | ,SUBSCHEMA-EXPANSION = NO / YES
    |       | ,INSERT-ERROR-MSG = NO / YES
    | ,DIAGNOSTICS = NO / YES(...)
    |     YES(...)
    |       |  MINIMAL-WEIGHT = NOTE / WARNING / ERROR / SEVERE-ERROR / FATAL-ERROR
    |       | ,IMPLICIT-SCOPE-END = STD / REPORTED
    |       | ,MARK-NEW-KEYWORDS = NO / YES
    |       | ,REPORT-2-DIGIT-YEAR = *ACCEPT-STMT / *NO
    | ,NAME-INFORMATION = NO / YES(...)
    |     YES(...)
    |       |  SORTING-ORDER = ALPHABETIC / BY-DEFINITION
    |       | ,CROSS-REFERENCE = NONE / REFERENCED / ALL
    |       | ,SUPPRESS-GENERATION = NO / AT-SEVERE-ERROR
    | ,LAYOUT = STD / PARAMETERS(...)
    |     PARAMETERS(...)
    |       |  LINES-PER-PAGE = 64 / <integer 20..128>
    |       | ,LINE-SIZE =  132 / <integer 119..172>
    | ,OUTPUT = SYSLST / STD-FILES / LIBRARY-ELEMENT(...)
    |     LIBRARY-ELEMENT(...)
    |       | LIBRARY = <filename 1..54>
```

LISTING = NONE
The compiler is to generate no listings.

LISTING = STD
The default values of the following PARAMETERS structure are to be used.

LISTING = PARAMETERS(...)
The following parameters determine which listings are to be generated, their layout, and the output destination to which they are to be directed.

OPTIONS = NO / YES(...)
By default, the compiler generates a listing specifying the control statements that apply during compilation, the environment of the compilation process and information for maintenance and diagnostic purposes.

SOURCE = YES(...)
The compiler generates a source listing and a library listing.

COPY-EXPANSION = NO
The COPY elements copied into the source program will not be printed in the source listing. This setting is recommended for frequently occurring COPY elements, in order to save paper.

COPY-EXPANSION = VISIBLE-COPIES
Only COPY elements containing no SUPPRESS entry will be printed in the source listing. Every line of a COPY element is identified by a “C” in column 1 of the source listing.

COPY-EXPANSION = ALL-COPIES
All COPY elements will be printed in the source listing, including any that contain a SUPPRESS entry. Every line of a COPY element is identified by a “C” in column 1 of the source listing.

SUBSCHEMA-EXPANSION = NO / YES
If YES is specified, the SUB-SCHEMA SECTION will be listed and each line will be identified by a “D” in column 1.
This operand is not available in COBOL-BC.

INSERT-ERROR-MSG = NO / YES
If YES is specified, any (error) messages that occur during compilation are “merged” with the source listing. The message line always appears immediately after the source program line in which the construct responsible for triggering the message begins. Messages that the compiler cannot trace to a particular source program line are output after the last source program line.
The operand also works if no error list has been requested.
For merging to function correctly, the source listing should not contain more than 65535 source program lines (see source listing in the Appendix).

DIAGNOSTICS = YES(...)
The compiler is to generate a diagnostic listing.

MINIMAL-WEIGHT = NOTE / WARNING / ERROR / SEVERE-ERROR / FATAL-ERROR
The diagnostic listing will contain no messages with a weighting less than the specified value. The default value NOTE causes all (error) messages that occurred during the compilation to be listed.

IMPLICIT-SCOPE-END = STD / REPORTED
If REPORTED is specified, a remark message is added to the diagnostic listing each time a structured statement is ended by a period.

MARK-NEW-KEYWORDS = NO / YES
If YES is specified, keywords from the future standard will be marked in the diagnostic listing with a message with severity code I.

REPORT-2-DIGIT-YEAR = *ACCEPT-STMT / *NO
If *ACCEPT-STMT is specified, the compiler indicates that the year numbers are processed without century digits for every ACCEPT statement and for every variable accessed in the statement. MINIMAL-WEIGHT should be set to NOTE. If *NO is specified, these indications are suppressed.

NAME-INFORMATION = NO / YES(...)
If YES is specified, the compiler will generate a locator map or a locator map and cross-reference listing. The listing contains data, section and paragraph names.

SORTING-ORDER = ALPHABETIC
The symbolic names are to be listed in ascending alphabetical order.

SORTING-ORDER = BY-DEFINITION
The symbolic names are to be listed in the order in which they are defined in the source program.

CROSS-REFERENCE = NONE
No cross-reference listing will be generated.

CROSS-REFERENCE = REFERENCED
Only the data and procedure names that are actually addressed in the program will be listed in the cross-reference listing.

CROSS-REFERENCE = ALL
A cross-reference listing containing all data and procedure names will be generated.

SUPPRESS-GENERATION = NO / AT-SEVERE-ERROR
AT-SEVERE-ERROR can be specified to suppress the generation of the module if an error with a severity code >= 2 occurs during compilation.

LAYOUT = STD
The layout of the generated listings is to correspond to the default settings of the PARAMETERS structure.

LAYOUT = PARAMETERS(...)
The following parameters can be used to modify the layout of the generated listings.

LINES-PER-PAGE = 64 / <integer 20..128>
This parameter can be used to define the maximum number of lines to be printed per page. A page throw will be performed when this line number is reached.

LINE-SIZE = 132 / <integer 119..172>
This parameter defines the maximum number of characters to be printed per line.

OUTPUT = *SYSLST
This causes the generated listings to be written into the temporary system file SYSLST, from where they will automatically be output on the printer at end of task (i.e. after LOGOFF). The first requested listing is preceded by a title page (COMOPT listing) with details concerning the system environment and a list of all the COMOPT operands in effect at compilation.

OUTPUT = STD-FILES
This setting causes each requested listing to be placed in a separate cataloged file. The cataloged files created in this way have the default names given in the right-hand column of the following table. *program-name* is derived from the PROGRAM-ID name and may, if necessary, be abbreviated to 16 characters.

Listing	**File name**
control statement listing	OPTLST.COB85.*program-name*
source listing or library listing	SRCLST.COB85.*program-name*
diagnostic listing	ERRFIL.COB85.*program-name*
locator map listing / cross-reference listing	LOCLST.COB85.*program-name*

File names and file characteristics for these cataloged files are preset by default. However, the user can change these defaults by means of the SET-FILE-LINK command, e.g. assigning user-defined names to the files. In order to do this, the desired characteristics must be defined in a SET-FILE-LINK command before the compiler is called so that they can be linked with the respective file link name used by the compiler:

Listing	**Link name**
control statement listing	OPTLINK
source listing/library listing	SRCLINK
address listing/cross-reference listing	LOCLINK
diagnostic listing	ERRLINK

To store the generated listings in the POSIX file system, you must assign them to the POSIX file system using SDF-P variables. The default names of these variables are:

Listing	**Name of SDF-P variable**
control statement listing	SYSIOL-OPTLINK
source listing/library listing	SYSIOL-SRCLINK
locator map/cross-reference listing	SYSIOL-LOCLINK
diagnostic listing	SYSIOL-ERRLINK

OUTPUT = LIBRARY-ELEMENT(LIBRARY = <filename 1..54>)
The requested listings are output to the PLAM library specified by <filename>. Each listing occupies its own type R library element, which has the highest possible version number. The following standard names are assigned to these elements: :

Listing	**Element name**
control statement list	OPTLST.COB85.*program-name*
source listing/library listing	SRCLST.COB85.*program-name*
address listing/cross-reference listing	LOCLST.COB85.*program-name*
diagnostic listing	ERRLST.COB85.*program-name*

program-name is derived from the PROGRAM-ID name and abbreviated, if necessary, to 16 characters. After the compilation there is a TFT entry for the link name LIBLINK, which is linked with the <filename> of the PLAM library.

Example 3-2: Outputting listings to cataloged files

The compiler is to generate a diagnostic (error) listing only, and save this in the cataloged file ERRORS.

```
/SET-FILE-LINK ERRLINK,ERRORS  ──────────────────────────────────────── (1)

/START-COBOL85-COMPILER? ────────────────────────────────────────────── (2)

Entry in operand form:

LISTING=PAR(OPTIONS=NO,SOURCE=NO) ───────────────────────────────────── (3)
```

(1) The SET-FILE-LINK command creates the cataloged file ERRORS which is linked with the default link name ERRLINK.

(2) The compiler is called in menu mode.

(3) The default setting (generation of options, source program and diagnostic listings) is changed; the compiler is to generate a diagnostic listing only and output this by default to the cataloged file ERRORS.

Example 3-3: Outputting listings to a PLAM library

The compiler is to generate all listings and save them as elements in the PLAM library LISTLIB.

```
/START-COBOL85-COMPILER? ────────────────────────────────────────────── (1)

 Entry in operand form:

LISTING=PAR(NAME-INFORMATION=YES(CROSS-REFERENCE=ALL),-
OUTPUT=*LIBRARY-ELEMENT(LIBRARY=LISTLIB)) ───────────────────────────── (2)
```

(1) The compiler is called in menu mode.

(2) The default setting (generation of options, source program and diagnostic listings) is changed; the compiler is also to generate a locator map and cross-reference listing and to save all listings to a PLAM library under the name LISTLIB.

Example 3-4: Outputting listings to the POSIX file system

The compiler is to generate a source listing and a diagnostic listing and store them in the POSIX file system.

```
          /DECL-VAR SYSIOL-SRCLINK,INIT=‘*P(xpl.srclst)‘,SCOPE=*TASK    (1)
          /DECL-VAR SYSIOL-ERRLINK,INIT=‘*P(xpl.errlst)‘,SCOPE=*TASK    (1)
          /START-COBOL85-COMPILER?                                       (2)
```

(1) The DECL-VARIABLE command assigns the desired name to the variable. As the file name does not include a path specification, the file will be stored in the home directory.

(2) The compiler is called in SDF menu mode.

3.3.7 TEST-SUPPORT option

This option controls whether a program execution is to be monitored with the AID debugger. It can also determine certain characteristics of the AID debugger.

This option is not available in COBOL-BC.

Format

```
TEST-SUPPORT = NONE / AID(...)

  AID(...)

    | STMT-REFERENCE = LINE-NUMBER / COLUMN-1-TO-6
    |,PREPARE-FOR-JUMPS = NO / YES
    |,WINDOW-DEBUG-SUPPORT = NO / YES
```

TEST-SUPPORT = NONE
No debugging aid is requested. The compiler generates only ESD debugger information of the type compilation unit. This means that the module (or every module in the case of segmented programs) is assigned a symbolic name consisting of the first 8 characters of the name in the PROGRAM-ID paragraph. When debugging with AID, this name can be used for source program qualification.

TEST-SUPPORT = AID(...)
This parameter is required if the program is to be monitored symbolically using AID. It causes the compiler to generate both LSD information and ESD debugger information, which means that symbolic names from the source program can be used for debugging with AID (see description in manual [8]).
In segmented programs it is possible to generate LSD information - and thus create conditions for symbolic debugging with AID - only if the object module is written to a PLAM library.

STMT-REFERENCE = LINE-NUMBER
The AID source references are formed using the line numbers generated by the compiler.

STMT-REFERENCE = COLUMN-1-TO-6
The AID source references are formed using the user-assigned sequence numbers in the source program (columns 1 to 6).
Debugging with AID is useful only if the assigned sequence numbers are sorted in ascending numeric order.

PREPARE-FOR-JUMPS = NO / YES
YES must be specified if, during the AID debugging session,

- the AID command %JUMP is to be used (see manual [8] and section 7.1.3) or
- test points are to be set selectively on paragraphs or chapters, e.g. when debugging nested GO TO loops (as generated by the COLUMBUS preprocessor COLCOB) in which several paragraph headings follow one another in immediate succession or follow after a section heading.

Use of this function increases the size of the object and lengthens the program run time.

WINDOW-DEBUG-SUPPORT = NO / YES
If YES is specified, it is possible to use the windowing mechanism of the AID debugging facility (AID-FE) to debug the object on the basis of the source program.

3.3.8 OPTIMIZATION option

This option can be used to activate and deactivate the optimization actions of the compiler.

Format

```
OPTIMIZATION = STD / PARAMETERS(...)
  PARAMETERS(...)
  |  CALL-IDENTIFIER = *STD / *OPTIMIZE
```

OPTIMIZATION = STD
The default of the PARAMETERS structure applies.

OPTIMIZATION = PARAMETERS(...)

CALL-IDENTIFIER = *STD / *OPTIMIZE
If *OPTIMIZE is specified, the optimization is activated. Multiple calls of the same subprogram by means of CALL identifier are processed without calling by system interfaces (possible for the first 100 subprograms called).

3.3.9 RUNTIME-CHECKS option

This option can be used to activate the check routines of the runtime system.

Format

```
RUNTIME-CHECKS = NONE / ALL / PARAMETERS(...)
   PARAMETERS(...)
        TABLE-SUBSCRIPTS = NO / YES
       ,FUNCTION-ARGUMENTS = NO / YES
       ,PROC-ARGUMENT-NR = NO / YES
       ,RECURSIVE-CALLS = NO / YES
       ,REF-MODIFICATION = NO / YES
```

RUNTIME-CHECKS = NONE
No check routines of the runtime system are requested.

RUNTIME-CHECKS = ALL
All check routines of the runtime system that are named in the PARAMETERS structure are to be activated.

RUNTIME-CHECKS = PARAMETERS(...)

TABLE-SUBSCRIPTS = NO / YES
If YES is specified, the runtime system checks that table bounds are kept to (both for subscripting and for indexing).

Checks are made to determine whether

- index values are greater than zero,
- index values are not greater than the number of elements in the corresponding dimensions,
- index values are not greater than associated values in DEPENDING ON items,
- values in DEPENDING ON items are within the bounds defined in corresponding OCCURS clauses.

The runtime system responds with message COB9144 or COB9145 and aborts the program in the event of an error if ERROR-REACTION = TERMINATION was specified in the RUNTIME-OPTIONS option.

FUNCTION-ARGUMENTS = NO / YES
If YES is specified, the value range, number, and length of function arguments are checked at runtime. If invalid values are detected, one of the messages COB9123, COB9125, COB9126 or COB9127 is issued; the program will abort if ERROR-REACTION = TERMINATION was specified in the RUNTIME-OPTIONS option.

PROC-ARGUMENT-NR = NO / YES
If YES is specified, a check is made when a COBOL subprogram is called to determine whether the number of parameters passed matches the number expected. If there is a discrepancy, message COB9132 is issued, and the program will abort if ERROR-REACTION = TERMINATION was specified in the RUNTIME-OPTIONS option.
The check is only effective if the called program was compiled with this option and if the calling program was compiled with a compiler version ≥ 2.0.

RECURSIVE-CALLS = NO / YES
If YES is specified, a check will be made on the call hierarchy of a program run unit; that is, the runtime system uses a table to check whether a subprogram is being called recursively, i.e. is still active. In this case the program run is aborted with error message COB9157.
Any source program containing a CALL identifier and/or CANCEL should be compiled using RECURSIVE-CALLS=YES.
If the parameter is deactivated explicitly with NO, the source program must not contain either a CALL identifier or a CANCEL statement.

REF-MODIFICATION = NO / YES
Specifying YES causes the runtime system to verify compliance with data-item limits for identifiers subject to reference modification. If data-item limits are not complied with, error message COB9140 is issued and the program is continued or aborted depending on the ERROR-REACTION parameter of the RUNTIME-OPTIONS option.

3.3.10 COMPILER-TERMINATION option

This option can be used to initiate a termination of the compilation run dependent on the number of errors that have occurred.

Format

```
COMPILER-TERMINATION = STD / PARAMETERS(...)
   PARAMETERS(...)
     |  MAX-ERROR-NUMBER = NONE / <integer 1..100>
```

COMPILER-TERMINATION = STD
The default settings of the PARAMETERS structure are to apply.

COMPILER-TERMINATION = PARAMETERS(...)

MAX-ERROR-NUMBER = NONE / <integer 1..100>
An integer can be used to specify the number of errors allowed before the compilation run is terminated. The count begins from the error severity class specified in the MINIMAL-WEIGHT parameter of the LISTING option (default value: NOTE, see section 3.3.6).
The specified error number can be exceeded because the compilation is terminated only after execution of a compiler segment has been completed (see appendix).

3.3.11 MONJV option

This option can be used to create a job variable which will monitor the compiler run.

Format

MONJV = *NONE / <filename 1..54 >

MONJV = *NONE / <filename 1..54>
The user uses <filename> to define a monitoring job variable. During the compilation run, the compiler will then store a code in the return code indicator of the job variable, giving information about any errors that occurred during the execution of the compiler.

3.3.12 RUNTIME-OPTIONS option

The parameters of this option control certain characteristics of the executable COBOL program.

Format

```
RUNTIME-OPTIONS = STD / PARAMETERS(...)

   PARAMETERS(...)

     |  ACCEPT-STMT-INPUT = UNMODIFIED / UPPERCASE-CONVERTED
     | ,FUNCTION-ERR-RETURN = UNDEFINED / STD-VALUE
     | ,SORTING-ORDER = STD / BY-DIN
     | ,ACCEPT-DISPLAY-ASSGN = SYSIPT-AND-SYSLST / TERMINAL
     | ,ERR-MSG-WITH-LINE-NR = NO / YES
     | ,ERROR-REACTION = CONTINUATION / TERMINATION
     | ,ENABLE-UFS-ACCESS = NO / YES
```

RUNTIME-OPTIONS = STD
The preset default values of the PARAMETERS structure will be used.

RUNTIME-OPTIONS = PARAMETERS(...)

ACCEPT-STMT-INPUT = UNMODIFIED / UPPERCASE-CONVERTED
If UPPERCASE-CONVERTED is specified, letters entered in lowercase in an ACCEPT statement will be converted to uppercase if the input is typed in from the terminal.

FUNCTION-ERR-RETURN = UNDEFINED / STD-VALUE
If STD-VALUE is specified, the value range, number, and length of function arguments are checked at runtime. If invalid argument values are detected, the appropriate return code for the error is assigned to the function in which the error occurs.

SORTING-ORDER = STD / BY-DIN
Specifying BY-DIN causes the SORT utility routine to perform the sort according to the DIN standard for EBCDIC; that is,

– lowercase letters are equated to the corresponding uppercase letters
– the character “ä” or “Ä” is identified with “AE”,
  “ö” or “Ö” is identified with “OE”,
  “ü” or “Ü” is identified with “UE” and
  “ß” is identified with “SS”.
– digits are sorted before letters.

ERR-MSG-WITH-LINE-NR = NO / YES
If YES is specified, the message COB9102 is output instead of the COB9101 message and is supplemented by the source program line number assigned by the compiler to the statement in the process of being executed when the message was output.

ACCEPT-DISPLAY-ASSGN = SYSIPT-AND-SYSLST / TERMINAL
Specifying *TERMINAL causes the system files SYSDTA and SYSOUT to be assigned instead of system files SYSIPT and SYSLST (defaults) for ACCEPT and DISPLAY statements without FROM and UPON phrases.

ERROR-REACTION = CONTINUATION / TERMINATION
By default (CONTINUATION), the program run will continue after the following messages are output:
COB9120 to COB9127, COB9131, COB9132, COB9134, COB9140, COB9144, COB9145 and COB9197.
If TERMINATION is specified, the aforementioned error conditions lead to abnormal program termination (see also section 6.6, “Program termination”).

ENABLE-UFS-ACCESS = NO / YES
If YES is specified, the compiler generates an object
- that is capable of accessing the POSIX file system as a program
- that can be further processed (linked) in the POSIX subsystem.

Chapter 13 describes how to access a file from the POSIX file system and the conditions to which file processing is subject.

This operand is not available in COBOL-BC.

4 Controlling the compiler with COMOPT statements

The COBOL85 compiler can be controlled as usual via COMOPT statements as well. In this case it is invoked with the command

START-PROGRAM [FROM-FILE =] $COBOL85

The input of the source program, the output of listings and of the module, and the internal execution of the compilation run are controlled by means of options that the user specifies in one or more COMOPT statements. The options are read via SYSDTA after COBOL85 is invoked.
There are three ways in which the user can enter compiler options:

– The COMOPT statement(s) can be entered directly by calling the compiler without first reassigning the system file SYSDTA with the ASSIGN-SYSDTA command. In this case, the compiler explicitly requests the entry of the options by entering an asterisk (*) in column 1.

– The user can write the COMOPT statement(s) into a file and issue them via the file. This file can be either a source program file (the options are entered before the source program) or a separate file.
The file used is assigned to the system file SYSDTA by means of an ASSIGN-SYSDTA command issued before the compiler is called.

– COMOPT statement(s) can be entered directly and the END statement used to reassign SYSDTA to a file that contains further COMOPT statements before the source program.

When no further control statements are encountered, the compiler immediately begins to read the program text.
The compiler determines the location of the source program via the END statement and continues reading at that point.

In the batch process compilation is aborted on errored input of COMOPT or END statements (error message COB9005).

Format of the COMOPT statement

```
                         ⎧ YES                  ⎫
 ⎧ COMOPT ⎫              ⎪ NO                   ⎪
 ⎨        ⎬  operand=    ⎨                      ⎬
 ⎩ COBRUN ⎭              ⎪ option               ⎪
                         ⎩ (option[,option]...) ⎭
```

– Input lines for COMOPT statements can be up to 128 characters in length. For ISAM files, this includes the length of the record key. The standardized reference format for writing COBOL source programs has no significance for the input of COMOPT statements.

– Operands may be specified beyond the end of a line, i.e. they can be continued in the next line. The end of a line has no syntactical significance and does not replace the comma, which is used to separate individual operands.

– An operand consists of a keyword, followed by a sign of equality and one or more parameters. If several parameters can be specified in a single operand, these must be enclosed in parentheses.

If errors are detected during the processing of a COMOPT statement, all previously evaluated options from the same line remain in effect. As indicated in the error message, the rest of the operand line or the remaining part of the operand is then ignored. Error messages for operands are only output to SYSOUT. The COMOPT statements only apply to the compiler run for which they were specified.
If the same COMOPT statement is entered more than once, the last specified value applies.
If conflicting COMOPT statements are entered, the statement specified last is applicable.

Format of the END statement

```
      ⎧ filename                ⎫
END   ⎨                         ⎬
      ⎩ libname(elementname)    ⎭
```

END filename or libname can be used to reassign SYSDTA to a file or a library element.

END (without any further qualification) indicates to the compiler that the input of COMOPT statements is terminated and that the compilation of the source program can start.

4.1 Source data input under COMOPT control

Input to the compiler may consist of the following source data:

- Source programs (individual source programs or source program sequences)
- Source program segments (COPY elements)
- COMOPT statements

The compiler expects the source data from the system input file SYSDTA.

By default, SYSDTA is assigned to the terminal in interactive mode and to the spoolin file or the enter file in batch mode.
If source data is to be entered directly, no input control operations are required. The compiler is simply invoked, and the control statements and source program are directly entered.
However, if the source data is to come from a cataloged file or a library, the input file must be explicitly assigned to SYSDTA. Separate control statements are available to control the input of COPY elements. The assignments to be made with the ASSIGN-SYSDTA command and the input of COPY elements are described in section 2.2.

Assigning the source program with the END statement

The input of source programs and control statements can also be effected without making use of the ASSIGN-SYSDTA command. After invocation, the compiler expects input from the terminal via SYSDTA. When the asterisk appears in the first column, the user can enter source code or compiler options. All entered characters that do not represent a valid COMOPT control statement are interpreted as source code by the compiler.
The END statement can be used to assign a cataloged file or a library element. If a file or library element is specified with it, the END statement can also be the first statement to be issued after the compiler is called. Further COMOPT statements may be included at the start of the assigned file.

Note

If the END statement is used to assign a library element, the source program name cannot be correctly mapped in the compiler listings and at the AID-FE interface.

Example 4-1: Assigning a cataloged file after input of COMOPT statements

```
/START-PROGRAM $COBOL85──────────────────────────────────────────── (1)
*COMOPT... ──────────────────────────────────────────────────────── (2)
*END SOURCE.MULTABLE─────────────────────────────────────────────── (3)
```

(1) The compiler is invoked. In interactive mode SYSDTA is assigned to the terminal.

(2) The keyword COMOPT informs the compiler that the following entries are control statements.

(3) The END statement assigns SYSDTA to the cataloged file SOURCE.MULTABLE, which contains the source program to be compiled or a sequence of control statements.
At the end of compilation SYSDTA and SYSCMD are linked together.

Example 4-2: Assigning a library without the use of COMOPT statements

```
/START-PROGRAM $COBOL85──────────────────────────────────────────── (1)
*END PLAM.LIB(EXAMP3)────────────────────────────────────────────── (2)
```

(1) Invocation of the compiler; in interactive mode SYSDTA is assigned to the terminal.

(2) The system file SYSDTA is assigned to the element EXAMP3 in the PLAM library PLAM.LIB. At the end of the compilation SYSDTA and SYSCMD are linked together.

Assigning the source program with the SET-FILE-LINK command and COMOPT SOURCE-ELEMENT

Input from libraries can also be initiated directly - bypassing SYSDTA by means of the SET-FILE-LINK command. The standard link name SRCLIB must be used in this case. The general format of the SET-FILE-LINK command for the input of source programs from libraries is shown below:

```
SET-FILE-LINK [LINK-NAME=]SRCLIB,[FILE-NAME=]libname
```

Example 4-3: Input from a PLAM library

```
/SET-FILE-LINK SRCLIB,PLAM.LIB ---------------------------------------- (1)
/START-PROGRAM $COBOL85 ----------------------------------------------- (2)

*COMOPT SOURCE-ELEMENT=EXAMP3 ----------------------------------------- (3)
*COMOPT SOURCE-VERSION=V001 ------------------------------------------- (4)
*END ------------------------------------------------------------------ (5)
```

(1) The SDF command (in positional operand form) assigns the PLAM library PLAM.LIB and links it with the standard link name SRCLIB.

(2) Invocation of the compiler.

(3) The program to be compiled is stored under the element name EXAMP3 in the PLAM library assigned with the SET-FILE-LINK command.

(4) The PLAM.LIB library contains several versions of the element named EXAMP3. In this case, the version designated as V001 is referenced.

(5) The input of options is terminated, and the compiler begins the compilation run.

4.2 Table of COMOPT operands

Almost all the options have a default value. This automatically applies if the user does not explicitly specify an alternative. If all the default values of the system are to be used as options, COMOPT entries are superfluous.

The following table summarizes all COMOPT operands that can be used to control the compiler.
The following points refer to the representation of the statement formats:

– If an operand can be abbreviated, the short form is indicated below its full designation (e.g. ACC-L-T-U for ACCEPT-LOW-TO-UP). The equal sign must be specified between the operand and the value in every case.

– The default operand values are either shown underlined in the format or mentioned explicitly in the summarized description of the function.

In the “Function” column, under the keyword “SDF option”, you will find the short form of the SDF operand equivalent of the respective COMOPT operand. If there is no equivalent SDF operand, this is indicated by a dash

Operand format	**Function**
ACCEPT-LOW-TO-UP={YES/NO} ACC-L-T-U	specifies whether letters entered in lowercase are to be converted to uppercase when an ACCEPT statement is executed. The conversion is performed only if the input is typed in at the terminal. *SDF option:* RUNTIME-OPTIONS = PARAMETERS(...) ACCEPT-STMT-INPUT =
ACTIVATE-WARNING-MECHANISM={YES/NO} ACT-W-MECH	specifies whether the existence of - obsolete language elements and - non-standard language extensions that are detected in the program during compilation should be identified in the diagnostic listing by means of a message of severity code F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which ACTIVATE-WARNING-MECHANISM=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO In addition, the operand MINIMAL-SEVERITY=I is set in this case in order that messages of severity code F can also be listed. *SDF option:* ACTIVATE-FLAGGING = ANS85

ACTIVATE-XPG4-RETURNCODE={YES/NO}	specifies that, after C subprograms have been called, their function values are available in the COBOL special register RETURN-CODE.
	
	SDF option:
	SOURCE-PROPERTIES = PARAMETERS(...)
	RETURN-CODE =.

CHECK-DATE={YES/NO} CHECK-D	determines whether the compiler is to report two-digit year numbers for ACCEPT FROM DATE/DAY. *SDF option*: LISTING=PARAMETERS(...) DIAGNOSTICS=YES REPORT-2-DIGIT-YEAR=

Operand format	Function

CHECK-CALLING-HIERARCHY={YES/<u>NO</u>}
 	
CHECK-C-H
	specifies whether the calling hierarchy should be checked. A program in which the statements CALL identifier and/or CANCEL are used, must be compiled using CHECK-CALLING-HIERARCHY=YES.
	
	SDF option:
	RUNTIME-CHECKS = PARAMETERS(...)
	    RECURSIVE-CALLS =

CHECK-FUNCTION-ARGUMENTS={YES/<u>NO</u>}
 	
CHECK-FUNC
	causes function arguments to be checked for validity and a message to be issued by the runtime system when errors occur.
	
	SDF option:
	RUNTIME-CHECKS = PARAMETERS(...)
	    FUNCTION-ARGUMENTS =

CHECK-PARAMETER-COUNT={YES/<u>NO</u>}
 	
CHECK-PAR-C
	specifies whether the number of parameters passed should be compared with the number of parameters expected when a COBOL subprogram is called.
	
	SDF option:
	RUNTIME-CHECKS = PARAMETERS(...)
	    PROC-ARGUMENT-NR =

CHECK-REFERENCE-MODIFICATION =
{YES/<u>NO</u>}
 	
CHECK-REF
	determines whether the runtime system should verify compliance with data-item limits for identifiers subject to reference modification.
	
	SDF option:
	RUNTIME-CHECKS = PARAMETERS(...)
	    REF-MODIFICATION

CHECK-SCOPE-TERMINATORS={YES/<u>NO</u>}
 	
CHECK-S-T
	checks the syntax of the statements in the PROCEDURE DIVISION for correct scope termination.
	
	SDF option:
	LISTING = PARAMETERS(...)
	    DIAGNOSTICS = YES(...)
	        IMPLICIT-SCOPE-END =

CHECK-SOURCE-SEQUENCE={YES/<u>NO</u>} CHECK-S-SEQ	determines whether record pairs that are found not to be in ascending order should be identified in the diagnostic listing by means of an error message of severity code 0. *SDF option:* --

CHECK-TABLE-ACCESS={YES/<u>NO</u>}
 	
CHECK-TAB
	determines whether the runtime system should verify compliance with table limits (both for subscripts and for indexing).
	
	SDF option:
	RUNTIME-CHECKS = PARAMETERS(...)
	    TABLE-SUBSCRIPTS =

Operand format	**Function**
CONTINUE-AFTER-MESSAGE={YES/NO} CON-A-MESS	determines whether the runtime system should be continued or terminated following specific COB91 messages. *SDF option:* RUNTIME-OPTIONS = PARAMETERS(...) ERROR-REACTION =
ELABORATE-SEGMENTATION={YES/NO}	If NO is specified, segmentation-related language elements are ignored (SEGMENT-LIMITclause, segment numbers in section header). Warnings are output. YES supports segmentation. However, the compilation is aborted with a message if the program contains nested source programs and non-fixed segments. If this combination does not exist, only segmentation-related language elements are rejected with warnings. If ELABORATE-SEGMENTATION=YES is specified together with GENERATE-SHARED-CODE=YES or GENERATE-LLM=YES, it is also rejected. *SDF option:* COMPILER-ACTION=MODULE-GENERATION(...) SEGMENTATION=
ENABLE-UFS-ACCESS={YES/NO} Not available in COBOL85-BC	specifies whether the compiler is to generate an object which is also capable of processing files from the POSIX file system. *SDF option:* RUNTIME-OPTIONS = PARAMETERS(...) ENABLE-UFS-ACCESS =
EXPAND-COPY={YES/NO} EXP-COPY	controls whether COPY elements inserted in the source program are printed in the source listing. *SDF option:* LISTING = PARAMETERS(...) SOURCE = YES(...) COPY-EXPANSION =
EXPAND-SUBSCHEMA={YES/NO} EXP-SUB Not available in COBOL85-BC	controls whether the Sub-schema Section of the source program is logged on the source listing. *SDF option:* LISTING = PARAMETERS(...) SOURCE = YES(...) SUBSCHEMA-EXPANSION =

Operand format	**Function**
FLAG-ABOVE-MINIMUM={YES/NO}	In the diagnostic listing, all language elements that belong to the “intermediate” or “high” subset of ANS85 are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-ABOVE-MINIMUM=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) ABOVEMIN-SUBSET
FLAG-ABOVE-INTERMEDIATE={YES/NO}	In the diagnostic listing, all language elements that belong to the “high” subset of ANS85 are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-ABOVE-INTERMEDIATE=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) ABOVEINTERMED-SUBSET =
FLAG-ALL-SEGMENTATION={YES/NO}	In the diagnostic listing, all language elements that belong to the Segmentation Feature are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-ALL-SEGMENTATION=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) ALL-SEGMENTATION =

Operand format	**Function**
FLAG-INTRINSIC-FUNCTIONS={YES/<u>NO</u>}	In the diagnostic listing, all language elements that belong to the Intrinsic Functions module are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-INTRINSIC-FUNCTIONS=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) INTRINSIC-FUNCTIONS =
FLAG-NONSTANDARD={YES/<u>NO</u>}	In the diagnostic listing, all non-standard language extensions are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-NONSTANDARD=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) NONSTANDARD-LANGUAGE =
FLAG-OBSOLETE={YES/<u>NO</u>}	In the diagnostic listing, all obsolete language extensions are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-OBSOLETE=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) OBSOLETE-FEATURES =

Operand format	**Function**
FLAG-REPORT-WRITER={YES/NO}	In the diagnostic listing, all language elements that belong to the Report Writer are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-REPORT-WRITER=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) REPORT-WRITER =
FLAG-SEGMENTATION-ABOVE1={YES/NO}	In the diagnostic listing, all language elements that belong to segmentation level 2 are flagged with F. Note The COMOPT operands listed below are ineffective in the case of compilation runs for which FLAG-SEGMENTATION-ABOVE1=YES has been specified. They would otherwise produce a deviation from the ANS85 Standard during compilation. RESET-PERFORM-EXITS = NO USE-APOSTROPHE = YES REPLACE-PSEUDOTEXT = NO *SDF option:* ACTIVATE-FLAGGING = FIPS(...) SEGMENTATION-ABOVE1 =
GENERATE-INITIAL-STATE={YES/NO} GEN-INIT-STA	specifies whether the compiler should make areas available for the initialization. All programs affected by a CANCEL statement must be compiled with GENERATE-INITIAL-STATE=YES. *SDF option:* COMPILER-ACTION = MODULE-GENERATION(...) PREPARE-CANCEL-STMT =
GENERATE-LINE-NUMBER={YES/NO} GEN-L-NUM	determines whether the COB9101 message is output instead of the COB9102 message. The COB9102 message is supplemented by the source program line number (generated by COBOL85) of the statement during whose execution the message concerned was issued. *SDF option:* RUNTIME-OPTIONS = PARAMETERS(...) ERR-MSG-WITH-LINE-NR =

Operand format	**Function**

GENERATE-LLM={YES/NO}
 	
GEN-LLM
	defines the module format for the module to be generated. If YES is specified, a link-and-load module (LLM) is generated; if NO is specified, an object module (OM) is generated. These specifications are ignored if MODUL-OUTPUT=<c-string...> has been specified.
	
	SDF option:
	COMPILER-ACTION = MODULE-GENERATION(...)
	MODULE-FORMAT = OM / LLM

GENERATE-RISC-CODE={YES/NO} GEN-RISC	If NO is specified, /390 code is generated. If YES is specified, RISC code is generated for the RISC systems under OSD-SVP. Only the LLM module format is permitted here. *SDF option:* COMPILER-ACTION=MODULE-GENERATION(...) DESTINATION=CODE=
GENERATE-SHARED-CODE={YES/NO} GEN-SHARE	specifies whether the Procedure Division code (without DECLARATIVES) is written to a separate code module. The name for this module is program name, shortened to 7 characters if necessary, with appended “@”. *SDF option:* COMPILER-ACTION = MODULE-GENERATION(...) SHAREABLE-CODE =
IGNORE-COPY-SUPPRESS={YES/NO} IGN-C-SUP	determines whether any COPY elements in the source program should be listed in the source listing using the SUPPRESS phrase. *SDF option:* LISTING = PARAMETERS(...) SOURCE = YES(...) COPY-EXPANSION =
INHIBIT-BAD-SIGN-PROPAGATION={YES/NO}	NO enables faster code to be generated when one data item is transferred to another, and both items are numerical and described with USAGE DISPLAY. No code is generated which would prevent encoded operational signs which do not match the PICTURE clause from being transferred.

Operand format	Function
LIBFILES= (list-id[,list-id]...)	determines which compilation protocols are to be created and output to a PLAM library. list-id will be one of the following specifications [NO]OPTIONS [NO]DIAG SYSLIST [NO]SOURCE [NO]OBJECT ALL [NO]MAP [NO]XREF <u>NO</u> SYSLIST contains the listings which have been specified in the COMOPT SYSLIST. The requested listings are processed from left to right. The value set last applies to the listing. If XREF is specified, MAP is also automatically assumed to apply. Each requested listing is generated with a standard name as an element of type R. The standard names are as follows: OPTLST.COB85.programmname (control statement listing) SRCLST.COB85.program-name (source listing) ERRLST.COB85.program-name (diagnostics listing) LOCLST.COB85.program-name (locator map/cross-reference listing) OBJLST.COB85.program-name (object listing) if necessary, program-name is abbreviated to 16 characters. The PLAM library must be assigned with the SET-FILE-LINK command by means of the link name LIBLINK. If no library name is assigned, the compiler stores the requested listings in the default library PLIB.COB85.program-name. *SDF option:* LISTING = PARAMETERS(...) OUTPUT = LIBRARY-ELEMENT(...) LIBRARY=<filename 1..54>

LINE-LENGTH=<u>132</u> / 119..172
 	
LINE-L
	specifies the maximum number of characters that are printed per line in the compiler listings.
	
	SDF option:
	LISTING = PARAMETERS(...)
	    LAYOUT = PARAMETERS(...)
	        LINE-SIZE =

Operand format	**Function**
LINES-PER-PAGE=64 / 20..128 LINES	specifies the maximum number of lines that are printed in the compiler listings per page. A page throw is effected as soon as the specified number of lines is reached. *SDF option:* LISTING = PARAMETERS(...) LAYOUT = PARAMETERS(...) LINES-PER-PAGE =
LISTFILES=(list-id[,list-id]...)	specifies which compiler listings are to be created and output to cataloged files. list-id can be one of the following entries: [NO]OPTIONS [NO]DIAG SYSLIST [NO]SOURCE [NO]OBJECT ALL [NO]MAP [NO]XREF NO For more information, read the description of COMOPT LIBFILES, which is similar. *SDF option:* LISTING = PARAMETERS(...) OUTPUT = STD-FILES
MARK-NEW-KEYWORDS={YES/NO} M-N-K	marks keywords from the future standard in the diagnostic listing with a message with severity code I. *SDF option:* LISTING=PARAMETERS(...) DIAGNOSTICS=YES MARK-NEW-KEYWORDS=
MAXIMUM-ERROR-NUMBER=integer MAX-ERR	specifies from what error number onwards (depending on the MINIMAL-SEVERITY phrase) compilation should be aborted. *SDF option:* COMPILER-TERMINATION = PARAMETERS(...) MAX-ERROR-NUMBER =

MERGE-DIAGNOSTICS=YES/NO
 	
M-DIAG
	“merges” all error messages that occurred during compilation with the source listing. For merging to function correctly, the source listing should not contain more than 65535 source program lines (see source listing in the Appendix).
	
	SDF option:
	LISTING=PARAMETERS(...)
	SOURCE=YES(...)
	INSERT-ERROR-MSG=

Operand format	Function
MINIMAL-SEVERITY={I/0/1/2/3} MIN-SEV	suppresses messages in the diagnostic listing if their severity codes are less than the specified value. *SDF option:* LISTING = PARAMETERS(...) DIAGNOSTICS = YES(...) MINIMAL-WEIGHT =
MODULE={*OMF/libname}	specifies where the object module that is generated during compilation is to be output. *OMF initiates output to the temporary EAM file of the current task. libname is the file name of the PLAM library in which the object module is to be placed. libname must be a valid BS2000 file name. *SDF option:* MODULE-OUTPUT = *OMF / *LIBRARY-ELEMENT(...) LIBRARY =
MODULE-ELEMENT=element-name MODULE-ELEM	specifies the name of the element under which an LLM is to be stored in the PLAM library. Max. length of element name: 32 chars. Note: This compiler option is ignored for object modules and when a sequence of source programs is compiled (error message severity code I). *SDF option:* MODULE-OUTPUT = *LIBRARY-ELEMENT(...) LIBRARY = <filename> ,ELEMENT =
MODULE-VERSION=version MODULE-VERS	enables the assignment of a version designation to the element which contains the module generated during compilation. version can be one of the following entries: *UPPER-LIMIT / *UPPER *HIGHEST-EXISTING / *HIGH *INCREMENT / *INCR <alphanum-name 1..24> For a description of the entries see *SDF option:* MODULE-OUTPUT = *LIBRARY-ELEMENT(...) LIBRARY = <filename> ,ELEMENT = <composed-name> VERSION =

Operand format	**Function**
OPTIMIZE-CALL-IDENTIFIER={YES/NO} O-C-I	enables repeated calls for the same subprogram to be processed via CALL identifier without calling system interfaces (this is possible for the first 100 subprograms to be called) *SDF option:* OPTIMIZATION = PARAMETERS(...) CALL-IDENTIFIER =
PRINT-DIAGNOSTIC-MESSAGES={YES/NO} PRI-DIAG Not available in COBOL85-BC	makes it possible to have all COBOL85 error messages listed. Compilation is not carried out in this case. *SDF option:* COMPILER-ACTION = PRINT-MESSAGE-LIST
REDIRECT-ACCEPT-DISPLAY={YES/NO}	causes the system files SYSDTA and SYSOUT to be assigned instead of system files SYSIPT and SYSLST (defaults) for ACCEPT and DISPLAY statements without FROM and UPON phrases. *SDF option:* RUNTIME-OPTIONS = PARAMETERS(...) ACCEPT-DISPLAY-ASSGN =
REPLACE-PSEUDOTEXT={YES/NO} REP-PSEUDO	determines how COPY elements are to be divided up into individually replaceable text words. If NO is specified, the separators colon, open brackets, close brackets and pseudo-text delimiter do not act as separators for text words and are not independent text words. One particular effect of this is that no replacements are made within brackets in mask strings. If NO is specified, the REPLACE statement may not be used. The options in the REPLACING clause are limited to the replacement of a single text word by a text word or an identifier. COPY elements may not contain COPY statements. *SDF option:---*
RESET-PERFORM-EXITS={YES/NO} RES-PERF	specifies whether the control mechanisms for all PERFORM statements are – reset for EXIT PROGRAM according to the ANS85 Standard (default value or YES specification) or – to remain active on exiting from the subprogram (NO specification). *SDF option:---*

Operand format	**Function**
ROUND-FLOAT-RESULTS-DECIMAL={YES/NO} ROUND-FLOAT	specifies whether floating-point data items are to be rounded to 7 (COMP-1) or 15 (COMP-2) decimal places before being transferred to fixed-point fields. *SDF option:*---

SEPARATE-TESTPOINTS={YES/NO}
 	
SEP-TESTP
 	
Not available in COBOL85-BC
	specifies whether a separate address is to be generated for all paragraph and section headings in the PROCEDURE DIVISION for debugging with AID.
	
	SDF option:
	TEST-SUPPORT = AID(...)
	    PREPARE-FOR-JUMPS =

SET-FUNCTION-ERROR-DEFAULT={YES/NO}
 	
S-F-E-D
	causes function arguments to be checked for validity and an appropriate return code to be assigned to any function in which a corresponding error occurs.
	
	SDF option:
	RUNTIME-OPTIONS = PARAMETERS(...)
	    FUNCTION-ERR-RETURN =

SHORTEN-OBJECT={YES/NO} SHORT-OBJ Not available in COBOL85-BC	specifies whether only ESD information should be listed in the requested object listing. *SDF option:*---

SHORTEN-XREF={YES/NO}
 	
SHORT-XREF
	determines whether the desired cross-reference listing should be shortened by including only data names and procedure names addressed in the program.
	
	SDF option:
	LISTING = PARAMETERS(...)
	    NAME-INFORMATION = YES(...)
	        CROSS-REFERENCE =

SORT-EBCDIC-DIN={YES/NO}
 	
SORT-E-D
	enables selection of the ED format for SORT (see [6]); among other things, characters with an umlaut, such as ä, ö or ü, are treated as AE, OE or UE during sort operations.
	
	SDF option:
	RUNTIME-OPTIONS = PARAMETERS(...)
	    SORTING-ORDER =

Operand format	**Function**

SORT-MAP={YES/<u>NO</u>}	enables output of the locator map listing from the source program, sorted by symbolic names in ascending order. The locator map listing comprises lists for data, section, and paragraph names.
	
	SDF option:
	LISTING = PARAMETERS(...)
	    NAME-INFORMATION = YES
	        SORTING-ORDER =

SUPPORT-WINDOW-DEBUGGING = {YES/<u>NO</u>} S-W-D Not available in COBOL85-BC!	enables debugging of the generated object with the graphical AID debugging facility (AID-FE). If SUPPORT-WINDOW-DEBUGGING=YES is specified, SEPARATE-TESTPOINT=YES is also accepted. *SDF option:* TEST-SUPPORT = AID(...) WINDOW-DEBUG-SUPPORT =
SOURCE-ELEMENT=element SOURCE-ELEM	assigns a PLAM library element as the source program to the compiler. The library must be assigned with a SET-FILE-LINK command (using the link name SRCLIB) prior to compilation. element is the name of the library element. It must be included in a PLAM library under element type S. “element” can have a maximum length of 40 characters. *SDF option:* SOURCE = *LIBRARY-ELEMENT(...) LIBRARY = ELEMENT =
SOURCE-VERSION=version SOURCE-VERS	indicates to the compiler which version of the element assigned with SOURCE-ELEMENT should be compiled. version is one of the following entries: <u>*HIGHEST-EXISTING</u> / *HIGH *UPPER-LIMIT / *UPPER <alphanum-name 1..24> For a description of the entries see *SDF option:* SOURCE = *LIBRARY-ELEMENT(...) LIBRARY = ,ELEMENT = VERSION =

Operand format	Function
SUPPRESS-LISTINGS={YES/<u>NO</u>} SUP-LIST	suppresses output of the - object program - locator map and - cross-reference (XREF) listings when an error with a severity code ? 2 occurs. In such cases, only the diagnostic listing and source listing are output (if requested). *SDF option:* LISTING = PARAMETERS(...) NAME-INFORMATION = SUPPRESS-GENERATION =
SUPPRESS-MODULE={YES/<u>NO</u>} SUP-MOD	suppresses the generation of an object module when an error message with severity code ? 2 occurs. SUPPRESS-MODULE=YES has the additional effect of the SUPPRESS-LISTINGS=YES operand. *SDF option:* COMPILER-ACTION = MODULE-GENERATION(...) SUPPRESS-GENERATION =
SYMTEST={ALL/<u>NO</u>} Not available in COBOL85-BC	specifies the information that the compiler provides for the advanced interactive debugger AID (see [8]). ALL: The compiler generates LSD information and ESD debugger information. NO: The compiler generates only ESD debugger information. *SDF option:* TEST-SUPPORT = AID(...)
SYSLIST=(list-id[,list-id]...)	defines which compiler listings are to be created and output to the SYSLST system file. list-id can be one of the following entries: [NO]OPTIONS ALL [NO]SOURCE <u>NO</u> [NO]MAP [NO]DIAG [NO]OBJECT [NO]XREF *SDF option:* LISTING = PARAMETERS(...) OUTPUT = SYSLST

Operand format	**Function**
TCBENTRY=name Not available in COBOL85-BC	specifies the name of the UTM communi- cation table, which is generated by COBOL85. This table contains pointers to the internal work areas which must be reinitia-lized by UTM in case of a UTM program unit rerun. name is the name of the communication table. It marks the beginning of these pointer tables. “name” can have a maximum length of 8 characters. *SDF option:* --
TERMINATE-AFTER-SEMANTIC={YES/<u>NO</u>} TERM-A-SEM	causes the source program to only be checked for syntax and semantic errors, without a module being generated. Only source and diagnostic listings can be output in this case. *SDF option:* COMPILER-ACTION = SEMANTIC-CHECK
TERMINATE-AFTER-SYNTAX={YES/<u>NO</u>} TERM-A-SYN	causes the source program to only be checked for syntax errors, without a module being generated. Only source and diagnostic listings can be output in this case. *SDF option:* COMPILER-ACTION = SYNTAX-CHECK
TEST-WITH-COLUMN1={YES/<u>NO</u>} TEST-W-C Not available in COBOL85-BC	defines for SYMTEST=ALL whether the AID source references are to be formed with the help of sequence numbers (columns 1-6) from the source program. *SDF option:* TEST-SUPPORT = AID(...) STMT-REFERENCE =
USE-APOSTROPHE={YES/<u>NO</u>} USE-AP	provides the option of declaring the apostrophe (') instead of quotes (") as a delimiter for literals in the source program. This declaration is also valid for the figurative constant QUOTE. Note A source program with the apostrophe (') as a delimiter for literals does not conform to the ANS85 Standard. *SDF option:*---

5 COBOL85 Structurizer

Not supported in COBOL85-BC !

The COBOL85 Structurizer is a program package which facilitates handling of COBOL source programs. It can be used after editing, during testing, and also for program documentation.

The COBOL85 Structurizer is controlled via SDF and is invoked using the following command:

```
/START-COBOL85-STRUCTURIZER [options]
(Abbreviation: S-COB-S)
```

Processing begins immediately after the command is entered.

If the source program is to be processed without any explicit options (i.e. with the default operand values), it must be assigned to the system file SYSDTA before the Structurizer is called.
SDF control of the Structurizer formally mirrors the compiler control; the various input options available are described in section 3.1; these also apply to the Structurizer.

The conditions for input of COPY elements to the Structurizer are the same as for input of COPY elements to the compiler (see section 2.2.2). In particular, this means that the standard link names COBLIB and COBLIB1 through COBLIB9 must be used where necessary.

The COBOL85 Structurizer offers the following functions:

- Source text editing (“beautify” function)
  - Indentation of source program lines in accordance with the COBOL reference format
  - Inclusion of explicit scope terminators
  - Conversion of obsolete language elements into comments

  Once prepared in this way, the source program can be compiled.

  Output from such source text preparation is automatically stored in a cataloged SAM file named *filename*.IND or *elementname*.IND.

- Source program structure list (“pretty print” function)

  The Structurizer generates a source program listing in which the source text is presented in an edited format (similar to the “beautify” function) with a graphical representation of the statement structure and (optionally) with cross-references.

  Because of its graphical format, the structure list cannot be compiled.

  The structure list is automatically stored in a cataloged SAM file named STRLST.COB85.*program-id-name*.

Language scope

The Structurizer processes all language elements of the COBOL85 compiler in BS2000. However, in the “pretty print” function the statements
COPY textname REPLACING ==pseudotext==BY==pseudotext== and
REPLACE==pseudotext==BY==pseudotext==
are accepted by the Structurizer as being syntactically correct, but the intended replacement of text does not take place. However, COPY REPLACING word BY word is performed internally to produce a correct XREF listing if necessary. REPLACE statements and REPLACING clauses using pseudo-text or identifiers are ignored in the creation of the XREF.

As a general rule, COBOL source text must be written in COBOL reference format. If there is an incorrect character in column 7, it is replaced in the output by a blank.

5.1 Source text editing (“beautify” function)

It is recommended practice to edit the source program into an error-free state (e.g. by performing a compilation with COMPILER-ACTION=SEMANTIC-CHECK) before using the “beautify” function. Although the Structurizer is able to detect syntax errors, it generally recognizes only one error per call.

Following is a summary of the main editing operations that take place.

- The COPY statements in the source program are optionally expanded; the text of the COPY elements is not output.
- Data entries in the Data Division are output as follows when the option DATA - FORMATTING = YES is set:
  - Level numbers 01 and 77 are output in columns 8 and 9.
  - All remaining level numbers are indented by four columns with respect to the next higher level number, but only as far as column 36.
  - The data names are indented by four positions with respect to the associated level number.
- Statements in the Procedure Division are output as follows:
  - Each statement begins on a new line.
  - All IF and EVALUATE statements are terminated with the associated scope terminator.
  - The optional keyword THEN is inserted if applicable.
  - In the case of nesting, each statement is indented with respect to the next higher statement within the nesting. The depth of indentation can be set with the INDENTATION-AMOUNT operand of the LAYOUT parameter.
  - Optionally, keywords added by the Structurizer are written in lower case.
  - The condition after an IF statement is always indented by three positions.
  - The following keywords and exception conditions are always output on a separate line:

    THEN, ELSE, END-IF, WHEN OTHER, END-EVALUATE, END-PERFORM, EXIT PERFORM, [NOT] AT END, [NOT] INVALID KEY, [NOT] ON SIZE ERROR, [NOT] ON OVERFLOW, [NOT] AT END-OF-PAGE
    as well as all explicit scope terminators after an exception condition.
  - Paragraph names are also always output on a separate line of their own.
  - Blank lines, comment lines, continuation lines and DEBUG lines are output unaltered.

- The layout of the statements remains unaltered.
- Superfluous periods are removed.
- A period appearing after an exception condition is replaced by the appropriate explicit scope terminator for the statement (e.g. END-READ). If the last statement dependent on the exception condition is the same as the conditional statement, the scope terminator is duplicated.

  Example

  The program extract

  ```
  ADD 1 TO Z
  ON SIZE ERROR
  MOVE X TO FLAG
  ADD 1 TO ERRN.
  ```

  will appear like this after editing:

  ```
  ADD 1 TO Z
  ON SIZE ERROR
    MOVE X TO FLAG
    ADD 1 TO ERRN END-ADD
  END-ADD
  ```

  If only one END-ADD had been inserted, only the indented ADD statement would have been terminated.
- The following obsolete language elements are converted into comment lines: NOTE, REMARKS, ENTER COBOL, ENTER LINKAGE, EXHIBIT, ON, READY TRACE, RESET TRACE, EXAMINE, TRANSFORM
  The last two statements additionally initiate a request for them to be converted manually.

Example 5-1: Source text editing

Source program extract before the “beautify” function:

```
...

