

English



Fujitsu Software BS2000

# C/C++ Compiler

User Guide

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C/C++ V4.0B05

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## Comments... Suggestions... Corrections...

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## Certified documentation according to DIN EN ISO 9001:2015

To ensure a consistently high quality standard and user-friendliness, this documentation was created to meet the regulations of a quality management system which complies with the requirements of the standard DIN EN ISO 9001:2015.

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## C/C++ Compiler

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# 1 Preface

This chapter provides information concerning the following topics:

- Brief product description
- Summary of contents and target group
- Changes since the previous version
- Notational conventions
  - General notational conventions
  - SDF notational conventions

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## 1.1 Brief product description

C/C++ provides users with a versatile compiler that supports both the C and C++ programming languages with different language modes (see "[C language support of the compiler](#)" and "[C++ language support of the compiler](#)").

Programmers who are developing C and C++ programs are also supported by a global listing generator which, among other things, can be used to create listings for multiple modules (e.g. cross-reference listings, project listings).

Both the C/C++ compiler and the supplementary development tools can be operated and controlled via a convenient SDF user interface.

In order to generate and execute C/C++ programs, you will also need the **CommonRunTime Environment CRTE**, which is supplied with the following components:

- headers and modules for the C library (ANSI C functions, POSIX functions as defined in XPG4 spec1170, BS2000-specific extensions) and
- headers and modules for various C++ libraries (i.e. the C++ V2.1 compatible C++ library, the standard C++ library and the Tools.h++ library).

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## 1.2 Summary of contents and target group

This User Guide describes how C/C++ programs are processed with the C/C++ compiler and other components of the C/C++ Development System in a BS2000 system environment (SDF) under the BS2000 operating system.

It is intended for users who are familiar with the programming languages C and C++ as well as the BS2000 operating system.

The following topics are dealt with here:

- Preparing and compiling source programs
- Creating listings with the global listing generator
- Linking, loading and starting
- Executing C/C++ programs (parameter input, debuggers)
- Linkage to functions and languages
- C language support of the compiler (overview of C language modes, implementation defined behavior, `#pragma` directives, extensions to the ANSI/ISO C standard)
- C++ language support of the compiler (overview of C++ language modes, implementation defined behavior)
- Brief description of the C++ libraries supplied with CRTE

You can also develop programs in a POSIX environment by using the `cc`, `c89`, `CC` and `cclistgen` commands.

These commands are described in a separate manual under the title “POSIX Commands of the C/C++ Compiler” [1], which serves as the main reference source for POSIX commands.

For more detailed information on the features and functionality of the compiler (beyond the scope of POSIX control), see also the following sections and chapters in this User Guide:

- [section “The optimization process”](#)
- [section “Structure of compiler messages”](#)
- [chapter “C language support of the compiler”](#)
- [chapter “C++ language support of the compiler”](#)
- [chapter “Linkage to functions and languages”](#)
- [chapter “The C++ libraries and C++ runtime system”](#)

In the text, references to other publications are given using short titles. The full title of each publication is listed in the “References” section.

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## 1.3 Changes since the previous version

### Compared to C/C++ version V4.0B04 some significant topics have changed.

Bitfields may now have the type `long long`.

### Compared to C/C++ version V4.0B03 some significant topics have changed.

The `switch` statement accepts an expression of type `long long`.

The content of the ETR file has changed. The new content can not be used with a compiler V4.0B03 or older.

### Compared to C/C++ version V4.0B00 some significant topics have changed.

The library for the language modes C++2017 and C++ 2020 is now available in two versions. Version 1 is the default and compatible with the previous library. Version 2 implements some features of the standard C++ 2020. See chapter "[The C++ library for the language modes C++ 2017 and C++ 2020](#)" for more details.

### Compared to C/C++ version V4.0A50 some significant topics have changed.

There is a new statement: `//MODIFY-LIBRARY-VERSION`. The shortcut `//MO-LI` is now ambiguous.

### Compared to C/C++ version V4.0A30 some significant topics have changed.

The compiler now supports the language features of the C++ 2020 standard. See chapter "[Restrictions to ANSI-/ISO-C++](#)" for some restrictions. Full library support is currently not available and instead the existing C++ 2017 library is used.

There is a new option for this language mode. The option value `*LATEST` will be mapped to `*2020`. Up until version 4.0A30 `*LATEST` was mapped to `*2017`.

The arguments of a `printf` call will be checked against the specifiers in the format string. (see [\\_\\_printf\\_args pragma](#) and [\\_\\_scanf\\_args pragma](#))

### Compared to C/C++ version V3.2D some significant topics have changed.

The changes in this manual compared to the C/C++ V3.2D User Guide mainly affect the new language modes C11 and C++ 2017 and the changes to compiler options due to them.

The most important point is the default setting of the compiler. If the language mode is not specified explicitly, it always uses the most modern implemented language standard. This was and is the case with version 3. For Version 3 the (then) most modern standard was C89. Now the compiler supports C11 and this is also the default. This is similar for C ++. The version 3 had as (at that time) most modern standard a preliminary version of C++ 98, the current compiler supports C++ 17.

The new compiler now supports 10 language modes, 5 for C and 5 for C++. For better handling of this variety, the syntax for specifying the language mode has been redesigned. The options used in Version 3 will continue to be recognized and mapped to new options. The mapping is:

MODIFY-SOURCE-PROPERTIES LANGUAGE=	
*C(MODE=*ANSI)	*C(MODE=*1990,STRICT=*NO)
*C(MODE=*STRICT-ANSI)	*C(MODE=*1990,STRICT=*YES)

---

*CPLUSPLUS(MODE=*ANSI)	*CPLUSPLUS(MODE=*V3,STRICT=*NO)
*CPLUSPLUS(MODE=*STRICT-ANSI)	*CPLUSPLUS(MODE=*V3,STRICT=*YES)
*CPLUSPLUS(MODE=*CPP)	*CPLUSPLUS(MODE=*V2)

For MODIFY-SOURCE-PROPERTIES the option VIRTUAL-FUNCTION-TAB has been moved to the end and made hidden. The last operand with unchanged position is INSTANTIATION.

With the support of the new language modes, the recognition of questionable source constructs has also been revised. In some situations, messages are now different than C/C++ V3.2D. The error weight, the error number and the text may have changed. There are a few situations where either C/C++ V3.2 gives a message or C/C++ V4.0 but not both.

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## 1.4 Notational conventions


All notational conventions used in this manual to represent commands, statements and compiler options are explained in detail in the two subsections below:

- [General notational conventions](#)
- [SDF notational conventions](#)

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## 1.4.1 General notational conventions

The following general notational conventions are used in this manual to indicate the format of BS2000 commands and program statements:

*STD	All uppercase letters, digits, and special characters that are not part of the “metalanguage” denote keywords or constants and must be entered exactly as shown.
-R msg_id	Uppercase and lowercase letters, digits, and special characters in <i>typewritten text</i> denote constants and must be entered exactly as shown.
<i>name</i>	Lowercase letters in <i>italics</i> denote variables that must be replaced by current values at the time of input (see also <name>).
<name>	In SDF formats, variables are additionally enclosed in angle brackets.
YES <u>NO</u>	Underlining denotes the default value, i.e. the value that is automatically used if no specification is made.
{ YES / <u>NO</u> } { OFF   ON }	Braces enclose alternatives, i.e. one of the specified values must be selected. The alternatives are separated by a slash or a vertical line.  No entry is required if the underlined default value is desired.
[ ]	Square brackets enclose options that may be omitted.
( )	Parentheses are constants and must be specified.
'BLANK'	This symbol indicates that at least one whitespace character is necessary for the syntax.
...	Ellipses signify repetition, which means that the preceding unit can be repeated several times in succession.
	For informative texts.

## 1.4.2 SDF notational conventions

The following tables describe the notational conventions used to represent SDF commands and statements of the C/C++ compiler and the global listing generator.

**Table 1: Special characters**

The special characters and notational conventions used in SDF statement formats are explained in the table below:

Format	Meaning	Examples
UPPERCASE	Uppercase letters indicate keywords (names of commands, statements, and operands, keyword values). Some keywords start with *.	START-CPLUS-COMPILER COMPILE ELEMENT = <u>*STD-ELEMENT</u>
=	The equals sign connects an operand name with the corresponding operand values.	LISTING = <u>*NONE</u>
< >	Angle brackets indicate variables, the values of which are defined by data types and their suffixes (see the following tables).	VERSION = <text 1..24>
<u>Underline</u>	Underlining indicates default values of operands, i.e. values which are automatically used when no explicit specification is made.	SUMMARY = *YES / <u>*NO</u>
/	A slash separates alternative operand values.	TEST-SUPPORT = *YES / <u>*NO</u>
(...)	Parentheses indicate operand values which introduce a structure.	LIBRARY = *LINK(...)
[ ]	Square brackets indicate optional operand values that introduce structures. The structure that follows may be specified without the introductory operand value.	SOURCE = [*YES](...)
Indentation	Indentation indicates dependence on the higher- ranking operand.	LIBRARY = <filename> / *LINK(...) *LINK(...)   LINK-NAME =

	Vertical lines denote associated operands in a structure. The top and bottom of the line indicate the beginning and end of a structure. Further structures may occur within a structure. The number of vertical lines before an operand corresponds to the depth within the structure.	*LIBRARY-ELEMENT(...)   LIBRARY =   ,ELEMENT =     VERSION =
,	A comma precedes further operands of the same level within the structure.	,SOURCE = *NO ,SUMMARY = *NO
list-poss(n): list-poss:	A list can be generated from the operand values following list-poss. If (n) is specified, the list may contain at most n elements. If the list contains more than one element, it must be enclosed within parentheses. In this manual, (n) is indicated only if a compiler-specific maximum number is involved. list-poss without (n) means that the maximum SDF default value of 2000 applies.	list-poss (127): *STD / BY-SOURCE / <c-string> list-poss: <filename> / *LINK(...)

## Table 2: Data types

Variable operand values are indicated in SDF by data types. Each data type represents a specific value range. The number of data types is restricted to those described in the table below.

The following descriptions of data types apply to all statements. Consequently, only the operands which deviate from the definitions given here are explained in the individual operand descriptions.

Data type	Character set	Meaning
alphanum-name	A...Z 0...9 \$, #, @	
c-string	EBCDIC characters	A sequence of EBCDIC characters enclosed in single quotes. C may precede the characters. Single quotes within the c-string must be duplicated. The data type c-string is provided with the suffix with-low, which means that a distinction is made between uppercase and lowercase letters. Examples of valid representations: 'abc' , C'_abc' , 'ABC' , 'printf("macro-text\ n")'.
composed-name	A...Z 0...9 \$, #, @ hyphen period	Name or version of a PLAM library element. composed-name is provided with the suffix with-under (underscore) (see also <a href="#">Table 3</a> ).
filename	A...Z 0...9 \$, #, @ hyphen period	Link name or fully-qualified name of a cataloged file or a PLAM library. The maximum length for link names is 8 characters; the maximum length for fully-qualified names including the cat-id and user-id is 54 characters (or 41 characters excluding the cat-id and user-id).
		Input Format:
		linkname
		:cat:\$user.{ datei / datei(nr) / gruppe / gruppe{ (*abs) / (+rel) / (-rel) } }

---

linkname

The first and last character must not be a hyphen or period; maximum of 8 characters; must contain at least A...Z.

Data type	Character Set	Meaning
filename (continuation)		<p>:cat:</p> <p>Optional catalog identifier; character set restricted to A...Z and 0...9; maximum of 4 characters; must be enclosed in colons; the default value is the catalog identifier assigned to the user ID in accordance with the entry in the user catalog (also called the JOIN entry).</p>
		<p>\$user.</p> <p>Optional user ID; character set is A...Z, 0...9, \$, #, @; maximum of 8 characters; must not begin with a digit; \$ and the period must be included; the default value is the own user ID.</p>
		<p>\$.  (special case) System default identifier.</p>
		<p>file</p> <p>File or job variable name; first and last character must not be a hyphen or period; maximum of 41 characters; must contain at least A...Z.</p>
		<p>#file @file  (special case) # or @ as the first character indicates temporary files or job variables, depending on system generation.</p>
		<p>file(no)</p> <p>Tape file name no: version number; character set is A...Z, 0...9, \$, #, @. Parentheses must be included.</p>

Data type	Character Set	Meaning
filename (continuation)		group  Name of a file generation group (see "file" for character set )
		group{ (*abs) / (+rel) / (-rel) }
		(*abs): Absolute generation number (1-9999); * and parentheses must be included..
		(+rel) / (-rel):  Relative generation number (0-99); sign and parentheses are required.
integer	0...9,+,-	+ or - are possible only as the first character.
name	A...Z 0...9 \$,#,@	C/C++ name for DEFINE / UNDEFINE in the MODIFY-SOURCE-PROPERTIES statement. The data type name is provided with the suffix underscore (see also <a href="#">Table 3</a> ). Lowercase letters cannot be represented with name; <b>c-string</b> must be used for this purpose. Maximum length: 125 characters
posix-filename	A...Z 0...9 special characters	String with a maximum length of 255 characters; consists of either one or two periods, or alphanumeric characters and special characters; all special characters must be escaped with a preceding \ (backslash); the / character is not allowed. A distinction is made between uppercase and lowercase letters
posix-pathname	A...Z 0...9 special characters structural identifiers: slashes	Input format: [/]part <sub>1</sub> [/.../part <sub>n</sub> ] where part <sub>1</sub> is a posix-filename;  up to1023 characters; up to 247 characters for source and header files. The data type posix-pathname is provided with the suffix mandatory-quotes and must therefore always be enclosed within single quotes.
x-string	Hexadecimal: 00...FF	Sequence of hexadecimal values enclosed within single quotes; must be preceded by the letter X.

### Table 3: Data type suffixes

Data type suffixes denote further input specifications for data types. These suffixes place restrictions on the value range or extend it. The following suffixes are used in their abbreviated form in the manual:

cat-id	cat
correction-state	corr
generation	gen
lower-case	low
manual-release	man
underscore	under
user-id	user
version	vers

The following descriptions of suffixes apply to all statements. Consequently, only the operands which deviate from the definitions given here are explained in the individual operand descriptions.

Suffix	Meaning
x..y	<ol style="list-style-type: none"> <li>For data type integer: interval  x: Minimum value permitted for integer. x is an integer which may be given a sign.  y: Maximum value permitted for integer. y is an integer which may be given a sign.</li> <li>For other data types: length  x: Minimum length for the operand value; x is an unsigned integer.  y: Maximum length for the operand value; y is an unsigned integer.</li> </ol>
with	Extends the options for specifying a data type.
-low	A distinction is made between uppercase and lowercase letters.
-under	The underscore ( _ ) is permitted as an additional character.
without	Restricts the options for specifying a data type.
-cat	Specifying a catalog identifier is not permitted..
-corr	Eingabeformat: [[C] ][V][m]m.na[ ' ] No correction status may be included in the product-version data type.
-gen	Specifying a file generation or file generation group is not permitted.

---

-man	Input format: [[C] ][V][m]m.n[ ] Neither the release status nor the correction status may be included in the product-version data type.
-user	Specifying a user identifier is not permitted.
-vers	Specifying a version (siehe file(no)) is not permitted for tape-files.
mandatory	Makes certain entries mandatory for a data type
-quotes	Specifications for the data types posix-filename and posix-pathname must be enclosed within single quotes.

---

## 2 Overview of the C/C++ development system

This chapter provides information concerning the following topics:

- From source program to program execution
- General requirements for compilation, linkage and program execution
- General features of the C/C++ compiler
- Specific CRTE components required for C/C++
  - Include libraries
  - Module libraries
- Editing source programs
- POSIX support
  - Compiler I/O in the POSIX file system
  - Use of POSIX library functions
- Introductory examples
  - Example 1: Compiling, linking, and starting a C program
  - Example 2: Compiling, linking, and starting a C++ program
  - Example 3: Compiling a C source program that is located in a POSIX file and uses POSIX library functions

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## 2.1 From source program to program execution

Three steps are necessary to convert a C/C++ source program into an executable program:

1. Preparation of the source program and header files

The source program may be in a cataloged BS2000 file, a PLAM library element (oftype S), or a POSIX file. Header files may be located in PLAM library elements (type S), in POSIX files, or also in cataloged files if the source program itself is located in a cataloged file. The standard headers for the C and C++ library functions (excluding POSIX functions) are located by default in the CRTE libraries \$.SYSLIB.CRTE, \$.SYSLIB.CRTE.CPP, \$.SYSLIB.CRTE.CXX01 and \$.SYSLIB.CRTE.CXX02; the standard headers for POSIX library functions are located in the library \$.SYSLIB.POSIX-HEADER.

2. Compilation

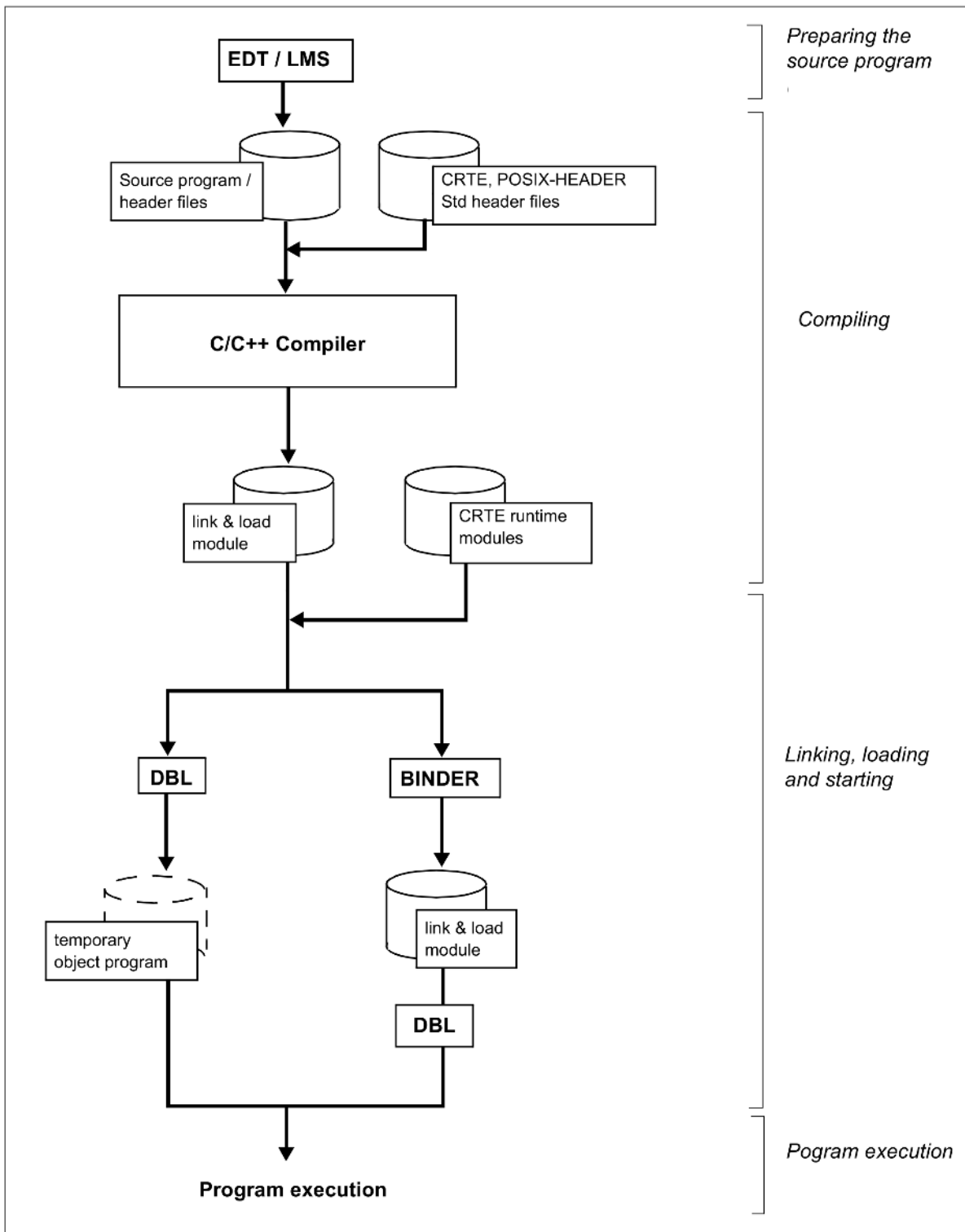
The source program must be compiled into machine language. The compiler generates all modules only in LLM format and optionally saves them in PLAM library elements (of type L) or in POSIX object files.

3. Linkage

The modules generated during compilation are linked with modules from the C runtime system and the C++ runtime system (if C++ library functions are used) to create an executable unit.

Modules created in the modes C++ V3, C++ 2017 or C++ 2020 should not be linked with a direct call to BINDER, but only with the compiler statements MODIFY-BIND-PROPERTIES and BIND.

The following overview illustrates these basic steps and indicates where other relevant information can be found in this manual.



---

## 2.2 General requirements for compilation, linkage and program execution

In order to compile, link and execute a program successfully, you will need the following components:

- Calling programs of the C/C++ compiler and global listing generator
- SDF C/C++ syntax file
- DMS/PLAM/BINDER message files
- C/C++ message file

In addition, you will also need the Common Runtime Environment CRTE from version V10.1A resp. V11.1A, which is supplied with the components below:

- C and C++ runtime modules
- ILCS runtime modules
- Standard headers for C library functions (excluding the POSIX functions) and for C++ library functions

The preparatory steps required to enable SDF control and the message files are described in the release notice for C/C++ V4.0.

Notes on the installation and operation of CRTE can be found in the release notice for CRTE and in the CRTE User Guide [4].

In principle, the C/C++ compiler can be used with any BS2000/OSD version as of V10.0. Note, however, that many of its features described in this manual are based on higher operating system versions and may also require some additional software products:

- Compiler I/O in the POSIX file system and the use of POSIX library functions: POSIX-HEADER from V10.1A resp. V11.1A.

For more details on software requirements, see also the release notice for C/C++ V4.0.

The compiler requires a sufficient amount of virtual memory. It is recommended to set the `ADDRESS-SPACE-LIMIT` of the account to 256MB or higher. Please note that the default on some systems is lower.

---

## 2.3 General features of the C/C++ compiler

### Supported C and C++ language standards

The following C and C++ standards are supported by the C/C++ compiler:

- ANSI/ISO C with the ISO C Addendum 1 (1994), also called C89
- ISO/IEC C (2011), also called C11
- ISO/IEC C++ (2017), also called C++ 2017
- ISO/IEC C++ (2020), also called C++ 2020

### Compatibility

The following language modes are offered by the compiler to enable the migration or porting of older C and C++ applications:

- Kernighan&Ritchie C,
- Cfront C++ V3.0.3, also called C++ V2
- the version of C++ offered by C/C++ V3.2 also called C++ V3
- the preprocessor dialect based on Reiser cpp and Johnson pcc

### Portable software

To develop portable software, the compiler also supports “strict” C and C++ modes. All deviations from the corresponding language standards are diagnosed in these modes.

---

## 2.4 Specific CRTE components required for C/C++

This section provides you with a quick overview of the CRTE “containers” that are relevant for programming in C++ and C. More explicit details on the functionality, scope and use of the C++ libraries provided with the CRTE are presented in the chapter [“The C++ libraries and C++ runtime system”](#).

Detailed information on the general concept of CRTE can be found in the CRTE User Guide [\[4\]](#).

See also the various reference manuals and publications for C and C++ library functions listed in the References section.

---

## 2.4.1 Include libraries

### The SYSLIB.CRTE library

This library contains:

- Standard headers (type S) for C library functions (ANSI C and BS2000-specific extensions)
- Standard headers (type S) for classes and functions of the standard C++ library for the language mode C++ V3
- Standard headers (type S) for classes and functions of the C++ V3 library Tools.h++

This library does not include:

- Standard headers for the use of POSIX library functions. Following the installation of POSIX-HEADER (release unit of BS2000/OSD-BC), these headers are made available in the SYSLIB.POSIX-HEADER library.
- Standard headers of the standard-C++ library according to the standard C ++ 2017; these are part of the library SYSLIB.CRTE.CXX01.
- Standard headers of the Cfront-compatible C++ library functions for complex math and stream-oriented I/O. These headers are located in the SYSLIB.CRTE.CPP library.

### The SYSLIB.CRTE.CXX01 library

This library contains the standard headers for classes and functions of the standard C++ library version 1. These headers can be used in language modes C++ 2017 and C++ 2020.

See also the section [“The modern C++ library in version 1”](#).

### The SYSLIB.CRTE.CXX02 library

This library contains the standard headers for classes and functions of the standard C++ library version 2. These headers can be used in language modes C++ 2017 and C++ 2020.

See also the section [“The modern C++ library in version 2”](#).

### The SYSLIB.CRTE.CPP library

This library contains the standard headers for classes and functions of the Cfront-compatible C++ library for complex math and stream-oriented I/O. These headers are used by the compiler in the Cfront C++ mode.

See also the section [“The C++ library for the Cfront C++ language mode C++ V2”](#).

---

## 2.4.2 Module libraries

### The SYSLNK.CRTE library

This library contains:

- Individual modules of the C runtime system (object modules of type R)  
These modules can be linked statically or dynamically. The C runtime system can also be linked dynamically, provided the SYSLNK.CRTE.PARTIAL-BIND library (for the standard partial bind linking method) or the SYSLNK.CRTE.COMPL library (for the complete partial bind linking method) is specified instead of the SYSLNK.CRTE library when linking with BINDER.  
The C runtime system is always required in order to run C/C++ programs. Among other things, it contains the code for all the C library functions, the central I/O routines for the implementation of C++ I/O functions, and additional routines for the implementation of operating system interfaces.  
Many entry names of the C runtime system begin with “IC@”, “ICS” or “ICX”.
- Name adapter modules for new C library functions (object modules of type R and LLMs of type L)  
Adapter modules belong to the non-preloadable components of the C runtime system and must consequently be linked into the application program. They are contained both in the SYSLNK.CRTE library and in the SYSLNK.CRTE.PARTIAL-BIND library.  
Detailed technical information on these adapter modules can be found in the section [“Concept of a name adapter module in the C runtime system”](#).
- The C runtime system as a dynamically loadable prelinked module (LLM, type L).  
This prelinked module is dynamically loaded into the user address space at runtime if the library SYSLNK.CRTE.PARTIAL-BIND is specified instead of the SYSLNK.CRTE library and if the dynamically loadable C runtime system has not been preloaded.

### The SYSLNK.CRTE.PARTIAL-BIND and SYSLNK.CRTE.COMPL libraries

These libraries allow C programs to be linked without unresolved external references and enable the C runtime system to be loaded dynamically only at the time of execution. Connection modules, which are linked instead of the C runtime module and satisfy all unresolved external references of a C program to the C runtime system, are included in the libraries for this purpose. These libraries also contain all the other modules that are required in order to link a C program without any unresolved external references to the CRTE (e.g. ILCS modules and name adapter modules).

SYSLNK.CRTE.PARTIAL-BIND is needed for the standard partial bind linking method while SYSLNK.CRTE.COMPL is used for the complete partial bind linking method. For details concerning the partial bind linking method as well as for differences between standard partial bind and complete partial bind see the CRTE user guide [4].

The C runtime system itself is available in the form of a dynamically loadable prelinked module in the library SYSLNK.CRT and is dynamically loaded into the user address space at runtime if the program cannot be connected to the preloaded C runtime system.

Since only the connection modules are linked and not the entire C runtime system, the finished (i.e. fully-linked) program or module is significantly smaller in size and requires much less disk storage space than when statically linking C runtime modules from the library SYSLNK.CRTE. Furthermore, this also results in faster load times if the C runtime system is preloaded.

See also the CRTE user guide [4] for more technical information.

---

## The SYSLNK.CRTE.CPP and SYSLNK.CRTE.CFCPP libraries

These libraries contain the modules of the Cfront-compatible C++ runtime system (LLMs, type L).

SYSLNK.CRTE.CPP contains the modules of all C++ library functions for complex math and standard I/O that are available in the Cfront C++ mode of the compiler. The entry names begin with "ICP".

SYSLNK.CRTE.CFCPP contains the modules for the internal runtime routines that are needed in the Cfront C++ mode of the compiler to implement initialization, storage management, etc. The entry names begin with "IPP".

The modules can be linked statically or dynamically with BINDER or DBL, respectively. Note that modules from the SYSLNK.CRTE.CFCPP library must be linked with precedence before the modules from the SYSLNK.CRTE.CPP library.

See also section ["The C++ library for the Cfront C++ language mode C++ V2"](#).

## The SYSLNK.CRTE.POSIX library

This library contains a "linkage option" module, which must be linked whenever the POSIX functions of the C runtime system are to be used. This module must always be linked with precedence before the modules in the library SYSLNK.CRTE,

SYSLNK.CRTE.PARTIAL-BIND or SYSLNK.CRTE.COMPL. When linking with BINDER, this library should preferably be linked by means of an INCLUDE statement (without specifying the module name), since the use of RESOLVE statements, by contrast, would require the linkage order to be strictly observed. This also applies when linking with the BIND statement of the compiler, which means that the INCLUDE option should be used in the MODIFY-BIND-PROPERTIES statement.

## The SYSLNK.CRTE.STDCPP and SYSLNK.CRTE.RTSCPP libraries

These libraries contain the modules of the C++ V3 runtime system (LLMs, type L).

SYSLNK.CRTE.STDCPP contains the modules for the standard C++ library, which can be used in the C++ V3 mode of the compiler.

SYSLNK.CRTE.RTSCPP contains the modules for the internal runtime routines that are needed in the C++ V3 mode of the compiler to implement, among other things, the C++ exception handling and the C++ runtime type information (RTTI).

The modules can be linked statically with the BIND statement of the compiler or dynamically with DBL.

See also section ["The C++ library for the language mode C++ V3"](#).

## The SYSLNK.CRTE.TOOLS library

This library contains the modules (LLMs, type L) for the C++ V3 library Tools.h++, which can be used in the C++ V3 mode of the compiler.

The modules can be linked statically with the BIND statement of the compiler or dynamically with DBL.

See also section ["The C++ V3 library Tools.h++"](#).

## The SYSLNK.CRTE.CPP-COMPL library

This library contains adapters for the SYSLNK.CRTE.STDCPP, SYSLNK.CRTE.RTSCPP and SYSLNK.CRTE.TOOLS libraries.

---

## **The SYSLNK.CRTE.CXX01 library**

This library contains the modules of the C++ 2017 and C++ 2020 runtime system (LLMs, type L). This library will be used when library version 1 is selected.

See also section "[The modern C++ library in version 1](#)".

## **The SYSLNK.CRTE.CXX02 library**

This library contains the modules of the C++ 2017 and C++ 2020 runtime system (LLMs, type L). This library will be used when library version 2 is selected.

See also section "[The modern C++ library in version 2](#)".

---

## 2.5 Editing source programs

### Storage methods for source programs and header files

The C/C++ compiler processes source programs and header files which are stored as follows:

Source programs stored as

- cataloged SAM and ISAM files (with KEYPOS=5 and KEYLEN <= 16)
- PLAM library elements of type S
- POSIX source files

Header files stored as

- cataloged files if the source program is itself a cataloged file
- PLAM library elements of type S
- POSIX source files

### The file editor EDT

The file editor EDT is available in BS2000 for editing a C/C++ source program. EDT can process cataloged SAM /ISAM files, PLAM library elements and POSIX files.

EDT converts lowercase letters to uppercase letters by default. Since source program texts in C/C++ usually contain a large number of lowercase letters, automatic conversion to uppercase must be prevented by issuing the command LOWER ON after EDT is called.

The following table provides an overview of the most important EDT statements for processing files and library elements.

The file editor EDT is described in detail in the manual "EDT (BS2000/OSD)" [15].

<b>SAM files</b>	
@READ'file'	Read contents of a SAM file into the current work file.
@WRITE'file'	Write contents of the current work file to a SAM file
<b>ISAM files</b>	
@GET'file'	Read contents of an ISAM file into the current work file
@SAVE'file'	Write contents of the current work file to an ISAM file
@OPEN'file'	Physically open ISAM file
@CLOSE	Close an ISAM file opened with @OPEN
<b>PLAM library elements</b>	
@OPEN LIB=lib(ELEM=elem)	Open library element in the current work files
@COPY LIB=lib(ELEM=elem)	Read contents of a library element into the current work file
@WRITE LIB=lib(ELEM=elem)	Write contents of the current work file to a library element

@CLOSE	Close a library element opened with @OPEN
<b>POSIX files</b>	
@XOPEN FILE=pathname,MODE=ANY/UPDATE/NEW/REPLACE	Open and read an existing POSIX file or create a new POSIX file
@CLOSE	Close a POSIX file opened with @XOPEN
@XCOPY FILE=pathname	Read contents of a POSIX file into the current work file
@XWRITE FILE=pathname,MODE=ANY/UPDATE/NEW/REPLACE	Write contents of a current work file to a POSIX file

EDT statements for processing files and library elements (extract)

By default, PLAM library elements are stored by EDT as elements of type S with the highest version number (X'FF').

## Key assignments

In order to program in C and C++, the user requires a number of special characters, some of which may not be available on all keyboards. For example, keyboards with the German character set have “umlauts” assigned instead of some characters specifically required for C and C++.

The following table lists the different key assignments and their (international) hexadecimal codes. This information can be used to create a user-specific keyboard configuration if required.

Identifier / Functions in C and C++	“English” keyboard	“German” keyboard	Hexadecimal code
left angle bracket	<	<	4C
right angle bracket	>	>	6E
logical OR		ö	4F
logical exclusive OR	^	^	6A
underscore	_	_	6D
left square bracket	[	Ä	BB
right square bracket	]	Ü	BD
backslash	\	Ö	BC
left brace	{	ä	FB
right brace	}	ü	FD
bit complement	~	ß	FF

---

## 2.6 POSIX support

This section provides information concerning the following topics:

- [Compiler I/O in the POSIX file system](#)
- [Use of POSIX library functions](#)

---

## 2.6.1 Compiler I/O in the POSIX file system

The C/C++ compiler supports the BS2000 file system (DMS files, PLAM libraries, etc.) as well as the POSIX file system. All inputs and outputs of the compiler in a compilation, preprocessor or syntax analysis run can also be effected via POSIX files. This includes, in particular:

- the input of source programs (see the SOURCE option in the COMPILE, PREPROCESS and CHECK-SYNTAX statements)
- the input of header files (see the USER-INCLUDE-LIBRARY and STD-INCLUDE-LIBRARY options in the MODIFY-INCLUDE-LIBRARY statement)
- the output of LLMs (see the MODULE-OUTPUT option in the COMPILE statement)
- the output of recompilable source programs (see the OUTPUT option in the PREPROCESS statement)
- the output of compiler listings (see the OUTPUT option in the MODIFY-LISTING-PROPERTIES statement)
- the output of message lists (see the OUTPUT option in the MODIFY-DIAGNOSTIC-PROPERTIES statement)
- the output of CIF information (see the OUTPUT option in the MODIFY-CIF-PROPERTIES statement)

Arbitrary combinations, i.e. the input and output of both BS2000 as well as POSIX files in the same compilation run, are also possible.

### Storage of source programs and header files

Source programs and header files may exist in EBCDIC and ASCII codes. EBCDIC is the default in the POSIX file system; ASCII is the default for file systems on remote UNIX computers or PCs. All files of a file system (POSIX file system or attached remote file systems) must, however, be in the same respective (default) codeset. The compiler checks the codeset of a file system centrally, not for each individual file. Files of an ASCII file system are internally converted to EBCDIC for the compilation.

In contrast to program development in the POSIX shell (see the manual “POSIX commands of the C/C++ Compiler [1]”), the file names of source programs need not always contain one of the standard suffixes “.c”, “.C” or “.i”.

### Output of LLMs

The LLMs generated by the compiler can be written to POSIX object files (“.o” files). These LLM object files can only be processed meaningfully in the POSIX subsystem (by using the command `cc`, `c11`, `c89` or `CC`; see the manual “POSIX commands of the C/C++ Compiler [1]”). The generated object file format (LLM) is not supported on UNIX systems.

### Other compiler outputs

- Expanded recompilable source programs  
The result of a preprocessor run can be written to a POSIX source file (“.i” file in C, “.I” file in C++). This file can be processed further in the POSIX shell with the command `cc`, `c89` or `CC` and in the BS2000 environment via the SDF interface of the C/C++ compiler.
- Compiler listings  
Compiler listings can be written to a POSIX list file (“.lst” file). This list file can be printed in the POSIX shell with the command `bs21p` and in the BS2000 environment with the SDF command `PRINT-DOCUMENT`.

- 
- Diagnostic messages  
Error messages of the compiler can be written to a POSIX file (“`.diag`” file). This file can be read with a file editor such as EDT in the POSIX shell (`edt` command) and in the BS2000 environment (see note on EDT on ["Editing source programs"](#)).
  - CIF information  
The local CIF information for individual modules that is used to create global listings can be stored in a POSIX file (“`.cif`” file). These CIF files can be processed further in the POSIX shell with the command `cclistgen` (see the manual “POSIX Commands of the C/C++ Compiler [1]”) and via the SDF interface of the global listing generator in the BS2000 environment (see START-CPLUS-LISTING-GENERATOR, ["Controlling the global listing generator"](#)).

## Output codeset

The output codeset of the files (EBCDIC or ASCII) is determined by the codeset of the target file system. The compiler stores files in EBCDIC code in the POSIX file system and in ASCII code in file systems on UNIX computers.

Only EBCDIC execution code is generated. For example, the names of external entries are only stored in EBCDIC code.

## Description of the term `<posix-pathname>`

When `<posix-pathname>` is specified as an input or output, the following can be specified:

- a file name with no path specification
- a relative path to a file
- an absolute path to a file
- a relative path to a directory
- an absolute path to a directory

If no absolute path exists, the name/path is interpreted relative to the user’s home directory.

All directories in the path must already exist.

When an input file is requested, no directory may be specified.

When an input directory is requested, no file may be specified.

It only makes sense to specify an output file when a single source is processed. When multiple sources are processed, it is generally not permissible to specify an output file.

When the file name is created, it must be borne in mind that meaningful further processing of the output file in the POSIX subsystem is possible only if the name has a suitable suffix. When a directory is specified, the compiler itself determines the name of the output file (see section ["Default names for output containers"](#)).

---

## 2.6.2 Use of POSIX library functions

With CRTE a C runtime system is provided, that supports C library functions with BS2000 functionality as well as POSIX functionality.

The library functions with BS2000 functionality include all ANSI-defined functions and about fifty BS2000-specific extensions.

Only these functions may be used in the following cases:

- if no POSIX subsystem is available, or
- if no preparatory steps are taken (see below) at compile and link time in a BS2000 operating system with an available POSIX subsystem.

The library functions with BS2000 functionality are described in the manual “C Library Functions” [2].

The following functions of the C runtime system, which were introduced for the first time with CRTE V2.0, are library functions with POSIX functionality: all functions required by the XPG4 standard and about thirty UNIX-specific extensions. For more information on these functions and all functions with BS2000 functionality, see the manual “C Library Functions for POSIX Applications” [3].

### Compilation and linkage of programs that use POSIX library functions

The following steps are required in order to use library functions with POSIX functionality when developing programs in the BS2000 environment (SDF):

1. The library SYSLIB.POSIX-HEADER, which contains the standard headers for POSIX functions, must be specified in addition to the CRTE library SYSLIB.CRTE in the search for standard headers at compilation.

```
//MOD-INCLUDE-LIB STD-INCLUDE-LIB=( *STANDARD-LIBRARY , &( INSTALLATION-PATH  
( 'SYSLIB' , 'POSIX-HEADER' , DEFAULT=' $.SYSLIB.POSIX-HEADER' ) ) )
```

2. The `_OSD_POSIX` directive must always be set before the preprocessor encounters the first `#include` directive in the program. This can be ensured by a global setting for the entire compilation run with the `SOURCE-PROPERTIES` statement instead of a definition in the source program with the `#define` directive.

```
//MODIFY-SOURCE-PROPERTIES DEFINE=_OSD_POSIX
```

3. When linking, the link option library SYSLNK.CRTE.POSIX must be linked with precedence before the library SYSLNK.CRTE, SYSLNK.CRTE.PARTIAL-BIND or SYSLNK.CRTE.COMPL. When linking with `BINDER`, it is advisable to use an `INCLUDE` statement for the link option library (without specifying the module name), since the use of `RESOLVE` statements, by contrast, would require the appropriate order to be strictly observed. In the case of the `BINDER` statement, for example:

```
//INCLUDE-MODULES *LIB(LIB=$.SYSLNK.CRTE.POSIX , ELEM=*ALL)
```

This also applies when linking with the `BIND` statement of the compiler, i.e. the `INCLUDE` option should be used in the `MODIFY-BIND-PROPERTIES` statement:

```
//MOD-BIND-PROP INCLUDE=*LIB-ELEM(LIB=&( INSTALLATION-PATH( 'SYSLNK.POSIX' ,  
'CRTE' , DEFAULT=' $.SYSLNK.CRTE.POSIX' ) ) , ELEM=*ALL)
```

When developing programs in the POSIX environment, by contrast, no special preparatory steps are required in order to use the POSIX library functions (see also the manual “POSIX Commands of the C/C++ Compiler” [1]).

---

## 2.7 Introductory examples

Using three simple examples, this section demonstrates how C/C++ programs are compiled, linked, and executed in BS2000. The examples are based on the assumption that the C/C++ compiler and the C and C++ runtime systems were installed by default under the user ID TSOS.

- [Example 1: Compiling, linking, and starting a C program](#)
- [Example 2: Compiling, linking, and starting a C++ program](#)
- [Example 3: Compiling a C source program that is located in a POSIX file and uses POSIX library functions](#)

---

## 2.7.1 Example 1: Compiling, linking, and starting a C program

The C source program is contained in the cataloged file HELLO. The compiler generates an LLM and places it in the library PLAM.TEST. This module is then linked by different methods:

Variation 1: with the BIND statement of the compiler

Variation 2: with BINDER

Variation 3: with DBL

### Source program file HELLO

```
#include <stdio.h>
int main(void)
{
    printf("Hello, I am a C program\n");
    return 0;
}
```

The source program was written using EDT and saved in a file named HELLO.