PROCEDURE DIVISION.
MAIN.
   DISPLAY "PLEASE, GIVE TRIANGLE SIDES, EACH ONE DIGIT"
                       UPON T
    PERFORM 4 TIMES
    CALL "INPUTFILE" USING I J K
    IF I + J NOT GREATER K OR
    J + K NOT GREATER I OR
    K + I NOT GREATER J
    THEN
    DISPLAY "NOT A TRIANGLE" UPON T
    ELSE
    MOVE ZERO TO MATCH
    IF I = J
     THEN
    ADD 1 TO MATCH
    END-IF
    IF J = K
    THEN
       ADD 1 TO MATCH
    END-IF
     IF K = I
    THEN
    ADD 1 TO MATCH
    END-IF
        EVALUATE TRUE
        WHEN MATCH = ZERO
       DISPLAY "SCALENE TRIANGLE" UPON T
        WHEN MATCH = 1
       DISPLAY "ISOSCELES TRIANGLE" UPON T
       WHEN OTHER
       DISPLAY "EQUILATERAL TRIANGLE" UPON T
        END-EVALUATE
     END-IF
     END-PERFORM
      STOP RUN.
```

Edited source program after the “beautify” function:

```
...

 PROCEDURE DIVISION.
 MAIN.
     DISPLAY "PLEASE, GIVE TRIANGLE SIDES, EACH ONE DIGIT"
       UPON T
     PERFORM 4 TIMES
       CALL "INPUTFILE" USING I J K
       IF I + J NOT GREATER K OR
          J + K NOT GREATER I OR
          K + I NOT GREATER J
       THEN
         DISPLAY "NOT A TRIANGLE" UPON T
       ELSE
         MOVE ZERO TO MATCH
         IF I = J
         THEN
           ADD 1 TO MATCH
         END-IF
         IF J = K
         THEN
           ADD 1 TO MATCH
         END-IF
         IF K = I
         THEN
           ADD 1 TO MATCH
           END-IF
         EVALUATE TRUE
         WHEN MATCH = ZERO
           DISPLAY "SCALENE TRIANGLE" UPON T
         WHEN MATCH = 1
           DISPLAY "ISOSCELES TRIANGLE" UPON T
         WHEN OTHER
           DISPLAY "EQUILATERAL TRIANGLE" UPON T
         END-EVALUATE
       END-IF
     END-PERFORM
     STOP RUN.
```

5.2 Source program structure list (“pretty print” function)

The structure list of the source program may be generated in two stages:

- Structure list without cross-reference information
- Structure list with cross-reference information

The following structurizer options are common to both lists:

- Source text editing, akin to the “beautify” function (see section 5.1). The setting DATA-FORMATTING = YES is taken to be implicit, i.e. formatting is also performed in the DATA DIVISION.
- The COPY statements in the source program are optionally expanded and the text of the COPY elements is output.
- Statement blocks are enclosed by horizontal and vertical lines.
- Page numbering
- Line numbering, akin to the line numbering in the compiler source listing
- Boldface printing of keywords generated by the Structurizer during source text editing
- Page layout of the listing (no. of lines per page/line length)

With the exception of source text editing, all Structurizer functions can be switched on or off.

5.2.1 Structure list without cross-reference information

Example 5-2:

(generated with CROSS-REFERENCE=NO,
INFORMATION parameter SEQUENCE-AREA=NO,
IDENTIFICATION-AREA=NO and LAYOUT parameter LINE-SIZE=80)

```
COBOL85 V02.1B00  PRETTY-PRINTING  DATE: 1994-03-03 TIME: 10:21:08 PAGE: 1
LINE ID   SOURCE: TRIANGLE

          ...

14        PROCEDURE DIVISION.
15        MAIN.
16            DISPLAY "PLEASE, GIVE TRIANGLE SIDES, EACH ONE DIGIT"
17              UPON T
18          ┌─PERFORM 4 TIMES
18          ├──────────────────────────────────────────────────────────
19          │   CALL "EINGABE" USING I J K
20          │ ┌─IF I + J NOT GREATER K OR
21          │ │    J + K NOT GREATER I OR
22          │ │    K + I NOT GREATER J
23          │ ├─THEN───────────────────────────────────────────────────
24          │ │   DISPLAY "NOT A TRIANGLE" UPON T
25          │ ├─ELSE───────────────────────────────────────────────────
26          │ │   MOVE ZERO TO MATCH
27          │ │ ┌─IF I = J
28          │ │ ├─THEN─────────────────────────────────────────────────
29          │ │ │   ADD 1 TO MATCH
30          │ │ └─END-IF───────────────────────────────────────────────
31          │ │ ┌─IF J = K
32          │ │ ├─THEN─────────────────────────────────────────────────
33          │ │ │   ADD 1 TO MATCH
34          │ │ └─END-IF───────────────────────────────────────────────
35          │ │ ┌─IF K = I
36          │ │ ├─THEN─────────────────────────────────────────────────
37          │ │ │   ADD 1 TO MATCH
38          │ │ └─END-IF───────────────────────────────────────────────
39          │ │ ┌─EVALUATE TRUE
40          │ │ ├─WHEN MATCH = ZERO────────────────────────────────────
41          │ │ │   DISPLAY "SCALENE TRIANGLE" UPON T
42          │ │ ├─WHEN MATCH = 1───────────────────────────────────────
43          │ │ │   DISPLAY "ISOSCELES TRIANGLE" UPON T
44          │ │ ├─WHEN OTHER───────────────────────────────────────────
45          │ │ │   DISPLAY "EQUILATERAL TRIANGLE" UPON T
46          │ │ └─END-EVALUATE─────────────────────────────────────────
47          │ └─END-IF─────────────────────────────────────────────────
48          └─END-PERFORM──────────────────────────────────────────────
49        <───STOP RUN.
```

5.2.2 Structure list with cross-reference information

As well as producing a graphical representation of the statement blocks, the structure list with cross-reference information also contains cross-references to all defined names. The user therefore has access to two important sources of information within the structure list:

- On the line where the name is defined, a reference is given to all other line numbers where the name is used;
- On the lines where a name is used, a reference is given indicating the line number where the name is defined.

The structure list is primarily intended to serve the programmer as a basis for programming activity at the workstation. A structure list with cross-reference information is a particularly useful tool when creating, amending and documenting the source program. Remote effects, name conflicts, etc., are quickly identified, and unintended side-effects when modifying the source program are avoided. The structure list with cross-reference information is therefore an indispensable part of program documentation.

Identification of lines

The file name of the source program appears in the header line of the listing; the name of a COPY element is given in the COPY statement immediately preceding it. To facilitate the location of lines in COPY elements, a list is appended to the end of the structure list; this list indicates the identification and line number of each COPY element.

Each line of the program text is uniquely identifiable by a consecutive number relating to the corresponding line of the source program or COPY element.

The lines made up of COPY elements are identified by the letters A - Z and the numbers 1 - 9. If more than 35 COPY elements are present, they are identifiable by a unique letter/ number combination (e.g. “A1” or “QZ”).

Reference from definition to usage

At the point in the output listing where a name is defined, the right-hand column lists all the lines in which this name is used.

In addition the type of usage is identified by means of the following abbreviations:

- for data objects:

space	No change of contents
*:	Change of contents
F-	Formal parameter in USING group in PROCEDURE DIVISION or ENTRY
R-	Actual parameter in USING group in CALL by reference (default)
C-	Actual parameter in USING group in CALL by content
=:	Used in REDEFINES or RENAMES clause

- for files:

I:	OPEN INPUT
O:	OPEN OUTPUT
B:	OPEN I-O
X:	OPEN EXTENDED

- for procedures (sections and paragraphs):

P-	Call with PERFORM
E-	CALL with literal
N-	CALL with identifier
G-	Branch with GO TO
A-	Used in ALTER
S-	Used in SORT

Any one line contains only the references of one type. The references of a type are output in the order in which they are used in the program, in other words in ascending numerical sequence within the source program and each COPY call.
If several data items are defined on one input line, usages of different data items are output on different lines.

Reference from usage to definition

At the point at which a referenced name is used, the number of the line in which the name was defined is also indicated.

Where several usages occur in one line, the references to where they are defined are listed in the same sequence as the usages within the line.

If usage of a name with identification occurs (e.g. C OF B OF A), only the definition of the lowest name in the hierarchy (in the example, C) is indicated, with its corresponding line number.

A question mark (“?”) as a reference indicates usage of a non-defined name.

Two question marks (“??”) indicate an ambiguous name, i.e. there are several definitions to which the name refers.

Example 5-3: Structure list with cross-reference information

(generated with INFORMATION parameter SEQUENCE-AREA=NO, IDENTIFICATION-AREA=NO and with LAYOUT parameter LINE-SIZE=80)

```
  COBOL85 V02.1B00  PRETTY-PRINTING  DATE: 1994-03-03 TIME: 11:36:59 PAGE: 1
 LINE ID   SOURCE: CHECK.COB                                   REFERENCES

     1       IDENTIFICATION DIVISION.
     2       PROGRAM-ID.
     2           CHECK.
     3       ENVIRONMENT DIVISION.
     4       INPUT-OUTPUT SECTION.
     5       FILE-CONTROL.
     6           SELECT CHECKS   ASSIGN TO PRINTER.          |D: A-  2
     7           SELECT ACCOUNTS ASSIGN TO PRINTER.          |D: B-  2
     8       DATA DIVISION.
     9       FILE SECTION.
    10           COPY   CHECKS.
A    1      *
A    2       FD  CHECKS LABEL RECORD STANDARD.               |       6     72
A    2                                                       |   E-  3
A    2                                                       |I:    35
A    3       01  S-DATA.                                     |   G-  5 I-  5
A    3                                                       |   J-  5
A    4           05  S-NR          PIC 9(7).
A    5           05  S-ACCNT-NR    PIC 9(8).                 |   D-  4 D-  6
A    5                                                       |   F-  4
A    5                                                       |=: A-  6
A    6           05  FILLER     REDEFINES S-ACCNT-NR.        |D: A-  5
A    7               10  POSITN     OCCURS 8 PIC 9.          |   D- 13 D- 17
A    8           05  AMOUNT     PIC 9(7)V9(2).               |      46    48
A    8                                                       |      50 C- 12
A    8                                                       |   C- 16 C- 21
A    8                                                       |   C- 54 C- 58
A    8                                                       |   C- 63
A    9      *
    11           COPY  ACCOUNTS.
B    1      *
B    2       FD  ACCOUNTS LABEL RECORD STANDARD.             |       7     72
B    2                                                       |   F-  3
B    2                                                       |I:    35
B    3       01  K-DATA.                                     |   G-  6
B    4           05  K-TYPE        PIC XX.                   |   F-  7
B    5           05  K-STATUS      PIC XX.                   |   F-  6
B    6           05  K-ACCNT-NR    PIC 9(8).                 |   F-  4
B    7           05  SALARY     PIC 9(7)V9(2).               |   C- 22 C- 64
B    8           05  CREDIT     PIC 9(7)V9(2).               |   C- 14 C- 17
B    8                                                       |   C- 56 C- 59
B    9           05  BALANCE    PIC 9(7)V9(2).               |   C- 12 C- 16
B    9                                                       |   C- 22 C- 54
B    9                                                       |   C- 58 C- 64
B   10      *
    12       WORKING-STORAGE SECTION.
    13       01  CHECK                 PIC 9(16).            |   D- 13
    13                                                       |*: D- 11 D- 13
    13                                                       |=:    14
    14       01  FILLER       REDEFINES CHECK.               |D:    13
    15           05  CHKDIGIT     OCCURS 16 PIC 9.           |   D- 17
    16        77  ACCNT-TYPE           PIC XX.                |*: F-  7
    17            88  SPECIAL-CODE        VALUE "SC".         |   C-  6 C- 48
    18            88  SALARYACCT          VALUE "GK".         |   C- 19 C- 61
    19        77  ACCNT-STATUS         PIC XX.                |   K-  5
    19                                                        |*:    42 F-  3
    19                                                        |*: F-  6 F-  9
    20            88  ACCNT-FOUND         VALUE SPACES.
    21            88  ACCNT-NOTFD         VALUE "NV".         |      61
    22            88  ACCNT-SUSPD         VALUE "KS".         |   C- 10 C- 52
    23        77  CHECK-STATUS         PIC XX.                |   K-  6
    23                                                        |*:    43 D-  8

 COBOL85 V02.1B00  PRETTY-PRINTING  DATE: 1994-03-03 TIME: 11:36:59 PAGE: 2
 LINE ID   SOURCE: CHECK.COB                                     REFERENCES

    23                                                        |*: D- 19 D- 21
    23                                                        |*: E-  3
    24            88  ACCNT-NR-WRONG      VALUE "KF".
    25            88  EOF-CHECKS          VALUE "EF".         |      36    39
    26            88  ACCNT-NR-OK         VALUE "KO".         |      58 K-  9
    27        77  AMOUNT-STATUS        PIC XX.                |   K-  7
    27                                                        |*:    44    47
    27                                                        |*:    49    51
    27                                                        |*:    53
    28            88  AMOUNT-NOT-NUM      VALUE "BN".
    29            88  AMOUNT-OK           VALUE "BO".         |      56 K-  9
    30            88  AMOUNT-SUSPD        VALUE "BS".         |   C-  8 C- 50
    31        77  I                    PIC 9.                 |   D- 12 D- 13
    31                                                        |*: D- 10 D- 14

 COBOL85 V02.1B00  PRETTY-PRINTING  DATE: 1994-03-03 TIME: 11:36:59 PAGE: 3
 LINE ID   SOURCE: CHECK.COB                                     REFERENCES

    32        PROCEDURE DIVISION.
    33        CONTROL SECTION.
    34        CONTROL-1001.
    35            OPEN INPUT CHECKS ACCOUNTS                  |D: A-  2 B-  2
    36          ┌─PERFORM UNTIL EOF-CHECKS                    |D:    25
    36          │──────────────────────────────────────────────
    37          │   PERFORM READ-CHECK                        |D: E-  1
    38          │ ┌─IF
    39          │ │    EOF-SCHECK                             |D:    25
    39          │ ├─THEN───────────────────────────────────────
    40          │ │   EXIT PERFORM
    41          │ └─END-IF─────────────────────────────────────
    42          │   MOVE SPACES TO ACCNT-STATUS               |D:    19
    43          │     CHECK-STATUS                            |D:    23
    44          │     AMOUNT-STATUS                           |D:    27
    45          │ ┌─EVALUATE TRUE
    46          │ │-WHEN AMOUNT NOT NUMERIC───────────────────|D: A-  8
    47          │ │   MOVE "BN" TO AMOUNT-STATUS              |D:    27
    48          │ ├─WHEN AMOUNT < 5───────────────────────────|D: A-  8
    49          │ │   MOVE "BS" TO AMOUNT-STATUS              |D:    27
    50          │ ├─WHEN AMOUNT > 1000000─────────────────────|D: A-  8
    51          │ │   MOVE "BS" TO AMOUNT-STATUS              |D:    27
    52          │ ├─WHEN OTHER─────────────────────────────────
    53          │ │   MOVE "BO" TO AMOUNT-STATUS              |D:    27
    54          │ └─END-EVALUATE───────────────────────────────
    55          │   PERFORM TEST-ACCNT-NR                     |D: D-  1
    56          │ ┌─IF AMOUNT-OK                              |D:    29
    57         │ │    AND
    58         │ │    ACCNT-NR-OK                           │D:    26
    59         │ ├─THEN────────────────────────────────────────
    60         │ │   PERFORM READ-ACCOUNT                   │D: F-  1
    61         │ │ ┌─IF ACCNT-NOTFD                         │D:    21
    62         │ │ │-THEN──────────────────────────────────────
    63         │ │ │   PERFORM ERROR-MESSAGE                │D: K-  1
    64         │ │ │   PERFORM REJECT-CHECK                 │D: I-  1
    65         │ │ ├─ELSE──────────────────────────────────────
    66         │ │ │   PERFORM TEST-CHECK                   │D: C-  1
    67         │ │ └─END-IF────────────────────────────────────
    68         │ │-ELSE────────────────────────────────────────
    69         │ │   PERFORM ERROR-MESSAGE                  │D: K-  1
    70         │ └─END-IF──────────────────────────────────────
    71         └─END-PERFORM─────────────────────────────────────
    72           CLOSE CHECKS ACCOUNTS.                     │D: A-  2 B-  2
    73       CONTROL-1002.
    74       <───STOP RUN.
    .
    .
    .

 COBOL85 V02.1B00  PRETTY-PRINTING  DATE: 1994-03-03 TIME: 11:36:59 PAGE: 10
 LINE ID   SOURCE: CHECK.COB                                      REFERENCES

 TABLE OF ALL INCLUDED COPY ELEMENTS IN THE PROGRAM

           COPY  CALL  IN  COPY ELEMENT
           ID    ID   LINE

           A :         10  CHECKS
           B :         11  ACCOUNTS
           C :         76  TEST-CHECK
           D :         78  TEST-ACCNT-NR
           E :         80  READ-CHECK
           F :         82  READ-ACCOUNT
           G :         84  PROCESS-CHECK
           H :         86  PROCESS-ERROR
           I :   H-     1  REJECT-CHECK
           J :   H-     2  BLOCK-CHECK
           K :   H-     3  ERROR-MESSAGE
```

5.3 SDF options for controlling the COBOL85 Structurizer

A short description of the syntax and use of the SDF interface is given in chapter 3.

5.3.1 SOURCE option

The parameters for this option determine whether the source program is to be read in from SYSDTA, from a cataloged file or from a PLAM library.

Format

```
SOURCE = *SYSDTA / <filename 1..54> / *LIBRARY-ELEMENT(...)

  *LIBRARY-ELEMENT(...)
   |  LIBRARY = <filename 1..54 without gen>
   | ,ELEMENT = <filename 1..40 without gen-vers>(...)
   |     <filename 1..40 without gen-vers>(...)
   |        | VERSION = *HIGHEST-EXISTING / *UPPER-LIMIT /<alphanum-name 1..24>
```

SOURCE = <u>*SYSDTA</u>
The source program is read in from the SYSDTA system file, which is normally assigned to the terminal in interactive mode. If, prior to the compilation run, the source program file has been assigned to the system file SYSDTA by means of the ASSIGN-SYSDTA command, no SOURCE option need be entered.

SOURCE = <filename 1..54>
The <filename> option assigns a cataloged file.

SOURCE = *LIBRARY-ELEMENT(...)
This parameter specifies a PLAM library and an element within it.

LIBRARY = <filename 1..54)
Name of the PLAM library in which the source program resides as an element.

ELEMENT = <filename 1..40>
Name of the library element containing the source program.

VERSION =
Version designation of the library element.

VERSION = <u>*HIGHEST-EXISTING</u>
If no version or *HIGHEST-EXISTING is specified, the Structurizer reads from the element with the highest existing version number.

VERSION = *UPPER-LIMIT
The Structurizer reads from the element with the highest possible version number (“@”).

VERSION = <alphanum-name 1..24>
The Structurizer reads from the element with the specified version designation.

5.3.2 STRUCTURIZER-ACTION option

This option determines the amount of information required, the layout and the output medium of the tool employed.

Format

```
STRUCTURIZER-ACTION = PRETTY-PRINT(...) / BEAUTIFY(...)

   PRETTY-PRINT(...)
      |  CROSS-REFERENCE = YES / NO
      | ,INFORMATION = STD / PARAMETERS(...)
      |     PARAMETERS(...)
      |        |  SEQUENCE-AREA = YES / NO
      |        | ,IDENTIFICATION-AREA = YES / NO
      |        | ,COPY-EXPANSION = YES / NO
      |        | ,SUB-SCHEMA = YES / NO
      |        | ,LINE-NUMBERS = YES / NO
      |        | ,STATEMENTS = YES / NO
      |
      | ,LAYOUT = STD / PARAMETERS(...)
      |     PARAMETERS(...)
      |        |  LOWER-CASE-KEYWORDS = YES / NO
      |        | ,INDENTATION-AMOUNT = 2 / <integer 1..8>
      |        | ,BOLD-FACE = YES / NO
      |        | ,BLOCK-FRAMES = EBCDIC-CHARS / GRAPHIC / NONE
      |        | ,LINES-PER-PAGE = 64 / <integer 20..144> / AS-NEEDED
      |        | ,LINE-SIZE = 132 / <integer 52..132>
      |        |
      | ,OUTPUT = *STD-FILES / <filename 1..54> / SYSLST


   BEAUTIFY(...)
      | INFORMATION = STD / PARAMETERS(...)
      |     PARAMETERS(...)
      |        |  SEQUENCE-AREA = YES / NO
      |        | ,IDENTIFICATION-AREA = YES / NO
      |
      | ,LAYOUT = STD / PARAMETERS(...)
      |     PARAMETERS(...)
      |        |  LOWER-CASE-KEYWORDS = YES / NO
      |        | ,INDENTATION-AMOUNT = 2 / <integer 1..8>
      |        | ,DATA-FORMATTING = YES/NO
   ,OUTPUT = *STD-FILES / <filename 1..54> /*LIBRARY-ELEMENT(...)

     *LIBRARY-ELEMENT(...)
          LIBRARY = <filename 1..54 without gen>
         ,ELEMENT = <filename 1..40 without gen-vers>(...)
               VERSION = *UPPER-LIMIT / *INCREMENT /  *HIGHEST-EXISTING /
                                  <alphanum-name 1..24>
```

STRUCTURIZER-ACTION = PRETTY-PRINT(...)
A structure list of the edited source program is to be generated.

CROSS-REFERENCE = YES / NO
If YES is specified, the structure list is supplemented with cross-references.

INFORMATION = STD
The default settings of the PARAMETERS structure are to be used.

INFORMATION = PARAMETERS(...)

SEQUENCE-AREA = YES / NO
If YES is specified, the “Sequence Number Area” (columns 1-6 of the reference format) of the input source program is used.

IDENTIFICATION-AREA = YES / NO
If YES is specified, the “Program Identification Area” (columns 73-80 of the reference format) of the input source program is used.

COPY-EXPANSION = YES / NO
If YES is specified, the contents of the COPY elements and the SUB-SCHEMA section are included in the output. Reading of the COPY elements is controlled by the COPY-STATEMENTS option.

SUB-SCHEMA = YES / NO
If YES is specified, the contents of the SUB-SCHEMA section are read. The output is controlled by the COPY-EXPANSION operand.

LINE-NUMBERS = YES / NO
If YES is specified, consecutive line numbers similar to the source program listing of the COBOL85 compiler are output.

STATEMENTS = YES / NO
If NO is specified, statements are not output. The list will then contain only structured statements of COBOL85, conditions, and comments. This method of compressing a list can be typically used to suppress implementation details so that the structure list only shows the flow of control and the inline documentation of the program.

LAYOUT = <u>STD</u>
The default values of the following PARAMETERS structure are used.

LAYOUT = PARAMETERS(...)

LOWER-CASE-KEYWORDS = YES / <u>NO</u>
Specifying YES causes the keywords added by the Structurizer (e.g. explicit scope terminators) to be lowercased. This function is useful only if the input source program is written in lowercase.

INDENTATION-AMOUNT = <u>2</u> / <integer 1..8>
The <integer> value specifies the amount by which statements are to be indented within structure blocks.

BOLD-FACE = YES / <u>NO</u>
Specifying YES causes the statements that introduce a structure block, the structurizing options (e.g. THEN) and the explicit scope terminators to be printed in boldface.

BLOCK-FRAMES = EBCDIC-CHARS
The structure block frames are represented using the following EBCDIC characters:

"|" = X'4F'
"–" = X'60'
"+" = X'4E'

BLOCK-FRAMES = GRAPHIC
The structure block frames are represented using graphic characters. The character set used for printing must contain the following characters in addition to those required for COBOL:

X'22'	for the top left corner
X'41'	for the vertical bar
X'2E'	for the central axis
X'28'	for the bottom left corner
X'3D'	for the horizontal line
X'3A'	for intersecting lines

BLOCK-FRAMES = NONE
The structure block frames are not represented, i.e. they are replaced with spaces.

LINES-PER-PAGE = <u>64</u> / <integer 20..144> / AS-NEEDED
The specified value determines the number of lines per page. If AS-NEEDED is specified, a form feed is triggered only by the beginning of sections (SECTION) or by the character "/" in column 7, and not by a line counter.

LINE-SIZE = 132 / 92 <integer 52..132>
This value determines the number of characters per line. The default for lists containing cross-references is 132, and for lists without cross-references 92. For structure lists without cross-references, the list width is limited to 92 characters.

OUTPUT = *STD-FILES
The list is output into a cataloged SAM file with the default name STRLST.COB85.program-id-name.

OUTPUT = <filename 1..54>
The result of the PRETTY-PRINT action is written to a cataloged file with the specified name.

OUTPUT = *SYSLST
The list is output on SYSLST.

STRUCTURIZER-ACTION = BEAUTIFY(...)
The source program is to be beautified (lines are to be indented in accordance with the COBOL reference format).

INFORMATION = STD
The default values of the following PARAMETERS structure are to be used.

INFORMATION = PARAMETERS(...)

SEQUENCE-AREA = YES / NO
Specifying YES causes the “Sequence Number Area” (columns 1-6 of the reference format) to be included in the output.

IDENTIFICATION-AREA = YES / NO
Specifying YES causes the “Program Identification Area” (columns 73-80 of the reference format) to be included in the output.

LAYOUT = STD
The default values of the following PARAMETERS structure are to be used.

LAYOUT = PARAMETERS(...)

LOWER-CASE-KEYWORDS = YES / NO
Specifying YES causes the keywords added by the Structurizer (e.g. explicit scope terminators) to be written in lowercase. This function is useful only if the input source program is written in lowercase.

INDENTATION-AMOUNT = 2 / <integer 1..8>
The <integer> value specifies the amount by which statements are to be indented within structure blocks.

DATA-FORMATTING = YES / NO
If YES is specified, data entries in the DATA DIVISION are formatted in accordance with the description in section 5.1.
If NO is specified, the DATA DIVISION output is not formatted. This is intended to provide support for programmers who want to carry on using their own formatting rules for the DATA DIVISION.

OUTPUT = *STD-FILES
The result of the BEAUTIFY action is written into a cataloged file with a name formed from the name of the source program file or library element and the suffix ".IND".

OUTPUT = <filename 1..54>
The result of the BEAUTIFY action is written into a cataloged file with the specified name.

OUTPUT = *LIBRARY-ELEMENT(...)
The result of the BEAUTIFY action is written into a PLAM library element.

LIBRARY = <filename 1..54>
Name of the PLAM library

ELEMENT = <filename 1..40>(...)
Name of the element in the PLAM library.

VERSION =
Specifies the version designation

VERSION = *UPPER-LIMIT
If no version designation or *UPPER-LIMIT is specified, the element receives the highest possible version number ("@").

VERSION = *INCREMENT
The element receives the version number of the highest existing version incremented by 1, provided that the highest existing version designation ends with a digit. Otherwise, the version designation cannot be incremented. In this case, *UPPER-LIMIT is assumed.

Example:

Highest existing version	Version generated by *INCREMENT
ABC1	ABC2
ABC	@
ABC9	@
ABC09	ABC10
003	004
none	001

VERSION = *HIGHEST-EXISTING
The highest existing version in the library is overwritten.

VERSION = <alphanum-name 1..24>
The element receives the specified version designation. If the version designation is to be incrementable, the last character at least must be a digit (see example above).

5.3.3 COPY-STATEMENTS option

This option determines how COPY statements are to be handled.

Format

```
COPY-STATEMENTS = FLAGGED / IGNORED
```

COPY-STATEMENTS = FLAGGED
If an element named in a COPY statement cannot be found in any of the assigned COPY libraries, an error message appears. The output of COPY elements in the structure list is controlled by the INFORMATION parameter COPY-EXPANSION of the “pretty print” function. COPY elements are not output by the “beautify” function.

COPY-STATEMENTS = IGNORED
Only the COPY statements themselves are output, but no COPY libraries are opened and no COPY elements are read.

5.3.4 DIAGNOSTICS option

This option controls the scope of messages to be output, and the output medium.

Format

```
DIAGNOSTICS = YES(...) / NO

  YES(...)
     |  MINIMAL-WEIGHT = FATAL-ERROR / ERROR / WARNING / NOTE
     | ,OUTPUT = STD-FILES / SYSLST
     | ,SYSOUT = YES / NO
```

DIAGNOSTICS = YES(...) / NO
If YES is specified, messages are output.

MINIMAL-WEIGHT = FATAL-ERROR / ERROR / WARNING / NOTE
This specifies the weight as of which messages are to be output. If a “fatal error” condition occurs, the Structurizer run is immediately aborted and the reason for the abort is reported on the screen.

OUTPUT = STD-FILES
The messages are to be output into a cataloged file with the default name STRERR.COB85.program-id-name. If all messages are suppressed, the message file contains only its name and the totals line indicating the number and type of messages that occurred.
If the Structurizer run ends before program-id-name has been determined (e.g. due to a serious input error), the TSN number is used as a default suffix in place of the program-id-name.

OUTPUT = SYSLST
The messages are to be output on SYSLST.

SYSOUT = YES / NO
If YES is specified, all messages are output to SYSOUT (i.e. at the display terminal).
If NO is specified, only the totals line is shown at the display terminal.

5.3.5 MONJV option

This option can be used to assign a BS2000 job variable.

Format

```
MONJV = *NONE / <filename 1..54 without gen-vers>
```

MONJV = <filename 1..54>
The <filename> entry causes a monitoring job variable to be assigned; the Structurizer will use this to output a flag concerning possible runtime errors.

6 Linking, loading, starting

In the course of compilation, COBOL85 generates object modules or link-and-load modules (LLMs) which are then available in a PLAM library or in the temporary EAM file of the current task.
The program cannot, however, run in this form because its machine code is not yet complete: each module contains references to external addresses, i.e. to other modules, which must supplement it when execution takes place. The compiler generates these **external**
references during compilation for one or more of the following reasons:

- The COBOL program contains statements which
  - require complex routines at machine code level (e.g. SEARCH ALL, INSPECT) or
  - constitute interfaces to other software products or the operating system (e.g. SORT or input/output statements such as READ, WRITE).

  This applies to all COBOL programs, because the routines for program initialization and program termination are also in this category. The machine instruction sequences for these statements are not generated during compilation; they are already available as finished modules in a library, the **runtime system**. An external reference to the corresponding module in the runtime system is entered into the module generated by the compiler for each such COBOL statement.

- The COBOL program calls an external subprogram. The CALL statements in the “CALL literal” format cause the compiler to generate external references for the linkage run at the appropriate locations in the generated module.
  CALL statements in the “CALL identifier” format cause the dynamic binder loader to dynamically load the appropriate modules at runtime (see section 12.1).

- The COBOL program has been compiled with
  COMOPT GENERATE-SHARED-CODE=YES (in SDF: SHAREABLE-CODE=YES).
  The compiler generates a non-shareable data module and a shareable code module (see section 6.7). The data module contains an external reference to the associated code module.

6.1 Functions of the linkage editor

The process during which these external references are resolved (i.e. the additionally required modules are linked with the generated module into an executable unit) is called linking; the utility routine which performs this task is called a **linkage editor**.

A linkage editor processes either the result of a compilation (object module or LLM) or a module already prelinked in a linkage run. A prelinked module may consist of one or more object modules or a link-and-load module.

To enable the unit generated during linking to run, a **loader** must be used to bring it into memory to allow the processor to access and execute the code.

The **Binder-Loader-Starter system** in BS2000 provides the following functional units for linking and loading:

- The static linkage editor TSOSLNK (**TSOS LINK**age editor)

  links one or more object modules into an object program (also called a load module) and saves it in a cataloged file or as an element of type C in a PLAM library;

  or

  links a number of object modules into a single prelinked module and stores it as an element of type R in a PLAM library or in a temporary EAM file.

  You are advised to use the BINDER linkage editor instead of TSOSLNK since TSOSLNK will not be further developed and will be replaced by BINDER.

- The linkage editor BINDER

  links modules (object modules, link-and-load modules) to form a logically and physically structured loadable unit. This unit is referred to as a **l**ink-and-**l**oad **m**odule (**LLM**) and is stored by BINDER as an element of type L in a PLAM library.

- The **d**ynamic **b**inder **l**oader DBL

  combines modules (i.e. object modules and LLMs, possibly generated by an earlier linkage run with BINDER) into a temporary loadable unit, which it then loads into main memory and executes immediately. COBOL programs that call at least one external subprogram with “CALL identifier” can only be executed by this method (see section 12.1).

- The static loader ELDE

  loads a program that was linked by TSOSLNK and stored in a file or as an element of type C in a PLAM library.

The COBOL85 compiler generates object modules or LLMs at compilation. Object modules are placed in the temporary EAM file of the current task or in a PLAM library as an element of type R.
LLMs are stored as elements of type L in a PLAM library.

The following table shows which modules are generated and/or processed by the individual functional units of the Binder-Loader-Starter system.

Module type	**System component**			
	BINDER	DBL	TSOSLNK	ELDE
Object module	yes	yes	yes	no
Link-and-load module (LLM)	yes	yes *)	no	no
Prelinked module	yes	yes	yes	no
Object program (load module)	no	no	yes	yes

*) Only in ADVANCED run mode

The linkage run in the POSIX subsystem is explained in chapter 13.

The following diagram shows an overview of the various options that are provided to generate and call temporary and permanent executable COBOL programs in BS2000.

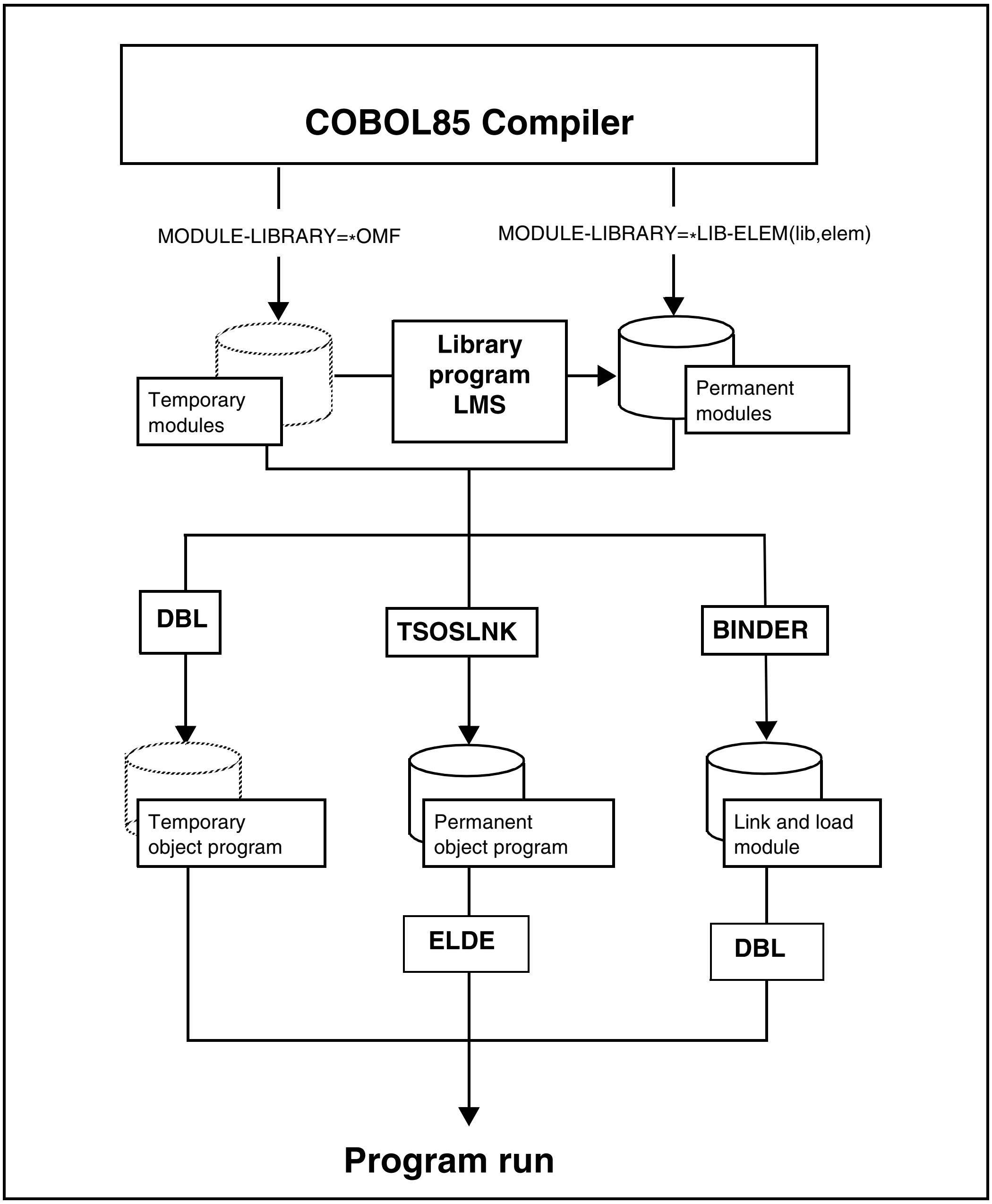


Fig. 6-1 Generating and calling permanent and temporary executable COBOL programs in BS2000

6.2 Static linkage using TSOSLNK

The static linkage editor TSOSLNK processes one or more object modules or prelinked modules to generate either

- an executable program, which it outputs to a separate catalog file or to a PLAM library as a type C library element, or
- a prelinked module, which it stores in the temporary EAM file of the current task, or in a PLAM library as a type R library element.

The TSOSLNK utility routine is called with the START-PROGRAM command. It subsequently expects control statements from SYSDTA that specify

- for output:
  - whether the result of the linkage run is to be an executable program or a prelinked object module, and
  - where the result is to be output
- for input:
  - which object modules it should link in, and
  - which libraries should be used for the resolution of unresolved external address references.

Control statements for TSOSLNK

The following table provides an overview of the most important control statements of TSOSLNK.

Statement	**Short description**
PROGRAM PROG	instructs the linkage editor to generate a program from the read object modules, and specifies its characteristics and output location (PLAM library or cataloged file). Among the operands which can be specified are the following: – SYMTEST=MAP or SYMTEST=ALL allows the user to use symbolic names from the source program when debugging with the AID debugger. This is provided that an appropriate control statement was issued to COBOL85 during compilation in order to have LSD information generated. SYMTEST=ALL instructs the linkage editor to pass this information on to the program, whereas SYMTEST=MAP allows LSD information from the object module to be loaded dynamically during debugging (see [8] for further information). – LOADPT=*XS defines the load address of the program in the address space above 16 Mbytes. This specification is not possible unless only the XS runtime system and object modules that can be loaded into the upper address space are being linked. – ENTRY/START=entry-point specifies the starting point of the program run. This specification becomes necessary when the COBOL main program is not the first program to be linked into an executable program. entry-point is then the PROGRAM-ID name (abbreviated to 7 positions, if necessary) followed by the suffix “$”. The PROGRAM and MODULE statements (see below) are mutually exclusive.
MODULE MOD	causes the linkage editor to link the read object modules into a prelinked object module and defines its output location. The MODULE and PROGRAM statements (see above) are mutually exclusive.
INCLUDE	specifies individual object modules from which the linkage editor is to create the program or prelinked module.
RESOLVE	assigns PLAM libraries to TSOSLNK for the autolink procedure (which is described on the next page).
EXCLUDE	excludes the specified PLAM libraries from the autolink procedure (described below).
ENTRY	see ENTRY or START operand of the PROGRAM statement.
END	signals the end of the input of linkage editor statements.

TSOSLNK autolink procedure

On finding external address references (in a generated module) that cannot be resolved by modules specified in INCLUDE statements, TSOSLNK proceeds according to the following **autolink procedure**:

1. TSOSLNK first checks whether a library containing a corresponding module was explicitly assigned to the external reference by means of a RESOLVE statement.
2. If TSOSLNK cannot resolve the external reference in the first step, it searches all libraries specified in RESOLVE statements. Libraries can be excluded from this search by means of EXCLUDE statements.
3. If TSOSLNK does not succeed in resolving the external reference in the second step, it searches the library TASKLIB, provided that this has not been prevented by the NCAL statement or a corresponding EXCLUDE statement.
   If there is no file named TASKLIB listed under the user ID of the current task, TSOSLNK uses the system library $.TASKLIB.

If unresolved external references are present even after the autolink procedure, TSOSLNK outputs a list of their names to SYSOUT and SYSLST.

It is not permitted to link COBOL programs as class 1 programs.

Example 6-1: Static link-editing into an executable program

```
/START-PROGRAM FROM-FILE = $TSOSLNK ---------------------------------- (1)
%  BLS0500 PROGRAM 'TSOSLNK', VERSION 'V21.0E02' OF '1999-03-15' LOADED
%  BLS0552 COPYRIGHT (C) FUJITSU TECHNOLOGY SOLUTIONS   2009. ALL
 RIGHTS RESERVED
*PROG COB85PROG,LIB=PLAM.LIB,ELEM=COB85LAD --------------------------- (2)
*INCLUDE COB85MOD,PLAM.LIB ------------------------------------------- (3)
*RESOLVE ,$.SYSLNK.CRTE ---------------------------------------------- (4)
*END ----------------------------------------------------------------- (5)
%  LNK0500 PROG BOUND
%  LNK0506 PROGRAM LIBRARY : PLAM.LIB
%  LNK0507 ELEMENT WRITTEN : COB85LAD
```

(1) The utility routine TSOSLNK is called.

(2) The PROG statement specifies that TSOSLNK is to generate an executable program whose program name is COB85PROG, and store it as library element COB85LAD in the PLAM library PLAM.LIB.

(3) The INCLUDE statement informs the linkage editor that it is to link object module COB85MOD from the PLAM library PLAM.LIB.

(4) TSOSLNK is to initially resolve external references with modules from the runtime system, which is cataloged on this system under the name $.SYSLNK.CRTE.

(5) END terminates the input of control statements and starts the linkage process; after its completion, TSOSLNK provides information on the program that has been generated.

Linking segmented programs with overlay structure

By using appropriate COBOL language elements, the compiler can be made to output the machine code for a source program in parts, i.e. in the form of a number of object modules rather than just one. This procedure is known as **segmentation**. The program sections created in the process are called **segments**.

An overlay structure can be defined during link-editing of a segmented program:

With the exception of the root segment, which remains in main memory for the entire program run, it is possible to have the individual segments overlay-loaded under program control whenever they are necessary for execution. Segments can overlay one another under these circumstances, i.e. the segments can occupy a common memory area one after the other. Which segments can overlay one another is determined by means of control statements during linkage-editing of the program.

However, since the Executive of BS2000 automatically subdivides the object program into pages (i.e. 4096-byte sections) and only loads pages into main memory as and when required during execution of the program, segmentation to relieve the load on main memory is not necessary in BS2000. It only becomes essential if virtual storage is not large enough to accept the entire program, including data. For this reason, it is neither practical nor possible to define a true overlay structure for programs that are intended to run in the upper address space.

Overlay structures for segmented programs can be defined with the following TSOSLNK statements.

Statement	**Short description**
OVERLAY	determines the overlay structure for the program: The OVERLAY statements of a linkage-editor run define – which segments can overlay one another and – at which locations in the object program they are to mutually overlap. OVERLAY statements are only permitted during linkage editing of a load module (PROGRAM statement); in the case of a prelinked object module (MODULE statement), they are rejected with an error message. In the address space above 16 Mbytes, (LOADPT=*XS entry in the PROGRAM or OVERLAY statement) no true overlay structures are possible; although the linkage editor will accept the OVERLAY statement, it will arrange the segments sequentially on the basis of their addresses.
TRAITS	defines for a program segment that it – should be aligned on page boundaries during loading, – can only be read during the program run. (READONLY=Y specified)

6.3 Linking using BINDER

Using BINDER, object modules and LLMs can be linked into a single link-and-load module (LLM) and stored as a type-L element in a PLAM library. BINDER is described in detail in the manual “BINDER” [25]).

Example 6-2: Generating an LLM from object modules

```
/START-PROG $BINDER ──────────────────────────────────────────────────── (1)
%  BLS0500 PROGRAM 'BINDER', VERSION 'V02.6A30' OF '2010-10-19' LOADED
%  BLS0552 COPYRIGHT (C) FUJITSU TECHNOLOGY SOLUTIONS   2009.
   ALL RIGHTS RESERVED
//START-LLM-CREATION INT-NAME=PROG ───────────────────────────────────── (2)
//INCLUDE-MODULES LIB=*OMF,ELEM=MAIN ─────────────────────────────────── (3)
//INCLUDE-MODULES LIB=PLAM.BSP,ELEM=SUB ──────────────────────────────── (4)
//RESOLVE-BY-AUTOLINK LIB=$.SYSLNK.CRTE ──────────────────────────────── (5)
//SAVE-LLM LIB=PLAM.BSP,ELEM=TESTPROG ────────────────────────────────── (6)
%  BND3101 SOME EXTERNAL REFERENCES UNRESOLVED
%  BND3102 SOME WEAK EXTERNS UNRESOLVED
%  BND1501 LLM FORMAT : '1
//END ────────────────────────────────────────────────────────────────── (7)
%  BND1101 BINDER NORMALLY TERMINATED. SEVERITY CLASS: 'UNRESOLVED
   EXTERNAL'

/START-PROG *MOD(LIB=PLAM.BSP,ELEM=TESTPROG,RUN-MOD=ADVANCED) ────────── (8)
%  BLS0523 ELEMENT 'TESTPROG', VERSION '@' FROM LIBRARY 'PLAM.BSP' IN
   PROCESSING
%  BLS0524 LLM 'TESTPROG', VERSION ' ' OF '2013-02-26:14:51:46' LOADED
```

(1) BINDER is called.

(2) The START-LLM-CREATION statement generates a new LLM in the work area with the internal name PROG. The generated LLM is subsequently stored as an L-type element in a PLAM library by means of the SAVE-LLM statement (see 6).

(3) This INCLUDE-MODULES statement specifies the name of the module containing the main program (MAIN). The module is held in the temporary EAM file (*OMF).

(4) This INCLUDE-MODULES statement specifies the name of the module containing the subprogram (SUB). The module is held in the PLAM library PLAM.LIB.

(5) The RESOLVE-BY-AUTOLINK statement specifies the name of the runtime library from which external references are to be resolved.

(6) The SAVE-LLM statement stores the generated LLM under the name TESTPROG as an L-type element in the PLAM library PLAM.LIB. The BINDER message “SOME WEAK EXTERNS UNRESOLVED” refers to the ILCS module IT0INITS.

This module contains weak external references to all languages potentially provided for ILCS. Only the language COBOL85 is involved in this example and the other references remain unresolved.

(7) The END statement terminates the BINDER run.

(8) The LLM is loaded and started.

With the INCLUDE-MODULES and RESOLVE-BY-AUTOLINK statements, LIB=*BLS-LINK may also be specified instead of the library name (LIB=library). In this case the libraries to be searched must be assigned with the link name BLSLIBnn (00 ≤ nn ≤ 99). This is done by means of the SET-FILE-LINK command before BINDER is called, e.g.:

```
/SET-FILE-LINK LINK-NAME=BLSLIB01,FILE-NAME=$.SYSLNK.CRTE
```

An LLM generated by means of BINDER can - provided all external references are resolved - be loaded and started using DBL with no assignment of alternative libraries:

```
START-PROGRAM *MODULE(LIB=library,ELEM=module,RUN-MODE=ADVANCED)
```

Warning!

LLMs with a linked runtime system must not be stored in libraries from which other LLMs that are not prelinked are also to be directly loaded.

Note:

When the LLM format is generated, a CSECT is created with the name `program-name&#` and with the following entries:

`program-name`	for the start of the subprogram
`program-name&$`	for the start of the main program
`program-name&A`	for the service entry

When shared-code is generated, the code CSECT `progam-name&@` is also created.

6.4 Dynamic linking and loading using DBL

The dynamic binder loader DBL links modules temporarily into a loadable unit, which it then loads into memory and executes immediately. The generated load unit is automatically deleted at the end of the program run.

The mode of operation of DBL is described in detail in the “Binder-Loader-Starter” manual [9].

DBL is called implicitly by the commands START-PROGRAM and LOAD-PROGRAM. The following overview summarizes the options of the START-PROGRAM and LOAD-PROGRAM commands that are most relevant to calling DBL; a detailed description of all the available operands is given in [9].