### Runtime listing for compilation, linkage and execution

```
(IN)  indicates user inputs
(OUT) indicates system program messages
(IN)  /START-CPLUS-COMPILER _____ (1)
(OUT) % BLS0523 ELEMENT 'SDFCC', VERSION '04.0B02', TYPE 'L' FROM LIBRARY
      ':P401:$TSOS.SYSLNK.CPP.040' IN PROCESS
(OUT) % BLS0524 LLM 'SDFCC', VERSION '04.0B02' OF '2023-04-02 13:40:11'
      LOADED
(OUT) % BLS0551 COPYRIGHT (C) 2023 Fujitsu Technology Solutions GmbH. ALL
      RIGHTS RESERVED
(OUT) % CDR9992 : BEGIN C/C++ VERSION 04.0B02
(IN)  //MODIFY-SOURCE-PROP LANGUAGE=*C _____ (2)
(IN)  //COMPILE SOURCE=HELLO,MODULE-OUTPUT=*LIB-ELEM(LIB=PLAM.TEST) — (3)
(OUT) % CDR9907 : NOTES: 0  WARNINGS: 0  ERRORS: 0  FATALS: 0
(OUT) % CDR9937 : MODULES GENERATED, CPU TIME USED = 0.0030 SEC
```

#### Variation 1: Linking with the BIND statement

```
(IN)  //MOD-BIND-PROP INCLUDE=*LIB(LIB=PLAM.TEST,ELEM=HELLO),-
      //RUNTIME-LANG=*C,STDLIB=*STATIC _____ (4)
(IN)  //BIND OUTPUT=*LIB(LIB=PLAM.TEST1,ELEM=HELLO) _____ (5)
(OUT) % BND3102 SOME WEAK EXTERNS UNRESOLVED
(OUT) % BND1501 LLM FORMAT: '1'
(OUT) % BND1101 BINDER NORMALLY TERMINATED. SEVERITY CLASS:
      'UNRESOLVED EXTERNAL'
(IN)  //END _____ (6)
(OUT) % CDR9936 END; SUMMARY: NOTES: 0  WARNINGS: 0  ERRORS: 0  FATALS: 0
(OUT) % CCM0998 CPU TIME USED: 1.9967 SECONDS
```

#### Variation 2: Linking with BINDER

```

(IN) /START-BINDER _____ (7)
(OUT) % BND0500 BINDER VERSION 'V02.7A12' STARTED
(IN) //START-LLM-CREATION INT-NAME=XY
(IN) //INCLUDE-MODULES *LIB(LIB=PLAM.TEST,ELEM=HELLO)
(IN) //RESOLVE-BY-AUTOLINK LIB=$.SYSLNK.CRTE
(IN) //SAVE-LLM LIB=PLAM.TEST1,ELEM=HELLO,MAP=*NO
(OUT) % BND3102 SOME WEAK EXTERNS UNRESOLVED
(OUT) % BND1501 LLM FORMAT: '1'
(IN) //END
(OUT) % BND1101 BINDER NORMALLY TERMINATED. SEVERITY CLASS:
      'UNRESOLVED EXTERNAL'

```

### Variant 3: Linking, loading and starting with DBL

```

(IN) /ADD-FILE-LINK LINK-NAME=BLSLIB01,FILE-NAME=$.SYSLNK.CRTE _____ (8)
(IN) /START-EXECUTABLE-PROGRAM FROM-FILE=*LIB-ELEM(LIBRARY=PLAM.TEST,-
      /ELEMENT-OR-SYMBOL=HELLO),DBL-PARAMETERS=*PARAM(-
      /RESOLUTION=*PARAM(ALTERNATE-LIBRARIES=*BLSLIB##))
(OUT) % BLS0524 LLM 'HELLO', VERSION ' ' OF '2020-04-02 13:33:56' LOADED
(OUT) Hello, I am a C program
(OUT) % CCM0998 CPU TIME USED: 0.0021 SECONDS

```

### Starting programs linked with variants 1 and 2

```

(IN) /START-EXECUTABLE-PROGRAM FROM-FILE=*LIB-ELEM(LIBRARY=PLAM.TEST1,-
      /ELEMENT-OR-SYMBOL=HELLO) _____ (9)
(OUT) % BLS0524 LLM 'XY', VERSION ' ' OF '2020-04-02 13:33:50' LOADED
(OUT) Hello, I am a C program
(OUT) % CCM0998 CPU TIME USED: 0.0028 SECONDS

```

- (1) The compiler is started.
- (2) The MODIFY-SOURCE-PROPERTIES statement is used to set the language mode C (the default setting is language mode C++).
- (3) The COMPILE statement is issued with selected options to begin compilation. The SOURCE option specifies the name of the source program to be compiled, and the MODULE-OUTPUT option specifies a PLAM library as the output destination. The name of the object module to be generated is derived from that of the source program (HELLO).
- (4) The MODIFY-BIND-PROPERTIES statement specifies the modules to be linked and other conditions for the subsequent linkage run with the BIND statement of the compiler. The INCLUDE option (which corresponds to the BINDER statement INCLUDE-MODULES) specifies the LLM HELLO, which was generated earlier and placed in the library PLAM.TEST. The RUNTIME-LANGUAGE option specifies that the program to be linked is a C program (C++ is the default). Due to this option, all additional modules of the C runtime system which are required for C programs are automatically linked with the autolink mechanism. The \*STATIC entry in the STDLIB option instructs the compiler to load the C runtime system from the library \$.SYSLNK.CRTE instead of the library \$.SYSLNK.CRTE.PARTIAL-BIND (the default).

- 
- (5) The BIND statement is issued to start the linkage run. The OUTPUT option (which corresponds to the BINDER statement SAVE-LLM) causes the fully-linked LLM to be stored under the name HELLO as an element of type L in the PLAM library PLAM.TEST1. The BINDER message "SOME WEAK EXTERNS UNRESOLVED" refers to the ILCS module IT0INITS. This module contains WEAK-EXTERN references to all languages potentially required for ILCS. In this example, only the C language is involved, so the other references remain unresolved.
  - (6) The END statement terminates the compiler run.
  - (7) The HELLO module that was generated at compilation in the PLAM library PLAM.TEST is linked with BINDER.
  - (8) The HELLO module, which was generated at compilation and placed in the PLAM library PLAM.TEST, is dynamically linked, loaded and started with DBL.
  - (9) The finished program HELLO, which was fully linked with the BIND statement of the compiler (see variant 1) and with BINDER (see variant 2) and placed in the library PLAM.TEST1, is loaded and started. The entry ALT-LIB=\*BLSLIB## (see variant 3), which is required for dynamic linking with DBL, is not needed in this case.

---

## 2.7.2 Example 2: Compiling, linking, and starting a C++ program

The C++ source program consists of two PLAM library elements PROG1 and PROG2. The compiler generates LLMs and writes them to the PLAM library SYS.PROG.LIB. These modules are then linked with the BIND statement of the compiler.

### Source program element PROG1

```
#include <iostream.h>
extern void invoke(void);
int main(void)
{
    cout << "main(prog1)" << '\n';
    invoke();
    return 0;
}
```

### Source program element PROG2

```
#include <iostream.h>
void invoke(void)
{
    cout << "invoke(prog2)" << '\n';
}
```

The source program extracts shown above were produced using EDT and then written separately to the PLAM library PLAM.EXP with explicit WRITE statements of the form:WRITE L=PLAM.EXP(E=element-name)

## Runtime listing for compilation, linkage and execution

```
(IN)  indicates user inputs
(OUT) indicates system program messages
(IN)  /START-CPLUS-COMPILER _____ (1)
(OUT) % BLS0523 ELEMENT 'SDFCC', VERSION '04.0B02', TYPE 'L' FROM LIBRARY
      ':P401:$TSOS.SYSLNK.CPP.040' IN PROCESS
(OUT) % BLS0524 LLM 'SDFCC', VERSION '04.0B02' OF '2023-04-02 13:40:11'
      LOADED
(OUT) % BLS0551 COPYRIGHT (C) 2023 Fujitsu Technology Solutions GmbH. ALL
      RIGHTS RESERVED
(OUT) % CDR9992 : BEGIN C/C++ VERSION 04.0B02
(IN)  //MOD-SOURCE-PROP LANGUAGE=*CPLUS(V3-COMPATIBLE) _____ (2)
(IN)  //MOD-BIND-PROP RUNTIME-LANGUAGE=*CPLUS(*V3-COMPATIBLE) _____ (2)
(IN)  //COMPILE SOURCE=( *LIB(LIB=PLAM.EXP,ELEM=PROG1),-
      // *LIB(LIB=PLAM.EXP,ELEM=PROG2)) _____ (3)
(OUT) % CDR9907 : NOTES: 0  WARNINGS: 0  ERRORS: 0  FATALS: 0
(OUT) % CDR9937 : MODULES GENERATED, CPU TIME USED = 0.0030 SEC
(OUT) % CDR9907 : NOTES: 0  WARNINGS: 0  ERRORS: 0  FATALS: 0
(OUT) % CDR9937 : MODULES GENERATED, CPU TIME USED = 0.0020 SEC
(IN)  //MOD-BIND-PROP INCLUDE=( *LIB(LIB=SYS.PROG.LIB,ELEM=PROG1),-
      // *LIB(LIB=SYS.PROG.LIB,ELEM=PROG2)) _____ (4)
(IN)  //BIND OUTPUT=*LIB(LIB=PLAM.EXP1,ELEM=PROG) _____ (5)
(OUT) % BND1501 LLM FORMAT: '4'
(OUT) % BND3102 SOME WEAK EXTERNS UNRESOLVED
(OUT) % BND1101 BINDER NORMALLY TERMINATED. SEVERITY CLASS:
      'UNRESOLVED EXTERNAL'
(IN)  //END _____ (6)
(OUT) % CDR9936 END; SUMMARY: NOTES: 0  WARNINGS: 0  ERRORS: 0  FATALS: 0
(OUT) % CCM0998 CPU TIME USED: 1.9967 SECONDS
(IN)  /START-EXECUTABLE-PROG*L(LIB=PLAM.EXP1,E-O-S=PROG) _____ (7)
(OUT) % BLS0523 ELEMENT 'PROG', VERSION '@', TYPE 'L' FROM LIBRARY
      ':2OS2:$USERIDXY.PLAM.EXP1' IN PROCESS
(OUT) % BLS0524 LLM '$LIB-ELEM$PLAM$EXP1$$PROG$$SUPPE', VERSION ' '
      OF '2020-04-02 14:22:01' LOADED
(OUT) main(prog1)
(OUT) invoke(prog2)
(OUT) % CCM0998 CPU TIME USED: 0.0018 SECONDS
```

- (1) The compiler run is started.
- (2) The language mode is set for compiling and linking.
- (3) The COMPILE statement is issued to start compiling the C++ source program elements PROG1 and PROG2. The name of the PLAM library and that of the library element to be compiled are specified individually in the SOURCE option in the form of a list. By default, the compiler places the generated LLMs in the library SYS.PROG.LIB. The names of the LLMs are derived from the names of the source program elements (PROG1, PROG2).
- (4) The MODIFY-BIND-PROPERTIES statement specifies which modules are to be linked in the following linkage run. The INCLUDE option (which corresponds to the BINDER statement INCLUDE-MODULES) specifies the names of the LLMs to be linked, i.e. the LLM containing the main function (PROG1) and the additional LLM with the subroutine (PROG2). All other C and C++ runtime library modules required for C++ V3 programs are linked in automatically (with the autolink mechanism, see "[MODIFY-BIND-PROPERTIES](#)").

- 
- (5) The linkage run is started with BIND statement. The OUTPUT option (which corresponds to the BINDER statement SAVE-LLM) causes the generated LLM to be saved under the name PROG as an element of type L in a PLAM library. The BINDER message "SOME WEAK EXTERNS UNRESOLVED" refers to the ILCS module IT0INITS. This module contains WEAK-EXTERN references to all potential languages for ILCS. Only the C and C++ languages are involved in this example, so the other references remain unresolved. For more information on the LLM format generated by BINDER (Format 4 in this example), please refer to the OUTPUT-FORMAT option of the BIND statement ("[BIND](#)").
  - (6) The compiler run is terminated with the END statement.
  - (7) The fully-linked program is loaded and started with the START-EXECUTABLE-PROGRAM command.

---

### 2.7.3 Example 3: Compiling a C source program that is located in a POSIX file and uses POSIX library functions

The C source program exists as a POSIX source file with the name `hello.c` in the directory `/USERIDXY/source`. The program uses POSIX library functions. The compiler generates an LLM and writes it to a POSIX object file with the default name `hello.o`. This object file is stored in the directory of the source program. The object file is then processed further in the POSIX shell environment.

#### Source program file `hello.c`

```
#include <stdio.h>
FILE *fp;
int main(void)
{
    printf("Hello, I am a C program\n");
    fp = fopen("/USERIDXY/posixfiles/hello", "w");
    fputs("hello", fp);
    fclose(fp);
    return 0;
}
```

The source program was created with EDT and saved with the statement `@XWRITE FILE=/USERIDXY/source/hello.c`.

#### Runtime listing for compilation, linkage and execution

```
(IN)  indicates user inputs
(OUT) indicates system program messages
(IN)  /START-CPLUS-COMPILER _____ (1)
(OUT) % BLS0523 ELEMENT 'SDFCC', VERSION '04.0B02', TYPE 'L' FROM LIBRARY
      ':P401:$TSOS.SYSLNK.CPP.040' IN PROCESS
(OUT) % BLS0524 LLM 'SDFCC', VERSION '04.0B02' OF '2023-04-02 13:40:11'
      LOADED
(OUT) % BLS0551 COPYRIGHT (C) 2023 Fujitsu Technology Solutions GmbH. ALL
      RIGHTS RESERVED
(OUT) % CDR9992 : BEGIN C/C++ VERSION 04.0B02
(IN)  //MOD-SOURCE-PROP LANG=*C,DEFINE=_OSD_POSIX _____ (2)
(IN)  //MOD-INCL-LIB STD-INCL=($.SYSLIB.POSIX-HEADER,*STANDARD-LIB) ____ (3)
(IN)  //COMPILE SOURCE='/USERIDXY/source/hello.c',-
      //MODULE-OUTPUT=*SOURCE-LOC _____ (4)
(OUT) % CDR9907 : NOTES: 0 WARNINGS: 0 ERRORS: 0 FATALS: 0
(OUT) % CDR9937 : MODULES GENERATED, CPU TIME USED: 0.3829 SECONDS
(IN)  //END _____ (5)
(OUT) % CDR9936 END; SUMMARY: NOTES: 0 WARNINGS: 0 ERRORS: 0 FATALS: 0
(OUT) % CCM0998 CPU TIME USED: 0.3829 SECONDS
```

```

(IN)  /START-POSIX-SHELL _____ (6)
(OUT) POSIX Basissshell 10.0A45 created Jun 14 2016
      POSIX Shell 10.0A45 created Jul 12 2016
      Copyright (C) Fujitsu Technology Solutions 2009
          All Rights reserved
      Last login: Thu Mar 26 10:45:44 2020 on term/002
(IN)  cd source _____ (7)
(IN)  ls hello* _____ (8)
(OUT) hello.c    hello.o
(IN)  cc hello.o _____ (9)
(IN)  a.out _____ (10)
(OUT) Hello, I am a C program

```

- (1) The compiler run is started.
- (2) The MODIFY-SOURCE-PROPERTIES statement activates the C language mode (the C++ mode is set by default) and sets the `_OSD_POSIX` define required for the use of POSIX library functions.
- (3) The library containing the standard headers for POSIX library functions is assigned with the MODIFY-INCLUDE-LIBRARY statement in addition to the CRTE library `$.SYSLNK.CRTE (*STANDARD-LIBRARY)`.
- (4) The COMPILE statement is issued to start the compilation run. The absolute path name of the POSIX source file to be compiled is specified with the SOURCE option. POSIX file names must always be enclosed within single quotes. The operand value `*SOURCE-LOCATION` in the MODULE-OUTPUT option causes the compiled module to be written to a POSIX object file with the default name `hello.o` and stored in the directory of the source program.
- (5) The compiler run is terminated with the END statement.
- (6) Since POSIX object files can only be processed further in the POSIX subsystem, the POSIX command START-POSIX-SHELL is used to switch from the BS2000 system environment (SDF) to the POSIX environment (shell). The call places the user in the home directory of the current BS2000 user ID (USERIDXY).
- (7) The POSIX command `cd` is used to change to the `source` directory in which the source program and the object file generated by the compiler are located.
- (8) On entering the POSIX command `ls`, the source file `hello.c` and the object file `hello.o` are listed.
- (9) The POSIX command `cc` links the object file `hello.o` into an executable unit and places it in an executable POSIX file with the default name `a.out`. The `cc` command is described in detail in the manual "POSIX Commands of the C/ C++ Compiler" [1].
- (10) The program is executed.

---

## 3 Compilation

This chapter provides information concerning the following topics:

- General aspects of the compiler run
  - Input sources and output destinations of the compiler
  - Construction of default names
  - Default names for output containers
  - Rules for constructing module names
  - Structure of compiler messages
- Controlling the compiler
  - Calling the compiler (START-CPLUS-COMPILER)
  - Description of compiler statements
    - Overview of statements
    - Basic principles and general input rules
    - BIND
    - CHECK-SYNTAX
    - COMPILE
    - Notes on input via SYSDDTA
    - END
    - MODIFY-BIND-PROPERTIES
    - Interaction between the MODIFY-BIND-PROPERTIES and BIND statements
    - MODIFY-CIF-PROPERTIES
    - MODIFY-DIAGNOSTIC-PROPERTIES
    - MODIFY-INCLUDE-LIBRARIES
    - MODIFY-LIBRARY-VERSION
    - MODIFY-LISTING-PROPERTIES
    - MODIFY-MODULE-PROPERTIES
    - MODIFY-OPTIMIZATION-PROPERTIES
    - The optimization process
    - MODIFY-RUNTIME-PROPERTIES
    - MODIFY-SOURCE-PROPERTIES
    - MODIFY-TEST-PROPERTIES
    - PREPROCESS
    - RESET-TO-DEFAULT
    - SHOW-DEFAULTS
    - SHOW-PROPERTIES

- 
- Controlling the global listing generator
    - Calling the listing generator (START-CPLUS-LISTING-GENERATOR)
    - Description of statements
      - Overview of statements and input rules
      - END
      - GENERATE-LISTING
      - MODIFY-LISTING-PROPERTIES

---

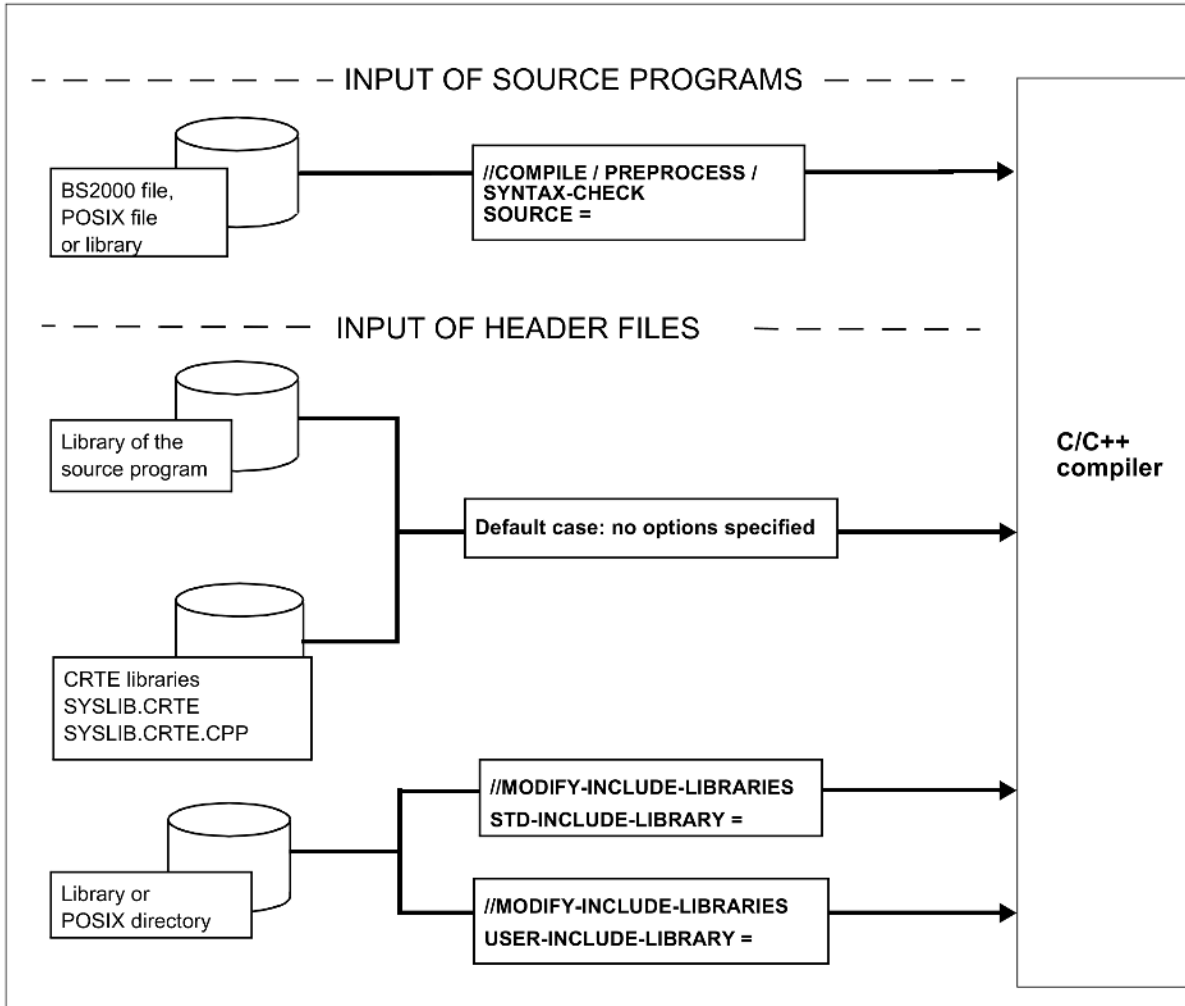
## 3.1 General aspects of the compiler run

This section provides information concerning the following topics:

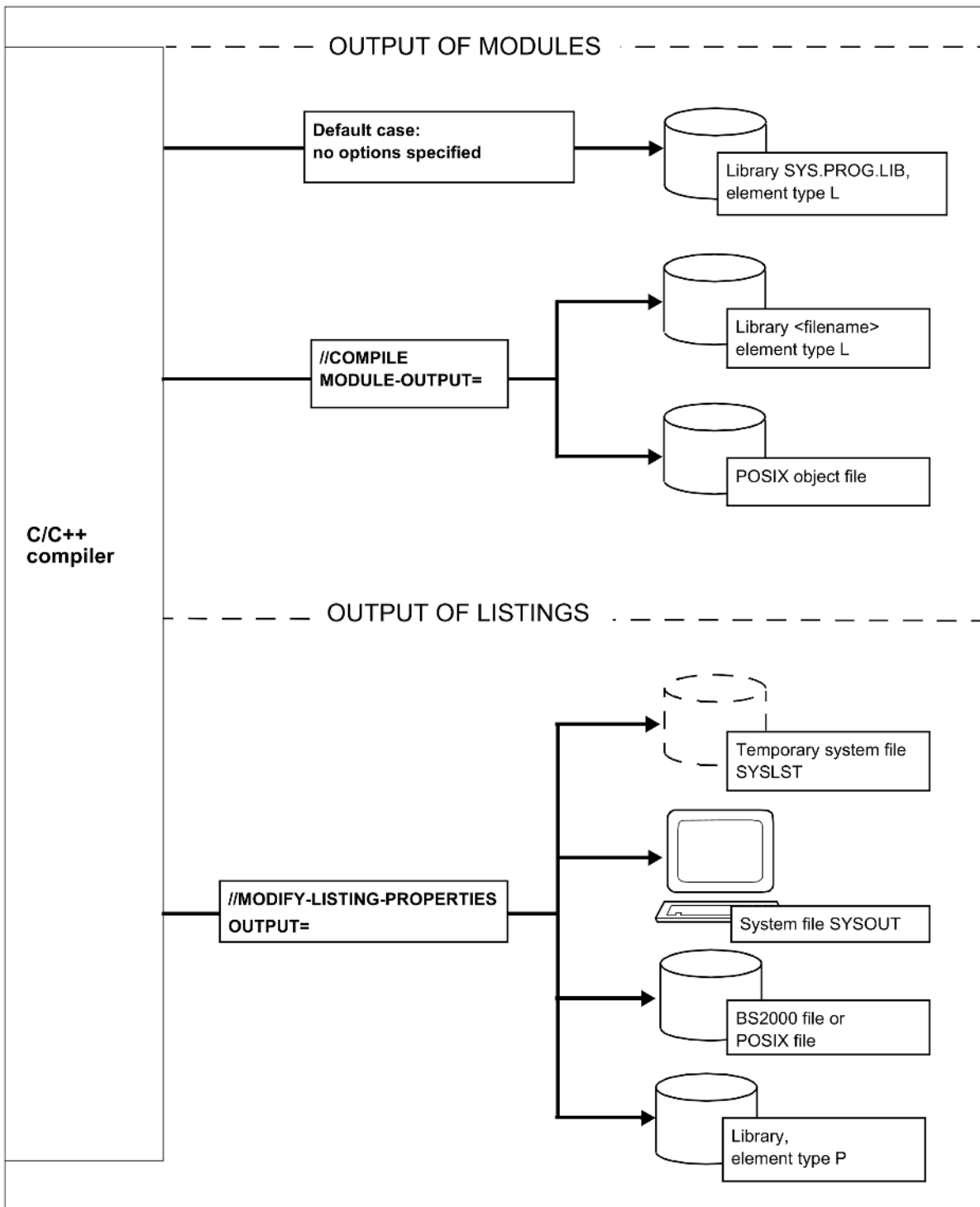
- [Input sources and output destinations of the compiler](#)
- [Construction of default names](#)
- [Default names for output containers](#)
- [Rules for constructing module names](#)
- [Structure of compiler messages](#)

### 3.1.1 Input sources and output destinations of the compiler

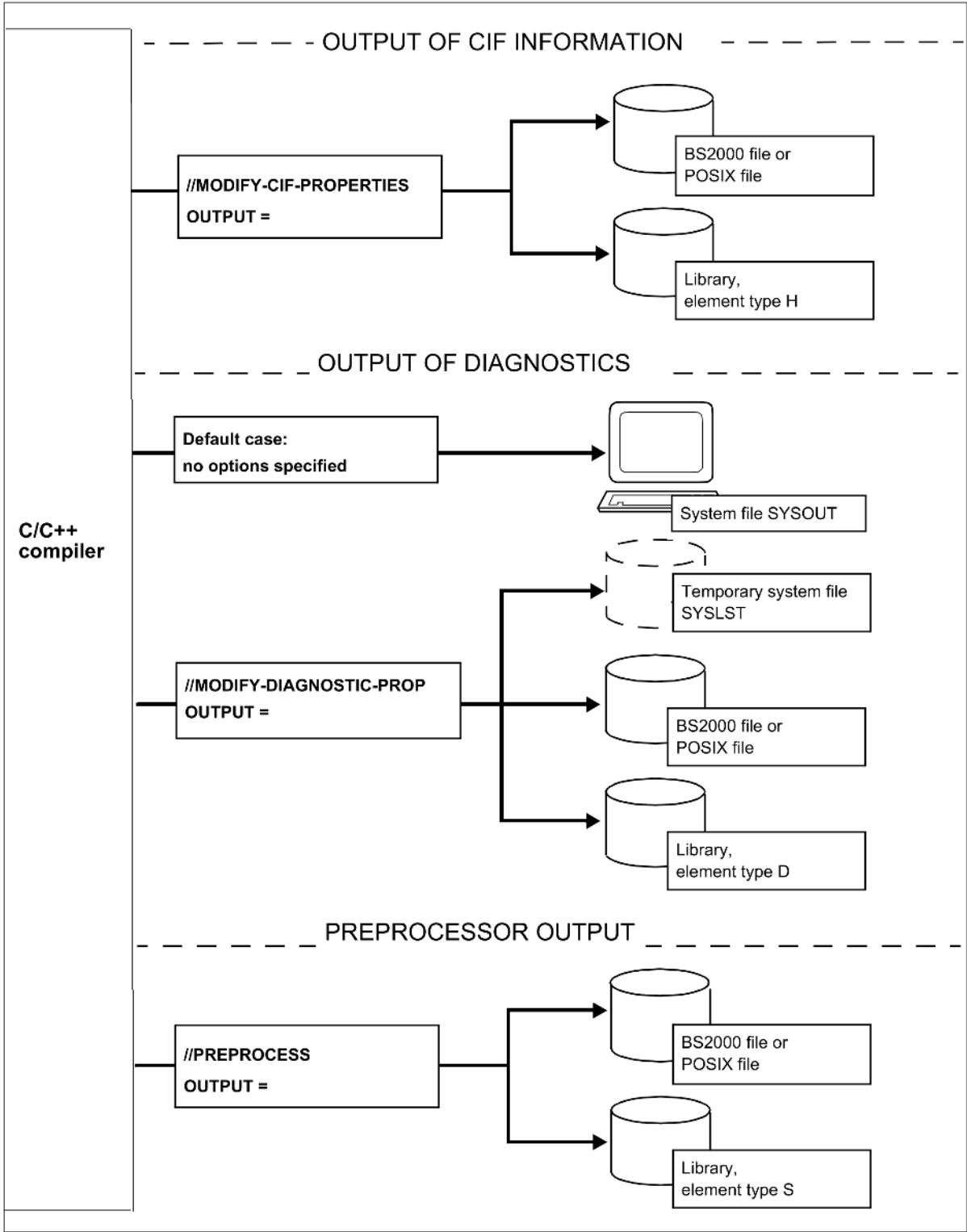
Input of source programs and header files



Output of modules and listings



Output of CIF information, diagnostics and preprocessor output



---

### 3.1.2 Construction of default names

If no output files are explicitly specified for the compilation results, the compiler generates default names by deriving them from the respective source program name.

The section [“Default names for output containers”](#) below describes the rules by which the compiler constructs default names for output containers of the following compilation results: preprocessor output, messages, listings and CIF information.

The rules for constructing module names are described in the section [“Rules for constructing module names”](#).

---

### 3.1.3 Default names for output containers

This section summarizes the rules by which the compiler constructs default names for output containers of the following compilation results:

- Result of a preprocessor run (PREPROCESS)
- Compiler listings (MODIFY-LISTING-PROPERTIES)
- Diagnostic messages (MODIFY-DIAGNOSTIC-PROPERTIES)
- CIF information (MODIFY-CIF-PROPERTIES)

Default names are generated, i.e. derived from the source program name, when the following entries are made in the OUTPUT options listed above:

OUTPUT=\*STD-FILE

OUTPUT=\*SOURCE-LOCATION

OUTPUT=\*LIB-ELEM(LIB=...,ELEM=\*STD-ELEMENT)

OUTPUT=<posix-pathname> (name of a POSIX file directory)

### Construction of default names for cataloged BS2000 files

The output is placed in cataloged BS2000 files with default names

- whenever OUTPUT=\*STD-FILE is specified;
- if OUTPUT=\*SOURCE-LOCATION is specified and the source program is read from a BS2000 file or SYSDTA.
  1. The following source program name components, if present, are not used to construct the default file name and are therefore dropped:
    - name components for the catid and userid in BS2000 file and library names.Exception: If the source program entered with OUTPUT=\*SOURCE-LOCATION is catalogued as a BS2000 file, then catid and userid will be kept.
    - directory names in POSIX pathnames
    - the suffixes .C , .CPP, .CXX, .CC and .I if the source program exists as a cataloged BS2000 file or PLAM library element
    - the suffixes .c , .C , .cpp , .CPP, .cxx , .CXX, .cc , .CC, .c++ , .C++ , .i and .I if the source program exists as a POSIX file
  2. If the source program exists as a cataloged BS2000 file or a POSIX file, the remaining portion of the name is truncated from the right to 33 characters.
  3. For OUTPUT=\*STD-FILE only:

If the source program exists as a PLAM library element, the library and element names are combined with a hyphen and used in the default name as shown below:libraryname-elementnameIf this name (including the hyphen) exceeds 33 characters, the library name and, if required, also the element name, are both truncated to 16 characters from the right, starting with the library name.
  4. Special characters not allowed in file names are always converted to "\$". The permitted special characters are \$, @, #, . (period) and - (hyphen).
  5. Lowercase letters (in POSIX source file names) are converted to uppercase.
  6. The name truncated to 33 characters is then extended with the appropriate suffix, i.e.: .I , .LST , .CIF or .DIAG.

## Summary

Contents	Source program input from			
	*SYSDTA	BS2000 file	PLAM library	POSIX file
PREPROCESS	CSTDEXP.I	file.I	lib-elem.I	file.I
LISTING	CSTDLST.LST	file.LST	lib-elem.LST	file.LST
DIAGNOSTIC	CSTDDIAG.DIAG	file.DIAG	lib-elem.DIAG	file.DIAG
CIF	CSTDCIF.CIF	file.CIF	lib-elem.CIF	file.CIF

Default names for cataloged BS2000 files, depending on input source and contents

## Construction of default names for PLAM library elements

The output is placed in PLAM library elements with default names

- if OUTPUT=\*LIB-ELEM(ELEMENT=\*STD-ELEMENT) is specified;
- if OUTPUT=\*SOURCE-LOCATION is specified and the source program exists as a PLAM library element.

If the output location is specified as OUTPUT=\*LIB-ELEM(LIB=\*STD-LIBRARY), the elements are written to the PLAM library with the default name SYS.PROG.LIB.

1. The following source program name components, if present, are not used to construct the default element name and are therefore dropped:
  - name components for the catid and userid in BS2000 file and library names
  - directory names in POSIX path names
  - the suffixes .C , .CPP, .CXX, .CC and .I if the source program exists as a cataloged BS2000 file or PLAM library element
  - the suffixes .c , .C , .cpp, .CPP, .cxx, .CXX, .cc, .CC, .c++, .C++, .i and .I if the source program exists as a POSIX file
2. The remaining portion of the source program name is truncated from the right to 59 characters.
3. Special characters not allowed in element names are always converted to "\$". The permitted special characters are \$, @, #, . (period), - (hyphen), and \_ (underscore).
4. Lowercase letters (in POSIX source file names) are converted to uppercase.
5. The name truncated to 59 characters is then extended with the appropriate suffix .I, .LST, .CIF or .DIAG.

## Summary

Contents	Source program input from			
	*SYSDTA	BS2000 file	PLAM library	POSIX file
PREPROCESS	CSTDEXP.I, S	file.I, S	elem.I, S	file.I, S
LISTING	CSTDLST.LST, P	file.LST, P	elem.LST, P	file.LST, P
DIAGNOSTIC	CSTDDIAG.DIAG, D	file.DIAG, D	elem.DIAG, D	file.DIAG, D

---

CIF	CSTDCIF.CIF, H	file.CIF, H	elem.CIF, H	file.CIF, H
-----	----------------	-------------	-------------	-------------

Default names for PLAM library elements, depending on input source and contents

### Construction of default names for POSIX files

The output is placed in POSIX files with default names

- if OUTPUT=\*SOURCE-LOCATION is specified, and the source program exists as a POSIX file;
- if OUTPUT=<posix-pathname> is specified, and if <posix-pathname> specifies the name of a POSIX file directory (without file name).
  1. The following suffixes in source program names, if present, are not used to construct default names and are therefore dropped: .C , .CPP, .CXX, .CC or .I (for BS2000 files) and .c, .C , .cpp, .CPP, .cxx, .CXX, .cc, .CC, .c++, .C++, .i or .I (for POSIX files).
  2. The name is extended with the appropriate suffix, i.e.: .i (C compilation), .I (C++ compilation), .lst, .cif or .diag.
  3. Lowercase letters and other special characters are accepted unaltered. No name truncation occurs.

---

### 3.1.4 Rules for constructing module names

As far as module names are concerned, a distinction must be made between the element name (i.e. the name of the “container”) under which the module is stored as a library element and the internal module and CSECT names.

If the name of the module is not explicitly specified in the MODULE-OUTPUT option of the COMPILE statement, the element name and the internal module/CSECT names are derived from the name of the source program.

If the name of the module is explicitly specified in the MODULE-OUTPUT option of the COMPILE statement, the element name and the internal module / CSECT names are constructed from that name.

#### Construction of element names from LLMs in PLAM libraries

- Derivation from the source program name
  1. The following parts of the source program name, if present, are not used to construct the element name and are therefore dropped: <cat-id>, <user-id>, and the suffixes .C , .CPP, .CXX, .CC or .I (for BS2000 files) and .c, .C , .cpp, .CPP, .cxx, .CXX, .cc, .CC, .c++, .C++, .i or .I (for POSIX files).
  2. If the remaining portion of the source program name exceeds 59 characters, it is truncated from the right to 59 characters.
  3. Special characters not permitted for element names are always converted to “\$”. The permitted special characters are \$, @, #, . (period), - (hyphen), and \_ (underscore). Lowercase letters in POSIX file names are converted to uppercase.
  4. If the source program is read from SYSDTA, the element name is “CSTDMOD”. This applies even if SYSDTA was assigned to a cataloged file or a library element with the ASSIGN-SYSDTA command.
- Derivation from the explicitly specified name

In this case, the specified name is accepted as the element name without changes, i.e. the suffix .C , .CPP, .CXX, .CC or .I, if present, is not removed. Similarly, no truncation of the name occurs, i.e. the name can have a length of up to 64 characters.

#### *Special Note*

To enable further processing with DBL, the maximum permissible length for the element names of LLMs is currently 32 characters. This applies to the LLM specified in the START-EXECUTABLE-PROGRAM command (module containing the main function) as well as all LLMs to be dynamically linked.

LLMs that have element names which exceed 32 characters must therefore be linked with BINDER.

#### Construction of LLM object file names in the POSIX file system

- Derivation from the source program name

The name of the LLM object file is derived from the name of the POSIX source file as follows: only the suffix .c, .C , .cpp, .CPP, .cxx, .CXX, .cc, .CC, .c++, .C++, .i or .I, if present, is removed from the name of the POSIX source file, and the suffix .o is appended to the remaining portion. No truncation of names or conversion of special characters to the dollar sign “\$” and of uppercase to lowercase letters occur.
- Derivation from the explicitly specified name

The specified name is accepted without changes. Note, however, that LLM object files must be provided with the suffix .o to enable further processing with the appropriate link editors in the POSIX subsystem.

---

## Construction of the internal module and CSECT names of LLMs

- Derivation from the source program name
  1. The following parts of the source program name, if present, are not used to construct the module/CSECT name and are therefore dropped: <cat-id>, <user-id> and the suffixes .C , .CPP, .CXX, .CC or .I (for BS2000 files), and .c, .C , .cpp, .CPP, .cxx, .CXX, .cc, .CC, .c++, .C++, .i or .I (for POSIX files).
  2. If the remaining portion of the source program name exceeds 30 characters, it is truncated from the right to 30 characters.
  3. Special characters that are not permitted for internal LLM names are always converted to “\$”. The permitted special characters are \$, @, #, - (hyphen), and \_ (underscore). Lowercase letters in POSIX file names are converted to uppercase.
  4. If the source program is read from SYSDTA, “CSTDMOD” is used as a basis for constructing the name. This also applies if SYSDTA is assigned to a cataloged file or a library element by means of an ASSIGN-SYSDTA command.
  5. The core name obtained by applying rules 1 through 4 is then used to construct the final module and CSECT names by appending a 2-character suffix, i.e. “&@” or “&#”:  
  
Module name <core-name>&@  
  
Code CSECT <core-name>&@  
  
Data CSECT <core-name>&#
- Derivation from the explicitly specified name
  1. The complete specified name is used to construct the module/CSECT name, i.e. the suffix .c, .C , .cpp, .CPP, .cxx, .CXX, .cc, .CC, .c++, .C++, .i or .I, if present, is not removed.
  2. The truncation of the name from the right to 30 characters, the conversion of invalid special characters to the dollar sign “\$”, and the appending of suffixes occurs as described for the derivation from the source program name.

## Construction of the names of ii files

An instantiation information file (ii file) is created for each of the source files used by a template, as long as one does not already exist.

The name of this ii file is derived from the associated object and is formed by adding the suffix .ii.

For example, the compiled version of `hugo.C` would have the ii file `hugo.o.ii`, unless an object name other than `hugo.o` is specified.

The ii file is located in that library in which the object file itself is stored.

---

### 3.1.5 Structure of compiler messages

The compiler issues the following types of messages:

- Information messages that notify the user about the general compilation process (e.g. the start and termination messages from the compiler and messages such as 'MODULES GENERATED').
- Error messages (of the frontend compiler) that directly refer to the compiled source program (e.g. syntax and semantic errors).

These consist of

1. the actual error message line
  2. the invalid source program line (optional)
  3. a flag ^ to indicate the error location (optional)
- Error messages not related to the source program (e.g. disk full, error on opening files, etc.).

Information and error messages are output to one or more of the following destinations during compilation:

- at the terminal and/or
- optionally to files or libraries.

The output destination for these messages can be controlled with the `MODIFY-DIAGNOSTIC-PROPERTIES` statement ("[MODIFY-DIAGNOSTIC-PROPERTIES \(C/C++-Compiler, #44\)](#)").

Error messages that refer to the source program are also documented in the source/error listing (controlled by the `MODIFY-LISTING-PROPERTIES` statement; see "[MODIFY-LISTING-PROPERTIES \(C/C++-Compiler, #46\)](#)").

General format of the compiler messages:

---

Error message line:

*message-number* [*message-weight*] : *filename* / *line-number*: *message-text*

Optional for error messages referring to the source program:

*Invalid source program line*

^ *marker to indicate the error location*

---

The file name and line number are omitted in error messages (with a message weight of FATAL or ERROR) which do not refer to the source program. In information messages, the message weight is also omitted.

*message-number*

The 7-digit message number consists of a 3-digit message class, which identifies the compiler component, and a 4-digit message number.

Message class	Components
CFE	Frontend of the compiler: scanner, preprocessor, parser, listing generator, message facility
CDR	Compiler driver, II-UPDATE

UMP	Intermediate language module ULS, optimizer, inliner
BEM	Backend
SIS	Compiler I/O interface (PROSOS), Object format (module) generator (OFG), Diagnostic information generator for AID (DIG)
BND	BINDER (when linking with the BIND statement of the compiler)
CCM	C runtime system

*[message weight]*

Indicates the message weight, i.e. the severity of the error that has occurred:

[NOTE]	Inconsequential errors, e.g. "ugly" or superfluous constructs which usually have no impact on subsequent program behavior. Notes are not issued automatically unless the options <code>-R minweight,notes</code> or <code>MINIMAL-MSG-WEIGHT=*NOTE</code> are specified.
[WARNING]	Errors for which the compiler will generate a module, but which could lead to situations resulting in deviant program behavior.
[ERROR], [*ERROR]	Errors for which no module is generated. The compiler will attempt to continue the compilation until the number of errors specified with the <code>-R limit,n</code> or <code>MAX-ERROR-NUMBER=n</code> option is reached. Errors of the frontend compiler that can either be reduced to the severity of a WARNING/NOTE with the <code>-R warning/note</code> or <code>CHANGE-MSG-WEIGHT=*WARNING()/*NOTE()</code> option and warnings that were upgraded to the severity of an ERROR with the <code>-R error</code> or <code>CHANGE-MSG-WEIGHT=*ERROR()</code> option are flagged with an asterisk.
[FATAL]	Fatal errors leading to abortion of the compilation
[INTERNAL]	Compiler errors, also leading to abortion of the compilation

*filename*

Name of the file or library element with the invalid source program code

*line-number*

Indicates the source program line in which the error occurred.

*message-text*

Text of the error message; can be output in English or German.

*Invalid source program line with a marker to indicate the error location*

---

-R `show_column` or `SHOW-COLUMN=*YES` is the default setting, which means that the original source program line is shown with the error location marked (with `^`) in addition to the diagnostic message itself. If -R `no_show_column` or `SHOW-COLUMN=*NO` is specified, the marked source program line is not output.

### Example

```
//MODIFY-SOURCE-PROP LANG=*C(MODE=1990,STRICT=*YES)
//MODIFY-DIAGNOSTIC-PROP CHANGE-MSG-WEIGHT=*ERROR(CFE1064)
//COMPILE SOURCE=TEST.C
% CFE1064 [*ERROR]: TEST.C / 1: declaration does not declare anything
  struct { int a; };
  ^
% CFE1020 [ERROR]: TEST.C / 3: identifier "abc" is undefined
  abc def;
  ^
% CFE2095 [*ERROR]: USER.H / 3: too few arguments in invocation of macro "M"
  int i = M(3);
          ^
```

The error number CFE1064 was originally a warning, but was upgraded to the ERROR class with the option `CHANGE-MSG-WEIGHT=*ERROR(CFE1064)`.

The class of errors that are not originally output with an asterisk (e.g. CFE1020 in this case) cannot be changed. Error number CFE2095 is an example of an error that is generated in strict C89 mode, but can be downgraded to the message weight of a warning with `CHANGE-MSG-WEIGHT=*WARNING(CFE2095)`. The same error number is assigned the error class WARNING in extended C89 mode.