```
 { START-PROGRAM }                                 { *OMF,ELEMENT=modul          }
 {               } FROM-FILE =] *MODULE (LIBRARY= { *OMF [,ELEMENT=*ALL]        }
 { LOAD-PROGRAM  }                                 { bibliothek,ELEMENT=element  }

            [,RUN-MODE = { STD                  } ])
                         { ADVANCED(ALT-LIB=YES) }
```

The START-PROGRAM command instructs DBL to generate an executable program, load it into memory, and start it. Since the program is run immediately after the command, the necessary resources (files) must be assigned to DBL before the START-PROGRAM command is given (see section 9.1.2).

The LOAD-PROGRAM command instructs DBL to generate an executable program and load it into memory without starting it. This makes it possible to enter additional commands prior to program execution, e.g. commands for program monitoring using a debugging aid. The program can subsequently be started by means of

– a %RESUME command, if tests are to be performed using the advanced interactive debugger (AID) or
– a RESUME-PROGRAM command in all other cases.

LIBRARY=*OMF
indicates the temporary EAM file of the current task into which the compiler has output the compiled object module.

> ELEMENT=module
> is the name of the module that is to be loaded first. The string “module” consists of the first eight characters of the PROGRAM-ID name in the source program. “module” can also be the ENTRY name of the program segment that is to be loaded first.

ELEMENT=*ALL
causes DBL to fetch all the modules from the EAM object module file. If this is what is desired, there is no need to specify it explicitly as this value is preset as the default.

LIBRARY=library
is the name of a PLAM library in which the module is stored as a library element. Using *LINK(LINK-NAME=linkname) it is also possible to specify a predefined file link name for the library.

ELEMENT=element
is the name of the module that is stored as a type-R element in the specified PLAM library. If there is more than one element with the same name in the library, the element with the (alphabetically) highest version designation is used.

RUN-MODE=STD
In this mode, the runtime system CRTE must be assigned as the TASKLIB by using the SET-TASKLIB command before DBL is called.
Apart from the TASKLIB and, if applicable, the library containing the modules, no other libraries can be taken into consideration during link-editing.

RUN-MODE=ADVANCED(ALTERNATE-LIBRARIES=YES)
In this mode, in order to resolve external references DBL searches up to 99 different libraries assigned by means of the link name BLSLIBnn ($00 \le nn \le 99$) prior to invocation of DBL.

Dynamic loading

Object modules with external subprograms that are called exclusively with “CALL identifier”, are loaded dynamically by DBL at runtime. Before DBL is called, the library containing the object modules to be dynamically loaded must be assigned with the link name COBOBJCT, and the runtime system must be assigned with a link name in the form BLSLIBnn (where nn = 01 to 99):

```
/SET-FILE-LINK [LINK-NAME=]COBOBJCT,[FILE-NAME=]library
```

```
/SET-FILE-LINK [LINK-NAME=]BLSLIB00,[FILE-NAME=]$.SYSLNK.CRTE
```

Use of the link name BLSLIBnn is possible only if RUN-MODE=ADVANCED (ALTERNATE-LIBRARIES=YES) is specified in the calling command,

See also section 12.1, example 12-1.

Example 6-3 : Dynamic linking and loading of a module from a PLAM library

```
/START-PROGRAM *MOD(LIB=PLAM.BSP,ELEM=COB85MOD) ─────────────────────────── (1)
%  BLS0001 ### DBL VERSION 070 RUNNING
%  BLS0335 UNRESOLVED EXTERNAL REFERENCES 'ITCN021D ITCSACA0 ITCSBEG0
ITCSDSA0 ITCSEND0'  ───────────────────────────────────────────────────── (2)

%  BLS0336 CONTINUE PROCESSING? REPLY (Y=YES; N=NO)?
N
%  NRTT101 ABNORMAL JOBSTEP TERMINATION BLS0532
/SET-TASKLIB $.SYSLNK.CRTE  ───────────────────────────────────────────── (3)
/START-PROGRAM *MOD(LIB=PLAM.BSP,ELEM=COB85MOD)
%  BLS0001 ### DBL VERSION 070 RUNNING
%  BLS0517 MODULE 'COB85MOD' LOADED
```

(1) The START-PROGRAM command instructs DBL to link, load and start the module COB85MOD from the PLAM library PLAM.LIB. There was no prior declaration of a TASKLIB.

(2) DBL reports that external references to COBOL85 runtime modules (ITC...) cannot be resolved; i.e. they are not present in a library named TASKLIB and are not available under the user ID of the current task or the $.TASKLIB.

(3) On this system, the runtime system is cataloged under the name $.SYSLNK.CRTE. After it has been declared a TASKLIB by means of a SET-TASKLIB command, the following START-PROGRAM command can be successfully executed, and the program is run.

6.5 Loading and starting executable programs

Before a statically linked program can execute, it has to be loaded into main memory. In BS2000 this function is performed by a static loader. This, like the dynamic binder loader, is called with the START-PROGRAM or LOAD-PROGRAM command (see [9]):

- The START-PROGRAM command instructs the static loader to load the program into main memory and start it. As the program is run immediately after the command is issued, the necessary resources (files) have to be assigned to the loader first (see section 9.1.2).
- The LOAD-PROGRAM command instructs the static loader to load the program into main memory without starting it. This makes it possible to enter additional commands prior to program execution, e.g. commands for program monitoring using a debugging aid. The program can subsequently be started by issuing a RESUME-PROGRAM or %RESUME command.

The following overview summarizes the options of the START-PROGRAM and LOAD-PROGRAM commands that are most relevant for calling the static loader; a detailed description is given in the manual “Binder-Loader-Starter” [9].

```
{ START-PROG }              { *PHASE(LIB=library,ELEM=element,VERS=version) }
{            } FROM-FILE =  {                                               }
{ LOAD-PROG  }              { filename                                      }
```

library	specifies the name of a PLAM library in which the program generated by TSOSLNK is stored as a library element.
element	is the name of the library element in which the program is stored. It must be a type C element.
version	specifies the element version as a string of 24 characters or less.
filename	is the name of the cataloged file which contains the program generated by TSOSLNK.

6.6 Program termination

The termination action taken by a program is of special importance when it is invoked within a procedure or is monitored by a job variable.

If error messages to which an internal return code is assigned (see error message COB9119 in chapter 15) are issued during program execution, this return code is passed to the last two bytes of the return code indicator of a monitoring job variable (see [7]).

The following table provides an overview of

- the possible contents of the return code indicator in job variables,
- the associated error messages, and
- their impact on the further course of a procedure.

Return code indicator 1)	**Error number** 2)	**Short description of the error**	**Continuation controllable with option** 3)	**Dump**	**Behavior in procedures**
01**00**	none	No error detected by the runtime system	---	no	No branch
11**20**	COB9120	Job variables not available	yes		Branch to the next STEP, ABEND, ABORT or LOGOFF command
11**21** 11**22**	COB9121 COB9122	End of file during ACCEPT processing	yes yes		
11**23** 11**24** 11**25** 11**26** 11**27**	COB9123 COB9124 COB9125 COB9126 COB9127	Invalid argument in a standard function	yes yes yes yes yes		
11**28**	COB9128	User return code is set	no		
11**31**	COB9131	Job variables: ACCEPT set to empty job variable	yes		
11**32**	COB9132	Wrong number of parameters (CALL)	yes		
11**33**	COB9133	Program execution in BS2000 Version < 10.0	no		
11**34**	COB9134	Sort error	yes		
21**40**	COB9140	Reference modification error	yes	no / yes 4)	
21**42**	COB9142	GO TO has no ALTER	no		
21**43**	COB9143	Purge date for the volume has not yet expired	no		
21**44**	COB9144	Table: Subscript/index range violation	yes		
21**45**	COB9145	Table (with DEPENDING ON element): Subscript/index range violation	yes		
21**46**	COB9146	COBOL85 runtime system is incompatible with the object program	no		
21**48**	COB9148	CALL not executable	no		
21**49**	COB9149	Incompatible data in numeric edited item	no		
21**51**	COB9151	Files: Undetected I/O error (no USE procedure, no INVALID KEY, no AT END)	no		

Table 6-1: Return code indicators in job variables

Return code indicator 1)	**Error number** 2)	**Short description of the error**	**Continuation controllable with option** 3)	**Dump**	**Behavior in procedures**
21**52**	COB9152	Connection to the database could not be established	no	no /yes 4)	Branch to the next STEP, ABEND, ABORT or LOGOFF command
21**54**	COB9154	REPORT WRITER: user error	no		
21**55**	COB9155	Error on exit from a USE procedure	no		
21**56**	COB9156	DML: SUB-SCHEMA module too small for processing an extensive DML statement	no		
21**57**	COB9157	CALL not executable	no		
21**58**	COB9158	More than 9 recursive calls to DEPENDING paragraphs	no		
21**60**	COB9160	Runtime unit uses CANCEL, but contains programs compiled with a compiler < V2.0	no		
21**62**	COB9162	The attributes of an external file are not consistent within the programs of a runtime unit	no		
21**63**	COB9163	The storage space for DYNAMIC data could not be set up	no		
21**64**	COB9164	Program called with CALL is not available	no		
21**68** 21**69** 21**71**	COB9168 COB9169 COB9171	REPORT WRITER: user error	no no no		
2173	COB9173	SORTrun not succesful	no		
21**74** 21**75**	COB9174 COB9175	Error handling in the program: user error	no no		
21**76**	COB9176	REPORT WRITER: user error	no		
21**78**	COB9178	Record to be sorted does not match SD description	no		
21**80**	COB9180	RELEASE/RETURN not under the control of SORT/MERGE	no		
21**81**	COB9181	DATABASE-HANDLER has not yet finished processing the last DML statement	no		
21**84**	COB9184	SORT within the SORT controller	no		

Table 6-1: Return code indicators in job variables

Return code indicator [1)]	**Error number** [2)]	**Short description of the error**	**Continuation controllable with option** [3)]	**Dump**	**Behavior in procedures**
31**92**	COB9192	The end of the program was reached but neither STOP RUN nor EXIT PROGRAM was executed	no	yes	Branch to the next STEP, ABEND, ABORT or LOGOFF command
31**93**	COB9193	DISPLAY error	no		
31**94**	COB9194	Error during input from SYSDATA	no		
31**95**	COB9195	Error during output to SYSLST	no		
31**96**	COB9196	ACCEPT or DISPLAY statement error at the runtime system/operating system interface	no		
31**97**	COB9197	Job variables: access failed	yes		
31**98**	COB9198	Hardware interrupt	no		
31**99**	none	WROUT error: No further messages can be output	no		

Table 6-1: Return code indicators in job variables

1) The first digit indicates the weight of the message (0: note, 1: warning, 2: error, 3: fatal error).
The second digit (always 1) identifies the program as a COBOL object.
The final two digits (in bold print) represent the internal return code.

2) For content and meaning of messages see chapter 15.

3) Program abortion can be induced with RUNTIME-OPTIONS=PAR(ERROR-REACTION = TERMINATION) or COMOPT CONTINUE-AFTER-MESSAGE=NO. After the program has been aborted, the associated return code is set in the job variable monitoring the program.

4) Batch processing: no
Interactive processing: query yes/no

6.7 Shareable COBOL programs

In large programs it may be advantageous to make individual program segments shareable if they are to be accessed by several users (tasks).

For this, the following control statement must be specified at compilation time:

COMOPT GENERATE-SHARED-CODE=YES

or

SHAREABLE-CODE=YES
in the MODULE-GENERATION parameter of the COMPILER-ACTION option

The compiler then generates two object modules, one of which contains the nonshareable section and the other the shareable section of the object. These are referred to in the following as the “nonshareable” and “shareable” module, respectively. The shareable and nonshareable modules can themselves be linked into prelinked modules.

The shareable modules must be stored in a PLAM library either directly by the compiler (via a COMOPT MODULE statement or the SDF option MODULE-LIBRARY) or by means of the LMS utility routine (see [10]).
The system administrator declares these modules as shareable with the ADD-SHARED-PROGRAM command and loads them into class 4 memory so that they are available for all tasks.
All nonshareable sections of a program are loaded separately for each task and user into class 6 memory.
Program systems with shareable modules can only be called using DBL. The call always uses the name of the nonshareable (data) module. This contains external references to its shareable code module as well as to any other nonshareable modules.

Sample call:

```
/SET-TASKLIB $.SYSLNK.CRTE ──────────────────────────────────────────────(1)
/START-PROGRAM *MOD(library,element) ────────────────────────────────────(2)
```

(1) The SET-TASKLIB command is used to assign the library that contains the COBOL runtime system.

(2) element is the name of the data module or prelinked module which must contain at least the nonshareable section of the main program. library is the library containing the user-written modules.

The following figure illustrates program runs with and without shared code.

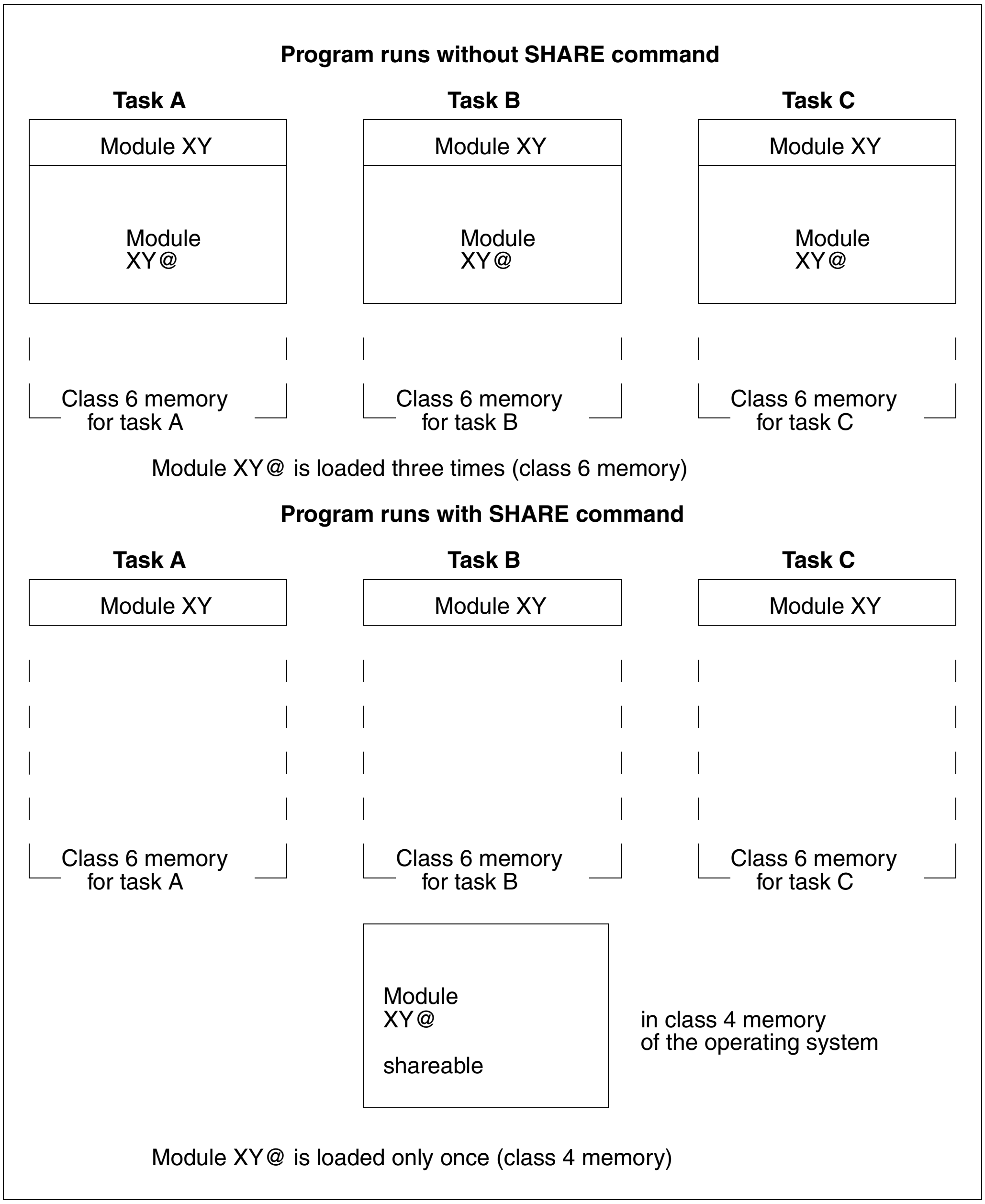

Program runs without SHARE command
Task A
Task B
Task C
Module XY
Module XY@
Class 6 memory for task A
Class 6 memory for task B
Class 6 memory for task C
Module XY@ is loaded three times (class 6 memory)
Program runs with SHARE command
Task A
Task B
Task C
Module XY
Class 6 memory for task A
Class 6 memory for task B
Class 6 memory for task C
Module XY@ shareable
in class 4 memory of the operating system
Module XY@ is loaded only once (class 4 memory)

Fig. 6-2 Shared code

7 Debugging aids for program execution

Even a syntactically correct COBOL program may still have logic errors and therefore not run as intended. A number of different aids are available to the COBOL programmer for detecting and correcting such errors:

– The programmer can use the **A**dvanced **I**nteractive **D**ebugger (AID) during program execution. This requires no special programming provisions and permits errors to be detected and corrective action to be taken while the loaded program is being executed.

– Debugging lines can be inserted in the source program and activated by the programmer as the need arises. This assumes that potential error conditions were anticipated and provided for when the source program was written. The diagnosis of an unexpected error can therefore make it necessary to modify or add debugging lines and then to recompile the entire source program. Debugging lines are described in [1] and in section 7.2.

The debugging aids can be used analogously in the POSIX subsystem (see chapter 13).

7.1 Advanced Interactive Debugger (AID)

Not supported in the COBOL85-BC !

Only a short introduction to AID is given in this User Guide. For a detailed description of this debugger, refer to manuals [8], [22] and [23].

AID has the following features:

1. It makes it possible to test “symbolically”, i.e. to specify symbolic names from the source program in commands rather than absolute addresses. For this purpose, the required LSD information must be generated at compile time and passed to the loaded program at a later stage (see section 7.1.2).

   However, with respect to the program in its entirety, it is not always necessary to load this information together with the program. Instead, AID allows LSD information to be dynamically loaded for each compilation unit, provided the associated modules (with LSD information) reside in a PLAM library. In this way, more efficient use of resources is achieved:

   – Program memory space is saved, as LSD information has to be loaded only when it is required for debugging (memory space for a program increases by about a factor of 5 if the information is loaded at the same time as the program).

   – A program that runs without errors at debugging time does not have to be recompiled (without LSD information) or relinked for the production run.

   – When the results of a production run make a test run desirable, the necessary LSD information is available and can be used without any need for the program to be recompiled and relinked.

2. It provides functions permitting

   – program execution to be traced at symbolic level and logged (TRACE function)

   – program execution to be interrupted at specified points or when defined events occur, in order to initiate AID or BS2000 commands (referred to as “subcommands”)

   – a section or a paragraph in the Procedure Division to be specified after a program interrupt. Debugging is continued with the section or paragraph specified, irrespective of the coded program logic (%JUMP statement (see [8])); this is possible only if the program was compiled with PREPARE-FOR-JUMPS=YES in the AID parameter of the TEST-SUPPORT option or using COMOPT SEPARATE-TESTPOINTS=YES (see sections 3.3.7 and 4.2, respectively).

   – the contents of fields to be output in a form that takes account of the data definitions of the source program

   – the contents of fields to be changed, with AID performing the necessary moves according to the specifications of the COBOL MOVE statement.

3. It supports the analysis of dumps in disk files as well as the diagnosis of loaded programs.
4. It can be used in batch mode as well as in interactive mode. For program testing, however, interactive mode is recommended as it does not require the sequence of the commands to be defined in advance and allows this sequence to be tailored to suit the current debugging environment.

7.1.1 Conditions for symbolic debugging

For debugging at a symbolic level, AID permits data items, sections, and paragraphs to be addressed using the names defined in the source program. It also permits statement lines and individual COBOL verbs in the Procedure Division to be referenced. Consequently, AID must be provided with the appropriate information on these symbolic names. This information can be subdivided into two parts (see [24]):

– the List for Symbolic Debugging (LSD), in which the symbolic names and statements defined in the module are cataloged, and

– the External Symbol Dictionary (ESD), which records a module's external references.

Generation or transfer of this information is initiated or suppressed by means of appropriate operands in the call command or control statement at each of the following stages:

– compilation with COBOL85

– linking and loading with the dynamic binder loader (DBL) or

– linking with the static linkage editor (TSOSLNK) and

– loading with the static loader (ELDE)

The ESD information is generated and transferred as standard, whereas the LSD information can be made accessible to AID in two ways. After it has been generated at compile time, this information can be:

– loaded together with the entire program, or

– dynamically loaded for each compilation unit as necessary, provided the associated object modules are available in a PLAM library.

For each of these cases, the following table provides an overview of the operands that need to be specified in order to generate and transfer the LSD information.

Stages in the development of the program	**Operands to be specified**	
	if the LSD information is to be loaded jointly with the entire program	if the LSD information is to be dynamically loaded by AID at a later stage [1)]
Compile with COBOL85	TEST-SUPPORT=AID() or COMOPT SYMTEST=ALL	TEST-SUPPORT=AID() or COMOPT SYMTEST=ALL
Link and load with the dynamic binder loader	LOAD-PROGRAM ..., TEST-OPTIONS=AID or START-PROGRAM ..., TEST-OPTIONS=AID	LOAD-PROGRAM ..., [TEST-OPTIONS=NONE] or START-PROGRAM ..., [TEST-OPTIONS=NONE]
Link with TSOSLNK	PROGRAM...,SYMTEST=ALL	PROGRAM...[,SYMTEST=MAP]
Load or load and start with the static loader	LOAD-PROGRAM ..., TEST-OPTIONS=AID or START-PROGRAM ..., TEST-OPTIONS=AID	LOAD-PROGRAM ..., [TEST-OPTIONS=NONE] or START-PROGRAM ..., [TEST-OPTIONS=NONE]

Table 7-1: Operands for generating LSD information

1) This is possible only if the associated modules reside in a PLAM library.

Information about the object being debugged

You can use the AID command

```
            ⎧_COMPILER          ⎫
            ⎪_COMPILATION_DATE  ⎪
%D[ISPLAY] ⎨_COMPILATION_TIME  ⎬
            ⎪_PROGRAM_NAME      ⎪
            ⎩                   ⎭
```

to call up general information relating to the object which is being debugged:

`_COMPILER`	the compiler that compiled the object
`_COMPILATION_DATE`	the date of compilation
`_COMPILATION_TIME`	the time of compilation
`_PROGRAM_NAME`	the PROGRAM-ID name of the object

7.1.2 Symbolic debugging with AID

Symbolic debugging with AID permits data items, sections, and paragraphs to be referenced by the names defined in the source program.

However, in order to reference a line in the Procedure Division, the programmer must specify a name in the form

– S’n’ (for a line with a section or paragraph name) or

– S’nverbm’ (for a line with COBOL verbs).

Such an **LSD name** is created by COBOL85 for each line in the Procedure Division and for each COBOL verb in a statement line (see example 7-1). Its components have the following meaning:

n	is the number (5 digits at most) of the line in the Procedure Division. The number, which is assigned by COBOL85 at compile time, must be specified without leading zeros.
verb	is the predefined abbreviation of a COBOL verb in the line concerned. A list of the abbreviations is given below.
m	is a one-digit number specifying which of several identical verbs within a line nnnnn is to be indicated. If k is equal to 1, it is omitted.

Example 7-1: Creation of LSD names

```
000026          IF A = B MOVE A TO D MOVE B TO E.
```

In this statement line

– the first verb has the LSD name S’26IF’,

– the second verb has the LSD name S’26MOV’, and

– the third verb has the LSD name S’26MOV2’.

A detailed example explaining how a COBOL program can be debugged with AID is provided in the AID manual “Debugging of COBOL programs” [8].

List of COBOL verbs and their abbreviations:

ACC	ACCEPT	INI	INITIATE
ADD	ADD	INSP	INSPECT
ADDC	ADD CORRESPONDING	KEE	KEEP
ALT	ALTER	MOD	MODIFY
CALL	CALL	MOV	MOVE
CANC	CANCEL	MOVC	MOVE CORRESPONDING
CLO	CLOSE	MRG	MERGE
COM	COMPUTE	MUL	MULTIPLY
CON	CONNECT	OPE	OPEN
CONT	CONTINUE	PER	PERFORM or EXIT PERFORM or end of main part of loop 2)
DEL	DELETE		
DIS	DISPLAY	PERT	TEST OF PERFORM
DIV	DIVIDE	REA	READ
DSC	DISCONNECT	REDY	READY
END	END-xxx 1) 2)	REL	RELEASE
		RET	RETURN
ERA	ERASE	REW	REWRITE
EVAL	EVALUATE	SEA	SEARCH
EXI	EXIT	SET	SET
EXIT	EXIT PROGRAM	SOR	SORT
FET	FETCH	STA	START
FIN	FINISH	STO	STOP
FND	FIND	STOR	STORE
FRE	FREE	STRG	STRING
GEN	GENERATE	SUB	SUBTRACT
GET	GET	SUBC	SUBTRACT CORRESPONDING
GOT	GO TO	TER	TERMINATE
IF	IF	UNST	UNSTRING
INIT	INITIALIZE	WRI	WRITE

1) Explicit scope terminator (e.g. END-ADD)

2) The point at which END is to stop comes after the scope terminator; for ENDPERFORM, in particular, this point comes after the PERFORM has been completed. A further stopping point exists prior to END-PERFORM, after a single loop. You can use PER to address this second stopping point.

Notes on symbolic debugging of nested programs

- Setting test points
  - A test point at the beginning of the outermost containing program can be set by means of a PROG qualification:
    %INSERT PROG=program-id.program-id
    or written out in full:
    %INSERT S=program-id.PROC=program-id.program-id
  - A test point for the start of a contained program cannot be set by means of a PROG qualification since S and PROC are different, instead it must be specified as follows:

    %INSERT [S=program-id.]PROC=program-id-contained.program-id-contained
  - The S qualification must be specified whenever the test point is to be set in a different, separately compiled program.
  - Paragraphs and sections of the contained program in which the interrupt point lies can be referenced without qualification.
  - Sections and paragraphs in a different contained program that may also lie in a different compilation unit are accessed through the S and PROC qualification:

    %INSERT [S=program-id.]PROC=program-id-contained.paragraph [IN section]
- Accessing data
  - %D locates the data of the current nested program and also data having the GLOBAL attribute that is not locally concealed, i.e. it is possible to access the same data that the program itself can also access at this point.
  - %SD can be used to give the data of all the surrounding programs, in accordance with the current call hierarchy.
  - The PROC qualification can be used to specifically access one item of data from a different program.

    %D PROC=program-id-contained.data-item

    %SD is also possible here instead of %D provided the item of data lies in a calling program.
- Both when accessing test points and also when accessing data, it is the case that the PROC qualification can be multiply repeated in accordance with program nesting.
- The %TRACE command logs all statements of the current CSECT, i.e. including all statements of the called contained programs, but not including the statements in separately compiled programs.
- If the statement types are to be indicated in the trace, additional LABEL specifications are occasionally reported on account of internally generated paragraphs.

7.2 Debugging lines

At the source program level, COBOL85 offers debugging lines for the diagnosis of logic errors. These are specially identified lines in the source program which

- contain only COBOL statements for test purposes and
- at compile time can be treated as statement lines or comment lines, as necessary.

COBOL85 supports the use of debugging lines with the following language elements (see [1]):

- The WITH DEBUGGING MODE clause in the SOURCE-COMPUTER paragraph of the Environment Division:

  This clause defines how debugging lines are to be treated by the compiler: If the clause is specified, debugging lines are compiled as normal statement lines; if it is not specified, the compiler treats debugging lines as comment lines.

  This facility allows debugging lines to be left untouched in the source program after the test phase. Only the WITH DEBUGGING MODE clause has to be removed before the program is compiled for productive use.

- The identification of debugging lines by means of a "D" in the indicator area (column 7):

  A "D" in column 7 of a line specifies that the line is to be treated either as a statement line or as a comment line by the compiler, depending on whether or not the WITH DEBUGGING MODE clause is present.

  When defining debugging lines, the following should be noted:

  - In the source program, debugging lines are permitted only after the OBJECT-COMPUTER paragraph.
  - The COBOL source program must be syntactically correct, with or without the debugging lines being considered as comment lines.

8 Interface between COBOL programs and BS2000

The interface between COBOL programs and the POSIX subsystem is described in chapter 13.

8.1 Input/output via system files

System files are standardized input/output areas of the system to which particular terminals or files can be assigned. They are available to any task and require no prior declaration. They include

- the logical input files of the operating system SYSDTA and SYSIPT
- the logical output files of the operating system SYSOUT, SYSLST, SYSLSTnn (nn = 01...99) and SYSOPT

8.1.1 COBOL language elements

COBOL programs can use system files to input or output low-volume data (e.g. control statements). COBOL85 supports access to system files and the console with the following language elements (see [1]):

- Program-internal mnemonic names for system files, declared in the SPECIAL-NAMES paragraph of the Environment Division:

  Procedure Division statements can reference the assigned system files via these mnemonic names (see below). Among other things, mnemonic names can be declared for the following files:

  - input files:

SYSDTA	with TERMINAL IS mnemonic-name
SYSIPT	with SYSIPT IS mnemonic-name

– output files:

SYSOUT	with TERMINAL IS mnemonic-name
SYSLST	with PRINTER IS mnemonic-name
SYSLSTnn	with PRINTERnn IS mnemonic-name (nn = 01...99)
SYSOPT	with SYSOPT IS mnemonic-name

The statements ACCEPT, DISPLAY and STOP literal of the Procedure Division:

- These access system files or the console according to the following rules:
  - ACCEPT...FROM mnemonic-name

    reads data from the **input file** that is associated (in the SPECIAL-NAMES paragraph) with mnemonic-name

    This causes the data to be transferred left-justified to the receiving item specified in the ACCEPT statement, its length being determined by this item as follows:
    If the item is longer than the value to be transferred, it is padded with spaces on the right; if it is shorter, the value is truncated on the right during the transfer to conform to the length of the item.

    If the input file has record format F (fixed-length records, see section 8.1.2), the following also applies:
    If the length of the receiving item of the ACCEPT statement is greater than the logical record length of the system file, additional data is automatically requested, i.e. additional read operations (macro calls) are initiated.

    If the program detects the end-of-file condition while reading the system file, it issues message COB9121 or COB9122.
    Depending on the COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION in the RUNTIME-OPTIONS option (SDF), the program run is subsequently continued (default) or terminated.

    When the program run is continued the string “/*” is stored in the first two positions of the receiving item (“/” is stored if the receiving item is only one character long) and processing continues with the statement following ACCEPT.
  - ACCEPT (without FROM phrase)

    reads data by default from the system input file SYSIPT.

    With COMOPT REDIRECT-ACCEPT-DISPLAY=YES or ACCEPT-DISPLAY-ASSGN= *TERMINAL in the SDF option RUNTIME-OPTIONS, it is possible to switch the assignment to system file SYSDTA.

– DISPLAY...UPON mnemonic-name

  writes data into the **output file** that is associated (in the SPECIAL-NAMES paragraph) with mnemonic-name.

  The size of the data transfer is determined by the length of the sending items or literals specified in the DISPLAY statement:
  If the total number of characters to be transferred is greater than the maximum record length for the output file (see Table 8-3), additional records are output until all characters are transferred. In the case of files with fixed-length records, if the number of characters is smaller than the record length, the records are space-filled on the right.

– DISPLAY (without UPON phrase)

  writes data by default to the system output file SYSLST.

  With COMOPT REDIRECT-ACCEPT-DISPLAY=YES or ACCEPT-DISPLAY-ASSGN= *TERMINAL in the SDF option RUNTIME-OPTIONS, it is possible to switch the assignment to system file SYSOUT.

– STOP literal

  outputs a literal (with a maximum length of 122 characters) on the **console**.

Example 8-1: Accessing a system file via a declared mnemonic name

```
IDENTIFICATION DIVISION.
    ...
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
    ...
SPECIAL-NAMES.
    SYSIPT IS SYS-INPUT  ----------------------------------------------- (1)

    ...
PROCEDURE DIVISION.
     ...
    ACCEPT CONTROL-FIELD FROM SYS-INPUT. ------------------------------- (2)

     ...
```

(1) The program-internal mnemonic name SYS-INPUT is declared for the system file SYSIPT.

(2) ACCEPT reads (via the mnemonic name SYS-INPUT) a value from SYSIPT into the item CONTROL-FIELD.

8.1.2 System files: primary assignments, reassignments, record formats

Primary assignments

At the start of a task, the system files in BS2000 are assigned to particular input/output devices. This is known as the **primary assignment** of the files and is dependent on the type of job (interactive mode or batch mode). The various options are summarized in the following table.:

System file	**Primary assignment**	
	in interactive mode	in batch mode
SYSDTA	Terminal	Spoolin file or ENTER file
SYSIPT	No primary assignment	Spoolin file or ENTER file
SYSOUT	Terminal	Temporary spoolout file (EAM file) which is output on the printer at task end and then deleted
SYSLST SYSLSTnn	Temporary spoolout files (EAM files), which are output on the **printer** at task end and then deleted	
SYSOPT	Temporary spoolout file (EAM file), which is output on **floppy disk** or **card punch** at task end and then deleted.	

Table 8-1: Primary assignments of the system files

Reassignments

The assignment of the system files can be changed in the course of a task by using the ASSIGN-*system-file* command, i.e. they can be redirected to other
– devices,
– system files, or even
– cataloged files.

A detailed description of the command can be found in [3].

system-file	**Reassigned to ...**	**using the command**
SYSDTA	cataloged disk file (SAM or ISAM) or PLAM library	ASSIGN-SYSDTA filename ASSIGN-SYSDTA *LIBRARY(library, element)
	card reader	ASSIGN-SYSDTA *CARD(...)
	floppy disk	ASSIGN-SYSDTA *DISKETTE(...)
SYSIPT	cataloged disk file (SAM or ISAM)	ASSIGN-SYSIPT filename
	card reader	ASSIGN-SYSIPT *CARD(...)

Table 8-2: Reassignments of system files

system-file	**Reassigned to ...**	**using the command**
SYSOUT	cataloged disk file (tape or disk)	ASSIGN-SYSOUT filename (in batch mode only)
SYSLST SYSLSTnn	cataloged disk file (SAM)	ASSIGN-SYSLST filename ASSIGN-SYSLST *SYSLST-NUMBER(...)
	dummy file (*DUMMY)	ASSIGN-SYSLST *DUMMY
SYSOPT	cataloged disk file (SAM)	ASSIGN-SYSOPT filename or ASSIGN-SYSOPT filename, OPEN-MODE = EXTEND
	dummy file (*DUMMY)	ASSIGN-SYSOPT *DUMMY

Table 8-2: Reassignments of system files

Record formats

The system files process fixed-length records (record format F) or variable-length records (record format V). The following table provides an overview of the record formats and record lengths permissible in each case.

System file	**Record format**	**Record length**
SYSDTA	V	When input via terminal or disk file: max. 32 Kbytes
	F	When input via card reader: max. 80 bytes
SYSIPT	F	80 bytes
SYSOUT	V	In batch mode: max. 132 bytes (+ 1 line-feed character)
		In interactive mode: max. 32 Kbytes
SYSLST SYSLSTnn	V	Max. 133 bytes: 1 byte control information and 132 bytes data
SYSOPT	F	Max. 80 bytes: 72 bytes of data; bytes 73-80 contain the first 8 characters of the name from the PROGRAM-ID

Table 8-3: Record formats and record lengths for system files

8.2 Job switches and user switches

BS2000 makes 32 job switches (numbered from 0 to 31) available to each job (task) and 32 user switches (numbered from 0 to 31) available to each user identification (see [3]). Each switch is able to assume an ON or an OFF status. They may be used to control activities within a task or to coordinate the activities of several tasks. Thus, for example:

– job switches can be used when two or more (COBOL) programs within one job need to communicate, e.g. when the execution of one program is dependent on the processing steps of another program that was invoked earlier;

– user switches can be used when two or more jobs need to communicate. When the communicating jobs belong to different user IDs, user switches associated with one ID can be interrogated by the jobs of another ID, but cannot be modified by these jobs.

Job and user switches can be accessed and modified at operating system level (by means of commands) or at program level (via COBOL statements). COBOL85 supports access to job and user switches with the following language elements (see [1]):

- Program-internal mnemonic names for job and user switches and their status, declared in the SPECIAL-NAMES paragraph of the Environment Division:

  These mnemonic names allow Procedure Division statements to reference the assigned switches and their status (see below). The mnemonic names can be declared as described below:

  – For the job switches

    via the implementor-names TSW-0, TSW-1,..., TSW-31, where the additional phrase ON IS... and OFF IS... allow the user to define condition names for the respective switch status.
    It is thus possible, for example, to declare the mnemonic name and status for task switch 17 with the phrases

```
TSW-17 IS mnemonic-name-17
   ON  IS switch-status-on-17
   OFF IS switch-status-off-17
```

  – For the user switches

    via the implementor-names USW-0, USW-1,..., USW-31, where the additional phrases ON IS... and OFF IS... allow the user to define condition names for the respective switch status.
    It is thus possible, for example, to declare the mnemonic name and status for user switch 18 with the phrases

```
USW-18 IS mnemonic-name-18
   ON  IS switch-status-on-18
   OFF IS switch status-off-18
```

- Interrogation and modification of switches in the Procedure Division:
  - Conditions (e.g. in the IF, PERFORM or EVALUATE statement) can contain the names (declared in the SPECIAL-NAMES paragraph) of switch status conditions and in this way evaluate them for the control of program execution.
  - SET (format 3; see [1]) can access switches (via the mnemonic names declared in the SPECIAL-NAMES paragraph) and change their status.

Example 8-2: Use of job switches

In the following extract from an interactive task, a DO procedure provides for different processing paths, depending on the status of job switches 12 and 13. The switches are evaluated and changed both at operating system level and at program level:
First, job switch 12 can be set at operating system level in order to control processing within the succeeding DO procedure, where its status will be evaluated at program level. Job switch 13 is then set, depending on the status of program execution. This switch is subsequently evaluated at operating system level.

```
/MODIFY-JOB-SWITCHES ON=12,OFF=13  ---------------------------- (1)
  ...
/DO PROG.SYSTEM

    The PROG.SYSTEM file contains  ------------------------- (2)
    following commands:

    /BEGIN-PROC ...
      ...
    /START-PROGRAM PROG-1  ---------------------------------- (3)

        Extract from PROG-1:
        ...
        SPECIAL-NAMES.           }
            TSW-12 IS SWITCH-12  }
                ON IS ON-12      }  ------------------ (4)
            TSW-13 IS SWITCH-13  }
                ON IS ON-13      }
        ...
        PROCEDURE DIVISION.
            ...
            IF ON-12 PERFORM A-PAR.  ------------------ (5)
            PERFORM B-PAR.
            ...
            IF FIELD = 99 SET SWITCH-13 TO ON. -------- (6)
            STOP RUN.
        A-PAR.
            ...
        B-PAR.
            ...

     ...
    /SKIP-COMMANDS TO-LABEL .END,IF=JOB-SWITCHES (OFF=13) ----- (7)
    /START-PROGRAM PROG-2
    /.END MODIFY-JOB-SWITCHES OFF=(12,13) -------------------- (8)
    /END-PROC

/...
```

(1) Job switch 12 is set to ON, job switch 13 to OFF at the operating system level.

(2) Extract from a DO procedure.

(3) The COBOL program PROG-1 is called.

(4) The internal names SWITCH-12 and SWITCH-13 are declared in the program for job switches 12 (TSW-12) and 13 (TSW-13) respectively, and the condition names ON-12 or ON-13 for their respective ON status.

(5) If job switch 12 is ON (see (1)), the statement PERFORM A-PAR is executed before PERFORM B-PAR.

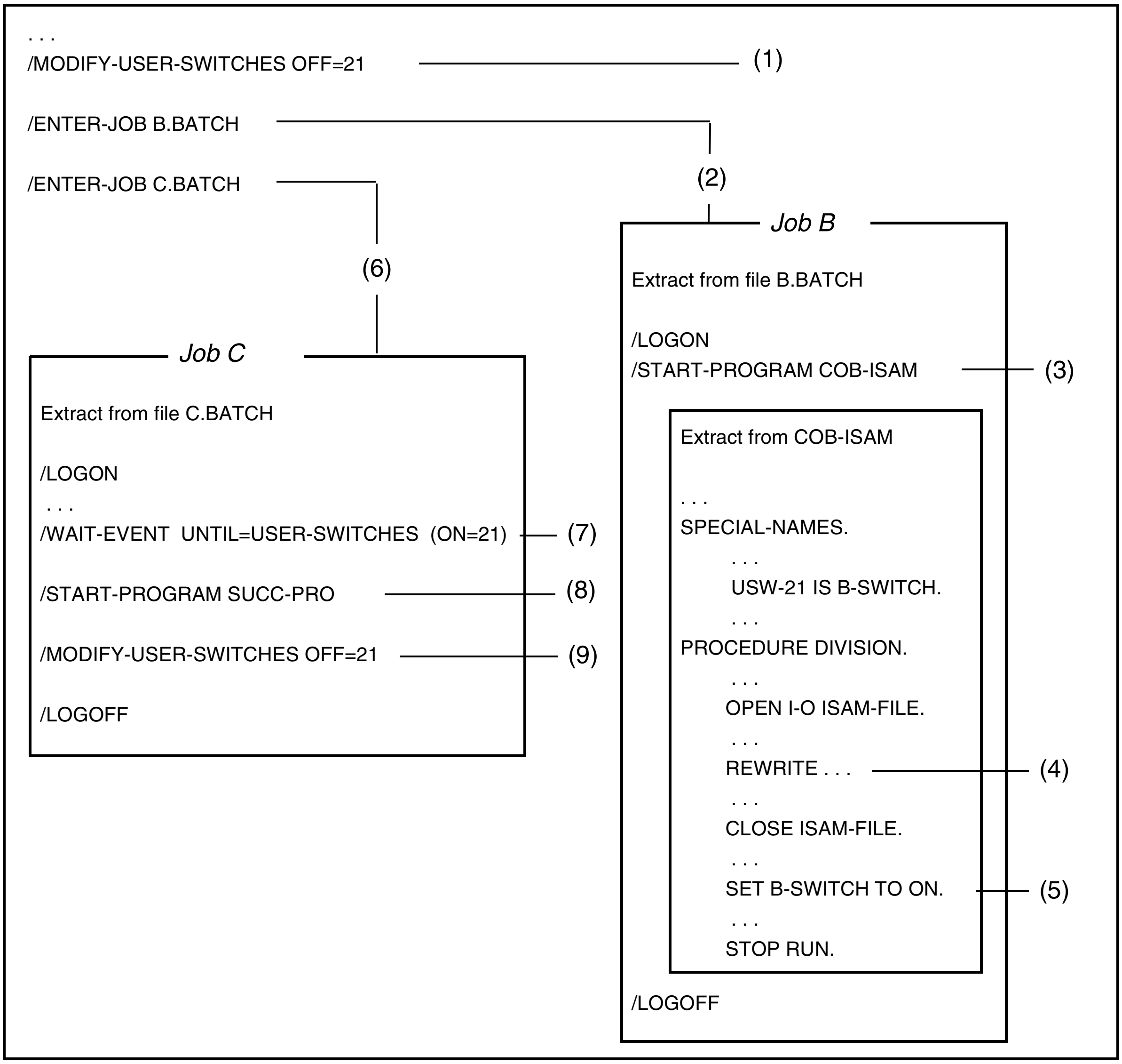
(6) If the indicator FIELD contains the value 99 at the end of program execution, PROG-1 sets the job switch to ON.

(7) The procedure evaluates the status of job switch 13: if it was not set to ON by PROG-1, the procedure branches to the end. Otherwise, PROG-2 is executed in addition to PROG-1.

(8) At the operating system level, job switches 12 and 13 are reset.

Example 8-3: Use of user switches

In the following extract, interactive job A generates two batch jobs, B and C. In job B, an ISAM file is updated. Job C can only execute after this takes place. User switch 21 is used in three different jobs. It is set at program level, and evaluated and reset at operating system level.



```
. . .
/MODIFY-USER-SWITCHES OFF=21                          (1)

/ENTER-JOB B.BATCH                                    (2)

/ENTER-JOB C.BATCH                                    (6)
```

Job B

```
Extract from file B.BATCH

/LOGON
/START-PROGRAM COB-ISAM                               (3)

    Extract from COB-ISAM

    . . .
    SPECIAL-NAMES.
          . . .
          USW-21 IS B-SWITCH.
          . . .
    PROCEDURE DIVISION.
          . . .
         OPEN I-O ISAM-FILE.
          . . .
         REWRITE . . .                                (4)
          . . .
         CLOSE ISAM-FILE.
          . . .
         SET B-SWITCH TO ON.                          (5)
          . . .
         STOP RUN.

/LOGOFF
```

Job C

```
Extract from file C.BATCH

/LOGON
 . . .
/WAIT-EVENT  UNTIL=USER-SWITCHES  (ON=21)             (7)

/START-PROGRAM SUCC-PRO                               (8)

/MODIFY-USER-SWITCHES OFF=21                          (9)

/LOGOFF
```

(1) User switch 21 is initialized to OFF.

(2) The ENTER procedure B.BATCH is called; it generates batch job B.

(3) Batch job B calls the COBOL program COB-ISAM.

(4) COB-ISAM updates the file ISAM-FILE.

(5) When updating is completed, COB-ISAM sets user switch 21 to ON.

(6) The ENTER procedure C.BATCH is called; it generates batch job C.

(7) Job C waits until the user switch is set to ON in job B.

(8) As soon as user switch 21 is set to ON, job C calls the COBOL program SUCC-PRO; it can then access the ISAM-FILE updated in job B.

(9) User switch 21 is set to OFF, in order to mark the (normal) end of job C.

8.3 Job variables

Job variables are available as a separate software product. Like job and user switches, they too are useful in information exchange

– between user programs and the operating system, or

– between different user programs.

Compared with switches, however, job variables offer the following additional facilities:

– They can be declared as monitoring job variables when a program is called. As such, they are automatically supplied with status and return codes, which provide information on program status and termination action, as well as on potential runtime errors.

– At the operating system or program level, they can be loaded with records of up to 256 bytes in length (128 bytes in the case of monitoring job variables). Because of this, they are able to communicate more detailed information than job or user switches, which are only capable of switching between ON and OFF status.

– In contrast to job and user switches, they can also be modified by jobs running under different user IDs.

Before a COBOL program can access a job variable, the variable must first be assigned to it via a link name, in a similar way to a file. The SET-JV-LINK command performs this function for job variables. Its format is described in manuals [3] and [7], and an example of its usage is contained in the following section. The link name to be specified in the command is apparent from the declarations in the COBOL program (see below).

COBOL85 supports access to job variables with the following language elements (see [1]):

● Link names and program-internal mnemonic names for job variables, declared in the SPECIAL-NAMES paragraph of the Environment Division:
Job variables can be assigned via link names, and the statements of the PROCEDURE DIVISON can refer to them via their mnemonic names (see below). Link names and mnemonic names for job variables can be declared with phrases in the following format:

  JV-jvlink IS mnemonic-name

jvlink	specifies the link name for the job variable. When the link name is formed, an “*” is prefixed to jvlink as its first character; the resulting link name is therefore *jvlink. For this reason, the string jvlink must not be longer than 7 bytes.
mnemonic-name	declares the program-internal mnemonic name for the job variable.

- The ACCEPT and DISPLAY statements of the Procedure Division:
  - ACCEPT...FROM mnemonic-name

    reads the contents of the job variable that is associated (in the SPECIAL-NAMES paragraph) with mnemonic-name. The data is transferred left-justified into the receiving item specified in the ACCEPT statement, according to the length of this item. If the item is longer than 256 bytes (128 bytes in the case of monitoring job variables), it is space-filled on the right; if it is shorter, the contents of the job variable are truncated on the right during the transfer to conform to the length of the item.
  - DISPLAY...UPON mnemonic-name

    writes data in the job variable that is associated (in the SPECIAL-NAMES paragraph) with mnemonic-name.
    The size of the data transfer is determined by the length of the sending items or literals of the DISPLAY statement, provided the maximum record length of 256 bytes (128 bytes for monitoring job variables) is not exceeded. If the total number of characters to be transferred is greater than the maximum record length, the record is truncated to the maximum length when it is transferred.
    When data is written to a monitoring job variable it should be noted that the first 128 bytes of the job variable are protected by the system against write access. Thus, only that part of the record starting at position 129 is written to the job variable, beginning at position 129 of the variable.

If a COBOL program which includes statements for job variables is run on a BS2000 installation that does not support job variables, these statements are not executed. After an ACCEPT statement, the receiving item contains the characters “/*”, starting in column 1. The first attempt to access a job variable causes message COB9120 to be output to SYSOUT.

A failed access to a job variable in a BS2000 installation that does support job variables causes message COB9197 to be output to SYSOUT (see table in section 6.6).

Example 8-4: Communication via a job variable

In the following interactive job, the job variable CONTROL.RUN is used both by a COBOL program and at command level. Depending on the contents of the job variable, the program can go through various processing branches, updating the contents of the job variable if required. A different job - even one under another user identification - can access this job variable, provided the job variable was cataloged with the command CREATE-JV ...,USER-ACCESS=ALL-USERS.

```
/SET-JV-LINK LINK-NAME=UPDATE,JV-NAME=CONTROL.RUN ---------------- (1)
/START-PROGRAM PROG.WORK-1

     Extract from the program:
     ...
     ENVIRONMENT DIVISION.
     CONFIGURATION SECTION.
     SPECIAL-NAMES.
         TERMINAL IS T
         JV-UPDATE IS FIELDJV.  --------------------------------- (2)
          ...
     DATA DIVISION.
     WORKING-STORAGE SECTION.
     01  DATE-TODAY      PIC X(6).  ----------------------------- (3)
     01  CONTENTS-JV. ------------------------------------------- (4)
       05  DATE-UPDATE   PIC X(6).
       05  FILLER        PIC X(20).
       05  NUM-UPDATE    PIC 9(4).
          ...
     PROCEDURE DIVISION.
         ACCEPT CONTENTS-JV FROM FELDJV. ------------------------ (5)
         ACCEPT DATE-TODAY FROM DATE.
         IF DATE-UPDATE NOT EQUAL DATE-TODAY -------------------- (6)
           PERFORM WORK
             ELSE PERFORM ALREADY-UPDATED.
          ...
     WORK.
          ...
         MOVE DATE-TODAY TO AKT-DAT.          }
         ADD 1 TO NUM-UPDATE.                 } ----------------- (7)
         DISPLAY CONTENTS-JV UPON FIELDJV.    }
          ...
     ALREADY-UPDATED.
         DISPLAY "END OF UPDATE"
           UPON T.
          ...

/SHOW-JV JV-NAME(CONTROL.RUN) ------------------------------------ (8)
%930629 UPDATE NR. 1679
```

(1) The job variable CONTROL.RUN is assigned to the COBOL program called after it (PROG.WORK-1) via the link name *UPDATE.

(2) The link name *UPDATE and the (program-internal) mnemonic name FIELDJV are declared for the job variable in the SPECIAL-NAMES paragraph of PROG.WORK-1.

(3) DATE-TODAY is reserved as the receiving item for the date.

(4) The receiving item for the contents of the job variable is declared. It contains subordinate items for recording the most recent update date (DATE-UPDATE) and an updating counter (NUM-UPDATE).

(5) ACCEPT transfers the contents of the job variable FIELDJV to CONTENTS-JV.

(6) Depending on whether the update date (DATE-UPDATE) of the job variable corresponds to the current date (DATE-TODAY), different processing procedures are executed in the program.

(7) At the end of processing, the items DATE-UPDATE and NUM-UPDATE are updated and written back to the job variable with DISPLAY CONTENTS-JV... .

(8) The job variable is read at operating system level: it contains the date and the number of the most recent update.

8.4 Accessing an environment variable

You can access an environment variable using the ACCEPT or DISPLAY statements.
The names of environment variables are defined using format 4 in the DISPLAY statement.
Format 5 of the ACCEPT statement is required in order to access the contents of environment variables.
At system level, the environment variables must be set up using an SDF-P variable.

Example 8-5: Accessing an environment variable

```
/SET-VAR TSTENV='AAAA BBB CC D'
/START-PROGRAM ...

Program excerpt:

IDENTIFICATION DIVISION.
...
SPECIAL-NAMES.
    ENVIRONMENT-NAME IS ENV-NAME
    ENVIRONMENT-VALUE IS ENV-VAR
    TERMINAL IS T
...
WORKING-STORAGE SECTION.
01  A   PIC X(15).
...
PROCEDURE DIVISION.
...
    DISPLAY "TSTENV" UPON ENV-NAME
    ACCEPT A FROM ENV-VAR
      ON EXCEPTION DISPLAY "ENVIRONMENT 'TSTENV' IS UNKNOWN!" UPON T
                   END-DISPLAY
      NOT ON EXCEPTION DISPLAY "VALUE IS:" A UPON T
                       END-DISPLAY
    END-ACCEPT
```

The exception condition appears with every failed access. Causes of a failed access can be, for example:

– missing SET-VAR command

– content of the variable is longer than the receiving field

8.5 Compiler and operating system information

COBOL programs can access information held by the compiler and the operating system. This includes information about

- the compilation of the source program
- CPU time used since LOGON
- the task in which the object program is running, and
- the terminal from which the program was called.

COBOL85 supports access to this information with the following language elements:

- Program-internal mnemonic names for the individual types of information, declared in the SPECIAL-NAMES paragraph of the Environment Division:

  The ACCEPT statement of the Procedure Division can access the relevant information via these mnemonic names. Mnemonic names can be declared for information on

  - the compilation with COMPILER-INFO IS mnemonic-name
  - the CPU time used with CPU-TIME IS mnemonic-name
  - the task with PROCESS-INFO IS mnemonic-name
  - the terminal with TERMINAL-INFO IS mnemonic-name
  - the date with DATE-ISO4 IS mnemonic-name

    (with century)

- The ACCEPT statement in the Procedure Division:

  ACCEPT...FROM mnemonic-name

  moves the information that is associated (in the SPECIAL-NAMES paragraph) with mnemonic-name into the specified receiving item.

  The size of the data transfer is determined by the length of the receiving item specified in the ACCEPT statement; the data is aligned on the left in the item, as follows:
  If the item is longer than the value to be transferred, it is padded with spaces on the right; if it is shorter, the value is truncated on the right during transfer to conform to the length of the item. This does not apply to CPU TIME: here a numerically correct transfer is always carried out.
  The length (and possibly the structure) to be declared for the receiving item is determined by the type of information that the item is to receive. The formats of the various types of information are listed in the following section.

Contents and structure of the information

The following table explains the structure of the information that is made available to a COBOL program via the implementor-names COMPILER-INFO, CPU-TIME, PROCESS-INFO, TERMINAL-INFO and DATE-ISO4.

Character position(s)	**Information for COMPILER-INFO**
1-10	Compiler name
11-20	Compiler version Format: `Vdd.dldddd` `d` = digit or blank `l` = letter or blank (e.g. “`V02.2A    `”)
21-30	Date of compilation Format: YYYY-MM-DD (e.g. “2013-12-31”)
31-38	Time of compilation Format: HH-MM-SS (e.g. “23-59-59”)
39-68	The first eight characters of the PROGRAM-ID name

	Information for CPU-TIME
PIC 9(6)V9(4)	CPU time in ten thousandths of a second

Character position(s)	**Information for PROCESS-INFO**
1	Type of job Contents: B for Batch D for Dialog (= interactive)
2-5	Job sequence number
6-13	User identification
14-21	Account number
22	Privilege class of the job Contents: U for user S for system administrator
23-32	Operating system version Format: `Vdd.dldddd` (e.g. “`V11.2     `”)
33-40	Name of the next processor to which the terminal is connected.

Character position(s)	Information for PROCESS-INFO
41-120	System administrator privileges; the fields contain 8 blanks if the privilege is not present
41-48	SECADM
49-56	USERADM
57-64	HSMSADM
65-72	SECOLTP
73-80	TAPEADM
81-88	SATFGMMF
89-96	NETADM
97-104	FTADM
105-112	FTACADM
113-120	TSOS

Character position(s)	Information for TERMINAL-INFO
1-8	Terminal name
9-13	Number of characters per line
14-18	Number of physical lines that can be output without activating the information overflow control.
19-23	Number of characters that can be output without activating the information overflow control.
24-27	Device type
	If a device type is not known to the runtime system, these positions are filled with blanks.

Character position(s)	Information for DATE-ISO4
1-14	Current date (including century YYYY and numbered day NNN of the current year) Format: YYYY-MM-DDNNN␣

Example 8-6: Data structures for acceptance of compiler and operating system information by means of the ACCEPT statement

```
*
 01  COMPILER-INFORMATION.
     02  COMPILER-NAME                      PIC X(10).
     02  COMPILER-VERSION                   PIC X(10).
     02  DATE-OF-COMPILATION                PIC X(10).
     02  TIME-OF-COMPILATION                PIC X(8).
     02  PROGRAM-NAME                       PIC X(30).
*
 01  CPU-TIME-IN-SECONDS                    PIC 9(6)V9(4).
*
 01  TASK-INFORMATION.
     02  TASK-TYPE                          PIC X.
         88  BATCH-TASK                              VALUE "B“.
         88  INTERACTIVE-TASK                        VALUE "D“.
     02  TASK-SEQUENCE-NUMBER               PIC 9(4).
     02  USER-IDENTIFICATION                PIC X(8).
     02  ACCOUNT-NUMBER                     PIC X(8).
     02  PRIVILEGE-IDENTIFIER               PIC X.
         88  SYSTEM-ADMINISTRATOR                    VALUE "S“.
         88  USER                                    VALUE "U“.
     02  OPERATING-SYSTEM-VERSION           PIC X(10).
     02  PROCESSOR-NAME                     PIC X(8).
     02  SYSTEM-ADMINISTRATOR-PRIVILEGE     PIC X(80).
*
 01  TERMINAL-INFORMATION.
     02  TERMINAL-NAME                      PIC X(8).
     02  CHARS-PER-LINE                     PIC 9(5).
     02  LINES-PER-SCREEN                   PIC 9(5).
     02  CHARS-PER-SCREEN                   PIC 9(5).
     02  DEVICE-TYPE                        PIC X(4).
*
 01  CURRENT-DATE.
     05  YEAR                               PIC X(4).
     05  FILLER                             PIC X.
     05  MONTH                              PIC X(2).
     05  FILLER                             PIC X.
     05  DAY-OF-THE-MONTH                   PIC X(2).
     05  DAY-OF-THE-YEAR                    PIC X(3).
     05  FILLER                             PIC X.
```

9 Processing of cataloged files

The processing of POSIX files is described in chapter 13.

9.1 Basic information on the structure and processing of cataloged files

9.1.1 Basic concepts relating to the structure of files

From the viewpoint of a COBOL application program, a file is a named collection of data records that is provided with a logical structure (**file organization**), has specific **record formats**, and is stored on one or more data storage media, which are referred to as volumes. COBOL programs access files by making use of functions provided by the Data Management System (DMS). The particular **DMS access method** used for this purpose is determined by the file organization.
As seen from the perspective of DMS, the accessing of a file always represents a transfer of **data blocks** between a peripheral storage device and a part of the main memory, called the **buffer**, which is an area set up by the application program for accommodating the data blocks.

File organization and DMS access methods

The logical structure of a file, and thus the method by which it is accessed, is defined by its type of organization. The file organization is specified at file creation and cannot be changed subsequently.
In COBOL, files may be organized as sequential, relative, or indexed files. The features and characteristics of the various types of file organization are detailed in sections 9.2, 9.3 and 9.4. Each of the above organization types corresponds to an access method of the DMS. The relationship is shown in the following table:

File organization	**DMS access method**
sequential	SAM
relative	ISAM/UPAM
indexed	ISAM

Table 9-1: File organization and DMS access methods

Data records and record formats

A (logical) data record represents the unit of a file that can be accessed by a COBOL program with a single I-O statement. Each read operation makes a record available to the program, while each write statement creates a record in the file.

The records of a file may be classified according to their record format. Depending on the type of file organization, the following record formats are permitted in COBOL:

– Fixed-length records (RECFORM=F)

  All records of a file are of the same length and contain no information regarding the record length.

– Variable-length records (RECFORM=V)

  The records of a file can have different lengths; each record contains a specification of its length in the first word, called the record length field.
  In a COBOL program, this record length field does not form a part of the record description entry. This means that its content cannot be explicitly accessed unless a RECORD clause with the DEPENDING ON phrase is specified for the file (see [1]).

– Records of undefined length (RECFORM=U)

  The records of a file may vary in length but include no record length information.

Data blocks and buffers

A (logical) data block is the unit of a file that is transferred (by the DMS) between peripheral storage and main memory during a file access operation. In order to such data blocks, the program reserves a storage area in its address space. This reserved area is called the buffer.

A logical block may consist of one or more records; however, a record must not be distributed over more than one logical block.

If a logical block contains more than one data record, these records are said to be blocked. Only records of fixed or variable length can be blocked. Blocking is not possible with records of undefined length.

In terms of size, a logical block (and thus a buffer) may be defined:

– for disk files, as a standard block, i.e. a physical block (PAM block) of 2048 bytes or integral multiples thereof (up to 16 PAM blocks) and

– for magnetic tape files, additionally as a non-standard block of any length up to 32767 bytes.

During compilation, the compiler calculates a value for the buffer size for each file on the basis of record and block length specifications given in the source program. This default value can be modified during the assignment of the file by specifying the BUFFER-LENGTH operand in the SET-FILE-LINK command. It must be noted, however, that

- the buffer must be at least as large as the longest data record, and
- there must be space for the management information (PAM key) in the buffer when processing in non-key format (BLKCTRL = DATA) (see section 9.1.4).

Except in the case of newly created files (OPEN OUTPUT), the block size entered in the catalog always takes priority over block size specifications in the program or SET-FILE-LINK command.

9.1.2 Assignment of cataloged files

A program-internal name is specified in the SELECT clause (see [1]) for each file to be processed by a COBOL program. The COBOL statements for a given file reference the file via this name. During program execution, each of the specified file-names must be assigned an actual file.

This assignment can be defined before the program call by means of a SET-FILE-LINK or ASSIGN system-file command. Which of the two commands should be used is determined by the entry in the ASSIGN clause (see [1]) for the file. If no file is explicitly assigned, the default values generated during compilation come into effect.

The individual methods used for the assignment of files are summarized below:

Assignment via the SET-FILE-LINK command

This method can only be used on condition that the name of a system file was not specified in the ASSIGN clause. The system files are identified by implementor-name-1 (PRINTER) or implementor-name-2 (PRINTER01...PRINTER99, SYSIPT, SYSOPT).

Assignment via the SET-FILE-LINK command is therefore possible only if “literal” is specified in the ASSIGN clause, where “literal” is the file link name.

To assign a cataloged file, the user must issue a SET-FILE-LINK command for this file before the program call; this SET-FILE-LINK command must include a LINK-NAME operand specifying the declared link name. File attributes can also be specified at the same time using other operands of the SET-FILE-LINK command.

Any link name must conform to BS2000 requirements in respect of link names (see also [3]). More specifically, this means that

– it must be alphanumeric,

– it may consist of a maximum of eight characters, and

– it must not contain any lowercase letters.

Example 9-1: Assignment of a cataloged file via the SET-FILE-LINK command

Entry in the FILE-CONTROL paragraph of the COBOL program LINKLIT:	`SELECT MASTER-FILE ASSIGN TO „MASTLNK“.`
Link name generated at compilation:	`MASTLNK`

Assignment of file STORE.INVENTORY
 	
and program call:
	`/SET-FILE-LINK LINK-NAME=MASTLNK,`
	`FILE-NAME=STORE-INVENTORY`
	`/START-PROGRAM LINKLIT`

In the case of COBOL programs using SORT (see chapter 10), the following link names are reserved for the SORT utility routine and are thus not available for other files:

MERGEnn (nn=01,...99)
SORTIN
SORTINnn (nn=01,...99)
SORTOUT
SORTWK
SORTWKn (n=1,...9)
SORTWKnn (nn=01,...99)
SORTCKPT

If a cataloged file has not been explicitly assigned at program runtime to an internal file name (with the link name “linkname”), the following defaults come into effect:

- In the case of an output file and ENABLE-UFS-ACCESS = NO, the program attempts to access a cataloged file with the name from the SELECT clause. If no catalog entry is found under this name, the program writes to a previously created file with the name FILE.COB85.linkname.
  In the case of ENABLE-UFS-ACCESS = YES, the program writes directly to the file FILE.COB85.linkname.
- For an input file whose SELECT clause contains the OPTIONAL phrase (see also section 9.2.2), the first read access attempt causes an AT END condition and passes control to the procedures declared in the program for such a case.
- In the case of an input file (without the OPTIONAL phrase in the SELECT clause) and ENABLE-UFS-ACCESS = NO or of an input-output file, the program attempts to access a cataloged file with the name from the SELECT clause. If no catalog entry is found under this name, execution is interrupted with error message COB9117 and may be continued with the RESUME-PROGRAM command after a correct file assignment is made.

A file assignment remains in effect until it is
- released explicitly by a REMOVE-FILE-LINK command or implicitly at end of task, or
- modified by means of a subsequent SET-FILE-LINK command.

This should be noted particularly where several different files are to be successively assigned to one program-internal file-name within the same task.

Information regarding currently assigned cataloged files can be obtained by using the SHOW-FILE-LINK command (see [3]).

Example 9-2: Changing file assignments

In this example, the COBOL program UPDPROG declares the link name INOUTFIL for an I-O file. The cataloged files FILE.UPDATE.1 and FILE.UPDATE.2 are to be updated in succession:

```
/SET-FILE-LINK INOUTFIL,FILE.UPDATE.1  ------------------------------------ (1)
/START-PROGRAM UPDPROG
   ...
/SET-FILE-LINK INOUTFIL,FILE.UPDATE.2  ------------------------------------ (2)
/START-PROGRAM UPDPROG
   ...
/REMOVE-FILE-LINK INOUTFIL  ----------------------------------------------- (3)
```

(1) The file named FILE.UPDATE.1 is assigned via link name INOUTFIL to the program UPDPROG for subsequent processing.

(2) After processing, a further SET-FILE-LINK command terminates the previously valid file assignment for the link name INOUTFIL and assigns the file named FILE.UPDATE.2 as the new file.

(3) The file assignment for link name INOUTFIL is released by means of the REMOVE-FILE-LINK command.

Assignment via the ASSIGN-*systemfile* command

This method requires that the ASSIGN clause contains the name of a system file.

By issuing a ASSIGN-*systemfile* command for the specified system file,

- a cataloged file or
- another system file

can be assigned before the program is called. The permissible assignments for each system file are given in the description of the ASSIGN-*systemfile* command in [3].

Example 9-3: Assigning a cataloged file via the ASSIGN system-file command

Entry in the FILE-CONTROL paragraph of the COBOL program LISTPROG:	SELECT PRINT-FILE ASSIGN TO PRINTER.
Assignment of the LIST.FILE and program call:	/ASSIGN-SYSLST LIST.FILE /START-PROGRAM LISTPROG

If no file is explicitly assigned at program runtime, the program will execute its I-O operations on the specified system file.

A file assignment remains in effect until it is

- released at the end of the task, or
- modified by means of a subsequent ASSIGN-*systemfile* command.

This should be noted particularly where several different files are to be successively assigned to one program-internal file name within the same task.

Information regarding current file assignments can be obtained by using the SHOW-SYSTEM-FILE-ASSIGNMENTS command.

9.1.3 Definition of file attributes

The SET-FILE-LINK command

BS2000 provides the SET-FILE-LINK command for creating files and defining file attributes. The complete format for this command and a detailed description are provided in manuals [3] and [4].

Task file table (TFT)

Whenever a SET-FILE-LINK command with the operand LINK-NAME=linkname is issued for a file, the DMS creates an entry for the file under this link name in the task file table (TFT) and stores all file attributes explicitly defined in the SET-FILE-LINK command under this entry.

Each of these entries is retained in the TFT until it is

– removed by a REMOVE-FILE-LINK command for the assigned file link name, or deleted together with the TFT at the end of the task, or

– overwritten by a new SET-FILE-LINK command for the same file link name.

Information on the current contents of the TFT can be obtained by using the SHOW-FILE-LINK command.

When a COBOL program attempts to open a file, the DMS first checks whether the TFT contains the link name that was defined for the file at compilation (see section 9.1.2). If such an entry is found, the program takes over file attributes from

– the TFT entry under this link name,

– the file attributes that were explicitly or implicitly specified in the program, and

– the catalog entry of the associated file.

The specifications from the TFT entry (i.e. file attributes explicitly defined in the SET-FILE-LINK command) overwrite file specifications from the COBOL program. The catalog entry is referred to only for file attributes that are defined neither in the program nor in the TFT entry or those that were specified as null operands in the SET-FILE-LINK command.

This approach could lead to conflicts during file access, especially when file attributes specified in the SET-FILE-LINK command are not compatible with the (explicitly or implicitly) defined characteristics in the COBOL program or in the catalog entry of the assigned file. This is especially applicable in the following situations:

– Conflicting entries on the **open mode**

COBOL program	SET-FILE-LINK command
OPEN INPUT...[REVERSED]	OPEN-MODE=OUTPUT or OPEN-MODE=EXTEND
OPEN OUTPUT	OPEN-MODE=INPUT or OPEN-MODE=REVERSE
OPEN EXTEND	OPEN-MODE=INPUT or OPEN-MODE=REVERSE

– Conflicting entries on the **organization type of the file**

COBOL program	SET-FILE-LINK command
ASSIGN clause ORGANIZATION clause	ACCESS-METHOD operand

– Conflicting entries on the **record format**

COBOL program	SET-FILE-LINK command
RECORD clause RECORDING MODE clause	RECORD-FORMAT operand

– Conflicting entries on the **record length**

COBOL program	SET-FILE-LINK command
RECORD clause record description entry	RECORD-SIZE operand

– Conflicting entries on the **record key**

COBOL program	SET-FILE-LINK command
RECORD KEY clause record description entry	KEY-POSITION operand KEY-LENGTH operand

– Conflicting entries on the **disk format** or **file format**

Catalog entry	SET-FILE-LINK command
BLK-CONTR = BUF-LEN =	BLOCK-CONTROL-INFO operand BUFFER-LENGTH operand

Example 9-4: Creating and displaying a TFT entry
(shown in BS2000/OSD V9.0)

```
/SET-FILE-LINK INOUTFIL,ISAM.UPDATE,           ⎫
               BUFFER-LENGTH=BY-CATALOG,       ⎬ ──────────────── (1)
               SUPPORT=DISK(SHARED-UPDATE=YES) ⎭
/SHOW-FILE-LINK INOUTFIL,INFORMATION=ALL ──────────────────────── (2)
```

```
LINK-NAME ───────── FILE-NAME ──────────────────────────────────────────
INOUTFIL            :N:$F2190202.ISAM.UPDATE
──────────────────── STATUS ────────────────────────────────────────────
STATE       = INACTIVE    ORIGIN     = FILE
──────────────────── PROTECTION ────────────────────────────────────────
RET-PER     = *BY-PROG    PROT-LEV   = *BY-PROG
BYPASS      = *BY-PROG    DESTROY    = *BY-CAT
──────────────────── FILE-CONTROL-BLOCK - GENERAL ATTRIBUTES ───────────
ACC-METH    = *BY-PROG    OPEN-MODE  = *BY-PROG    REC-FORM   = *BY-PROG
REC-SIZE    = *BY-PROG    BUF-LEN    = *BY-CAT     BLK-CONTR  = *BY-PROG
F-CL-MSG    = STD         CLOSE-MODE = *BY-PROG
──────────────────── FILE-CONTROL-BLOCK - DISK FILE ATTRIBUTES ─────────
SHARED-UPD  = YES         WR-CHECK   = *BY-PROG    IO(PERF)   = *BY-PROG
IO(USAGE)   = *BY-PROG    LOCK-ENV   = *BY-PROG
──────────────────── FILE-CONTROL-BLOCK - TAPE FILE ATTRIBUTES ─────────
LABEL       = *BY-PROG   (DIN-R-NUM  = *BY-PROG,   TAPE-MARK  = *BY-PROG)
CODE        = *BY-PROG    EBCDIC-TR  = *BY-PROG    F-SEQ      = *BY-PROG
CP-AT-BLIM  = *BY-PROG    CP-AT-FEOV = *BY-PROG    BLOCK-LIM  = *BY-PROG
REST-USAGE  = *BY-PROG    BLOCK-OFF  = *BY-PROG    TAPE-WRITE = *BY-PROG
STREAM      = *BY-PROG
──────────────────── FILE-CONTROL-BLOCK - ISAM FILE ATTRIBUTES ─────────
KEY-POS     = *BY-PROG    KEY-LEN    = *BY-PROG    POOL-LINK  = *BY-PROG
LOGIC-FLAG  = *BY-PROG    VAL-FLAG   = *BY-PROG    PROPA-VAL  = *BY-PROG
DUP-KEY     = *BY-PROG    PAD-FACT   = *BY-PROG    READ-I-ADV = *BY-PROG
WR-IMMED    = *BY-PROG    POOL-SIZE  = *BY-PROG
──────────────────── VOLUME ────────────────────────────────────────────
DEV-TYPE    = *NONE       T-SET-NAME = *NONE
VSN/DEV     = PUBN03/D3480
```

(1) The SET-FILE-LINK command assigns the link name INOUTFIL to the file ISAM.UPDATE and defines
- that the value from the catalog entry for ISAM.UPDATE will be assigned for the BUFFER-LENGTH operand when the file is opened, and
- SHARED-UPDATE=YES, i.e. ISAM.UPDATE can be updated by more than one user simultaneously.

The DMS creates a TFT entry under the name INOUTFIL and stores these specifications in it.

(2) The SHOW-FILE-LINK command outputs the contents of the TFT entry for INOUTFIL with the operand values. Note that the values
- BUF-LEN = *CAT and
- SHARUPD = YES

are derived from the specifications in the SET-FILE-LINK command. The remaining operands were not explicitly defined and thus have the default values *BY-PROG or *NONE.

9.1.4 Disk and file formats

Disk formats

BS2000 supports disks with different formats:

- **K**eyed volumes (or K disks) are used for files in which block control information is stored in a separate field (“Pamkey”) for each 2K data block. These files have the PAMKEY block format.
- **N**on-**K**ey volumes (or NK disks) are used for files in which no separate Pamkey fields exist, i.e. files that have no block control information (block format NO) or files in which the block control information is stored in each respective data block (block format DATA).

In BS2000 NK volumes are differentiated on the basis of the minimum transfer unit. NK2 volumes have the usual transfer unit of 2K; NK4 volumes have a transfer unit of 4K.

The block format of a COBOL file can be defined by means of the BLOCK-CONTROL-INFO operand of the SET-FILE-LINK command:

```
SET-FILE-LINK ...
  ,BLOCK-CONTROL-INFO = BY-PROGRAM / BY-CATALOG / WITHIN-DATA-BLOCK / PAMKEY
```

Note
Files with BLOCK-CONTROL-INFO = NO can be neither created nor read with a COBOL program.

Two additional operand values are available for NK-ISAM files:

WITHIN-DATA-2K-BLOCK / WITHIN-DATA-4K-BLOCK

A detailed description of the BLOCK-CONTROL-INFO operand, the various file and volume formats, and the conversion of K file formats to NK file formats can be found in the manual “DMS Introductory Guide and Command Interface” [4].

If the values specified in the BLOCK-CONTROL-INFO or BUFFER-LENGTH operands of the SET-FILE-LINK command are not compatible with
- the block format of the file or
- the volume on which the file is stored or
- the required blocking factor,

file processing is aborted without success, and the runtime system reports the fact with I/O status (File Status) 95.

If no SET-FILE-LINK command is used for a COBOL file, the default value to be set by the system administrator in the BLKCTRL operand of the CLASS2-OPTION applies.

K-ISAM and NK-ISAM files

ISAM files in K format that use the maximum record length become longer than the usable area of the data block when converted to NK format. But they can still be handled in NK format because the DMS extends the data block by creating so-called “overflow blocks”.

The creation of overflow blocks is attended by the following problems:

– The overflow blocks increase space requirements on the disk and thus the number of input/output operations during file processing.

– The ISAM key must never be located within an overflow block.

Overflow blocks can be avoided by ensuring that the longest record in the file is shorter than the usable area of a logical block in NK-ISAM files.

The following table shows how to calculate how much space per logical block is available for data records in ISAM files.

File format	RECORD-FORMAT	Maximum usable area
K-ISAM	VARIABLE	BUF-LEN
	FIXED	BUF-LEN - (s*4) where s = number of records per logical block
NK-ISAM	VARIABLE	BUF-LEN - (n*16) - 12 - (s*2) (rounded down to next number divisible by 4) where n = blocking factor s = number of records per logical block
	FIXED	BUF-LEN - (n*16) - 12 - (s*2) - (s*4) (rounded down to next number divisible by 4) where n = blocking factor s = number of records per logical block

Table 9-2: Maximum usable block area in ISAM files

Explanation of the formulae:

With RECORD-FORMAT=FIXED, every record of both K-ISAM and NK-ISAM files contains a 4-byte record length field, but this is not included in the RECSIZE value. In these cases, therefore, it is necessary to deduct 4 bytes per record.
In NK-ISAM files, each PAM page of a logical block contains 16 bytes of management information. The logical block additionally contains a further 12 bytes of management information and a 2-byte record pointer per record.

Example 9-5 : Maximum record length for an NK-ISAM file (fixed-length records)

File declaration:

```
/SET-FILE-LINK ...,RECORD-FORMAT=FIXED,BUFFER-LENGTH=STD(SIZE=2),
                              BLOCK-CONTROL-INFO=WITHIN-DATA-BLOCK
```

maximum record length (according to formula in table 9-2):
4096 - (2*16) - 12 - 1*2 - 1*4 = 4046,
rounded down to next number divisible by four: 4044 (bytes).

K-SAM and NK-SAM files

SAM files do not have overflow blocks. This means that SAM files in K format that use the maximum record length are not converted to NK-SAM files. COBOL programs that work with records having the maximum length possible for K-SAM files are not executable with NK-SAM files.

The following table shows how much space per logical block is available for data records in SAM files.

File format	RECORD-FORMAT	Maximum usable area
K-SAM	VARIABLE	BUF-LEN - 4
	FIXED / UNDEFINED	BUF-LEN
NK-SAM	VARIABLE / FIXED / UNDEFINED	BUF-LEN - 16

Table 9-3: Maximum usable block area in SAM files

The reason for deducting 4 bytes from the block size in K-SAM files with variable-length records is that the logical blocks of such files contain a 4-byte block length field that is not counted in the BUF-LEN value.

9.2 Sequential file organization

Two types of file are organized sequentially: record-sequential and line-sequential files. The following general description refers to record-sequential files.
Differences to and restrictions for line-sequential files are described in section 9.2.5.

9.2.1 Characteristics of sequential file organization

Records of a sequentially organized file are always arranged logically in the order in which they were written to the file. Consequently,

– every record (except for the last) has a unique successor, and

– every record (except for the first) has a unique predecessor.

This relationship between predecessor and successor cannot be modified during the entire life of the file.

It is thus not possible to

– insert records,

– delete records, or

– change the position of a record within the specified order

in a sequential file.

However, sequential file organization does permit the

– updating of records already in existence

  (provided that their lengths remain the same and that the file is a disk storage file), and the

– appending of new records to the end of the file.

Individual records of a file cannot be directly (randomly) accessed; they can only be processed in the same order in which they are stored in the file.

To process sequential files, COBOL programs make use of the SAM access method, which is provided by DMS for this purpose. Further details on this topic are provided in manual [4].

Sequential files can be set up on magnetic tape devices or direct access devices (disk storage units).

9.2.2 COBOL language tools for the processing of sequential files

The following program skeleton summarizes the most important clauses and statements provided in COBOL85 for the processing of sequential files. The most significant phrases and entries are briefly explained thereafter:

```
IDENTIFICATION DIVISON.
    .
    .
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT internal-file-name
    ASSIGN TO external-name
    ORGANIZATION IS SEQUENTIAL
    ACCESS MODE IS SEQUENTIAL
    FILE STATUS IS status-items.
    .
    .
DATA DIVISION.
FILE SECTION.
FD  internal-file-name
    BLOCK CONTAINS block-length-spec
    RECORD record-length-spec
    RECORDING MODE IS record-format
    ...
01  data-record.
    nn item-1              type&length.
    nn item-2              type&length.
    ...
PROCEDURE DIVISION.
    ...
    OPEN open-mode internal-file-name.
    ...
    WRITE data-record.
    ...
    READ internal-file-name
    ...
    REWRITE data-record.
    ...
    CLOSE internal-file-name.
    ...
    STOP RUN.
```

`SELECT internal-file-name`

specifies the name by which the file is to be referenced in the source program.

internal-file-name must be a valid user-defined word.

The SELECT clause format also permits use of the OPTIONAL phrase for input files whose presence is not essential at program runtime.

If a file name declared with SELECT OPTIONAL is not assigned any file during program execution, then:

– in the case of OPEN INPUT, the program run is interrupted with message COB9117 and a SET-FILE-LINK command is requested (in dialog mode), or the AT-END condition is initiated (in batch mode)

– in the case of OPEN I-O or OPEN EXTEND, a file with the name FILE.COB85.link-name is created.

`ASSIGN TO external-name`

specifies the system file associated with the file and defines the name via which a cataloged file can be assigned.

external-name must be either

– a permissible literal or

– a permissible data name defined in the DATA DIVISION

– a valid implementor name

from the ASSIGN clause format (see [1]).

`ORGANIZATION IS SEQUENTIAL`

specifies that the file is sequentially organized.

The ORGANIZATION clause may be omitted in the case of sequential files, since the compiler assumes sequential file organization by default.

`ACCESS MODE IS SEQUENTIAL`

specifies that the records of the file can only be accessed sequentially.

The ACCESS MODE clause is optional and only serves for documentation purposes in the case of sequential files. This is because sequential access is the default value assumed by the compiler and is the only permitted access mode for sequential files.

`FILE STATUS IS status-items`

specifies the data items in which the runtime system stores status information after each access operation on a file. This information indicates

- whether the I-O operation was successful and
- the type of any errors that may have occurred.

The status items must be declared in the Working-Storage Section or the Linkage Section. Their format and the meanings of individual status codes are described in section 9.2.8.

The FILE STATUS clause is optional. If it is not specified, the information mentioned above is not available.

`BLOCK CONTAINS block-length-spec`

defines the maximum size of a logical block. It determines how many records are to be transferred together by each I/O operation into/from the buffer of the program.

block-length-spec must be a permissible value from the format of BLOCK CONTAINS clause.

The blocking of records reduces

- the number of accesses peripheral storage and thus the runtime of the program;
- the number of interblock gaps on the storage medium and thus the physical storage space required by the file.

During compilation, the compiler calculates a value for the buffer size on the basis of the record and block length entries given in the source program. In the case of disk files, the runtime system rounds up this value for the DMS to the next multiple of a PAM block (2048 bytes). This default value can be modified during the file assignment by specifying the BUFFER-LENGTH operand in the SET-FILE-LINK command (see section 9.1.3).

In this case, it must be noted that

- the buffer must be at least as large as the longest data record, and
- there must be space for the management information (PAM key) in the buffer when processing in non-key format (BLKCTRL = DATA) (see section 9.1.4).

Except in the case of newly created files (OPEN OUTPUT), the block size entered in the catalog always takes priority over block size specifications in the program or SET-FILE-LINK command.

The BLOCK CONTAINS clause is optional. If it is omitted, the compiler assumes BLOCK CONTAINS 1 RECORDS, i.e. unblocked records.

```
RECORD record-length-spec
```

– specifies whether records of fixed or variable length are to be processed and

– defines, for variable-length records, a range of permissible values for the record length. If provided for in the format, a data item is additionally specified for the storage of current record length information.

record-length-spec must conform to one of the three RECORD clause formats provided in COBOL85. It must not be in conflict with the record lengths computed by the compiler from the specifications in the associated record description entry or entries.

The RECORD clause is optional. If it is not specified, the record format is obtained from the phrase in the RECORDING MODE clause (see below). Should this clause also be omitted, records of variable length are assumed by the compiler (see section 9.2.3 for the relationship between the RECORD and RECORDING MODE clauses).

```
RECORDING MODE IS U
```

defines the format of the logical records as “undefined”; i.e. the file may contain an optional combination of fixed or variable records.

The RECORDING MODE clause is optional and is only required when declaring records of undefined length, since fixed- and variable-length records can also be specified in the RECORD clause (see section 9.2.3).

```
01 data-record.
   nn item-1            type&length
   nn item-2            type&length
```

represents a record description entry for the associated file. It describes the logical format of data records.

At least one record description entry is required for each file. If more than one record description entry is specified for a file, the declared record format must satisfy the following rules:

– for fixed-length records, all record description entries must specify the same record size

– for variable-length records, they must not be in conflict with the record length specified in the RECORD clause.

The subdivision of data-record into data items (item-1, item-2, ...) is optional. For type&length, the required length and format declarations (PICTURE and USAGE clauses etc.) must be entered.

```
OPEN open-mode internal-file-name
```

opens the file for processing in the specified open mode. The following phrases can be entered for open-mode:

INPUT	opens the file as an input file; it can only be read.
OUTPUT	opens the file as an output file; it can only be written.
EXTEND	opens the file as an output file; it can be extended.
I-O	opens the file as an I-O file; it can be read (one record at a time), updated and rewritten.

The open-mode entry determines with which I-O statements a file may be accessed (see section 9.2.4).

```
WRITE data-record
READ internal-file-name
REWRITE data-record
```

are I-O statements for the file that
– write or
– read or
– rewrite

one record at a time.

The open-mode declared in the OPEN statement determines which of these statements is admissible for the file. The relationship between access mode and open mode is described in section 9.2.4.

```
CLOSE internal-file-name
```

terminates processing. Depending on the entry in the format, it may apply to
– the file (no further phrase) or
– a disk storage unit (phrase: UNIT) or
– a magnetic tape reel (phrase: REEL).

This clause can optionally be used to prevent
– a tape from being rewound (phrase: WITH NO REWIND) or
– a file from being opened again (phrase: WITH LOCK) in the same program run.

9.2.3 Permissible record formats and access modes

Record formats

Sequential files may contain records of fixed length (RECFORM=F), variable length (RECFORM=V), or undefined length (RECFORM=U). However, blocking is possible only in the case of fixed- or variable-length records.

In the COBOL source program, the format of records to be processed is defined in the RECORD or RECORDING MODE clause (see [1]). The following table lists the phrases associated with each record format:

	Phrase in the	
Record format	RECORD clause	RECORDING MODE clause
Fixed-length records	RECORD CONTAINS...CHARACTERS (format 1)	
Variable-length records	RECORD IS VARYING IN SIZE... (format 2) or RECORD CONTAINS...TO... (format 3)	
Records of undefined length	Declaration not possible with the RECORD clause	RECORDING MODE IS U

Table 9-4: Specification of record formats in the RECORD or RECORDING MODE clause

If neither of the two clauses is specified, the compiler assumes that the records are of variable length.

Access modes

Records of a sequential file can only be accessed sequentially, i.e. the program can only process them in the order in which they were written to the file during its creation.

The mode of access is specified in the ACCESS MODE clause in the COBOL source program. In the case of sequential files, ACCESS MODE IS SEQUENTIAL is the only admissible entry. Since this also happens to be the default value assumed by the compiler, the ACCESS MODE clause may be omitted in this case.

9.2.4 Open modes and types of processing

The various language elements available for use in a COBOL program can be sequential files to be
- created,
- read,
- extended (by adding new records at the end of the file), and
- updated (by making changes in existing records)

The individual I-O statements that may be used in the program to process a given file are determined by its open mode, which is specified in the OPEN statement.

OPEN OUTPUT

WRITE is permitted as an I-O statement in the following format:

```
                          ⎧BEFORE⎫
WRITE... [FROM...] [      ⎨      ⎬  ...]
                          ⎩AFTER ⎭

        [AT END-OF-PAGE...]
        [NOT AT END-OF-PAGE...]
        [END-WRITE]
```

In this mode, it is possible to create new sequential files (on tape or disk). Each WRITE statement places one record in the file. See section 9.2.5 for notes on the creation of print files.

OPEN INPUT or
OPEN INPUT...REVERSED

READ is permitted as an I-O statement in the following format:

```
READ...[NEXT]
       [INTO...]
       [AT END...]
       [NOT AT END...]
       [END-READ]
```

In this mode sequential files can be read (from disk or tape). Each READ statement reads one record from the file.

The OPEN INPUT...REVERSED phrase causes the records to be read in reversed order, beginning with the last record in the file.

```
OPEN EXTEND
```

WRITE is permitted as an I-O statement in the following format:

```
                      ⎧BEFORE⎫
WRITE...[FROM...] [  ⎨      ⎬ ]
                      ⎩AFTER ⎭
        [AT END-OF-PAGE...]
        [NOT AT END-OF-PAGE...]
        [END-WRITE]
```

In this mode, new records can be appended to the end of a sequential file. Already existing records are not overwritten.

```
OPEN I-O
```

READ and REWRITE are permitted as I-O statements in the following formats:

```
READ...[NEXT]
       [INTO...]
       [AT END...]
       [NOT AT END...]
       [END-READ]

REWRITE...[FROM...]
          [END-REWRITE]
```

In this mode, records of a sequentially organized disk file can be retrieved (READ), updated by the program and subsequently written back (REWRITE) to disk. It must be noted, however, that a record can only be written back with REWRITE if

– it was previously retrieved by a successful READ statement, and

– its record length was not changed during the update.

The OPEN I-O phrase is only permitted for disk files.

9.2.5 Line-sequential files

The line-sequential organization used in COBOL files is a language element defined by the X/Open standard. The corresponding language format is as follows:

```
FILE-CONTROL.
...
[ORGANIZATION IS] LINE SEQUENTIAL
...
```

In BS2000, a line-sequential file can be stored
– as a cataloged SAM file
– or as an element in a PLAM library.

This provides the option of processing both cataloged files and files in the form of library elements in a COBOL program.
Restrictions by comparison with record-sequential files:

– Only variable-length records are permissible (RECORD-FORMAT=V). Does not apply to ENABLE-UFS-ACCESS=YES.

– These files can only be opened with OPEN INPUT and OPEN OUTPUT, without the specifications REVERSED and NO REWIND.

– The only permissible input/output statements are READ (for OPEN INPUT) and WRITE (for OPEN OUTPUT).

– The only specification that can be made in the CLOSE statement is WITH LOCK.

As with record-sequential files, a line-sequential file can be linked to a current SAM file using the SET-FILE-LINK command (see section 9.1.2).
They can be linked to a library element with the SDF-P command SET-VARIABLE, which must have the following structure:

```
SET-VAR SYSIOL-name='*LIBRARY-ELEMENT(library,element[version],type)'
```

SYSIOL-name	SDF-P variable. name must be the external name of the file in the ASSIGN clause.
library	Name of the PLAM library
element	Name of the element
version	Version indicator. Permissible values are: <alphanum-name 1..24> / *UPPER[-LIMIT] / *HIGH[EST-EXISTING] / *INCR[EMENT] (only for write accesses) If no version is specified, the highest possible version is generated during write accesses; read operations access the highest available version.
type	Element type. Permissible values: S, M, J, H, P, U, F, X, R, D.

Line-sequential COBOL files can only be processed in library elements if the LMSLIB library exists under the TSOS ID.
When linking the program that is to process the line-sequential files, the $LMSLIB library must be specified in addition to CRTE in order to satisfy the requirements of external references.

Example 9-6: Generating a line-sequential file in a library element

Entries in the COBOL source program:

```
...
FILE-CONTROL.
SELECT AFILE ASSIGN TO "LIBELEM"
    ORGANIZATION IS LINE SEQUENTIAL
...
PROCEDURE DIVISION.
...
    OPEN OUTPUT AFILE.
...
```

Assignment of library and element before the program is called:

```
/SET-VAR SYSIOL-LIBELEM='*LIBRARY-ELEMENT(CUST.LIB,MEYER,S)'
```

Note

1. The SET-VARIABLE command can be inserted in a BS2000 procedure if it is a structured SDF-P procedure. This kind of structured procedure is described in the user's guide of SDF-P [30].
2. The phrases in the SET-VARIABLE command within the quotes must all be written in upper-case.

9.2.6 Creating print files

COBOL language elements for print files

COBOL85 provides the following language elements for the creation of files that are to be printed:

- Specification of the symbolic device names in the ASSIGN clause
- The LINAGE clause in the file description entry
- The ADVANCING phrase and the END-OF-PAGE phrase in the WRITE statement.

The use of these language elements is detailed in the COBOL85 Language Reference Manual [1]. The following table shows the use of the symbolic device names in conjunction with the WRITE statement and the generation of the associated control characters:

Symbolic device name	WRITE statement without ADVANCING phrase	WRITE statement with ADVANCING phrase	Comments
PRINTER literal	Standard spacing when ADVANCING is omitted as if AFTER 1 LINE had been specified; the first character of the record is available for user data.	The first character of the record is available for user data.	The place for the carriage control character is reserved by the compiler and is not accessible to the user. This type of printer supports specification of the LINAGE clause in the file description entry. Write statements both with and without the ADVANCING phrase specified are allowed for a given file.
PRINTER PRINTER01 - PRINTER99	As above.	As above.	The place for the carriage control character is reserved by the compiler and is not accessible to the user. The LINAGE clause is not permitted for this file. Use of WRITE statements with and without the ADVANCING phrase for the same file is not permitted. If this does occur, a WRITE AFTER ADVANCING is executed implicitly for the records without the ADVANCING phrase.
literal	Spacing is controlled by the first character in each logical record; the user must therefore supply the appropriate control character before every execution of such a WRITE statement.	Spacing is controlled by the first character in each logical record; the user must therefore supply the appropriate control character before every execution of such a WRITE statement.	Mixed use of WRITE statements both with and without specifications of the ADVANCING phrase is permitted. In either case, however, the user information of the printer record begins only with the second character of the record.

Table 9-5: Use of symbolic device names in conjunction with the WRITE statement

Line-feed control characters for print files

When a WRITE statement is executed, the control byte of all print files (whose ASSIGN clauses do not contain the “literal” specification) is automatically supplied with an EBCDIC printer control character, which causes the page to be advanced as specified in the ADVANCING phrase (see the two following tables). Should the ADVANCING phrase be omitted, single-line spacing is assumed. The place for the carriage control character is reserved by the compiler and is inaccessible to the user.

When “literal” is specified in the ASSIGN clause for a file, a line-feed control character can be supplied to the control byte in two ways:

– A WRITE statement with the ADVANCING phrase generates an EBCDIC control character on execution causing the printer to be advanced as specified in the ADVANCING phrase.

– A WRITE statement without the ADVANCING phrase does not supply a value to the control byte; the required control character must be explicitly transferred to it prior to the execution of the statement.

  This allows the user not only to use EBCDIC vertical positioning data but also to define other control characters in the program (e.g. for special printers). Information concerning the validity of individual characters and how they are interpreted during printing is available in the relevant printer manuals.

  Since carriage control characters are usually not printable, they must be defined in the program by means of the SYMBOLIC CHARACTERS clause, so as to ensure that they can be referenced in MOVE statements (see example 9-7).

Depending on the output destination different feed control characters are generated:

	Feed with output to BS2000	**Feed with output to POSIX file system**
PRINTER literal	BS2000 feed control charac-ters as per Tables 9-6, 9-7	Feed control characters and lines as per UNIX/SINIX conventions
PRINTER	as above	as above
PRINTER01-99	as above	not supported
literal	as above	BS2000 feed control charac ters as per Tables 9-6, 9-7

The following tables list EBCDIC control characters for vertical positioning:

Advance by number of lines	Control characters for line spacing		
	After printing	Before printing	
		Hex code*)	Printed form
1	01	40	(space)
2	02	41	non-printable
3	03	42	non-printable
. .	. .	. .	. .
11	0B	4A	c (CENT)
12	0C	4B	. (period)
13	0D	4C	< (less than)
14	0E	4D	((parenthesis
15	0F	4E	+ (plus sign)

Table 9-6: EBCDIC control characters for line-feed

*) Due to hardware characteristics, the values of the second half-byte are 1 less than the desired number of lines.

Skip to punched tape channels *)	Printer control character		
	After printing	Before printing	
		Hex. code	Printed form
1	81	C1	A
2	82	C2	B
3	83	C3	C
4	84	C4	D
5	85	C5	E
6	86	C6	F
7	87	C7	G
8	88	C8	H
10	8A	CA	non-printable
11	8B	CB	non-printable

Table 9-7: EBCDIC control characters for printer advance via punched tape channels

*) Skipping to channel 9 or 12 is not possible as these are reserved for an end-of-form condition.

The SPECIAL-NAMES paragraph of the Environment Division enables the user to assign a symbolic name to any hexadecimal value, thus ensuring that all such values (including non-printable line-feed control characters) can be addressed in the COBOL source program (see [1]). The example that follows illustrates how line-feed control characters can be defined in this way.

Example 9-7: Supplying a hexadecimal control character to the control byte

In this example, the hexadecimal value 0A is to be transferred to the control byte of the print record. This causes the printer to advance 10 lines after printing.

```
IDENTIFICATION DIVISION.
    ...
 ENVIRONMENT DIVISION.
 INPUT-OUTPUT SECTION.
 FILE-CONTROL.
     SELECT PRINTER-FILE ASSIGN TO "OUTPUT“.
 CONFIGURATION SECTION.
    ...
 SPECIAL-NAMES.
    ...
    SYMBOLIC CHARACTERS HEX-0A IS 11  ---------------------------------- (1)

     ...
  DATA DIVISION.
 FILE SECTION.
 FD  PRINTER-FILE
     ...
01  PRINT-RECORD.
     02 CONTROL-BYTE          PIC X.
     02 PRINT-LINE            PIC X(132).
     ...
  PROCEDURE DIVISION.
     ...
    MOVE "CONTENTS" TO PRINT-LINE.
    MOVE HEX-0A TO CONTROL-BYTE.  -------------------------------------- (2)
    WRITE PRINT-RECORD.
     ...
```

(1) The eleventh character of the EBCDIC character set - corresponding to the hexadecimal value 0A - is assigned the symbolic name HEX-0A.

(2) The MOVE statement refers to this symbolic name in order to transfer hexadecimal value 0A to the control byte.

Using ASA line-feed control character

ASA line-feed control characters can only be used in files that are assigned with ASSIGN TO literal or ASSIGN TO data-name.
In addition, the following SET-FILE-LINK command is required for the file to be processed:

SET-FILE-LINK filename, REC-FORM=(V,A)

The ASA control characters and the corresponding WRITE statements that can be used under these conditions are listed in the table below::

ASA line-feed control characters	**Format of the WRITE statement**
+	WRITE ... BEFORE ADVANCING 0
0	WRITE ... AFTER ADVANCING 0 or 1
-	WRITE ... AFTER ADVANCING 2
1	WRITE ... AFTER ADVANCING PAGE or C01
2	WRITE ... AFTER ADVANCING C02
3	WRITE ... AFTER ADVANCING C03
4	WRITE ... AFTER ADVANCING C04
5	WRITE ... AFTER ADVANCING C05
6	WRITE ... AFTER ADVANCING C06
7	WRITE ... AFTER ADVANCING C07
8	WRITE ... AFTER ADVANCING C08
A	WRITE ... AFTER ADVANCING C10
B	WRITE ... AFTER ADVANCING C11

Table 9-8: ASA line-feed control characters and corresponding WRITE statements

9.2.7 Processing files in ASCII or in ISO 7-bit code

COBOL85 supports the processing of sequential files in ASCII or ISO 7-bit code by means of the following clauses (see [1]):

- ALPHABET alphabet-name-1 IS STANDARD-1(for ASCII code) or
  ALPHABET alphabet-name-1 IS STANDARD-2 (for ISO 7-bit code)
  in the SPECIAL-NAMES paragraph of the Configuration Section and
- CODE-SET IS alphabet-name-1 in the file description entry of the File Section.

ASCII code

The following program skeleton indicates the phrases that must be entered in the COBOL source program in order to process a file in ASCII code.

```
IDENTIFICATION DIVISION.
...
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
...
SPECIAL-NAMES.
...
    ALPHABET alphabetname-1 IS STANDARD-1  ------------------------------ (1)
     ...
DATA DIVISION.
FILE SECTION.
FD  file
    CODE-SET IS alphabetname-1  ----------------------------------------- (2)
     ...
```

(1) The ALPHABET clause links code type STANDARD-1 (i.e. ASCII code) to the name alphabet-name-1.

(2) The CODE-SET clause specifies the code type connected with alphabet-name-1 as the character set for the file.

ISO 7-bit code

The declarations to be made in the source program for the processing of a file in ISO 7-bit code are similar to those specified for the ASCII code above.
The only difference is that the keyword entered in the ALPHABET clause must be STANDARD-2 instead of STANDARD-1.
For magnetic tape files in ISO 7-bit code there is a further alternative (see also section 9.2.8): namely, to specify SUPPORT=TAPE(CODE=ISO7) for the file assignment in the SET-FILE-LINK command.

9.2.8 Processing magnetic tape files

COBOL85 supports the processing of magnetic tape files by means of the following language elements (see [1]):

– The INPUT...REVERSED and WITH NO REWIND phrases in the OPEN statement:

  Each of these phrases prevents the file position indicator being set to the start of the file when the file is opened.

  INPUT...REVERSED causes a file to be positioned at its last record when the file is opened. Records of the file can then be read in reversed (i.e. descending) order.

  WITH NO REWIND can be specified for OPEN INPUT as well as OPEN OUTPUT and prevents the file from being repositioned when the OPEN statement is executed.

– The REEL, WITH NO REWIND and FOR REMOVAL phrases in the CLOSE statement:

  REEL is permitted only for multi-volume files, i.e. files that are distributed over more than one data volume (magnetic tape reels in this case). Depending on the open mode of each file, this phrase initiates the execution of different volume-closing operations at the end of the current reel (see CLOSE statement in [1]). If the WITH NO REWIND or FOR REMOVAL has also been specified, the actions associated with these phrases (see below) are also performed at the end of the volume.

  The WITH NO REWIND phrase causes the current reel to be left in its current position (i.e. not repositioned to the start of the reel) when processing of the file or reel is closed.

  FOR REMOVAL indicates that the current reel is to be unloaded at the end of the file or at the end of the magnetic tape reel.

Assignment of magnetic tape files

Like disk files, magnetic tape files can also be assigned via the SET-FILE-LINK command and supplied with attributes (see sections 9.1.2 and 9.1.3). A detailed description of the command format for tape files is provided in manuals [3] and [4].

Example 9-8: Assigning a tape file

```
/SEC-RESOURCE-ALLOC,TAPE=PAR(VOL=CA176B,TYPE=T6250,ACCESS=WRITE) ──────── (1)
/CREATE-FILE STOCK.NEW,SUPPORT=TAPE(VOLUME=CA176B,DEVICE-TYPE=T6250) ──── (2)
/SET-FILE-LINK OUTFILE,STOCK.NEW ──────────────────────────────────────── (3)
/START-PROGRAM *LIB(PLAM.LIB,UPDATE) ──────────────────────────────────── (4)
...
/REMOVE-FILE-LINK OUTFILE,UNLOAD-RELEASED-TAPE=YES ────────────────────── (5)
```

(1) For batch operations in particular, it is recommended that the required private volumes and devices be reserved with SECURE-RESOURCE-ALLOCATION before processing begins. In the above example, the tape with VSN CA176B is requested on a tape device with a recording density of 6250 bpi (TYPE=T6250) and a mounted write-permit ring (ACCESS=WRITE).

(2) The CREATE-FILE command

- catalogs the file STOCK.NEW as a tape file and
- links the volume serial number (VOLUME) and the tape device (DEVICE-TYPE)

(3) The SET-FILE-LINK command links the file name STOCK.NEW with the link name OUTFILE.

(4) START-PROGRAM calls the problem program that is stored as a program under the element name UPDATE in the PLAM library PLAM.LIB.

(5) On completion of processing, the REMOVE-FILE-LINK command

- releases the link between the file STOCK.NEW and the link name OUTFILE and
- causes the tape CA176B to be unloaded; the tape device is released by default.

9.2.9 I-O status

The status of each access operation performed on a file is stored by the runtime system in specific data items which can be assigned to every file in the program. These items, which are specified by using the FILE STATUS clause, provide information on

– whether the I/O operation was successful, and

– the type of any errors that may have occurred.

This data can be evaluated (by USE procedures in the DECLARATIVES, for example) and used by the program to analyze I-O errors. As an extension to Standard COBOL, COBOL85 provides the option of including the keys of the DMS error messages in this analysis, thus allowing a finer differentiation between different causes of errors.

The FILE STATUS clause is specified in the FILE-CONTROL paragraph of the Environment Division. Its format is (see [1]):

```
FILE STATUS IS data-name-1 [data-name-2]
```

where data-name-1 and data-name-2 (if specified) must be defined in the Working-Storage Section or the Linkage Section. The following rules apply with regard to the format and possible values for these two items:

data-name-1

– must be declared as a two-byte numeric or alphanumeric data item, e.g.