The `HELP-MSG` command can be used to obtain a more detailed explanation of all the error messages:

```
HELP-MSG MSG-ID=msgid[, LANGUAGE=D / E]
```

The compiler messages can be output in English or German. The default setting depends on system generation. The following command can be used to change the task-specific default:

```
MODIFY-MSG-ATTRIBUTES TASK-LANGUAGE = D / E
```

---

## 3.2 Controlling the compiler

As in the case of many other BS2000 programs (BINDER, LMS, etc.), the C/C++ compiler can be called as an independent program and controlled via a convenient SDF command interface. This provides the user with all the facilities offered by the product SDF (System Dialog Facility) for the input of program statements, i.e.: various levels of guided and unguided dialogs, input from procedure or command files, etc.

A detailed explanation of the SDF dialog interface with examples on the various forms of SDF control can be found in the manual "SDF Dialog Interface, User Guide" [12].

### 3.2.1 Calling the compiler (START-CPLUS-COMPILER)

START-CPLUS-COMPILER  
SRCPC, CPLUS-COMPILER, CPC

Abbreviations:

`MONJV= *NONE / <filename 1..54>`  
`,CPU-LIMIT= *JOB-REST / <integer 1..32767>`

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

The compiler run can be monitored by means of a BS2000 job variable.

<filename> assigns a monitoring job variable in which the compiler indicates runtime errors that may occur.

Two values are entered into a job variable by the operating system:

a status indicator with a length of 3 bytes, and  
a return code with a length of 4 bytes.

The status indicator specifies whether the last statement was executed correctly. In case of a fatal error it is set to "\$A ", in other cases it is set to "\$T ".

The compiler issues messages with different weight. The return code specifies the most severe message weight issued.

message weight	return code
no error	0000
[NOTE]	1001
[WARNING]	1002
[ERROR]	2003
[FATAL]	3005

The two parts are independent. Here are two examples with unusual results:

```
/START-CPLUS-COMPILER  
//COMPALE MUELL  
//END
```

This example writes "\$A 0000" into the job variable. The syntax error in the SDF statement results in "\$A ". Since the compiler did not issue any message, the return code is "0000".

```
/START-CPLUS-COMPILER  
//COMPILE FATAL.C  
//STEP  
//COMPILE GOOD.C  
//END
```

This example writes "\$T 3005" into the job variable. The success in the second compilation results in "\$T ". The fatal in the first compilation results in "3005".

---

**CPU-LIMIT = \*JOB-REST / <integer 1..32767>**

This option can be used to define the maximum CPU time for the compiler run. The value entered here corresponds to the CPU-LIMIT operand of the START-EXECUTABLE-PROGRAM command.

---

## 3.2.2 Description of compiler statements

This section provides information concerning the following topics:

- Overview of statements
- Basic principles and general input rules
- BIND
- CHECK-SYNTAX
- COMPILE
- Notes on input via SYSDDTA
- END
- MODIFY-BIND-PROPERTIES
- Interaction between the MODIFY-BIND-PROPERTIES and BIND statements
- MODIFY-CIF-PROPERTIES
- MODIFY-DIAGNOSTIC-PROPERTIES
- MODIFY-INCLUDE-LIBRARIES
- MODIFY-LIBRARY-VERSION
- MODIFY-LISTING-PROPERTIES
- MODIFY-MODULE-PROPERTIES
- MODIFY-OPTIMIZATION-PROPERTIES
- The optimization process
- MODIFY-RUNTIME-PROPERTIES
- MODIFY-SOURCE-PROPERTIES
- MODIFY-TEST-PROPERTIES
- PREPROCESS
- RESET-TO-DEFAULT
- SHOW-DEFAULTS
- SHOW-PROPERTIES

---

### 3.2.2.1 Overview of statements

For more information on the principle of “executing” and “modifying” compiler statements, see the notes in the [section “Basic principles and general input rules”](#).

- Executing statements

    BIND

        Start the linkage and/or prelinker run

    CHECK-SYNTAX

        Start syntax analysis

    COMPILE

        Start the compilation run (including module generation)

    PREPROCESS

        Start the preprocessor run

- Modifying and defining statements

The following list shows the various MODIFY statements together with the executing statement(s) for which they are evaluated (in parentheses).

MODIFY-BIND-PROPERTIES

    Options to control the linkage and/or prelinker run (BIND)

MODIFY-CIF-PROPERTIES

    Options to output CIF information (CHECK-SYNTAX, COMPILE, PREPROCESS)

MODIFY-DIAGNOSTIC-PROPERTIES

    Options to control message output (CHECK-SYNTAX, COMPILE, PREPROCESS)

MODIFY-INCLUDE-LIBRARIES

    Options to specify header files (CHECK-SYNTAX, COMPILE, PREPROCESS)

MODIFY-LIBRARY-VERSION

    Option to specify the library version for C++ (BIND, CHECK-SYNTAX, COMPILE, PREPROCESS)

MODIFY-LISTING-PROPERTIES

    Options to output listings (CHECK-SYNTAX, COMPILE, PREPROCESS)

MODIFY-MODULE-PROPERTIES

    Options to control object and module attributes (COMPILE)

MODIFY-OPTIMIZATION-PROPERTIES

    Optimization options (COMPILE)

MODIFY-RUNTIME-PROPERTIES

    Runtime options (COMPILE)

MODIFY-SOURCE-PROPERTIES

    Frontend options (CHECK-SYNTAX, COMPILE, PREPROCESS)

MODIFY-TEST-PROPERTIES

    Debugging options (COMPILE)

- 
- Informative statements

SHOW-DEFAULTS

Show default settings of the compiler

SHOW-PROPERTIES

Show current option values of MODIFY statements

- RESET-TO-DEFAULT

Reset option values of MODIFY statements to the default settings of the compiler

- END

Terminate the compiler run

---

- Standard SDF statements

Besides the C/C++-specific statements listed above, the following standard SDF statements may also be used during a compiler run. A detailed description of these SDF statements can be found in the manual "SDF Dialog Interface, User Guide" [12].

**EXECUTE-SYSTEM-CMD**

Execute a system command during the compiler run

**HELP-MSG-INFORMATION**

Write text of a system or compiler message to SYSOUT

**HOLD-PROGRAM**

Stop the compiler run, e.g. to enter system commands. Control is returned to the statement mode of the compiler with the command RESUME-PROGRAM

**MODIFY-SDF-OPTIONS**

Enable/disable user syntax file and change SDF settings

**REMARK**

Enter comments in a sequence of statements

**RESET-INPUT-DEFAULTS**

Reset task-specific default values

**RESTORE-SDF-INPUT**

Show previously entered statements of commands

**SHOW-INPUT-DEFAULTS**

Show task-specific default values

**SHOW-INPUT-HISTORY**

Show contents of input buffer

**SHOW-SDF-OPTIONS**

Show information on all active syntax files and SDF options for the current task

**SHOW-STMT**

Show SDF syntax for a statement

**STEP**

Define restart point within a command/procedure file

**WRITE-TEXT**

Display text

### 3.2.2.2 Basic principles and general input rules

- Executing and modifying compiler statements

The compiler run is started with the command `START-CPLUS-COMPILER` and is terminated with `END` statement. During each compiler run, a number of different compilation and/or linkage runs may be started with appropriate "executing" statements (see "[Overview of statements](#)"). These compilation and linkage runs can be controlled by means of `MODIFY` statements, which must always precede the executing statements to be used. These `MODIFY` statements remain in effect even after the executing statements have been completed (see the [example](#) for details).

- The operand value `*UNCHANGED` and default settings of the compiler

When using the compiler in SDF interactive mode with guidance, the operand value `*UNCHANGED` is frequently displayed for many operands in the SDF statement menus of the compiler.

The value `*UNCHANGED` is an SDF default value that is always used in the current compiler statement (and displayed on the screen) whenever no explicit specification for an operand is made.

`*UNCHANGED` simply means that the operand value that was defined with an earlier compiler statement still applies to the operand involved. If no such value was specified in the entire compiler run, e.g. immediately after starting the compiler, `*UNCHANGED` refers to the default value of the compiler, and this default value remains in effect until some other operand value is specified with a compiler statement. In this manual, all default values of the compiler are underlined in the individual statement description. Some operands have a dynamic default, depending on the language mode. In this case no operand value is underlined.

The currently applicable operand values for compiler statements can be listed with the `SHOW-PROPERTIES` statement. In this case, the actual operand value is displayed instead of `*UNCHANGED`.

- Aliases

Most of the compiler statements have aliases, which may be used instead of the names displayed in the guided dialog. These aliases are listed for each statement at the start of the corresponding statement description.

- Spin-off mechanism

Executing statements that do not succeed trigger the spin-off mechanism. All statements up to the next `STEP` are ignored in such cases.

- Input/Output library elements

The version specification `VERSION=@` is rejected, since this is not a valid value for the LMS version.

#### Example

```
/START-CPLUS-COMPILER
//MODIFY-SOURCE-PROPERTIES DEFINE=_OSD_POSIX _____ (1)
//MODIFY-LISTING-PROPERTIES SOURCE=*YES _____ (2)
//MODIFY-INCLUDE-LIBRARIES STD-INCLUDE-LIBRARY=
  (*STANDARD-LIBRARY, $.SYSLIB.POSIX-HEADER)_____ (3)
//COMPILE SOURCE=HELLO1.CC _____ (4)
//MODIFY-SOURCE-PROPERTIES LANG=*C _____ (5)
//COMPILE SOURCE=HELLO2.C _____ (6)
//END
/
```

The `MODIFY-SOURCE-PROPERTIES` statement (1) only sets a define. So the default settings of the compiler, e.g. the latest C++ language mode `LANGUAGE=*CPLUSPLUS(MODE=*LATEST, STRICT=*NO)`, apply to all other operands.

---

On the first compilation (4) the preceding MODIFY statements are evaluated, and the following steps are performed as a result:

- The define `_OSD_POSIX` is set (1).
- The header libraries `$.SYSLIB.CRTE`, `$.SYSLIB.CRTE.CXX01` and `$.SYSLIB.POSIX-HEADER` are searched (3).
- The source program `HELLO1.CC` is compiled (4) in the extended C++ 2020 language mode (1) and a source /error listing is output to `SYSLST` (2).

Before the second compilation (6), the C language mode is set in a new `MODIFY-SOURCE-PROPERTIES` statement (5). The operands `MODE` and `STRICT` are not specified, so they are per default `*C(MODE=*LATEST, STRICT=*NO)`. Apart from this change, all other entries in the earlier `MODIFY` statements remain in effect when compiling the C source program `HELLO2.C`. The following steps are performed:

- The define `_OSD_POSIX` is set (1).
- The header libraries `$.SYSLIB.CRTE` and `$.SYSLIB.POSIX-HEADER` are searched (3).
- The source program `HELLO2.C` is compiled (6) in the extended C11 language mode (5) and a source/error listing is output to `SYSLST` (2).

Please note that `*STANDARD-LIBRARY` in (3) is resolved differently in the two compiles. This operand value depends on the language mode. The mapping of that value to a list of libraries is done at the compile statement (4,6), not the statement `MODIFY-INCLUDE-LIBRARIES` (3).

### 3.2.2.3 BIND

Alias: LINK

This statement starts a linkage run and, in the case of C++ V3, C++2017 and C++ 2020 objects, also activates the prelinker for automatic template instantiation. The input sources and other conditions for the linkage and prelinker runs are defined in the preceding MODIFY-BIND-PROPERTIES statements.

#### BIND

```
ACTION= list-poss: *PRELINK / *MODULE-GENERATION
,OUTPUT= *NONE / *LIBRARY-ELEMENT(...)
  *LIBRARY-ELEMENT(...)
    | LIBRARY= <filename 1..54> / *LINK(...)
    |   *LINK(...)
    |     | LINK-NAME= <filename 1..8>
    |     ,ELEMENT= <composed-name 1..64 with-under>(…)
    |     <composed-name 1..64 with-under>(…)
    |     | VERSION= *UPPER-LIMIT / *INCREMENT / <composed-name 1..24 with-under>
,OUTPUT-FORMAT= *UNCHANGED / *LLM(…)
  *LLM(...)
    | EXTERNAL-NAMES= *UNCHANGED / *STD / *SHORT
,ADD-OPTION= *UNCHANGED / *NONE / <c-string 1..1800 with-low>
```

#### **ACTION = list-poss: \*PRELINK / \*MODULE-GENERATION**

The \*PRELINK specification is only relevant in the modes C++ V3, C++ 2017 and C++ 2020 and affects the automatic template instantiation by the prelinker.

If the ACTION option is not specified, the following default applies:

```
ACTION = (*PRELINK,*MODULE-GENERATION)
```

This causes both a prelinker and a linkage run to be performed in the modes C++ V3, C++ 2017 and C++ 2020. The result comprises individual modules in which all templates are instantiated and a linked module. Note that the \*PRELINK specification is ignored in the C modes and in the Cfront C++ mode, so only a linkage run is performed in these modes.

If ACTION=\*PRELINK is specified, only a prelinker run is performed. The result consists of individual modules in which all templates are instantiated. Specifications in the OUTPUT and OUTPUT-FORMAT options, if any, are ignored.

If ACTION=\*MODULE-GENERATION is specified, only a linkage run is performed.

---

**OUTPUT = \*NONE / \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the linked module is to be stored. These values are passed to BINDER (as a MODULE-CONTAINER operand) in a SAVE-LLM statement. If no further specifications are made with the ADD-OPTION option, the remaining operands of the SAVE-LLM statement are set to the corresponding defaults for BINDER.

The \*NONE option is the default. But because this does not create a link object, this option can only sensibly be used with (see above, ACTION = ).

**LIBRARY =<filename 1..54>**

The module is written to a PLAM library with the specified name.

**LIBRARY = \*LINK(...)****LINK-NAME = <filename 1..8>**

<filename> can be used (instead of a cataloged library name) to specify a valid link name for the library. The link name must already have been assigned to the PLAM library with the ADD-FILE-LINK command before the compiler is called.

**ELEMENT = <composed-name 1..64 with-under>(...)**

The module is written to the element with the assigned name under the PLAM library specified with LIBRARY=.

**VERSION = \*UPPER-LIMIT**

The highest possible version is used by the compiler.

**VERSION = \*INCREMENT**

The element is assigned a version number that is obtained by incrementing the highest existing version number by 1, assuming that the highest existing version ID ends with a digit that can be incremented. If the version ID cannot be incremented, the compiler run is aborted with an error message.

See the [COMPILE](#) statement for an example.

**VERSION = <composed-name 1..24 with-under>**

The element is assigned the specified version.

**OUTPUT-FORMAT = \*LLM(EXTERNAL-NAMES = \*UNCHANGED / \*STD / \*SHORT)**

This option controls how symbol names in EEN (Extended External Name) format are handled by BINDER. In BINDER this is handled by the FOR-BS2000-VERSION operand of the SAVE-LLM statement. Depending on the value of this option an appropriate operand value will be given to BINDER.

EENs, i.e. external C++ symbols with untruncated names, are generally contained in modules that were generated with the compiler in the mode C++ V3, C++ 2017 or C++ 2020.

Untruncated external C symbols are generated only if the following option is specified at compilation: MODIFY-MODULE-PROPERTIES C-NAMES=\*UNLIMITED (see [MODIFY-MODULE-PROPERTIES](#)).

In this case, even longer external C symbols are not truncated by the compiler to 32 characters. Modules with EENs are stored by the compiler in LLM Format 4. The modules of the C++ libraries and of the CRTE runtime systems used in the modes C++ V3, C++ 2017 or C++ 2020 are also provided in LLM Format 4.

If the modules generated by the compiler do not include any EENs, i.e. are in LLM Format 1, this option has no effect, since the BINDER generates an input format corresponding to LLM Format 1.

---

**EXTERNAL-NAMES = \*UNCHANGED**

The specification in the last BIND statement applies.

**EXTERNAL-NAMES = \*STD**

By default, BINDER generates LLM Format 4. The EENs remain in the result module without being truncated. LLMs in Format 4 can be partially linked, i.e. first linked with unresolved external references to EENs and then processed further as desired by means of BINDER or DBL.

**EXTERNAL-NAMES = \*SHORT**

This entry is needed if BINDER is to generate LLM Format 1.

*Summary of generated LLM formats*

Input format	SDF option EXTERNAL-NAMES =	Output format
LLM 1	No entry / *STD / *SHORT	LLM 1
LLM 4 (EEN)	No entry / *STD	LLM 4
	*SHORT	LLM 1

**ADD-OPTION = \*UNCHANGED / \*NONE / <c-string 1..1800 with-low>**

<c-string> can be used to specify further operands of the BINDER statement SAVE-LLM in addition to the MODULE-CONTAINER operand (see OUTPUT option) and the FOR-BS2000-VERSION operand (see OUTPUT-FORMAT option). If more than one operand is specified, they must be separated by commas as follows:

*' operand1 , operand2 , ... '*

The operands are directly passed through to BINDER without SDF analysis.

The following operands of the BINDER statement SAVE-LLM are obtained from the MODIFY-BIND-PROPERTIES statement and must therefore not be specified with ADD-OPTION: TEST-SUPPORT (to save LSD information) and MAP (to generate a map listing).

*Automatic template instantiation*

The operands specified with ADD-OPTION are currently not considered during the automatic template instantiation by the prelinker, but only during subsequent linkage with BINDER. The operands should not affect the type, number or order of the modules to be linked, since different preconditions during the prelinker and linkage runs could result in duplicates or unresolved external references.

*Example*

```
//BIND OUTPUT=*LIB(LIB=PLAM.BSP,ELEM=HELLO),ADD-OPT='OVERWRITE=*NO,
NAME-COLLISION=*WARNING'
```

---

### 3.2.2.4 CHECK-SYNTAX

Alias: DO-SYNTAX-CHECK

The compilation run is terminated after checking the syntax of one or more source programs. No object code is generated.

#### CHECK-SYNTAX

```
SOURCE= *SYSDTA / list-poss: <filename 1..54> / <posix-pathname> / *LIBRARY-ELEMENT(...)  
*LIBRARY-ELEMENT(...)  
| LIBRARY= <filename 1..54> / *LINK(...)  
| *LINK(...)  
| | LINK-NAME= <filename 1..8>  
| ,ELEMENT= <composed-name 1..64 with-under>(...)  
| <composed-name 1..64 with-under>(...)  
| | VERSION= HIGHEST-EXISTING / <composed-name 1..24 with-under>
```

#### **SOURCE =**

This option specifies one or more source programs for which a syntax check is to be performed.

A source program can be read from the system file SYSDTA, a cataloged BS2000 file, a PLAM library or a POSIX file.

Note that if the source program is entered from SYSDTA, only one source program can be read per CHECK-SYNTAX statement.

#### **SOURCE = \*SYSDTA**

Input is accepted from the system file SYSDTA. SYSDTA is assigned to the terminal in interactive mode but can be reassigned to a cataloged file or a PLAM library element with the ASSIGN-SYSDTA command (see also "[Notes on input via SYSDTA \(C/C++-Compiler, #39\)](#)").

#### **SOURCE = <filename 1..54>**

<filename> is used to specify the name of a cataloged BS2000 file.

#### **SOURCE = <posix-pathname>**

Only a file name is permitted as <posix-pathname>. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

#### **SOURCE = \*LIBRARY-ELEMENT(...)**

This option is used to specify a PLAM library and an element in it.

#### **LIBRARY = <filename 1..54>**

<filename> assigns the name of a PLAM library.

#### **LIBRARY = \*LINK(...)**

#### **LINK-NAME = <filename 1..8>**

---

<filename> is the link name for a PLAM library. The link name must be assigned to the library name by means of the ADD-FILE-LINK command before the compiler is called.

**ELEMENT = <composed-name 1..64 with-under>(…)**

<composed-name> identifies the fully-qualified name of an element from the PLAM library specified earlier. The element must be of type S.

**VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the compiler uses the element with the highest existing version.

**VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

*Note*

[Implicit inclusion](#) for template instantiation does **not** take place (unlike to the COMPILE statement).

### 3.2.2.5 COMPILE

This statement compiles one or more source programs and generates a module for each compilation unit.

#### COMPILE

**SOURCE**= \*SYSDTA / list-poss: <filename 1..54> / <posix-pathname> / \*LIBRARY-ELEMENT(...)

\*LIBRARY-ELEMENT(...)

| **LIBRARY**= <filename 1..54> / \*LINK(...)

| \*LINK(...)

| | **LINK-NAME**= <filename 1..8>

| **,ELEMENT**= <composed-name 1..64 with-under>(...)

| <composed-name 1..64 with-under>(...)

| | **VERSION**= \*HIGHEST-EXISTING / <composed-name 1..24 with-under>

**,MODULE-OUTPUT**= \*SOURCE-LOCATION / <posix-pathname> / \*LIBRARY-ELEMENT(...)

\*LIBRARY-ELEMENT(...)

| **LIBRARY**= \*STD-LIBRARY / \*SOURCE-LIBRARY / <filename 1..54> / \*LINK(...)

| \*LINK(...)

| | **LINK-NAME**= <filename 1..8>

| **,ELEMENT**= \*STD-ELEMENT(...) / <composed-name 1..64 with-under>(...)

| \*STD-ELEMENT(...)

| | **VERSION** = \*UPPER-LIMIT / \*INCREMENT / <composed-name 1..24 with-under>

| <composed-name 1..64 with-under>(...)

| | **VERSION**= \*UPPER-LIMIT / \*INCREMENT / <composed-name 1..24 with-under>

#### **SOURCE =**

This option specifies one or more source programs to be compiled.

A source program can be read from the system file SYSDTA, a cataloged BS2000 file, a PLAM library or a POSIX file.

Note that if the source program is entered from SYSDTA, only one source program can be read per COMPILE statement.

#### **SOURCE = \*SYSDTA**

Input from the system file SYSDTA is only possible in the C modes and in the Cfront C++ mode of the compiler. In the modes C++ V3, C++ 2017 and C++ 2020 the value \*SYSDTA is rejected with a corresponding error message. SYSDTA is assigned to the terminal in interactive mode but can be reassigned to a cataloged file or a PLAM library element with the ASSIGN-SYSDTA command (see also "[Notes on input via SYSDTA](#)").

---

**SOURCE = <filename 1..54>**

<filename> is the name of a cataloged BS2000 file.

**SOURCE = <posix-pathname>**

Only a file name is permitted as <posix-pathname>. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

**SOURCE = \*LIBRARY-ELEMENT(...)**

This option is used to specify a PLAM library and an element in it.

**LIBRARY = <filename 1..54>**

<filename> assigns the name of a PLAM library.

**LIBRARY = \*LINK(...)****LINK-NAME = <filename 1..8>**

<filename> is used to specify a link name for a PLAM library. The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

**ELEMENT = <composed-name 1..64 with-under>(...)**

<composed-name> identifies the fully-qualified name of an element from the PLAM library specified earlier. The element must be of type S.

**VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the compiler uses the element with the highest existing version.

**VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

**MODULE-OUTPUT =**

This option allows the user to control the library and/or name under which the generated modules are stored.

**MODULE-OUTPUT = \*SOURCE-LOCATION**

The module is written to the same location as the source program. If the source program is a PLAM library element, the module is placed in the library of the source program. If the source program is a POSIX file, the module is written as an object file (".o" file) into the directory of the source program.

The element or object file name is derived from the name of the source program (see section "[Rules for constructing module names](#)").

The module cannot be written to a write-only file. In Posix, it must always be possible to read the library or object file.

The \*SOURCE-LOCATION specification is invalid if the source program is read from a cataloged BS2000 file or via SYSDTA (see "[Notes on input via SYSDTA](#)").

**MODULE-OUTPUT = <posix-pathname>**

The module is written as an LLM object file in the POSIX file system.

Both a file name and a directory are permitted as <posix-pathname>. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

---

When a file name is specified, the object file is stored under this name. Specification of a file name is illegal when compiling multiple source programs with one COMPILE statement.

When a directory name *dir* is specified, an object file for each compiled source program is written under the default name *sourcefile.o* to the directory *dir* (see also section “[Rules for constructing module names](#)”).

The directories specified with <posix-pathname> must already exist.

When constructing file names, it must be noted that object files can only be meaningfully processed further (i.e. linked) in the POSIX subsystem if the name contains the suffix *.o* or a suffix defined with the *-Y F* option of the *cc/c11/c89/CC* commands (see also the manual “POSIX Commands of the C/C++ Compiler” [1]).

### **MODULE-OUTPUT = \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name(ELEMENT=) under which the module is to be stored.

#### **LIBRARY = \*STD-LIBRARY**

Modules are stored in the library SYS.PROG.LIB by default.

#### **LIBRARY = \*SOURCE-LIBRARY**

The module is written to the PLAM library which contains the source program.

The \*SOURCE-LIBRARY specification is invalid if the source program is read from a cataloged BS2000 file, a POSIX file or via SYSDTA.

#### **LIBRARY = <filename 1..54>**

The module is written to a PLAM library with the specified name.

#### **LIBRARY = \*LINK(...)**

##### **LINK-NAME = <filename 1..8>**

<filename> can be used (instead of a cataloged library name) to specify a valid link name for the library.

The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

### **ELEMENT = \*STD-ELEMENT(...)**

The element name is derived from the name of the source program (see section “[Rules for constructing module names](#)”).

#### **VERSION = \*UPPER-LIMIT**

If the element entry does not contain a version ID, the highest possible version is used by the compiler.

#### **VERSION = \*INCREMENT**

The element is assigned a version number that is obtained by incrementing the highest existing version number by 1, assuming that the highest existing version ID ends with a digit that can be incremented. If the version ID cannot be incremented, the compiler run is aborted with an error message.

**Warning:** You may not specify \*INCREMENT in the modes C++ V3, C++ 2017 and C++ 2020.

*Example*

Highest existing version	Version generated by *INCREMENT
--------------------------	---------------------------------

---

ABC1	ABC2
ABC9	Error
ABC09	ABC10
003	004
None	001

**VERSION = <composed-name 1..24 with-under>**

The element is assigned the specified version.

**ELEMENT = <composed-name 1..64 with-under>(…)**

The module is written under the assigned name to the PLAM library specified with LIBRARY= . This specification is invalid when compiling multiple source programs with one COMPILE statement.

To enable further processing with DBL, element names of LLMs must not exceed a maximum of 32 characters (see section [“Rules for constructing module names”](#)).

**VERSION = \*UPPER-LIMIT / \*INCREMENT /  
<composed-name 1..24 with-under>**

The version can be specified as described above for  
ELEMENT=\*STD-ELEMENT(…).

**Warning:** You may not specify \*INCREMENT in the modes C++ V3, C++ 2017 and C++ 2020.

---

### 3.2.2.6 Notes on input via SYSDTA

For compatibility reasons, input of a source program via the system file SYSDTA can be enabled in the C language modes and in the Cfront C++ language mode of the compiler. The following option must be specified for this purpose:

```
SOURCE=*SYSDTA
```

Input via SYSDTA is not possible in the modes C++ V3, C++ 2017 and C++ 2020.

In interactive mode, SYSDTA is assigned to the terminal by default. Although source programs could basically be entered from the terminal, it would not be very practical, since the source would not be available later.

This means that if \*SYSDTA is specified with the SOURCE option, SYSDTA must be assigned to a cataloged file or a PLAM library element. The appropriate command for this purpose is as follows:

```
/ASSIGN-SYSDTA TO-FILE = {dateiname | *LIB-ELEM(LIB=bibliothek,ELEM=element)}The assignment can be made by the following methods:
```

#### 1. Assigning SYSDTA before calling the compiler

##### *Example*

```
/ASSIGN-SYSDTA TO-FILE=source  
/START-CPLUS-COMPILER
```

The assigned source must include all required MODIFY statements and the COMPILE statement before the actual source code:

```
//MODIFY-SOURCE-PROP LANG=*C  
//MODIFY-...  
//COMPILE SOURCE=*SYSDTA,...  
#include ...  
main() {  
...  
}
```

#### 2. Assigning SYSDTA after calling the compiler

##### *Example*

```
/START-CPLUS-COMPILER  
//MODIFY-SOURCE-PROP LANG=*C  
//MODIFY-...  
//EXECUTE-SYSTEM-CMD (ASSIGN-SYSDTA TO-FILE=source)
```

The required MODIFY statements are specified before reassigning SYSDTA and are hence not needed in the assigned source. Following the EXECUTE statement, no further SDF statements may be specified. The assigned source must include at least the COMPILE statement before the actual source code:

```
//COMPILE SOURCE=*SYSDTA,...  
#include ...  
main() {  
...  
}
```

---

When the end of the source file is reached, the compiler run terminates. SYSDTA cannot be reassigned again within a compiler run.

Note that the input source continues to be SYSDTA even though the source program has been assigned with the ASSIGN-SYSDTA command. Consequently, the source program name "CSTD" is used as the basis for generating default names (see also the output parameter \*SOURCE-LOCATION or ELEMENT=\*STD-ELEMENT).

Furthermore, when a library element is assigned with the ASSIGN-SYSDTA command instead of the SOURCE option, the \*SOURCE-LIBRARY specification has no effect.

---

### 3.2.2.7 END

This statement ends the compiler run.

END

### 3.2.2.8 MODIFY-BIND-PROPERTIES

Aliases: SET-BIND-PROPERTIES  
MODIFY-LINK-PROPERTIES  
SET-LINK-PROPERTIES

This statement specifies the input sources and other conditions for the prelinker and linkage run that is started thereafter with a BIND statement.

#### MODIFY-BIND-PROPERTIES

**START-LLM-CREATION**= \*YES / \*NO

**,INCLUDE**= \*UNCHANGED / \*NONE / list-poss: \*LIBRARY-ELEMENT(...)

\*LIBRARY-ELEMENT(...)

| **LIBRARY**= <filename 1..54> / \*LINK(...)

| \*LINK(...)

| | **LINK-NAME**= <filename 1..8>

| **,ELEMENT**= \*ALL(...) / <composed-name 1..64 with-under>(...)

| \*ALL(...)

| | **VERSION**= \*HIGHEST-EXISTING / <composed-name 1..24 with-under>

| <composed-name 1..64 with-under>(...)

| | **VERSION**= \*HIGHEST-EXISTING / <composed-name 1..24 with-under>

| **,ADD-OPTION**= \*UNCHANGED / \*NONE / <c-string 1..1800 with-low>

**,RESOLVE**= \*UNCHANGED / [\*AUTOLINK](...) / \*NONE

\*AUTOLINK(...)

| **LIBRARY**= list-poss(40) : <filename 1..54> / \*LINK(...)

| \*LINK(...)

| | **LINK-NAME**= <filename 1..8>

| **,INSTANTIATE**= \*NO / \*YES / \*IGNORE

| **,ADD-OPTION**= \*UNCHANGED / \*NONE / <c-string 1..1800 with-low>

**,ADD-PRELINK-FILES**= \*UNCHANGED / \*NONE / list-poss: \*LIBRARY-ELEMENT(...) / \*LIBRARY(...)

\*LIBRARY-ELEMENT(...)

| **LIBRARY**= <filename 1..54> / \*LINK(...)

| \*LINK(...)

```

|      | LINK-NAME= <filename 1..8>
| ,ELEMENT= *ALL(...) / <composed-name 1..64 with-under>(…)
|      *ALL(...)
|      | VERSION= HIGHEST-EXISTING / <composed-name 1..24 with-under>
|      <composed-name 1..64 with-under>(…)
|      | VERSION= HIGHEST-EXISTING / <composed-name 1..24 with-under>
*LIBRARY(...)
| LIBRARY-NAME= <filename 1..54> / *LINK(...)
|      *LINK(...)
|      | LINK-NAME= <filename 1..8>
,MAX-INSTANTIATE-ITER= 30 / *UNCHANGED / <integer 0..100>
,TEMPLATE-DEF-LIST= *UNCHANGED / *YES / NO
,ADD-STATEMENT= *UNCHANGED / NONE / list-poss: <c-string 1..1800 with-low>
,RUNTIME-LANGUAGE= *UNCHANGED / *C / CPLUSPLUS(…)
  CPLUSPLUS(…)
    | MODE= *UNCHANGED / LATEST / *2017 / *2020 / *V2-COMPATIBLE / *V3-COMPATIBLE
,STDLIB= *UNCHANGED / DYNAMIC / *DYNAMIC-COMPLETE / *STATIC / *NONE
,TOOLSIB= *UNCHANGED / *YES / NO
,TEST-SUPPORT= *UNCHANGED / *YES / NO
,LISTING= *UNCHANGED / NONE / *SYSLST / <filename 1..54>

```

### **START-LLM-CREATION = \*YES / \*NO**

The option START-LLM-CREATION=\*YES is analogous to the BINDER statement START-LLM-CREATION, which begins a new link process and creates a new LLM in the work area. This option resets a few lists built by previous statements //MODIFY-BIND-PROPERTIES. In detail:

- The list of INCLUDE will be set to \*NONE.
- The list of RESOLVE will be set to \*NONE.
- The list of ADD-PRELINK-FILES will be set to \*NONE.
- The list of ADD-STATEMENT will be set to \*NONE.
- The LISTING will be set to \*NONE.

The reset will be done before other parameters of the statement are analysed. As an example the statements

```
//MOD-BIND-PROPERTIES LLM_CREATION=*NO INCLUDE=*LIB-ELEM(inc,mod),RESOLVE=*LIBRARY(res)
```

```
//MOD-BIND-PROPERTIES LLM_CREATION=*YES INCLUDE=*LIB-ELEM(inc2,mod2)
```

will result in INCLUDE being \*LIB-ELEM(inc2,mod2) and RESOLVE being \*NONE.

---

With LLM\_CREATION=\*NO this reset will not be done. The parameters of INCLUDE, RESOLVE, ADD-PRELINK-FILES and ADD-STATEMENT will be added to the existing lists.

For more information on the interaction between the MODIFY-BIND-PROPERTIES and BIND statements, see also section [“Interaction between the MODIFY-BIND-PROPERTIES and BIND statements”](#).

#### **INCLUDE =**

This option, which is analogous to the MODULE-CONTAINER operand of the BINDER statement INCLUDE-MODULES, specifies the modules to be linked.

##### *Automatic template instantiation*

The modules specified with the INCLUDE option are always instantiated by the prelinker. In cases where the same library is also specified in the RESOLVE option, it is important to ensure that the template instantiation is not disabled there (see RESOLVE option, INSTANTIATE = \*NO / \*IGNORE, ["MODIFY-BIND-PROPERTIES"](#)).

#### **INCLUDE = \*UNCHANGED**

The values specified in the MODIFY-BIND-PROPERTIES statements since the last START-LLM-CREATION=\*YES apply.

#### **INCLUDE = \*NONE**

The operand \*NONE deletes the INCLUDE chain. NONE is the default value of the compiler, i.e. the value after starting the compiler of after a RESET-TO-DEFAULT.

#### **INCLUDE = list-poss: \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the module to be linked is stored.

Multiple \*LIBRARY-ELEMENT entries may be specified here in a list. These entries are converted internally into multiple INCLUDE-MODULES statements of the BINDER in the same order as the \*LIBRARY-ELEMENT entries in the list.

#### **LIBRARY = <filename 1..54>**

<filename> assigns the name of a PLAM library.

#### **LIBRARY = \*LINK(...)**

#### **LINK-NAME = <filename 1..8>**

<filename> is used to specify a link name for a PLAM library. The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

#### **ELEMENT = \*ALL(...)**

All modules from the PLAM library specified with LIBRARY= are linked.

#### **VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the compiler uses the element with the highest existing version.

#### **VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

---

**ELEMENT = <composed-name 1..64 with-under>(…)**

<composed-name> identifies the fully-qualified name of a module from the PLAM library specified with LIBRARY=.

**VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the compiler uses the element with the highest existing version.

**VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

**ADD-OPTION = \*UNCHANGED / \*NONE / <c-string 1..1800 with-low>**

<c-string> can be used to specify further operands of the BINDER statement INCLUDE-MODULES in addition to the MODULE-CONTAINER operand. If more than one operand is specified, they must be separated by commas as follows:

*' operand1 , operand2 , ... '*

The operands are directly passed through to BINDER without SDF analysis. See the BIND statement for an input example ("BIND (C/C++-Compiler, #36)").

*Automatic template instantiation*

The operands specified with ADD-OPTION are currently not considered during the automatic template instantiation by the prelinker, but only during subsequent linkage with BINDER. The operands should not affect the type, number or order of the modules to be linked, since different preconditions during the prelinker and linkage runs could result in duplicates or unresolved external references.

**RESOLVE =**

This option, which is analogous to the BINDER statement RESOLVE-BY-AUTOLINK, specifies the libraries from which unresolved external references are to be satisfied by BINDER (when using the autolink mechanism).

The C/C++ runtime libraries of the CRTE must not be specified with the RESOLVE option. These libraries are implicitly linked in the correct order and with the correct versions in accordance with the entries in the RUNTIME-LANGUAGE-MODE, STDLIB, TOOLSLIB and RUNTIME-ENVIRONMENT options.

*Automatic template instantiation*

In contrast to the INCLUDE option, the template instantiation can be controlled with the RESOLVE option. By default, modules within RESOLVE libraries are not instantiated by the prelinker. See also the [INSTANTIATE](#) specification.

**RESOLVE = \*UNCHANGED**

The values specified in the MODIFY-BIND-PROPERTIES statements since the last START-LLM-CREATION=\*YES apply.

**RESOLVE = [\*AUTOLINK](…)****LIBRARY = list-poss(40): <filename 1..54> / \*LINK(LINK-NAME = <filename 1..8>)**

This option can be used to specify the cataloged file name or link name of a PLAM library to be searched when using the autolink mechanism. If multiple libraries are specified in a list, this is equivalent to a RESOLVE-BY-AUTOLINK statement with a list of RESOLVE libraries. The list may contain a maximum of 40 libraries (binder restriction).

---

### **INSTANTIATE = \*NO / \*YES / \*IGNORE**

This option is only relevant for automatic template instantiation by the prelinker. It controls whether the libraries specified with the RESOLVE option are to be instantiated (\*YES), not instantiated (\*NO by default), or completely ignored (\*IGNORE) by the prelinker. Whereas libraries for which \*NO or \*YES is specified are taken into account at instantiation, i.e., are searched for existing definitions, libraries for which \*IGNORE is set are not even looked at by the prelinker and are only taken into account in the subsequent linkage process.

**i** If the same library is specified in both the RESOLVE and the INCLUDE option, the following must be observed: As soon as INSTANTIATE=\*NO (the default setting) or \*IGNORE is specified for a library in a RESOLVE option, the prelinker will not perform any template instantiations for all elements of that library, even if the elements have been explicitly been linked with the INCLUDE option.

### **ADD-OPTION = \*UNCHANGED / \*NONE / <c-string 1..1800 with-low>**

<c-string> can be used to specify further operands of the BINDER statement RESOLVE-BY-AUTOLINK in addition to the LIBRARY operand. If more than one operand is specified, they must be separated by commas as follows:

' operand1 , operand2 , ... '

The operands are directly passed through to BINDER without SDF analysis. See the BIND statement for an input example ("[BIND](#)").

#### *Automatic template instantiation*

The operands specified with ADD-OPTION are currently not considered during the automatic template instantiation by the prelinker, but only during subsequent linkage with BINDER. The operands should not affect the type, number or order of the modules to be linked, since different preconditions during the prelinker and linkage runs could result in duplicates or unresolved external references.

### **RESOLVE = \*NONE**

The operand \*NONE deletes the RESOLVE chain. NONE is the default value of the compiler, i.e. the value after starting the compiler or after a RESET-TO-DEFAULT.

### **ADD-PRELINK-FILES =**

This option is only relevant for automatic template instantiation by the prelinker. This option can be used to specify entire PLAM libraries or individual library modules, which are taken into account by the prelinker when determining the instances to be generated as follows:

- If the specified library contains the definition of a template entity (function or static data element), no instance that is a duplicate of that entity is generated.
- No instantiations are performed in the specified library itself. In other words, if the library requires instances for template entities (external references), these are not generated.

If the BIND statement is used to start both a prelinker and a linkage run, the libraries or modules specified with ADD-PRELINK-FILES are not considered for linkage.

#### *Problem*

The modules in the libraries PLAM.X and PLAM.Y contain references to the same template instances. If the modules of these two libraries are both preinstantiated in the BIND statement with the ACTION=\*PRELINK option, this will result in duplicates.

---

In such cases, the prelinker must be given a hint that symbols are defined elsewhere and that no instances should hence be generated. This can be done by using the ADD-PRELINK-FILES option.

### *Solution*

To begin with, the modules of the library PLAM.X are preinstantiated:

```
//MODIFY-BIND-PROPERTIES INCLUDE=*LIB-ELEM(LIB=PLAM.X,ELEM=*ALL)
//BIND ACTION=*PRELINK
```

This is followed by the preinstantiation of the modules in the library PLAM.Y, but the option ADD-PRELINK-FILES is used here to inform the prelinker that the library PLAM.X needs to be considered and that no duplicates for PLAM.X should be generated.

```
//MODIFY-BIND-PROPERTIES INCLUDE=*LIB-ELEM(LIB=PLAM.Y,ELEM=*ALL) ,-
//ADD-PRELINK-FILES=*LIBRARY(LIB=PLAM.X)
//BIND ACTION=*PRELINK
```

### **ADD-PRELINK-FILES = \*UNCHANGED**

The values specified in the MODIFY-BIND-PROPERTIES statements since the last START-LLM-CREATION=\*YES apply.

### **ADD-PRELINK-FILES = \*NONE**

The operand \*NONE deletes the ADD-PRELINK-FILES chain. NONE is the default value of the compiler, i.e. the value after starting the compiler of after a RESET-TO-DEFAULT.

### **ADD-PRELINK-FILES = list-poss: \*LIBRARY-ELEMENT(...)**

Like the INCLUDE option (or the INCLUDE-MODULES statement of BINDER), this option specifies library elements to be considered by the prelinker at preinstantiation.

#### **LIBRARY = <filename 1..54>**

<filename> assigns the name of a PLAM library.

#### **LIBRARY = \*LINK(...)**

#### **LINK-NAME = <filename 1..8>**

<filename> is used to specify a link name for a PLAM library. The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

#### **ELEMENT = \*ALL(...)**

All modules from the PLAM library specified with LIBRARY= are considered at preinstantiation.

#### **VERSION = \*HIGHEST-EXISTING**

If the element entry does not contain a version ID, the highest possible version is used by the compiler.

#### **VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

#### **ELEMENT = <composed-name 1..64 with-under>(...)**

<composed-name> identifies the fully-qualified name of a module from the PLAM library specified with LIBRARY=.

---

**VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the compiler uses the element with the highest existing version.

**VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

**ADD-PRELINK-FILES = list-poss: \*LIBRARY(...)**

The specified libraries are treated by the prelinker in the same way as RESOLVE libraries, i.e. only those library modules which could potentially be used to satisfy unresolved external references when actually linking the program are considered at preinstantiation.

**LIBRARY-NAME = <filename 1..54>**

<filename> assigns the name of a PLAM library.

**LIBRARY = \*LINK(...)****LINK-NAME = <filename 1..8>**

<filename> is used to specify a link name for a PLAM library. The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

**MAX-INSTANTIATE-ITER = 30 / \*UNCHANGED / <integer 0..100>**

This option is only relevant for automatic template instantiation by the prelinker. It defines the maximum number or prelinker iterations. The default value is 30. If a value of 0 is specified for <integer>, the number of prelinker iterations is unlimited.

**TEMPLATE-DEF-LIST = \*UNCHANGED / \*YES / \*NO**

This option is used to switch a communication technology on and off between the front end and prelinker during the internal post-compilation phase via a definition list (see also "[Automatic instantiation](#)").

**ADD-STATEMENT = \*UNCHANGED / \*NONE / list-poss: <c-string 1..1800 with-low>**<c-string> can be used to specify an additional BINDER statement. Multiple BINDER statements can be specified as a list of c-strings as follows:

( ' statement1 ' , ' statement2 ' , ' ... ' ).

The operands are directly passed through to BINDER without SDF analysis.

*Automatic template instantiation*

The BINDER statements specified with ADD-STATEMENT are currently not considered during the automatic template instantiation by the prelinker, but only during subsequent linkage with BINDER. The operands should not affect the type, number or order of the modules to be linked, since different preconditions during the prelinker and linkage runs could result in duplicates or unresolved external references.