```
        01 data-name-1        PIC X(2).
```

– contains a two-character numeric status code following each access operation on the associated file. The table provided at the end of this section lists all such codes together with their meanings.

data-name-2

– must be declared as a 6-byte group item with the following format:

```
01 data-name-2.
   02 data-name-2-1       PIC 9(2) COMP.
   02 data-name-2-2       PIC X(4).
```

– is used for storing the DMS error code for the relevant I-O status. Following each access operation on the associated file, data-name-2 contains a value that directly depends on the content of data-name-1. The relationship between the values is shown in the table below:

Contents of data-name-1≠0?	**DMS code ≠ 0?**	**Value of data-name-2-1**	**Value of data-name-2-2**
no	no	undefined	undefined
yes	no	0	undefined
yes	yes	64	DMS code of the associated error message

The DMS codes and the associated error messages are given in manual [4].

Caution

For *line-*sequential files, the only input/output status available is the one represented by data-name 1.

The status values and their meanings generally refer to *record*-sequential files. When *line-*sequential files are being processed, due consideration must be given to the peculiarities of line-sequential organization with regard to the interpretation of status values (see 9.2.5).

Table 9-9: I-O status for sequential files

I-O status	Meaning
	Execution successful
00	The I-O statement terminated normally. No further information regarding the I-O operation is available.
04	Record length conflict: A READ statement terminated normally. However, the length of the record read lies outside the limits defined in the record description entry for this file.
05	Successful execution of an OPEN INPUT/I-O/EXTEND on a file; however, the referenced file indicated by the OPTIONAL phrase was not present at the time the OPEN statement was executed.
07	1. Successful OPEN statement with NO REWIND clause on a file that is on a UNIT-RECORD medium. 2. Successful CLOSE statement with NO REWIND, REEL/UNIT, or FOR REMOVAL clause on a file that is on a UNIT-RECORD medium.
	Execution unsuccessful: AT END condition
10	1. An attempt was made to execute a READ statement. However, no next logical record existed, because the end-of-file was encountered. 2. A sequential READ statement with the OPTIONAL phrase was attempted for the first time on a nonexistent file.
	Execution unsuccessful: unrecoverable error
30	1. No further information regarding the I-O operation is available (the DMS code provides further information). 2. During line-sequential processing: access to a PLAM element was unsuccessful
34	An attempt was made to write outside the sequential file boundaries set by the system.
35	An OPEN statement with the INPUT/I-O phrase was attempted on a nonexistent file.
37	OPEN statement on a file that cannot be opened in any of the following ways: 1. OPEN OUTPUT/I-O/EXTEND on a write-protected file (password, RETENTION-PERIOD, ACCESS=READ in catalog) 2. OPEN I-O on a tape file 3. OPEN INPUT on a read-protected file (password)
38	An attempt was made to execute an OPEN statement for a file previously closed with the LOCK phrase.

I-O status	Meaning
39	The OPEN statement was unsuccessful as a result of one of the following conditions: 1. One or more of the operands ACCESS-METHOD, RECORD-FORMAT or RECORD-SIZE were specified in the SET-FILE-LINK command with values deviating from the corresponding explicit or implicit program specifications. 2. Record length errors occurred for input files (catalog check if RECFORM=F). 3. The record size is greater than the BLKSIZE entry in the catalog (in the case of input files). 4. The catalog entry of one of the FCBTYPE, RECFORM or RECSIZE (if RECFORM=F) operands for an input file is in conflict with the corresponding explicit or implicit program specifications or with the specifications in the SET-FILE-LINK command.
	Execution unsuccessful: logical error
41	An attempt was made to execute an OPEN statement for a file which was already open.
42	An attempt was made to execute a CLOSE statement for a file which was not open.
43	While accessing a disk file opened with OPEN I-O, the most recent I-O statement executed prior to a REWRITE statement was not a successfully executed READ statement.
44	Boundary violation: 1. An attempt was made to execute a WRITE statement. However, the length of the record is outside the range allowed for this file. 2. An attempt was made to execute a REWRITE statement. However, the record to be rewritten did not have the same length as the record to be replaced.
46	An attempt was made to execute a READ statement for a file in INPUT or I-O mode. However, there is no valid next record since: 1. the preceding READ statement was unsuccessful without causing an AT END condition 2. the preceding READ statement resulted in an AT END condition.
47	An attempt was made to execute a READ statement for a file not in INPUT or I-O mode.
48	An attempt was made to execute a WRITE statement for a file not in OUTPUT or EXTEND mode.
49	An attempt was made to execute a REWRITE statement for a file not open in I-O mode.

I-O status	Meaning
	Other conditions with unsuccessful execution
90	System error; no further information available regarding the cause.
91	System error; a system call terminated abnormally; either an OPEN error or no free device; the actual cause is evident from the DMS code (see “FILE STATUS clause”)
95	Incompatibility between values specified in the BLOCK-CONTROL-INFO or BUFFER-LENGTH operand of the SET-FILE-LINK command and the file format, block size, or the format of the used volume.

9.3 Relative file organization

9.3.1 Characteristics of relative file organization

Each record in a relatively organized file is assigned a number which indicates its position in the file: the first record is assigned number 1, the second, number 2 etc.
By specifying a relative key data item in the program, the user can access any record of the file directly (randomly) via its relative record number. In addition to the options provided by sequential file organization, relatively organized files

- can be randomly created, i.e. records can be placed on the file in any order,
- can be randomly processed, i.e. records can be retrieved and updated in any order,
- permit the insertion of records, provided the desired position (relative record number) is not yet occupied,
- permit the logical deletion of existing records.

For the processing of relative files, COBOL programs use the DMS access methods ISAM and UPAM (see [4]), which permit several users to update the file simultaneously (see section 9.5). Existing files have a defined FCBTYPE. For files to be created, FCBTYPE ISAM is always set unless FCBTYPE PAM has been defined with the ACCESS-METHOD operand of the SET-FILE-LINK command (SAM is rejected with an error message). For explicit (RECORD clause) variable record length and/or OPEN EXTEND, only FCBTYPE ISAM is allowed. When a relative file is mapped to ISAM, the 8-byte record key (hexadecimal) is inserted before the start of the record. The relative record key is mapped onto the key of the indexed file.
Relative files can only be stored on disk.

File structure

A description of the file structure of an ISAM file is given in section 9.4.1. The following considerations apply to PAM files:
In terms of its logical structure, a PAM file may be seen as a sequence of areas of equal length, each capable of holding one record (only fixed-length records are allowed for PAM files). Each of these areas can be accessed by means of its relative record number.
If the file is created sequentially, each of these areas - starting with the first - is filled in turn with a data record; no area can be skipped.

In the case of random creation, each record is written to the area whose relative record number was supplied in the relative key field of the record prior to the output statement. The program computes the associated position in the file on the basis of the specified record number and the record length. Unoccupied areas that are skipped during output are then created as empty records, i.e. the program reserves storage areas equal to the record length and supplies the first byte of each such area with the hexadecimal value FF (HIGH-VALUE), which identifies it as an empty record (see section 9.3.4).

9.3.2 COBOL language tools for the processing of relative files

The following program skeleton summarize the most important clauses and statements provided in COBOL85 for the processing of relative files. The most significant phrases and entries are briefly explained thereafter:

```
IDENTIFICATION DIVISION.
...
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT internal-file-name
    ASSIGN TO external-name
    ORGANIZATION IS RELATIVE
    ACCESS MODE IS mode RELATIVE KEY IS key
    FILE STATUS IS status-items.
    ...
DATA DIVISION.
FILE SECTION.
FD  internal-file-name
    BLOCK CONTAINS block-length-spec
    RECORD CONTAINS record-length-spec
    ...
01  data-record.
    nn item-1                type&length.
    nn item-2                type&length.
    ...
WORKING-STORAGE SECTION.
    ...
    nn key                   type&length
    ...
PROCEDURE DIVISION.
    ...
    OPEN open-mode internal-file-name
    ...
    START internal-file-name
    ...
    READ internal-file-name
    ...
    REWRITE data-record
    ...
    WRITE data-record
    ...
    DELETE internal-file-name
    ...
    CLOSE internal-file-name
    ...
    STOP RUN.
```

`SELECT internal-file-name`

specifies the name by which the file is to be addressed in the source program.

internal-file-name must be a valid user-defined word.

The format of the SELECT clause also permits the OPTIONAL phrase to be specified for input files that need not necessarily be present during the program run.

If, during program execution, no file has been assigned to a file name declared with SELECT OPTIONAL, then:

– in the case of OPEN INPUT, program execution is interrupted with message COB9117 and a SET-FILE-LINK command is requested (in dialog mode), or the AT END condition is initiated (in batch mode);

– in the case of OPEN I-O or OPEN EXTEND, a file named FILE.COB85.linkname is created.

`ASSIGN TO external-name`

specifies the system file associated with the file and defines the name via which a cataloged file can be assigned.

external-name must be either
– a permissible literal,
– a permissible data name defined in the DATA division, or
– a valid implementor name

from the ASSIGN clause format (see [1]).

`ORGANIZATION IS RELATIVE`

specifies that the file is organized as a relative file.

`ACCESS MODE IS mode`

specifies the mode in which the records in the file can be accessed.

The following may be specified for mode (see also section 9.3.4):

SEQUENTIAL	specifies that the records can only be processed sequentially.
RANDOM	declares that the records can only be accessed in random mode.
DYNAMIC	allows the records to be accessed in either sequential or random mode.

The ACCESS MODE clause is optional. If it is not specified, the compiler assumes the default value ACCESS MODE IS SEQUENTIAL.

```
RELATIVE KEY IS key
```

specifies the relative key data item for holding the relative record numbers in the case of random access to the records.
“key” must be declared as an unsigned integer data item and must not be a part of the associated record description entry.
In the case of random access, the relative record number of the record to be processed must be supplied in key before each I-O operation.
The RELATIVE KEY phrase is optional for files for which ACCESS MODE IS SEQUENTIAL is declared; it is mandatory when ACCESS MODE IS RANDOM or DYNAMIC is specified.

```
FILE STATUS IS status-items
```

specifies the data items in which the runtime system will store status information after each access to a file. This information indicates
- whether the I-O operation was successful and
- the type of any errors that may have occurred.

The status items must be declared in the Working-Storage Section or the Linkage Section. Their format and the meaning of the various status codes are described in section 9.3.6.
The FILE STATUS clause is optional. If it is not specified, the information mentioned above is not available

```
BLOCK CONTAINS block-length-spec
```

defines the maximum size of a logical block. It determines how many records are to be transferred together by each I-O operation into/from the buffer of the program.

block-length-spec must be an integer and must not be shorter than the record length of the file or greater than 32767. It specifies the size of the logical block in bytes.

The blocking of records reduces
- the number of accesses to peripheral storage and thus the runtime of the program;
- the number of interblock gaps on the storage medium and thus the physical storage space required by the file.

On the other hand, access employing the locking mechanism during shared update processing (see section 9.5) cause the entire block containing the current record to be locked. In each case, therefore, a large blocking factor would lead to a reduction in processing speed.

During compilation, the compiler calculates a value for the buffer size on the basis of the record and block length entries given in the source program. The runtime system rounds up this value for DMS to the next multiple of a PAM block (2048 bytes). This default value can be modified during the file assignment by specifying the BUFFER-LENGTH operand in the SET-FILE-LINK command. In this case, it must be noted that

- the buffer must be at least as large as the longest data record, and
- there must be space for the management information (PAM key) in the buffer when processing in non-key format (BLKCTRL = DATA) (see section 9.1.4).

Except in the case of newly created files (OPEN OUTPUT), the block size entered in the catalog always takes priority over block size specifications in the program or SET-FILE-LINK command.

The BLOCK CONTAINS clause is optional. If it is not specified, the compiler assumes the record length of the file as the block size.

```
RECORD record-length-spec
```

- specifies whether fixed or variable length records are to be processed and
- defines, for variable length records, a range for the valid record sizes and, if specified in the format, a data item to contain the current record length information.

record-length-spec must match one of the three formats in the RECORD clause supported by COBOL85. It must not conflict with the record lengths the compiler computes from the specifications in the associated record description entry or entries.

The RECORD clause is optional. If it is not specified, the compiler assumes that the records are of variable length.

```
01  data-record.
    nn  item-1          type&length
    nn  item-2          type&length
```

represents a record description entry for the associated file. It describes the logical format of data records.

At least one record description entry is required for each file. If more than one record description entry is specified for a file, the declared record format must be considered:

- For records of fixed length all record description entries must be of the same size,
- for records of variable length they must not conflict with the record length specification in the RECORD clause.

The subdivision of data-record into data items (item-1, item-2, ...) is optional. For type&length, the required length and format declarations (PICTURE and USAGE clauses etc.) must be entered.
The relative key data item declared in the RELATIVE KEY phrase must not be subordinate to data-record.

```
nn key type&length
```

defines the relative key data item specified in the RELATIVE KEY phrase.

When specifying values for type&length, it should be noted that key must be an unsigned integer data item.
In the case of random access, the relative record number of the record to be processed must be supplied in key before each I-O operation.

```
OPEN open-mode internal-file-name
```

opens the file for processing in the specified open mode.

The following phrases can be entered for open-mode:

INPUT	opens the file as an input file; it can only be read.
OUTPUT	opens the file as an output file; it can only be written.
EXTEND	opens the file as an output file; it can be extended.
I-O	opens the file as an I-O file; it can be read (one record at a time), updated and rewritten.

The open-mode entry determines with which I-O statements a file may be accessed (see section 9.3.4).

```
START internal-file-name
READ internal-file-name
REWRITE data-record
WRITE data-record
DELETE internal-file-name
```

are I-O statements for the file that
- position to a record in the file
- read a record
- rewrite a record
- write a record, and
- delete a record.

The open mode declared in the OPEN statement determines which of these statements is admissible for the file. The relationship between access mode and open mode is described in section 9.3.4.

```
CLOSE internal-file-name
```

terminates processing of the file.

The WITH LOCK phrase can be additionally specified to prevent the file from being opened again in the same program run.

9.3.3 Permissible record formats and access modes

Record formats

Relative files may contain fixed-length records (RECFORM=F) or variable-length records (RECFORM=V). In either case the records may be blocked or unblocked. COBOL source programs permit the format of records to be processed to be declared in the RECORD clause. The phrases that are associated with the record format concerned are summarized in the following table:

Record format	Phrase in the RECORD clause	
Fixed length records	RECORD CONTAINS...CHARACTERS	(Format 1)
Variable length records	RECORD IS VARYING IN SIZE... or RECORD CONTAINS...TO...	(Format 2) (Format 3)

Table 9-10: Record format and RECORD clause

Access modes

Access to records of a relative file may be sequential, random, or dynamic. In the COBOL source program, the access mode is defined with the ACCESS MODE clause. The following table lists the possible phrases together with their effect on the access mode.

Phrase in the ACCESS MODE clause	Access mode
SEQUENTIAL	Sequential access: The records can be processed only in the order in which they appear in the file. This order is determined by the relative record number. In other words: when reading records, the next logical record is made available; any preceding empty records are skipped. when writing records, each successive record output to the file is assigned the next relative record number; no empty records are written.
RANDOM	Random access: The records can be accessed in any order via the relative record number. For this purpose, the relative record number of the record to be processed must be supplied in the RELATIVE KEY item prior to each I-O operation.
DYNAMIC	Dynamic access: The records can be accessed sequentially as well as randomly. The applicable access mode is selected via the format of the I-O statement in this case.

Table 9-11: Relative files: ACCESS MODE clause and access mode

9.3.4 Open modes and types of processing

The various language elements available for use in a COBOL program allows relative files to be

- created,
- read,
- extended (by adding new records), and
- updated (by changing or deleting existing records).

The individual I-O statements that may be used in the program to process a given file are determined by its open mode, which is specified in the OPEN statement:

OPEN OUTPUT

Regardless of the phrase in the ACCESS MODE clause, WRITE is permitted as an I-O statement in the following format:

```
WRITE...[FROM...]
        [INVALID KEY...]
        [NOT INVALID KEY...]
        [END WRITE...]
```

In this mode, it is only possible to create (load) new relative files. Depending on the specified access mode, the WRITE statement has the following effect:

- ACCESS MODE IS SEQUENTIAL

  allows a relative file to be created sequentially i.e. WRITE writes records to the file successively with ascending relative record numbers (starting with 1).
  The RELATIVE KEY key item - if specified - is not evaluated by WRITE; it is loaded with the value of the (automatically incremented) relative record number of each record that is written.
  Since no empty records are generated, records cannot subsequently be inserted into a sequentially created file.

- ACCESS MODE IS RANDOM or DYNAMIC

  (both phrases have the same meaning here) enables the random creation of a file. WRITE causes each record to be written to the position in the file that is indicated by its relative record number.
  Thus, before each WRITE statement is executed, the RELATIVE KEY item must be supplied with the relative record number which the record to be written is to receive in the file. If the number of an already existing record is specified, the INVALID KEY condition occurs, and WRITE branches to the INVALID KEY statement or to the declared USE procedure without writing the record. It is thus not possible to overwrite records in this case.

`OPEN EXTEND`

OPEN EXTEND is used to extend an existing file. Access is only possible in sequential mode.

– ACCESS MODE IS SEQUENTIAL

  permits a relative file to be extended sequentially. Starting with the highest key+1, WRITE writes the records with continuous, ascending record numbers to the file.
  The RELATIVE KEY key item, if specified, is not interpreted by WRITE; it contains the (automatically updated) relative record number of the last written record.
  As no empty records are generated, it is not possible to enter records in a sequentially extended file later on.

`OPEN INPUT`

The phrase specified in the ACCESS MODE clause determines which I-O statements or statement formats are permitted. The following table lists the options available for OPEN INPUT:

Statement	**Entry in the ACCESS MODE clause**		
	SEQUENTIAL	RANDOM	DYNAMIC
START	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-START]	statement not permitted	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY] [END-START]
READ	READ...[NEXT] [INTO...] [AT END...] [NOT AT END...] [END-READ...]	READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]	For sequential access: READ...NEXT [INTO...] [AT END...] [NOT AT END...] [END-READ]
			For random access: READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]

Table 9-12: Relative files: I-O statements permitted for OPEN INPUT

Relative files can be read in this mode. Depending on the access mode specified, the READ statement has the following effect:

– ACCESS MODE IS SEQUENTIAL

  permits the file to be read sequentially only. READ retrieves records in ascending order, based on the value of the relative record numbers; any empty records in the file are skipped.
  The RELATIVE KEY key data item - if specified - is not evaluated by READ; it is loaded with the value of the relative record number of the last record that was read.
  However, if a RELATIVE KEY key data item was declared, a START statement can be used to position to any record of the file before execution of a READ statement: START uses a relation condition to establish the relative record number of the first record to be read and thus defines the starting point for sequential read operations that follow.
  If the comparison relation condition cannot be satisfied by any relative record number of the file, an INVALID KEY condition exists, and START transfers control to the imperative statement specified in the INVALID KEY phrase or to the declared USE procedure.

– ACCESS MODE IS RANDOM

  enables records of the file to be read randomly. READ retrieves the records in the specified order; access to each record is effected via its relative record number. Accordingly, the relative record number of each record to be read must be supplied in the RELATIVE KEY data item prior to each READ operation. If the number of a unavailable record (e.g. an empty record) is specified, the INVALID KEY condition exists, and READ transfers control to the INVALID KEY statement or to the USE procedure declared for this condition.

– ACCESS MODE IS DYNAMIC

  permits random and sequential reading of the file. The applicable access mode is selected via the format of the READ statement (see table 9-12).
  In this case, a START statement is meaningful for sequential reading only.

`OPEN I-O`

The phrase specified in the ACCESS MODE clause determines which I-O statements or statement formats are permitted. The following table lists the options available for OPEN I-O:

Statement	**Entry in the ACCESS MODE clause**		
	SEQUENTIAL	RANDOM	DYNAMIC
START	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-START]	statement not permitted	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY] [END-START]
READ	READ...[NEXT] [INTO...] [AT END...] [NOT AT END...] [END-READ...]	READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]	For sequential access: READ...NEXT [INTO...] [AT END...] [NOT AT END...] [END-READ]
			For random access: READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]
REWRITE	REWRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-REWRITE]	REWRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-REWRITE]	REWRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-REWRITE]
WRITE	Statement not allowed	WRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-WRITE]	WRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-WRITE]
DELETE	DELETE... [END-DELETE]	DELETE... [INVALID KEY...] [NOT INVALID KEY...] [END-DELETE]	DELETE... [INVALID KEY...] [NOT INVALID KEY...] [END-DELETE]

Table 9-13: Relative files: I-O statements permitted for OPEN I-O

When a file is opened in this mode, records can be
- read,
- added,
- updated by the program, and
- overwritten or
- deleted.

OPEN I-O assumes that the file to be processed already exists. It is therefore not possible to create a new relative file in this mode.

The specified access mode determines the type of processing that can be performed, as well as the effect of the individual I-O statements:

- ACCESS MODE IS SEQUENTIAL

  As in the case of OPEN INPUT, this access mode permits the sequential reading of a file with READ and the use of a preceding START to position to any record as the starting point.

  In addition, the record that is read by a successful READ operation can be
  - updated by the program and then rewritten with REWRITE
  - logically deleted with DELETE.

  However, no other I-O statement should be executed between the READ and REWRITE or DELETE statements.

- ACCESS MODE IS RANDOM

  enables records to be randomly retrieved with READ (as in OPEN INPUT).

  In addition,
  - new records can be inserted into the file with WRITE, and
  - existing records in the file can be rewritten or deleted with REWRITE or DELETE (regardless of whether they were read earlier).

  Prior to each WRITE, REWRITE, or DELETE statement, the RELATIVE KEY data item must be supplied with the relative number of the record that is to be added, rewritten, or deleted. If the following cases apply:
  - the number of an already existing record is specified for WRITE, or
  - the number of a unavailable record (e.g. an empty record) is specified for REWRITE or DELETE,

  an INVALID KEY condition exists, and WRITE, REWRITE, or DELETE branches to the INVALID KEY statement or to the USE procedure declared for this event.

- ACCESS MODE IS DYNAMIC

  allows a file to be processed sequentially or randomly. Here, the desired access mode is selected via the format of the READ statement.

9.3.5 Random creation of a relative file

The following example illustrates a simple COBOL program with which a relative file can be randomly created. The records may be written to the file in any order.

Example 9-9: Program for the random creation of a relative file

```
 IDENTIFICATION DIVISION.
  PROGRAM-ID.  RELATIV.
  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  SPECIAL-NAMES.
      TERMINAL IS T.
  INPUT-OUTPUT SECTION.
  FILE-CONTROL.
      SELECT RELATIVE-FILE
      ASSIGN TO „RELFILE“
      ORGANIZATION IS RELATIVE
     ACCESS MODE IS RANDOM ———————————————————————————————————————— (1)
     RELATIVE KEY IS REL-KEY —————————————————————————————————————— (2)
     FILE STATUS IS FS-CODE DMS-CODE. ————————————————————————————— (3)
  DATA DIVISION.
  FILE SECTION.
  FD  RELATIVE-FILE.
  01  RELATIVE-RECORD              PIC X(33).
  WORKING-STORAGE SECTION.
  01  REL-KEY                    PIC 9(3).
      88  END-OF-INPUT                      VALUE ZERO.
  01  I-O-STATUS.
      05  FS-CODE                PIC 9(2).
      05  DMS-CODE.
          06  DMS-CODE-1         PIC 9(2) COMP.
              88  DMS-CODE-2-DEFINED        VALUE 64.
          06  DMS-CODE-2         PIC X(4).
  01  CLOSE-SCWITCH              PIC X      VALUE „0“.
      88  FILE-OPEN                         VALUE „1“.
      88  FILE-CLOSED                       VALUE „0“.
  01  RELATIVE-TEXT.
      05                         PIC X(24)
        VALUE „******HERE IS RECORD NO. „.
      05  REC-NO                 PIC 9(3).
      05                         PIC X(6)   VALUE „$$$$$$“.
  PROCEDURE DIVISION.
  DECLARATIVES.
  OUTPUT-ERROR SECTION.
      USE AFTER STANDARD ERROR PROCEDURE ON RELATIVE-FILE.
 UNRECOVERABLE-ERROR. ————————————————————————————————————————————— (4)
      IF FS-CODE NOT LESS THAN 30
```

```
          DISPLAY „UNRECOVERABLE ERROR ON RELATIVE-FILE“
           UPON T
         DISPLAY „FILE STATUS: „ FS-CODE UPON T
         IF DMS-CODE-2-DEFINED
             DISPLAY „DMS-CODE:    „ DMS-CODE-2 UPON T
          END-IF
          IF FILE-OPEN
             CLOSE RELATIVE-FILE
          END-IF
          DISPLAY „PROGRAM TERMINATED ABNORMALLY“ UPON T
          STOP RUN
       END-IF.
   OUTPUT-ERROR-END.
          EXIT.
   END DECLARATIVES.
   INITIALIZATION.
       OPEN OUTPUT RELATIVE-FILE
       SET FILE-OPEN TO TRUE.
   LOAD-FILE.
       PERFORM INPUT-RELATIVE-KEY
          WITH TEST AFTER
          UNTIL REL-KEY IS NUMERIC
       PERFORM WITH TEST BEFORE UNTIL END-OF-INPUT
         WRITE RELATIVE-RECORD FROM RELATIVE-TEXT
             INVALID KEY ---------------------------------------------- (5)
                DISPLAY „RECORD NO. „ REL-KEY
                   „ALREADY EXISTS IN FILE“ UPON T
          END-WRITE
          PERFORM INPUT-RELATIVE-KEY
             WITH TEST AFTER
             UNTIL REL-KEY IS NUMERIC
       END-PERFORM.
   TRAILER.
       SET FILE-CLOSED TO TRUE
       CLOSE RELATIVE-FILE
       STOP RUN.
   INPUT-RELATIVE-KEY.
       DISPLAY „PLEASE ENTER RELATIVE KEY: THREE-DIGIT WITH L
  -       „EADING ZEROES“ UPON T
      DISPLAY „TERMINATE PROGRAM ENTERING ‚000‘“ UPON T
       ACCEPT REL-KEY FROM T
       IF REL-KEY NUMERIC
          THEN MOVE REL-KEY TO REC-NO
          ELSE DISPLAY „INPUT MUST BE NUMERIC“ UPON T
       END-IF.
```

(1) The ACCESS MODE clause specifies random access for records of the file named RELATIVE-FILE. They may thus be written to the file in any order during creation.

(2) The RELATIVE KEY clause defines REL-KEY as the relative key data item for the relative record number. It is declared in the Working-Storage Section as a three-digit numeric data item.

(3) The FILE STATUS clause is defined so as to make the DMS code available to the program in addition to the FILE STATUS code. The data items required for storing this information are declared in the Working-Storage Section and evaluated in the DECLARATIVES.

(4) The DECLARATIVES provide only one procedure for unrecoverable I-O errors (FILE STATUS ≥ 30), since an AT END condition cannot occur for output files and record key errors can be caught via INVALID KEY.

(5) An INVALID KEY condition occurs in the case of a random WRITE operation when the record with the associated relative record number is already present in the file.

9.3.6 I/O status

The status of each access operation performed on a file is stored by the runtime system in specific data items, which can be assigned to every file in the program. These items, which are specified by using the FILE STATUS clause, provide information on

- whether the I-O operation was successful, and
- the type of errors that may have occurred.

This data can be evaluated (by USE procedures in the DECLARATIVES, for example) and used by the program to analyze I-O errors. As an extension to Standard COBOL, COBOL85 provides the option of including the key of the DMS error messages in this analysis, thus allowing a finer differentiation between different causes of errors. The FILE STATUS clause is specified in the FILE-CONTROL paragraph of the Environment Division. Its format is (see [1]):

```
FILE STATUS IS data-name-1 [data-name-2]
```

where data-name-1 and data-name-2 (if specified) must be defined in the Working-Storage Section or the Linkage Section. The following rules apply with regard to the format and possible values for these two items:

data-name-1

- must be declared as a two-byte numeric or alphanumeric data item, e.g.

```
01 data-name-1          PIC X(2).
```

- contains a two-character numeric status code following each access operation on the associated file. The table provided at the end of this section lists all such codes together with their meanings.

data-name-2

– must be declared as a 6-byte group item with the following format:

```
01 data-name-2.
   02 data-name-2-1       PIC 9(2) COMP.
   02 data-name-2-2       PIC X(4).
```

– is used for storing the DMS error code for the relevant I-O status. Following each access operation on the associated file, data-name-2 contains a value that directly depends on the content of data-name-1. The relationship between the values is shown in the table below:

Contents of data-name-1≠0?	DMS code≠0?	Value of data-name-2-1	Value of data-name-2-2
no	no	undefined	undefined
yes	no	0	undefined
yes	yes	64	DMS code of the associated error message

The DMS codes and the associated error messages are given in manual [4].

Table 9-14: I-O status for relative files

I-O status	Meaning
	Execution successful
00	The I-O statement terminated normally. No further information regarding the I-O operation is available.
04	Record length conflict: A READ statement was executed successfully, but the length of the record which was read does not lie within the limits specified in the record description for the file.
	Successful OPEN INPUT/I-O/EXTEND for a file with the OPTIONAL phrase in the SELECT clause that was not present at the time of execution of the OPEN statement.
	Execution unsuccessful: AT END condition
10	An attempt was made to execute a READ statement. However, no next logical record was available, since the end-of-file was encountered (sequential READ).
	A first attempt was made to execute a READ statement for a non-existent file which is specified as OPTIONAL.
14	An attempt was made to execute a READ statement. However, the data item described by RELATIVE KEY is too small to accommodate the relative record number. (sequential READ).
	Execution unsuccessful: invalid key condition
22	Duplicate key An attempt was made to execute a WRITE statement with a key for which there is already a record in the file.
23	Record not located or zero record key An attempt was made (using a READ, START, DELETE or REWRITE statement with a key) to access a record not contained in the file, or the access was effected with a zero record key.
24	Boundary values exceeded. An attempt was made to execute a WRITE statement beyond the system-defined boundaries of a relative file (insufficient secondary allocation in the FILE command), or a WRITE statement is attempted in sequential access mode with a relative record number so large that it does not fit in the data item defined with the RELATIVE KEY phrase.
	Execution unsuccessful: permanent error
30	No further information regarding the I-O operation is available.
35	An attempt was made to execute an OPEN INPUT/I-O statement for a nonexistent file.

I-O status	Meaning
37	An OPEN statement is attempted on a file that cannot be opened due to the following conditions: 1. OPEN OUTPUT/I-O/EXTEND on a write-protected file (password, RETPD in catalog, ACCESS=READ in catalog) 2. OPEN INPUT on a read-protected file (password)
38	An attempt was made to execute an OPEN statement for a file previously closed with the LOCK phrase.
39	The OPEN statement was unsuccessful as a result of one of the following conditions: 1. One or more of the operands ACCESS-METHOD, RECORD-FORMAT or RECORD-SIZE were specified in the SET-FILE-LINK command with values which conflict with the corresponding explicit or implicit program specifications. 2. The catalog entry of the FCBTYPE operand for an input file does not match the corresponding explicit or implicit program specification or the specification in the SET-FILE-LINK command. 3. Variable record length has been defined for a file that is to be processed using the UPAM access method of the DMS.
	Execution unsuccessful: logical error
41	An attempt was made to execute an OPEN statement for a file which was already open.
42	An attempt was made to execute a CLOSE statement for a file which was not open.
43	For ACCESS MODE IS SEQUENTIAL: The most recent I-O statement executed prior to a DELETE or REWRITE statement was not a successfully executed READ statement.
44	Record length limits exceeded: An attempt was made to execute a WRITE or REWRITE statement, but the length of the record does not lie within the limits defined for the file.
46	An attempt was made to execute a sequential READ statement for a file in INPUT or I-O mode. However, there is no valid next record since: 1. the preceding START statement terminated abnormally, or 2. the preceding READ statement terminated abnormally without causing an AT END condition. 3. the preceding READ statement caused an AT END condition.
47	An attempt was made to execute a READ or START statement for a file not in INPUT or I-O mode.
48	An attempt was made to execute a WRITE statement for a file that – on sequential access is not in OUTPUT or EXTEND mode – on random or dynamic access is not in OUTPUT or I-O mode.

I-O status	Meaning
49	An attempt was made to execute a DELETE or REWRITE statement for a file not in I-O mode.
	Other conditions with unsuccessful execution
90	System error; no further information regarding the cause is available.
91	System error; OPEN error
93	For shared update processing only (see section 9.5, “Shared updating of files”): The I-O statement could not terminate normally because a different task is accessing the same file, and the access operations are incompatible.
94	For shared update processing only (see section 9.5, “Shared updating of files”): deviation from call sequence READ - REWRITE/DELETE.
95	Incompatibility between values specified in the BLOCK-CONTROL-INFO or BUFFER-LENGTH operand of the SET-FILE-LINK command and the file format, block size, or the format of the used volume.

9.4 Indexed file organization

9.4.1 Characteristics of indexed file organization

Each record in an indexed file is assigned a key, i.e. a sequence of arbitrary (including non-printable) characters that uniquely identify the record in the file. The starting position (KEYPOS) and the length (KEYLEN) of the keys are identical for all records of a file.

The position and length of the key in the record are specified by means of a key data item defined in the program. An index is maintained for this item, enabling any record in the file to be accessed directly (randomly) via its record key. In addition to the options available for sequentially organized files, this facility allows the following operations in an indexed file:

- records can be created randomly,
- records can be read and updated randomly,
- records may be inserted at a later stage, and
- existing records can be logically deleted.

COBOL programs use the indexed sequential access method (ISAM) of DMS (see [4]) for processed indexed files. This method allows several users to update a file simultaneously (see section 9.5).

Indexed files can be created on disk storage only.

File structure

A detailed description of the structure of ISAM files is provided in [4]; the following description merely provides a quick review of the most important facts:

An ISAM file consists of two components, each of which serve different functions:

- index blocks and
- data blocks.

If private volumes are used, index and data blocks may reside on different volumes.

- Data blocks contain the user’s records. These records are logically linked together in ascending order of their keys; their physical sequence on the volume is arbitrary.

  Data blocks can have a length of one PAM block (2048 bytes) or an integer multiple thereof (up to 16 PAM blocks).
- Index blocks serve to locate data records via the record key. They can be classified into various index levels:

Index blocks of the lowest level contain pointers to data blocks, while index blocks of higher levels have pointers to the index blocks of the next lower level.

The highest-level index block is always created in the file, even if the file does not hold any records. In addition to the pointers, this block contains a 36-byte area for ISAM label information.

Entries in index blocks are always arranged physically in the order of ascending record keys; they must therefore be reorganized whenever new index or data blocks are generated in the level below.

Index blocks have a fixed length of one PAM block.

Block splitting

When an ISAM file is extended, each new record is inserted into the data block to which it belongs, based on the value of its record key.
At times, the space available in this block may prove insufficient for the inclusion of a further record. In such cases, the old block is split, and the resulting halves are entered into new (empty) blocks. The old block remains allocated to the file, but is now marked as free (see the manual “DMS Introductory Guide and Command Interface” [4]).

Frequent splitting of blocks slows down processing. However, this can be largely avoided by reserving space in the data blocks for later extensions when the file is first created. This is achieved by using the PADDING-FACTOR operand in the ACCESS-METHOD=ISAM parameter of the SET-FILE-LINK command when the output file is assigned. The PADDING-FACTOR operand serves to specify the percentage of a data block that is to remain free for subsequent extensions when loading the file.

Example 9-10: Use of the PADDING-FACTOR operand when assigning an ISAM file

When the file ISAM.OUTPUT is created, only about one in four records is to be initially available, with 75% of each data block being reserved for future extensions. This is accomplished by means of the following SET-FILE-LINK command:

```
/SET-FILE-LINK AUSDAT,ISAM.AUSGABE,ACCESS-METHOD=ISAM(PADDING-FACTOR=75)
```

9.4.2 COBOL language tools for the processing of indexed files

The following program skeleton summarizes the most important clauses and statements provided in COBOL85 for the processing of indexed files. The most significant phrases and entries are briefly explained thereafter:

```
IDENTIFICATION DIVISION.
...
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT internal-file-name
    ASSIGN TO external-name
    ORGANIZATION IS INDEXED
    ACCESS MODE IS mode
    RECORD KEY IS primary-key
    ALTERNATE RECORD KEY IS secondary-key
    FILE STATUS IS status-items.
    ...
DATA DIVISION.
FILE SECTION.
FD  internal-file-name.
    BLOCK CONTAINS block-length-spec
    RECORD record-length-spec
    ...
01  data-record.
    nn item-1               type&length
    ...
    nn primary-key-item     type&length
    nn secondary-key-item   type&length
    ...
PROCEDURE DIVISION.
    ...
    OPEN open-mode internal-file-name
    ...
    START internal-file-name
    ...
    READ internal-file-name
    ...
    REWRITE data-record
    ...
    WRITE data-record
    ...
    DELETE internal-file-name
    ...
    CLOSE internal-file-name
    ...
    STOP RUN.
```

```
SELECT internal-file-name
```

specifies the name by which the file is to be addressed in the source program.

“internal-file-name” must be a valid user-defined word.

The format of the SELECT clause also permits the OPTIONAL phrase to be specified for input files that need not necessarily be present during the program run.

If, during program execution, no file has been assigned to a file name declared with SELECT OPTIONAL, then:

- in the case of OPEN INPUT, program execution is interrupted with message COB9117 and a SET-FILE-LINK command is requested (in dialog mode), or the AT END condition is initiated (in batch mode);
- in the case of OPEN I-O or OPEN EXTEND, a file named FILE.COB85.linkname is created.

```
ASSIGN TO external-name
```

specifies the system file associated with the file and defines the name via which a cataloged file can be assigned.

“external-name” must be either
- a valid literal
- a valid data-name defined in the Data Division, or
- a valid implementor-name

from the ASSIGN clause format (see [1]).

```
ORGANIZATION IS INDEXED
```

specifies that the file is organized as an indexed file.

```
ACCESS MODE IS mode
```

specifies the mode in which the records can be accessed.

The following may be specified for mode (see also section 9.4.4):

SEQUENTIAL	specifies that the records can only be processed sequentially.
RANDOM	declares that the records can only be accessed in random mode.
DYNAMIC	allows the records to be accessed in either sequential or random mode.

The ACCESS MODE clause is optional. If it is not specified, the compiler assumes the default value ACCESS MODE IS SEQUENTIAL.

`RECORD KEY IS primary-key`

specifies which field in the record holds the primary record key.

primary-key must be declared as a data item in the associated record description entry (see below).

Except in sequential read operations, the primary record key of the record to be processed must be entered for primary-key before the execution of each I-O statement.

`ALTERNATE RECORD KEY IS secondary-key`

COBOL programs can also be used for processing files with records containing one or more secondary keys (ALTERNATE RECORD KEY) in addition to the mandatory primary record key (RECORD KEY).
If secondary keys are defined in a file, the user can access the records either via the primary key or via the secondary key(s).

The secondary key must be declared as a data item within the associated record description entry (see below).

`FILE STATUS IS status-items`

specifies the data items in which the runtime system stores status information after each access to a file. This information indicates
– whether the I-O operation was successful and
– the type of any errors that may have occurred.

The status items must be declared in the Working-Storage Section or the Linkage Section. Their format and the meaning of the various status codes are described in section 9.4.6.

The FILE STATUS clause is optional. If it is not specified, the information mentioned above is not available to the program.

`BLOCK CONTAINS block-length-spec`

defines the maximum size of a logical block. It determines how many records are to be transferred together by each I-O operation into/from the buffer of the program.

block-length-spec must be a permissible specification from the BLOCK CONTAINS clause.

The blocking of records reduces

– the number of accesses to peripheral storage and thus the runtime of the program;

– the number of interblock gaps on the storage medium and thus the physical storage space required by the file.

On the other hand, accesses employing the locking mechanism during shared update processing (see section 9.5) cause the entire block containing the current record to be locked. In such a case, therefore a large blocking factor would lead to a reduction in processing speed.

During compilation, the compiler calculates a value for the buffer size on the basis of the record and block length entries given in the source program. The runtime system rounds up this value for DMS to the next multiple of a PAM block (2048 bytes). This default value can be modified during the file assignment by specifying the BUFFER-LENGTH operand in the SET-FILE-LINK command (see section 9.1.3). In this case, it must be noted that

– the buffer must be at least as large as the longest data record, and

– there must be space for the management information (PAM key) in the buffer when processing in non-key format (BLKCTRL = DATA) (see section 9.1.4).

Except in the case of newly created files (OPEN OUTPUT), the block size entered in the catalog always takes priority over block size specifications in the program or SET-FILE-LINK command.

The BLOCK CONTAINS clause is optional. If it is omitted, the compiler assumes the BLOCK CONTAINS 1 RECORDS, i.e. unblocked records.

`RECORD record-length-spec`

– specifies whether records of fixed or variable length are to be processed and

– defines, for variable-length records, a range of permissible values for the record length. If provided for in the format, a data item is additionally specified for the storage of current record length information.

The record-length-spec must conform to one of the three RECORD clause formats provided in COBOL85. It must not be in conflict with the record lengths computed by the compiler from the specifications in the associated record description entry or entries.

The RECORD clause is optional. If it is not specified, records of variable length are assumed by the compiler.

```
01 data-record.
   nn item-1           type&length
   ...
   nn primary-key        type&length
   ...
   nn secondary-key        type&length
```

represents a record description entry for the associated file. It describes the logical format of data records.

At least one record description entry is required for each file. If more than one record description entry is specified for a file, the declared record format must satisfy the following rules:

– for fixed-length records, all record description entries must specify the same size;
– for variable-length records, the entries must not conflict with the record length specified in the RECORD clause, and even the record description entry with the shortest record length must still be capable of containing the entire record key.

At least one of the record description entries must explicitly declare the primary record key data item as a subordinate item of data-record. For type&length, the required length and format declarations (PICTURE and USAGE clauses etc.) must be entered (primary-key may have a maximum length of 255 bytes).

secondary-key is the data-name from the corresponding ALTERNATE RECORD KEY clause. Each secondary key item can be up to 127 bytes long. Overlaps with the primary key or other secondary keys are permissible provided two key items do not start at the same position. The COBOL85 compiler also allows secondary keys defined as pure numeric (PIC 9) or alphabetic (PIC A) items.

The subdivision of data-record into subordinate data items (item-1, item-2, ...) is optional for all other record description entries.

```
OPEN open-mode internal-file-name
```

opens the file for processing in the specified open-mode.

The following phrases can be entered for open-mode:

INPUT	opens the file as an input file; it can only be read.
OUTPUT	opens the file as an output file; it can only be written.
EXTEND	opens the file as an output file; it can be extended.
I-O	opens the file as an I-O file; it can be read (one record at a time), updated and rewritten.

The open-mode entry determines with which I-O statements a file may be accessed (see section 9.4.4).

```
START internal-file-name
READ internal-file-name
REWRITE data-record
WRITE data-record
DELETE internal-file-name
```

are I-O statements for the file that
- position to a record in the file
- read a record
- rewrite a record
- write a record, and
- delete a record.

The open mode declared in the OPEN statement determines which of these statements is admissible for the file. The relationship between access mode and open mode is described in section 9.4.4.

```
CLOSE internal file-name
```

terminates processing of the file.

The WITH LOCK phrase can be additionally specified to prevent the file from being opened again in the same program run.

9.4.3 Permissible record formats and access modes

Record formats

Indexed files may contain records of fixed length (RECFORM=F) or variable length (RECFORM=V). In both of these formats, the records may be blocked or unblocked.

In the COBOL source program, the format of the records to be processed can be defined in the RECORD clause. The following table lists the phrases associated with each record format:

Record format	**Phrase in the RECORD clause**	
Fixed-length records	RECORD CONTAINS...CHARACTERS	(format 1)
Variable-length records	RECORD IS VARYING IN SIZE... or RECORD CONTAINS...TO...	(format 2) (format 3)

Table 9-15: Specification of record formats in the RECORD clause

Access modes

Access to records of an indexed file may be sequential, random, or dynamic.

In the COBOL source program, the access mode is defined by means of the ACCESS MODE clause. The following table lists the possible phrases together with their effect on the access mode.

Phrase in the ACCESS MODE clause	**Access mode**
SEQUENTIAL	Sequential access: The records can be processed only in ascending order of their record keys. This means: – when reading records, the next logical record is made available. – when writing records, the next logical record is output to the file.
RANDOM	Random access: The records can be accessed in any order via their record keys. For this purpose, the (primary or secondary) key of the record to be processed must be supplied in the (ALTERNATE) RECORD KEY item prior to each I-O operation.
DYNAMIC	Dynamic access: The records can be accessed sequentially and/or randomly. The applicable access mode is selected via the format of the I-O statement in this case.

Table 9-16: Indexed files: ACCESS MODE clause and access mode

9.4.4 Open modes and types of processing

The language elements available for use in a COBOL program allow indexed files to be
- created,
- read,
- extended (by adding new records), and
- updated (by changing or deleting existing records).

The individual I-O statements that may be used in the program to process a given file are determined by its open mode, which is specified in the OPEN statement:

```
OPEN OUTPUT
```

Regardless of the phrase in the ACCESS MODE clause, WRITE is permitted as an I-O statement in the following format:

```
WRITE...[FROM...]
        [INVALID KEY...]
        [NOT INVALID KEY...]
        [END-WRITE]
```

In this mode, it is only possible to create (load) new indexed files.

- ACCESS MODE IS SEQUENTIAL

  enables the sequential creation of an indexed file. The records must be sorted in ascending order of their record keys before they are made available to the WRITE statement. Before each WRITE statement, the RECORD KEY data item must therefore be supplied with the record key of the record to be output. Each new key must be greater than the preceding one. If this is not the case, an INVALID KEY condition exists, and WRITE branches to the INVALID KEY statement or to the declared USE procedure without writing the record. It is thus not possible to overwrite records in this case.

- ACCESS MODE IS DYNAMIC or RANDOM

  enables the random creation of an indexed file. Note that file creation based on ascending record keys is performed more efficiently.

```
OPEN EXTEND
```

OPEN EXTEND enables an existing file to be extended. The ACCESS MODE clause is used in the same way as for OPEN OUTPUT.

`OPEN INPUT`

The phrase specified in the ACCESS MODE clause determines which I-O statements or statement formats are permitted. The following table lists the options available for OPEN INPUT:

Statement	Entry in the ACCESS MODE clause		
	SEQUENTIAL	RANDOM	DYNAMIC
START	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-START]	statement not permitted	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY] [END-START]
READ	READ...[NEXT] [INTO...] [AT END...] [NOT AT END...] [END-READ...]	READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]	For sequential access: READ...NEXT [INTO...] [AT END...] [NOT AT END...] [END-READ]
			For random access READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]

Table 9-17: Indexed files: I-O statements permitted for OPEN INPUT

Indexed files can be read in this mode. Depending on the access mode specified, the READ statement has the following effect:

– ACCESS MODE IS SEQUENTIAL

  permits the file to be read sequentially only. READ retrieves records in ascending order of record keys.
  The (ALTERNATE) KEY item is not evaluated by READ. However, a START statement can be used to position to any record of the file before execution of a READ statement: START uses a relation condition to determine the record key of the first record to be read and thus establishes the starting point for subsequent sequential read operations (see also section 9.4.5). If the relation condition cannot be satisfied by any record key of the file, an INVALID KEY condition exists, and START makes a branch to the INVALID KEY imperative-statement or to the declared USE procedure.

– ACCESS MODE IS RANDOM

  enables records of the file to be randomly read. READ retrieves the records in a user-specified order; access to each record is effected via its record key.
  Accordingly, the record key of each record to be read must be supplied in the (ALTERNATE) KEY data item prior to each READ operation. If the record key of an unavailable record is specified, an INVALID KEY condition exists, and READ branches to the INVALID KEY statement or to the USE procedure declared for this condition.

– ACCESS MODE IS DYNAMIC

  permits random and/or sequential reading of the file. The desired access mode is selected via the format of the READ statement (see table 9-18).
  In this case, a START statement is meaningful for sequential reading only.

`OPEN I-O`

The phrase specified in the ACCESS MODE clause determines which I-O statements or statement formats are permitted.

Records in an indexed file opened in OPEN I-O mode can be
– read,
– added,
– updated by the program, and
– overwritten or
– deleted.

The following table lists the options available for OPEN I-O:

Statement	Entry in the ACCESS MODE clause		
	SEQUENTIAL	RANDOM	DYNAMIC
START	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-START]	statement not permitted	START... [KEY IS...] [INVALID KEY...] [NOT INVALID KEY] [END-START]
READ	READ...[NEXT] [INTO...] [AT END...] [NOT AT END...] [END-READ...]	READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]	For sequential access: READ...NEXT [INTO...] [AT END...] [NOT AT END...] [END-READ]
			For random access: READ... [INTO...] [KEY IS...] [INVALID KEY...] [NOT INVALID KEY...] [END-READ]
REWRITE	REWRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-REWRITE]	REWRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-REWRITE]	REWRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-REWRITE]
WRITE	statement not permitted	WRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-WRITE]	WRITE... [FROM...] [INVALID KEY...] [NOT INVALID KEY...] [END-WRITE]
DELETE	DELETE... [END-DELETE]	DELETE... [INVALID KEY...] [NOT INVALID KEY...] [END-DELETE]	DELETE... [INVALID KEY...] [NOT INVALID KEY...] [END-DELETE]

Table 9-18: Indexed files: I-O statements permitted for OPEN I-O

OPEN I-O assumes that the file to be processed already exists. It is therefore not possible to create a new indexed file in this mode.

The specified access mode determines the type of processing that can be performed, as well as the effect of the individual I-O statements:

- ACCESS MODE IS SEQUENTIAL

  As in the case of OPEN INPUT, this access mode permits the sequential reading of a file with READ and the use of a preceding START to position to any record as the starting point.

  In addition, the record that is read by a successful READ operation can be

  - updated by the program and rewritten with REWRITE, or
  - logically deleted with DELETE.

  However, it must be noted that

  - no further I-O statement must be executed for this file, and
  - the RECORD KEY data item must not be changed

  between the READ statement and the REWRITE or DELETE statement.

- ACCESS MODE IS RANDOM

  enables records to be randomly retrieved with READ (as in OPEN INPUT). In addition,

  - new records can be inserted into the file with WRITE, and
  - existing records in the file can be rewritten or deleted with REWRITE or DELETE (regardless of whether they were read earlier).

  Prior to each WRITE, REWRITE, or DELETE statement, the RECORD KEY data item must be supplied with the key of the record that is to be added, rewritten, or deleted. If the following conditions apply:

  - the number of an already existing record is specified for WRITE, or
  - the number of an unavailable record is specified for REWRITE or DELETE,

  an INVALID KEY condition exists, and WRITE, REWRITE, or DELETE branches to the INVALID KEY statement or to the USE procedure declared for this event.

- ACCESS MODE IS DYNAMIC

  allows a file to be processed sequentially or randomly. Here, the desired access mode is selected via the format of the READ statement.

9.4.5 Positioning with START

Any record in an indexed (or relative) file can be selected as the starting point for subsequent sequential read operations by means of START. START sets up a comparison via a relation condition in order to establish the (primary or secondary) key of the first record to be read.
The following example illustrates how the language extension (to ANS85) START...KEY LESS... can be used to sequentially process an indexed file in reverse order, i.e. in the order of descending record keys, beginning with the highest key in the file. The precise location within a file is identified by means of a conceptual entity called the file position indicator.

Example 9-11: Processing an indexed file in reverse order

```
 IDENTIFICATION DIVISION.
  PROGRAM-ID.  INDREV.
 *    INDREV PROCESSES THE RECORDS OF AN INDEXED FILE
 *    IN DESCENDING ORDER OF THEIR RECORD-KEYS.
  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  SPECIAL-NAMES.
      TERMINAL IS T.
  INPUT-OUTPUT SECTION.
  FILE-CONTROL.
      SELECT IND-FILE
      ASSIGN TO „INDFILE“
      ORGANIZATION IS INDEXED
      ACCESS IS DYNAMIC
      RECORD KEY IS REC-KEY.
  DATA DIVISION.
  FILE SECTION.
  FD  IND-FILE.
  01  IND-REC.
      05  REC-KEY                  PIC X(8).
      05  REC-TEXT                 PIC X(72).
  WORKING-STORAGE SECTION.
  01  PROCESSING-SWITCH            PIC X.
      88  END-OF-PROCESSING                  VALUE „1“.
  PROCEDURE DIVISION.
  INITIALIZATION.
      OPEN I-O IND-FILE --------------------------------------------- (1)
      MOVE HIGH-VALUE TO REC-KEY ------------------------------------ (2)
      MOVE „0“ TO PROCESSING-SWITCH.
  PROCESS-FILE.
      START IND-FILE KEY LESS OR EQUAL REC-KEY
         INVALID KEY
            DISPLAY „FILE IS EMPTY“ UPON T
            SET END-OF-PROCESSING TO TRUE
        NOT INVALID KEY
            READ IND-FILE NEXT ————————————————————————————————————— (3)
               AT END
                 SET END-OF-PROCESSING TO TRUE
               NOT AT END
                  DISPLAY „HIGHEST RECORD KEY: „ REC-KEY
                     UPON T
                  PERFORM PROCESS-RECORD
            END-READ
      END-START

      PERFORM WITH TEST BEFORE UNTIL END-OF-PROCESSING
         START IND-FILE KEY LESS REC-KEY ——————————————————————————— (4)
            INVALID KEY
               SET END-OF-PROCESSING TO TRUE
            NOT INVALID KEY
               READ IND-FILE NEXT
                  AT END
                     SET END-OF-PROCESSING TO TRUE
                  NOT AT END
                     DISPLAY „NEXT RECORD KEY: „ REC-KEY
                        UPON T
                     PERFORM PROCESS-RECORD
               END-READ
         END-START
      END-PERFORM.
  TRAILER.
      CLOSE IND-FILE
      STOP RUN.
  PROCESS-RECORD.
 *
 *    PROCESSING OF CURRENT RECORD ———————————————————————————————— (5)
 *
```

(1) The file IND-FILE is opened for processing with OPEN I-O.

(2) To obtain the record with the highest key in the file,
- the RECORD KEY is preset to the highest possible value (HIGH-VALUE in the NATIVE alphabet), and
- START...KEY LESS OR EQUAL sets the file position indicator to it.

(3) READ...NEXT reads the record to which the file position indicator was previously set by START.

(4) START...KEY LESS sets the file position indicator to the predecessor of the last record read.

(5) The read record is processed. If its RECORD KEY is changed during processing, the original value must be restored before the next START statement.

9.4.6 I-O status

The status of each access operation performed on a file is stored by the runtime system in specific data items, which can be assigned to every file in the program. These items, which are specified by using the FILE STATUS clause, provide information on

– whether the I-O operation was successful, and

– the type of errors that may have occurred.

This data can be evaluated (by USE procedures in the DECLARATIVES, for example) and used by the program to analyze I-O errors. As an extension to Standard COBOL, COBOL85 provides the option of using DMS codes to include error messages in this analysis, thus allowing a finer differentiation between different causes of errors.

The FILE STATUS clause is specified in the FILE-CONTROL paragraph of the Environment Division. Its format is (see [1]):

```
FILE STATUS IS data-name-1 [data-name-2]
```

where data-name-1 and data-name-2 (if specified) must be defined in the Working-Storage Section or the Linkage Section. The following rules apply with regard to the format and possible values for these two items:

data-name-1

– must be declared as a two-byte numeric or alphanumeric data item, e.g.

```
                  01 data-name-1            PIC X(2).
```

– contains a two-character numeric status code following each access operation on the associated file. The table provided at the end of this section lists all such codes together with their meanings.

data-name-2

– must be declared as a 6-byte group item with the following format:

```
01 data-name-2.
   02 data-name-2-1       PIC 9(2) COMP.
   02 data-name-2-2       PIC X(4).
```

– is used for storing the DMS error code for the I-O status. Following each access operation on the associated file, data-name-2 contains a value that directly depends on the content of data-name-1. The relationship between the values is shown in the table below.:

Contents of data-name-1≠0?	DMS code≠0?	Value of data-name-2-1	Value of data-name-2-2
no	no	undefined	undefined
yes	no	0	undefined
yes	yes	64	DMS code of the associated error message

The DMS codes and the associated error messages are given in manual [4].

Table 9-19: I-O status values for indexed files

I-O status	Meaning
	Execution successful
00	The I-O statement terminated normally. No further information regarding the I-O operation is available.
02	A record was read with ALTERNATE KEY and subsequent sequential reading with the same key has found at least one record with an identical key. A record was written with ALTERNATE KEY WITH DUPLICATES and there is already a record with an identical key value for at least one alternate key.
04	Record length conflict: A READ statement terminated normally. However, the length of the record read lies outside the limits defined in the record description entry for the given file.
05	An OPEN statement was executed for an OPTIONAL file which does not exist.
	Execution unsuccessful: AT END condition
10	An attempt was made to execute a sequential READ operation. However, no next logical record was available, as the end-of-file was encountered.
	Execution unsuccessful: invalid key condition
21	File sequence error in conjunction with ACCESS MODE IS SEQUENTIAL: 1. The record key value was changed between the successful execution of a READ statement and the execution of the next REWRITE statement for a file, or 2. the ascending sequence of record keys was violated in successive WRITE statements.
22	Duplicate key An attempt was made to execute a WRITE statement with a primary key for which there is already a record in the indexed file. An attempt was made to create a record with ALTERNATE KEY, but without WITH DUPLICATES, and there is already an alternate key with the same value in the file.
23	Record not located An attempt was made (using a READ, START, DELETE or REWRITE statement with key) to access a record not contained in the file.
24	Boundary values exceeded An attempt was made to execute a WRITE statement beyond the system-defined boundaries of an indexed file.
	Execution unsuccessful: unrecoverable error
30	No further information regarding the I-O operation is available (the DMS code provides further information).
35	An OPEN statement with the INPUT, I-O or EXTEND phrase was issued for a non-optional file which does not exist.

I-O status	Meaning
37	OPEN statement on a file that cannot be opened due to the following violations: 1. OPEN OUTPUT/I-O/EXTEND on a write-protected file (password, RETENTION-PERIOD, ACCESS=READ in catalog) 2. OPEN INPUT on a read-protected file (password)
38	An attempt was made to execute an OPEN statement for a file previously closed with the LOCK phrase.
39	The OPEN statement was unsuccessful as a result of one of the following conditions: 1. One or more of the operands ACCESS-METHOD, RECORD-FORMAT, RECORD-SIZE or KEY-LENGTH were specified in the SET-FILE-LINK command with values that conflict with the corresponding explicit or implicit program specifications. 2. Record length error occurred for an input file (catalog check, if RECFORM=F). 3. The record size is greater than the BLKSIZE entry in the catalog of an input file. 4. The catalog entry of one of the FCBTYPE, RECFORM, RECSIZE (if RECFORM=F), KEYPOS, or KEYLEN operands for an input file is in conflict with the corresponding explicit or implicit program specifications or with the corresponding specifications in the FILE command. 5. An attempt was made to open a file whose alternate key does not match the key values specified in the ALTERNATE RECORD KEY clause in the program.
	Execution unsuccessful: logical error
41	An attempt was made to execute an OPEN statement for a file which was already open.
42	An attempt was made to execute a CLOSE statement for a file which was not open.
43	For ACCESS MODE IS SEQUENTIAL: The most recent I-O statement executed prior to a DELETE or REWRITE statement was not a successfully executed READ statement.
44	Record length limits exceeded: An attempt was made to execute a WRITE or REWRITE statement. However, the length of the record is outside the range allowed for this file.
46	An attempt was made to execute a sequential READ statement for a file in INPUT or I-O mode. However, no valid next record is available since: 1. the preceding START statement was unsuccessful, or 2. the preceding READ statement was unsuccessful without leading to an AT END condition, or 3. an attempt was made to execute a READ statement after the AT END condition was encountered.

I-O status	Meaning
47	An attempt was made to execute a READ or START statement for a file that is not open in INPUT or I-O mode.
48	An attempt was made to execute a WRITE statement for a file that – on sequential access is not in OUTPUT or EXTEND mode – on random or dynamic access is not in OUTPUT or I-O mode.
49	An attempt was made to execute a DELETE or REWRITE statement for a file that is not in I-O mode.
	Other conditions with unsuccessful execution
90	System error; no further information regarding the cause is available.
91	OPEN error: the actual cause is evident from the DMS code (see “FILE STATUS clause” specifying data-name-2).
93	For shared update processing only (see section 9.5, “Shared updating of files”): The I-O statement could not terminate normally because a different task is accessing the same file, and the access operations are incompatible.
94	1. For shared update processing only (see section 9.5, “Shared updating of files”): deviation from call sequence READ - REWRITE/DELETE. 2. The record size is greater than the block size.
95	Incompatibility between values specified in the BLOCK-CONTROL-INFO or BUFFER-LENGTH operand of the SET-FILE-LINK command and the file format, block size, or the format of the used volume.

9.5 Shared updating of files (SHARED-UPDATE)

9.5.1 ISAM files

ISAM files with indexed or relative file organization can be shared by several users simultaneously by means of the SHARED-UPDATE operand in the SUPPORT parameter of the SET-FILE-LINK command:

```
/SET-FILE-LINK linkname,filename,SUPPORT=DISK(SHARED-UPDATE=YES)
```

The following table shows which OPEN statements are available to user B after the file has already been opened by user A.

		Options permitted for user B					
		SHARED-UPDATE =YES			SHARED-UPDATE=NO		
Options selected by user A	**OPEN statement**	INPUT	I-O	OUPUT/ EXTEND	INPUT	I-O	OUTPUT/ EXTEND
SHARED-UPDATE=YES	INPUT	X	X		X		
	I-O	X	X				
	OUTPUT / EXTEND						
SHARED-UPDATE=NO	INPUT	X			X		
	I-0						
	OUTPUT / EXTEND						

Table 9-20: OPEN statements permitted for shared updating

The permitted combinations of OPEN statement and SHARED-UPDATE operand value are indicated with an `X`.

It is clear from the table that the SHARED-UPDATE=YES option is superfluous for INPUT files if all users use OPEN INPUT. If SHARED-UPDATE=YES must nevertheless be specified for input files because at least one user uses OPEN I-O, the locks described below will not be set or released.

The SHARED-UPDATE=YES option makes sense, and is also necessary, only for the simultaneous updating of one or more ISAM files (OPEN I-O) by two or more interactive users.

Updates in batch processing mode must be executed successively in order to avoid both logic errors and excessive runtimes (unnecessary specification of SHARED-UPDATE=YES increases both runtime and CPU time).

If SHARED-UPDATE=YES is specified, WRITE-CHECK=YES will automatically be set also, i.e. the ISAM buffers will be rewritten immediately after each change. This is necessary for reasons of data security and consistency, but causes a considerable increase in the number of I-O operations.

In order to ensure data consistency during simultaneous updating of an ISAM file by several users, the COBOL85 runtime system utilizes the locking and unlocking mechanism of the DMS access method ISAM. This mechanism locks or unlocks the data blocks that contain the data records referenced by the COBOL statements READ, WRITE, REWRITE or DELETE.

A data block is the multiple of a PAM page (2048 bytes) defined implicitly or explicitly by the BUFFER-LENGTH parameter in the SET-FILE-LINK command when the file was created (see section 9.1.1).

In the following, a record lock is to be understood as the lockout of the entire block that contains the record.

To permit shared updating of ISAM files, a format extension to the READ or START statement is provided. However, this extension is effective only if SHARED-UPDATE=YES is specified in the SET-FILE-LINK command and the file was opened with OPEN I-O.

Format extension (for all READ/START formats):

```
READ  file-name [WITH NO LOCK]...
START file-name [WITH NO LOCK]...
```

Rules for shared updating

1. READ or START statement with the WITH NO LOCK phrase:

   If user A specifies the WITH NO LOCK phrase and the appropriate record is present, this record is read or selected irrespective of any lock set by any other user. The record is not locked. A REWRITE or DELETE statement cannot be performed on a record thus read.

   Simultaneously, a user B may read or update the same record.

2. READ or START statement without the WITH NO LOCK phrase:

   If user A does not specify the WITH NO LOCK phrase and the appropriate record is present, a READ or START statement can only be executed successfully if that record is not already locked by user B. If execution of the statement is successful, the record will be locked. Before the lock is released, user B can only read or select the same or another record in the same block by specifying WITH NO LOCK, but will not be able to update any record in this block. (If user B opened the file using OPEN INPUT, he will always be able to read records in the locked block.)

3. Updating of records:

   If a record is to be updated using a REWRITE or a DELETE statement, the appropriate record must be read immediately before this by a READ statement (without the WITH NO LOCK phrase). Between this READ statement and the REWRITE or DELETE statement, no further I-O statement may be executed for the same ISAM file. Between these two statements, only READ or START statements with the WITH NO LOCK phrase can be executed for other ISAM files whose SET-FILE-LINK command contains SHARED-UPDATE=YES and which are open at the same time in the OPEN I-O mode. Statements for other ISAM files (without SHARED-UPDATE=YES and OPEN I-O) can be executed. Any violation of these rules will lead to an unsuccessful REWRITE or DELETE statement with FILE STATUS 94.

4. Waiting times in the event of a lock:

   If user A has locked a data record following a successful READ or START statement, and user B attempts to perform a READ or START statement without the WITH NO LOCK phrase on the same data record or any other in the same data block, user B will not immediately be unsuccessful. User B must wait in a queue until the lock is released by user A. Only if the maximum waiting time elapses without the lock being released will the statement be considered unsuccessful and FILE STATUS 93 be set. If the lock is released before the waiting time has elapsed, user B can continue with the successful call.

5. Releasing a locked record:

   A user maintains a record lock until he executes one of the following statements:

   – Successful REWRITE or DELETE statement for the locked data record
   – WRITE statement for an ISAM file whose SET-FILE-LINK command contains SHARED-UPDATE=YES and which is open as OPEN I-O (i.e., for the same file that contains the locked record, or for another ISAM file; unlocking is also effected if the INVALID KEY condition occurs)
   – READ or START statement with the WITH NO LOCK phrase for the same file (unlocking is also effected if the AT END or INVALID KEY condition occurs)
   – READ or START statement without the WITH NO LOCK phrase for a record in another data block of the same file (unlocking is also effected if the AT END or INVALID KEY condition occurs)
   – READ or START statement without the WITH NO LOCK phrase for another ISAM file whose SET-FILE-LINK command contains SHARED-UPDATE=YES and which is open in OPEN I-O mode (unlocking is also effected if the AT END or INVALID KEY condition occurs)
   – CLOSE statement for the same file

   Thus, a statement for an ISAM file can release the record lock on another ISAM file.

Notes

1. If an ISAM file (with SHARED-UPDATE=YES and OPEN I-O) is to be processed in a program, a USE AFTER STANDARD ERROR procedure should be provided for this file. In this procedure, the file status values relating to shared update processing, i.e. 93 (record has been locked by a simultaneous user) and 94 (REWRITE or DELETE statement without preceding READ statement), can be interrogated and then processed accordingly.
2. It should be noted that when a record is locked using the ISAM block lockout mechanism, all records in the same block are locked to all concurrent users.
3. A user cannot lock more than one block at a time, i.e. can protect only one block against updating by other users. This is also true if the user has opened several ISAM files (all SHARED-UPDATE=YES) in OPEN I-O mode.
4. A deadlock (mutual locking of data blocks by different users) is excluded, because only one block of all ISAM files (all SHARED-UPDATE=YES) can be locked for each user. This does not, however, apply if a PAM file is accessed simultaneously with SHARED-UPDATE=YES in I-O mode.
5. If a READ statement for a record is not immediately followed by a REWRITE or DELETE statement but by an attempt to access some other data block (of the same or any other ISAM file) instead, the record will need to be read again if the intervening access operation simultaneously releases the previously locked data block to other users. Since the affected data block was unlocked to other users in the period between the READ and REWRITE or DELETE statements, the contents of the original record may have been changed (see example 9-12(a)).

   If an access attempt is made to another block or another file without the locking mechanism, the data made available might meanwhile have been changed by concurrent users before the REWRITE or DELETE statement is executed (see example 9-12(b)).
6. In order to prevent a user from working with data that is no longer up-to-date, the WITH NO LOCK phrase should only be used when absolutely necessary.
7. A locked record (block) will give rise to waiting times when concurrent users try to access the same record or another in the same block. To keep waiting times as short as possible, the lock should be released as soon as possible. If a lock is not released in due time, the waiting time will have elapsed, and the program branches to the appropriate USE procedure, if available (see example 9-13), or is aborted (message COB9151, FILE STATUS 93 and DMS error code DAAA).

Example 9-12: Reading and rewriting in file ISAM1 when data from file ISAM2 is required before rewriting:

(a) Without the WITH NO LOCK phrase: Two READ statements for the same file are necessary, but the locking times are shorter:

```
  ...

 READ ISAM1 INTO WORK1 ─────────────────────────────────────────── (1)
   INVALID KEY...
 ...

 READ ISAM2 ───────────────────────────────────────────────────── (2)
   INVALID KEY...
 ...
```

Processing of WORK1 taking into account ISAM2REC:

```
Š...

 READ ISAM1 ───────────────────────────────────────────────────── (3)
   INVALID KEY...
```

Check for changes to ISAM1REC in meantime; repeat processing if necessary:

```
  ...

 REWRITE ISAM1SATZ FROM WORK1 ──────────────────────────────────── (4)
  INVALID KEY...
```

(1) Reads a record from ISAM1 and buffers it in WORK1; relevant block in ISAM1 locked

(2) Reads a record from ISAM2, releases lock in ISAM1, locks relevant block in ISAM2

(3) Rereads record from ISAM1, releases lock in ISAM2, locks relevant block in ISAM1

(4) Rewrites record into ISAM1, releases lock in ISAM1

(b) With the WITH NO LOCK phrase: Only one READ statement is required for this file, but the locking times are consequently longer:

```
...
READ ISAM1 ──────────────────────────────────────────────────────── (1)
  INVALID KEY...
...
READ ISAM2 WITH NO LOCK ──────────────────────────────────────────── (2)
  INVALID KEY...
...
```

Processing of ISAM1REC taking into account ISAMREC:

```
...
REWRITE ISAM1SATZ FROM WORK1─────────────────────────────────────── (3)
 INVALID KEY...
```

(1) Reads a record from ISAM1; relevant block locked

(2) Reads a record from ISAM2; relevant block not locked

(3) Rewrites record into ISAM1; lock is released.

Example 9-13: Branch to USE AFTER STANDARD ERROR procedure

```
    ...
FILE-CONTROL.
    SELECT ISAM1

     ...
     FILE STATUS IS FILESTAT1.
WORKING-STORAGE SECTION.
77  FILESTAT1   PIC 99.
    ...
 PROCEDURE DIVISION.
DECLARATIVES.
ISAM1ERR SECTION.
    USE AFTER STANDARD ERROR PROCEDURE ON ISAM1.
LOCK-PAR.
    IF FILESTAT1 = 93
       THEN DISPLAY "RECORD CURRENTLY LOCKED" UPON T
       ELSE DISPLAY "DMS-ERROR ISAM1, FILE-STATUS="
                    FILESTAT1 UPON T.
ISAM1ERR-EX.
    EXIT.                                                    (1)
END DECLARATIVES.
CNTRL SECTION.
    ...
```

(1) Control is transferred to the statement following the statement that caused the error. Suitable error recovery measures depend on the application involved.

9.5.2 PAM files

Like ISAM files, files with relative organization and FCBTYPE=PAM can also be updated simultaneously by several users if the SET-FILE-LINK command contains SHARED-UPDATE=YES and the file was opened with OPEN I-O.

To ensure data consistency during shared updating, the COBOL85 runtime system uses the locking and unlocking mechanism of the DMS access method UPAM. Unlike ISAM, access coordination in this case is file-specific. Accordingly, statements for a specific file have no impact on any other file.

As with ISAM, the lock affects not just one specific record in a block, but the entire block in which that record is contained (see “Indexed files”).

For PAM files, as with ISAM files, the format extension WITH NO LOCK (see “Indexed files”) may also be used in all formats of the READ or START statement provided SHARED-UPDATE=YES and OPEN I-O were specified for these files.

Rules for shared updating

1. Reading and positioning with or without the WITH NO LOCK phrase is effected in the same manner as for ISAM files.
2. Updating of records:

   If a record is to be updated by a REWRITE or DELETE statement, the record must be read (as with ISAM files) immediately before this statement by means of a READ statement (without the WITH NO LOCK phrase). No other statement for this file must be executed between these statements. Unlike the conventions for ISAM files, statements for other PAM files are allowed (on account of the file-oriented access coordination).
3. Waiting times in the event of a lock

   The maximum waiting time for the release of a locked block is 999 seconds. After this time has elapsed, control is transferred to the USE AFTER STANDARD ERROR procedure, if present, or the program is terminated with error message COB9151 (FILE STATUS 93 and DMS error code D9B0 or D9B1).
4. Releasing a locked record

   The release of a locked block can be accomplished with the same statements as for ISAM files, but all statements must refer to the same file.

   In contrast to ISAM files, a statement for a PAM file does not release blocks of another PAM file.

Notes

1. If a PAM file (with SHARED-UPDATE=YES, OPEN I-O) is to be processed in a program, a USE AFTER STANDARD ERROR procedure should be defined for this file (see “Indexed files”).
2. Unlike ISAM files (with SHARED-UPDATE=YES, OPEN I-O), the simultaneous processing of two or more files (all with SHARED-UPDATE=YES, OPEN I-O), of which at least one is a PAM file, allows one record per user to be locked simultaneously in any number of files (but only one record in one file). This may result in a deadlock situation (see example 9-13).
3. As with ISAM files, any locks on records (blocks!) in PAM files should be released as soon as possible in order to minimize waiting times for other users.

Example 9-14: Deadlock

```
User A:                          User B:

READ file1 (record n)            READ file2 (record m)
   .                                  .
   .                                  .
READ file2 (record m)            READ file1 (record n)

(Block in file1 not unlocked)    (Block in file2 not unlocked
```

Both users are waiting for the particular block to be released (deadlock).

The maximum waiting time for the release of a locked block is 999 seconds. After this time has elapsed, the USE AFTER STANDARD ERROR procedure, if present, is activated or the program is terminated with error message COB9151 (FILE STATUS 93 and DMS error code D9B0 or D9B1).

10 Sorting and merging

10.1 COBOL language elements for sorting and merging files

COBOL85 supports sorting and merging with the following language elements (see [1]):

– Specification of the literal “SORTWK” in the ASSIGN clause:

  This explicitly declares the link name SORTWK for the sort file.

  The format of the ASSIGN clause for sort files also permits other specifications, but these are treated as comment entries by the compiler. The link name for the sort file is always SORTWK.

– The sort file description entry (SD) in the Data Division

  This corresponds to the file description entry (FD) for other files and defines the physical structure, the format and the size of the records.

– The SORT and MERGE statements in the Procedure Division:

  input procedure. The sorted records are written to a file or transferred SORT sorts records by one or more data items (up to 64), specified as sort keys.
  These data records can be made available to SORT from a file or via an to an output procedure.
  For sorting, COBOL85 uses the sorting function of the BS2000 utility SORT for sorting (see [6]).

  MERGE merges records from two or more sorted input files in a sort file on the basis of a number of data items (up to 64) that have been specified as sort keys.
  The merged records are written to a file or transferred to an output procedure.

– Declaration of input and output procedures

  An input procedure (INPUT PROCEDURE phase) can be declared for any SORT statement. The procedure allows the records which are to be sorted to be generated or processed before they are passed to the sort file via a RELEASE statement.

  An output procedure (OUTPUT PROCEDURE phase) can be declared for any SORT or MERGE statement. The procedure allows the sorted or merged records to be processed further, after they have been made available to it with a RETURN statement.

Note

If desired, text can be sorted according to the DIN standard for EBCDIC. To this end, sort format ED of the SORT utility routine is selected for all SORT statements in a program by compiling the program with the SDF option
RUNTIME-OPTIONS=PAR(SORTING-ORDER=BY-DIN) or, alternatively, with
COMOPT SORT-EBCDIC-DIN=YES (see manual [6]).
This means that

- lowercase letters are equated with the corresponding uppercase letters and
- the character

  “ä” / “Ä” is identified with “AE”,
  “ö” / “Ö” is identified with “OE”,
  “ü” / “Ü” is identified with “UE” and
  “ß” is identified with “SS” and
- digits are sorted before letters.

10.2 Files for the sort program

The following files are required for a sort operation:

Sort file

Data records are sorted in this file (work area). Its name is declared, for example, via the clause

```
SELECT sort-file ASSIGN TO "SORTWK"
```

In addition, the file must be described in the sort file description entry (SD) of the Data Division. The file is accessed with the statement

```
SORT sort-file ...
```

Without the user having to issue a SET-FILE-LINK command, this file will be cataloged under the name `SORTWORK.tsn.yymmdd.hhmmss` (where tsn = task sequence number, yy = year, mm = month, dd = day, hhmmss = time in six digits). The link name is SORTWK. After a normal termination of the sort operation the file is deleted.

By default, the size of the sort file when created without the SET-FILE-LINK command is 24 * 16 = 384 PAM pages (this value can be modified by supplying values to special registers for SORT). Accordingly, the primary allocation is 384 PAM pages; the secondary allocation is 1/4 of this, i.e. 96 PAM pages.

Using the command

```
MODIFY-FILE-ATTRIBUTES filename,SUPPORT=PUBLIC-DISK(SPACE=
              RELATIVE(PRIMARY-ALLOCATION=..,SECONDARY-ALLOCATION=..))
```

the user can define the sort file size independently (see manual [6]). This is recommended for large files. After normal termination of the sort operation this file will be closed, but **not** deleted.

Special registers for SORT (see [1]):

The programmer can load the following special registers for SORT before the sort operation:

– SORT-FILE-SIZE: This register is loaded with the total number of records.

– SORT-MODE-SIZE: This register is loaded with the average record size.

The SORT utility routine uses these two registers to calculate the file size. This implies that the programmer can indirectly affect the SPACE operand.

– SORT-CORE-SIZE: This register is loaded with the desired size of the internal work areas, expressed in bytes.

  These entries can be used to influence program execution.

  If they are omitted, 24 * 4096 bytes (i.e. 24 4-Kb pages) is assumed by default.
  For further information see [6] on sort run optimization.

After SORT, RELEASE and before RETURN statements, the programmer may interrogate the SORT special register SORT-RETURN:

“0” indicates that sorting was successful,

“1” that sorting was errored.

This interrogation is recommended because the program is not terminated in the event of an errored sort operation.

If an invalid value is loaded into a SORT special register, error message COB9134 is issued (see chapter 14).

Input file(s)

If no input procedure has been defined, COBOL85 generates an OPEN INPUT and a READ...AT END for the specified file. Each input file must be defined in the COBOL program.

The link names SORTIN and SORTINnn ($01 \leq nn \leq 99$) must not be used within a sort program.

Output file

If no output procedure has been defined, COBOL85 generates an OPEN OUTPUT and a WRITE for the specified file. The output file must be defined in the COBOL program.

The link name SORTOUT must not be used within a sort program.

10.3 Checkpointing and restart for sort programs

Specifying the RERUN clause (format 2) causes special checkpoints to be issued for sort files. Checkpoint records contain information concerning the status of the sort operation. They are necessary in order to enable a program which has been interrupted by the user or because of a computer malfunction to be restarted without having to repeat the entire program run up to that point. The taking of sort checkpoints is especially recommended when dealing with large quantities of sort data, because a successful presort will then not be lost in the event of an abnormal program termination.

Format 2 of the RERUN clause:

```
RERUN ON implementor-name EVERY SORT OF sort-file-name
```

implementor-name: SYSnnn (000 ≤ nnn ≤ 200)

Checkpoint records are written to a checkpoint file (see chapter 11) which is created by the sort program using the default file name `SORTCKPT.Dyyddd.Tnnnn` (where yy = year, ddd = current day of the year, nnnn = task sequence number of the current task) and the standard link name SORTCKPT (see [6]). Using the SPACE operand in the SUPPORT parameter of the MODIFY-FILE-ATTRIBUTES command, the user can independently determine the size of this file. Checkpoint output is logged on SYSOUT (message EXC0301; see chapter 11). The timing of the checkpoint output cannot be determined by the user independently.

When the sort operation terminates normally, the checkpoint file is closed, released and deleted, i.e. the user has no access to it.

If a sort program is terminated abnormally, program execution can be resumed from the last checkpoint taken. To do this, the user issues a RESTART-PROGRAM command which makes use of the information logged on SYSOUT. See chapter 11 and manual [3].

10.4 Sorting tables

The BS2000 sort function SORT can also be used for sorting tables. The equivalent COBOL language feature is the SORT statement (see COBOL85 Language Reference Manual [1]).

11 Checkpointing and restart

Checkpoint records are output by COBOL85 objects to an external checkpoint file (or two checkpoint files if necessary: see below). A checkpoint record comprises identification information, program status, associated system status and virtual memory contents. All this is required for any subsequent restart which might be effected.

By writing such checkpoint records, it is possible for a program to be continued at any time at the point where the last checkpoint record was written before the program was interrupted (whether intentionally or because of system malfunction). Checkpointing is especially recommended for programs with a fairly long execution time. However, it is only meaningful if the original data can be restored for a possible restart.

This functionality is not available in the POSIX subsystem (see chapter 13).

11.1 Checkpointing

The writing of checkpoint records is initiated by the user with the aid of the RERUN clause. The user can determine the point in time when the checkpoint records are to be written; for a given file, checkpointing is possible at each reel swapping, or after the processing of a specific number of records of that file.

Format 1 of the RERUN clause (extract; for a complete description, see [1]):

```
                                          ⎧        ⎧REEL⎫    ⎫
                                          ⎪END OF ⎨     ⎬    ⎪
RERUN [ON implementor-name] EVERY  ⎨        ⎩UNIT⎭    ⎬  OF file-name
                                          ⎪                  ⎪
                                          ⎩integer-1 RECORDS ⎭
```

implementor-name

Specified as SYSnnn (0 ≤ nnn ≤ 244)
COBOL85 generates either one or two checkpoint files:

a) One checkpoint file if nnn ≤ 200.
COBOL85 forms the standard name `progid.RERUN.SYSnnn` as well as the link name SYSnnn.
Checkpoint records are written to this file continuously. At end of file, additional storage space is requested internally.

a) Two checkpoint files, if nnn > 200.
COBOL85 forms the standard names `progid.RERUN.SYS.nnnA`, `progid.RERUN.SYS.nnnB` and the link names SYSnnnA and SYSnnnB.
Checkpoint records are written to each of the two files alternately; any previously written checkpoint record will be overwritten.

Format 2 of the RERUN clause is permitted for sort files only; it is therefore described in section 10.3.

After each successful output of a checkpoint record, information necessary for a possible restart will be displayed on SYSOUT.

Message format (see [6]):

```
EXC0301 CHECKPOINT 'aa' INITIATED ON HALF PAGE 'bb', DATE=cc, TIME=dd:ee
```

aa	checkpoint number
bb	PAM page number
cc	mm/dd/yy:month/day/year
dd	hour
ee	minute

11.2 Restart

The RESTART-PROGRAM command enables the user to restart an executable program at a point at which a checkpoint was taken.

Format of the RESTART-PROGRAM command (see [3]):

```
RESTART-PROGRAM filename,REST-OPT=START-PROG(CHECKPOINT=NUMBER(...)
```

filename	Name of the checkpoint file (COBOL standard name; see section 11.1)
NUMBER(...)	Number of the PAM page in which the checkpoint records begin

Notes

1. Before restart the user must assign all resources that are required by the program to be restarted, because data concerning the required resources is not saved when a checkpoint is taken.
2. The status of user data is **not** automatically restored at restart. Therefore, the user has to provide the data in an appropriate form as at the time the checkpoint was taken.

12 Program linkage

A program system consists of a main program (the program that is called at system level) and one or more external subprograms that may be written in the same language as the main program or in other programming languages.

Consequently, a means of linking the various programs is required; this function is performed by the Inter-Language Communication Services (ILCS). ILCS is a component of the Common Runtime Environment (CRTE) and is described in the CRTE User Guide [2].

Note

In contravention of the ILCS conventions, the most significant bit of the last parameter of the list is set when passing a number of parameters from a COBOL program to a called program, unless one or more parameters of the list are passed "by value" (see 12.3).

12.1 Linking and loading subprograms

The name of a subprogram can be specified in the CALL statement either as a literal or as the identifier of a data item that contains the subprogram name.
Depending on the kind of subprogram call, a program system is linked and loaded in different ways.

Subprogram call “CALL literal”

The name of the subprogram is already defined at compilation time. The compiler sets up external references to these subprograms; these are resolved by the relevant linkage editor in subsequent linkage runs. If a program system contains only calls in the form “CALL literal”, it may be linked into a permanent or temporary executable run unit and loaded subsequently, as described in chapter 6.

Subprogram call “CALL identifier”

The name of the subprogram need not be known before runtime (e.g. upon input at the terminal). For subprograms called as required by means of “CALL identifier” there are no external references; they are therefore loaded dynamically by DBL during program execution. Program systems with subprograms of this kind can only be run in one of the following ways:

1. Use DBL to dynamically link the modules generated during the compilation, and dynamically load the subprograms without external references.
2. Use TSOSLNK to create a prelinked module which contains the main program as well as the subprograms with external references. Call the prelinked module with DBL and dynamically load the subprograms without external references.
3. Use BINDER to (pre-)link one or more link-and-load modules (LLMs). Then use DBL to call the (prelinked) LLM or the LLM containing the main program, and dynamically load the subprograms without external references.

Generally, before calling DBL, the following assignments must be made:

```
/SET-FILE-LINK COBOBJCT,library
```

for the library containing the subprograms to be dynamically loaded

and

```
/SET-FILE-LINK BLSLIBnn,runtime-library
```

for the Common Run-Time Environment (CRTE), which contains the COBOL runtime system.

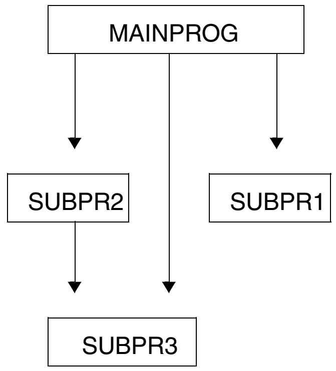
Note that use of the link name BLSLIBnn is possible only if
`RUN-MODE=ADVANCED(ALTERNATE-LIBRARIES=YES)`
is specified in the command for calling DBL (see section 6.4).

Note

In link-and-load modules (LLMs), program names with a length of up to 30 characters may be specified in CALL identifier or CANCEL identifier statements. In object modules, program names must not exceed eight characters. For CANCEL identifier statements these names must be unique in the *run-unit* in the first seven characters; the eighth character must not be a hyphen ‘-‘.

Example 12-1: Linking and loading techniques for program systems containing dynamically loadable subprograms

Program constellation and types of calls



MAINPROG:

```
...
CALL “SUBPR1” USING ...
MOVE “SUBPR2” TO identifier-1
MOVE “SUBPR3” TO identifier-2
CALL identifier-1 USING identifier-2
...
```

SUBPR2:

```
    ...
    PROCEDURE DIVISION USING identifier-2
    CALL identifier-2
```

```
...
CALL “SUBPR3”
...
```

SUBPR1 is called only in the form “CALL literal”.
SUBPR2 is called only in the form “CALL identifier”.
SUBPR3 is called in either way.

This means that external references are set up for SUBPR1 and SUBPR3; SUBPR2 is loaded dynamically.

The ways of initiating the program run for this program constellation are shown below.

The individual programs are stored as object modules under the element names MAINPROG, SUBPR1, SUBPR2 and SUBPR3 in the library USER-PROGRAMS.

1. Using DBL (dynamic linking)

```
/SET-FILE-LINK BLSLIB00,$.SYSLNK.CRTE  ———————————————————————————————— (1)
/SET-FILE-LINK COBOBJCT,USER-PROGRAMS  ———————————————————————————————— (2)
/START-PROGRAM *MODULE(LIB=USER-PROGRAMS,ELEM=MAINPROG,-   ———————————— (3)
 RUN-MODE=ADVANCED(ALT-LIB=YES,UNRES-EXT=DELAY,-
 LOAD-INF=REFERENCES))
```

(1) Assigns the runtime library.

(2) Assigns the library from which subprogram SUBPR2 will be dynamically loaded.

(3) Calls the object module containing the main program MAINPROG. DBL searches the library specified here (USER-PROGRAMS) to resolve the external references to SUBPR1 and SUBPR3.
The operands UNRESOLVED-EXTERNAL=DELAY and LOAD-INFORMATION=REFERENCES must always be specified whenever the load unit contains unresolved weak external references (WXTRNs) (see [9]). This typically occurs when additional files are to be processed in the subprogram with a different file organization than in the main program.

2. Using TSOSLNK (linking prelinked modules)

```
/START-PROGRAM $TSOSLNK
 MODULE PRLNKMOD,LET=Y,LIB=MODUL.LIB ──────────────────────────────────── (1)
 INCLUDE MAINPROG,USER-PROGRAMS ────────────────────────────────────────── (2)
 RESOLVE ,USER-PROGRAMS ────────────────────────────────────────────────── (3)
 RESOLVE ,$.SYSLNK.CRTE  ───────────────────────────────────────────────── (4)
 LINK-SYMBOLS *KEEP ────────────────────────────────────────────────────── (5)
 END

/SET-FILE-LINK BLSLIB00,$.SYSLNK.CRTE ──────────────────────────────────── (6)
/SET-FILE-LINK COBOBJCT,USER-PROGRAMS ──────────────────────────────────── (7)
/START-PROGRAM *MODULE(LIB=MODUL.LIB,ELEM=PRLNKMOD,-   ─────────────────── (8)
 RUN-MODE=ADVANCED(ALT-LIB=YES,UNRES-EXT=DELAY,-
 LOAD-INFO=REFERENCE))
```

(1) The prelinked module PRLNKMOD is stored in the MODUL.LIB library.

(2) Links in the MAINPROG module from the USER-PROGRAMS library.

(3) Links in the USER-PROGRAMS library to resolve external references to SUBPR1 and SUBPR3.

(4) Links in the library that contains the runtime routines.

(5) Symbols for the entry points and the program segments for subsequent execution under DBL are kept visible by means of this statement.

(6) Assigns the runtime library.

(7) Assigns the library from which subprogram SUBPR2 will be dynamically loaded.

(8) Calls the prelinked module PRLNKMOD. The operands UNRESOLVED-EXTERNAL=DELAY and LOAD-INFORMATION=REFERENCES must always be specified whenever the load unit contains unresolved weak external references (WXTRNs) (see [9]). This typically occurs when additional files are to be processed in the subprogram with a different file organization than in the main program.

3. Using BINDER (linking LLMs)

Unlike TSOSLNK, BINDER keeps all external references and entry points visible by default; this is essential for the succeeding DBL run.

Moreover, using BINDER enables external references to remain unresolved. This means that the runtime system does not have to be linked in. This is an advantage if a shareable runtime system is to be used for program execution.

a) Generating a single link-and-load module

```
/START-PROGRAM $BINDER
 START-LLM-CREA PRLNKMOD ———————————————————————————————————————————————— (1)
 INCLUDE-MODULES LIB=USER-PROGRAMS,ELEM=MAINPROG ———————————————————————— (2)
 INCLUDE-MODULES LIB=USER-PROGRAMS,ELEM=UPROG2 —————————————————————————— (3)
 RESOLVE-BY-AUTOLINK LIB=USER-PROGRAMS —————————————————————————————————— (4)
 SAVE-LLM LIB=MODUL.LIB ————————————————————————————————————————————————— (5)
 END

/SET-FILE-LINK BLSLIB00,$.SYSLNK.CRTE  —————————————————————————————————— (6)
/START-PROGRAM *MODULE(LIB=MODUL.LIB,ELEM=PRLNKMOD,-    ————————————————— (7)
 RUN-MODE=ADVANCED(ALT-LIB=YES,UNRES-EXT=DELAY,-
 LOAD-INFO=REFERENCE))
```

(1) Creates a link-and-load module named PRLNKMOD.

(2) Explicitly links in the main program module MAINPROG from the USER-PROGRAMS library.

(3) Explicitly links in the module SUBPR2 from the USER-PROGRAMS library in order to avoid dynamic loading. This makes it unnecessary to assign the USER-PROGRAMS library with the link name COBOBJCT in the ensuing link-and-load operation.

(4) Links in all other modules required (SUBPR1, SUBPR3) from the USER-PROGRAMS library.

(5) Stores the generated link-and-load module as a type L element in the program library MODUL.LIB.

(6) Assigns the runtime library.

(7) Calls the link-and-load module PRLNKMOD. The operands UNRESOLVED-EXTERNAL=DELAY and LOAD-INFORMATION=REFERENCES must always be specified whenever the load unit contains unresolved weak external references (WXTRNs) (see [9]). This typically occurs when additional files are to be processed in the subprogram with a different file organization than in the main program.

b) Converting object modules into single link-and-load modules

```
/START-PROGRAM $BINDER
 ...
 START-LLM-CREATION INTERNAL-NAME=MAINPROG          ⎫
 INCLUDE-MODULES LIB=USER-PROGRAMS,ELEM=MAINPROG    ⎬ ───────────────── (1)
 SAVE-LLM LIB=MODULE.LLM                            ⎭
 ...
 START-LLM-CREATION INTERNAL-NAME=UPROG1          ⎫
 INCLUDE-MODULES LIB=USER-PROGRAMS,ELEM=UPROG1    ⎬ ─────────────────── (2)
 SAVE-LLM LIB=MODULE.LLM,ENTRY-POINT=UPROG1       ⎭
 ...
 START-LLM-CREATION INTERNAL-NAME=UNTER2          ⎫
 INCLUDE-MODULES LIB=USER-PROGRAMS,ELEM=UPROG2    ⎬ ─────────────────── (3)
 SAVE-LLM LIB=MODULE.LLM,ENTRY-POINT=UPROG2       ⎭
 ...
 START-LLM-CREATION INTERNAL-NAME=UPROG3          ⎫
 INCLUDE-MODULES LIB=USER-PROGRAMS,ELEM=UPROG3    ⎬ ─────────────────── (4)
 SAVE-LLM LIB=MODULE.LLM                          ⎭
 END
 ...
/SET-FILE-LINK BLSLIB00,$.SYSLNK.CRTE ─────────────────────────────── (5)
/SET-FILE-LINK COBOBJCT,MODULE.LLM ────────────────────────────────── (6)
/START-PROGRAM *MODULE(LIB=MODULE.LLM,ELEM=MAINPROG,-  ────────────── (7)
 RUN-MODE=ADVANCED(ALT-LIB=YES,UNRES-EXT=DELAY,-
 LOAD-INFO=REFERENCE))
```

(1) Creates an LLM named MAINPROG; the name of the LLM is freely selectable. Links in the object module MAINPROG from the USER-PROGRAMS library. As the element name is omitted from the SAVE-LLM command, the name specified in the START-LLM-CREATION command is used; that is, MAINPROG.

(2) Creates an LLM named SUBPR1. Links in the object module SUBPR1 from the USER-PROGRAMS library. ENTRY-POINT=SUBPR1 defines this LLM as a subprogram.

(3) Creates an LLM named SPROG2. Links in the object module SUBPR2 from the USER-PROGRAMS library. ENTRY-POINT=SUBPR2 defines this LLM as a subprogram.

(4) Creates an LLM named SUBPR3. Links in the object module SUBPR3 from the USER-PROGRAMS library. As no ENTRY-POINT is specified in the SAVE-LLM command, SUBPR3 can be used both as a subprogram and as a main program.

(5) Assigns the runtime library.

(6) Assigns the library containing the LLMs by means of the link name COBOBJCT so that the unresolved external references of the previously created LLMs can be resolved.

(7) Calls the LLM containing the main program MAINPROG. The operands UNRESOLVED-EXTERNAL=DELAY and LOAD-INFORMATION=REFERENCES must always be specified whenever the load unit contains unresolved weak external references (WXTRNs) (see [9]). This typically occurs when additional files are to be processed in the subprogram with a different file organization than in the main program.

12.2 COBOL special register RETURN-CODE

The COBOL special register RETURN-CODE can be used for communication purposes between separately compiled COBOL programs of a run unit. The special register exists only once in the program system and is defined internally as a four-digit binary data item (PIC S9(9) COMP-5 SYNC).
RETURN-CODE can be interrogated or modified as required at run time by the separately compiled programs. On termination of the program run, the runtime system checks whether RETURN-CODE is zero. If this is not the case, the error message COB9119 (if the COBOL return code > 0) or COB9128 (if the user return code > 0) is output. If the program was called within a procedure, the program branches to the next STEP, ABEND, ABORT, ENDP or LOGOFF command.

When a COBOL subprogram is exited, the value of the special register RETURN-CODE is also loaded in registers 0 and 1. This makes the value available to the calling program in the form of a function value, in accordance with the ILCS conventions.

To use a function value from a C program, the calling COBOL program must be compiled with the control statement
RETURN-CODE=FROM-ALL-SUBPROGRAMS for the RUNTIME-OPTIONS option,
or with the COMOPT operand ACTIVATE-XPG4-RETURNCODE=YES.

To avoid the abnormal termination of the program, the user must ensure that RETURN-CODE contains the value 0 before the STOP RUN statement is reached.

12.3 Passing parameters to C programs

To enable C-compatible values to be passed directly to C programs, the CALL statement in either language format contains the specification

```
USING BY VALUE {identifier-3} ...
```

identifier-3 must be defined as a 2- or 4-byte long data item with USAGE COMP-5, or as a 1-byte long data item. Otherwise, the result of the parameter transfer will be uncertain.
If parameters are passed “by value”, this means that only the value of a parameter is passed to the C program that has been called. The called program can access this value and modify it, but the value of the parameter in the COBOL program remains unchanged.
If at least one of the parameters in a list is passed “by value”, then the last parameter in the list will not be marked.

13 COBOL85 and the POSIX subsystem

Not supported in COBOL85-BC !

The COBOL85 compiler (V2.3) can be invoked and passed control options in the POSIX environment (POSIX shell).

In addition, COBOL programs compiled in the POSIX environment or in BS2000 can be run in the POSIX environment.

Finally, if the POSIX subsystem is available, it is possible to access the POSIX file system even when running the compiler or a program in BS2000.

For further information on POSIX you can refer to the following publications:

POSIX in BS2000/OSD

This brochure provides a general overview of the strategies and objectives for POSIX in BS2000/OSD.

POSIX - Basics

This manual offers a helpful introduction to POSIX and supplies all the basic information needed to use the POSIX subsystem.

POSIX - Commands

This manuals contains descriptions of all the POSIX user commands.

13.1 Overview

The following three subsections summarize how the compiler is used in the POSIX subsystem.

13.1.1 Compiling

Generating an LLM object file (“.o” file)

For each source file it compiles, the compiler generates an LLM and stores it as a POSIX object file with the default name *basename*.o.
basename is the name of the source file without its directory components and without the .cob or .cbl extension.

When compiling source program sequences, the compiler generates an LLM for each source program and stores each LLM in a POSIX object file. In this case *basename* is the associated PROGRAM-ID name for the second to the last source program. Lower-case letters are converted to upper-case if necessary.
Unless otherwise specified, a linkage run is started once the compilation run is completed. You can use the `-c` option (see p. 275) to suppress the linking phase.

Generating a compiler listing

You can use the `-P` option (see p. 278) to request various compiler listings (source listing, diagnostic listing, cross-reference listing and so forth). The compiler writes the listings you request to a listing file with the default name *basename*.lst and stores it in the current directory. *basename* is the name of the source file without the directory components and without the suffix .cob or .cbl. In these cases, the name of the source file can also be specified with the option *-k file-name*.

To print listing files you can use the POSIX `lp` command (see the “POSIX Commands” manual).

Example of printing a compiler listing