**RUNTIME-LANGUAGE =**

This option causes the appropriate C/C++ runtime system of the CRTE to be automatically linked in accordance with the defined C or C++ language mode.

**RUNTIME-LANGUAGE = \*UNCHANGED**

The value specified in the last MODIFY-BIND-PROPERTIES statement applies.

---

## **RUNTIME-LANGUAGE = \*C**

The C runtime system is linked.

The STDLIB option defines the method by which the C runtime system is linked. The RUNTIME-ENVIRONMENT option determines whether the RISC version (“SRULNK”) of the C runtime system is to be used instead of the /390 version (“SYSLNK”).

## **RUNTIME-LANGUAGE = \*CPLUSPLUS(...)**

Apart from the C runtime system, which is always required, additional C++ libraries and runtime systems of the CRTE are linked.

The STDLIB option specifies the mode in which these CRTE libraries are linked.

## **MODE = \*UNCHANGED / \*LATEST / \*2017 / \*2020 / \*V2-COMPATIBLE / \*V3-COMPATIBLE**

Depending on the language modes the compiler used to create the user modules, the appropriate CRTE libraries will be required when linking.

### **\*UNCHANGED:**

The value specified in the last MODIFY-BIND-PROPERTIES statement applies.

### **\*LATEST:**

This is a short cut the latest supported standard and may change in future compiler versions. In this version of the compiler, the specification is the same as \*2020.

### **\*2017 / \*2020:**

Needs a modern C++ runtime system and library. With library version 1 it is SYSLNK.CRTE.CXX01, with library version 2 it is SYSLNK.CRTE.CXX02.

### **\*V2-COMPATIBLE:**

Needs the Cfront C++ runtime system (SYSLNK.CRTE.CFCPP) and Cfront C++ library for complex math and stream-oriented I/O (SYSLNK.CRTE.CPP).

This specification corresponds to the specification \*CPP of the C/C++ V3 compiler.

### **\*V3-COMPATIBLE:**

Needs the C++ V3 runtime system (SYSLNK.CRTE.RTSCPP) and library (SYSLNK.CRTE.STDCPP). The linkage of the Tools.h++ library, which can be used in the C++ V3 mode, is controlled by means of a separate [TOOLSIB](#) option.

This specification corresponds to the specification \*ANSI resp. \*STRICT-ANSI of the C/C++ V3 compiler.

## **STDLIB = \*UNCHANGED / \*DYNAMIC / \*DYNAMIC-COMPLETE / \*STATIC / \*NONE**

This option defines how external references to the C/C++ libraries of the CRTE corresponding to the RUNTIME-LANGUAGE options are resolved.

The \*DYNAMIC and \*STATIC entries currently have a different effect only when linking the C runtime system.

The C++ libraries are treated identically for both the \*DYNAMIC and \*STATIC specifications, i.e. are always linked fully (and “statically”).

### **\*UNCHANGED:**

The value specified in the last MODIFY-BIND-PROPERTIES statement applies.

### **\*DYNAMIC:**

---

All external references to the CRTE libraries are resolved. In the case of the C runtime system only an adapter module from the SYSLNK.CRTE.PARTIAL-BIND library is linked in permanently. The preloaded C runtime system is connected to the program only at runtime.

**\*DYNAMIC-COMPLETE:**

This option represents a variant of dynamic linkage that uses the complete partial bind libraries of CRTE.

This specification is not allowed in C++ 2017 or C++ 2020 mode.

The external references are resolved at runtime from the SYSLNK.CRTE.COMPL library. In the C++ V3 mode, i.e. when `RUNTIME-LANGUAGE=*CPLUSPLUS(MODE=*V3-COMPATIBLEI)` is specified, the SYSLNK.CRTE.CPP-COMPL library is used instead of the SYSLNK.CRTE.RTSCPP and SYSLNK.CRTE.STDCPP libraries.

**i** In the CFront-C++ mode the `STDLIB=DYNAMIC-COMPLETE` option is reset to `STDLIB=DYNAMIC`. In particular, the complete partial bind method is not supported in the CFront-C++ mode. You will find a complete description of the complete partial bind libraries in the "CRTE" manual [4].

**\*STATIC:**

All external references to the CRTE libraries are resolved. In the case of the C runtime system, all individual modules from the SYSLNK.CRTE library are linked in permanently.

**\*NONE:**

The external references to the CRTE libraries remain open and are subsequently resolved either in a later linkage run (i.e. permanently with `BINDER` or the `BIND` statement) or directly at runtime via dynamic linkage with `DBL`.

**i** The following must be observed when external references (`STDLIB=*NONE`) are left unresolved: The standard C++ library (SYSLNK.CRTE.STDCPP, SYSLNK.CRTE.CXX01 or SYSLNK.CRTE.CXX02) is not taken into account during the automatic template instantiation by the prelinker, which means that duplicate definitions could potentially exist. You will find more detailed information on this problem in section "Automatic instantiation".

**TOOLS\_LIB = \*UNCHANGED / \*YES / \*NO**

If `*YES` is specified, the library `Tools.h++` (SYSLNK.CRTE.TOOLS), which can only be used in C++ V3, is included. When the `STDLIB=DYNAMIC-COMPLETE` option is specified, the SYSLNK.CRTE.CPP-COMPL library is used instead of the SYSLNK.CRTE.TOOLS library.

If `*NO` is specified, the external references to the `Tools.h++` library remain unresolved.

**TEST-SUPPORT = \*UNCHANGED / \*YES / \*NO**

This option controls whether the LSD information generated at compilation is to be saved in the linked module for subsequent use with the Advanced Interactive Debugger AID. The value is passed as the `TEST-SUPPORT` operand of the `BINDER` statement `SAVE-LLM`.

---

**LISTING = \*UNCHANGED / \*NONE / \*SYSLST / <filename 1..54>**

This option, which is analogous to the MAP operand of the BINDER statement SAVE-LLM, can be used to request the standard listings of BINDER. These listings are output to the system file SYSLST or to a cataloged file specified with <filename>.

When START-LLM-CREATION=\*YES is specified, the listing is reset to \*NONE.

---

### 3.2.2.9 Interaction between the MODIFY-BIND-PROPERTIES and BIND statements

Several MODIFY-BIND-PROPERTIES statements may be collectively involved in a linkage run. The libraries specified with the RESOLVE, INCLUDE and ADD-PRELINK-FILES options, for example, are collected and remain in effect even for subsequent BIND statements until the option START-LLM-CREATION is set to \*YES or the statement //RESET-TO-DEFAULT is executed.

When START-LLM-CREATION=\*YES is specified, the listing is reset to \*NONE.

A list of libraries within a RESOLVE option has the same effect as a list of libraries within a RESOLVE-BY-AUTOLINK statement of BINDER. Additional MODIFY-BIND-PROPERTIES statements with a RESOLVE option are issued as independent RESOLVE-BY-AUTOLINK statements of BINDER and are processed separately.

### 3.2.2.10 MODIFY-CIF-PROPERTIES

Aliases: SET-CIF-PROPERTIES  
MODIFY-INFO-FILE-PROPERTIES  
SET-INFO-FILE-PROPERTIES

This statement can be used to instruct the compiler to create a CIF (Compiler Information File), which may include information on some or all compiler listings. For each compiled source program, the CIF is written to a separate file, which can then be processed further with the global listing generator (see "[Controlling the global listing generator](#)") for details).

#### MODIFY-CIF-PROPERTIES

```
CONSUMER= *UNCHANGED / *NONE / *ALL / list-poss(9): *BY-LISTING-PROPERTIES / *OPTIONS /
          *SOURCE / *PREPROCESSING-RESULT / *DATA-ALLOCATION-MAP /
          *CROSS-REFERENCE / *PROJECT-INFORMATION / *ASSEMBLER-CODE /
          *SUMMARY
,INCLUDE-INFORMATION= *UNCHANGED / *NONE / *ALL / *USER-INCLUDES-ONLY
,OUTPUT= *UNCHANGED / *NONE / *STD-FILE / *SOURCE-LOCATION / <filename 1..54> /
        <posix-pathname> / *LIBRARY-ELEMENT(...)
*LIBRARY-ELEMENT(...)
|   LIBRARY= *STD-LIBRARY / *SOURCE-LIBRARY / <filename 1..54>
|   ,ELEMENT= *STD-ELEMENT(...) / <composed-name 1..64 with-under>(…)
|   *STD-ELEMENT(...)
|       |   VERSION= *UPPER-LIMIT / <composed-name 1..24 with-under>
|       <composed-name 1..64 with-under>(…)
|       |   VERSION= *UPPER-LIMIT / <composed-name 1..24 with-under>
```

#### CONSUMER = \*UNCHANGED

The value specified in the last MODIFY-CIF-PROPERTIES statement applies.

#### CONSUMER = \*NONE

No permanent CIF is created.

When local listings are requested (with MODIFY-LISTING-PROPERTIES), a temporary CIF is created (with prefix #T) to generate these listings. This CIF is deleted at TASK end.

#### CONSUMER = \*ALL

The created CIF contains information on all listings that can be generated, depending on which compiler components (PREPROCESS, CHECK-SYNTAX, COMPILE) are run.

**CONSUMER = list-poss(9): \*BY-LISTING-PROPERTIES / \*OPTIONS / \*SOURCE / \*PREPROCESSING-RESULT / \*DATA-ALLOCATION-MAP / \*CROSS-REFERENCE / \*PROJECT-INFORMATION / \*ASSEMBLER-CODE / \*SUMMARY**

---

A CIF containing information on the specified listings is created.

**\*BY-LISTING-PROPERTIES:** CIF information is created for all listings requested with the **MODIFY-LISTING-PROPERTIES** statement.

**INCLUDE-INFORMATION = \*UNCHANGED / \*NONE / \*ALL / \*USER-INCLUDES-ONLY** This option can be used to control whether and from which header files CIF information is to be generated for the source, preprocessor and cross-reference listings. By default, only the user-defined headers and not the standard headers are taken into account.

**OUTPUT = \*UNCHANGED**

The value specified in the last **MODIFY-CIF-PROPERTIES** statement applies.

**OUTPUT = \*NONE**

No permanent CIF is created.

**OUTPUT = \*STD-FILE**

The CIF is written to a cataloged BS2000 file. The name of this file is derived from the name of the source program as follows:

<b>Source</b>	*SYSDTA	BS2000 file	PLAM library	POSIX file
<b>Default name</b>	CSTDCIF.CIF	file.CIF	lib-elem.CIF	file.CIF

If the source program is located in a PLAM library, the library and element name of the source are combined with a hyphen (lib-elem) and used in the default file name. The rules by which the compiler constructs default names are described in detail in the section ["Default names for output containers"](#).

**OUTPUT = \*SOURCE-LOCATION**

The output destination and name of the CIF are derived from the location and name of the source program as follows:

<b>Source</b>	*SYSDTA	BS2000 file	PLAM library	POSIX file
<b>Output destination</b>	BS2000 file	BS2000 file	Library of source	Directory of source
<b>Default name</b>	CSTDCIF.CIF	file.CIF	elem.CIF (type H)	file.cif

The rules by which the compiler constructs default names are described in detail in the section ["Default names for output containers"](#).

**OUTPUT = <filename 1..54>**

The CIF is written to a cataloged BS2000 file with the specified name. This entry is invalid when compiling multiple source programs.

**OUTPUT = <posix-pathname>**

The CIF is written to a POSIX file.

Both a file name and a directory are permitted as **<posix-pathname>**. See ["Compiler I/O in the POSIX file system \(C/C++-Compiler, #18\)"](#) for a description of the term **<posix-pathname>**.

---

When a file name is specified, the CIF is stored under this name. Specification of a file name is invalid when compiling multiple source programs with one statement.

When a directory name *dir* is specified, the CIF for each compiled source program is written under the default name *sourcefile.cif* to the directory *dir* (see also section “[Default names for output containers](#)”).

The directories specified with <posix-pathname> must already exist.

CIF files can be processed further in the POSIX subsystem with the global listing generator `cclistgen`.

**OUTPUT = \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the CIF is to be stored. The elements are stored as elements of type H.

**LIBRARY = \*STD-LIBRARY**

The CIF is written to the library SYS.PROG.LIB by default.

**LIBRARY = \*SOURCE-LIBRARY**

The CIF is written to the PLAM library which contains the source program.

The \*SOURCE-LIBRARY specification is invalid if the source program is read from a cataloged BS2000 file, a POSIX file or via SYSDTA.

**LIBRARY = <filename 1..54>**

The CIF is written to a PLAM library with the specified name.

**ELEMENT = \*STD-ELEMENT(...)**

By default, the element name of the CIF is derived from the name of the source program as follows:

Source	*SYSDTA	BS2000 file	PLAM library	POSIX file
Default name	CSTDCIF.CIF	file.CIF	elem.CIF	file.CIF

The rules by which the compiler constructs default names are described in detail in the section “[Default names for output containers](#)”.

**VERSION = \*UPPER-LIMIT**

If the element entry does not contain a version ID, the highest possible version is used by the compiler.

**VERSION = <composed-name 1..24 with-under>**

The CIF is written to the element with the specified version ID.

**ELEMENT = <composed-name 1..64 with-under>(...)**

The CIF is written to a library element (type H) with the specified name. This specification is invalid compiling multiple source programs.

**VERSION = \*UPPER-LIMIT / <composed-name 1..24 with-under>**

The version can be specified as described above for `ELEMENT=*STD-ELEMENT(...)`.

### 3.2.2.11 MODIFY-DIAGNOSTIC-PROPERTIES

Alias: SET-DIAGNOSTIC-PROPERTIES

This statement can be used to create a user-defined list of compiler messages and to specify various output destinations for it. In addition, it can be used to define error message weights and error conditions for aborting compilation.

#### MODIFY-DIAGNOSTIC-PROPERTIES

**MINIMAL-MSG-WEIGHT**= \*UNCHANGED / \*NOTE / \*WARNING / \*ERROR / \*FATAL

**,CHANGE-MSG-WEIGHT**= \*UNCHANGED / list-poss: \*NOTE(...) / \*WARNING(...) / \*ERROR(...)

\*DEFAULT(...)

\*NOTE(...)

| **MSGID**= list-poss: <alphanum-name 7..7>

\*WARNING(...)

| **MSGID**= list-poss: <alphanum-name 7..7>

\*ERROR(...)

| **MSGID**= list-poss: <alphanum-name 7..7>

\*DEFAULT(...)

| **MSGID**= \*ALL / list-poss: <alphanum-name 7..7>

**,SUPPRESS-MSG**= \*UNCHANGED / \*NONE / list-poss: \*USE-BEFORE-SET / <alphanum-name 7..7>

**,MAX-ERROR-NUMBER**= \*UNCHANGED / 50 / <integer 1..255>

**,ANSI-VIOLATIONS**= \*UNCHANGED / \*WARNING / \*ERROR

**,SHOW-COLUMN**= \*UNCHANGED / \*YES / \*NO

**,SHOW-INCLUDES**= \*UNCHANGED / \*YES / \*NO

**,VERBOSE**= \*UNCHANGED / \*NO / list-poss: \*VERSION / \*MESSAGES

**,GENERATE-ETR-FILE**= \*UNCHANGED / \*NO / \*ALL-INSTANTIATIONS / \*ASSIGNED-INSTANTIATIONS

```

,OUTPUT= *UNCHANGED / list-poss(10): *SYSOUT / *SYSLST / *STD-FILE / *SOURCE-LOCATION /
      *TO-LISTING / <filename 1..54> / <posix-pathname> / *LIBRARY-ELEMENT(...)
*LIBRARY-ELEMENT(...)
|   LIBRARY= *STD-LIBRARY / *SOURCE-LIBRARY / <filename 1..54> / *LINK(...)
|       *LINK(...)
|           LINK-NAME= <filename 1..8>
|   ,ELEMENT= *STD-ELEMENT(...) / <composed-name 1..64 with-under>(…)
|       *STD-ELEMENT(...)
|           VERSION= *UPPER-LIMIT / <composed-name 1..24 with-under>
|               <composed-name 1..64 with-under>(…)
|           VERSION= *UPPER-LIMIT / <composed-name 1..24 with-under>

```

**MINIMAL-MSG-WEIGHT = \*UNCHANGED / \*NOTE / \*WARNING / \*ERROR / \*FATAL**

This option can be used to specify the minimum message weight for which compiler messages are to be included in the message listing.

**CHANGE-MSG-WEIGHT =**

This option can be used to change the default message weight for diagnostic messages that are output by the frontend compiler (beginning with CFE). All information is collected, even across multiple instructions.

**CHANGE-MSG-WEIGHT = \*UNCHANGED**

The specification in the last MODIFY-DIAGNOSTIC-PROPERTIES statement applies.

**CHANGE-MSG-WEIGHT = list-poss: \*NOTE(...) / \*WARNING(...) / \*ERROR(...)**

The default message weight is changed to the specified weight. Notes can be upgraded to the message weight ERROR, and warnings can be downgraded to NOTE or upgraded to ERROR. Errors can be downgraded to the weight of a NOTE, but only if they were flagged with an asterisk in the original message: [ \*ERROR ]. The message weight for fatal errors cannot be changed.

**MSGID = list-poss: <alphanum-name 7..7>**

<alphanum-name> is the 7-digit message key of the compiler message for which the message weight is to be changed.

**CHANGE-MSG-WEIGHT = \*DEFAULT(...)**

The message weight is reset to its original value.

**MSGID = list-poss: <alphanum-name 7..7>**

<alphanum-name> is the 7-digit message key of the compiler message for which the message weight is to be reset to its original value.

---

**MSGID = \*ALL**

All message weights are to be reset to their original value.

**SUPPRESS-MSG = \*UNCHANGED / \*NONE / list-poss: \*USE-BEFORE-SET / <alphanum-name 7..7>**

This option can be used to suppress the output of selected compiler messages, thus restricting the listed messages to the ones most important to the user. These messages are still counted for the summary message. When an error is detected, no module will be generated. This is also the case when the output of the error is suppressed. All information is collected, even across multiple instructions, until \*NONE is specified.

**\*UNCHANGED**

The specification in the last MODIFY-DIAGNOSTIC-PROPERTIES statement applies.

**\*NONE**

All compiler messages are output according to the value of [MINIMAL-MSG-WEIGHT](#). Previous settings from SUPPRESS-MSG are reset.

**\*USE-BEFORE-SET**

The output of warnings is suppressed if local `auto` variables are used in the program before being assigned a value.

**<alphanum-name 7..7>**

specifies the message key of a compiler message (NOTE or WARNING) to be suppressed.

*Example*

```
SUPP-MSG=( CFE2802 , CFE9095 )
```

**MAX-ERROR-NUMBER = \*UNCHANGED / 50 / <integer 1..255>**

This option can be used to specify after how many errors the compiler run is to be aborted (notes and warnings are counted separately).

**UNCHANGED**

The specification in the last MODIFY-DIAGNOSTIC-PROPERTIES statement applies.

**50**

The compiler aborts any compilation in which more than 49 errors occur.

**<integer 1..255>**

specifies after how many errors the compiler run is to be aborted.

**ANSI-VIOLATIONS = \*UNCHANGED / \*WARNING / \*ERROR**

This option will be ignored when combined with the specification of LANGUAGE=...(STRICT=NO) (see [MODIFY-SOURCE-PROPERTIES](#)).

\*WARNING is the default setting, which means that warnings are issued on detecting the use of language constructs which deviate from the relevant C or C++ standard, but which are not a serious violation of the language rules defined therein (e.g. implementation specific language extensions; see also section "[Extensions to ANSI/ISO C](#)" and section "[Extensions to ANSI-ISO-C++](#)").

---

If \*ERROR is specified here, errors are reported in such cases. Serious violations automatically result in errors.

**SHOW-COLUMN = \*UNCHANGED / \*YES / \*NO**

This option determines whether the diagnostic messages of the compiler are generated in short or long form.

**UNCHANGED**

The specification in the last MODIFY-DIAGNOSTIC-PROPERTIES statement applies.

**\*YES**

The original source program line is shown with the error location marked (with ^) in addition to the diagnostic message itself.

**\*NO**

The marked source program line is not output.

**SHOW-INCLUDES = \*UNCHANGED / \*YES / \*NO**

If \*YES is specified, the names of header files used by the preprocessor are output.

**VERBOSE = \*UNCHANGED / \*NO / list-poss: \*VERSION / \*MESSAGES**

**UNCHANGED**

The specification in the last MODIFY-DIAGNOSTIC-PROPERTIES statement applies.

**\*VERSION:**

For each edited file the message CDR9402 is output. In link processes, the used CRTE version and the names of the CRTE libraries are also output.

**\*MESSAGES**

This value is currently meaningful only in the language modes C++ V3 and C++ 2017. It causes additional information on automatic template instantiation by the prelinker to be written to SYSOUT.

**GENERATE-ETR-FILE = \*UNCHANGED / \*NO / \*ALL-INSTANTIATIONS /\*ASSIGNED-INSTANTIATIONS**

This option can be used to create an ETR file (ETR=Explicit Template Request) which contains the instantiation statements for the templates used (see section [section “Generating explicit template instantiation statements \(ETR files\)”](#)). The file name is derived from the name of the object file and has the suffix .etr.

The default for this option is \*NO. This does not create an ETR file. If \*ALL-INSTANTIATIONS is specified, all used instances are recorded. If \*ASSIGNED-INSTANTIATIONS is specified only those instances assigned to this file by the prelinker, and are thus contained in the ii file.

**OUTPUT = \*UNCHANGED / list-poss(10): \*SYSOUT / \*SYSLST / \*STD-FILE / \*SOURCE-LOCATION / <filename 1..54> / <posix-pathname> / \*LIBRARY-ELEMENT(...)**

The OUTPUT option can be used to request the concurrent output of the message listing at different output destinations.

**i** In addition to the output destinations specified in this option information messages of the compiler (messages without message weight) are also output to SYSOUT. All other messages are only output to the specified output destinations.

**OUTPUT = \*SYSOUT**

Compilation messages are written to the terminal (system file SYSOUT) by default.

**OUTPUT = \*SYSLST**

The message listing is written to the temporary system file SYSLST and is sent from there to the printer at the end of the task (at LOGOFF).

**OUTPUT = \*STD-FILE**

The message listing is written to a cataloged BS2000 file. The name of this file is derived from the name of the source program as follows:

<b>Source</b>	*SYSDTA	BS2000 file	PLAM library	POSIX file
<b>Default name</b>	CSTDDIAG.DIAG	file.DIAG	lib-elem.DIAG	file.DIAG

If the source program is located in a PLAM library, the library and element name of the source are combined with a hyphen (lib-elem) and used in the default file name. The rules by which the compiler constructs default names are described in detail in the section [“Default names for output containers”](#).

**OUTPUT = \*SOURCE-LOCATION**

The output destination and name of the message listing are derived from the location and name of the source program as follows:

<b>Source</b>	*SYSDTA	BS2000 file	PLAM library	POSIX file
<b>Output destination</b>	BS2000 file	BS2000 file	Library of source	Directory of source
<b>Default name</b>	CSTDDIAG.DIAG	file.DIAG	elem.DIAG (type D)	file.diag

The rules by which the compiler constructs default names are described in detail in the section [“Default names for output containers”](#).

**OUTPUT = \*TO-LISTING**

The diagnostic output is appended to the end of the listing file as an own sublisting. The message list is sorted according to the message weight but information messages (messages without message weight) are not included in the message list. The name of the output file is defined by the value of the option OUTPUT in [MODIFY-LISTING-PROPERTIES](#). The restrictions given there for the modes C++ V3 and C++ 2017 must be taken into account.

**OUTPUT = <filename 1..54>**

The message listing is written to a cataloged BS2000 file with the specified name. This specification is not meaningful when compiling multiple source programs, since the file is overwritten in each case.

**OUTPUT = <posix-pathname>**

The message listing is written to the POSIX file system.

---

Both a file name and a directory are permitted as <posix-pathname>. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

When a file name is specified, the message listing is stored under this name.

When a directory name *dir* is specified, the message listing for each compiled source program is written under the default name *sourcefile.diag* to the directory *dir* (see also section "[Default names for output containers](#)").

The directories specified with <posix-pathname> must already exist. Note that the specification of a file name is not meaningful when compiling multiple source programs, since the file is overwritten in each case.

**OUTPUT = \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the message listing is to be stored. The elements are saved as elements of type D.

**LIBRARY = \*STD-LIBRARY**

The message listing is stored in the library SYS.PROG.LIB by default.

**LIBRARY = \*SOURCE-LIBRARY**

The message listing is written to the PLAM library which contains the source program. The \*SOURCE-LIBRARY specification is invalid if the source program is read from a cataloged BS2000 file, a POSIX file or via SYSDTA.

**LIBRARY = <filename 1..54>**

The message listing is stored in a PLAM library with the specified name.

**LIBRARY = \*LINK(...)**

**LINK-NAME = <filename 1..8>**

A link name can also be specified instead of the cataloged library name. This link name must already have been assigned to the PLAM library (with the ADD-FILE-LINK command) before the compiler is called.

**ELEMENT = \*STD-ELEMENT(...)**

By default, the element name of the message listing is derived from the name of the source program as follows:

<b>Source</b>	*SYSDTA	BS2000 file	PLAM library	POSIX file
<b>Default name</b>	CSTDDIAG.DIAG	file.DIAG	elem.DIAG	file.DIAG

The rules by which the compiler constructs default names are described in detail in the section "[Default names for output containers](#)".

**VERSION = \*UPPER-LIMIT**

If the element entry does not contain a version ID, the highest possible version is used by the compiler.

**VERSION = <composed-name 1..24 with-under>**

The message listing is stored in the element with the specified version ID.

---

**ELEMENT = <composed-name 1..64 with-under>(…)**

The message listing is written to a library element (type D) with the specified name. Note that the specification of an element name is not meaningful when compiling multiple source programs, since the element is overwritten in each case.

**VERSION = \*UPPER-LIMIT / <composed-name 1..24 with-under>**

The version can be specified as described above for **ELEMENT=\*STD-ELEMENT(…)**.

### 3.2.2.12 MODIFY-INCLUDE-LIBRARIES

Aliases: MODIFY-INCLUDE-SEARCH  
SET-INCLUDE-LIBRARIES  
SET-INCLUDE-SEARCH

This statement specifies which include (or header) libraries and file directories are to be searched by the compiler. It also defines the order in which these libraries and directories are searched.

MODIFY-INCLUDE-LIBRARIES

```
USER-INCLUDE-LIBRARY= *UNCHANGED / list-poss: *SOURCE-LIBRARY / *STANDARD-LIBRARY /  
    <filename 1..54> / <posix-pathname> / *LINK(...)  
  
*LINK(...)  
    LINK-NAME= <filename 1..8>  
  
,STD-INCLUDE-LIBRARY= *UNCHANGED / list-poss: *USER-INCLUDE-LIBRARY /  
    *STANDARD-LIBRARY / *SOURCE-LIBRARY / <filename 1..54> /  
    <posix-pathname> / *LINK(...)  
  
*LINK(...)  
    | LINK-NAME= <filename 1..8>  
  
,CURRENT-LIBRARY= *UNCHANGED / *YES / *NO
```

#### USER-INCLUDE-LIBRARY =

This option can be used to assign PLAM libraries or POSIX directories which contain user-defined header files (requested with `#include "..."`). Depending on the setting of the `CURRENT-LIBRARY` option, the library or directory containing the source or header file listed in the include directive `#include "..."` is searched first, i.e., before the libraries and directories specified with `USER-INCLUDE-LIBRARY`.

If the `USER-INCLUDE-LIBRARY` option is not specified, the following default is used:

```
USER-INCLUDE-LIBRARY = (*SOURCE-LIBRARY, *STANDARD-LIBRARY)
```

If header files are enclosed in quotes in the `#include` directive (`#include "name"`), the compiler will search for these elements in the library or directory of the source program first, and then in the CRTE libraries containing the standard header files. The CRTE library `$.SYSLIB.CRTE` is assigned for the search in all language modes. In the language mode Cfront C++ the CRTE library `$.SYSLIB.CRTE.CPP` is searched prior to `$.SYSLIB.CRTE`. In the language modes C++ 2017 and C++ 2020 the CRTE library for modern C++ is searched prior to `$.SYSLIB.CRTE`. The file for that library depends on the library version. With library version 1 the file is `$.SYSLIB.CRTE.CXX01`, with library version 2 it is `$.SYSLIB.CRTE.CXX02`.

If the option is specified, the above default is deactivated, and the compiler searches only in the libraries/directories explicitly specified. In other words, if the source program library or directory and the CRTE libraries are to be searched for header files, the `*SOURCE-LIBRARY` or `*STANDARD-LIBRARY` options must be explicitly specified. The libraries/directories are searched in the order in which they are specified.

---

**USER-INCLUDE-LIBRARY = \*UNCHANGED**

The values specified in the last MODIFY-INCLUDE-LIBRARY statement apply. If no values have been changed since starting the compiler, the default settings of the compiler (\*SOURCE-LIBRARY, \*STANDARD-LIBRARY) apply.

**USER-INCLUDE-LIBRARY = \*SOURCE-LIBRARY**

The library or directory containing the source program is searched for the required header file. The \*SOURCE-LIBRARY specification has no effect if the source program is in a cataloged BS2000 file or, in general, when source programs are entered via SYSDTA (see also "[Notes on input via SYSDTA](#)").

**USER-INCLUDE-LIBRARY = \*STANDARD-LIBRARY**

The CRTE library \$.SYSLIB.CRTE is assigned for the search in all language modes. In the language mode Cfront C++ the CRTE library \$.SYSLIB.CRTE.CPP is searched prior to \$.SYSLIB.CRTE. In the language modes C++ 2017 and C++ 2020 the CRTE library for modern C++ is searched prior to \$.SYSLIB.CRTE. The file for that library depends on the library version. With library version 1 the file is \$.SYSLIB.CRTE.CXX01, with library version 2 it is \$.SYSLIB.CRTE.CXX02.

**USER-INCLUDE-LIBRARY = <filename 1..54>**

<filename> identifies the name of the PLAM library in which the required user-defined header files are to be searched.

**USER-INCLUDE-LIBRARY = <posix-pathname>**

<posix-pathname> designates the name of the POSIX directory in which the required user-defined header files are to be searched. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

**USER-INCLUDE-LIBRARY = \*LINK(...)****LINK-NAME = <filename 1..8>**

A link name can also be specified instead of a cataloged PLAM library name. <filename> designates the link name of the assigned header library. This link name must already have been assigned to the PLAM library (with the ADD-FILE-LINK command) before the compiler is called.

**STD-INCLUDE-LIBRARY =**

This option can be used to specify the PLAM libraries and POSIX directories which contain the required standard headers (requested with `#include <...>`).

**STD-INCLUDE-LIBRARY = \*UNCHANGED**

The values specified in the last MODIFY-INCLUDE-LIBRARY statement apply. If no values have been changed since starting the compiler, the default settings of the compiler (\*USER-INCLUDE-LIBRARY, \*STANDARD-LIBRARY) apply.

**STD-INCLUDE-LIBRARY = \*USER-INCLUDE-LIBRARY**

The search order for standard header files is derived from specifications in the USER-INCLUDE-LIBRARY option. Only the libraries/directories which are explicitly specified in that option are taken into account, not the entries for \*SOURCE-LIBRARY and \*STANDARD-LIBRARY.

---

### **STD-INCLUDE-LIBRARY = \*STANDARD-LIBRARY**

The CRTE library \$.SYSLIB.CRTE is assigned for the search in all language modes. In the language mode Cfront C++ the CRTE library \$.SYSLIB.CRTE.CPP is searched prior to \$.SYSLIB.CRTE. In the language modes C++ 2017 and C++ 2020 the CRTE library for modern C++ is searched prior to \$.SYSLIB.CRTE. The file for that library depends on the library version. With library version 1 the file is \$.SYSLIB.CRTE.CXX01, with library version 2 it is \$.SYSLIB.CRTE.CXX02.

See also the notes on [standard header files for POSIX library functions](#).

### **STD-INCLUDE-LIBRARY = <filename 1..54>**

<filename> designates the name of the PLAM library that is to be searched for the required standard header files.

### **STD-INCLUDE-LIBRARY = <posix-pathname>**

<posix-pathname> designates the name of the POSIX directory in which the required header files are to be searched. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posixpathname>.

This specification is not meaningful for standard headers of the CRTE, since they are obtained from the CRTE libraries.

### **STD-INCLUDE-LIBRARY = \*LINK(...)**

#### **LINK-NAME = <filename 1..8>**

A link name can also be specified instead of the cataloged PALM library name. <filename> designates the link name of the assigned header library. This link name must already have been assigned to the PLAM library (with the ADD-FILE-LINK command) before the compiler is called.

### **CURRENT-LIBRARY = \*UNCHANGED / \*YES / \*NO**

This option determines the search for header files requested with the `#include "..."` directive.

\*YES: By default, when searching for headers, the library or directory of the source or header containing the `#include` directive is searched first, followed by the directories/libraries specified with the USER-INCLUDE-LIBRARY option. This corresponds to the behavior of the compiler in POSIX.

If the source program is contained in a cataloged BS2000 file, header files are searched for in the cataloged BS2000 files.

\*NO: If \*NO is set, only the directories/libraries specified in the USER-INCLUDE-LIBRARY option are searched. This corresponds to the behavior of the earlier C and C++ V2.2 compilers.

## **Standard header files for POSIX library functions**

The standard header files required for the use of the POSIX library functions are not contained in the library \$.SYSLNK.CRTE. They are located in the library \$.SYSLIB.POSIX-HEADER, which is supplied with the product BS2000/OSD BC. This library must always be specified in addition to the library \$.SYSLNK.CRTE if the program uses POSIX functions. Furthermore, the `_OSD_POSIX` directive must be set before the occurrence of the first `#include` directive in the program. This is guaranteed, for example, if the DEFINE option of the MODIFY-SOURCE-PROPERTIES statement is used for the definition at compilation.

## **Examples of the MODIFY-INCLUDE-LIBRARY statement**

### *Example 1*

The source program is located in a PLAM library named PLAM.SOURCE, and extended C11 is set as the language mode.

The source program contains the directive

```
#include "incl.h"
```

The user makes the following entries:

```
//MODIFY-INCLUDE-LIBRARIES USER-INCL-LIB=( *STANDARD-LIBRARY,LIB1,-  
// *LINK(LIB2), *SOURCE-LIBRARY, '/home/user-incl')
```

Since the CURRENT-LIBRARY option is not specified, CURRENT-LIBRARY=\*YES applies.

Search procedure:

The following libraries/directories are searched in sequence for the "incl.h" header:

PLAM.SOURCE	(Due to the option CURRENT-LIBRARY=*YES, the library of the source program containing the #include directive)
\$.SYSLIB.CRTE	(Standard header library)
LIB1	(Library with the name LIB1)
LIB2	(Library with the link name LIB2)
PLAM.SOURCE	(Source program library)
/home/user-incl	(POSIX directory with the name /home/user-incl)

### Example 2

The source program is located in a PLAM library named PLAM.SRC, and Cfront C++ is set as the language mode.

The user makes the following entries:

```
//MODIFY-INCLUDE-LIBRARIES USER-INCLUDE-LIBRARY = ($XYZ.LIB,-  
// *SOURCE-LIBRARY, LIB1),STD-INCLUDE-LIBRARY = (*USER-INCLUDE-LIBRARY,-  
// *STANDARD-LIBRARY),CURRENT-LIBRARY = *NO
```

In this case, the search for header files will proceed as follows:

#include "..."	#include <...>
\$XYZ.LIB	\$XYZ.LIB
PLAM.SRC	LIB1
LIB1	\$.SYSLIB.CRTE.CPP
	\$.SYSLIB.CRTE

### Example 3

The source program is located in the POSIX directory /home/xy/src, and extended C11 is set as the language mode.

The user makes the following entries:

---

```
//MODIFY-INCLUDE-LIBRARIES -  
//USER-INCLUDE-LIBRARY=( *SOURCE-LIBRARY, '/home/xy/incl1', *STANDARD-LIBRARY),-  
//STD-INCLUDE-LIBRARY=( *STANDARD-LIBRARY, $.SYSLIB.POSIX-HEADER,-  
// *USER-INCLUDE-LIBRARY, '/home/xy/incl2),CURRENT-LIBRARY=*NO
```

In this case, the search for header files will proceed as follows:

<b>#include "..."</b>	<b>#include &lt;...&gt;</b>
/home/xy/src	\$.SYSLIB.CRTE
/home/xy/incl1	\$.SYSLIB.POSIX-HEADER
\$.SYSLIB.CRTE	/home/xy/incl1
	/home/xy/incl2

---

### 3.2.2.13 MODIFY-LIBRARY-VERSION

This statement specifies the library version for C++ 2017 and C++ 2020.

The library version has an effect on the libraries used for include file search and resolving. In `//MODIFY-INCLUDE-LIBRARIES` the operand `*STANDARD-LIBRARY` is affected, in `//MODIFY-BIND-PROPERTIES` it is the option `RUNTIME-LANGUAGE=*CPLUS(...)`.

Details for the modern C++ libraries are in chapter [The C++ library for the language modes C++ 2017 and C++ 2020](#).

MODIFY-LIBRARY-VERSION
------------------------

<code>VERSION= *UNCHANGED / <u>1</u> / &lt;integer 1..2&gt; / *HIGHEST-SUPPORTED</code>
---

#### **VERSION = \*UNCHANGED**

The value specified in the last MODIFY-LIBRARY-VERSION statement applies.

#### **VERSION = 1 / <integer 1..2>**

Use the selected library version when the language is C++ 2017 or C++ 2020.

#### **VERSION = \*HIGHEST-SUPPORTED**

Use the highest supported library version. The chosen number will change in future compiler versions. In compiler version 4.0B03 this is equivalent to 2.

### 3.2.2.14 MODIFY-LISTING-PROPERTIES

Alias: SET-LISTING-PROPERTIES

This statement can be used to select which compiler listings are to be generated by the compiler. It can also be used to define the layout of the listings and their output destinations. The structure of the compiler listing is explained in the section “[Description of listings](#)” with the help of examples.

#### MODIFY-LISTING-PROPERTIES

```
OPTIONS= *UNCHANGED / *YES / *NO
,SOURCE= *UNCHANGED / *NO / [*YES](...)
  *YES(...)
    | MINIMAL-MSG-WEIGHT= *NOTE / *WARNING / *ERROR / *FATAL
,PREPROCESSING-RESULT= *UNCHANGED / *NO / *YES
,DATA-ALLOCATION-MAP= *UNCHANGED / *NO / [*YES](...)
  *YES(...)
    | STRUCTURE-LEVEL= *UNCHANGED / *NONE / *MAX / <integer 0..256>
,CROSS-REFERENCE= *UNCHANGED / *NO / [*YES](...)
  *YES(...)
    | PREPROCESSING-INFO= *UNCHANGED / *YES / *NO
    | ,TYPES= *UNCHANGED / *YES / *NO
    | ,VARIABLES= *UNCHANGED / *YES / *NO
    | ,FUNCTIONS= *UNCHANGED / *YES / *NO
    | ,LABELS= *UNCHANGED / *YES / *NO
    | ,TEMPLATES= *UNCHANGED / *YES / *NO
    | ,ORDER= *UNCHANGED / *STD / list-poss(6): *PREPROCESSING-INFO / *TYPES /
    | *VARIABLES / *FUNCTIONS / *LABELS / *TEMPLATES
,PROJECT-INFORMATION= *UNCHANGED / *YES / *NO
,ASSEMBLER-CODE= *UNCHANGED / *YES / *NO
,SUMMARY= *UNCHANGED / *YES / *NO
,LAYOUT= *UNCHANGED / *FOR-NORMAL-PRINT(...) / *FOR-ROTATION-PRINT(...)
  *FOR-NORMAL-PRINT(...)
    | LINE-SIZE= *UNCHANGED / *STD / <integer 120..255>
```

```

| ,LINES-PER-PAGE= *UNCHANGED / *STD / <integer 11..255>
*FOR-ROTATION-PRINT(...)
| LINE-SIZE= *UNCHANGED / *STD / <integer 120..255>
| ,LINES-PER-PAGE= *UNCHANGED / *STD / <integer 11..255>
,INCLUDE-INFORMATION= *UNCHANGED / *NONE / *ALL / *USER-INCLUDES-ONLY
,LISTING-PRAGMAS= *UNCHANGED / *IGNORED / *INTERPRETED / *SELECT(...)
*SELECT(...)
| PAGE= *UNCHANGED / *YES / *NO
| ,TITLE= *UNCHANGED / *YES / *NO
| ,SPACE= *UNCHANGED / *YES / *NO
| ,LIST= *UNCHANGED / *YES / *NO
,INITIAL-TITLE-TEXT= *UNCHANGED / *NONE / <c-string 1..256 with-low>
,OUTPUT= *UNCHANGED / *SYSLST / *SYSOUT / *STD-FILE / *SOURCE-LOCATION /
    <filename 1..54> / <posix-pathname> / *LIBRARY-ELEMENT(...)
*LIBRARY-ELEMENT(...)
| LIBRARY= *STD-LIBRARY / *SOURCE-LIBRARY / <filename 1..54> / *LINK(...)
| *LINK(...)
| | LINK-NAME= <filename 1..8>
| ,ELEMENT= *STD-ELEMENT(...) / <composed-name 1..64 with-under>(…)
| *STD-ELEMENT(...)
| | VERSION= *UPPER-LIMIT / *INCREMENT / <composed-name 1..24 with-under>
| <composed-name 1..64 with-under>(…)
| | VERSION= *UPPER-LIMIT / *INCREMENT / <composed-name 1..24 with-under>

```

**OPTIONS = \*UNCHANGED / \*YES / \*NO**

\*YES: The compiler creates a comprehensive listing of all predefined and user-specified compiler options.

**SOURCE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**SOURCE = \*NO**

No source/error listing is generated.

---

**SOURCE = \*YES(...)**

A source/error listing is generated (not for PREPROCESS).

**MINIMAL-MSG-WEIGHT = \*NOTE / \*WARNING / \*ERROR / \*FATAL**

This operand can be used to specify the minimum message weight for which error messages are to be included in the source/error listing.

Warning:

This suboption is used to limit the number of messages output as compared to the similar MODIFY-DIAGNOSTIC-PROPERTIES suboption, e.g. from WARNING to ERROR.

If MINIMAL-MSG-WEIGHT = \*WARNING (default setting) was specified for MODIFY-DIAGNOSTIC-PROPERTIES, you will not be able to output notes with MODIFY-LISTING-PROPERTIES.

*Examples*

1. To output error messages in the source listing with a message weight of NOTE:

```
MODIFY-DIAGNOSTIC-PROPERTIES MINIMAL-MSG-WEIGHT=*NOTE
MODIFY-LISTING-PROPERTIES SOURCE=*YES(MINIMAL-MSG-WEIGHT=*NOTE)
```

2. Write all error messages with a minimum message weight of NOTE to the system file SYSOUT, and error messages with a minimum message weight of WARNING to the source listing:

```
MODIFY-DIAGNOSTIC-PROPERTIES MINIMAL-MSG-WEIGHT=*NOTE
MODIFY-LISTING-PROPERTIES SOURCE=*YES(MINIMAL-MSG-WEIGHT=*WARNING)
```

(Default)

**i** When the value given in MAX-ERROR-NUMBER is reached, no further source program information will be output in the source/error listing. In this case the listing can no longer be used as a reliable guide to current error status.

**PREPROCESSING-RESULT = \*UNCHANGED / \*NO / \*YES**

\*UNCHANGED

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

\*NO

The compiler does not generate a preprocessor listing.

\*YES

The compiler generates a preprocessor listing.

**DATA-ALLOCATION-MAP = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**DATA-ALLOCATION-MAP = \*NO**

The compiler does not generate a map listing.

---

**DATA-ALLOCATION-MAP = \*YES(...)**

The compiler generates a map listing (only for COMPILE).

**STRUCTURE-LEVEL = \*UNCHANGED / \*NONE / \*MAX / <integer 0..256>**

**\*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**\*NONE**

Structure elements are not included in the map listing.

**\*MAX**

Only the structure elements up to a maximum nesting level (256) are included in the map listing.

**<integer 0..256>**

Only the structure elements up to the nesting level specified by <integer> are included in the map listing. If a nesting level of 0 is specified, no structure elements are output (equivalent to STRUCTURE-LEVEL=\*NONE).

Structure elements are represented with indentation and bracketing {}. Elements with a nesting level of 16 or higher are indented no further.

**CROSS-REFERENCE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**CROSS-REFERENCE = \*NO**

The compiler does not create a cross-reference listing.

**CROSS-REFERENCE = \*YES(...)**

The compiler creates a cross-reference listing (not for PREPROCESS). This listing always contains a FILETABLE section with the names of all files, libraries, and elements that are used as sources by the compiler.

The cross-reference listing is created for each compilation unit, i.e. for the local module. If a global (multi-module) cross-reference listing is required, the MODIFY-CIF-PROPERTIES statement can be used to create CIF information for subsequent processing with the global listing generator.

**PREPROCESSING-INFO = \*YES / \*NO**

The cross-reference listing may optionally include a list of names processed by the preprocessor.

**TYPES = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing may optionally include a list of user-defined types (typedefs, structure, union, class and enumeration types).

**VARIABLES = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing contains a list of variables (can be suppressed with \*NO).

**FUNCTIONS = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing contains a list of functions (can be suppressed with \*NO).

---

**LABELS = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing contains a list of labels (can be suppressed with \*NO).

**TEMPLATES = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing optionally contains a list of templates (only for C++ V3 or C++ 2017 compilations).

**ORDER = \*UNCHANGED / \*STD / list-poss(6): \*PREPROCESSING-INFO / \*TYPES / \*VARIABLES / \*FUNCTIONS / \*LABELS / \*TEMPLATES**

This option specifies the order in which the individual parts of the cross-referencelisting are shown.

\*STD

The default is the order shown after list-poss above.

**PROJECT-INFORMATION = \*UNCHANGED / \*YES / \*NO**

\*UNCHANGED

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

\*YES

The compiler creates a project listing (only for COMPILE) showing the names originally used in the source program and corresponding names internally generated by the compiler for the linkage editor. This is important especially in the case of C++ compilations because the generated names of functions also contain the types of their parameters in code form.

The project listing is created for each compilation unit, i.e. for the local module. If a global (multi-module) project listing is required, the MODIFY-CIF-PROPERTIES statement can be used to create CIF information for subsequent processing with the global listing generator.

\*NO

The compiler does not create such a list.

**ASSEMBLER-CODE = \*UNCHANGED / \*YES / \*NO**

\*UNCHANGED

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

\*YES

The compiler generates an object code listing (only for COMPILE).

\*NO

The compiler does not create such a list.

**SUMMARY = \*UNCHANGED / \*YES / \*NO**

\*UNCHANGED

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

\*YES

The compiler creates a listing containing statistical data on the compiler run.

---

**\*NO**

The compiler does not create such a list.

**LAYOUT =**

This option can be used to define the page length (number of lines per page) and the page width (number of characters per line) for the compiler listings.

If a line width of 120 characters is selected, all the listings will have narrower headers and footers. Text lines are wrapped only in the table listings (option, cross-reference and map listings). Overlong text lines in the source, preprocessor and object code listings may be truncated when the listings are printed.

When a BS2000 output file is specified, the first column of every line is reserved to control the line feed. When the output is sent to a POSIX file, the appropriate POSIX control characters for line and page feeds are generated. The result is that the line length in the POSIX output file is up to 3 characters larger than the selected line width specification.

**LAYOUT = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

Listings in landscape format.

**LAYOUT = \*FOR-NORMAL-PRINT(...)**

Listings in landscape format.

**LINE-SIZE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies. This also applies if that specification was made at \*FOR-ROTATION-PRINT.

**LINE-SIZE = \*STD**

132 characters per line are output.

**LINE-SIZE = <integer 120..255>**

120 to 255 characters per line are output.

**LINES-PER-PAGE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies. This also applies if that specification was made at \*FOR-ROTATION-PRINT.

**LINES-PER-PAGE = \*STD**

64 lines per page are printed.

**LINES-PER-PAGE = <integer 11..255>**

11 to 255 lines are printed per page.

The lower limit is fixed at 11 lines so that at least the listing header and footer and one line of text can be printed.

**LAYOUT = \*FOR-ROTATION-PRINT(...)**

Listings in portrait format.

In order to print such listings, the ROTATION parameter must be specified in the PRINT-FILE command.

---

**LINE-SIZE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.  
This also applies if that specification was made at \*FOR-NORMAL-PRINT.

**LINE-SIZE = \*STD**

120 characters per line are output.

**LINE-SIZE = <integer 120..255>**

120 to 255 characters per line are output.

**LINES-PER-PAGE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.  
This also applies if that specification was made at \*FOR-NORMAL-PRINT.

**LINES-PER-PAGE = \*STD**

84 lines per page are printed.

**LINES-PER-PAGE = <integer 11..255>**

11 to 255 lines are printed per page.

The lower limit is fixed at 11 lines so that at least the listing header and footer and one line of text can be printed.

**INCLUDE-INFORMATION = \*UNCHANGED / \*NONE\* / ALL / \*USER-INCLUDES-ONLY**

This option is used to specify which header files (if any) are to be shown in the source, preprocessor and cross-reference listings. By default, only the user-defined header files are shown, not the standard headers.

**LISTING-PRAGMAS =**

This operand controls which existing #pragma directives (if any) in the source text are to be interpreted when creating source and preprocessor listings.

A description of #pragma directives can be found in the section [“Pragmas to control the layout of listings”](#).

**LISTING-PRAGMAS = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**LISTING-PRAGMAS = \*INTERPRETED / \*IGNORED**

All #pragma directives are interpreted (\*INTERPRETED) or ignored (\*IGNORED).

**LISTING-PRAGMAS = \*SELECT(...)**

One or more of the following #pragma directives to control listings are interpreted (\*YES) or ignored (\*NO).

**PAGE = \*UNCHANGED / \*YES / \*NO**

Directive #pragma PAGE [*text*]:

for a page feed and optional line in the listing header

**TITLE = \*UNCHANGED / \*YES / \*NO**

Directive #pragma TITLE *text*:

for a line in the listing header

---

**SPACE = \*UNCHANGED / \*YES / \*NO**

Directive `#pragma SPACE [n]`:  
to insert blank lines

**LIST = \*UNCHANGED / \*YES / \*NO**

Directive `#pragma LIST[ING] ON` or `#pragma LIST[ING] OFF`:  
to suppress the output of source text lines

**INITIAL-TITLE-TEXT = \*UNCHANGED / \*NONE / <c-string 1..256>**

This operand can be used to specify if an additional line is to appear in the header of the listing and the text that is to be entered in it. In contrast to pragmas, which only apply to source and preprocessor listings, the INITIAL-TITLE-TEXT specification applies to all compiler listings.

In the case of source and preprocessor listings, TITLE and PAGE pragmas (if any) override the INITIAL-TITLE-TEXT specification.

**OUTPUT = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**OUTPUT = \*SYSLST**

The listings are written to the temporary system file SYSLST by default and are sent from there to the printer at the end of the task (at LOGOFF). Output to SYSLST is not supported in the modes C++ V3 and C++ 2017 and is rejected with a corresponding error message.

**OUTPUT = \*SYSOUT**

The listings are written to the system file SYSOUT, which is assigned to the terminal in interactive mode. Output to SYSLST is not supported in the modes C++ V3 and C++ 2017 and is rejected with a corresponding error message.

**OUTPUT = \*STD-FILE**

The listings are written to a cataloged BS2000 file. The name of this file is derived from the name of the source program as follows:

Source	*SYSDTA	BS2000 file	PLAM library	POSIX file
Default name	CSTD.LST	file.LST	lib-elem.LST	file.LST

If the source program is located in a PLAM library, the library and element name of the source are combined with a hyphen (lib-elem) and used in the default file name. The rules by which the compiler constructs default names are described in detail in the section [“Default names for output containers”](#).

**OUTPUT = \*SOURCE-LOCATION**

The output destination and name are derived from the location and name of the source program as follows:

Source	*SYSDTA	BS2000 file	PLAM library	POSIX file
Output destination	BS2000 file	BS2000 file	Library of source	Directory of source
Default name	CSTD.LST	file.LST	elem.LST (type P)	file.lst

---

The rules by which the compiler constructs default names are described in detail in the section [“Default names for output containers”](#).

**OUTPUT = <filename 1..54>**

The listings are written to a cataloged BS2000 file with the specified name. Note that this specification is not meaningful when compiling multiple source programs, since the file is overwritten in each case.

**OUTPUT = <posix-pathname>**

The listings are written to the POSIX file system.

Both a file name and a directory are permitted as <posix-pathname>. See [“Compiler I/O in the POSIX file system \(C/C++-Compiler, #18\)”](#) for a description of the term <posix-pathname>.

When a file name is specified, the listings are stored under this name.

When a directory name *dir* is specified, the listings for each compiled source program are written under the default name *sourcefile.lst* to the directory *dir* (see also section [“Defaultnames for output containers”](#)).

The directories specified with <posix-pathname> must already exist.

The specification of a file name is not meaningful when compiling multiple source programs, since the file is overwritten in each case.

**OUTPUT = \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the expanded program is to be stored. The elements are stored as elements of type P.

**LIBRARY = \*STD-LIBRARY**

The listings are written to the library SYS.PROG.LIB by default.

**LIBRARY = \*SOURCE-LIBRARY**

The listings are written to the PLAM library which contains the source program.

The \*SOURCE-LIBRARY specification is invalid if the source program is read from a cataloged BS2000 file, a POSIX file or via SYSDTA.

**LIBRARY = <filename 1..54>**

The listings are written to a PLAM library with the specified name.

**LIBRARY = \*LINK(...)**

**LINK-NAME = <filename 1..8>**

A link name can also be specified instead of the library name. <filename> designates the link name of the assigned library. This link name must already have been assigned to the PLAM library (with the ADD-FILE-LINK command) before the compiler is called.

**ELEMENT = \*STD-ELEMENT(...)**

By default, the element name of the listing is derived from the name of the sourceprogram as follows:

Source	*SYSDTA	BS2000 file	PLAM library	POSIX file
Default name	CSTDLIST.LST	file.LST	elem.LST	file.LST

The rules by which the compiler constructs default names are described in detail in the section [“Default names for output containers”](#).

---

**VERSION = \*UPPER-LIMIT**

If the element entry does not contain a version ID, the highest possible version is used by the compiler.

**VERSION = \*INCREMENT**

The element is assigned a version number that is obtained by incrementing the highest existing version number by 1, assuming that the highest existing version ID ends with a digit that can be incremented. If the version ID cannot be incremented, the compiler run is aborted with an error message.

See the [COMPILE](#) statement for an example.

**Warning:** You may not specify \*INCREMENT in the modes C++ V3 and C++ 2017.

**VERSION = <composed-name 1..24 with-underscore>**

The element is assigned the specified version.

**ELEMENT = <composed-name 1..64 with-underscore>(…)**

The listings are written to a library element (type P) with the specified name. Note that the specification of an element name is not meaningful when compiling multiple source programs, since the element is overwritten in each case.

**VERSION = \*UPPER-LIMIT / \*INCREMENT /****<composed-name 1..24 with-underscore>**

The version can be specified as described above for  
ELEMENT=\*STD-ELEMENT(…).

**Warning:** You may not specify \*INCREMENT in the modes C++ V3 and C++ 2017.

---

### 3.2.2.15 MODIFY-MODULE-PROPERTIES

Alias: SET-MODULE-PROPERTIES

This statement is used to define the properties of the module to be generated.

```
MODIFY-MODULE-PROPERTIES
```

```
SHAREABLE-CODE= *UNCHANGED / *NO / [*YES] (...)  
    *YES(...)  
        | PUBLIC-SLICING=*UNCHANGED / *YES / *NO  
,LINKAGE= *UNCHANGED / *ILCS-OUT / *ILCS-INLINE  
,WORKSPACE= *UNCHANGED / *TO-STATIC-AREA / *TO-STACK  
,SUBROUTINE-CALL= *UNCHANGED / *BASR / *LAB  
,ETPND-GENERATION= *UNCHANGED / *NO / [*YES] (...)  
    *YES(...)  
        | DATE-FORMAT= *UNCHANGED / *CALENDAR-DATE-ONLY / *WITH-JULIAN-DATE  
,LOWER-CASE-NAMES= *UNCHANGED / *YES / *NO  
,SPECIAL-CHARACTERS= *UNCHANGED / *CONVERT-TO-DOLLAR / *KEEP  
,STRING-LITERALS= *UNCHANGED / *WRITEABLE / *READ-ONLY  
,CONSTANTS= *UNCHANGED / *WRITEABLE / *READ-ONLY  
,C-NAMES= *UNCHANGED / *STD / *UNLIMITED / *SHORT  
,FP-ARITHMETICS= *UNCHANGED / *390-FORMAT / *IEEE-FORMAT
```

#### SHAREABLE-CODE =

This option controls whether or not the generated code is shareable.

#### SHAREABLE-CODE = \*UNCHANGED

The settings of the last MODIFY-MODULE-PROPERTIES statement are used.

#### SHAREABLE-CODE = \*NO

The compiler does not generate shareable code.

\*NO is the default setting.

#### SHAREABLE-CODE = [\*YES] (PUBLIC-SLICING = ...)

The compiler creates shareable code in the form of an LLM with a shareable code CSECT and a non-shareable data CSECT.

#### PUBLIC-SLICING =

PUBLIC SLICING defines whether or not the object generated immediately after the attribute PUBLIC is distributed in slices.

---

**\*UNCHANGED**

The settings of the last MODIFY-MODULE-PROPERTIES statement are used.

**\*YES**

The object will be distributed in slices immediately after the attribute PUBLIC.\*YES is the default setting.

**\*NO**

The object is placed in a slice.

**i** POSIX objects are always generated with PUBLIC-SLICING = \*NO. With very large programs it is a good idea to set PUBLIC-SLICING=\*NO. This will avoid the use of the long run times needed to read objects with slices.

**LINKAGE = \*UNCHANGED / \*ILCS-OUT / \*ILCS-INLINE**

Function calls in the generated module are handled via ILCS by default. This option can be used to specify whether the ILCS entry code for function calls is to be directly inserted at the calling point ("inline") or whether it is to be accessed "out-of-line" in the runtime system.

**\*UNCHANGED**

The settings of the last MODIFY-MODULE-PROPERTIES statement are used.

**\*ILCS-OUT**

The ILCS entry code for function calls is accessed "out-of-line" in the runtime system. This reduces the volume of code in the module.

**\*ILCS-INLINE**

By default, the ILCS entry code is generated inline. This causes the generated object to execute faster.

**WORKSPACE = \*UNCHANGED / \*TO-STATIC-AREA / \*TO-STACK**

This option affects some optimization steps of the compiler.

**WORKSPACE =\*UNCHANGED**

**\*UNCHANGED**

The values specified in the last MODIFY-MODULE-PROPERTIES statement apply.

**\*TO-STATIC-AREA**

The following optimizations are performed by the compiler:

- An auxiliary storage area is created in the static data area and supplied with constant values.
- In the case of innermost functions (i.e. those without further calls), data that is only valid within the function (auto variables) is not placed on the stack, but is stored together with the static data in the data module.

These optimization measures eliminate the need to maintain a separate stack for innermost functions and thus reduce the function entry code, and consequently the runtime of the generated object.

**\*TO-STACK**

The above optimizations are suppressed.

---

All data (doublewords for conversions as well as auto variables and tempos of innermost functions) is mapped on the stack.

If a function includes conversions, some of the conversions may require a doubleword to be placed on the stack and supplied dynamically (requiring an additional instruction) before each such conversion.

### **SUBROUTINE-CALL = \*UNCHANGED / \*BASR / \*LAB**

This option controls the implementation of subroutine entries via Assembler instructions.

#### **\*UNCHANGED**

The values specified in the last MODIFY-MODULE-PROPERTIES statement apply.

#### **\*BASR**

The BASR instruction is generated by default.

#### **\*LAB**

The LAB entry generates the machine-independent Assembler instructions LA and B. Programs with this instruction sequence are executable on all 7500 systems.

**Warning:** This option is not permitted in the modes C++ V3 and C++ 2017.

### **ETPND-GENERATION =**

This option serves to delete the `#pragma` directive used to generate an ETPND area (see ["ETPND pragma \(C/C++ Compiler, #94\)"](#)) or to specify the date format of the ETPND area.

#### **ETPND-GENERATION = \*UNCHANGED**

The values specified in the last MODIFY-MODULE-PROPERTIES statement apply.

#### **ETPND-GENERATION = \*NO**

By default, no ETPND area is created.

#### **ETPND-GENERATION = \*YES(...)**

### **DATE-FORMAT = \*UNCHANGED / \*CALENDAR-DATE-ONLY / \*WITH-JULIAN-DATE**

#### **\*UNCHANGED**

The values specified in the last MODIFY-MODULE-PROPERTIES statement apply.

#### **\*CALENDAR-DATE-ONLY**

The date format in the ETPND area is assigned the form: 8-byte calendar date - 4-byte load address.

#### **\*WITH-JULIAN-DATE**

The following date format is generated in the ETPND area: 6-byte calendar date - 3-byte Julian date - 4-byte load address.

### **LOWER-CASE-NAMES = \*UNCHANGED / \*NO / \*YES**

This option for converting lowercase letters to uppercase affects all external symbols in the C language modes and in the Cfront C++ mode, but only the symbols declared with `extern "C"` in the modes C++ V3 and C++ 2017.

When external C++ symbols are coded in the modes C++ V3 and C++ 2017, lowercase letters are always retained.

#### **\*UNCHANGED**

---

The values specified in the last MODIFY-MODULE-PROPERTIES statement apply.

**\*NO**

By default, lowercase letters are converted to uppercase when generating entry names.

**\*YES**

Lowercase letters are retained when generating entry names.

**SPECIAL-CHARACTERS = \*UNCHANGED / \*CONVERT-TO-DOLLAR / \*KEEP**

This option for converting the underscore affects all external symbols in the C language modes, but only the symbols declared with `extern "C"` directives (not the entry names of the C library functions) in the C++ language modes. When external C++ symbols are coded, underscores are always retained.

**\*UNCHANGED**

The values specified in the last MODIFY-MODULE-PROPERTIES statement apply.

**\*CONVERT-TO-DOLLAR**

By default, underscores are converted to dollar signs when generating entry names.

**\*KEEP**

Underscores are retained when generating entry names.

*Notes on LOWER-CASE-NAMES and SPECIAL-CHARACTERS*

- The (default) conversion of lowercase to uppercase and of underscores to dollar signs is required whenever the generated LLM is to be linked with objects in which the entry names have been converted accordingly. These are:
  - Object modules.
  - LLMs generated with the C V2.0 compiler.
  - LLMs generated with the C/C++ compiler, in cases where the entry names were converted accordingly.
  - Objects created with other language translators (e.g. COBOL, ASSEMBLER).
- The C library functions are only available in full when the options LOWER-CASE-NAMES and SPECIAL-CHARACTERS are present in one of the following combinations:
  - SPECIAL-CHARACTERS=\*CONVERT-TO-DOLLAR and LOWER-CASE-NAMES=\*NO
  - SPECIAL-CHARACTERS=\*KEEP and LOWER-CASE-NAMES=\*YES

**STRING-LITERALS = \*UNCHANGED / \*WRITEABLE / \*READ-ONLY**

This option determines whether string literals (e.g. "abc") are placed in the data module (\*WRITEABLE) or in the code module (\*READ-ONLY).

**CONSTANTS = \*UNCHANGED / \*WRITEABLE / \*READ-ONLY**

This option determines whether constants (i.e. objects declared with the `const` qualifier) are stored in the data module (\*WRITEABLE) or the code module (\*READ-ONLY).

---

**C-NAMES = \*UNCHANGED / \*STD / \*UNLIMITED / \*SHORT**

This option determines the length of external C names and affects all external symbols in the C language modes and only the symbols declared `extern "C"` in the C++ language modes (not the entry names of C library functions).

This option also works with static functions.

**\*UNCHANGED**

The values specified in the last `MODIFY-MODULE-PROPERTIES` statement apply.

**\*STD**

By default, external C names can have a maximum length of 32 characters. Longer names are truncated by the compiler to 32 characters. When generating shareable code, only 30 characters may be used.

**\*UNLIMITED**

No name truncation occurs. In this case, the compiler generates entry names in EEN format. EEN names can have a maximum length of 32000 characters. Modules containing EEN names are stored by the compiler in LLM Format 4. More details on the subsequent processing of LLMs in Format 4 can be found under the `OUTPUT-FORMAT` option of the `BIND` statement.

The `*UNLIMITED` value is not supported in the Cfront C++ mode.

**\*SHORT**

External C names are truncated by the compiler to 8 characters, which corresponds to the handling of external names within object modules. This option is required if external names exceeding 8 characters in length are used in the program and if the module generated by the C/C++ compiler is to be linked with object modules that were created with the earlier C/C++ compilers or with compilers for other ILCS languages (e.g. COBOL85).

**FP-ARITHMETICS = \*UNCHANGED / \*390-FORMAT / \*IEEE-FORMAT**

This option determines whether the C/C++ compiler generates floating-point numbers and operation codes in /390 format or IEEE format. This option effects all variables and constants of the float, double, and long double data types in C/C++ programs.

**\*UNCHANGED**

The values specified in the last `MODIFY-MODULE-PROPERTIES` statement apply.

**\*390-FORMAT**

The C/C++ compiler creates code for constants and operations in the /390 format (/390 floating-point arithmetics).

`*390-FORMAT` is the default setting.

**\*IEEE-FORMAT**

The C/C++ compiler creates code for constants and operations in IEEE format (IEEE floating-point arithmetics).

**Important!**

- There are no precautions when binding objects which have been compiled with different floating-point arithmetics. This characteristic can lead to unexpected results when these programs are run.

- 
- The same C/C++ program can produce different results depending on whether the IEEE format or the /390 format is used for floating-point data types and operations. The reasons for this are as follows:
    - IEEE floating-point numbers use a different internal notation from /390 floating-point numbers.
    - An IEEE `long double` has the same size and representation as a `double`. The layout of structures with a `long double` therefore depends on this option.
    - IEEE floating-point operations use different semantics from /390 floating-point operations even on the same type of operation. This is the case for example in rounding. IEEE format uses "Round to Nearest" as default whereas /390 format uses "Round to Zero" as default.

## Requirements:

- If you are using IEEE floating-point arithmetics, you must not declare the C library functions explicitly in your source program. C library functions should be declared indirectly by including the corresponding CRTE headers (see the "C Library Functions" manual [2]). Otherwise compilation error 'CFE1079[ERROR]..: Typangabe erwartet /expected a type specifier' can occur.
- For *each and every* CRTE function that works with floating-point numbers in your program, you must use the corresponding or matching include file. If you do not do this, the CRTE functions will not be able to process the floating-point numbers correctly. You should ensure that you include the include file `<stdio.h>` for the function `printf()` with `#include <stdio.h>`.

### Important!

C++ library functions do not support the IEEE format and must therefore be replaced with C functions where necessary.

- In the CRTE runtime environment, some C library functions use the IEEE format for floating-point arithmetics. If you are using the IEEE floating-point arithmetics, you should specify the `MODIFY-MODULE-PROPERTIES` statement as follows:

```
MODIFY-MODULE-PROPERTIES      -
    ...
    FP-ARITHMETICS=*IEEE-FORMAT, -
    LOWER-CASE-NAMES=*YES,      -
    SPECIAL-CHARACTERS=*KEEP,   -
    ...
```

### 3.2.2.16 MODIFY-OPTIMIZATION-PROPERTIES

Alias: SET-OPTIMIZATION-PROPERTIES

This option can be used to activate or deactivate some or all of the optimizations performed by the compiler. For more details on the effects of optimization, see the section starting on "[The optimization process \(C/C++ Compiler, #49\)](#)".

```
MODIFY-OPTIMIZATION-PROPERTIES
.
LEVEL= *UNCHANGED / *LOW / *HIGH(...) / *VERY-HIGH(...)
    *HIGH(...) / *VERY-HIGH(...)
        | ,LOOP-UNROLLING= *UNCHANGED / *NO / [*YES(...)]
        |     *YES(...)
        |     | FACTOR= 4 / <integer 1..100>
,INLINING= *UNCHANGED / *NO / [*YES(...)]
    *YES(...)
        | USER-FUNCTIONS= *UNCHANGED / list-poss(127): *STD / *BY-SOURCE /
        |     <c-string 1..255 with-low>
,BUILTIN-FUNCTIONS= *UNCHANGED / *NONE / *ALL / list-poss(11): <c-string 1..125 with-low>
```

#### **LEVEL = \*UNCHANGED**

The value specified in the last MODIFY-OPTIMIZATION-PROPERTIES statement applies.

#### **LEVEL = \*LOW**

With this optimization level, no standard optimizations are performed, so debugging with AID is possible. LEVEL=\*LOW is automatically set instead of the \*HIGH or \*VERY-HIGH specification when the TEST-SUPPORT=\*YES option has also been set.

#### **LEVEL = \*HIGH(...) / \*VERY-HIGH(...)**

If \*HIGH or \*VERY-HIGH is specified, all standard optimizations are performed (see "[Standard optimizations \(The optimization process\)](#)"). The only difference between these two levels is the fact that every optimization strategy is internally executed only once for \*HIGH, but several times for \*VERY-HIGH. Consequently, if the "highly-optimized" level \*VERY-HIGH is set, the overall compile time is much greater than the compile time for the \*HIGH optimization level.

The parameters of the \*HIGH or \*VERY-HIGH structure can be used to individually control the expansion of loops. Debugging with AID is not possible with this optimization level.

#### **LOOP-UNROLLING = \*UNCHANGED / \*NO / \*YES(FACTOR = 4 /<integer 1..100>...)**

This option controls the expansion of loops. Multiple expansion of the body of a loop reduces the execution time for the iterations of the loop. Expanding the body of the loop provides an opportunity for further optimization; however, the repetition of code also implies an increase in the size of the generated object.

---

By default, the optimizer expands the body of a loop 4 times.

- Where required, a separate expansion factor can be selected with `<integer>`. Specifying an expansion factor does not, however, ensure that the loop expansion will be carried out in all cases. In order to ensure that the expansion is carried out correctly, you should concentrate on optimizing the loop structure and the specified expansion factor.
- Loop expansion can be suppressed with `*NO`.

For further details, see [“Expansion of loops” \(The optimization process\)](#).

### **INLINING =**

This option controls the inline substitution of user-defined functions. As in the case of the inline substitution of some C library functions from the standard library (see `BUILTIN-FUNCTIONS`), each call to an inline function is replaced by the corresponding function code. Consequently, no call and return code sequence is required, and better execution time is achieved. This optimization measure is, however, associated with an increase in the size of the generated module due to the repetition of code.

For further details, see the section on [“Inline substitution of user-defined functions” \(The optimization process\)](#).

#### *Standard settings of the compiler*

If the `INLINING` option is not specified, the following default settings apply for the C and C++ language modes, respectively:

1. C modes (`MODIFY-SOURCE-PROPERTIES LANGUAGE=*C`):

`INLINING=*NO`

No inline substitution is performed.

2. C++ modes (`MODIFY-SOURCE-PROPERTIES LANGUAGE=*CPLUSPLUS`):

`INLINING=*YES(USER-FUNCTIONS=*BY-SOURCE)`

Inline substitution is performed for all C++-specific inline functions (i.e. functions with the `inline` attribute and member functions defined within classes).

### **INLINING = \*UNCHANGED**

The value specified in the last `MODIFY-OPTIMIZATION-PROPERTIES` statement applies.

### **INLINING = \*NO**

No user-defined functions are generated inline by the optimizer. `*NO` is the default setting in the C language modes if no `INLINING` option has been specified.

In addition, `*NO` is also automatically assumed by the compiler instead of `*YES(...)` values if the option `TEST-SUPPORT=*YES` has also been set.

### **INLINING = \*YES(USER-FUNCTIONS = \*UNCHANGED / list-poss: \*STD / \*BY-SOURCE / <c-string 1..255 with-low>)**

`*UNCHANGED`

The value specified in the last `MODIFY-OPTIMIZATION-PROPERTIES` statement applies.

`*STD`

---

If only `*STD` is specified, the optimizer selects functions for inline substitution on the basis of its own criteria. `*STD` implies `*BY-SOURCE`, which means that even inline pragmas and C++-specific inline functions are considered by the optimizer when searching for suitable candidates to be inlined (see also `*BY-SOURCE`). `*STD` is the default when `INLINING=*YES` is specified.

#### `*BY-SOURCE`

If only `*BY-SOURCE` is specified, only the following user-defined functions are substituted inline:

- In the C modes: all C functions specified with the following `#pragma` directive: `#pragma inline function-name`  
The inline pragma is not supported in the C++ language modes.  
See also section [“inline pragma”](#).
- In the C++ modes: all C++ functions with the `inline` attribute and all C++ functions defined within classes.

`*BY-SOURCE` is the default in the C++ language modes if no `INLINING` option is specified.

#### `<c-string>`

`<c-string>` can be used to specify the name of a user-defined function to be inlined by the optimizer. The specification of user-selected functions with `<c-string>` is only supported in the C language modes, since C++ has its own language elements for the inline substitution of functions. `<c-string>` implies the specification of `*BY-SOURCE`, which means that even inline pragmas are considered by the optimizer (see also `*BY-SOURCE` in the C modes).

#### `list-poss`

`*STD`, `<c-string>` and `-` for compatibility reasons - even `*BY-SOURCE` may also be specified together, in which case the optimizer will first attempt the inline substitution of the function(s) specified with `*BY-SOURCE` and/or `<c-string>` and then select other functions for inline substitution (provided `*STD` is also specified) according to its own criteria. Note that `*BY-SOURCE` need not be specified here, since it is implicitly assumed whenever `*STD` or `<c-string>` is specified at the same time.

The meaningful combinations are therefore:

`*STD, <c-string>`  
`<-c-string>, <c-string>, ...`

*Example of the `INLINING` option*

```
//MODIFY-OPTIMIZATION-PROP -  
//LEVEL=*HIGH, INLINING=*YES (USER-FUNCT=( *STD, ' funct1 ', ' funct2 ' ))
```

See [“Inline substitution of user-defined functions” \(The optimization process\)](#) for further details.

#### **BUILTIN-FUNCTIONS = `*UNCHANGED / *NONE / *ALL /list-poss: <c-string 1..125 with-low>`**

This option can be used to specify the C library functions for which the implementation in the CRTE can be assumed. This permits better optimization of the program.

---

**\*UNCHANGED**

The value specified in the last MODIFY-OPTIMIZATION-PROPERTIES statement applies.

**\*NONE**

No library function call is specially optimized.

**\*ALL**

All calls for known library functions are handled separately.

**<c-string>**

Calls for this function are handled separately.

The compiler achieves the greatest effect through inline substitution of a function. In this case the function code is directly inserted at the point of call. This eliminates some of the time-consuming administrative tasks of the runtime system (e.g. saving and restoring registers, return from the function, etc.) and thus reduces the overall execution time of the program.

The following C library functions can be expanded inline:

strcpy memcmp  
strcmp memset  
strncmp abs  
strlen fabs  
strcat labs  
memcpy

*Notes*

- Inlined functions cannot be replaced by other functions at link time and cannot be used as checkpoints when debugging with AID.
- Non-inlined functions are retained as a call. However, optimizations are possible which cannot be achieved in the user functions. For example, the compiler can use the information that the `isdigit()` function has no side effects.
- If a function is defined by the user with a name which the compiler knows, conflicts can occur with this option. The function written by the user will generally have a different implementation from the function in the CRTE. Warning CFE2067 is issued instead of the definition in order to indicate the conflict.
- Note that the features of the CRTE implementation are used in every compilation unit. However, the warning is only output in the compilation unit containing the private definition.

The default settings of the MODIFY-OPTIMIZATION-PROPERTIES statement and possible modifications are repeated in summarized form in the table below.

	<b>*HIGH(...) / *VERY-HIGH(...)</b>	<b>*LOW</b>
<b>Standard optimizations</b>	*YES	*NO

---

<b>LOOP-UNROLLING</b>	<b>*YES</b> (controllable)	<b>*NO</b>
<b>BULTIN-FUNCTIONS</b>	<b>*NONE</b> (controllable)	
<b>INLINING ( in C)</b>	<b>*NO</b> (controllable)	
<b>INLINING ( in C++)</b>	<b>*YES(USER-FUNCTIONS=*BY-SOURCE)</b> (controllable)	

---

### 3.2.2.17 The optimization process

In the description that follows, the term “standard optimizations” is used to collectively refer to all optimization measures that can only be activated or deactivated globally, i.e. which cannot be controlled individually.

In contrast to the standard optimizations, some optimization steps such as loop expansion, and inlining can be individually controlled. Selective control is provided in these cases because, among other things, the benefits of such optimization (e.g. quicker execution times) may need to be weighed against other disadvantages (e.g. an increase in the size of the generated module or longer compilation times).

In some cases, setting the LOOP-UNROLLING and INLINING options may actually degrade performance. It is therefore advisable to determine the best settings for each application by running some tests.

### Standard optimizations

The C++ compiler performs the following optimizations:

- evaluation of constant expressions at compile time
- optimization of subscript computation in loops
- elimination of superfluous assignments
- propagation of constant expressions
- elimination of redundant expressions
- optimization of branches to unconditional branch instructions

The term “base block” is fundamental to the concept of optimization and refers to a maximum, unbranched command sequence. Such a command sequence has precisely one entry point and one exit.

Base blocks are the units via which most optimization steps with the C++ compiler are implemented.

#### 1. Evaluation of constant expressions at compile time

By evaluating expressions for which operand values are known during compilation, the execution of commands is relocated from the program run to the compiler run. Consequently, the program executes faster.

Evaluations at compile time involve integer arithmetics and relational operations.

##### *Example*

Before optimization	After optimization
<code>I = 1 + 2;</code>	<code>I = 3;</code>
<code>I = 2 * 4;</code>	<code>I = 8;</code>
<code>1 &lt;= 5;</code>	<code>&lt;TRUE&gt;</code>

#### 2. Elimination of superfluous assignments

If an assignment to a variable *v* is followed by a change in the value of *v* without the original value ever being used, this assignment is eliminated. Assignments to variables whose values are of no further consequence to the program run are also eliminated.

##### *Example*

Before optimization	After optimization
<code>i = 5;</code>	
<code>i = 3;</code>	<code>i = 3;</code>

#### 3. Propagation of constant expressions

---

If a variable whose value is already known at the time of compilation is used in an expression, this variable will be replaced by the appropriate value.

*Example*

Before optimization	After optimization
<code>a = 3;</code>	<code>a = 3;</code>
<code>i = a;</code>	<code>i = 3;</code>

This optimization also has a bearing on other optimization techniques. After the successful propagation of a variable, the original assignment may be deleted, or a new constant expression that has already been evaluated at compile time may appear.

4. Elimination of redundant expressions

If the value of an expression occurring within a basic block is already known at the time of compilation as a result of an earlier calculation, then this expression is redundant. To avoid a repeat calculation, the expression is assigned to a new variable and replaced by this new variable wherever it occurs.

*Example*

Before optimization	After optimization
<code>a = b * c + 20;</code>	<code>h = b * c;</code>
<code>e = b * c - 10;</code>	<code>a = h + 20;</code>
	<code>e = h - 10;</code>

5. Optimization of subscript computation in loops

If an array element is subscripted in a loop via an iteration variable, the multiplication required in order to compute the address of the array element is reduced to additions. As a rule, the address of the array element is calculated as

$$\text{base address} + \text{index} * \text{length of an array element}$$

Before entering a loop, the optimizer supplies an address variable with the address of the array element that was referenced during the first iteration. With every following iteration, this address variable is then incremented with a fixed length of one array element.

This optimization technique is especially rewarding in the case of multidimensional arrays, since one multiplication step can be eliminated per dimension under optimum conditions.

6. Optimization of branches to unconditional branch instructions

In branch instructions that have an unconditional branch as their destination, the branch address of the unconditional branch is substituted for the original branch address. This also helps eliminate superfluous code, i. e. code which specifies addresses that cannot be accessed.

*Example*

Before optimization	a. After optimization
---------------------	-----------------------

```
goto lab1;
...
lab1:
goto lab2;
...
lab2:
```

```
goto lab2;
...
lab1:
goto lab2;
...
lab2:
```

---

## Inline substitution of user-defined functions

The inline substitution of a function eliminates the need to call the function at runtime, since the function code is integrated into the source code at the point of call. This reduces the administrative overhead and code required for function calls and returns (e.g. saving and restoring registers, allocating stacks, writing parameters to the transfer area, etc.) and can thus produce substantial savings in execution time. In addition, the inlining of functions enhances the effect of the standard optimizations due to the larger context.

Inlined `static` functions are deleted.

Inline substitution does, however, increase the size of the generated modules. It may produce extremely large functions with an increasing number of variables as potential recipients of registers that cannot all be supplied due to the limited number of registers available. This fact must be weighed against the advantages of this method of optimization.

Inline substitution is particularly suitable for small functions where the overhead for the function call and return constitutes a substantial part of the actual function code.

Functions with the following attributes can never be expanded inline:

- functions with a variable number of parameters (cf. `va_...` macros in `<stdarg.h>`)
- functions containing `setjmp` calls
- recursive functions

## Expansion of loops

Loop expansion reduces the number of iterations in a loop by repeating, i.e. “expanding” the body of the loop (statement block) one or more times. Since each iteration of a loop requires loop control statements to test the value of the current iteration and to branch accordingly, a reduction in the number of iterations also improves execution time.

For example, if the body of a loop is doubled (expansion factor 2), the overhead for loop control statements is reduced by half. In general, the following rule applies: an expansion factor of  $n$  reduces the overhead for loop control statements to  $1/n$ .

The size of the generated module is, however, increased by the repetition of code. By default, the optimizer uses an expansion factor of 4.

Expanding the body of a loop also creates the potential for new optimization. For example, the extended base blocks can be made more efficient by the propagation of constant expressions or the elimination of redundant expressions.

*Example of a loop expansion with expansion factor 4*

Before expansion:

```
i = 0;
while(i < 80) {
    a[i] = b[i+1];
    i++;
}
```

After expansion:

---

```
i = 0;
while(i < 80) {
    a[i] = b[i+1];
    i++;
    if(!(i < 80)) goto end;
    a[i] = b[i+1];
    i++;
    if(!(i < 80)) goto end;
    a[i] = b[i+1];
    i++;
    if(!(i < 80)) goto end;
    a[i] = b[i+1];
    i++;
}
end:
```

Optimizations in the body of the loop are also possible here.

---

### 3.2.2.18 MODIFY-RUNTIME-PROPERTIES

Alias: SET-RUNTIME-PROPERTIES

This statement can be used to influence runtime behavior when compiling the module containing the `main` function. When compiling other modules these settings have no effect.

```
MODIFY-RUNTIME-PROPERTIES
```

```
PARAMETER-PROMPTING= *UNCHANGED / *YES / *NO
```

```
,STACK-SIZE= 64 / *UNCHANGED / <integer 8..99999>
```

```
,STATISTIC-MESSAGES= *UNCHANGED / *CPU-TIME / *NONE
```

```
,PROGRAM-INTERRUPT= *UNCHANGED / *INTEGER-OVERFLOW / *NONE
```

```
,ENVIRONMENT-ENCODING= *UNCHANGED / *STD / *EBCDIC
```

#### **PARAMETER-PROMPTING = \*UNCHANGED / \*YES / \*NO**

\*YES: The executable program is to simulate the UNIX environment, in other words:

- the program with parameters can be called using `START-EXECUTABLE-PROGRAM`, or
- a parameter line should appear after the program is started to allow the input of parameters for the `main` function or redirection of `stdin`, `stdout` or `stderr` (see also [section“Parameter input at program start”](#)).

\*NO: The executable program is started without the parameter line being requested.

If the program is started from the POSIX shell, the entries in the `PARAMETER-PROMPTING` option will be meaningless, since parameters are always entered from the command line in this case.

#### **STACK-SIZE = 64 / \*UNCHANGED / <integer 8..99999>**

This option can be used to determine the amount of space to be reserved for the first segment of the C runtime stack.

64: The default value is 64 kilobytes.

<integer>: Between 8 and 99999 kilobytes of storage space can be reserved.

#### **STATISTIC-MESSAGES = \*UNCHANGED / \*CPU-TIME / \*NONE**

When a program is terminated, the CPU time used is reported by default. This message can be suppressed by specifying \*NONE.

#### **PROGRAM-INTERRUPT = \*UNCHANGED / \*INTEGER-OVERFLOW / \*NONE**

This operand can be used to set the program mask when compiling programs that contain the `main` function

\*INTEGER-OVERFLOW corresponds to the ILCS program mask `X'0C'`.



This option does not affect the selection of generated commands. The result is that permitting `INTEGER-OVERFLOWS` does not necessarily mean that an overflow is triggered in all cases.

\*NONE corresponds to the program mask `X'00'`.

---

The effects of these two program masks are as follows:

	INTEGER-OVERFLOW	NONE
fixed-point overflow	permitted	suppressed
decimal overflow	permitted	suppressed
exponent overflow	suppressed	suppressed
null mantissa	suppressed	suppressed

**i** No changes in the ILCS program mask are permitted if mixed languages are used!

**ENVIRONMENT-ENCODING = \*UNCHANGED / \*STD / \*EBCDIC**

These options control the manner in which external strings (arguments of `main` and environment variables) are handled.

\*STD is the default value. This causes the external strings to be coded in the manner specified in the `MODIFY-SOURCE-PROPERTIES LITERAL-ENCODING` option.

The \*EBCDIC option is offered for reasons of compatibility and causes external strings to be coded in EBCDIC even when `MODIFY-SOURCE-PROPERTIES=*ASCII` or `*ASCII-FULL` is specified.

### 3.2.2.19 MODIFY-SOURCE-PROPERTIES

Alias: SET-SOURCE-PROPERTIES

This statement can be used to define the properties of a source program and to control the behavior of the preprocessor and the C and C++ frontends.