```
lp -o control-mode=*physical cobbsp.lst
```

Output locations and output code

The compiler stores the output files in the current directory, i.e. in the directory from which the compiler run was started.
Character and character string constants in the program (object file) are always stored in EBCDIC.

If you store the POSIX file system on a mounted UNIX file system or edit the POSIX files in ASCII code with UNIX tools, you must store error files (ERRFIL or piped screen output) outside the POSIX file system in BS2000, since code conversion is available only in limited form for these files.

13.1.2 Linking

In the POSIX shell you use the `cobol` command to link a COBOL program into an executable file.

A linkage run is automatically started provided that the `-c` option is not specified (see p. 275) and that no serious errors occurred in a possible preceding compilation.
Once linked, the program is written to an executable POSIX file in the form of an LLM. The name of this file and the directory it is stored in are defined by the `-o` option. If this option is not specified, the executable POSIX file is stored in the current directory under the default name `a.out`.

When performing linking in the POSIX shell it is not possible to generate linkage editor listings. If errors occur, error messages are written to stderr.

Linking user modules

User-written modules can be linked in statically and dynamically (i.e. at runtime). Programs containing unresolved external references to user modules cannot be started in the POSIX shell.

The possible input sources for the linkage editor are:

- object files generated by the compiler (".o" files)
- archives created with the `ar` utility (".a" files)
- LLMs copied from PLAM libraries to POSIX object files using the POSIX `bs2cp` command. These may be LLMs directly generated by a compiler in a BS2000 environment or object modules written to an LLM using the BINDER linkage editor.
- LLMs and object modules stored in BS2000 PLAM libraries. This entails assigning the PLAM libraries using the BLSLIB*nn* environment variables (see `-l BLSLIB` option, p. 280).

The modules may be modules generated by any ILCS-capable BS2000 compiler (such as COBOL85, C, C++, ASSEMBH or Fortran90).

If modules generated in a BS2000 environment by the COBOL85 compiler are to be linked, they must have been compiled using the ENABLE-UFS-ACCESS option.

During the linkage run, INCLUDE-MODULES statements are issued internally for POSIX object files, while RESOLVE-BY-AUTOLINK statements are issued for ar archives and PLAM libraries. The modules are linked in the order described below.

When linking you must use the `-M` option to specify the name of the COBOL main program (PROGRAM-ID name). If you fail to do so, the linkage editor will assume the main program is a C program.

Linking CRTE runtime libraries

The linkage editor resolves open external references to the COBOL85 runtime system automatically from the CRTE library SYSLNK.CRTE.PARTIAL-BIND. The POSIX option (/opt/CRTE/lib/posix.o) is also automatically linked.

Linking order

1. All explicitly specified object files (“.o“ files) with INCLUDE-MODULES statements and, where appropriate, all explicitly specified ar libraries (“.a“ files). A separate RESOLVE-BY-AUTOLINK statement is issued for each ar library.
2. All compiler-generated object files with INCLUDE-MODULES statements
3. All ar libraries specified with the options `-l` and `-L`, and PLAM libraries assigned with `-l BLSLIB`. A separate RESOLVE-BY-AUTOLINK statement is issued for each ar library. The PLAM libraries assigned with `-l BLSLIB` are passed to the BINDER linkage editor in list form in a single RESOLVE-BY-AUTOLINK.
4. The CRTE libraries (/opt/CRTE/lib/posix.o, SYSLNK.CRTE.PARTIAL-BIND) and, if appropriate, the SORT library (SORTLIB)

The object files and libraries processed in steps 1 to 3 are linked in the order in which they appear in the command line. In the case of object files generated by the compiler (see step 2) the order of linking depends on the order of the associated source files.

Example

```
export BLSLIB99=‘$MYTEST.LIB2‘
export BLSLIB01=‘$MYTEST.LIB1‘
cobol -M COBBSP -o cobbsp cobupro1.cob cobupro2.cob cobbsp.o cobupro3-5.a
-L /usr/private -l xyz -l BLSLIB
```

Linking order:

1. cobbsp.o
2. cobupro3-5.a
3. cobupro1.o

4. cobupro2.o
5. /usr/private/libxyz.a
6. $MYTEST.LIB1
7. $MYTEST.LIB2
8. Runtime libraries

13.1.3 Debugging

Linked programs can be debugged with the AID Advanced Interactive Debugger.
This is conditional on the availability of debugging information (LSD) generated by the compiler when invoked with the `-g` option (see p. 281).

To activate the AID debugger, you use the POSIX command `debug` *program-name [arguments]* at a BS2000 terminal.
After you enter this command, the BS2000 environment will be your current environment, as indicated by the %DEBUG/ prompt. In this mode you can enter debugging commands as described in the manual “AID Debugging of COBOL Programs”. When you terminate the program, your current environment will again be the POSIX shell.

The `debug` command is described in the “POSIX Commands” manual.

13.2 Reading in the source program

The COBOL85 compiler identifies COBOL source files by the presence of one of the following standard file name extensions:

`.cob` or `.cbl`

COBOL source files with file names not ending in a standard extension can still be compiled, as long as the file names are specified with the **-k** option (see p. 275).

Source programs stored in BS2000 files or PLAM libraries cannot be processed by the compiler in the POSIX subsystem.

To transfer BS2000 files and PLAM library elements to the POSIX file system and back you can use the POSIX `bs2cp` command.

The POSIX `edt` command allows you to edit POSIX files at a BS2000 terminal
If the POSIX subsystem was accessed from a SINIX terminal, the POSIX command `vi` is available for editing purposes. Refer to the “POSIX Commands” manual.

Input of source program segments (COPY elements)

The format of the COPY statement for extracting COPY texts from POSIX files is as follows:

```
COPY text-name [IN/OF library-name]
```

text-name is the name of the POSIX file (without the directory components) containing the COPY text. The name may not contain lowercase letters.

library-name is the name of an environment variable containing one or more absolute path names of directories to search. The name may not contain lowercase letters.

If the IN/OF *library-name* argument is not included in the COPY statement, the compiler evaluates the contents of an environment variable named COBLIB.

Before the compiler is invoked, the environment variables must have been assigned the path names of the directories to search and exported with the POSIX `export` command.

Example

COPY statements in the source program:

```
   COPY TEXT1 IN COPYLNK
   COPY TEXT2 IN COPYLNK
```

Defining and exporting the environment variable in the POSIX shell:

```
export COPYLNK=/USERIDXY/copy1:/USERIDXY/copy2
```

The colon causes the COPYLNK environment variable to be initialized with the names of two directories to be searched for the POSIX files containing the COPY texts (TEXT1, TEXT2). The directory /USERIDXY/copy1 is first searched and then the directory /USERIDXY/copy2.

13.3 Controlling the compiler

In the POSIX shell you can use the **cobol** command to invoke the COBOL85 compiler and pass it control options.

Command-line syntax

`cobol`␣*option*␣ ... *input-file*␣ ...

Input rules

1. Options and input files may be specified in any order.
2. Options without arguments (e.g. `-c, -v, -g`) may be grouped together (e.g. `-cvg`).
3. An option (such as `-C`) and its arguments must not be grouped in this way. There must always be a blank (␣) between the option and the argument (e.g. `-C EXPAND-COPY=YES`).
4. The following options may appear more than once in the command line:

   `-C, -CC, -k, -L, -P, -l`

   All other options are only allowed once. If one of these options is specified more than once, the last instance in the command line will apply.

By default, i.e. if the `-c` option is not used to terminate the compiler run after compilation and if the program compiled without serious errors, a linkage run automatically follows compilation.

If a C compiler is present, you can use the `cobol` command to concurrently compile C source programs as well as COBOL sources and link them into the COBOL application.

The options for controlling the compilation and linkage run are described below.

13.3.1 General options

–c

This option terminates the compiler run once an LLM has been generated and stored in an object file named *basename*.o for each source file compiled. *basename* is the name of the source file without its directory components and without the .cob or .cbl extension.
The object file is written to the current directory.

If a source program is compiled without this option, a linkage run is started once compilation is complete.

–k *filename*

This option allows you to specify a COBOL source file which does not have the extension `.cbl` or `.cob`.

If the source file name specified with `-k` does however end with the suffix `.cbl` or `.cob`, this suffix is overwritten with the suffix `.o` or `.lst` when the basename for the object and listing files is formed.

–v

This option causes the following information to be displayed on the screen:

– messages of the COBOL85 compiler relating to accepted control statements
– the full command line for linkage editor invocation
– the copyright and version strings of the COBOL85 compiler and of the cobol command
– all the information and error messages of the compilation run
– CPU time consumed

This option affects only the output of the COBOL85 compiler.

The option `-CC -V` must be used if appropriate messages of the C compiler are also to be output when simultaneously compiling C sources.

–W *err-level*

This option is mapped internally to COMOPT MINIMAL-SEVERITY = err-level. The COMOPT MINIMAL-SEVERITY should not therefore be passed with -C.
As a result of this option, the diagnostic listing excludes any messages with an error level lower than the specified value. The possible values for *err-level* are:

`I`	information (default)
`0`	warning
`1`	error
`2`	unrecoverable error
`3`	system error

13.3.2 Option for compiler statements

–C *comopt*

comopt can be replaced by all the COMOPT statements listed below, either in full or abbreviated form.
The functions of the various COMOPTs are described in chapter 4.

Example

```
-C SET-FUNCTION-ERROR-DEFAULT=YES or -C S-F-E-D=YES
```

Overview: COMOPTs that can be passed with the –C option

COMOPT	Possible abbreviation
ACCEPT-LOW-TO-UP={YES/<u>NO</u>}	ACC-L-T-U
ACTIVATE-WARNING-MECHANISM={YES/<u>NO</u>}	ACT-W-MECH
ACTIVATE-XPG4-RETURNCODE={YES/<u>NO</u>}	
CHECK-CALLING-HIERARCHY={YES/<u>NO</u>}	CHECK-C-H
CHECK-DATE={<u>YES</u>/NO}	CHECK-D
CHECK-FUNCTION-ARGUMENTS={YES/<u>NO</u>}	CHECK-FUNC
CHECK-PARAMETER-COUNT={<u>YES</u>/NO}	CHECK-PAR-C
CHECK-REFERENCE-MODIFICATION={YES/<u>NO</u>}	CHECK-REF
CHECK-SCOPE-TERMINATORS={YES/<u>NO</u>}	CHECK-S-T
CHECK-SOURCE-SEQUENCE={YES/<u>NO</u>}	CHECK-S-SEQ

CHECK-TABLE-ACCESS={YES/NO}	CHECK-TAB
CONTINUE-AFTER-MESSAGE={YES/NO}	CON-A-MESS
EXPAND-COPY={YES/NO}	EXP-COPY
FLAG-ABOVE-INTERMEDIATE={YES/NO}	
FLAG-ABOVE-MINIMUM={YES/NO}	
FLAG-ALL-SEGMENTATION={YES/NO}	
FLAG-INTRINSIC-FUNCTIONS={YES/NO}	
FLAG-NONSTANDARD={YES/NO}	
FLAG-OBSOLETE={YES/NO}	
FLAG-REPORT-WRITER={YES/NO}	
FLAG-SEGMENTATION-ABOVE1={YES/NO}	
GENERATE-INITIAL-STATE={YES/NO}	GEN-INIT-STA
GENERATE-LINE-NUMBER={YES/NO}	GEN-L-NUM
GENERATE-SHARED-CODE={YES/NO}	GEN-SHARE
IGNORE-COPY-SUPPRESS={YES/NO}	IGN-C-SUP
INHIBIT-BAD-SIGN-PROPAGATION={YES/NO}	
LINE-LENGTH=132 / 119..172	LINE-L
LINES-PER-PAGE=64 / 20..128	LINES
MARK-NEW-KEYWORDS={YES/NO}	M-N-K
MAXIMUM-ERROR-NUMBER=integer	MAX-ERR
MERGE-DIAGNOSTICS={YES/NO}	M-DIAG
OPTIMIZE-CALL-IDENTIFIER={YES/NO}	O-C-I
RESET-PERFORM-EXITS={YES/NO}	RES-PERF
ROUND-FLOAT-RESULTS-DECIMAL={YES/NO}	ROUND-FLOAT
SEPARATE-TESTPOINTS={YES/NO}	SEP-TESTP
SET-FUNCTION-ERROR-DEFAULT={YES/NO}	S-F-E-D
SHORTEN-OBJECT={YES/NO}	SHORT-OBJ
SHORTEN-XREF={YES/NO}	SHORT-XREF
SORT-EBCDIC-DIN={YES/NO}	SORT-E-D
SORT-MAP={YES/NO}	
SUPPORT-WINDOW-DEBUGGING={YES/NO}	S-W-D
SUPPRESS-LISTINGS={YES/NO}	SUP-LIST
SUPPRESS-MODULE={YES/NO}	SUP-MOD
TCBENTRY=name	

TERMINATE-AFTER-SEMANTIC={YES/NO}	TERM-A-SEM
TERMINATE-AFTER-SYNTAX={YES/NO}	TERM-A-SYN
TEST-WITH-COLUMN1={YES/NO}	TEST-W-C
USE-APOSTROPHE={YES/NO}	USE-AP

13.3.3 Option for compiler listing output

–P "(*listing, ...*)"

This option controls which listings are generated by the compiler.
This option is mapped internally to COMOPT SYSLIST=(listing,...). The COMOPT SYSLIST should not therefore be passed with -C.
The *listing* argument takes the form of a list of any of the following values (as with COMOPT SYSLIST in BS2000):

```
OPTIONS
NOOPTIONS
SOURCE
NOSOURCE
MAP
NOMAP
DIAG
NODIAG
XREF
NOXREF
ALL
NO
```

By default (NO), no compiler listings are generated.

The compiler writes listings requested with the `–P` option to a listing file named *basename*.lst, where *basename* is the name of the source file without its directory components and without the .cob or .cbl extension. The listing file is stored in the current directory.

Example

```
–P "(ALL,NOXREF)"
```

13.3.4 Options for the linkage run

The following linkage editor options have no effect if the `–c` option is used to terminate the compiler run once compilation is complete. The `cobol` command issues a warning for any such unused option.
General information on linking and the linking order is provided in section 13.1.2 (p.269ff).

–L *directory*

You use this option to specify path names of directories that the linkage editor is to search for libraries named `lib`*name*`.a`. These libraries must be specified with the `–l` *name* option. By default, only `/usr/lib` and `/usr/ccs/lib` are searched for libraries.
The order of the `–L` options is significant. The directories specified with `–L` are always searched with higher priority ahead of the default directories.

–M *name*

name must be the PROGRAM-ID name of the COBOL main program in uppercase letters. This option must always be specified if the main program is a COBOL program.

–o *output-file*

The executable file generated by the linkage editor is written to *output-file*.
If *output-file* does not include any directory components, the file will be stored in the current directory; otherwise it will be stored in the directory specified as part of *output-file*.
By default, the executable is stored in the current directory under the name `a.out`.

–l *name*

This option causes the linkage editor to search the library named `lib`*name*`.a` when resolving external references using the AUTOLINK mechanism.
If no other directory is specified with the linkage editor's `–L` option, the linkage editor looks for the specified library in `/usr/lib` and `/usr/ccs/lib`.
The sort library lib*sort.a* (for example) is not in the default directories, but is installed as a PLAM library in BS2000.
The linkage editor searches the libraries in the order in which they appear in the command line.

`-l BLSLIB`

This option causes the linkage editor to scan PLAM libraries that have been assigned using the shell environment variables named BLSLIB*nn* (00 ≥ *nn* ≤ 99). The environment variables must have been assigned the library names and exported with the POSIX `export` command before the compiler is invoked. The libraries are scanned in ascending order of *nn*.
All the libraries assigned with the BLSLIB*nn* environment variables are internally passed to the BINDER in list form in a single RESOLVE statement.

Example

```
export BLSLIB00=‘$RZ99.SYSLNK.COB.999‘
export BLSLIB01=‘$MYTEST.LIB‘
cobol mytest.o –l BLSLIB –M MYTEST
```

13.3.5 Debugger option

–g

The compiler generates additional information (LSD) for the AID debugger. By default no debugging information is generated.
This option is mapped internally to COMOPT SYMTEST=ALL. The COMOPT SYMTEST should not therefore be passed with -C.

13.3.6 C-specific option

–CC *option*

option is passed through to the C compiler (c89 command).
If the option you pass requires an argument, then by contrast with the usual option conventions there must be no blank between the option name and the argument. The options of the c89 command are detailed in the manual “POSIX Commands of the C and C++ Compilers”.

Example

```
-CC -Xls -CC -FIabs
```

13.3.7 Input files

The compiler deduces the contents of a file from its file name extension and performs the appropriate compilation actions. Hence the file name must have the extension which is appropriate to the file's contents in accordance with POSIX conventions. The choices are:

Extension	**Meaning**
.cob/.cbl	COBOL source file
.o	Object file generated in an earlier compilation
.a	Object file archive generated by the `ar` utility
.c/.C/.i	C source file (see manual "POSIX Commands of the C and C++ Compilers")

Files with a .cob or .cbl extension are the input sources for the COBOL85 compiler. The COBOL85 compiler also recognizes COBOL source files with names which do not have one of these standard extensions, but in this case the names of the source files must be specified with the `-k` *filename* option (see p. 275), not as operands.

Files with a .o or .a extension are the input sources for the linkage editor.

File names with other extensions are passed through to the c89 command for the C compiler.

13.3.8 Output files

The following files are generated with default names and stored in the current directory. You can select a different file name and a different directory for the linkage editor output file (a.out) by using the `-o` option (see p. 279).
basename is the name of the source file without its default extension and without its directory components.

basename.lst	file containing all the compiler listings
basename.o	LLM object file generated by the compiler, suitable for further processing by the linkage editor
a.out	executable file generated by the linkage editor

When source program sequences are compiled, the names of the LLM object files for the second through to the last source program are formed from the PROGRAM-ID name and the .o extension.

13.4 Introductory examples

Compiling and linking with the cobol command

```
cobol -M BSPPROG hugo.cob
```

compiles `hugo.cob` and generates an executable named `a.out`.
The program with the PROGRAM-ID name BSPPROG becomes the main program

```
cobol -o hugo -M BSPPROG hugo.cob
```

compiles `hugo.cob` and generates an executable named `hugo`.
The program with the PROGRAM-ID name BSPPROG becomes the main program

```
cobol -c -P "(SOURCE,DIAG)" hugo.cob upro.cob
```

compiles `hugo.cob` and `upro.cob` and generates the object files `hugo.o` and `upro.o` and a source and diagnostic listing for each program. The listings are stored in the listing files `hugo.lst` and `upro.lst` respectively.

```
cobol -M BSPPROG -o hugo hugo.o upro.o
```

links the main program `hugo.o` and the subprogram `upro.o` into an executable named `hugo`.
The program with the PROGRAM-ID name BSPPROG becomes the main program

13.5 Differences from COBOL85 in BS2000

Owing to the system-specific differences between POSIX and BS2000, when developing programs to run under POSIX you need to allow for a number of special features related to the scope of the language and its runtime behavior, as discussed in the following subsections.

13.5.1 Restrictions on the functionality of the language

The following language tools of the COBOL85 compiler are not supported when the program is run in the POSIX subsystem.

Dynamic subprogram call

In POSIX it is not possible to call a subprogram using the COBOL statement CALL *identifier*. The runtime system responds to a dynamic subprogram call by issuing error message COB9164 (CALL cannot be executed).

ENTRY statement

The ENTRY statement is not allowed when the program is run under POSIX because it can only be used to define entry points to object modules, and under POSIX the compiler always generates link-and-load modules (LLMs).

Segmentation

As the compiler under POSIX always generates link-and-load modules (LLMs), COBOL program segmentation is not possible in POSIX.

File processing

- Label handling when processing magnetic tapes is not possible in POSIX.
- Checkpointing for restart of magnetic tapes is not possible in POSIX.
- Shared updating of files is not possible in POSIX.

13.5.2 Extensions to the functionality of the language

Access to the command line

Under POSIX it is possible to access the command line from within a program by means of ACCEPT/DISPLAY statements in conjunction with the special names ARGUMENT-NUMBER and ARGUMENT-VALUE (see COBOL85 Reference Manual [1]).

Example

```
IDENTIFICATION DIVISION.
...
SPECIAL-NAMES.
    ARGUMENT-NUMBER IS NO-OF-CMD-ARGUMENTS
    ARGUMENT-VALUE  IS CMD-ARGUMENT
...
WORKING-STORAGE SECTION.
01  I    PIC  99   VALUE 0.
01  J    PIC  99   VALUE 0.
01  A    PIC  X(5) VALUE ALL "x".
...
PROCEDURE DIVISION.
...
  ACCEPT I FROM NO-OF-CMD-ARGUMENTS
  DISPLAY "no. of command arguments=" I
  PERFORM VARYING J FROM 1 BY 1 UNTIL J > I
    ACCEPT A FROM CMD-ARGUMENT
    DISPLAY "cmd argument-" J " <" A ">"
  END-PERFORM
...
 DISPLAY 2 UPON NO-OF-CMD-ARGUMENTS
 ACCEPT  A  FROM CMD-ARGUMENT
 DISPLAY "argument-2" " :" A ":"
...
```

Calling the program

```
/a.out AAAA BBB CC D
```

Runtime log

```
no. of command arguments=4
cmd argument-1 <AAAA >
cmd argument-2 <BBB  >
cmd argument-3 <CC   >
cmd argument-4 <D    >
argument-2 :BBB  :
```

13.5.3 Differences in the program/operating system interfaces

COBOL programs running in POSIX behave differently in some respects to when running in BS2000:

Low-volume data I/O

In POSIX, the COBOL85 implementor names in ACCEPT/DISPLAY statements for low-volume data I/O are assigned the following standard input and output streams:

COBOL85	**BS2000**	**POSIX**
TERMINAL	SYSDTA	stdin
SYSIPT	SYSIPT	undefined
TERMINAL	SYSOUT	stdout
PRINTER	SYSLST	stdout
PRINTER01..99	SYSLST01..99	undefined
SYSOPT	SYSOPT	undefined
CONSOLE	CONSOLE	undefined

Sorting and merging

The sort file is automatically stored in the BS2000 file system, and the POSIX user has no access to it.

Job variable

The use of BS2000 job variables is not possible for programs run under POSIX.

Job switches and user switches

The use of BS2000 job switches and user switches is not meaningful for programs run under POSIX.

File processing

– The link between the external file name in the ASSIGN clause and the file name in the POSIX file system is established using an environment variable whose name is identical to the external file name in the ASSIGN clause. The name of the environment variable must always be in uppercase letters. Detailed information is provided in section 13.6.2, p.290ff.

- Program execution is not interrupted after an unsuccessful OPEN INPUT on a file for which OPTIONAL has not been specified.
- Some I/O status values are different in POSIX::

BS2000	**POSIX**
37	30
93, 94, 95	90

- In the extended I/O status that can be requested with filename-2 in the FILE STATUS clause, the (POSIX) SIS code is output instead of the (BS2000) DMS code.
- The file attributes are finally defined when the file is opened for the first time and cannot be modified later.
- Relative files which use the BS2000 access method UPAM cannot be processed.

13.6 Processing POSIX files

13.6.1 Program execution in the BS2000 environment

A COBOL program developed and executed in BS2000 can, in certain circumstances, access files from the POSIX file system as well as cataloged (BS2000) files.

Requirements

– When compiling, the compiler option ENABLE-UFS-ACCESS=YES or the SDF option RUNTIME-OPTIONS=PAR(ENABLE-UFS-ACCESS=YES) must be specified.

– When linking, the POSIX link option module contained in the CRTE library SYSLNK.CRTE.POSIX must be linked **with higher priority** ahead of the modules in the library SYSLNK.CRTE or SYSLNK.CRTE.PARTIAL-BIND.
When linking using TSOSLNK or BINDER, this library should be linked using an INCLUDE or INCLUDE-MODULES statement (without specifying the module name).
When linking dynamically using the DBL, the library must be assigned a BLSLIB*nn* with a lower *nn* than the CRTE libraries to be linked with lower priority.
When developing programs in the POSIX shell using the cobol command, the CRTE library is automatically linked.

Restrictions

The processing of a POSIX file is subject to the following restrictions:

– no label processing

– no checkpointing for restart

– no shared updating

– The file attributes are finally defined when the file is opened for the first time and cannot be modified later.

– Relative files which use the BS2000 access method UPAM cannot be processed.

The extended I/O status contains the (POSIX) SIS code instead of the (BS2000) DMS code (see p.290).

Assigning a POSIX file

A POSIX file is assigned using an SDF-P variable named SYSIOL-*external-name*, where SYSIOL is a fixed component of the name and *external-name* must contain the link name from the program's ASSIGN clause.

The SDF-P variable is set up with the command DECLARE-VARIABLE, which has the following format:

```
                                   ⎧'*POSIX(filename)'           ⎫
/[SET-VAR] SYSIOL-external-name=  ⎨'*POSIX(relative-pathname)'  ⎬ )
                                   ⎩'*POSIX(absolute-pathname)'  ⎭
```

`filename` identifies the requested file if it resides in the home directory of the POSIX file system.

`relative-pathname` is the file name with the directory components as of the home directory.

`absolute-pathname` is the file name with all directory components including the root directory (beginning with /).

Example of mixed file processing

COBOL source program:

```
...
FILE-CONTROL.
    SELECT POSFILE ASSIGN TO "CUST1"
    SELECT BS2FILE ASSIGN TO "CUST2"
...
```

Linkage with the POSIX file before calling the program:

```
/SET-VAR SYSIOL-CUST1='*POSIX(USERIDXY/customers/cust1)'
```

Linkage with the BS2000 file before calling the program:

```
/SET-FILE-LINK CUST2, CUST.FILE
```

13.6.2 Program execution in the POSIX shell

A COBOL program developed and executed in the POSIX shell or in BS2000 can process POSIX files without any preparatory steps when compiling and linking (cf. program execution in BS2000).
It is not possible to process BS2000 files from the POSIX shell.

When processing POSIX files, the same restrictions apply as for program execution in BS2000 (see p.288).

Assigning a POSIX file

A POSIX file is assigned using a shell environment variable named `external-name`.

`external-name` is a file name from the program's ASSIGN clause.
The environment variable must be initialized with the name of the POSIX file and exported using the POSIX export command.

The environment variable is initialized as follows:

```
               ⎧filename           ⎫
external-name= ⎨relative-pathname  ⎬
               ⎩absolute-pathname  ⎭
```

`filename` identifies the requested POSIX file if it is in the current directory.

`relative-pathname` is the file name with the directory components as of the current directory.

`absolute-pathname` is the file name with all directory components including the root directory (beginning with /).

Examplel

COBOL source program:

```
...
FILE-CONTROL.
SELECT AFILE ASSIGN TO "CUST1"
...
```

Linkage with the POSIX file cust1 before calling the program:

```
export CUST1=/USERIDXY/customers/cust1
```

13.6.3 I-O status

The status of each access operation performed on a file is stored by the runtime system in specific data items which can be assigned to every file in the program. These items, which are specified by using the FILE STATUS clause, provide information on

– whether the I/O operation was successful, and

– the type of any errors that may have occurred.

This data can be evaluated (by USE procedures in the DECLARATIVES, for example) and used by the program to analyze I-O errors. As an extension to Standard COBOL, COBOL85 provides the option of including the keys of the POSIX error messages in this analysis, thus allowing a finer differentiation between different causes of errors. The FILE STATUS clause is specified in the FILE-CONTROL paragraph of the Environment Division. Its format is described in section 9.2.9, p.189f.

The functions of the two data items definable in the FILE STATUS clause are as follows:

data-name-1

contains a two-character numeric status code following each access operation on the associated file.

data-name-2

is broken down into data-name-2-1 and data-name-2-2 and is used for storing the (POSIX) SIS codes for the relevant I-O status. Following each access operation on the associated file, it contains a value that directly depends on the content of data-name-1. The value can be derived from the table below:

Content of data-name-1 ≠ 0?	SIS code ≠ 0?	Value of data-name-2-1	Value of data-name-2-2
no	not relevant	undefined	undefined
yes	no	0	undefined
yes	yes	96	SIS code of the associated error message

For program execution in BS2000, the meaning text of each SIS code can be output using the command HELP-MSG-INFORMATION SIS<data-name-2-2>.

The base and extended I-O status values are described in the two tables that follow.

Base I-O status

Value	Org[*)]	Meaning
0x		Execution successful
00	SRI	No further information
02	I	Successful READ, allowable duplicate key
04	SRI	Successful READ, but record length error
05	SRI	Successful OPEN on nonexistent OPTIONAL file
07	S	- Successful OPEN with NO REWIND
		- Successful CLOSE with NO REWIND, REEL/UNIT or FOR REMOVAL
1x		Execution unsuccessful: AT END condition
10	SRI	Unsuccessful READ - end of file reached
14	R	Unsuccessful READ - key item length error
2x		Execution unsuccessful, key error
21	I	Incorrect key sequence on sequential access
22	RI	WRITE for existing record
23	RI	READ for nonexistent record
24	RI	Key item length error
3x		Execution unsuccessful, unrecoverable error
30	SRI	No further information (check SIS code)
34	S	Insufficient secondary allocation in SET-FILE-LINK command
35	SRI	OPEN INPUT/I-O on nonexistent file
38	SRI	OPEN for file closed using CLOSE WITH LOCK
39	SRI	OPEN error due to incorrect file attributes
4x		Execution unsuccessful, logical error
41	SRI	OPEN for a file which is already open
42	SRI	CLOSE for a file which is not open
43	S	REWRITE not preceded by successful READ
	RI	DELETE/REWRITE not preceded by successful READ
44	SRI	WRITE/REWRITE with invalid record length
46	S	Repeated READ after unsuccessful READ or after detection of AT END
	RI	Sequential READ after unsuccessful READ/START or after detection of AT END
	S	READ for file not opened for reading
47	RI	READ/START for file not opened for reading
	SRI	WRITE for file not opened for writing
48	S	REWRITE for file not opened in I-O mode
49	RI	DELETE/REWRITE for file not opened in I-O mode
9x		Other conditions with unsuccessful execution
90	SRI	System error, no further information
91	SRI	OPEN error or no free device

*) S = sequential organization, R = relative organization, I = indexed-sequential organization

Extended I-O status - (SIS code)

I/O status	Meaning
0601	End-of-file detected
0602	Specified record does not exist
0603	Specified record exists
0604	Start-of-file detected
0605	Specified link does not exist
0606	File name longer than P_MAXFILENAME
0607	Path string longer than P_MAXPATHSTRG
0608	Path name longer than P_MAXPATHNAME
0609	Link name longer than P_MAXLINKNAME
0610	Out of memory
0611	Number of path elements exceeds P_MAXHIERARCHY
0612	Function not supported
0613	File name missing or syntactically incorrect
0614	Number of secondary keys exceeds P_MAXKEYS
0615	Too many files open at once
0616	Specified file does not exist
0617	Write access not allowed
0618	No file name specified
0619	File is locked
0620	Invalid combination of file attributes
0621	Invalid file handling specified
0622	Current record shorter than MINSIZE
0623	Current record longer than MAXSIZE
0625	No sequential READ before sequential REWRITE
0626	Invalid record format
0627	MINSIZE larger than MAXSIZE
0628	Invalid file organization
0629	File exists though declared as nonexistent
0630	Specified access function not allowed
0631	Specified key
0632	Key duplication not allowed
0633	Current record is locked

I/O status	Meaning
0634	Current key out of sequence
0635	Specified path undefined
0636	System-specific error occurred
0637	End-of-line reached
0638	Record truncated
0640	No space available to extend file
0643	Invalid file open mode
0644	Length of link exceeds P_MAXLINKSTRG
0645	Invalid version string specified
0646	Specified file lifespan invalid
0647	Syntax error in file, link or path string
0649	File close mode invalid
0650	Access denied
0651	Parameter error
0652	Invalid pointer to I/O area
0653	Invalid record length detected
0654	Storage limits reached on device
0655	Specified feed control invalid
0656	Specified code invalid
0657	Invalid combination of open mode and file lifespan
0658	I/O aborted
0659	Length of key identifierexceeds P_MAXKEYWORD
0660	Key identifier ambiguous
0661	Number of exits exceeds P_MAXEXITS
0662	New line detected
0663	New page detected
0664	Not all paths closed
0665	Next indexed record has same secondary key
0666	Secondary key of written record already exists
0667	Current record number exceeds MAX_REC_NR
0668	Path name already exists
0669	Link name already exists
0670	Specified value for positioning condition invalid

I/O status	**Meaning**
0671	Unknown control character detected
0672	A unique file name could not be generated
0673	Last record incomplete; function not executed
0674	Specified value for positioning invalid
0675	Unidentifiable record format
0676	Unidentifiable MAXSIZE
0677	Internal PROSOS-D error
0678	Specified file is a file container
0679	Specified file cannot be reached on given path
0680	Version not incrementable
0681	Defective reopen after implicit close
0682	Defective PROSOS-D initialization
0683	Number of link indirections exceeds P_MAXLINKNESTING

14 Useful software for COBOL users

14.1 Advanced Interactive Debugger (AID)

Product characteristics

AID is an efficient and powerful debugging system which allows users to diagnose errors, test programs, and provisionally correct programming errors under the BS2000 operating system.

AID supports symbolic debugging of programs written in COBOL, C, Assembler, FORTRAN, and PL/1 as well as non-symbolic debugging at machine-code level of programs written in any BS2000 programming language.

Symbolic debugging of a COBOL program means that symbolic names from a COBOL source program can be used for addressing. Non-symbolic debugging at machine-code level is generally required whenever symbolic testing proves insufficient or impossible as a result of lacking diagnostic information.

Some of the basic functions that can be called using special AID commands are listed below:

- execution monitoring
  - specific types of source statements
  - selected events in the program run
  - declared program addresses
- access to data items and modification of item contents
- management of AID output files and libraries
- detection of global declarations
- control of
  - output data sets
  - AID output volumes

Handling is supported by an additional HELP function

- for all AID commands and operands
- for the meaning of AID messages and possible actions to be taken.

The user can control program execution by instructing AID to interrupt a program run and execute certain subcommands at defined addresses, during the execution of selected types of statements, or when specific events take place. A subcommand is an individual command or a sequence of AID and BS2000 commands. It is defined as an operand of an AID command. Starting with version V2.0, the execution of subcommands can be made dependent on conditions. This enables dynamic monitoring of program states and the values of variables.

AID also provides facilities for the modification of data items and the output of elementary data items, group items, or entire Data Divisions of COBOL programs.

An AID command can be used to display the level of the call hierarchy at which the program was interrupted and the modules which are contained in the CALL nesting.

AID can be used to process a running program as well as to analyze a memory dump in a disk file. It is possible to switch between these two options within a single debugging session, e.g. in order to compare data in an executing program with the data obtained from a memory dump.

Description of functions

AID is a diagnostic and debugging tool for testing application programs at source language level (high level language debugger).
The debugging and diagnostic functions available for the testing of COBOL source programs compiled with COBOL85 are:

– Output and setting of user-defined data:

  Data defined in the user program can be addressed interactively, subject to the COBOL rules pertaining to qualification, uniqueness, indexing, and scope.
  The data itself is converted and edited in accordance with the attributes specified in the user program.

– Symbolic dump:

  All or selected data from dynamically nested programs can be edited and output according to the current program nesting.

– Setting of test points:

  Test points at which specific actions are to be executed can be set or reset via source references or markers in the program (paragraphs, sections, etc.). Markers are referenced according to the qualification rules applicable in COBOL.

– Tracing of the program at statement level:

  Dynamic tracing of the program is controllable via statement classification (e.g. procedure trace, control flow trace, assignment trace...). AID outputs the source reference of executing statements that correspond to the statement classification.

Documentation

AID Core Manual [22]

AID - Debugging of COBOL Programs [8]

AID - Debugging on Machine Code Level [23].

14.2 Library Maintenance System (LMS)

Product characteristics

The library maintenance system LMS can be used to create and maintain program libraries and to process the elements contained in them.

Program libraries are BS2000 PAM files that are processed with the program library access method PLAM (and hence also referred to as PLAM libraries).

The main advantages of LMS are as follows:

- All element types in a library can be processed by means of uniform statements.
- Elements may have identical names and be differentiated by type or version.
- Versions are incremented automatically.
- The library can be accessed simultaneously by many users and also be written to concurrently.
- Different access rights can be assigned for each element.
- Access to elements can be monitored.
- LMS provides uniform data management and common access functions for most of the data elements involved in the development of software.
- Utility routines and compilers can access the data repository and also process individual elements directly.

LMS thus provides vital support in the creation, maintenance, and documentation of programs.

Structure of libraries

A program library is a file with a substructure. It contains elements as well as a directory of the elements stored in it.

An element is a logically related data set, e.g. a file, a procedure, an object module, or a source program. Each element in the library can be addressed independently.

Each library has an entry in the system catalog. The user can define the library name and other file attributes such as retention periods and shareability.

The collective storage of several files in a library reduces the load on the system catalog, since only the library is entered there and not each element. It also saves storage space, since library elements are stored in compressed form.

Support for multiple versions

If the delta technique is used for multiple versions of an element, only the differences (deltas) with respect to the previous version are stored. This also helps to save storage space.

When such delta versions are read, LMS inserts the required deltas at the appropriate positions and thus provides the user with a complete element.

LMS supports symbolic version identifiers and automatically increases the version ID in accordance with the selected version format.

Embedding in the program environment

Utility routines of the programming environment such as EDT, compilers, etc., can directly access program libraries.

Documentation

LMS Reference Manual [10]

14.3 Job variables

Product characteristics

Job variables are data objects that are used for the exchange of information between individual users, and between the operating system and users

Job variables can be created and modified by the user. The user can also instruct the operating system to set specific job variables to predefined values when certain events occur.

Job variables represent a flexible tool for job control under user supervision. They offer the option of defining the interrelationships in a complex production run in simple terms and form the basis for event-driven job processing.

Description of functions

Job variables are objects that are managed by the operating system. They can be addressed via names and can each hold up to 256 bytes of data. They are used for the exchange of information between individual users, as well as between the operating system and users. Job variables can be accessed via the command and macro interfaces. When the SDF component of BS2000-BC is used, job variables can serve as global parameters on the command level.

In conditional statements, job variables can be linked via Boolean operations. In this way, actions can be made dependent on the truth value of the condition. In addition, user job variables and monitoring job variables (see below) offer the option of synchronous or asynchronous event control at command and program level.

Different job variables are available for different functions:

- User job variables

In their most general form, job variables are available as user job variables. The name, life, and data to be stored in such a variable is determined exclusively by the user. These job variables can be supplied with protection attributes such as passwords, write-protection, and retention period. Access to a user job variable can be restricted to a particular user ID or be universally granted.

User job variables are particularly suitable for the exchange of information. However, they can also be used for job control.

- Monitoring job variables

The monitoring job variable is a special form of the user job variable. It is assigned to a job or a program. The name, lifespan, and protection attributes are defined by the user. However, in contrast to the user job variable, these variables are supplied with predetermined values by the operating system and reflect the status of the assigned job or program.

Monitoring job variables are particularly suitable for job control, such as is required, for example, for managing interdependencies in production runs.

Documentation

Job Variables Reference Manual [7]

14.4 Database interface ESQL-COBOL

Product characteristics

ESQL-COBOL (BS2000/OSD) V2.0 implements the “embedded SQL” application program interface to the SESAM/SQL Server V2.0 database management system for COBOL applications in BS2000/OSD.
ESQL-COBOL V2.0 is the successor to ESQL-COBOL V1.1 for SESAM/SQL

ESQL-COBOL V1.1 is still the version to use for the UDS/SQL database management system.

The new architecture of the compiler and database management system ESQL-COBOL (BS2000/OSD) V2.0 / SESAM/SQL Server V2.0 entails a reallocation of tasks between the precompiler and the DBMS.

ESQL-COBOL (BS2000/OSD) V2.0 allows unrestricted use of the extended SQL functionality of SESAM/SQL Server V2.0:
the extensions relate to data manipulation, data definition, data monitoring and utility and information functions (schema information tables).

ESQL-COBOL (BS2000/OSD) V2.0 also offers

– graded syntax and semantics checking of embedded SQL at precompile time, optionally with or without a database linkup
– for error handling purposes, the standardized SQLSTATE return code of the 1992 ISO standard in addition to the earlier SQLCODE of the 1989 ISO standard. This greatly enhances SQL application portability.

ESQL-COBOL (BS2000/OSD) V2.0 is required purely as an SQL precompiler for program development. The SQL runtime system is a component of SESAM/SQL Server.

The SQL runtime system of SESAM/SQL V2.0 is required in order to use ESQL-COBOL (BS2000/OSD) V2.0, with or without a database linkup.

Scope of SQL functions

– searches for data records (SELECT statement) including higher functions such as join, arithmetic, aggregate functions (e.g. averaging)
– adding, modifying, deleting records.

ESQL-COBOL (BS2000) also offers certain functions that surpass the ISO standard in order to mirror the existing functionality of the database systems, e.g. multiple fields for SESAM/SQL, structured fields (vectors, repeating groups, and data groups) for UDS/SQL.

Technical notes

The SQL statements of an ESQL-COBOL program are embedded in the COBOL code and are replaced with COBOL CALLs by a precompiler. The output from the precompiler is regular COBOL source code that has to be compiled with the COBOL85 compiler. In addition, the precompiler extracts the SQL statements and transforms them into “SQL objects”.

The compiled COBOL program is linked with the SQL objects, the COBOL and DBMS runtime modules, and with a runtime system for the SQL objects; the result is an executable program.

Documentation

SQL/ESQL manuals [15] - [20]

14.5 Universal Transaction Monitor UTM

UTM simplifies the task of developing and running transaction applications.

A standardized programming interface (KDCS, DIN 66265) that is supported by most programming languages is available for program creation.

Format-driven input/output is supported in conjunction with the FHS formatting system.

UTM guarantees that a transaction is executed either in its entirety, with all data updates, or not at all. It also ensures consistency of user data in combination with UDS, SESAM, LEASY and PRISMA.

UTM offers restart functions in the event of application abortion, power failure/disruption or screen malfunctions. UTM supports both interactive (dialog) and asynchronous processing, with the option of determining the start time of the programs.

Control facilities for distributing resources (tasks) are also offered.

Secure print processing is offered by virtue of built-in control functions for print outputs to remote printers.

Inquiry-and-transaction processing means that a large number of terminals can work with UTM applications.

Accounting requirements are catered for by an accounting procedure specially tailored to inquiry-and-transaction processing.

UTM offers comprehensive data protection mechanisms for access to applications and for selection of subfunctions of an application.

UTM serves as a basis for a series of software products.

Documentation

UTM manuals [26] - [29]

15 Messages of the COBOL85 system

The COBOL85 compiler and the COBOL85 runtime system comprehensively log all errors that occur during compilation and execution of a COBOL program. The messages which are output when errors are encountered can be divided into two groups:

1. Messages which refer to errors in the COBOL source program: These are output in a diagnostic listing and/or an error file by the compiler at the end of compilation and have the following structure:

```
Msg-Index       Source Seq. No        Severity Code      Error Text
```

   where:

Msg-Index	designates a 5-digit (hexadecimal) error message number (the first two characters indicate the compiler module which detected the error)
Source Seq. No	is the sequence number of the source program line containing the error
Severity Code	is the error class of the error, and
Error Text	is the text of the error message, which contains a more detailed description of the error and possibly a recovery measure.

   Message texts can be output in English or German; the language can be selected via the SDF command
   MODIFY-MSG-ATTRIBUTES TASK-LANGUAGE=E/D.

   A current list of all error messages of the COBOL85 compiler can be requested with COMOPT PRINT-DIAGNOSTIC-MESSAGES=YES or with the SDF option COMPILER-ACTION=PRINT-MESSAGE-LIST (see sections 4.2 and 3.3.4).

   Important note

   Errors for which the message text begins with SE-1 or S.E. must always to reported to the system administrator/supervisor.

Severity code	Meaning	
F	Information	The compiler has identified language elements in the source program which – represent an extension to the COBOL standard ANS85, – will not be supported by future COBOL standards, – as per FIPS (Federal Information Processing Standard), must be assigned to a particular language set. COBOL85 issues severity code F messages only if they are explicitly requested with COMOPT ACTIVATE-WARNING-MECHANISM=YES or ACTIVATE-FLAGGING=ALL-FEATURES (SDF).
I	Information	The compiler has identified control statements or COBOL language elements that should be brought to the user' s attention but do not justify issuing a warning or diagnostic message.
0	Warning	There may be an error in the source program, but the program can still be executed in spite of this.
1	Diagnostic	The compiler has detected an error; it will normally assume a corrective option. The program may be executed for test purposes.
2	Unrecoverable error	Normally the compiler will not assume a corrective option; the erroneous statement will not be generated.
3	System error	The error is so severe that the compiler is incapable of continuing the compilation.

Table 15-1: Severity codes and their meaning

2. The following messages:
   – messages which the compiler generates with regard to the execution and termination of the compilation run (COB90xx)
   – messages which the COBOL85 runtime system generates with regard to the execution and termination of user program runs (COB91xx)
   – messages of the POSIX driver for COBOL (COB92xx)

   These are output to SYSOUT during compilation or program execution and have the following structure:

   $$\left\{\begin{array}{l}\text{COB90nn}\\\text{COB91nn}\\\text{COB92nn}\end{array}\right\}\quad\text{text}$$

   where:

COB90nn COB91nn COB92nn	is the message identification number
Text	is the text of the message. It contains – a note on the execution of the compiler or user program run or – a more detailed description of the error that has occurred and – in some cases, the request for user input which would make the error recoverable. Error messages can be output either in English or in German; the language can be selected via the SDF command MODIFY-MSG-ATTRIBUTES TASK-LANGUAGE=E/D.

   The program name specified in “COMPILATION UNIT IS program-name” in the messages COB9101 and COB9102 always identifies a separately compiled program. This may be an individual program or the outermost containing program of a nested program.

   Specifying the COMOPT operand GENERATE-LINE-NUMBER=YES or ERR-MSG-WITH-LINE-NR=YES in the SDF option RUNTIME-OPTIONS causes message COB9102 to be output with each program message instead of COB9101. The COB9102 message also contains the number of the source program line being executed when the message was issued.

   Messages COB9004, COB9017, COB9095, COB9097 and COB9099 (output during compilation) are suppressed if job switch 4 is set before the compiler is invoked.

3. “Old” 90xx messages from the COBOL runtime system regarding the execution of objects compiled by earlier versions of the compiler (< 2.1B):

Old message number	Corresponding new message number
9034	no longer applies
9054	COB9112
9067	COB9151
9068	COB9168
9069	COB9169
9070	COB9154
9071	COB9171
9074	COB9134
9076	COB9176
9077	COB9117
9079	COB9179

The most important messages of the COBOL85 compiler and COBOL85 runtime system are summarized in the list below. The following information is given for each message:

– Message number and message text (in English) and

– Additional explanations that are also output via SYSOUT; these are structured as follows:

  Type (of message)

  Meaning (of variables in the message)

  Action (of the program)

  Response (of the user)

Important note

If messages are issued that do not figure in the following list (compiler and system errors), the systems engineer should be informed.

```
COB9000   Copyright (C) FUJITSU TECHNOLOGY SOLUTIONS   2009
                     All Rights Reserved
```

Type
Remark

Meaning
Copyright

```
COB9001   aaa TOTAL FLAGS: bbb /SI=ccc /S0=ddd /S1=eee /S2=fff /S3=ggg
```

Type
Remark

Meaning

aaa:	Program name
bbb:	Total number of errors
ccc:	Number of severity code I remarks (and number of severity code F remarks, if any)
ddd:	Number of errors with severity code 0
eee:	Number of errors with severity code 1
fff:	Number of errors with severity code 2
ggg:	Number of errors with severity code 3

```
COB9002   COMPILATION OF aaa ABORTED
```

Type
User error or system error or COBOL85 error

Meaning
aaa: Program name

Response
Eliminate error and repeat compilation; inform system administrator/systems engineer if necessary.