#### MODIFY-SOURCE-PROPERTIES

```
/* Options to select the language mode */
```

```
LANGUAGE= *UNCHANGED / *C(...) / *CPLUSPLUS(...)
```

```
*C(...)
```

```
| MODE= *UNCHANGED / *LATEST / *1990 / *2011 /
```

```
          *KERNIGHAN-RITCHIE
```

```
| STRICT = *UNCHANGED / *NO / *YES
```

```
*CPLUSPLUS(...)
```

```
MODE= *UNCHANGED / *LATEST / *2017 / *2020 /
```

```
          *V2-COMPATIBLE / *V3-COMPATIBLE
```

```
| STRICT = *UNCHANGED / *NO / *YES
```

```
/* Preprocessor options */
```

```
,DEFINE= *NONE / *UNCHANGED / list-poss: <c-string 1..125 with-low> / <name 1..125 with-under> /
```

```
          *SUBSTITUTE(...)
```

```
*SUBSTITUTE(...)
```

```
| IDENTIFIER= <c-string 1..125 with-low> / <name 1..125 with-under>
```

```
| ,TOKEN-STRING= <c-string 1..125 with-low> / <name 1..125 with-under>
```

```
,UNDEFINE= *NONE / *UNCHANGED / *ALL / list-poss: <c-string 1..125 with-low> /
```

```
          <name 1..125 with-under> /
```

```
,ASSERT= *NONE / *UNCHANGED / list-poss: *SUBSTITUTE(...)
```

```
*SUBSTITUTE(...)
```

```
| IDENTIFIER= <c-string 1..125 with-low> / <name 1..125 with-under>
```

```
| ,TOKEN-STRING= <c-string 1..125 with-low> / <name 1..125 with-under>
```

```
,PREINCLUDE= *UNCHANGED / *NONE / <c-string 1..1024 with-low>
```

```
,COMMENTS= *UNCHANGED / *YES / *NO
```

```
,PREPROCESSING-MODE= *UNCHANGED / *ANSI / *KR
```

```

,IMPLICIT-INCLUDE= *UNCHANGED / *YES / *NO
/* Common frontend options in C and C++ */
,SIGNED-CHARACTER= *UNCHANGED / *YES / *NO
,AT-ALLOWED= *UNCHANGED / *YES / *NO
,DOLLAR-ALLOWED= *UNCHANGED / *YES / *NO
,ENUM-TYPE= *UNCHANGED / *VALUE-DEPENDENT / *LONG
,SIGNED-FIELDS= *UNCHANGED / *SIGNED / *UNSIGNED
,PLAIN-FIELDS= *UNCHANGED / *SIGNED / *UNSIGNED
,PRESERVING= *UNCHANGED / *UNSIGNED / *LONG
,ALTERNATIVE-TOKENS= *UNCHANGED / *YES / *NO
,EXTERNAL-DEFINITION= *UNCHANGED / *BY-SOURCE-LANGUAGE / *UNIQUE /
    *MULTIPLY-ALLOWED
,LOGLONG= *UNCHANGED / *YES / *NO
,END-OF-LINE-COMMENTS= *UNCHANGED / *YES / *NO
,LITERAL-ENCODING= *UNCHANGED / *NATIVE / *ASCII / *ASCII-FULL / *EBCDIC / *EBCDIC-FULL
/* C++ specific options */
,INSTANTIATION= *UNCHANGED / *NONE / *AUTO / *LOCAL / *ALL
,USE-STD-NAMESPACE= *UNCHANGED / *YES / *NO
,USE-STD-NAMESPACE= *UNCHANGED / *YES / *NO
,KEYWORD-BOOL= *UNCHANGED / *YES / *NO
,KEYWORD-WCHAR= *UNCHANGED / *YES / *NO
,LOOP-INIT= *UNCHANGED / *OLD / *NEW
,SPECIALIZATION= *UNCHANGED / *OLD / *NEW

```

*Options to select the language mode*

#### **LANGUAGE =**

This option specifies in which programming language (C or C++) the sources to be compiled were written. The default setting of the compiler is LANGUAGE=\*CPLUSPLUS(MODE=\*LATEST, STRICT=\*NO).

#### **LANGUAGE = \*C(...)**

The source program is a C program.

**MODE = \*UNCHANGED / \*LATEST / \*1990 / \*2011 / \*KERNIGHAN-RITCHIE**

---

The operand `MODE` determines the language mode:

**\*UNCHANGED:**

The value specified in the last `MODIFY-SOURCE-PROPERTIES` statement with `LANGUAGE=*C` applies.

**\*LATEST:**

This is a short cut for latest supported standard. It is the default setting. It is currently mapped to `*2011`. This mapping might change in a future compiler version.

**\*1990:**

C89 mode

The compiler supports C code, as defined in the ANSI/ISO-C standard from 1990. The same standard is also known as ANSI C89.

This value corresponds to the specification `*ANSI` resp. `*STRICT-ANSI` of the C/C++ V3 compiler.

`__STDC_VERSION__` has the value 199409L.

**\*2011:**

C11 mode

The compiler supports C code, as defined in the C-standard of 2011.

`__STDC_VERSION__` has the value 201112L.

**\*KERNIGHAN-RITCHIE:**

K&R-C-mode

The compiler accepts C code, as defined by Kernighan&Ritchie in the reference manual ("The C Programming Language", First Edition). It also supports C language elements of the ANSI C standard that are semantically identical to the Kernighan&Ritchie "definition" of the C language (e.g. function prototypes, `const`, `volatile`). This simplifies the conversion of a K&R C source to ANSI C. All C library functions of the CRTE (i.e. ANSI functions, POSIX and X/OPEN functions, UNIX extensions) are available for use.

As far as the preprocessor behavior is concerned, ANSI/ISO C is the default. If desired, the option `PREPROCESSING-MODE=*KR` can be specified to convert the preprocessor behavior to K&R C (as required when porting old C sources from a UNIX system, for example).

`__STDC_VERSION__` is not defined. The operand `STRICT` has no effect, i.e. `STRICT=*NO` always applies.

**STRICT = \*UNCHANGED / \*NO / \*YES**

**\*NO:**

Some required diagnostics are omitted, the name space is not restricted to names that are specified by the standard and some extensions are included.

`__STDC__` has the value 0, `__STRICT_STDC` is not defined.

**\*YES:**

The namespace is restricted to the names defined in the standard, and only the C library functions defined in the ANSI/ISO standard are available. Certain extensions (such as the `asm` keyword) and some commonly expected header file declarations are not available

---

Deviations from the standard result in compiler messages (mostly warnings). If desired, the output of errors can be forced in such cases by specifying the option `ANSI-VIOLATIONS=*ERROR` (see "[MODIFY-DIAGNOSTIC-PROPERTIES](#)").

`__STDC__` has the value 1, `__STRICT_STDC` is defined.

### **LANGUAGE = \*CPLUSPLUS(...)**

The source program is a C++ program. This is also the default setting of the compiler before the programming language is defined for the first time with the LANGUAGE option.

### **MODE = \*UNCHANGED / \*LATEST / \*2017 / \*2020 / \*V2-COMPATIBLE / \*V3-COMPATIBLE**

The operand MODE determines the language mode:

#### **\*UNCHANGED:**

The value specified in the last `MODIFY-SOURCE-PROPERTIES` statement with `LANGUAGE=*CPLUSPLUS` applies.

#### **\*LATEST:**

This is a short cut for latest supported standard. It is the default setting. It is currently mapped to `*2020`. This mapping might change in a future compiler version.

#### **\*2017:**

C++ 2017 mode

The compiler supports C++ code, as defined in the C++-standard of 2017.

`__cplusplus` has the value 201703L and `__STDC_VERSION__` the value 199409L.

#### **\*2020:**

C++ 2020 mode

The compiler supports C++ code, as defined in the C++-standard of 2020. Full C++ 2020 library support is currently not available and instead the existing C++ 2017 library is used.

`__cplusplus` has the value 202002L and `__STDC_VERSION__` the value 199409L.

#### **\*V2-COMPATIBLE:**

Cfront-C++ mode

The compiler supports the C++ language elements of Cfront V3.0.3. Cfront V3.0.3 was first released with the C++ compiler V2.1.

The Cfront compatible C++ library with complex math and stream-oriented I/O is available.

More information on the Cfront C++ library can be found in the section "[The Cfront C++ library](#)".

C++ sources must be compiled with `MODE=*V2-COMPATIBLE` if their modules are to be linkable with C++ V2.1/V2.2 modules.

This value corresponds to the specification `*CPP` of the C/C++ V3 compiler.

`__cplusplus` has the value 1 and `__STDC_VERSION__` the value 199409L. The operand `STRICT` has no effect, i.e. `STRICT=*NO` always applies.

#### **\*V3-COMPATIBLE:**

C++ V3 mode

The compiler supports C++ code like the C/C++ compiler version 3.2.

---

This value corresponds to the specification \*ANSI resp. \*STRICT-ANSI of the C/C++ V3 compiler.

`__cplusplus` has the value 2 (if STRICT=\*NO) resp. 199612L (if STRICT=\*YES) and  
`__STDC_VERSION__` has the value 199409L.

### **STRICT = \*UNCHANGED / \*NO / \*YES**

#### **\*NO:**

Some required diagnostics are omitted, the name space is not restricted to names that are specified by the standard and some extensions are included.

`__STDC__` has the value 0, `_STRICT_STDC` is not defined.

#### **\*YES:**

The namespace is restricted to the names defined in the standard, and only the C library functions defined in the ANSI/ISO standard are available. Certain extensions (such as the `asm` keyword) and some commonly expected header file declarations (`stdio.h`, `stdlib.h` etc.) are not available.

Deviations from the standard result in compiler messages (mostly warnings). If desired, the output of errors can be forced in such cases by specifying the option `ANSI-VIOLATIONS=*ERROR` (see "[MODIFY-DIAGNOSTIC-PROPERTIES](#)").

`__STDC__` has the value 1, `_STRICT_STDC` is defined.

### *Preprocessor options*

#### **DEFINE = \*NONE**

Only the names and values that are specified by `#define` directives in the program or are predefined by the compiler are considered valid for the current compiler run.

#### **DEFINE = \*UNCHANGED**

The values specified in the last `MODIFY-SOURCE-PROPERTIES` statement apply.

#### **DEFINE = <c-string 1..125 with-low> / <name 1..125 with-under>**

<c-string> / <name> is used to define a name. This definition has the same effect as the following statement in a program:

```
#define name 1
```

Such names are queried in the program with, for example, the preprocessor directives `#ifdef`, `#ifndef` or `#if defined()`, `#if ! defined()`. See also the example below. When POSIX library functions are used, the `_OSD_POSIX` directive must be set before the occurrence of the first `#include` directive in the program. The easiest way to do this is by means of a definition at the time of compilation.

#### **DEFINE = \*SUBSTITUTE(...)**

This substructure is used to define macros and symbolic constants (analogous to a `#define` directive for replacing text). See also the example below.

#### **IDENTIFIER = <c-string 1..125 with-low> / <name 1..125 with-under>**

<c-string> / <name> designates the name to be replaced in the source program by the value or text specified with `TOKEN-STRING`.

---

**TOKEN-STRING = <c-string 1..125 with-low> / <name 1..125 with-under>**

<c-string> / <name> specifies the value or text to be substituted in the source program for the name indicated by IDENTIFIER.

*Note*

If data in the DEFINE option is inconsistent with any #define directives in the source program, the entries in the source program will always be given precedence!

*Example: DEFINE option*

```
MODIFY-SOURCE-PROP DEFINE=( 'mch_file',DEBUG,_OSD_POSIX,*SUB('host',BS2000),*SUB(LAN,'C++'))
```

Values set with DEFINE must be enclosed in single quotes if they contain characters other than uppercase A to Z, the digits 0 to 9, or the special characters \$, #, @, and \_ (see also the table on "[SDF notational conventions \(C/C++-Compiler, #8\)](#)").

The above entries in the DEFINE option correspond to the following #define directives in the source program:

```
#define mch_file 1
#define DEBUG 1
#define _OSD_POSIX 1
#define host BS2000
#define LAN C++
```

**UNDEFINE = \*NONE**

The DEFINE entries (see above) remain unmodified by default.

**UNDEFINE = \*UNCHANGED**

The values specified in the last MODIFY-SOURCE-PROPERTIES statement apply.

**UNDEFINE = \*ALL**

All DEFINE entries are deleted.

**UNDEFINE = <c-string 1..125 with-low> / <name 1..125 with-under>**

The names specified with DEFINE <c-string> / <name> are deleted.

**ASSERT = \*NONE / \*UNCHANGED / list-poss: \*SUBSTITUTE(...)**

This option can be used to define an assertion, as if by a preprocessor #assert directive (see "[Extensions to ANSI /ISO C](#)").

**ASSERT= \*SUBSTITUTE(...)**

**IDENTIFIER = <c-string 1..125 with-low> / <name 1..125 with-under>**

<c-string> / <name> designates the name of the assertion.

**TOKEN-STRING = <c-string 1..125 with-low> / <name 1..125 with-under>**

<c-string> / <name> specifies the value or text to be substituted for the assertion designated by IDENTIFIER.

---

**PREINCLUDE = \*UNCHANGED / \*NONE / <c-string 1..1024 with-low>**

The pre-include option specifies an include file which is to be included at the start of the source program via an imaginary `#include` statement. The preprocessor searches for this include file in the USER-INCLUDE paths.

The include file specified via the PREINCLUDE option will be handled like an include file which is specified inside an `#include` statement at the beginning of the source program.

If several include files are to be pre-included then the corresponding `#include` statements should be collected together in a single include file and this include file should then be specified via the PREINCLUDE option.

**COMMENTS = \*UNCHANGED / \*YES / \*NO**

This option can be used to specify whether the expanded and recompilable source program created by the preprocessor may also contain comments.

**PREPROCESSING-MODE = \*UNCHANGED / \*ANSI / \*KR**

**\*UNCHANGED**

The values specified in the last MODIFY-SOURCE-PROPERTIES statement apply.

**\*ANSI**

This is the default setting in all C and C++ language modes of the compiler. In other words, preprocessor behavior in accordance with the ANSI/ISO C standard is also supported in the K&R C mode by default.

**\*KR**

The obsolete preprocessor behavior based on Reiser's `cpp` and Johnson's `pcc` can be turned on with `*KR`.

**IMPLICIT-INCLUDE = \*UNCHANGED / \*YES / \*NO**

This option only affects C++ templates. It determines whether or not the definition of a template is included implicitly (see the [section "Implicit inclusion"](#)).

*Common frontend options in C and C++*

**SIGNED-CHARACTER = \*UNCHANGED / \*YES / \*NO**

**\*UNCHANGED**

The values specified in the last MODIFY-SOURCE-PROPERTIES statement apply.

**\*NO:** The data type `char` is unsigned by default.

**\*YES:** `char` is treated as a `signed char` in expressions and conversions. Note that the use of this option may result in portability problems!

**AT-ALLOWED = \*UNCHANGED / \*YES / \*NO**

Determines whether the "at" sign '@' is allowed (`*YES`) or not allowed (`*NO`) in names.

**i** The Cfront-C++ library contains declarations with the "at" sign (@) (see "[The standard C++ library \(C/C++ Compiler, #120\)](#)").

---

**DOLLAR-ALLOWED = \*UNCHANGED / \*YES / \*NO**

Determines whether the "dollar" sign '\$' is allowed (\*YES) or not allowed (\*NO) in names.

**ENUM-TYPE = \*UNCHANGED / \*VALUE-DEPENDENT / \*LONG**

This option controls the handling of `enum` data.

**\*UNCHANGED**

The values specified in the last `MODIFY-SOURCE-PROPERTIES` statement apply.

**\*VALUE-DEPENDENT:** depending on the range of values, `enum` data is represented as `char`, `short`, or `long`.

**\*LONG:** `enum` data is always treated as objects of type `long`.

**SIGNED-FIELDS = \*UNCHANGED / \*SIGNED / \*UNSIGNED****\*UNCHANGED**

The values specified in the last `MODIFY-SOURCE-PROPERTIES` statement apply.

**\*SIGNED:** By default, `signed` bit fields are treated as `signed`.

**\*UNSIGNED:** `signed` bit fields are always interpreted as `unsigned`. This option is only offered for compatibility reasons with older C versions and is only meaningful in K&R C mode.

**PLAIN-FIELDS = \*UNCHANGED / \*SIGNED / \*UNSIGNED**

This option controls whether integer bit fields (`short`, `int`, `long`) are treated as `signed` (\*SIGNED) or `unsigned` (\*UNSIGNED) types. `signed` is the default.

**PRESERVING = \*UNCHANGED / \*UNSIGNED / \*LONG**

This option controls whether arithmetic operations with operands of type `long` and `unsigned int` return a result of type `long` (\*LONG) in accordance with K&R mode (first edition; see section 6.6 in the appendix) or of type `unsigned long` (\*UNSIGNED) in accordance with ANSI/ISO C.

**ALTERNATIVE-TOKENS = \*UNCHANGED / \*YES / \*NO**

This option controls whether alternative tokens are to be recognized by the compiler. This includes:

- digraph sequences (e.g. `<: for []`) in the C and C++ modes and
- additional keywords for operators (e.g. `and` for `&&`, `bitand` for `&`), which are only valid in the C++ language mode.

\*YES is the default for the modes C11, C++ V3, C++ 2017 and C++2020.

\*NO is the default for all other modes.

**EXTERNAL-DEFINITION =**

This option controls how the compiler reserves memory for the externally visible variables of a module. This is important if the program consists of several modules that are to be subsequently linked into an object program.

**EXTERNAL-DEFINITION = \*UNCHANGED**

The values specified in the last `MODIFY-SOURCE-PROPERTIES` statement apply.

---

## **EXTERNAL-DEFINITION = \*BY-SOURCE-LANGUAGE**

The value of the EXTERNAL-DEFINITION option depends on the information in the language mode options:

```
LANGUAGE=*C(MODE=*KERNIGHAN-RITCHIE): MULTIPLY-ALLOWED
LANGUAGE=*C(MODE=*1990/*2011): UNIQUE
LANGUAGE=*CPLUSPLUS(): UNIQUE
```

## **EXTERNAL-DEFINITION = \*UNIQUE**

Externally visible variables may be defined in precisely one module only and must be declared in all other modules as `extern`. The memory space for such variables is set up in the data module of the object in which the variable has been defined. If the variable is defined in more than one module, an appropriate error message will be issued at the time of linking.

## **EXTERNAL-DEFINITION = \*MULTIPLY-ALLOWED**

This option is used for programs in which an externally visible variable is defined in more than one module, but is to be assigned to precisely one memory area. To achieve this, the variable must not be statically initialized in any definition. The compiler sets aside the memory for this variable in the COMMON area so that later, after linkage, only one memory area is assigned to the multiply defined variable.

If the variable is initialized statically in the definition, the memory area is created not in the COMMON area but in the data area. Assignment to precisely one memory area is then not possible!

This specification is not allowed in the C++ language modes.

## **LONGLONG = \*UNCHANGED / \*YES / \*NO**

This option determines whether the data type `long long` is recognized by the compiler.

### **\*UNCHANGED**

The values specified in the last MODIFY-SOURCE-PROPERTIES statement apply.

### **\*YES**

By default, the data type `long long` is recognized and the preprocessor define `_LONGLONG` is set.

### **\*NO**

The use of the data type `long long` results in an error. This setting is only allowed in strict C89 mode and strict C++ V3 mode.

## **END-OF-LINE-COMMENTS = \*UNCHANGED / \*YES / \*NO**

This option determines whether the compiler accepts C++ comments (`//...`) in C programs as well. C++ comments can only be allowed in the extended C89 mode (`MODE=*1990, STRICT=*NO`). They are not allowed in the other C modes (strict C89 and K&R) and are always valid in the C++ modes and in C11 mode.

### **\*UNCHANGED**

The values specified in the last MODIFY-SOURCE-PROPERTIES statement apply.

### **\*YES**

The compiler accepts C++ comments in extended C89 mode.

### **\*NO**

---

The compiler does not accept C++ comments in extended C89 mode (default setting).

**LITERAL-ENCODING = \*UNCHANGED / \*NATIVE / \*ASCII / \*ASCII-FULL / \*EBCDIC / \*EBCDIC-FULL**

This option determines whether the C/C++ compiler object code for EBCDIC characters and EBCDIC literal strings creates characters and literal strings in EBCDIC or ASCII format (ISO 8859-1).

In C/C++, literal strings can contain binary coded characters as octal or hexadecimal escape sequences with the following syntax:

- octal escape sequences:            \[0-7] [0-7] [0-7]
- hexadecimal escape sequences:    \x[0-9A-F] [0-9A-F]

Whether or not the C/C++ compiler escape sequences are converted into ASCII format depends on the value specified for the option LITERAL-ENCODING = ... .

**LITERAL-ENCODING = \*UNCHANGED**

The settings of the last MODIFY-SOURCE-PROPERTIES statement apply.

**LITERAL-ENCODING = \*NATIVE**

The C/C++ compiler leaves the character and literal string code in the EBCDIC format, i.e. it transfers the characters and strings into the object code without converting them.

\*NATIVE is the default setting.

**LITERAL-ENCODING = \*ASCII**

The C/C++ compiler encodes the characters and literal strings in ASCII format. Escape sequences *will not be* converted into ASCII format.

**LITERAL-ENCODING = \*ASCII-FULL**

The C/C++ compiler encodes the characters and literal strings in ASCII format. Escape sequences *will be* converted into ASCII format.

**LITERAL-ENCODING = \*EBCDIC**

The C/C++ compiler leaves the character and literal string code in the EBCDIC format, i.e. it transfers the characters and strings into the object code without converting them.

LITERAL-ENCODING=\*EBCDIC has the same effect as LITERAL-ENCODING=\*EBCDIC-FULL or LITERAL-ENCODING=\*NATIVE

**LITERAL-ENCODING = \*EBCDIC-FULL**

The C/C++ compiler leaves the character and literal string code in the EBCDIC format, it transfers the characters and strings into the object code without converting them.

LITERAL-ENCODING=\*EBCDIC-FULL has the same effect as LITERAL-ENCODING=\*EBCDIC or LITERAL-ENCODING=\*NATIVE

**Requirements:**

- If you are using ASCII notation for characters and literal strings, you must not declare C library functions explicitly in your source program. C library functions should be declared indirectly by including the corresponding CRTE headers. Otherwise the compilation error 'CFE1079[ERROR]...: Typangabe erwartet / expected a type specifier' can occur.

- 
- If you select the ASCII or ASCII\_FULL options, you should note the following. For *each and every* CRTE function (C library function) in your program that works with characters or strings, you must use the corresponding or matching include file. If you do not do this, the CRTE functions will not be able to process the character strings correctly. You should ensure that you include the include file `<stdio.h>` for the function `printf()` with `<stdio.h>`. In the CRTE runtime environment, some C library functions work with ASCII character strings.

If you are using ASCII character strings, you should specify the MODIFY-SOURCE-PROPERTIES statement as follows:

```
MODIFY-SOURCE-PROPERTIES      -
    ...
    LITERAL-ENCODING=ASCII [-FULL]  -
    ...
```

You must also specify the MODIFY-MODULE-PROPERTIES statement with the following entries:

```
MODIFY-MODULE-PROPERTIES      -
    ...
    LOWER-CASE-NAMES=*YES,      -
    SPECIAL-CHARACTERS=*KEEP,   -
    ...
```

### Caution:

C++ library functions do not support ASCII format and must therefore possibly be replaced by C functions.

*C++ specific frontend options*

### INSTANTIATION = \*UNCHANGED / \*NONE / \*AUTO / \*LOCAL / \*ALL

This option is only relevant in the language modes C++ V3, C++ 2017 and C++ 2020. It controls how templates with external linkage are instantiated. This includes function templates as well as (non-static and non-inline) functions and static variables that are members of template classes. These templates types are combined under the generic term "template entity" below.

All instantiations requested explicitly with the instantiation directive `template declaration` or with the instantiation pragma `#pragma instantiate template-entity` are always created by the compiler for each compilation unit in all instantiation modes.

The remaining template entities are instantiated as follows:

#### \*NONE

No instantiations other than those requested explicitly are created.

#### \*AUTO (default setting):

Instantiation is performed across all compilation units by means of a prelinker. This prelinker is activated with the BIND statement (see "[BIND \(C/C++-Compiler, #36\)](#)"). The principle of automatic instantiation is discussed in detail in the [section "Automatic instantiation"](#).

#### \*LOCAL:

---

Instantiations are created per compilation unit, i.e. all template entities that are used in a compilation unit are instantiated. The generated functions are given internal linkage. This mode provides a very simple mechanism for getting started with template programming. The compiler will instantiate the functions that are used in each compilation unit as local functions, and the program will link and run correctly. This method does, however, result in multiple copies of instantiated functions and is therefore not suitable for production use. Note that there may also be problems due to multiple copies of local static variables. For the same reasons, this method is also not suitable if one of the templates contains a `static` variable.

### Warning:

The `basic_string` template contains a `static` variable in order to represent an empty string. If you use the `*LOCAL` option and the type `string` from the library, this empty string is no longer recognized. Try to avoid using this combination as it can lead to serious problems.

#### \*ALL:

Instantiations are created per compilation unit, i.e. all template entities that are declared or referenced in a compilation unit are instantiated. All member functions and static variables of a template class are instantiated, regardless of whether or not they are used.

Template functions are instantiated even if they have only been declared.

#### USE-STD-NAMESPACE = \*UNCHANGED / \*YES / \*NO

This option determines the use of C++ library functions for which names have been defined in the standard `std` namespace.

\*YES is the default setting in extended C++ V3 mode. The compiler behaves as if the following lines were entered at the start of a compilation unit:

```
namespace std{  
  
using namespace std;
```

\*NO is the default setting in strict C++ V3 mode, in mode C++ 2017 and in mode C++ 2020 and the only possible behavior in Cfront C++ mode.

If `USE-STD-NAMESPACE=*NO` is set in the mode C++ V3, C++ 2017 or C++ 2020, the source program must contain the statement `using namespace std;` otherwise, the names must be qualified appropriately before the first call to a C++ library function.

#### KEYWORD-BOOL = \*UNCHANGED / \*YES / \*NO

This option can be used to define whether `bool` is recognized as a keyword.

\*YES is the default behavior in mode C++ V3 and the only allowed behavior in mode C++ 2017 and C++ 2020. In this case, the preprocessor macro `_BOOL` is defined.

\*NO is the default setting and the only possible behavior in the Cfront C++ mode.

#### KEYWORD-WCHAR = \*UNCHANGED / \*YES / \*NO

This option can be used to define whether `wchar_t` is recognized as a keyword.

\*YES is the default behavior in mode C++ V3 and the only allowed behavior in mode C++ 2017 and C++ 2020. In this case, the preprocessor macro `_WCHAR_T` is defined.

---

\*NO is the default setting and the only possible behavior in the Cfront C++ mode.

**LOOP-INIT = \*UNCHANGED / \*OLD / \*NEW**

This option defines how an initialization statement in `for` and `while` loops is to be treated.

\*OLD is the default behavior in the Cfront-C++ mode and specifies that an initialization statement has the same scope as the entire loop.

\*NEW is the default behavior in mode C++ V3 and the only allowed behavior in mode C++ 2017 and C++ 2020. It specifies the new ANSI C++-conformant scope rule, which surrounds the entire loop in its own implicitly generated scope.

**SPECIALIZATION = \*UNCHANGED / \*OLD / \*NEW**

This option is only relevant in the modes C++ V3, C++ 2017 and C++ 2020. It is used to specify whether template specializations need the new syntax `template<>`.

\*NEW is the default behavior in mode C++ V3 and the only allowed behavior in mode C++ 2017 and C++ 2020. In this case, the compiler does not define the macro `__OLD_SPECIALIZATION_SYNTAX`.

If \*OLD is specified, the compiler implicitly defines the macro `__OLD_SPECIALIZATION_SYNTAX` with the value 1.

---

### 3.2.2.20 MODIFY-TEST-PROPERTIES

Alias: SET-TEST-PROPERTIES

This statement controls whether information is generated for the AID debugger.

MODIFY-TEST-PROPERTIES
------------------------

TEST-SUPPORT= *UNCHANGED / *YES / * <u>NO</u>
---

#### **TEST-SUPPORT = \*YES**

Debugging information is generated for AID.

In order to debug without any restrictions with AID, the optimization and inline substitution of user-defined functions must be suppressed (see [MODIFY-OPTIMIZATION-PROPERTIES](#)). The compiler assumes INLINING=\*NO for all configurations. The optimization level is reset to \*LOW.

#### **TEST-SUPPORT = NO**

No debugging information is generated for AID.

However, call hierarchies can be traced back (e.g. by specifying %SDUMP %NEST after the program terminates).

### 3.2.2.21 PREPROCESS

Alias: DO-PREPROCESSING

This statement can be used to end the compilation of one or more source programs on completion of the preprocessor phase. During the preprocessing, an expanded and recompilable source program can be generated for each compilation unit.

#### PREPROCESS

```
SOURCE= *SYSDTA / list-poss: <filename 1..54>/ <posix-pathname> / *LIBRARY-ELEMENT(...)

*LIBRARY-ELEMENT(...)
| LIBRARY= <filename 1..54> / *LINK(...)
| *LINK(...)
| | LINK-NAME= <filename 1..8>
| ,ELEMENT= <composed-name 1..64 with-under>(…)
| <composed-name 1..64 with-under>(…)
| | VERSION= *HIGHEST-EXISTING / <composed-name 1..24 with-under>

,OUTPUT= *NONE / *STD-FILE / *SOURCE-LOCATION / <filename 1..54>/
<posix-pathname> / *LIBRARY-ELEMENT(...)

*LIBRARY-ELEMENT(...)
| LIBRARY= *STD-LIBRARY / *SOURCE-LIBRARY / <filename 1..54> / *LINK(...)
| *LINK(...)
| | LINK-NAME= <filename 1..8>
| ,ELEMENT= *STD-ELEMENT(...) / <composed-name 1..64 with-under>(…)
| *STD-ELEMENT(...)
| | VERSION = *UPPER-LIMIT / *INCREMENT / <composed-name 1..24 with-under>
| <composed-name 1..64 with-under>(…)
| | VERSION= *UPPER-LIMIT / *INCREMENT / <composed-name 1..24 with-under>
```

#### SOURCE =

This option specifies one or more source programs to be compiled.

A source program can be read from the system file SYSDTA, a cataloged BS2000 file, a PLAM library or a POSIX file.

Note that if the source program is entered from SYSDTA, only one source program can be read per PREPROCESS statement.

#### SOURCE = \*SYSDTA

---

Input is accepted from the system file SYSDTA. SYSDTA is assigned to the terminal in interactive mode but can be reassigned to a cataloged file or a PLAM library element with the ASSIGN-SYSDTA command (see also "[Notes on input via SYSDTA](#)").

**SOURCE = <filename 1..54>**

<filename> is the name of a cataloged BS2000 file.

**SOURCE = <posix-pathname>**

Only a file name is permitted as <posix-pathname>. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

**SOURCE = \*LIBRARY-ELEMENT(...)**

This option is used to specify a PLAM library and an element in it.

**LIBRARY = <filename 1..54>**

<filename> assigns the name of a PLAM library.

**LIBRARY = \*LINK(...)**

**LINK-NAME = <filename 1..8>**

<filename> is used to specify a link name for a PLAM library. The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

**ELEMENT = <composed-name 1..64 with-under>(...)**

<composed-name> identifies the fully-qualified name of an element from the PLAM library specified earlier. The element must be of type S.

**VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the compiler uses the element with the highest existing version.

**VERSION = <composed-name 1..24 with-under>**

The compiler uses the element with the specified version.

**OUTPUT =**

This option can be used to specify if and where the result of the preprocessor run is to be stored.

**OUTPUT = \*NONE**

No expanded and recompilable source program is generated. The result of the preprocessor run (expansions and error messages, if any) can only be checked by requesting a preprocessor listing.

**OUTPUT = \*STD-FILE**

The expanded program is written by default to a cataloged BS2000 file. The name of this file is derived from the name of the source program as follows:

Output	*SYSDTA	BS2000 file	PLAM library	POSIX file
Default name	CSTDEXP.I	file.I	lib-elem.I	file.I

If the source program is located in a PLAM library, the library and element name of the source are combined with a hyphen (lib-*elem*) and used in the default file name. The rules by which the compiler constructs default names are described in detail in the [section “Default names for output containers”](#).

**OUTPUT = \*SOURCE-LOCATION**

The output destination and name of the expanded program are derived from the location and name of the source program as follows:

<b>Source</b>	*SYSDTA	BS2000 file	PLAM library	POSIX file
<b>Output destination</b>	BS2000 file	BS2000 file	Library of source	Directory of source
<b>Default name</b>	CSTDEXP.I	file.I	elem.I (type S)	file.i (C source) file.I (C++ source)

The rules by which the compiler constructs default names are described in detail in section [“Default names for output containers”](#).

**OUTPUT = <filename 1..54>**

The expanded program is written to a cataloged BS2000 file with the specified name. This specification is invalid when compiling multiple source programs.

**OUTPUT = <posix-pathname>**

The expanded program is written to a POSIX file system.

Both a file name and a directory are permitted as <posix-pathname>. See ["Compiler I/O in the POSIX file system"](#) for a description of the term <posix-pathname>.

When a file name is specified, the expanded program is stored under this name. Specification of a file name is invalid when compiling multiple source programs with one statement.

When a directory name *dir* is specified, the expanded program for each source program is written under the default name *sourcefile.i* (C source) or *sourcefile.I* (C++ source) to the directory *dir* (see also section [“Default names for output containers”](#)).

The directories specified with <posix-pathname> must already exist.

When constructing file names, it must be noted that expanded source programs can only be meaningfully processed further in the POSIX subsystem if the name contains the suffix *.i* or *.I* or a suffix defined with the *-Y F* option of the *cc/c11/c89/CC* commands (see also the manual [“POSIX Commands of the C/C++ Compiler” \[1\]](#)).

**OUTPUT = \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the expanded program is to be stored. The elements are stored as elements of type S.

**LIBRARY = \*STD-LIBRARY**

The expanded program is written by default to the library SYS.PROG.LIB.

**LIBRARY = \*SOURCE-LIBRARY**

The expanded program is written to the PLAM library which contains the sourceprogram.

The \*SOURCE-LIBRARY specification is invalid if the source program is read from a cataloged BS2000 file, a POSIX file or via SYSDTA.

---

**LIBRARY = <filename 1..54>**

The expanded program is written to a PLAM library with the specified name.

**LIBRARY = \*LINK(...)****LINK-NAME = <filename 1..8>**

<filename> can be used to specify a valid link name for the PLAM library.

The link name must already have been assigned to the library name with the ADD-FILE-LINK command before the compiler is called.

**ELEMENT = \*STD-ELEMENT(...)**

By default, the element name of the expanded program is derived from the name of the source program as follows:

Output	*SYSDTA	BS2000 file	PLAM library	POSIX file
Default name	CSTDEXP.I	file.I	elem.I	file.I

The rules by which the compiler constructs default names are described in detail in the section [“Default names for output containers”](#).

**VERSION = \*UPPER-LIMIT**

If the element entry does not contain a version ID, the highest possible version is used by the compiler.

**VERSION = \*INCREMENT**

The element is assigned a version number that is obtained by incrementing the highest existing version number by 1, assuming that the highest existing version ID ends with a digit that can be incremented. If the version ID cannot be incremented, the compiler run is aborted with an error message.

See the COMPILE statement ([“COMPILE”](#)) for an example.

**VERSION = <composed-name 1..24 with-under>**The compiler uses the version specified.

**ELEMENT = <composed-name 1..64 with-under>(..)**<composed-name> designates the fully-qualified element name of the expanded program. This specification is invalid when compiling multiple source programs.

**VERSION = \*UPPER-LIMIT / \*INCREMENT / <composed-name 1..24 with-under>**

The version can be specified as described above for ELEMENT=\*STD-ELEMENT(..).

---

### 3.2.2.22 RESET-TO-DEFAULT

This statement resets the current option values in the corresponding MODIFY statements to the default values of the compiler, i.e., the values that take effect immediately after the START-CPLUS-COMPILER command.

RESET-TO-DEFAULT
------------------

<code>SELECT= *UNCHANGED / <u>*ALL</u> / list-poss(11): *INCLUDE / *SOURCE / *MODULE / *OPTIMIZATION / *RUNTIME / *TEST / *DIAGNOSTIC / *LISTING / *CIF / *BIND / *LIBRARY-VERSION</code>
---

#### **SELECT = \*UNCHANGED**

The value specified in the last RESET-TO-DEFAULT statement applies.

#### **SELECT = \*ALL**

The option values of all MODIFY statements are reset to the default values of the compiler.

#### **SELECT = list-poss(11): \*INCLUDE / \*SOURCE / \*MODULE / \*OPTIMIZATION / \*RUNTIME / \*TEST / \*DIAGNOSTIC / \*LISTING / \*CIF / \*BIND / \*LIBRARY-VERSION**

Only the option values of the specified MODIFY statements are reset to the default values of the compiler. For example, \*INCLUDE stands for MODIFY-INCLUDE-LIBRARIES, \*SOURCE for MODIFY-SOURCE-PROPERTIES, etc.

In addition to the options of MODIFY-BIND-PROPERTIES statement, \*BIND also resets the ACTION and OUTPUT-FORMAT options of the BIND statement to the default values of the compiler.

Information on default values of the compiler can also be obtained by means of the SHOW-DEFAULTS statement (see "[SHOW-DEFAULTS](#)"). In this manual, the default values of the compiler are underlined.

---

### 3.2.2.23 SHOW-DEFAULTS

This statement can be used to show the default values of the compiler, i.e., the values which apply to the corresponding MODIFY statements immediately after calling the START-CPLUS-COMPILER command and which remain in effect until a value is explicitly changed. These default values can also be set with the RESET-TO-DEFAULT statement.

SHOW-DEFAULTS

```
SELECT= *UNCHANGED / *ALL / list-poss(11):*INCLUDE / *SOURCE / *MODULE / *OPTIMIZATION /  
        *RUNTIME / *TEST / *DIAGNOSTIC / *LISTING / *CIF / *BIND / *LIBRARY-VERSION  
,OUTPUT= *UNCHANGED / *SYSOUT / *SYSLST
```

#### **SELECT = \*UNCHANGED**

The value specified in the last SHOW-DEFAULTS statement applies.

#### **SELECT = \*ALL**

Information on all MODIFY statements is shown.

#### **SELECT = list-poss(11): \*INCLUDE / \*SOURCE / \*MODULE / \*OPTIMIZATION / \*RUNTIME / \*TEST / \*DIAGNOSTIC / \*LISTING / \*CIF / \*BIND / \*LIBRARY-VERSION**

Information is shown only for the specified MODIFY statements.

For example, \*INCLUDE stands for MODIFY-INCLUDE-LIBRARIES, \*SOURCE for MODIFY-SOURCE-PROPERTIES, etc.

#### **OUTPUT = \*UNCHANGED / \*SYSOUT / \*SYSLST**

The information is output via SYSOUT (default setting) or SYSLST.

#### *Note*

Some options are displayed with the option value `__unset__`. These are options that can have different default values (so-called "alternative defaults"), depending on the language mode.

---

### 3.2.2.24 SHOW-PROPERTIES

This statement can be used to view the currently set option values in the selected or all MODIFY statements. In the output indirect values are replaced by real ones if possible.

```
SHOW-PROPERTIES
```

```
SELECT= *UNCHANGED / *ALL / list-poss(11): *INCLUDE / *SOURCE / *MODULE / *OPTIMIZATION /  
        *RUNTIME / *TEST / *DIAGNOSTIC / *LISTING / *CIF / *BIND / *LIBRARY-VERSION  
,OUTPUT= *UNCHANGED / *SYSOUT / *SYSLST
```

#### **SELECT = \*UNCHANGED**

The value specified in the last SHOW-PROPERTIES statement applies.

#### **SELECT = \*ALL**

Information on all MODIFY statements is shown.

**SELECT = list-poss(11): \*INCLUDE / \*SOURCE / \*MODULE / \*OPTIMIZATION / \*RUNTIME / \*TEST / \*DIAGNOSTIC / \*LISTING / \*CIF / \*BIND / \*LIBRARY-VERSION**

Information is shown only for the specified MODIFY statements.

For example, \*INCLUDE stands for MODIFY-INCLUDE-LIBRARIES, \*SOURCE for MODIFY-SOURCE-PROPERTIES, etc.

#### **OUTPUT = \*UNCHANGED / \*SYSOUT / \*SYSLST**

The information is output via SYSOUT (default setting) or SYSLST.

#### *Note*

The outputs of the SHOW-PROPERTIES and SHOW-DEFAULTS statements are virtually identical on starting the compiler and just after a RESET-TO-DEFAULT statement, except for the fact that SHOW-PROPERTIES displays the actual value (in accordance with the predefined language mode) instead of the option value \_\_unset\_\_.

---

### 3.3 Controlling the global listing generator

The global listing generator is called with the `START-CPLUS-LISTING-GENERATOR` command. The input source for the listing generator consists of CIF information, which is created by the compiler for each compilation unit and stored in PLAM library elements (type H), in cataloged BS2000 files or in POSIX files (see "[MODIFY-CIF-PROPERTIES](#)"). All listings generated by the global listing generator are written to a single output file, which may be the system file `SYSLST`, by default, or the output file specified with the `OUTPUT` option. The listing generator uses the CIF information stored for local cross-reference and project listings to create global (i.e. multi-module) crossreference and project listings. The remaining listings are generated per source file.

---

### 3.3.1 Calling the listing generator (START-CPLUS-LISTING-GENERATOR)

/START-CPLUS-LISTING-GENERATOR    Abbreviations: S-CP-L-G, CPLUS-LISTING-GENERATOR, CPLG

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

,CPU-LIMIT = \*JOB-REST / <integer 1..32767>

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

<filename> is used to assign a monitoring job variable in which the listing generator can indicate runtime errors that may occur. The status indicators and return codes used here are identical to those of the C/C++ compiler (see "[Calling the compiler \(START-CPLUS-COMPILER\)](#)").

---

### 3.3.2 Description of statements

This section provides information concerning the following topics:

- [Overview of statements and input rules](#)
- [END](#)
- [GENERATE-LISTING](#)
- [MODIFY-LISTING-PROPERTIES](#)

---

### 3.3.2.1 Overview of statements and input rules

The following statements can be used to control the global listing generator:

- The modification statement MODIFY-LISTING-PROPERTIES defines the type, layout and output destination of the listing to be generated.
- The execution statement GENERATE-LISTING defines the input sources and starts the actual generation of the listing.
- The END statement terminates the global listing generator.
- The SDF standard statements (analogous to controlling the compilers; see "[Overview of statements](#)")

The MODIFY-LISTING-PROPERTIES statement must precede the GENERATE-LISTING statement. If no MODIFY-LISTING-PROPERTIES statement is specified, no listings are generated (in accordance with the default setting). The general rules for the SDF statement interface of the compiler are also applicable to the global listing generator (see "[Basicprinciples and general input rules](#)").

---

### 3.3.2.2 END

This statement ends the listing generator run.

END

---

### 3.3.2.3 GENERATE-LISTING

Aliases: DO-LISTING-GENERATION, LIST

This statement defines the input sources for the global listing generator and starts the generation of the listing. The scope, layout and output destination of listings depend on the specifications in a preceding MODIFY-LISTING-PROPERTIES statement.

#### GENERATE-LISTING

```
CIF-FILE= list-poss: <filename 1..54> / <posix-pathname> / *LIBRARY-ELEMENT(...)  
  
*LIBRARY-ELEMENT(...)  
    | LIBRARY= *STD-LIBRARY / <filename 1..54> / *LINK(...)  
    | *LINK(...)  
    | | LINK-NAME= <filename 1..8>  
    | ,ELEMENT= <composed-name 1..64 with-under>(...)  
    | <composed-name 1..64 with-under>(...)  
    | | VERSION= *HIGHEST-EXISTING / <composed-name 1..24 with-under>
```

#### **CIF-FILE = <filename 1..54>**

<filename> specifies the name of a cataloged BS2000 file containing the CIF information.

#### **CIF-FILE = <posix-pathname>**

<posix-pathname> specifies the name of a POSIX file containing the CIF information. See "[Compiler I/O in the POSIX file system \(C/C++-Compiler, #18\)](#)" for a description of the term <posix-pathname>.

#### **CIF-FILE = \*LIBRARY-ELEMENT(...)**

This option is used to specify a PLAM library and one or more of its (type H) elements containing the CIF information.

#### **LIBRARY = \*STD-LIBRARY**

The listing generator processes CIF elements contained in the library SYS.PROG.LIB by default.

#### **LIBRARY = <filename 1..54>**

<filename> assigns the name of a PLAM library.

#### **LIBRARY = \*LINK(...)**

#### **LINK-NAME = <filename 1..8>**

<filename> is used to specify a link name for a PLAM library. The link name must be assigned to the library name by means of the ADD-FILE-LINK command before the listing generator is called.

#### **ELEMENT = <composed-name 1..64 with-under>(...)**

<composed-name> identifies the fully-qualified name of a CIF element from the PLAM library specified earlier. The element must be of type H.

---

**VERSION = \*HIGHEST-EXISTING**

If the element specification contains no version ID, the listing generator uses the element with the highest existing version.

**VERSION = <composed-name 1..24 with-under>**

The listing generator uses the element with the specified version.

### 3.3.2.4 MODIFY-LISTING-PROPERTIES

Alias: SET-LISTING-PROPERTIES

This statement can be used to select which listings are to be generated by the listing generator. It can also be used to define the layout and the output destinations for these listings. Apart from a few deviations in the OUTPUT option, the syntax of this statement is identical to the compiler statement of the same name.

#### MODIFY-LISTING-PROPERTIES

```
OPTIONS= *UNCHANGED / *YES / *NO
, SOURCE= *UNCHANGED / *NO / [*YES](...)
        *YES(...)
            | MINIMAL-MSG-WEIGHT= *NOTE / *WARNING / *ERROR /
              *FATAL
, PREPROCESSING-RESULT= *UNCHANGED / *NO / *YES
, DATA-ALLOCATION-MAP= *UNCHANGED / *NO / [*YES](...)
        *YES(...)
            | STRUCTURE-LEVEL= *UNCHANGED / *NONE / *MAX /
              <integer 0..256>
, CROSS-REFERENCE= *UNCHANGED / *NO / [*YES](...)
        *YES(...)
            | PREPROCESSING-INFO= *UNCHANGED / *YES / *NO
            | , TYPES= *UNCHANGED / *YES / *NO
            | , VARIABLES= *UNCHANGED / *YES / *NO
            | , FUNCTIONS= *UNCHANGED / *YES / *NO
            | , LABELS= *UNCHANGED / *YES / *NO
            | , TEMPLATES= *UNCHANGED / *YES / *NO
            | , ORDER= *UNCHANGED / *STD / list-poss(6):
              *PREPROCESSING-INFO / *TYPES / *VARIABLES /
            |           *FUNCTIONS / *LABELS / *TEMPLATES
, PROJECT-INFORMATION= *UNCHANGED / *YES / *NO
, ASSEMBLER-CODE= *UNCHANGED / *YES / *NO
, SUMMARY=
*UNCHANGED / *YES / *NO
```

```

OPTIONS= *UNCHANGED / *YES / *NO
,SOURCE= *UNCHANGED / *NO / [*YES](...)
    *YES(...)
        |   MINIMAL-MSG-WEIGHT= *NOTE / *WARNING / *ERROR / *FATAL
,PREPROCESSING-RESULT= *UNCHANGED / *NO / *YES
,DATA-ALLOCATION-MAP= *UNCHANGED / *NO / [*YES](...)
    *YES(...)
        |   STRUCTURE-LEVEL= *UNCHANGED / *NONE / *MAX / <integer 0..256>
,CROSS-REFERENCE= *UNCHANGED / *NO / [*YES](...)
    *YES(...)
        |   PREPROCESSING-INFO= *UNCHANGED / *YES / *NO
        |   ,TYPES= *UNCHANGED / *YES / *NO
        |   ,VARIABLES= *UNCHANGED / *YES / *NO
        |   ,FUNCTIONS= *UNCHANGED / *YES / *NO
        |   ,LABELS= *UNCHANGED / *YES / *NO
        |   ,TEMPLATES= *UNCHANGED / *YES / *NO
        |   ,ORDER=*UNCHANGED / *STD / list-poss(6): *PREPROCESSING-INFO / *TYPES /
        |       *VARIABLES / *FUNCTIONS / *LABELS / *TEMPLATES
,PROJECT-INFORMATION= *UNCHANGED / *YES / *NO
,ASSEMBLER-CODE= *UNCHANGED / *YES / *NO
,SUMMARY= *UNCHANGED / *YES / *NO
,LAYOUT= *UNCHANGED / *FOR-NORMAL-PRINT(...) / *FOR-ROTATION-PRINT(...)
    *FOR-NORMAL-PRINT(...)
        |   LINE-SIZE= *UNCHANGED / *STD / <integer 120..255>
        |   ,LINES-PER-PAGE= *UNCHANGED / *STD / <integer 11..255>
    *FOR-ROTATION-PRINT(...)
        |   LINE-SIZE= *UNCHANGED / *STD / <integer 120..255>
        |   ,LINES-PER-PAGE= *UNCHANGED / *STD / <integer 11..255>
,INCLUDE-INFORMATION= *UNCHANGED / *NONE / *ALL / *USER-INCLUDES-ONLY
,LISTING-PRAGMAS= *UNCHANGED / *IGNORED / *INTERPRETED / *SELECT(...)

```

```
*SELECT(...)
```

```
| PAGE= *UNCHANGED / *YES / *NO
```

```
| ,TITLE= *UNCHANGED / *YES / *NO
```

```
| ,SPACE= *UNCHANGED / *YES / *NO
```

```
| ,LIST= *UNCHANGED / *YES / *NO
```

```
,INITIAL-TITLE-TEXT= *UNCHANGED / *NONE / <c-string 1..256 with-low>
```

```
,OUTPUT= *UNCHANGED / *SYSLST / *SYSOUT / <filename 1..54> / <posix-pathname> /
```

```
    *LIBRARY-ELEMENT(...)
```

```
*LIBRARY-ELEMENT(...)
```

```
| LIBRARY= *STD-LIBRARY / <filename 1..54> / *LINK(...)
```

```
| *LINK(...)
```

```
| | LINK-NAME= <filename 1..8>
```

```
| ,ELEMENT= <composed-name 1..64 with-under>(...)
```

```
| <composed-name 1..64 with-under>(...)
```

```
| | VERSION= *UPPER-LIMIT / *INCREMENT / <composed-name 1..24 with-under>
```

**OPTIONS = \*UNCHANGED / \*YES / \*NO**

\*YES: The listing generator creates a listing of all default and user-defined compiler options.

**SOURCE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**SOURCE = \*NO**

No source/error listing is generated.

**SOURCE = \*YES(...)**

A source/error listing is generated.

**MINIMAL-MSG-WEIGHT = \*NOTE / \*WARNING / \*ERROR / \*FATAL**

This option can be used to specify the minimum message weight for which error messages are to be included in the source listing.

Note that the CIF information only contains the messages which were output during the compile. That was controlled with the compiler statement [MODIFY-DIAGNOSTIC-PROPERTIES](#). This suboption can only limit the number of messages output compared to the CIF information, for example from WARNING to ERROR. If MODIFY-DIAGNOSTIC-PROPERTIES for MINIMAL-MSG-WEIGHT = \*WARNING (default setting) was specified in the compilation, MODIFY-LISTING-PROPERTIES cannot achieve that notes are output.

For examples see the compiler statement [MODIFY-DIAGNOSTIC-PROPERTIES](#).

---

**i** When the value given in MAX-ERROR-NUMBER (controlled via MODIFY-DIAGNOSTIC-PROPERTIES) is reached, no further source program information will be output in the source/error listing. In this case the listing can no longer be used as a reliable guide to current error status.

**PREPROCESSING-RESULT = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**PREPROCESSING-RESULT = \*NO**

The listing generator does not create a preprocessor listing.

**PREPROCESSING-RESULT = \*YES(...)**

The listing generator creates a preprocessor listing.

**COMMENTS = \*YES / \*NO**

Comments from the source file are included in the preprocessor listing (can be suppressed with \*NO).

**DATA-ALLOCATION-MAP = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**DATA-ALLOCATION-MAP = \*NO**

The listing generator does not create a map listing.

**DATA-ALLOCATION-MAP = \*YES(...)**

The listing generator creates a preprocessor listing.

**STRUCTURE-LEVEL = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**STRUCTURE-LEVEL = \*NONE**

Structure elements are not included in the map listing.

**STRUCTURE-LEVEL = \*MAX**

Structure elements up to the maximum nesting level (256) are included in the map listing.

**STRUCTURE-LEVEL = <integer 0..256>**

Only the structure elements up to the nesting level specified by <integer> are included in the map listing. If the specified as the nesting level is 0, no structure elements are included (corresponds to STRUCTURE-LEVEL=\*NONE).

**CROSS-REFERENCE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**CROSS-REFERENCE = \*NO**

The listing generator does not create a cross-reference listing.

**CROSS-REFERENCE = \*YES(...)**

The listing generator creates a "global" cross-reference listing, i.e. a cross-reference listing for multiple modules. This listing always contains a FILETABLE section with the names of all files, libraries, and elements that are used as sources by the compiler.

---

**PREPROCESSING-INFO = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing may optionally include a list of names processed by the preprocessor.

**TYPES = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing may optionally include a list of user-defined types (typedefs, structure, union, class and enumeration types).

**VARIABLES = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing contains a list of variables (can be suppressed with \*NO).

**FUNCTIONS = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing contains a list of functions (can be suppressed with \*NO).

**LABELS = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing contains a list of labels (can be suppressed with \*NO).

**TEMPLATES = \*UNCHANGED / \*YES / \*NO**

The cross-reference listing may optionally contain a list of templates.

**ORDER = \*STD / list-poss(6): \*PREPROCESSING-INFO / \*TYPES / \*VARIABLES / \*FUNCTIONS / \*LABELS / \*TEMPLATES**

This option specifies the order in which the individual parts of the cross-reference-listing are shown.

\*STD: The default is in the order shown after list-poss above.

**PROJECT-INFORMATION = \*UNCHANGED / \*YES / \*NO**

\*YES: The listing generator creates a project listing showing a comparison of all external names originally used in the source program and the names internally generated by the compiler for the linkage editor.

**ASSEMBLER-CODE = \*UNCHANGED / \*YES / \*NO**

\*YES: The listing generator creates an object code listing.

**SUMMARY = \*UNCHANGED / \*YES / \*NO**

\*YES: The listing generator creates a listing containing statistical data on the compiler run.

**LAYOUT =**

This option can be used to define the page width (number of characters per line) and the page length (number of lines per page) for the listings.

If a line width of 120 characters is selected, all the listings will have narrower headers and footers. Text lines are wrapped only in the table listings (option, cross-reference and map listings). Overlong text lines in the source, preprocessor and object code listings may be truncated when the listings are printed.

When a BS2000 output file is specified, the first column of every line is reserved to control the line feed.

When the output is sent to a POSIX file, the appropriate POSIX control characters for line and page feeds are generated. The result is that the line length in the POSIX output file is up to 3 characters larger than the selected line width specification.

---

**LAYOUT = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**LAYOUT = \*FOR-NORMAL-PRINT(...)**

Listings in landscape format.

**LINE-SIZE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

This also applies if that specification was made at \*FOR-ROTATION-PRINT.

**LINE-SIZE = \*STD**

132 characters per line are output.

**LINE-SIZE = <integer 120..255>**

120 to 255 characters per line are output.

**LINES-PER-PAGE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

This also applies if that specification was made at \*FOR-ROTATION-PRINT.

**LINES-PER-PAGE = \*STD**

64 lines per page are output.

**LINES-PER-PAGE = <integer 11..255>**

11 to 255 lines are printed per page.

The lower limit is fixed at 11 lines so that at least the listing header and footer and one line of text can be printed.

**LAYOUT = \*FOR-ROTATION-PRINT(...)**

Listings in portrait format.

In order to print such listings, the ROTATION parameter must be specified in the PRINT-FILE command.

**LINE-SIZE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

This also applies if that specification was made at \*FOR-NORMAL-PRINT.

**LINE-SIZE = \*STD**

120 characters per line are output.

**LINE-SIZE = <integer 120..255>**

120 to 255 characters per line are output.

**LINES-PER-PAGE = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

This also applies if that specification was made at \*FOR-NORMAL-PRINT.

**LINES-PER-PAGE = \*STD**

84 lines per page are output.

---

**LINES-PER-PAGE = <integer 11..255>**

11 to 255 lines are printed per page.

The lower limit is fixed at 11 lines so that at least the listing header and footer and one line of text can be printed.

**INCLUDE-INFORMATION = \*UNCHANGED / \*ALL / \*NONE / \*USER-INCLUDES-ONLY**

This option is used to specify which header files (if any) are to be shown in the source, preprocessor and cross-reference listings. By default, only the user-defined header files are shown, not the standard headers. Note that this option can only restrict the information created on the include files at compilation, include file that are explicitly or implicitly determined using the operand of the same name in the MODIFY-CIF-PROPERTIES statement.

**LISTING-PRAGMAS =**

This option controls which existing #pragma directives (if any) in the source text are to be interpreted when creating source and preprocessor listings.

A description of the #pragma directives can be found in the section "[Pragmas to control the layout of listings](#)").

**LISTING-PRAGMAS = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**LISTING-PRAGMAS = \*INTERPRETED / \*IGNORED**

All #pragma directives are interpreted (\*INTERPRETED) or ignored (\*IGNORED).

**LISTING-PRAGMAS = \*SELECT(...)**

One or more of the following #pragma directives to control listings are interpreted (\*YES) or ignored (\*NO).

**PAGE = \*UNCHANGED / \*YES / \*NO**

Directive #pragma PAGE [*text*]:

for a page feed and optional line in the listing header

**TITLE = \*UNCHANGED / \*YES / \*NO**

Directive #pragma TITLE *text*:

for a line in the listing header

**SPACE = \*UNCHANGED / \*YES / \*NO**

Directive #pragma SPACE [*n*]:

to insert blank lines

**LIST = \*UNCHANGED / \*YES / \*NO**

Directive #pragma LIST[ING] ON or #pragma LIST[ING] OFF:

to suppress the output of source text lines

**INITIAL-TITLE-TEXT = \*UNCHANGED / \*NONE / <c-string 1..256>**

This option can be used to specify if an additional line is to appear in the header of the listing and the text that is to be entered in it. In contrast to pragmas, which only apply to source and preprocessor listings, the INITIAL-TITLE-TEXT option applies to all compiler listings. If the text is longer than the line length defined with the LINE-SIZE option (see compiler statement "[MODIFY-LISTING-PROPERTIES](#)"), it is split into multiple lines of appropriate length.

In the case of source and preprocessor listings, TITLE and PAGE pragmas (if any) override the INITIAL-TITLE-TEXT specification.

---

**OUTPUT = \*UNCHANGED**

The value specified in the last MODIFY-LISTING-PROPERTIES statement applies.

**OUTPUT = \*SYSLST**

The listings are written to the temporary system file SYSLST by default and are sent from there to the printer at the end of the task (at LOGOFF).

**OUTPUT = \*SYSOUT**

The listings are written to the system file SYSOUT, which is assigned to the terminal in interactive mode.

**OUTPUT = <filename 1..54>**

The listings are written to a cataloged BS2000 file with the specified name.

**OUTPUT = <posix-pathname>**

The listings are written to a POSIX file.

Only a file name is permitted as <posix-pathname>. See "[Compiler I/O in the POSIX file system](#)" for a description of the term <posix-pathname>.

**OUTPUT = \*LIBRARY-ELEMENT(...)**

This option specifies the PLAM library (LIBRARY=) and the element name (ELEMENT=) under which the listings are to be stored. The element is stored as element of type P.

**LIBRARY = \*STD-LIBRARY**

The listings are stored in the library SYS.PROG.LIB by default.

**LIBRARY = <filename 1..54>**

The listings are written to a PLAM library with the specified name.

**LIBRARY = \*LINK(...)****LINK-NAME = <filename 1..8>**

A link name can also be specified instead of the library name.

<filename> designates the link name of the assigned library. This link name must already have been assigned to the PLAM library (with the ADD-FILE-LINK command) before the listing generator is called.

**ELEMENT = <composed-name 1..64 with-under>(...)**

The listings are written to a PLAM library element (type P) with the specified name.

**VERSION = \*UPPER-LIMIT**

If the element entry does not contain a version ID, the highest possible version is used by the listing generator.

**VERSION = \*INCREMENT**

The element is assigned a version number that is obtained by incrementing the highest existing version number by 1, assuming that the highest existing version ID ends with a digit that can be incremented. If the version ID cannot be incremented, the generation of the listing is aborted with an error message. See the [COMPILE](#) statement for an example.

**VERSION = <composed-name 1..24 with-under>**

The element is assigned the specified version.

---

## 4 Linkage and program execution

This chapter provides information concerning the following topics:

- Linkage
  - Dynamic linking and loading with DBL
  - Linking with BINDER
  - Shareable C/C++ programs
  - Restriction on linking C++ programs
- Program execution
  - Parameter input at program start
  - Redirecting standard I/O files
  - Input of parameters for the main function
  - Definition of the main function with parameters
  - The advanced interactive debugger AID
  - Requirements for symbolic debugging

---

## 4.1 Linkage

The result produced by the C/C++ compiler on compiling a source program consists of a link-and-load module or LLM. This module already consists of machine code, but cannot be executed on the computer until all generated modules have been combined (i.e. linked) with other modules to create an executable unit.

The additionally required modules are usually modules of the runtime system, but other modules (e.g. modules of subroutines in other languages or separately compiled C/C++ program segments) can also be linked in, if required. These additional modules may include modules that were compiled by different compilers at various times.

The main function of the **linkage editor** is to select the modules required for the loadable unit from various sources (files, libraries) and link them to one another. Linkage basically means that the linkage editor supplements each module with the addresses that refer to areas external to the module (external references).

Before the unit generated during the linkage phase can be run, a **loader** must load it into memory so that the processor can access the code and execute it.

The following functional units are available in the **Binder-Loader-Starter** system of BS2000 for performing the linking and loading tasks:

- Dynamic binder loader DBL  
The dynamic binder loader DBL combines three steps into a single operation by linking modules (object modules, LLMs) into a temporary loadable unit, loading it immediately into memory and then starting it.
- Linkage editor BINDER  
BINDER links modules (object modules, LLMs) to form a logically and physically structured loadable unit. This unit is called a link-and-load module (Link and Load Module, LLM). BINDER stores an LLM as a type-L element in a PLAM library.

There are two ways of linking programs with BINDER:

1. directly, i.e. by calling BINDER with the START-BINDER command, and
2. implicitly, i.e. with the compiler statements BIND and MODIFY-BIND-PROPERTIES

The above compiler statements are not dealt with here, since they are described in detail the sections "[BIND](#)" and "[MODIFY-BIND-PROPERTIES](#)" in chapter "[Compilation](#)".

Modules generated in the compilers C modes or Cfront-C++ mode, can be linked dynamically with the DBL, statically with the BINDER and with the [BIND](#) statement of the compiler (i.e. implicitly with the BINDER).

C++ V3, C++ 2017 and C++ 2020 modules have to be linked with the [BIND](#) statement of the compiler. See also section "[Restriction on linking C++ programs](#)".

The C and C++ runtime modules needed for linking C/C++ programs are a component of the CRTE runtime system. An overview of all C/C++-specific CRTE libraries is provided in section "[Specific CRTE components required for C/C++](#)". More detailed information, with appropriate notes on linking the C++ runtime libraries, in particular, can be found in chapter "[The C++ libraries and C++ runtime system](#)".

---

### 4.1.1 Dynamic linking and loading with DBL

When the dynamic binder loader DBL is used, modules are temporarily linked into a loadable unit, which is then loaded into memory and executed, all in one operation. The generated load unit is automatically deleted after the program run.

The mode of operation of DBL is described in detail in the “Dynamic Binder Loader / Starter” manual [[13 \(Related publications \)](#)].

Since the C/C++ compiler always generates modules only in LLM format, the START-EXECUTABLE-PROGRAM always must be used when linking and loading with DBL.

With this command, object modules and LLMs can be processed. Alternative libraries to be searched (runtime libraries and possibly other libraries) are assigned with the link name BLSLIBnn (00 nn 99). This is done with the ADD-FILE-LINK command before the linkage editor is called. For example:

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01,FILE-NAME=PLAM.USER
/ADD-FILE-LINK LINK-NAME=BLSLIB02,FILE-NAME=$.SYSLNK.
CRTE
```

To ensure that DBL searches these alternative libraries, the following entry must be made in the RESOLUTION parameter of the START-EXECUTABLE-PROGRAM command:

```
..ALTERNATE-LIBRARIES=*BLSLIB##
```

The linkage run with DBL is initiated by means of the START-EXECUTABLE-PROGRAM or LOAD-EXECUTABLE-PROGRAM command.

If the START-EXECUTABLE-PROGRAM command is used, the program is executed immediately. With the LOAD-EXECUTABLE-PROGRAM command, however, you have the option of entering additional commands (e.g. debugging commands).

```
{START-EXECUTABLE-PROGRAM / LOAD-EXECUTABLE-PROGRAM}
FROM-FILE=*LIBRARY-ELEMENT(LIBRARY=bibliothek,ELEMENT-OR-SYMBOL=mainmod),
DBL-PARAMETERS=*PARAMETERS(RESOLUTION=*PARAMETERS(ALTERNATE-
LIBRARIES=*BLSLIB##))
```

LIB=*library*,ELEM=*mainmod*

DBL accesses the specified PLAM library. The name of the module containing the `main` function must be specified as the element name.

RESOLUTION=\*PARAMETERS (ALTERNATE-LIBRARIES=\*BLSLIB##)

This entry is always required when LLMs are to be linked dynamically.

#### *Load and start function of DBL*

Any LLM that has been fully linked with BINDER (i.e. with all external references resolved) can be loaded and started with DBL without assigning alternative libraries as follows:

```
START-EXECUTABLE-PROGRAM FROM-FILE=*LIBRARY-ELEMENT(*LIBRARY=library,
ELEMENT-OR-SYMBOL=module)
```

*Recommended BLSLIBnn order for assigning CRTE libraries*

## 1. C programs

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01 , FILE-NAME=user-library  
/ADD-FILE-LINK LINK-NAME=BLSLIB02 , FILE-NAME=$ .SYSLNK .CRTE
```

## 2. Cfront C++ programs

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01 , FILE-NAME=user-library  
/ADD-FILE-LINK LINK-NAME=BLSLIB02 , FILE-NAME=$ .SYSLNK .CRTE .CFCPP  
/ADD-FILE-LINK LINK-NAME=BLSLIB03 , FILE-NAME=$ .SYSLNK .CRTE .CPP  
/ADD-FILE-LINK LINK-NAME=BLSLIB04 , FILE-NAME=$ .SYSLNK .CRTE
```

## 3. C++ V3 programs (using the Tools.h++ library)

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01 , FILE-NAME=user-library  
/ADD-FILE-LINK LINK-NAME=BLSLIB02 , FILE-NAME=$ .SYSLNK .CRTE .TOOLS  
/ADD-FILE-LINK LINK-NAME=BLSLIB03 , FILE-NAME=$ .SYSLNK .CRTE .STDCPP  
/ADD-FILE-LINK LINK-NAME=BLSLIB04 , FILE-NAME=$ .SYSLNK .CRTE .RTSCPP  
/ADD-FILE-LINK LINK-NAME=BLSLIB05 , FILE-NAME=$ .SYSLNK .CRTE
```

## 4. C++ 2017 or C++ 2020 programs with library version 1

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01 , FILE-NAME= user-library  
/ADD-FILE-LINK LINK-NAME=BLSLIB02 , FILE-NAME=$ .SYSLNK .CRTE .CXX01  
/ADD-FILE-LINK LINK-NAME=BLSLIB03 , FILE-NAME=$ .SYSLNK .CRTE
```

## 5. C++ 2017 or C++ 2020 programs with library version 2

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01 , FILE-NAME= user-library  
/ADD-FILE-LINK LINK-NAME=BLSLIB02 , FILE-NAME=$ .SYSLNK .CRTE .CXX02  
/ADD-FILE-LINK LINK-NAME=BLSLIB03 , FILE-NAME=$ .SYSLNK .CRTE
```

### ! Achtung!

Templates are not instantiated when linking and loading C++ V3, C++ 2017 or C++ 2020 programs with the DBL. All instances must be pre-instantiated using the statement `BIND ACTION=*PRELINK`.

---

## 4.1.2 Linking with BINDER

BINDER enables object modules and LLMs to be linked into an LLM and stored as a type-L element in a PLAM library. BINDER is described in detail in the “BINDER” manual [14].

Note that modules generated in the language modes C++ V3, C++ 2017 or C++ 2020 cannot be linked with a direct call to BINDER. These modules can only be linked with the compiler statement `BIND` (see also section “[Restriction on linking C++ programs](#)”).

### Control statements for BINDER (selection)

#### Steueranweisungen für den BINDER (Auswahl)

```
/START-BINDER _____ (1)
//START-LLM-CREATION INT-NAME= name _____ (2)
//INCLUDE-MODULES -
// MOD-CONTAINER=*LIB(LIB= bibliothek ,ELEM={ mainmod / *ALL } _____ (3)
[//INCLUDE-MODULES MOD-CONTAINER=*LIB(LIB=... , ELEM=...)] _____ (4)
[//INCLUDE-MODULES -
// MOD-CONTAINER=*LIB(LIB=$.SYSLNK.CRTE.POSIX,ELEM=*ALL)] _____ (5)
[//RESOLVE-BY-AUTOLINK LIB=... , [SYMBOL-NAME= externverweis ]] _____ (6)
[//RESOLVE-BY-AUTOLINK LIB=
{ ([$.SYSLNK.CRTE.CFCPP,$.SYSLNK.CRTE.CPP,]$.SYSLNK.CRTE) /
{ ([$.SYSLNK.CRTE.CFCPP,$.SYSLNK.CRTE.CPP,]$.SYSLNK.CRTE.PARTIAL-BIND) ]} (7)
[//MODIFY-SYMBOL-VISIBILITY ... , VISIBLE=*NO] _____ (8)
//SAVE-LLM MOD-CONTAINER=*LIB(LIB= bibliothek , ELEM= element ) _____ (9)
//END _____ (10)
```

- (1) BINDER is invoked.
- (2) This statement generates a new LLM with the internal name *name* in the work area. The generated LLM is saved with the SAVE-LLM statement (see 9) as a type-L element in a PLAM library.
- (3) *mainmod* is the name of the LLM that contains the `main` function. *library* is the name of the PLAM library in which the object modules are stored. If \*ALL is specified, all the modules from the specified input source are linked.
- (4) Further INCLUDE-MODULE statements can be used to link in additional modules from various libraries.
- (5) The library SYSLNK.CRTE.POSIX must always be linked if POSIX library functions are used. Since this “linkage option” library must be linked with precedence before the C runtime system, the INCLUDE-MODULES statement should always be used for linkage.

---

(6) The RESOLVE-BY-AUTOLINK statements inform BINDER of the external references (=module names) and the corresponding libraries (or only the libraries) that are to be searched with the autolink mechanism for external references that are still unresolved. RESOLVE-BY-AUTOLINK statements for user-defined libraries and modules must always be specified before those for runtime libraries (see 7).

(7) The respective CRTE runtime libraries to be linked are specified in a list.

All modules of the C runtime system that are required by the program are linked in permanently with a RESOLVE on the SYSLNK.CRTE library.

The RESOLVE on the library SYSLNK.CRTE.PARTIAL-BIND links in a connection module instead of the C runtime system. All external references to the C runtime system are satisfied from this module. The C runtime system itself is loaded dynamically at runtime. The fully linked module requires far less disk storage space than when statically linking C runtime modules from the library SYSLNK.CRTE.

Furthermore, the program executes faster.

If no RESOLVE-BY-AUTOLINK statement is specified, the external references to the runtime system remain unresolved. The runtime modules are then dynamically linked and loaded at runtime (see section [“Dynamic linking and loading with DBL”](#)).

(8) The MODIFY-SYMBOL-VISIBILITY statement can be used to mask external symbols for subsequent linkage runs. The symbols remain visible by default. See also [“Masking symbols”](#).

(9) This statement stores the current LLM generated with START-LLM-CREATION as a type-L element in a PLAM library.

(10) The END statement terminates the BINDER run.

In 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 BLSLIB $nn$  (00  $nn$  99). This is done with the ADD-FILE-LINK command before BINDER is called. For example:

```
/ADD-FILE-LINK LINK-NAME=BLSLIB01 , FILE-NAME=PLAM.USER1
/ADD-FILE-LINK LINK-NAME=BLSLIB02 , FILE-NAME=PLAM.USER2
```

If all external references have been resolved, any LLM generated with BINDER can be loaded and started with DBL without assigning alternative libraries as follows:

```
START-EXECUTABLE-PROGRAM *LIBRARY-ELEMENT( LIB= library , ELEM= modul )
```

## Masking symbols

In contrast to TSOSLNK, symbols (CSECTs, ENTRYs) are not masked by default when linking with BINDER and thus remain visible for subsequent linkage runs with BINDER or DBL.

This affects dynamic linking with DBL and can, among other things, have the following consequences:

If a PLAM library contains individual modules generated by the compiler as well as LLMs with a linked-in runtime system, then external references to the runtime system will be resolved from any prelinked module and not from the runtime library when the individual modules are linked dynamically. This results in several “DUPLICATES” warnings from DBL. Due to the autolink mechanism, the library in which the individual module resides is searched first, before the runtime libraries assigned with the link name BLSLIB $nn$ .

---

To ensure that external references are always resolved from the current runtime library at link time rather than some arbitrary module,

- the individual modules and prelinked modules must be maintained in different libraries,
- or the symbols must be masked with the `MODIFY-SYMBOL-VISIBILITY` statement when linking with `BINDER`.

---

### 4.1.3 Shareable C/C++ programs

In the case of large programs, it is often advantageous to ensure that all individual program sections to be accessed concurrently by several users (or tasks) are made shareable.

The following compiler option must be specified at compilation in order to generate shareable programs:

```
//MODIFY-MODULE-PROP SHAREABLE-CODE=*YES
```

For each compilation unit, the compiler generates one LLM containing a non-shareable data CSECT and a shareable code CSECT. The code CSECT is marked with the attribute PUBLIC.

A subsequent linkage run creates a PUBLIC slice from the code CSECT and a PRIVATE slice from the data CSECT.

The PUBLIC slice is declared shareable by the system administrator with the ADD-SHARED command, and only the PRIVATE slice is subsequently loaded with the START-EXECUTABLE-PROGRAM command.

#### *Example*

```
/START-CPLUS-COMPILER
//MOD-SOURCE-PROP LANG=*C
//MOD-MODULE-PROP SHAREABLE-CODE=*YES
//COMPILE SOURCE=MODUL1.C,MODULE-OUTPUT=*LIB-ELEM(LIB=A.TEST)
//COMPILE SOURCE=MODUL2.C,MODULE-OUTPUT=*LIB-ELEM(LIB=A.TEST)
//END
/START-BINDER
//START-LLM-CREATION INT-NAME=TEST, //
    SLICE-DEFINITION=BY-ATTRIBUTE(PUBLIC=*YES)
//INCLUDE-MODULES LIB=A.TEST,ELEM=(MODUL1)
//INCLUDE-MODULES LIB=A.TEST,ELEM=(MODUL2)
//SAVE-LLM LIB=B.TEST,ELEM=TEST
//END
/ADD-FILE-LINK LINK-NAME=BLSLIB01,FILE-NAME=$.SYSLNK.CRTE
/START-EXECUTABLE-PROGRAM FROM-FILE=*LIBRARY-ELEMENT( //
    LIB=B.TEST,ELEM=TEST), /
    DBL-PAR=*PAR(RESOLUTION=*PAR(ALTERNATE-LIBRARIES=*BLSLIB##))
```

---

#### 4.1.4 Restriction on linking C++ programs

It is only when using the [BIND](#) statement of the compiler that the correct linkage of C++ V3, C++ 2017 or C++2020 program can be guaranteed. This is because, among other things, the automatic template instantiation by the prelinker is performed with the [BIND](#) statement (see also "[Template instantiation](#)").

---

## 4.2 Program execution

This section provides information concerning the following topics:

- [Parameter input at program start](#)
- [Redirecting standard I/O files](#)
- [Input of parameters for the main function](#)
- [Definition of the main function with parameters](#)
- [The advanced interactive debugger AID](#)
- [Requirements for symbolic debugging](#)

---

## 4.2.1 Parameter input at program start

By default, a C/C++ program is executed immediately as soon as it is invoked with the `START-EXECUTABLE-PROGRAM` command.

The `PARAMETER-PROMPTING` option of the `MODIFY-RUNTIME-PROPERTIES` statement (see "[MODIFY-RUNTIME-PROPERTIES](#)") can be used to control whether the standard I/O files are to be redirected before program execution and whether parameters can be passed to the `main` function.

### **PARAMETER-PROMPTING = \*NO**

By default, the program is executed immediately after it is started with the `START-EXECUTABLE-PROGRAM` command, i.e. without a preceding dialog step for the input of parameters. Only the name of the program is passed to the `main` function.

### **PARAMETER-PROMPTING = \*YES**

After it is started with the `START-EXECUTABLE-PROGRAM` command, the program issues the message:

```
CCM0001 enter options :
```

```
*
```

The `START-EXECUTABLE-PROGRAM` or `SRX` command also enables the parameters to be transferred at the same time:

```
/START-EXECUTABLE-PROGRAM...,PROGRAM-PARAMETERS='...'
```

As in the command line of the UNIX operating system, one or more parameter lines can now be used

- to redirect the standard I/O files for C (`stdin`, `stdout` and `stderr`) and C++ (`cin`, `cout`, `cerr` and `clog`; see "[Redirecting standard I/O files](#)"), and
- to pass parameters to the `main` function (see "[Input of parameters for the main function](#)").

To ensure that these parameters can be addressed in the program, the `main` function must include two formal parameters, which are usually named `argc` (argument count) and `argv` (argument vector). See "[Definition of the main function with parameters](#)".

The individual entries (for redirection and `main` parameters) must be separated in the parameter line by whitespace characters.

If one parameter line is not sufficient for the input, the line can be terminated with a backslash (`\`), and the next parameter can be entered at the start of the following line. As with the whitespace character, the backslash (`\`) is interpreted here as a delimiter between two parameters (see also "[Input of parameters for the main function](#)" for further meanings of `\`).

#### *Example*

```
*par1 par2 par3\  
*par4
```

---

## 4.2.2 Redirecting standard I/O files

At the start of program execution, the standard I/O files are assigned to the following BS2000 system files:

stdin/cin	SYSDTA
stdout/cout	SYSOUT
stderr/cerr/clog	SYSOUT

These default values can be modified in the parameter line. The dummy parameters *input* and *output* must be replaced by currently applicable values.

*<input*

The standard input (*stdin*, *cin*) is to be read in from *input*.

*>output*

The standard output (*stdout*, *cout*) is to be written to *output*.

If the file already exists, it is overwritten; if not, it is created as a new file.

*>>output*

The standard output (*stdout*, *cout*) is to be appended to *output*.

If the file does not exist, it is created as a new file.

*2>output*

The standard error output (*stderr*, *cerr*, *clog*) is to be written to *output*. If the file already exists, it is overwritten; if not, it is created as a new file.

*2>>output*

The standard error output (*stderr*, *cerr*, *clog*) is to be appended to *output*. If the file does not exist, it is created as a new file.

The following current values can be inserted for *input* or *output*.

(SYSDTA)

designates the system file SYSDTA. This specification can only be used for *input*.

(SYSOUT)

(SYSLST)

designate the system files SYSOUT and SYSLST. These entries are only valid for *output*.

*filename*

designates the name of a cataloged BS2000 file. This specification is valid for both *input* and *output*.

\*POSIX(*filename*)

*filename* designates the name of a POSIX file. This redirection specification is valid for both *input* and *output* and is only possible if the POSIX link option library is linked (see point 3 in section "[Use of POSIX library functions](#)").

Files to be used as input files must already exist.

If an output file does not exist, it is created as a new file. If it already exists, it will either be overwritten (> or 2>) or extended by the addition of new output (>> or 2>>).

---

*Note*

The redirection of standard I/O files affects all I/O functions that read from standard input or write to standard output by default, as well as all functions that use the file pointers `stdin/stdout` or the file descriptors 0/1 as arguments. No redirection takes place for I/O operations on files that were explicitly opened with the names "(SYSDTA)", "(SYSOUT)", or "(SYSTEM)".

---

### 4.2.3 Input of parameters for the main function

Input data that is in the parameter line but does not serve to redirect the standard I/O files (see ["Redirecting standard I/O files"](#)) is passed to the `main` function as parameters (i.e. actual arguments). In the program, these parameters can be processed as strings that are terminated with the null byte (`\0`).

In the explanation given below, the dummy parameters in italics must be replaced by currently applicable values:

*%pattern*

All file names that correspond to the specified pattern are passed as parameters.

*pattern* is a fully or partially qualified file name with wildcard syntax.

For compatibility reasons, further parameters can also be specified in order to control which files are selected, e.g.:

- file and catalog attributes (FCBTYPE, SHARE, etc.)
- creation and access date (CRDATE, EXDATE, etc.)

These parameters must be specified in the syntax of the ISP command FSTAT.

For example, the following specification supplies the names of all files that were created today with the suffix `.C`.

```
%*.C,cr=t
```

*other-parameters*

Other parameters are passed to the program directly. Quotes within a parameter build a string. Whitespace characters and the backslash at the end of the line are treated as delimiters between two parameters, except when they are inside a string.

A string (*'string'* or *"string"*) is delimited by a matching pair of quotes and may contain any characters, including whitespace characters. These characters are passed to the program without the delimiting quotes (`'` or `"`). If the single or double quote that is used as a delimiter appears in the string, it must be preceded by a backslash (`\`). For example: `'\quotation\'` or `"\quotation\""`.

The end-of-line character (`\n`) can also be passed to the program by terminating the line (with a backslash) within the string and entering any further characters as well as the closing quote in the continuation line. For example:

```
'Part 1\  
Part 2'
```

If characters with a special meaning when passing parameters (e.g. `%` or `>`) are to be transferred to the program, they must be preceded by a backslash. In such a case, the backslash is removed, and the character itself is transferred. This method can also be used to cancel the special meaning of the backslash. Thus, `\\` stands for a backslash without special meaning.

To enable the transfer of lowercase letters via procedure parameters, any uppercase letter that is preceded by a backslash is converted to the corresponding lowercase letter.

Effect of the backslash (summary):

*Vetter*

---

The letter is passed as a lowercase letter. This makes it possible to pass lowercase letters even in cases where the BS2000 command interpreter automatically converts lowercase into uppercase (e.g. in procedure parameters).

#### *\end-of-line*

Backslash immediately followed by end-of-line.

Outside quoted strings, the backslash is interpreted as a delimiter between two parameters. Consequently, additional parameters can be entered in continuation lines.

Within quoted strings, the end-of-line loses its special meaning and is passed to the program as an end-of-line character (`\n`).

#### *\other-character*

The backslash is removed, and the *other-character* is passed. This method can be used to cancel the special meaning of specific characters.

#### *Examples*

Input:	Passed parameters:
<code>\AB\C</code>	<code>"aBc"</code>
<code>%exp.</code>	All file names with the prefix EXP.
<code>'string with \</code> <code>newline'</code>	<code>"string with \nnewline"</code>
<code>str"ing with space"</code>	<code>"string with space"</code>

---

## 4.2.4 Definition of the main function with parameters

Two formal parameters are required in the `main` function in order to enable the program to address data that has been entered in the parameter line (see "[Input of parameters for the main function](#)"):

```
int main(int argc, char *argv[])
```

The names of the parameters (*argc*, *argv*) may be freely selected, but these are the names commonly used in the UNIX operating system.

The first parameter *argc* indicates the number of parameters that have been passed (including the program name).

The second parameter *argv* is a pointer to an array of char pointers (strings). The program name (in `argv[0]`) and all entered parameters are stored in it as strings that are terminated with the null byte (`\0`).

### *Example*

The following example outputs the program name and all entered parameters.

```
#include <stdio.h>
int main(int argc, char *argv[])
{
    int i;
    printf("Program name: %s\n", argv[0]);
    for (i=1; i<argc; ++i)
        printf("%d. parameter is: %s\n", i, argv[i]);
    return 0;
}
```

---

## 4.2.5 The advanced interactive debugger AID

C and C++ programs can be tested using the Advanced Interactive Debugger AID.

This User Guide only provides a brief description of AID. A complete description of the debugger can be found in the manual "AID, Debugging of C/C++ programs" [9].

AID offers the following features:

- It enables "symbolic" debugging, i.e. symbolic names from the source program may be specified in commands instead of hexadecimal addresses, provided LSD information is generated during compilation and passed to the loaded program.

It is not always necessary to load this information for the complete program together with that program. AID allows the LSD information to be dynamically loaded for each translation unit if the associated object modules are stored with the LSD information in a PLAM library. This means that resources can be used more efficiently:

- Program memory is freed, since LSD information needs to be loaded only when required for debugging
  - A program which is found to be error-free in the debugging session does not need to be recompiled or relinked (without LSD information) before being used.
  - If a program needs to be debugged when in productive use, the required LSD information will already be available without having to recompile and relink the program.
- It offers functions which, in particular, enable:
    - program execution to be traced and logged on a symbolic level (TRACE function)
    - program execution to be interrupted at fixed points or on the occurrence of defined events so that AID or BS2000 commands (so-called "subcommands") can be executed
    - the contents of variables to be output in a format that takes data definitions of the source program into account
    - the contents of variables to be changed
    - call hierarchies to be traced even without LSD informations (%SDUMP %NEST).
  - In addition to the diagnosis of loaded programs, it supports the analysis of memory dumps in disk files.
  - It can be used in batch mode and in interactive mode. Note, however, that the interactive dialog mode is recommended for debugging programs, since the sequence of commands need not be defined in advance but can be adapted to suit the particular situation.

The following types of symbols can be addressed in C:

- simple (scalar) types
- arrays and elements of arrays
- structures/unions and their components
- enumeration constants (enum)
- bit fields
- pointers
- functions
- labels

Note, however, that preprocessor constants and macros (#DEFINES), typedef names, enum, structure and union types (labels), and inline substituted functions cannot be referenced.

In addition, the following types of symbols can be addressed in C++:

- 
- functions and data elements within classes
  - overloaded functions and operators
  - references
  - templates
  - namespaces

Source references are used to refer to individual statement lines and block references to the start of blocks:

S' [<UNIQUE-no.> -] <line-no.> [: <rel.statement-no.>]' or

BLK = ' [<UNIQUE-no.> -] <line-no.> [: <rel.block-no.>]'

The UNIQUE number and line number also appear in the source/error listing.

---

## 4.2.6 Requirements for symbolic debugging

For debugging at symbolic level, AID enables variables to be addressed with the names defined in the source program and source references to be used to refer to individual statement lines. LSD information must be made available to AID for this purpose.

The generation and transfer of this information is controlled in each of the following steps by specifying appropriate operands in the control statements or commands:

- compiling with the C++ compiler
- linking and loading with the dynamic binder loader
- linking with BINDER
- linking with the compiler statement BIND

### Compiling with the C/C++ compiler

The generation of LSD information is controlled with the following option:

```
//MODIFY-TEST-PROPERTIES TEST-SUPPORT = *NO / *YES
```

**\*NO** \*NO is the default value, which means that the compiler does not generate LSD information. Even without LSD information, it is possible to trace the call hierarchies. In other words, %SDUMP %NEST can always be used if the program is aborted.

**\*YES** The compiler generates LSD information. However, this is only possible for non-optimized programs. If optimization happens to be set (see the [MODIFY-OPTIMIZATION-PROPERTIES](#) statement), the compiler treats the request for debugging support as the higher priority, switches the optimization level to \*LOW, and issues an appropriate message.

### Linking, loading and starting

Once the LSD information has been generated during compilation, it is possible to

- load it together with the overall program or
- dynamically load it on request for each translation unit if the associated modules are maintained in a PLAM library.

The table below shows which operands have to be specified in both cases in order to transfer LSD information:

Method of linking/loading	Loading LSD information with the overall program:	Dynamic loading of LSD information by AID (%SYMLIB):
Linking, loading and starting with DBL	LOAD-EXECUTABLE-PROGRAM ..., TEST-OPTIONS=*AID or START-EXECUTABLE-PROGRAM ..., TEST-OPTIONS=*AID	LOAD-EXECUTABLE-PROGRAM ..., [TEST-OPTIONS=*NONE] or START-EXECUTABLE-PROGRAM ..., [TEST-OPTIONS=*NONE]

Linking with BINDER	START-LLM-CREATION ..., INC-DEF=*PAR(..., TEST-SUPPORT=*YES) or INCLUDE-MODULES ..., TEST-SUPPORT=*YES	START-LLM-CREATION ..., [INC-DEF=*PAR(..., TEST-SUPPORT=*NO)] or INCLUDE-MODULES ..., [TEST-SUPPORT=*NO]
Linking with the BIND statement	MODIFY-BIND-PROP ..., TEST-SUPPORT=*YES	MODIFY-BIND-PROP ..., [TEST-SUPPORT=*NO]
Loading and starting with DBL	LOAD-EXECUTABLE-PROGRAM ..., TEST-OPTIONS=*AID or START-EXECUTABLE-PROGRAM ..., TEST-OPTIONS=*AID	LOAD-EXECUTABLE-PROGRAM ..., [TEST-OPTIONS=*NONE] or START-EXECUTABLE-PROGRAM ..., [TEST-OPTIONS=*NONE]

A program to be tested should be loaded with the LOAD-EXECUTABLE-PROGRAM command so that AID commands can be subsequently entered.