```
COB9004   COMPILATION OF aaa USED bbb CPU SECONDS
```

Type
Remark

Meaning

aaa:	Program name
bbb:	Number of seconds

COB9005 INCORRECT “COMOPT”/”END” STATEMENT OR “END” STATEMENT MISSING

Type
User error

Action
Compilation aborted

Response
Correct or insert COMOPT or END statement and repeat compilation

COB9006 REASSIGNMENT OF SYSDTA NOT POSSIBLE

Type
System error

Action
Compilation aborted

Response
Inform system administrator/systems engineer

COB9008 COMPILER ERROR. OVERLAY aaa ADDRESS bbb LAST SOURCE SEQUENCE NUMBER ccc

Type
Compiler error

Action
Compilation aborted

Response
Inform system administrator/systems engineer

COB9017 COMPILATION INITIATED, VERSION IS aaa

Type
Remark

Meaning
aaa: Version number of compiler

`COB9027    INPUT TRUNCATED`

Type
Remark

Action
Compilation continues

Response
Shorten COMOPT lines

`COB9044  ERROR SIS (&00) OPENING POSIX LISTING-FILE`

Type
User or system error

Meaning
(&00): SIS error code

Action
Compilation aborted

Response
Check disk space and access rights; if necessary, inform system administrator/ systems engineer

`COB9059    COMPILER COBOL85 NOT RELEASED FOR BS2000 VERSION < V10.0`

Type
System error

Action
Compilation aborted

Response
Inform system administrator/systems engineer

`COB9085    COBOL85-BC DOES NOT SUPPORT AID`

Type
User error

Action
Compilation aborted

Action
Use the full-featured COBOL85 package

COB9090 `HARDWARE INTERRUPT ADDRESS aaa, OVERLAY=bbb, SOURCE SEQUENCE NUMBER=ccc, INTERRUPT WEIGHT CODE=ddd`

Type
Compiler error

Meaning

aaa:	Program counter
bbb:	Overlay name
ccc:	Line number
ddd:	Interrupt weight

Action
Compilation aborted

Response
Inform your system administrator/systems engineer.

COB9095 `SAVLST FILE aaa CREATED AND CLOSED`

Type
Remark

Meaning
aaa: Name of the generated report file, e.g. SRCLST.COB85.program-name

Action
Compilation continues

COB9097 `COMPILATION COMPLETED WITHOUT ERRORS`

Type
Remark

COB9099 `aaa`

Type
Remark

Meaning
aaa: COMOPT statement

Action
Compilation continues

`COB9100` `AWAITING REPLY`

Type
Remark

Meaning
Program run interrupted

Response
Enter a response for ACCEPT FROM CONSOLE

`COB9101` `COMPILATION UNIT ID aaa`

Type
Remark

Meaning
Supplement to the text of the previous message

`COB9102` `COMPILATION UNIT ID aaa, PROCEDURE DIVISION LINE NUMBER=bbb`

Type
Remark

Meaning
Supplement to the text of the previous message

`COB9105` `REPLY T (TERMINATE) OR D (DUMP)`

Type
User or system error described by the previous message

Action
Program is waiting for a response

Response

T	to abort the program
D	for a dump followed by a program abort

`COB9108` `NESTING TOO DEEP`

Type
User error

Meaning
Supplements the previous message

COB9109 `ALTERNATE-KEYS FOR LINK= aaa DO NOT MATCH THE ALTERNATE-KEYS IN THE PROGRAM`

Type
User error

Meaning
aaa: Link name for file

Action
Program aborts

Response
Modify program and/or file

COB9110 `ERROR IN A CREAIX-MACRO: SUBRETURNCODE= aaa  MAINRETURNCODE= bbb DMSERRCODE= ccc`

Type
User or system error

Action
Program aborts

Response
Depending on command/DMS error code, either correct command or notify system administrator/systems engineer

COB9111 `ERROR IN A SHOWAIX-MACRO: SUBRETURNCODE= aaa  MAINRETURNCODE= bbb DMSERRCODE= ccc`

Type
User or system error

Action
Program aborts

Response
Depending on command/DMS error code, either correct command or notify system administrator/systems engineer

`COB1112    ERROR OCCURRED TAKING CHECKPOINT. RETURNCODE=aaa, DMS=bbb, LINK=ccc`

Type
User or system error

Meaning
aaa: One of the following values in register 15:

04	Work area in class 5 memory could not be allocated.
08	Error in user operand list.
0C	Checkpoint file not open.
10	Secondary allocation omitted or write operation invalid.
14	FCB not PAM, or OPEN not INOUT or OUTIN.
18	Unrecoverable error encountered by DMS.
1C	Error in catalog management.
24	Checkpoint could not be set because a common memory pool is being used (ENAMP macro is in effect).
28	Checkpoint could not be set because a serialization item is present (ENASI macro is in effect).
2C	Checkpoint could not be set because an event item is present (ENAEI macro is in effect).
30	Checkpoint could not be set because contingency process was defined (ENACO macro is in effect).

Action
Compilation continues

Response
Modify program or assignment; inform system administrator/systems engineer if necessary

`COB9117    LINK=aaa NO ENTRY IN CATALOG. ISSUE NEW SET-FILE-LINK COMMAND`

Type
User error

Meaning
aaa: Link name

Action
Program interrupted

Response
Enter valid SET-FILE-LINK command and RESUME-PROGRAM.
If another invalid SET-FILE-LINK command is given, the error message is not repeated and the program is terminated.

COB9118 `"STOP LITERAL" - AWAITING REPLY aaa`

Type
Remark

Meaning
aaa: Output literal

Action
Program interrupted; message to the console

Response
Wait for operator entry; any input from operator will cause program to continue.

COB9119 `ABNORMAL TERMINATION. USERS RETURN CODE=aaa. COBOL RETURN CODE=bbb`

Type
User error or system error

Meaning
aaa: >0. The program set a user return code which resulted in program termination.
bbb: >0. The COBOL85 system detected an error and set an internal return code for diagnostic purposes.
Each return code is associated with an error message or a user return code explaining its meaning.If the program is monitored by a job variable, the internal return code will also be passed in its return code indicator (see section 6.6, table 6-1, “Return code indicator in job variables”)

Response
Note the message issued immediately prior to this one; modify program or assignment; inform system administrator/systems engineer if necessary.

COB9120 `JOB-VARIABLES ARE NOT SUPPORTED IN THIS OPERATING SYSTEM`

Type
Remark

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program continues or terminates

Response
Lease “Job Variables” selectable unit

`COB9121    END OF FILE ON "ACCEPT" FROM SYSIPT`

Type
Remark

Action
Depending on COMOPT CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program continues or terminates

Response
Check SYSIPT assignment; if necessary, reassign and restart program

`COB9122    END OF FILE ON "ACCEPT" FROM SYSDTA`

Type
Remark

Action
Depending on COMOPT CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program continues or terminates

Response
Check SYSDTA assignment; if necessary, reassign and restart program.

`COB9123    FUNCTION aaa IN STATEMENT bbb IN LINE ccc : UNEXPECTED ERROR`

Type
User or system error

Meaning

aaa:	Name of standard function
bbb:	COBOL statement
ccc:	Line number

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted.

Response
Correct program

COB9124 `FUNCTION aaa IN STATEMENT bbb IN LINE ccc : NOT ENOUGH ARGUMENTS`

Type
User error

Meaning

aaa:	Name of standard function
bbb:	COBOL statement

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted.

Response
Correct program

COB9125 `FUNCTION aaa IN STATEMENT bbb IN LINE ccc : ARGUMENT HAS INVALID VALUE`

Type
User error

Meaning

aaa:	Name of standard function
bbb:	COBOL statement
ccc:	Line number

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted.

Response
Correct program

COB9126 `FUNCTION aaa IN STATEMENT bbb IN LINE ccc : ARGUMENT HAS INVALID LENGTH`

Type
User error

Meaning

aaa:	Name of standard function
bbb:	COBOL statement
ccc:	Line number

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted.

Response
Correct program

COB9127 `FUNCTION aaa IN STATEMENT bbb IN LINE ccc : TABLE SUBSCRIPTED WITH “ALL” HAS NO ELEMENT`

Type
User error

Meaning

aaa:	Name of standard function
bbb:	COBOL statement
ccc:	line number

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted.

Response
Correct program

COB9128 `ABNORMAL TERMINATION. USERS RETURN CODE=aaa`

Type
User error or system error

Meaning
aaa: >0. The program set a user return code which resulted in program termination.

Response
Modify program, or inform the system administrator/systems engineer, if necessary.

COB9131 `ACCESS TO JOB-VARIABLE aaa FAILED. JOB-VARIABLE IS EMPTY`

Type
User error

Meaning
aaa: Name of the job variable

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program continues or terminates

Response
Supply job variable before run

COB9132 `NUMBER OF PARAMETERS IN "CALL" STATEMENT IS NOT EQUAL TO NUMBER OF PARAMETERS EXPECTED BY THE CALLED SUBPROGRAM`

Type

Remark

Action
Depending on COMOPT CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program is continued or terminated

Response
- if necessary, also compile calling program with COMOPT operand CHECK-PARAMETER-COUNT=YES or PROC-ARGUMENT-NR=YES (SDF option RUNTIME-CHECKS)
- otherwise change program in such a way that the number of parameters passed matches the number of parameters expected

COB9133 `COBOL85 RUNTIME SYSTEM NOT RELEASED FOR BS2000 VERSIONS LOWER THAN V10.0`

Type
System error

Action
Program aborts

Response
Inform system administrator/systems engineer

COB9134 `A SORT SPECIAL REGISTER HOLDS AN INVALID VALUE`

Type
Remark

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program continues or terminates

Response
Correct program

COB9140 `REFERENCE MODIFICATION: RANGE VIOLATION IN aaa STATEMENT, RELATIVE ADDRESS IS bbb, COMPUTED LENGTH IS ccc, SIZE OF DATA ITEM IS ddd`

Type
User error

Meaning

aaa:	Statement
bbb:	Value of address specification
ccc:	Value of length specification, or computed length if no length specified.
ddd:	Length of reference-modified data item

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted

Response
Correct program

`COB9142` `UNALTERED GO TO.`

Type
User error

Action
Program aborts

Response
Modify program: do not run a GO TO without paragraphs/chapters until an ALTER has been performed

`COB9143` `VOLUME aaa UNEXPIRED PURGE DATE.`

Type
User error

Meaning

aaa:	Volume serial number

Action
Program run interrupted

Response
Use a volume whose purge date has already expired.

`COB9144` `SUBSCRIPT-/INDEX-RANGE VIOLATION IN aaa STATEMENT, VALUE OF SUBSCRIPT/INDEX IS bbb, TABLE BOUNDARY IS ccc`

Type
User error

Meaning

aaa:	Statement
bbb:	Invalid index value
ccc:	Maximum permissible index value

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted

Response
Modify program

COB9145 `RANGE VIOLATION IN aaa STATEMENT, VALUE OF "DEPENDING ON" ELEMENT IS bbb, TABLE BOUNDARY IS ccc`

Type
User error

Meaning

aaa:	Statement
bbb:	Invalid value in DEPENDING ON item
ccc:	Maximum permissible value

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS), the program is continued or aborted

Response
Modify program

COB9146 `COBOL85 RUNTIME SYSTEM VERSION aaa IN CRTE IS INCOMPATIBLE WITH OBJECT CODE COMPILED BY COBOL85 VERSION bbb`

Type
User error

Meaning

aaa:	Version number of the runtime system
bbb:	Version number of the compiler

The runtime system is older than the compiler that generated the program.

Action
Program aborts

Response
Install a compatible runtime system as a shareable RTS.

COB9148 `PROGRAM-NAME IN "CALL" OR "CANCEL" STATEMENT VIOLATES SYSTEM CONVENTION FOR ESD SYMBOLS`

Type
User error

Action
CALL without EXCEPTION clause: program termination
CALL with EXCEPTION clause: continuation with EXCEPTION clause
CANCEL: continuation with statement after CANCEL

Response
Enter the program name correctly

`COB9149` `INCOMPATIBLE DATA IN NUMERIC EDITED ITEM`

Type
User error

Action
Program aborts

Response
Modify program

`COB9151` `PC=aaa, STATUS=bbb, FILE=ccc, LINK=ddd, DMS/SIS=eee, NO USE ERROR PROCEDURE`

Type
User error or system error:
severe error during input/output or programming error (no USE procedure, no INVALID KEY or no AT END clause)

Meaning

aaa:	Program name
bbb:	Current status of program counter
ccc:	Current COBOL FILE STATUS
ddd:	File name
eee:	Link name
fff:	DMS error code

Action
Program aborts

Response
Depending on DMS error code: correct program or inform system administrator/ systems engineer

`COB9152` `NO CONNECTION WITH DATABASE DURING PROGRAM INITIALIZATION`

Type
User error (either DBH not loaded or SET-FILE-LINK command incorrect)

Action
Program aborts

Response
Load DBH and restart program, changing SET-FILE-LINK command if necessary

COB9154 `REPORT SEQ# aaa: "INITIATE" STATEMENT ISSUED TO REPORT WHICH IS NOT TERMINATED`

Type
User error

Meaning
aaa: Line number

Action
Program aborts

Response
Modify program

COB9155 `ERROR ON EXIT FROM THE USE-PROCEDURE ON PC: aaa`

Type
User error

Meaning
aaa: Program counter

Action
Program aborts

Response
Correct program

COB9156 `SUB-SCHEMA MODULE TOO SMALL TO PROCESS AN EXTENSIVE DML-STATEMENT`

Type
User error

Action
Program aborts

Response
Modify program (shorter DML statements, since FIND-7/FETCH-7 are too extensive)

COB9157 `PROGRAM REFERENCED BY "CALL" OR "CANCEL" STATEMENT IS STILL ACTIVE`

Type
User error

Action
Program aborts

Response
Check and correct program calls (no recursion allowed)

COB9158 `MORE THAN 9 RECURSIVE CALLS OF DEPENDING PARAGRAPHS`

Type
User error

Action
Program aborts

Response
Modify program

COB9160 `PROGRAMS COMPILED BY VERSIONS <= COBOL85 V1.2A FOUND IN RUNUNIT USING "INITIAL" OR "CANCEL"`

Type
User error

Action
Program aborts

Response
Recompile old programs with new COBOL85 version

COB9162 `INCONSISTENT DESCRIPTIONS FOR EXTERNAL FILE aaa IN DIFFERENT PROGRAMS`

Type
User error

Meaning
aaa: Name of external file

Action
Program aborts

Response
Use the same description for the external file in all programs

COB9163 `NOT ENOUGH SPACE AVAILABLE FOR DYNAMIC DATA`

Type
User or system error

Action
Program aborts

Response
Reduce amount of DYNAMIC data in program, or reduce the length and number of arguments in non-numeric functions or, if appropriate, increase ADDRSPACE in the Join entry.

COB9164 `PROGRAM aaa REFERENCED BY "CALL IDENTIFIER" STATEMENT CAN NOT BE MADE AVAILABLE, BLS RETURNCODE= bbb`

Type
User error

Action
Program run aborted

Meaning
aaa: Name of program to be dynamically loaded
bbb: Return code of BIND/LINK macro

Response
Assign library for the program using the link name COBOBJCT; assign library for the runtime system using the link name BLSLIBxx

COB9168 `REPORT SEQ# aaa: GROUP bbb REQUIRES TOO MANY LINES`

Type
User error

Meaning
aaa: Line number
bbb: Name of group

Action
Program aborts

Response
Modify program

COB9169 `REPORT DEFINED IN LINE aaa: GROUP bbb LINE CONFLICTS WITH HEADING`

Type
User error

Meaning
aaa: Line number
bbb: Name of group

Action
Program aborts

Response
Modify program

COB9171 `REPORT SEQ# aaa: "GENERATE" ISSUED TO TERMINATED REPORT`

Type
User error

Meaning

aaa:	Line number

Action
Program aborts

Response
Modify program

COB9173 `SORT NO. aaa UNSUCCESSFUL`

Type
User error or system error

Meaning

aaa:	Number of SORT run

Action
Program aborts

Response
Inform system administrator/systems engineer

COB9174 `DML-EXCEPTION ON STATEMENT PC aaa, DB-STATUS=bbb - ccc. EXCEPTION`

Type
User error

Meaning

aaa:	Program counter
bbb:	DB status value
ccc:	Number of exception conditions

Action
Program aborts

Response
Check program and modify if necessary

COB9175 `DMS/SIS-EXCEPTION ON STATEMENT PC aaa, FILE-STATUS=bbb (DMS/SIS CODE=ccc) ON ddd - eee. EXCEPTION`

Type
User error

Meaning

aaa:	Program counter
bbb:	File status value
ccc:	DMS/SIS error code
ddd:	Link name
eee:	Number of exception conditions

Action
Program aborts

Response
Check program and modify if necessary

COB9176 `REPORT SEQ# aaa: "TERMINATE" ISSUED TO REPORT WHICH IS NOT INITIATED`

Type
User error

Meaning
aaa: Line number

Action
Program aborts

Response
Modify program

COB9178 `THE LENGTH OF THE RECORD TO RELEASE TO THE SORT IS LARGER / LESS THAN THE MAXIMUM / MINIMUM RECORD LENGTH OF THE SORT FILE`

Type
User error

Action
Program aborts

Response
Modify program, match record lengths

COB9179 THE LENGTH OF THE RECORD RETURNED FROM SORT IS LARGER / LESS THAN THE MAXIMUM / MINIMUM RECORD LENGTH OF THE GIVING FILE

Type
User error

Action
Program aborts

Response
Modify program, match record lengths

COB9180 "RELEASE"/"RETURN" OUTSIDE "SORT"/"MERGE" CONTROL

Type
User error

Action
Program aborts

Response
Modify program

COB9181 THE DATABASE-HANDLER HAS NOT YET PROCESSED THE LAST DML-STATEMENT

Type
User error
The DBH is interrupted by STXIT and has received a new DML statement before the interrupting statement could be processed.

Action
Program aborts

Response
Correct program

COB9184 "SORT" INSIDE "SORT" CONTROL

Type
User error

Action
Program aborts

Response
Modify program

COB9192 `END OF PROCEDURE DIVISION OR ROOT SEGMENT OF MAINPROGRAM ENCOUNTERED WITHOUT "STOP RUN" HAVING BEEN EXECUTED`

Type
Remark

Action
Program aborts

Response
Set a STOP RUN statement at the logical end of the main program.

COB9193 `UNRECOVERABLE ERROR DURING DISPLAY UPON TERMINAL`

Type
System error

Action
Program aborts

Response
Inform system administrator/systems engineer

COB9194 `UNRECOVERABLE ERROR ON “ACCEPT” FROM SYSDTA`

Type
System error

Action
Program aborts

Response
Inform system administrator/systems engineer

COB9195 `UNRECOVERABLE ERROR DURING “DISPLAY” UPON SYSLST`

Type
System error

Action
Program aborts

Response
Inform system administrator/systems engineer

COB9196 `ERROR ON INTERFACE RUN-TIME-SYSTEM - OPERATING-SYSTEM IN "ACCEPT" OR "DISPLAY" STATEMENT`

Type
System error

Action
Program aborts

Response
Inform system administrator/systems engineer

COB9197 `ACCESS TO JOB-VARIABLE aaa FAILED. ERROR CODE=bbb`

Type
Remark

Meaning

aaa:	Link name of JV
bbb:	Code of system message

Action
Depending on COMOPT operand CONTINUE-AFTER-MESSAGE or ERROR-REACTION (SDF option RUNTIME-OPTIONS) the program continues or terminates

Response
Modify access permissions to job variables

COB9198 `INTERRUPT-CODE=aaa, AT PC=bbb`

Type
Hardware interrupt in user program

Meaning

aaa:	Interrupt weight
bbb:	Program counter

Action
Program aborts

Response
Correct program

COB9201 `POSIX Driver for COBOL -- Version aaa`

Type
Remark

Meaning
aaa: Driver version number

COB9205 `usage: cobol [options] filename ...`

Type
User error

Meaning
No file specified for processing

COB9206 `missing argument for option -xxx`

Type
User error

Meaning
-xxx: Option for which an argument is missing

COB9207 `Warning: Option xxx ignored`

Type
Remark

Meaning
Option xxx was not required

COB9211 `Cobol compiler returned with error nn`

Type
System error

Meaning
Program aborted

Response
Inform system administrator/systems engineer

COB9212 `ccc: command not found`

Type
User or system error

Response
Find out why the command could not be found, or inform system administrator/ systems engineer

COB9213 `cannot execute ccc (errno=nn)`

Type
System error

Meaning

ccc:	Command which cannot be executed
nn:	Number of error which occurred when trying to execute command

Response
Inform system administrator/systems engineer

COB9214 `cannot create file aaa (errno=nn)`

Type
System error

Meaning

aaa:	File name
nn:	Number of error which occurred when trying to create file

Response
Inform system administrator/systems engineer

COB9215 `cannot remove file aaa (errno=nn)`

Type
System error

Meaning

aaa:	File name
nn:	Number of error which occurred when trying to delete file

Response
Inform system administrator/systems engineer

COB9216 `cannot set environment variable xxx`

Type
System error

Response
Inform system administrator/systems engineer

COB9217 `cannot generate temporary filename`

Type
System error

Response
Inform system administrator/systems engineer

COB9221 `insufficient memory`

Type
System error

Meaning
The operating system was unable to supply any more dynamic memory

Response
Buy a bigger computer

COB9231 `ccc terminated by signal nn`

Type
Remark

Meaning
The process within which command ccc was executing was killed by signal number nn

COB9232 `ccc stopped by signal nn`

Type
Remark

Meaning
The process within which command ccc was executing was halted by signal number nn

`COB9233` `ccc: strange termination status`

Type
System error

Meaning
ccc: Command that terminated unexpectedly

Response
Inform system administrator/systems engineer

`COB9241` `cannot fork (errno=nn)`

Type
System error

Meaning
It was not possible to spawn a child process; nn was returned as error number

Response
Inform system administrator/systems engineer

`COB9242` `wait() call failed (errno=nn)`

Type
System error

Meaning
nn: Number of the error which occurred when the wait() call was executed

Response
Inform system administrator/systems engineer

`COB9243` `unexpected son process returned (Pid=nn)`

Type
System error

Meaning
nn: Number of the child (son) process

Response
Inform system administrator/systems engineer

16 Appendix

16.1 Structure of the COBOL85 system

The COBOL85 system consists of compiler modules and runtime modules. The structure of the compiler and the names of the modules are described below in detail. The runtime modules for COBOL85 are included in the Common Runtime Environment (CRTE). Their names and individual functions are described in the CRTE manual [2].

Structure of the COBOL85 compiler

The COBOL85 compiler consists of a number of modules that are linked in linear sequence.

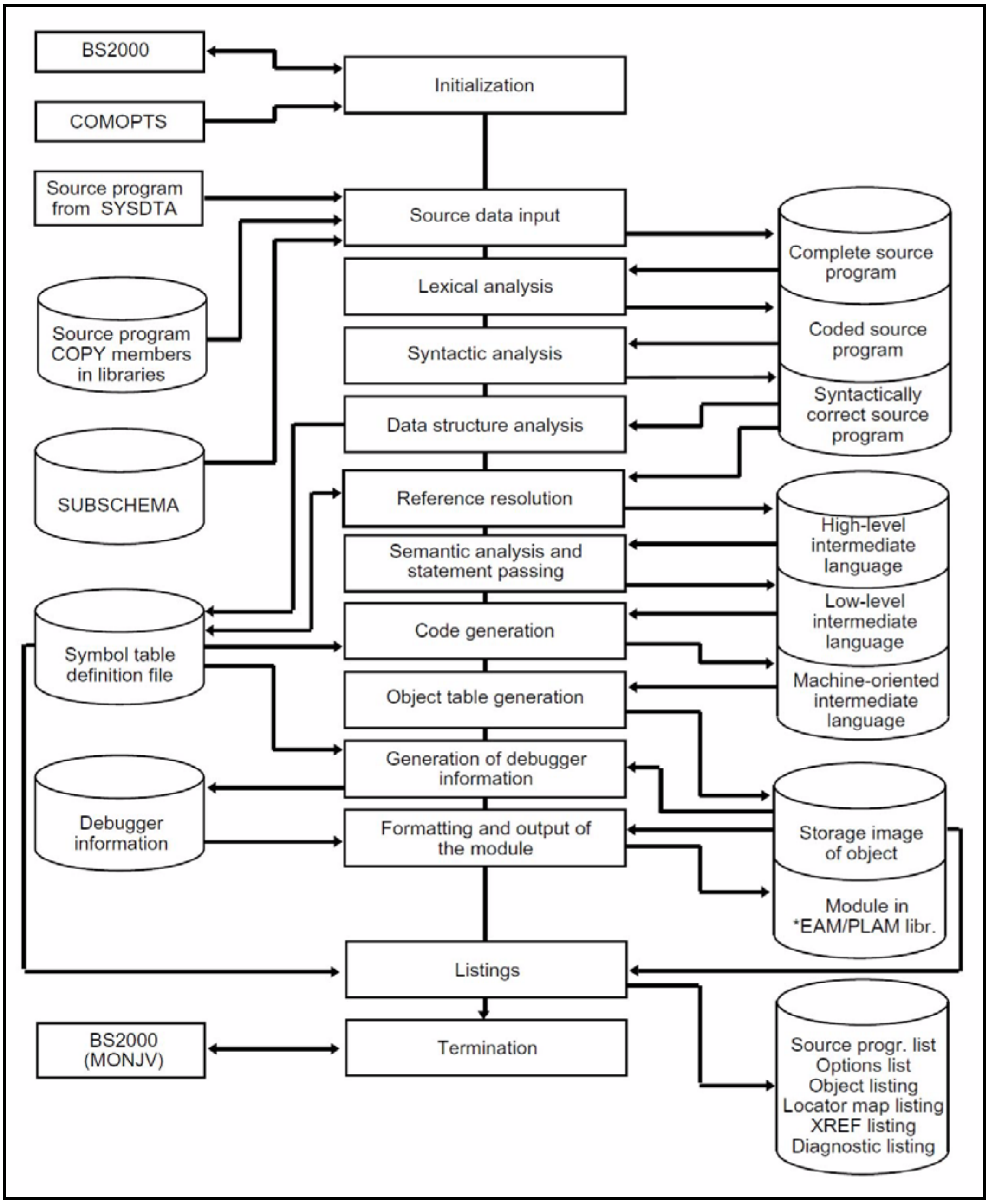
The individual modules constitute functional units that have been formed by a COBOL compilation run and by the structuring of the COBOL program into different Divisions.

The compilation process is divided into the following functional units:

1. Initialization
2. Source data input
3. Lexical analysis
4. Syntactic analysis
5. Semantic analysis
6. Code generation
7. Assembly run
8. Module generation
9. Report generation

The structure of the compiler and the arrangement of the individual function units in working storage are presented in the following diagram.

Structure of the compiler



The COBOL85 runtime system

The COBOL85 runtime system is a component of the **C**ommon **R**un**T**ime **E**nvironment (CRTE) for COBOL85 and C/C++ programs.

CRTE is described in a separate manual.

The COBOL85 runtime routines are subprograms that are known to the COBOL85 compiler. They can basically be divided into three groups:

1. Subprograms for complex COBOL statements

Examples of complex COBOL statements are given in manual [1] (e.g. SEARCH ALL...). However, even seemingly simple functions (e.g. COMPUTE A = B ** C), for which no corresponding machine instructions exist, are broken down by forming subprograms which are then stored externally in precompiled modules.

2. Subprograms for connecting the generated module to operating system functions

The main purpose of these subprograms is to ensure that the code generation of the compiler is totally independent of the operating system. The resulting loss in efficiency is offset by greater operating system independence. If interfaces to the operating system are changed, it is generally sufficient to relink the existing modules with the new runtime system.

Essential functions in this context are:

– Connection of COBOL programs to the input-output system

– Connection of COBOL programs to SORT

– Connection of COBOL programs to UDS

– Connection of COBOL programs to Executive functions

The following table contains a list of the names and functions of the COBOL85 runtime modules. The table does not include those runtime modules that must be present in the COBOL85 runtime system for compatibility reasons only, nor those modules that are used for access to the POSIX file system.

Name	Function
ITCMAID1 *)	AID connection module (Data Division)
ITCMECE1 *)	ENTRY, CANCEL, EXIT
ITCMERF1 *)	Error analysis routine for input/output
ITCMINIT *)	ILCS initialization
ITCMMAT1 *)	Data for math (IML...-) functions
ITCMMDP0 *)	OCCURS DEPENDING (recursive)
ITCMPOVH *)	COBOL85 program manager
ITCMSMG0 *)	SORT/MERGE statement
ITCMTBS1 *)	Table sort (non-shareable)
ITCMTBS2 *)	Table sort (data)
ITCRACA0	ACCEPT statement
ITCRACX0	ACCEPT statement for environment variable/command line
ITCRAID2	AID connection module (Procedure Division)
ITCRBEG0	Program system initialization routine
ITCRCCL1	CLOSE for INITIAL / CANCEL
ITCRCHP0	RERUN clause with integer RECORDS phrase
ITCRCHP2	RERUN clause for SORT files and END OF REEL
ITCRCLA0	Compare ALL literal
ITCRCLI0	CLOSE statement for indexed files
ITCRCLR0	CLOSE statement for relative files
ITCRCLS0	CLOSE statement for sequential files
ITCRCVB0	Conversion of packed decimal to binary > 15 positions
ITCRCVD0	Conversion of binary to packed decimal > 15 positions
ITCRCVF0	Conversion to and from floating point
ITCRDBL0	Connection module to UDS database system
ITCRDFE0	Division external floating point
ITCRDPL0	Division of decimal numbers > 15 positions
ITCRDSA0	DISPLAY statement
ITCRDSI1	Storage assignment DYNAMIC data
ITCRDSX0	DISPLAY statement for environment variable

Name	**Function**
ITCRDYF1	Reservation of storage space for the functions REVERSE, UPPER-CA-SE, and LOWER-CASE
ITCRECE0	ENTRY, CANCEL, EXIT for separately compiled programs
ITCREND0	Program termination routine (normal and abnormal)
ITCREV0	Event handling (return from subroutine of another language)
ITCREV1	Event handling (“recoverable interrupts”)
ITCREV2	Event handling (“unrecoverable interrupts”)
ITCREV3	Event handling (remaining events)
ITCRFAC0	Table for FACTORIAL function
ITCRFCH0	Message output for function argument check
ITCRFCT1	Floating point constants
ITCRFDT0	Date conversion functions
ITCRFMD0	MEDIAN function
ITCRFMX0	Functions: MAX, MIN, ORD-MAX, ORD-MIN, RANGE, MIDRANGE
ITCRFNM0	Functions: NUMVAL, NUMVAL-C
ITCRFPV0	PRESENT-VALUE function
ITCRFRN0	RANDOM function
ITCRFST0	Functions: REVERSE, UPPER-CASE, LOWER-CASE
ITCRFVR0	VARIANCE function
ITCRHSW0	Set and check job/user switches
ITCRIFA0	FCB initialization; control routine
ITCRIFC1	RERUN clause FCB generation
ITCRIFI1	ISAM FCB generation for indexed files
ITCRIFL1	SAM FCB generation for line-sequential files
ITCRIFR1	ISAM FCB generation for relative files
ITCRIFS1	SAM FCB generation for sequential files
ITCRINI	ILCS COBOL initialization
ITCRINI0	INITIALIZE statement
ITCRINS0	INSPECT statement
ITCRLHS2	User label handling for sequential files
ITCRLNL1	LINKAGE clause with WRITE for line-sequential files

Name	**Function**
ITCRLNS1	LINKAGE clause with WRITE for record-sequential files
ITCRMAT0	Connection module for math (IML...-) functions
ITCRMEV2	Interrupt message for event handling routine
ITCRMPL0	Multiplication of decimal numbers > 15 positions
ITCRMSG3	Output of error messages
ITCRMVE0	MOVE for numeric-edited items
ITCRNED0	De-editing MOVE
ITCRNSP0	CALL, CANCEL, ENTRY, EXIT in nested program
ITCROPI0	OPEN statement for indexed files
ITCROPL0	OPEN statement for line-sequential files
ITCROPR0	OPEN statement for relative files
ITCROPS0	OPEN statement for sequential files
ITCRPAM1	Physical read/write routine for relative files (PAM)
ITCRPCA0	Comparisons under PROGRAM COLLATING SEQUENCE
ITCRPCS0	Comparisons under PROGRAM COLLATING SEQUENCE
ITCRPND0	ILCS routine for UTM termination
ITCRRCH0	Check table limits
ITCRRDI0	READ/START statement for indexed files
ITCRRDL0	READ/START statement for line-sequential files
ITCRRDR0	READ/START statement for relative files
ITCRRDS0	READ statement for sequential files
ITCRRPW0	REPORT-WRITER control module
ITCRSCH0	SEARCH ALL statement
ITCRSEG0	Activation of segmented COBOL programs
ITCRSPC0	Print control character evaluation
ITCRST11	CODE SET table for ASCII
ITCRST21	CODE SET table for ISO-7
ITCRSTG0	STRING statement
ITCRSTP0	STOP literal statement
ITCRTBS0	Table sort
ITCRTCA1	Class test table for ALPHABETIC test

Name	**Function**
ITCRTCD1	Class test table for NUMERIC (COMP-3 with sign) test
ITCRTCE1	Class test table for NUMERIC (COMP-3 without sign) test
ITCRTCL1	Class test table for ALPHABETIC-LOWER test
ITCRTCP1	Class test table for ALPHABETIC-UPPER test
ITCRTCS1	Class test table for NUMERIC test (with sign)
ITCRTCU1	Class test table for NUMERIC test
ITCRTCV0	Class test for data items > 256 bytes or variables
ITCRUPC2	Control module for declaratives
ITCRUST0	UNSTRING statement
ITCRVCL0	Comparison for items of variable length/address or > 256 bytes
ITCRVMA0	MOVE ALL literal
ITCRVMP0	Padding for items > 256 bytes in case of MOVE
ITCRVMV0	MOVE for items of variable length/address or > 256 bytes
ITCRWRI0	WRITE/REWRITE statement for indexed files
ITCRWRL0	WRITE/REWRITE statement for line sequential files
ITCRWRR0	WRITE/REWRITE statement for relative files
ITCRWRS0	WRITE statement for sequential files
ITCRXIT0	FILE STATUS and error handling routine
ITCRXPF0	Exponentiation

*) Module not shareable

16.2 Database operation (UDS)

Not supported in COBOL85-BC !

A description of the universal database management system UDS is given in the UDS manuals: Design and Definition [12], Creation and Restructuring [13], and Application Programming [14].

UDS databases are processed by user programs via

- COBOL-DML language elements (DML is an integral component of COBOL)
- CALL DML (database handling via subprogram call).

The following text concentrates on COBOL-DML. Furthermore, it is assumed that schema and subschema have already been generated. The individual steps towards generating a UDS user program are briefly explained.

The Database Handler (DBH), the main component of the UDS database system, is responsible for communication between the user program and the database (via the subschema). A distinction is made between:

- Linked-in DBH: It is linked into the user program and is therefore suitable for cases where only one user program is to work with the database.
- Independent DBH: This is not linked into the user program and is therefore capable of controlling more than one user program (independent task).

Structure of a COBOL-DML program

```
DATA DIVISION.
    .
    .
    .
SUB-SCHEMA SECTION.
    DB subschema-name WITHIN schema-name.
PROCEDURE DIVISION.
    .
    .
    .
    Sequence of COBOL-DML statements
    ...
```

The formats of the COBOL-DML statements are described in [14].

schema-name/subschema-name are defined at schema/subschema generation time.

Compiling a COBOL-DML program

The COBOL85 compiler generates a program module and a subschema module from a COBOL-DML program.

The compiler is informed of the name of the database (dbname) by means of a SET-FILE-LINK command (with link name DATABASE). This is the same name as that used at database generation time. It enables the compiler to identify the file dbname.COSSD, from which it copies the subschema. This file was generated by UDS at subschema generation time.

Example of a command sequence:

```
/SET-FILE-LINK DATABASE,dbname
 /START-PROGRAM $COBOL85
  *COMOPT MODULE=module-library
  *END source-program-file
```

Linking a COBOL-DML program

The link-editing of COBOL programs is described at length in the chapter “Generating and calling executable programs”.

Note that for COBOL-DML programs a suitable UDS connection module must be linked in, depending on the DBH version used (linked-in/independent. For further information see [14].)

Example of a linkage editor run:

```
 /START-PROGRAM $TSOSLNK
  *PROG␣program-name[,FILENAM=filename]
  *INCLUDE␣cobol-dml-program,module-library
  *INCLUDE␣uds-connection-module,uds-module-library
 [*RESOLVE␣,$.SYSLINK.CRTE]
```

Execution of a UDS user program

When the independent DBH is used, execution of a UDS user program is possible only within a UDS session. The connection to this session or to the database is provided by the SET-FILE-LINK command.

Execution with linked-in DBH:

```
/SET-FILE-LINK DATABASE,dbname
 /START-PROGRAM filename
  [DBH parameters]
  PP END
  [user-program-parameters]
```

Execution with independent DBH:

```
/START-PROGRAM filename
  [user-program-parameters]
```

The compilation, linking and execution of COBOL-SQL programs is described in the “ESQL-COBOL” manual [15].

16.3 Description of listings

In this section, the formats of the following listings output by COBOL85 during compilation are explained briefly, using a programming example as the basis for the description:

- Control statement listing
- Source listing
- Locator map/ cross-reference listing
- Diagnostic listing

Header line

Each page of a listing starts with a header line (see below), which, regardless of the type of listing, contains the following information:

(1) Name and version of the compiler

(2) PROGRAM-ID name

(3) Type of listing

(4) Time of compilation

(5) Date of compilation

(6) Page number

```
     (1)             (2)                             (3)                       (4)      (5)           (6)
COBOL85 V02.3A00    COPYING                         LIBRARY LISTING              14:46:36 2013-09-14  PAGE 0003
```

Control statement listing

In this listing, COBOL85 logs

(1) the environment of the compilation run,

(2) the selected compiler options (OPTIONS IN EFFECT; COMOPTs),

(3) the compiler options (COMOPTs) set by default (OPTIONS BY DEFAULT) at compilation time, and

(4) information for maintenance and diagnostic purposes.

```
COBOL85 V02.3A00  COPYING                            COMOPT LISTING             14:46:36 2013-09-14  PAGE 0001

ENVIRONMENT  ——————————————————————  (1)

                          PROCESSOR                    : 7.500-  S170-30

                          OPERATING SYSTEM             : BS2000 V16.0

                          COMPILER                     : COBOL85  V02.3A00

                          TASK-SEQUENCE-NO             : 2A5K

                          USER-ID                      : H2610491

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                                        All Rights Reserved

OPTIONS IN EFFECT ————————————————  (2)

                          SYMTEST                      = ALL
                          SYSLIST                      = (OPTIONS,DIAG,MAP,SOURCE,XREF)
                          FLAG-OBSOLETE                = YES
                          LINES-PER-PAGE               = 070
                          FLAG-NONSTANDARD             = YES
                          MERGE-DIAGNOSTICS            = YES
                          GENERATE-SHARED-CODE         = YES
OPTIONS BY DEFAULT ———————————————  (3)

                          MODULE                       = *OMF
                          EXPAND-COPY                  = YES
                          LINE-LENGTH                  = 132
                          EXPAND-SUBSCHEMA             = YES
                          MINIMAL-SEVERITY             = I
                          REPLACE-PSEUDOTEXT           = YES
                          RESET-PERFORM-EXITS          = YES
                          CONTINUE-AFTER-MESSAGE       = YES


FOR CUSTOMER SERVICE —————————————  (4)

REV# = A
REV# = B
```

Source listing

Each line of a source listing is subdivided into the following areas:

(1) Indicator field

Column 1 gives information about errors in the user-defined numbering of the input records (S flag) and about any violations of the maximum line length of 80 characters (T flag). Furthermore, it identifies records copied from a COPY library (C flag), declared by a REPLACING or REPLACE (R flag) or associated with the Sub-schema Section (D flag). Column 3 shows the nesting depth for expanded COPY elements.

(2) Sequence number field

Contains a number (max. 5 digits) assigned by COBOL85 to identify the input source program record. This number uniquely identifies the source code lines. It appears in all the listings generated by COBOL85 as a cross-reference number. It is also used for reference in any error messages. Its maximum value is 65535. If a source program exceeds this number, consecutive numbering starts again from 0.

(3) At the beginning of each new page of a source program listing, a line containing column markers (V) is generated after the heading. These markers conform to the COBOL reference format and make it easier for the user to recognize any violations of the column format required by COBOL.

(4) Source program line number

(5) Source program area

Contains the record entered by the user. Note that only printable characters are shown.

```
COBOL85   V02.3A00   COPYING                           SOURCE LISTING              14:46:36 2013-09-14  PAGE 0002


(1) (2)  (3) (4)  (5)
          V   VV    V                                                            V
    00001        IDENTIFICATION DIVISION.
    00002        PROGRAM-ID. COPYING.
    00003        ENVIRONMENT DIVISION.
    00004        INPUT-OUTPUT SECTION.
    00005        FILE-CONTROL.
    00006            SELECT SAM-DATEI ASSIGN TO "DATAIN"
    00007                   ORGANIZATION IS SEQUENTIAL
    00008                   FILE STATUS IS SAM-FILE-STATE.
    00009            SELECT ISAM-DATEI ASSIGN TO "DATAOUT"
    00010                   ORGANIZATION IS INDEXED
    00011                   RECORD KEY ISAM-KEY
    00012                   FILE STATUS IS IDATSTA
    00013                   ACCESS IS SEQUENTIAL.
    00014        DATA DIVISION.
    00015        FILE SECTION.
    00016        COPY SAM-FILE.
C 1 00017        FD  SAM-FILE RECORD IS VARYING IN SIZE FROM 1 TO 255
C 1 00018                                DEPENDING ON SAM-RECORD-LENGTH.
C 1 00019        01  SAM-RECORD.
C 1 00020          05 CHAR       PIC X OCCURS 1 TO 255
C 1 00021                                  DEPENDING ON I-LENGTH.
    00022        COPY ISAM-FILE REPLACING CHAR BY ====.
C 1 00023        FD  ISAM-FILE RECORD IS VARYING IN SIZE FROM 9 TO 263
C 1 00024                                 DEPENDING ON ISAM-RECORD-LENGTH.
C 1 00025        01  ISAM-RECORD.
C 1 00026          05 ISAM-KEY      PIC 9(8).
C 1 00027          05 RECORD-CONTENT.
C 1 00028           10 PIC X OCCURS 1 TO 255 DEPENDING ON I-LAENGE.
    00029        WORKING-STORAGE SECTION.
    00030        01  SAM-FILE-STATE  PIC XX.
    00031          88 FILE-END        VALUE "10"
    00032        01  IDATSTA      IS EXTERNAL PIC XX.
   >>>>>  31018 >>>>> 1    PERIOD MISSING AFTER DATA DESCRIPTION ENTRY. PERIOD ASSUMED.
    00033        01  I-LENGTH                 PIC 9(3) BINARY.
    00034        01  ISAM-RECORD-LENGTH       PIC 9(3) BINARY.
    00035        01  SAM-RECORD-LENGTH        PIC 9(3) BINARY.
    00036        PROCEDURE DIVISION.
    00037        EXECUTION SECTION.
    00038        EXECUTION-001.
    00039            OPEN INPUT SAM-FILE
    00040                 OUTPUT ISAM-FILE
    00041            PERFORM WITH TEST AFTER
    00042                    VARYING ISAM-KEY FROM 100 BY 100
    00043                    UNTIL FILE-END
    00044                       OR ISAM-KEY NOT LESS 99999900
    00045              MOVE 255 TO I-LENGTH
    00046              READ SAM-FILE INTO RECORD-CONTENT
    00047                   AT END EXIT TO TEST OF PERFORM
   >>>>>  71113 >>>>> F    COLUMNNUMBER '26': 'EXIT-STATEMENT' IS "NONCONFORMING NONSTANDARD".
    00048              END-READ
    00049              ADD 8 TO SAM-RECORD-LENGTH GIVING ISAM-RECORD-LENGTH
    00050              WRITE ISAM-RECORD
    00051                    INVALID KEY CALL "IOERROR"
    00052              END-WRITE
    00053            END-PERFORM
    00054            CLOSE SAM-FILE ISAM-FILE
   >>>>>  71168 >>>>> 1    PERIOD MISSING BEFORE PARAGRAPH OR SECTION. PERIOD ASSUMED.
    00055        EXECUTION-999.
    00056            STOP RUN.
```

A library listing is output as the second part of the source listing. The sources from which the COBOL program processed in this compilation run was created can be found in this library listing. The first line states that the source was read from SYSDTA. Additional lines printed for each COPY statement contain the following information:

(6) Sequence number of the source line containing the COPY statement

(7) Link name from the COPY statement

(8) File name under which the library is entered in the BS2000 file catalog

(9) Library type

(10) Element (member) name

(11) Date, and

(12) Version number under which the library element is entered in the library. Date and version number are not always present.

```
COBOL85    V02.3A00  COPYING                         LIBRARY LISTING         14:46:36 2013-09-14  PAGE 0003


  (6)     (7)       (8)                                                  (9)       (10)         (11)       (12)

 SOURCE LIBRARY- FILE-NAME                                               (LIB-) ELEMENT-NAME   USER       VERSION
 SEQ-NO NAME                                                             ORG                   DATE

 SOURCE          :X:$H2610491.COPYING                                    ISAM
 00016  COBLIB   :X:$H2610491.COBOL-LIBRARY                              PLAM   SAM-FILE      2013-09-14  -
 00022  COBLIB   :X:$F2610491.COBOL-LIBRARY                              PLAM   ISAM-FILE     2013-09-14  -
```

Format control statements TITLE, EJECT, SKIP

The COBOL85 compiler supports the format control statements TITLE, EJECT and SKIP. These statements can be used in the source program to control the format of the source listing.

Format control statements are governed by the following rules:

– They must not be concluded with a period.

– They must be contained in the B area of a line.

– They are not effective if written in the Identification Division (where any text in the B area is treated as a comment).

– They themselves do not appear in the source listing.

TITLE statement

Function

This statement is used to print in the header lines of the next source listing a title other than the standard title (SOURCE LISTING). In addition a page throw is performed unless a new page was to be started anyway.

Format

```
 A   B
-↓   ↓
     TITLE literal
```

Rule

literal must be a non-numeric literal of up to 53 characters.

EJECT statement

Function

This statement specifies that the next text of the source listing is to be printed at the top of the next page. This statement is ineffective if a new page was to be started anyway.

Format

```
 A   B
 |   |
-▼───▼──────────────────────────────────────────
     EJECT
```

SKIP statement

Function

The SKIP statement is used to feed the following text by up to three lines. The statement is ineffective if the blank lines would be the first lines to appear at the top of the next page.

Format

```
 A   B
 |   |
-▼───▼──────────────────────────────────────────
    {SKIP1}
    {SKIP2}
    {SKIP3}
```

Example: Format control statements

```
IDENTIFICATION DIVISION.
PROGRAM-ID. EXAMPLE.
DATA DIVISION.
    TITLE "WORKING-STORAGE SECTION"  ------------------------------- (1)
WORKING-STORAGE SECTION.
01 ALPHA1 PIC 99 VALUE 1.
01 BETA1  PIC 99 VALUE 2.
01 GAMMA1 PIC 99.
    TITLE "PROCEDURE DIVISION"  ------------------------------------ (2)
PROCEDURE DIVISION.
    EJECT  --------------------------------------------------------- (3)
BEGIN SECTION.
MULT.
    MULTIPLY ALPHA1 BY BETA1 GIVING GAMMA1.
    MULTIPLY BETA1 BY GAMMA1 GIVING ALPHA1.
    MULTIPLY GAMMA1 BY ALPHA1 GIVING BETA1.
    SKIP3  --------------------------------------------------------- (4)
FIN SECTION.
STOPP.
    STOP RUN.
```

Effect:

(1) The header line of the next page of the source listing will read:
“WORKING-STORAGE SECTION”

(2) The header line of the next page(s) of the source listing will read:
“PROCEDURE DIVISION”.

(3) Next text to be printed (BEGIN SECTION...) will begin on a new page.

(4) Next text to be printed (FIN SECTION) will be preceded by three blank lines.

Error message listing

The diagnostic listing generated by COBOL85 provides information about all syntactical and semantic errors detected during the compilation.

The header line is followed by a subheading line which divides the listed diagnostic message lines into the following fields:

(1)	SOURCE SEQ NO	indicates the sequence number of the source program line in which the error occurred.
(2)	MSG INDEX	indicates the message identifier.
(3)	SEVERITY CODE	indicates the error class (see table 15-1).
(4)	ERROR MESSAGE	contains an explanatory text and, if applicable, the corrective action taken by COBOL85 or a default value assumed by COBOL85.

The diagnostic listing is concluded by summary information concerning the total number of all detected errors and the total number of errors in the various severity classes.

```
COBOL85 V02.3A00   COPYING                          DIAGNOSTIC LISTING          14:46:36 2013-09-14  PAGE 0004


   (1)     (2)      (3)        (4)

   SOURCE  MSG   SEVERITY
   SEQ-NO  INDEX     CODE   ERROR MESSAGE

    00032  31018       1    THE PERIOD IS MISSING AFTER A DATA RECORD DECLARATION.
                            A PERIOD WAS ASSUMED.
    00047  71113       F    COLUMN NUMBER '26': 'EXIT-STATEMENT' IS "NONCONFORMING NONSTANDARD".
    00054  71168       1    A PERIOD IS MISSING BEFORE A PARAGRAPH OR SECTION.
                            A PERIOD WAS ASSUMED.


   TOTAL 00003 STATEMENTS IN THIS DIAGNOSTIC LISTING.
         00001 IN SEVERITY CODE F
         00002 IN SEVERITY CODE 1
```

Locator map listing

(1) Specification of program division, section and program name

(2) File name, file sequence number and address of file control block of all files used in the program.

(3) SOURCE SEQ NO
indicates the sequence number of the source line containing the definition.

(4) MODULE REL ADDR
indicates the relative starting address of a data definition within the module.

(5) GROUP REL ADDR
identifies the relative starting address of a data definition within a 01-level entry (hexadecimal).

(6) POSITION IN GROUP DEC
is the number of the first byte of a data definition within a 01-level entry (decimal, counting from 1).

(7) LEV NO
contains the level number of the definition. A “G” preceding the level number identifies an item of data as “global”.

(8) contains the data-name defined by the user.

(9) LENGTH IN BYTES
indicates, in decimal (DEC) and hexadecimal (HEX) notation, the length of the area to which the data name is assigned.

(10) FORMAT
indicates the symbolic name of the data class.

(11) REFERENCED BY STATEMENTS
lists all the source program line numbers, in ascending order, in which there are statements which reference this data definition.
If there are more cross-references than fit on a line, a continuation line is generated (see COMOPT LINE-LENGTH, p.74).

(12) LVL
indicates the nesting level of the program, starting at 000 for the outside program.

(13) PROGRAM NAME / SECTION NAME / PARAGRAPH NAME
indicates the program name and the section and paragraph names occurring in this program.

```
COBOL85   V02.3A00   COPYING                         LOCATOR MAP LISTING              14:46:36 2013-09-14  PAGE 0005


                                                DATA DIVISION            COPYING     ————————————————————————— (1)
                                                FILE SECTION

                                         FILE NAME               SAM-FILE  ——————————————————————————— (2)
                                         FILE SERIAL NO.         01
                                         ADDR LHE FCB            000458

 (3)    (4)       (5)      (6)     (7)   (8)                         (9)                (10)       (11)

       MODULE    GROUP  POSITION                                   LENGTH
SOURCE REL       REL    IN GROUP  LEV                              IN BYTES                        REFERENCED
SEQ NO ADDR      ADDR   DEC        NO                              DEC        HEX       FORMAT     BY STATEMENTS

 00017                             FD SAM-FILE                                                     00039 00046 ...
 00019 000000B48 000000 00000001   01 SAM-RECORD                   0000000255 000000FF
 00020           000000 00000001   05 CHAR                         0000000001 00000001  CHAR


                                         FILE NAME               ISAM-FILE
                                         FILE SERIAL NO.         02
                                         ADDR LHE FCB            000830

       MODULE   GROUP  POSITION                                    LENGTH
SOURCE REL      REL    IN GROUP LEV                                IN BYTES                        REFERENCED
SEQ NO ADDR     ADDR   DEC       NO                                DEC        HEX      FORMAT      BY STATEMENTS

 00023                          FD ISAM-FILE                                                       00039 00054
 00025 00000D70 000000 00000001  01 ISAM-RECORD                    0000000263 00000107             00050
 00026 00000D70 000000 00000001  05 ISAM-KEY                       0000000008 00000008 ZONED DEC   00011 00041
 00027 00000D78 000008 00000009  05 RECORD-CONTENT                 0000000255 000000FF             00046
 00028 00000D78 000008 00000009  10 FILLER                         0000000001 00000001 CHAR
```

```
COBOL85    V02.3A00  COPYING                        LOCATOR MAP LISTING               14:46:36 2013-09-14  PAGE 0006

                                             DATA DIVISION           COPYING
                                             WORKING-STORAGE SECTION

       MODULE   GROUP  POSITION                                    LENGTH
SOURCE REL      REL    IN GROUP LEV                                IN BYTES                        REFERENCED
SEQ NO ADDR     ADDR   DEC       NO                                DEC        HEX      FORMAT      BY STATEMENTS

 00002                         G77 TALLY                           0000000004 00000004 COMP
 00003                         G77 RETURN-CODE                     0000000004 00000004 COMP-5
 00030 00000E78 000000 00000001  01 SAM-FILE-STATUS                0000000002 00000002 CHAR        00008 00041
 00031                           88 FILE-END                                                       00041
 00032 EXTERNAL 000000 00000001  01 IDATSTA                        0000000002 00000002 CHAR        00012
 00033 00000E80 000000 00000001  01 I-LENGTH                       0000000002 00000002 BINARY      00020 00028
 00034 00000E88 000000 00000001  01 ISAM-RECORD-LENGTH             0000000002 00000002 BINARY      00024 00049
 00035 00000E90 000000 00000001  01 SAM-RECORD-LENGTH              0000000002 00000002 BINARY      00018 00049
```

```
COBOL85    V02.3A00  COPYING                         LOCATOR MAP LISTING              14:46:36 2013-09-14  PAGE 0007

                                               PROCEDURE DIVISION

                    (12)    (13)                         (11)

                     LVL PROGRAM NAME
SOURCE   REL               SECTION NAME                 REFERENCED
SEQ-NO   ADDR                PARAGRAPH NAME             BY STATEMENTS

                     000 COPYING
 00037   00000000          EXECUTION
 00038   00000000            EXECUTION-001
 00055   00000286            EXECUTION-999
```

Related publications

You will find the manuals on the internet at *http://manuals.ts.fujitsu.com*. You can order printed copies of those manuals which are displayed with an order number.

[1] **COBOL85** (BS2000)
COBOL Compiler
Reference Manual

[2] **CRTE** (BS2000)
Common RunTime Environment
Reference Manual

[3] **BS2000/OSD-BC**
Commands
User Guide

[4] **BS2000/OSD-BC** V2.0A
DMS Introductory Guide
User Guide

[5] **SDF**
(BS2000/OSD)
SDF Dialog Interface
User Guide

[6] **SORT** (BS2000)
SDF Format

[7] **JV (BS2000) Job Variables**
Reference Manual

[8] **AID** (BS2000)
Advanced Interactive Debugger
Debugging of COBOL Programs
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[9] **BLSSERV**
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[16] **ESQL-COBOL (BS2000) for SESAM/SQL**
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Portable SQL Applications for BS2000 and SINIX Language Reference Manual

[18] **SQL for SESAM/SQL**
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[19] **SQL für UDS/SQL**
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Commands
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[32] **POSIX** (BS2000/OSD)
POSIX Basics for Users and System Administrators
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[33] **C/C++** (BS2000/OSD)
POSIX Commands of the C and C++ Compiler
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