A program that is to be processed with AID only if an error occurs can be loaded and started with the START-EXECUTABLE-PROGRAM command.

*Note on linking the C runtime systems*

If the modules from the CRTE library SYSLNK.CRTE.PARTIAL-BIND are linked, and the C runtime system itself is loaded dynamically only at runtime (which reflects the default setting when linking with the BIND statement of the compiler), the following restriction applies when debugging with AID: in the case of some program errors, e.g. due to invalid parameter passing to C library functions, AID cannot display the call hierarchy fully, since the last function before the error occurred may be missing. This restriction can be eliminated by linking the C runtime system statically. The following entry is required for this purpose when linking with the BIND statement of the compiler: MODIFY-BIND-PROPERTIES STDLIB=\*STATIC.

**Name of the translation unit in the S qualification**

For LLMs, the so-called “source module name” is specified. This name is derived from the name of the source program by the C/C++ compiler as follows:

1. The <cat-id> and <user-id> name components, if present, are not used.
2. If the file or element name of the source program exceeds 32 characters, it is truncated from the right to 32 characters.

If the source module name contains periods, it must be specified in the S qualification using the n' name' notation.

*Example*

The file name of the source program is HELLO.C.

The S qualification in the %TRACE command, for example, would be:

---

`/%t 1 in s=n'hello.c'`

---

## 5 Linkage to functions and languages

The C++ compiler complies with the conventions of the program communications interface ILCS (Inter-Language Communication Services). In other words, it normally creates ILCS objects at compilation.

These objects can be linked to objects in other languages, provided such objects also comply with ILCS conventions.

A detailed description of the inter-language communication services (ILCS) and the general conventions for linkage to other languages can be found in the CRTE User Guide [\[4\]](#).

This chapter contains supplementary details with respect to special conventions that must be observed for linkage between C and C++ programs.

---

## 5.1 Linkage conventions specific to C and C++

Some of the specific conventions to be observed in C/C++ in addition to the ILCS conventions described in the CRTE User Guide are outlined below.

### Parameter passing by value

In C/C++, parameters are passed “by value” (as defined in the respective language standards). The parameter list therefore contains the values of the individual parameters. This form of parameter passing is possible only if all objects to be linked are C and C++ objects.

The internal structure of the parameter list is described in section [“Implementationdefined behavior based on the ANSI/ISO C standard”](#).

The following actions are necessary for linkage to objects in other languages:

- When a routine in some other language is called, the address of the data element to be transferred must be specified (e.g. `&par`). Technically speaking, the address of the data element is then passed “by value”.
- If a C/C++ routine is called from a routine in another language, the formal parameters in C and C++ must be declared as pointers to the data elements to be transferred, e.g. `f(T *par)`.

### Passing of floating-point numbers

The following points must be noted with respect to the passing of floating-point numbers when specifying linkage from K&R C to C89, C11 or C++ objects:

In K&R mode, `float` values are always passed as `double`. In the other modes, `float` values are only passed as `double` if no prototype declaration exists; otherwise, they are actually passed as `float` values.

In C++ mode, `float` values are always passed unconverted.

The proper transfer of floating-point numbers between K&R C and C89, C11 or C++ can only be guaranteed if floating-point parameters are declared `double` in the C89, C11 or C++ program.

### Passing function return values

In the case of a structure function, the result structure is copied to the parameter list, and a pointer to the parameter list is supplied in R1.

---

## 5.2 Linkage between C and C++

The C programming language is the foundation for C++. One of the main advantages of C++ is that libraries written in C can also be easily used.

External names, however, are handled differently in C and C++ implementations. In contrast to C, external names in C++ are coded so they can be used by BINDER.

To enable the common use of functions and data in C++ and C (or other languages), the coding of external names must therefore be suppressed. The appropriate language element in C++ for this purpose is as follows:

```
extern "C" declaration;
```

or

```
extern "C" {  
    declarations  
}
```

The above `extern "C"` declarations are required in the C++ program for all functions and data that are defined in C++ as well as those which are defined in C (or other languages).

When standard C library functions are called from C++ source programs, only the corresponding standard header elements (e.g. `stdio.h`) need to be specified, since they already contain the `extern "C"` declarations for all C library functions.

To provide linkage between C and C++, only C89 or C11 objects should be used.

Linkage between C++ objects and K&R C objects is also technically possible, but may create problems in some cases (different restrictions apply to function declarations; `float` parameters are passed differently, etc.).

---

## 5.2.1 Common types

In order to use data and functions in C and C++, they must have the same or comparable types. C++ contains the same set of basic data types as C; however, since C++ is a true superset of C, it also contains more types than C.

The following C++ types may be used for linkage between C++ and other languages:

- fundamental types: `char`, `short`, `int`, `long`, `long long`, `float`, `double`, `long double`, `void`
- qualifiers: `unsigned`, `const`, `volatile`
- pointers to common types
- arrays of common types (passed as pointers)
- structures and unions  
These must not contain the following components in C++: member functions, constructors, destructors, base classes, and access specifiers. The structure and union components must have common types, i.e. must be syntactically identical.
- simple enumerations
- functions with common argument and result types  
Ellipses (...) are permitted.

The following types must not be used if linkage to other languages is required:

- reference types
- pointers to members of classes, unions, or structures
- classes
- structures and unions containing member functions, constructors, destructors, base classes, or access specifiers
- enumerations with explicit type or scope: `enum E1 : int;` `enum struct E2;`
- types defined locally in a class
- member functions
- templates
- `std::nullptr_t`
- `bool`
- `_Complex`, `_Imaginary` (a C11 feature)
- variable length arrays (a C11 feature)

---

## 5.2.2 Calling C functions in C++

C functions can be used in C++ without any problems, provided each C function is declared in C++ with an `extern "C"` directive and its complete prototype.

*Example:*

C source:

```
/* file = C_file.c */
int error_level;
void error(int number, char *text)
{
    printf("Error %d, Reason: %s\n", number, text);
}
```

C++ source:

```
// file = C++_file.C
extern "C" int error_level;
extern "C" void error(int, char *);
int main(void)
{
    error_level = 100;
    error(error_level, "TEST");
    return 0;
}
```

The C++ source contains `extern "C"` declarations for all the C identifiers used in it.

---

## 5.2.3 Calling C++ functions in C

C++ functions can be used in C only if they have a type that can also be represented in C.

Depending on whether or not the C++ source is available, there are different ways to achieve linkage between functions.

If the C++ source code is available, the C++ function can be declared there with an `extern "C"` directive; however, it must be declared with `extern "C"` in every C++ source fragment that calls the function!

In the calling C source code, a "plain" `extern` declaration is required for the C++ function.

If the C++ source is not available or a general new declaration and recompilation is too cumbersome, an additional function level can be inserted. This is done by writing a so-called "wrapper" function in C++ and defining it as `extern "C"`. The wrapper function can then be called in C without restrictions.

### *Example*

C++ function to be called:

```
int hidden(int i)
{
    // ...
}
```

Wrapper function:

```
extern int hidden(int);
extern "C" int wrapper(int i)
{
    return hidden(i);
}
```

C source fragment that calls the wrapper function:

```
extern int wrapper(int);
int main(void)
{
    printf("%d\n", wrapper(100));
    return 0;
}
```

This technique can also be used if a C++ function contains a parameter with a type that does not directly match a C type. In the case of a C++ function with a reference type parameter, for example, a wrapper function with a parameter of type pointer could be written and called instead.

---

## 5.2.4 Problems and restrictions

The combined usage of C and C++ in a program system is subject to the following restrictions:

- Free store management

The `new` and `delete` operators in C++ provide a separate facility for free store management. Storage space management in C, by contrast, is achieved by the functions `malloc` and `free`. These two methods must not be combined.

The effect of using `delete` to free storage that was requested with `malloc` (or using `free` on storage that was requested with `new`) is undefined.

- Standard I/O files

C++ offers a new interface for file processing. The C++ standard files `cin`, `cout`, `cerr` and `clog` correspond to the standard I/O files `stdin`, `stdout` and `stderr` in C.

Note that if the corresponding standard files are used in both C and C++, the behavior of the program cannot be guaranteed.

If the standard I/O files for C and C++ are to be used in combination in the same C++ program, the C++ function `ios::sync_with_stdio()` must be called (see the manual “C++ Library Functions” [5]).

---

## 5.3 Linkage between different C++ variants

The [C++ language modes](#) supported by the compiler fall into 3 groups:

- C++ V2 (Cfront C++)
- C++ V3
- C++ 2017, C++ 2020

Modules within a group can be linked together without any problems.

Modules from two different groups cannot be combined. If a function is defined in a module of one group and called in a module of another group, these functions are not linked to each other when binding. An open reference is created.

The modern C++ library for the language modes C++ 2017 and C++ 2020 is delivered in two versions. These versions are not compatible and are implemented in two different namespaces. A program can use only one version, a version mix is not possible.

---

## 5.4 Notes on linkage to ILCS programs in other languages

### Linkage to C++

In C++, external names are encoded for the link editor (BINDER).

If a combination of functions and data in C++ and some other ILCS language is being used, the encoding of external names must be suppressed. The C++ language construct for this purpose is:

```
extern "C" declaration;
```

or

```
extern "C" {  
    declarations  
}
```

Note that `extern "C"` declarations are needed in the C++ program not only for the data and functions defined in C++, but also for those defined in the other ILCS language.

### Shared file processing

Shared files must be opened both in the C/C++ section and in the other language section. Control over their processing is implemented internally via different FCBs.

Since processing of a shared file is accomplished using different FCBs, alternate reading of the file into the C section and the other language section is not possible. All characters of the file are supplied both to the C section and to the other language section.

### Calling the main function

Calling a `main` function is possible. `MAIN` must be then used as the entry address.

If there are several modules with `main` functions in a library, the desired `main` function can be selected by explicitly linking in the appropriate module (by using an `INCLUDE` statement instead of `RESOLVE`).

It is not possible to redirect the standard I/O files or pass parameters to the `main` function.

### Shared STXIT event handling

ILCS distinguishes between implicit language-specific event handling and event handling that can be enabled and disabled explicitly.

Implicit language-specific event handling is restricted to the STXIT events `ERROR` and `PROCHK`, while explicit enabling and disabling is possible for all STXIT events.

STXIT routines explicitly enabled by routines in different languages are managed in parallel, i.e. when an event occurs, the enabled routines of all languages involved are called (in the order in which they were enabled).

Implicit event handling is rendered ineffective by an explicitly enabled routine.

---

C/C++ has no implicit language-specific event handling. Explicit enabling and disabling is possible using the C library functions `signal` and `cstxist`.

Enabling event handling routines for the STXIT event classes ERROR and PROCHK causes implicit event handling by other languages to be deactivated. On exiting from the C/C++ language environment, the event handling routines for ERROR and PROCHK should therefore be explicitly disabled in order to reactivate implicit event handling by other languages.

With the C library function `signal`, the routines are disabled by assigning SIG\_DFL.

---

## 6 C language support of the compiler

The compiler supports the C language scope as defined by Kernighan & Ritchie as well as the ANSI/ISO standard.

The Kernighan & Ritchie definition is documented in:

“The C Programming Language” by B.W. Kernighan and D.M. Ritchie, First Edition, Prentice Hall, 1978

The ANSI/ISO definition is documented in:

„International Standard ISO/IEC 9899 : 1990, Programming languages - C“

„International Standard ISO/IEC 9899 : 1990, Programming languages - C /Amendment 1 : 1994“

„International Standard ISO/IEC 9899 : 2011, Programming languages - C“

The following sections, which are intended as a supplement to the vendor-independent literature listed above, describe the implementation and machine-specific characteristics of this compiler and the various extensions to the standard C language definitions above.

Section [Overview of the C language modes](#) compares the C language modes of the compiler and points out the most important differences between them.

Section [Implementation-defined behavior based on the ANSI/ISO C standard](#) describes implementation-defined behavior based on the ANSI/ISO standard.

Section [Extensions to ANSI/ISO C](#) describes the C language extensions to the definition in the ANSI/ISO standard.

Section [Pragmas](#) describes the `#pragma` directives supported by this compiler.

---

## 6.1 Overview of the C language modes

In accordance with the different language standards defined for C, the compiler supports five C compilation modes:

*K&R C mode (POSIX option -X kr, SDF option MODE=KERNIGHAN-RITCHIE)*

The compiler accepts C code based on the language definition by Kernighan & Ritchie as well as some ANSI-specific extensions.

*Extended C89 mode (POSIX option -X 1990 -X nostrict, SDF option MODE=1990, STRICT=NO)*

The compiler accepts C code based on the ANSI C89 definition resp. the ISO C standard from 1990 (including ISO C Amendments 1) in extended mode.

*Strict C89 mode (POSIX option -X 1990 -X strict, SDF option MODE=1990, STRICT=YES)*

The compiler accepts C code based on the ANSI C89 definition resp. the ISO C standard from 1990 (including ISO C Amendments 1) in strict mode.

*Extended C11 mode (POSIX option -X 2011 -X nostrict, SDF option MODE=2011, STRICT=NO)*

The compiler accepts C code based on the ISO C standard from 2011 in extended mode.

*Strict C11 mode (POSIX option -X 2011 -X strict, SDF option MODE=2011, STRICT=YES)*

The compiler accepts C code based on the ISO C standard from 2011 in strict mode.

The following table contains an overview of the language elements defined in the ANSI/ISO C standard and indicates which of those elements are supported in the language modes modes.

Key to the entries in the table:

- X Fully supported in strict and extended language mode
- o Supported syntactically, but not semantically
- Not supported

## Lexical elements

C language elements	Language definition			Compilation mode		
	C11	C89	K&R	C11	C89	K&R
Multibyte characters	X	X	-	X	X	X
Trigraph sequences ??= # ??( [ ??/ \ ??) ] ??' ^ ??< { ??!   ??> } ??- ~	X	X	-	X	X	X
Digraph sequences <sup>1)</sup> <: [ :> ] <% { %> } %: # %:%: ##	X	X	-	X	X	X
Escape sequences						
\a	X	X	-	X	X	-
\b	X	X	X	X	X	X
\e, \E	-	-	-	X	X	X
\f	X	X	X	X	X	X
\n	X	X	X	X	X	X
\r	X	X	X	X	X	X
\t	X	X	X	X	X	X
\v	X	X	-	X	X	X
\'	X	X	X	X	X	X
\"	X	X	-	X	X	X
\?	X	X	-	X	X	X

\\	X	X	X	X	X	X
\ <i>octdigits</i>	X	X	X	X	X	X
\u <i>decdigits</i> \U <i>decdigits</i>	X	-	-	X	-	-
\x <i>hexdigits</i>	X	X	-	X	X	X
Lengths of identifiers						
internal	63	31	8	all characters are significant		
external	31	6	<8	30/32/32K <sup>2)</sup>		
Keywords <sup>3)</sup>						
Constants						
integer	X	X	X	X	X	X
float	X	X	X	X	X	X
character	X	X	X	X	X	X
L'character'	X	X	-	X	X	X
u'character'	X	-	-	X	-	-
U'character'						
string	X	X	X	X	X	X
L"string"	X	X	-	X	X	X
u"string"	X	-	-	X	-	-
U"string"						
enum	X	X	X	X	X	X
Suffixes						
integer L, l	X	X	X	X	X	X
integer U, u	X	X	-	X	X	X
integer LL, ll	X	-	-	X	X	X
float F, f	X	X	-	X	X	X
float L, l	X	X	-	X	X	X

Lexical elements

## Notes

## 1) Digraph sequences

Digraph sequences are defined in the ISO C Amendment 1 and are recognized in the C compilation modes only if the POSIX option `-K alternative_tokens` or the SDF option `ALTERNATIVE-TOKENS=*YES` is set. In language mode C11 they are activated by default.

## 2) Length of external names

For more information see ["Implementation-defined behavior based on the ANSI/ISO C standard"](#), sub-item "Identifiers".

## 3) Reserved keywords

asm    continue    extern    int            signed    union  
auto    default    float    long          sizeof    unsigned  
break    do            for        register    static    void  
case    double    goto    restrict    struct    volatile  
char    else        if        return    switch    while  
const    enum        inline    short        typedef

The `asm` keyword is reserved in K&R mode and in extended C mode. However, since the inline substitution of Assembler code is not yet supported, the use of this keyword will result in an error. The `asm` keyword is not reserved in the strict C mode.

The `inline` and `restrict` keywords are only defined and available in mode C11.

## Data type declarations

C language elements	Language definition			Compilation mode		
	C11	C89	K&R	C11	C89	K&R
Type specifiers						
<code>void</code> <sup>1)</sup>	X	X	-	X	X	X
<code>void *</code> <sup>1)</sup>	X	X	-	X	X	X
<code>char</code>	X	X	X	X	X	X
<code>short</code>	X	X	X	X	X	X
<code>int</code>	X	X	X	X	X	X
<code>long</code>	X	X	X	X	X	X
<code>long long</code>	X	-	-	X	X	X
<code>float</code>	X	X	X	X	X	X

double	X	X	X	X	X	X
long double	X	X	-	X	X	X
signed	X	X	-	X	X	X
unsigned	X	X	X	X	X	X
array [ ]	X	X	X	X	X	X
structure <sup>2)</sup>	X	X	X	X	X	X
union <sup>2)</sup>	X	X	X	X	X	X
(*)	X	X	X	X	X	X
enum	X	X	X	X	X	X
()	X	X	X	X	X	X
Type qualifiers						
const	X	X	-	X	X	o
volatile	X	X	-	X	X	o
Initialization						
auto aggregate	X	X	-	X	X	X
Storage classes						
typedef	X	X	X	X	X	X
extern	X	X	X	X	X	X
static	X	X	X	X	X	X
auto	X	X	X	X	X	X
register	X	X	X	X	X	X
Bitfield types						
int	X	X	X	X	X	X
signed int	X	X	X	X	X	X
_Bool	X	-	-	X	X	X
all integral	-	-	-	X	X	X

Data type declarations

## Notes

1) void

---

The type `void` signifies an empty set of values. It can be used in the following three ways:

1. Result type of functions which do not return a value.
2. A pointer to `void` points to an object of any data type.
3. The number of parameters and the data types of the parameters can be specified in a function declaration (see Prototyping). If `void` is used instead of the parameter list, then the function has no parameters.

## 2) structure, union

In accordance with ANSI C, structures and unions may be mutually assigned (if of the same type), passed to functions as parameters, and returned as exit values of functions.

These options are also supported in K&R mode.

## Conversion rules

C language elements	Language definition			Compilation mode		
	C11	C89	K&R	C11	C89	K&R
value preserving	X	X	-	X	X	-
sign preserving	-	-	X	-	-	X

Conversion rules

One important difference between ANSI and K&R lies in the area of implicit arithmetic conversions.

In K&R C, operands of an expression are converted using the “unsigned preserving” rule, i.e. extending an operand of type `unsigned char` or `unsigned short` produces a result of type `unsigned int`. If unsigned types appear in an expression together with other types, the result is always `unsigned`.

In ANSI C, by contrast, the “value-preserving” rule applies, i.e. the result type depends on the size of the operand type. Extending an operand of type `unsigned char` or `unsigned short` thus produces a result of type `int` if `int` is large enough to represent all values of the smaller type. Otherwise, the result is an `unsigned int`.

Due to this difference, the results of arithmetic expressions could differ in some cases and thus lead to different program behavior. This must be taken into account when moving from K&R C to ANSI C.

## Functions

C language elements	Language definition			Compilation mode		
	C11	C89	K&R	C11	C89	K&R
Definition "old" <sup>1)</sup>	X	X	X	X	X	X
Definition "new"	X	X	-	X	X	X
Prototyping <sup>2)</sup>	X	X	-	X	X	o
Parameter type matching <sup>3)</sup>	X	X	-	X	X	-

Functions

## Notes

## 1) Definition of functions

In contrast to K&R, ANSI has introduced a new syntax for the definition of formal function parameters, but also allows the “old-style” (K&R) syntax.

Both definition types are also supported in K&R mode.

## 2) Prototyping

In contrast to K&R, ANSI defines function prototypes. These are function declarations in which the number and types of individual parameters are also specified. This enables the compiler to compare the types of current parameters with those of formal parameters in the declaration and to adapt them to the formal parameters as required.

Prototype declarations are syntactically allowed in K&R mode, but have no semantic significance

## 3) Parameter type matching

The advantage of prototyping is that the parameters specified in the function declaration are not subject to standard conversion rules. A parameter that is declared there as `float` will also be passed as `float`, without first being converted to `double`. If K&R and ANSI objects are to be combined, floating-point parameters should always be declared `double`.

The automatic matching of parameter types is not supported in K&R mode.

## Preprocessor directives

C language elements	Language definition			Compilation mode		
	C11	C89	K&R	C11	C89	K&R
# (stringizing)	X	X	-	X	X	X
## (token pasting)	X	X	-	X	X	X
#assert / #unassert	-	-	-	X	X	X
#define	X	X	X	X	X	X
defined	X	X	-	X	X	X
#elif	X	X	-	X	X	X
#else	X	X	X	X	X	X
#endif	X	X	X	X	X	X
#error	X	X	-	X	X	X
#include	X	X	X	X	X	X
#if	X	X	X	X	X	X
#ifdef	X	X	X	X	X	X
#ifndef	X	X	X	X	X	X

#ident	-	-	-	o	o	o
#line	X	X	X	X	X	X
#line (old style)	-	-	X	X	X	X
#pragma	X	X	-	X	X	X
#pragma STDC	X	-	-	o	o	o
#undef	X	X	X	X	X	X
# (null directive)	X	X	-	X	X	X

Preprocessor directives

## Predefined macro names

C language elements	Language definition			Compilation mode		
	C11	C89	K&R	C11	C89	K&R
__LINE__	X	X	-	X	X	X
__FILE__	X	X	-	X	X	X
__DATE__	X	X	-	X	X	X
__TIME__	X	X	-	X	X	X
__STDC__	X	X	-	X	X	X
__STDC_VERSION__ <sup>1)</sup>	X	X	-	X	X	-

Predefined macro names

### Notes

1) `__STDC_VERSION__`

For more information see "[Predefined preprocessor names](#)".

---

## 6.2 Implementation-defined behavior based on the ANSI/ISO C standard

### Identifiers

In principle, both internal and external names can have any length. In the case of internal names, all characters are significant. For external names, the compiler evaluates a maximum of 32 characters by default (see the rules below). In accordance with ANSI/ISO C, the following characters are allowed when constructing names: the digits 0 to 9, the uppercase letters A to Z, the lowercase letters a to z, and the underscore `_`. Furthermore, as an extension to ANSI/ISO C, the “dollar” character `$` and the “at” sign `@` are also allowed in names by default, but this can be turned off with the appropriate options (`-K no_dollar`, `-K no_at` and `DOLLAR-ALLOWED=*NO`, `AT-ALLOWED=*NO`).

Multibyte characters are not supported in identifiers. In mode C11, however, universal character names can be used. These have the form `\u0123` or `\U01234567`. Not all sequences of digits are allowed.

The following applies to external names:

- By default, i.e. when the options `-K c_names_std` and `C-NAMES=*STD` are set, external names can have a maximum length of 32 characters. Longer names are truncated by the compiler to 32 characters. Up to 30 characters may be used when generating shared code (with the `-K share` and `SHAREABLE-CODE=*YES` options).  
If the options `-K c_names_unlimited` and `C-NAMES=*UNLIMITED` are set, no name truncation occurs. The compiler generates entry names in the EEN format. EEN names can have a maximum length of 32000 characters.
- By default, lowercase letters are converted to uppercase, and underscores (`_`) are converted to the dollar character (`$`). These conversions can be suppressed by specifying the appropriate options (`-K llm_case_lower`, `-K llm_keep` or `LOWER-CASE-NAMES=*YES`, `SPECIAL-CHARACTERS=*KEEP`) so that lowercase letters and underscores are retained in external names.
- External names must not begin with “I”.
- If the identifier contains universal character names, these are mapped as a character sequence in the external name. The backslash is replaced by a minus sign. The letter `u` or `U` and the digits are retained.

The above rules also apply to external names that are declared as `extern "C"` in C++ and also for static functions.

### main function

The compiler allows the return types `int` and `void` for the `main` function. The return type `void` always leads to a compiler message (usually a warning).

Two formal parameters are provided for the `main` function to allow arguments to be passed to a program in a call:

```
int main(int argc, char *argv[])
```

The first parameter `argc` shows the number of passed arguments. Since the first argument `argv[0]` is conventionally the program name, the number of arguments is at least 1.

The second parameter `argv` is a pointer to an array of strings. It holds the program name (in `argv[0]`) and all arguments entered in the program call in the form of strings terminated with the null byte (`\0`).

As an extension to ANSI/ISO C, it is also possible to declare a third parameter `char *envp[]` for the `main` function (see ["Extensions to ANSI/ISO C"](#)).

---

More details on passing parameters to `main` functions can be found in section [“Input of parameters for the main function”](#).

## Characters

By default, the data type `char` is treated as `unsigned` by the compiler (see also the `-K uchar`, `-K schar` and `SIGNED-CHARACTER=*NO/*YES` options).

The value of an EBCDIC character is always positive.

The value of `'\377'` (octal) or `'\xFF'` (hexadecimal) is thus 255.

If a character constant contains a numeric value that is not included in the EBCDIC character set, behavior is undefined.

The value of a character constant that contains more than one character (e.g. `'ab'`) is computed from the EBCDIC value of the character as a number to the base 256. The first (right) character is multiplied by 1, the second character by 256, the third character by  $256 * 256$ , the fourth character by  $256 * 256 * 256$ .

For example, `'abcd'` produces the value  $'a' * 256^3 + 'b' * 256^2 + 'c' * 256 + 'd'$  (= 2172814212).

The value of a multibyte character constant in the form `L'ab'` is identical to the value of a character constant in the form `'ab'` in this implementation.

If a character constant contains five or more characters, an error occurs, and no code is generated.

The assignment of `int` to `char` occurs modulo 256.

## Multibyte characters

In this implementation, multibyte characters always have a length of 1 byte, and `wchar_t` values are always 32-bit integer values.

## Pointers

A pointer is represented in 4 bytes and is aligned on a word boundary. The difference between two pointers is of type `int` (`ptrdiff_t`).

## Arrays

In C, arrays usually have fixed limits; the size of an array in such cases is already known at compile time. The VLA (variable length array) from C11 are an exception. These can only occur on block scope.

An array name in C is always treated as a pointer that points to the first element of the array.

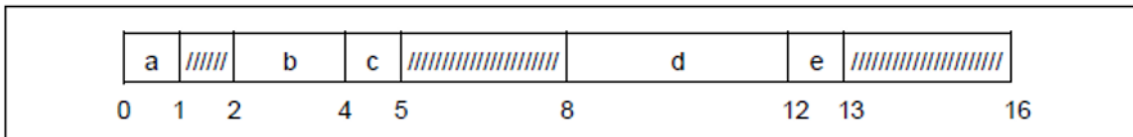
The elements are sequentially stored in memory; the first element has the index zero. In the case of multi-dimensional arrays, the elements are stored in memory in such a way that the last index is the first to vary. Like the array itself, each element is aligned in accordance with the element type.

## Structures

In structures, components occupy space in the order of their declaration. Each component is aligned in accordance with its type. The structure itself is aligned on the maximum alignment size required for a component. The size of the structure is a multiple of this alignment so that arrays can be constructed from these structures. See also [“Internal representation of data types \(alignment and representation in registers\)”](#) and the preprocessor directive `#pragma aligned` on [“aligned pragma”](#).

### Example

```
struct {
    char a;      Size: 1 byte   Alignment: byte boundary   Offset: 0 (word boundary)
    short b;     Size: 2 bytes  Alignment: half-word boundary 2
    char c;      Size: 1 byte   Alignment: byte boundary   Offset: 4
    long d;      Size: 4 bytes  Alignment: word boundary     Offset: 8
    char e;      Size: 1 byte   Alignment: byte boundary   Offset: 12
};              Size:         Alignment:      Offset:
                16 (structure end)
```



## Bitfields

Bitfields are stored from left to right in a maximum of 64 bits (double-word).

Bitfields can be defined as follows:

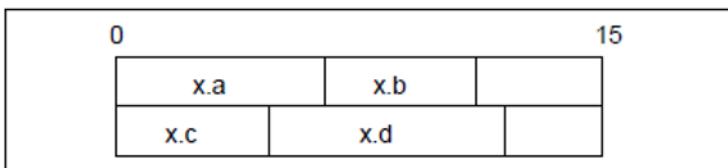
```
int          unsigned int      signed int
long         unsigned long     signed long
long long   unsigned long long signed long long
short       unsigned short     signed short
char        unsigned char      signed char
```

Bitfields without the `unsigned` or `signed` keyword are represented in accordance with the base type, i.e. `char` as unsigned and `int`, `long`, `long long` and `short` as signed. If `signed` or `unsigned` is specified explicitly, the bitfields are represented accordingly. This default behavior can be modified by means of the following options: `-K schar`, `-K signed_fields_unsigned` and `-K plain_fields_unsigned` or `SIGNED-FIELDS=*UNSIGNED`, `PLAIN-FIELDS=*UNSIGNED`, `SIGNED-CHARACTER=*YES`.

If the bitfield fits in the current byte, half-word, word or double-word, the specified number of bits are placed in it without being aligned; otherwise, the bitfield is aligned on a byte, halfword, word or double-word boundary in accordance with its base type (see example below).

### Example

```
struct
{
    unsigned short a : 7;
    unsigned short b : 5;
    unsigned short c : 5;
    unsigned short d : 8;
} x;
```



---

## Enumerations (enum)

Without an explicit value assignment, the numbers 0, 1, etc. are sequentially assigned to the constants when an enumeration type is defined. If a value is explicitly assigned to a constant, the following constants automatically receive a correspondingly higher value.

By default, an enumeration type is represented as `char`, `short` or `long`, depending on the threshold limits (highest and lowest values). Regardless of the actual storage space requirements, `enum` data can always be represented as `long` by using the `-K enum_long` or `ENUM-TYPE=*LONG` compiler options .

## Type qualifier volatile

`volatile` prevents optimization on accessing a variable. This means that instead of using the old contents, new values are always read from storage. For all assignments, including redundant ones, the appropriate value is directly written to storage. In contrast to non-`volatile` objects, which are subject to extensive optimization and are typically held in registers, the implementation guarantees that all references to `volatile` objects will always point to values in storage.

`volatile` is only accepted syntactically in K&R mode.

## size\_t

In this implementation, `size_t` corresponds to `unsigned int`.

## ptrdiff\_t

In this implementation, `ptrdiff_t` corresponds to `int`.

## Conversion of data types

- integer --> integer

When an unsigned integer value is converted to a signed integer type of the same size, the bit pattern is retained. If the value cannot be accommodated, the result corresponds to the subtraction of the largest possible number + 1 from the given size.

If a conversion of an integer value to a smaller integer type is involved, and the value cannot be accommodated, the bit pattern is retained and the higher-valued bits are truncated.

- floating-point number --> integer

When a floating-point number is converted to an integer, the number is truncated toward zero.

*Example*

`(int)(-1.5)` is -1

`(int)( 1.5)` is 1

The result is undefined if the floating-point number to be converted is too large to be represented as an integer value.

- integer --> floating-point number

The conversion of an integer to a floating-point type that cannot accept the correct value is accomplished by rounding.

- 
- floating-point number --> floating-point number

The conversion of a floating-point number to a smaller floating-point number (e.g. `double` to `float`) is accomplished by rounding.

- integer <--> pointer

When an integer is converted to a pointer, and vice versa, the bit pattern is not changed (simple reinterpretation).

## Sign of division remainder

The remainder of an integral division always has the same sign as the dividend.

*Example*

`(-5) / 2` is -2, `(-5) % 2` is -1

`5 / (-2)` is -2, `5 % (-2)` is 1

## Logical and arithmetic right shift

If the left operand is unsigned, the right shift is logical (padding of 0 bits); otherwise, arithmetic (padding of signed bits).

*Example*

`(-8) >> 1` is -4

## Bitwise operations on signed integer values

Bitwise operations (operators `~`, `<<`, `&`, `^`, and `|`) are executed as unsigned integers on interpretation; however, the result is signed.

## Declarators

Any number of declarators may be used to declare a type.

## switch statement

Any number of `case` branches may be used per `switch` statement.

## Preprocessor directives

- `#include`

`#include` directives cannot be specified with a sequence of `<name>` or "name" headers. Only the first name is accepted.

The compiler accepts `#include` directives in which the names of headers contain slashes (/) for directories even in the case of PLAM library elements. Every slash in the names of user-defined and standard headers is internally converted to a period for the search in PLAM libraries.

Consequently, in source programs which are ported out of POSIX or UNIX system, for example, the slashes need not be converted to periods.

*Example*

```
#include <sys/types.h>
```

The compiler looks for the standard header `SYS.TYPES.H` in the CRTE library `$.SYSLIB.CRTE`.

There are no restrictions with respect to the nesting of header files.

- #pragma  
See section “Pragmas”.

- \_\_DATE\_\_, \_\_TIME\_\_

If the date and time of compilation are not available, these macros are defined as follows:

\_\_DATE\_\_ "Jan 1 1970"

\_\_TIME\_\_ "01:00:00"

## Size and value ranges for elementary data types

Type	Bit	Value ranges
char	8	0 .. 255
signed char	8	-128 .. 127
short	16	-32768 .. 32767
unsigned short	16	0 .. 65535
int	32	-2147483648 .. 2147483647 ( $-2^{31} .. 2^{31}-1$ )
unsigned int	32	0 .. 4294967295 ( $0 .. 2^{32}-1$ )
long	32	same as int
unsigned long	32	same as unsigned int
long long	64	-9223372036854775808 .. 9223372036854775807 ( $-2^{63} .. 2^{63}-1$ )
unsigned long long	64	0 .. 18446744073709551615 ( $0 .. 2^{64}-1$ )
float	32	$10^{-75} .. 0.79 \cdot 10^{76}$
double	64 124	same as float
long double	124	same as float

## Internal representation of data types (alignment and representation in registers)

This section illustrates how individual C data types are internally represented in memory.

For scalar types, additional details are provided on their representation in registers. On the one hand, this defines how the variables are represented with the `register` storage class; on the other, it illustrates how the value of such a variable is interpreted in expressions.

Data type	Size	Alignment	Representation in registers
char, unsigned char, signed char	1 byte	byte boundary	right aligned

short, unsigned short	2 bytes	half-word boundary	right aligned
int, unsigned int	4 bytes	word boundary	as in memory
long, unsigned long	4 Byte	word boundary	as in memory
long long, unsigned long long	8 bytes	double-word boundary	no representation in registers
pointer	4 bytes	word boundary	as in memory
float	4 bytes	word boundary	left aligned
double	8 bytes	double-word boundary	no conversion is required for representation
long double	16 bytes	double-word boundary	represented by a pair of floating point registers

Data type	Size and alignment
Enumerations	Represented as char, short or long with corresponding alignment, depending on limits.
Arrays	Size and alignment correspond to element type.
Structures	Size and alignment for individual components based on above rules; overall alignment based on maximum alignment for components.
Bitfields	If the alignment boundary for the base type is not exceeded, the specified number of bits is created without alignment; otherwise, the bits are aligned in accordance with the base type.

## Implementation-defined limits

Most limits depend on the available system resources (e.g. on virtual memory). Only the following limits are implementation-defined:

Characteristic	Maximum value
Number of parameters in a macro definition	$2^{24}-1$
Number of arguments in a macro call	$2^{24}-1$
sizeof limit	$2^{31}$

## Storage classes

This section summarizes how storage space is assigned to variables, depending on their storage class.

*Storage class register*

---

Variables can be declared as register variables with `register`. This is a hint to the compiler that the variables are used relatively often and should therefore be held in registers. This saves the high overhead of accessing storage when reading and writing such variables. Note, however, that the optimization mechanism of the compiler may ignore such hints and implement variables as register variables in accordance with its own algorithm.

#### *Storage class auto (default)*

Storage space is reserved in an Automatic Data Area for local variables with the (predefined) storage class `auto`.

#### *Parameters in the parameter list*

Function parameters are passed in the order of their appearance in a parameter list.

All `unsigned...` parameters are represented as `unsigned`; all other integer parameters (`char`, `short`) as `int`: right-justified in one word each, aligned on a word boundary, and padded on the left with sign bits (`int`) or zeros (`unsigned...`) where necessary. Pointers occupy one word.

Depending on the language mode, floating-point numbers are passed differently.

In K&R mode, floating-point numbers (`float`, `double`) are always passed in double precision, i.e. as a double-word aligned on a double-word boundary.

In C89 or C11 mode, `float` values are passed in double precision only if no prototype declaration is present.

Otherwise, `float` values are passed in single precision, i.e. as a word aligned on a word boundary.

In C++ mode, `float` values are always passed in single precision, since prototype declarations must be present.

`long double` is passed in two double-words, aligned on a double-word boundary.

Structure parameters are aligned on a word or double-word boundary as required. The size of a structure is padded in accordance with the maximum alignment requirement for a component. For example, if a structure contains only `short` and `char` components, the size will be a multiple of 2 bytes.

Arrays cannot be passed as values. A pointer to the first array element is passed.

#### *Static variables*

The compiler reserves storage space for the following types of static variables already at the time of compilation:

- local static variables
- global static variables
- global external variables

The difference between these storage classes lies in their scope:

- Local static variables are variables that are defined with the `static` storage class specifier within a function. They are only recognized in the function in which they are defined.
- Global static variables are variables that are defined with the `static` storage class specifier outside a function. They are only recognized within a compilation unit.
- Global external variables are variables that are defined outside a function without the `static` storage class specifier. These variables can also be accessed in other compilation units, provided they are declared there with the `extern` storage class specifier.

#### *Functions without a prototype*

If a function without a prototype is called and there is parameter information present, then an error may be output in some cases. An error is output when an “old style” definition or a prototype in the K&R mode is found.

---

If the argument and the parameter are of different types (according to their customary type extensions) and one of the following arises, then an error is output:

- Parameter and argument are of different sizes
- Parameter and argument have different alignments
- The parameter is of type float, double or long double
- The argument is of type float, double or long double

The error can be downgraded to a warning. If this is done, the call made at runtime will generally fail.

---

## 6.3 Deviations from ANSI/ISO C

This section provides information concerning the following topics:

- [Extensions to ANSI/ISO C](#)
- [Restrictions to ANSI/ISO C](#)

---

### 6.3.1 Extensions to ANSI/ISO C

The extensions described below do not conform to the language features described in the ANSI/ISO standard and could thus result in potentially non-portable source programs if used.

#### Special character \$ and @ in identifiers

By default, the “dollar” symbol \$ and the “at” sign @ are permitted in internal and external names. This can be suppressed by means of options (see [“Identifiers” \(Implementation-defined behavior based on the ANSI/ISO C standard \)](#)).

#### main function with three parameters

In addition to the two parameters *argc* and *argv* (see [“Implementation-defined behavior based on the ANSI/ISO C standard \(C/C++-Compiler, #89\)”](#)), a third parameter `char *envp[ ]` may be declared, where *envp* is a pointer to an array of strings that is supplied with information on the system environment. See the manual “C Library Functions for POSIX Applications” [3 ([Related publications](#) )] for details.

#### Scope of functions

`extern` declarations of functions within blocks apply to the entire compilation unit. If multiple `extern` declarations are available for the same function, they are tested for a match.

#### Write access to string literals

In this implementation, string literals can be overwritten by default. This ensures that the literals do not overlap. Identical literals are stored in separate areas.

The `-K rostr` and `STRING-LITERALS=*READ-ONLY` options can be used to specify read-only access for string literals.

#### Conversion of function pointers

The cast operator can be used to convert pointers to objects to pointers to functions, and vice versa. In the case of implicit conversions, warnings are issued by the compiler.

#### Non-integer bitfields

All integral types can be used as bitfields (see also [“Bitfields” \(Implementation-defined behavior based on the ANSI/ISO C standard \)](#)). The standard only defines the types `int`, `unsigned int` and `signed int`.

#### The `asm` keyword

The `asm` keyword is reserved in K&R mode and in extended C mode. However, since the inline substitution of Assembler code is not yet supported, the use of this keyword will result in an error. The `asm` keyword is not reserved in the strict C mode.

#### Multiple definitions of external variables

If there are so-called “tentative” definitions for the same object (i.e. external declarations of variables without the attribute `extern` or `static`) in several compilation units, these must always be of the same type. Different type declarations for the same external object are not recognized by the compiler. Multiple initializations of external variables will result in errors on linkage. This behavior can be controlled with options (`-K external_multiple`, `-K external_unique` and `EXTERNAL-DEFINITION=*UNIQUE/*MULTIPLY-ALLOWED`).

---

## Empty macro arguments

When calling macros, it is also possible to pass empty arguments.

### Example

```
#define F(a,b)    f(a)+f(b);
F(1)             /* produces f(1)+f(); */
F(,1)           /* produces f()+f(1); */
```

## Predefined macros

For compatibility reasons, some predefined macros do not begin with the underscore (`_`) character (see the section [“Predefined preprocessor names”](#)).

## Additional preprocessor directives

The following additional preprocessor directives are accepted by the compiler: `#line` (old format), `#ident`, `#assert` and `#unassert`.

`#line` directive (old format):

---

```
# 'BLANK' digit-sequence 'BLANK' [ header-file ]
```

---

This directive is identical to the `#line` directive, except for the fact that the keyword `line` is omitted.

`#ident` directive:

---

```
#ident 'BLANK' "string"
```

---

The `#ident` directive, which is equivalent to the `#pragma ident`, is accepted syntactically, but does cause any changes in the generated object. The compiler does not issue any notes or warnings, since these directives are used internally in system headers.

`#assert` directive:

---

```
#assert 'BLANK' name [ ( token-sequence ) ]
```

---

The `#assert` directive can be used to define an assertion. Assertions are independent of macro definitions.

*name* is the name of the assertion, and *token-sequence* is the value to which the assertion applies.

A single *token* may be one of the following lexical units: name, keyword, constant, string, operator, separator /punctuation character. If no *token-sequence* is specified, the assertion is considered defined as in the case of a symbolic constant, but no value is assigned.

The `#if` statement can be used to test whether an assertion applies to a value:

```
#if #name(non-empty-token-sequence)
```

*name* is the name of the assertion, and *non-empty-token-sequence* is the value to be tested. For example, the following test for the predefined assertion `compiler` would return the value “true”:

---

```
#if #system(bs2000)
```

The predefined assertions are described in the appendix under [“Predefined preprocessor assertions \(#assert\)”](#) ([Predefined preprocessor names](#)).

`#unassert` directive:

---

```
#unassert 'BLANK' name [ ( token-sequence ) ]
```

---

The `#unassert` directive has the same syntax as `#assert` and can be used to remove any assertion.

If a *token-sequence* is specified, only the assertion for that value is removed; otherwise, i.e. if no *token-sequence* is specified, the entire assertion is deleted.

---

## 6.3.2 Restrictions to ANSI/ISO C

The following language elements are not supported by the compiler described here, or only to a limited extent.

### Alignment

The compilers offers three ways to increase an alignment: `#pragma aligned`, the keyword `_Alignas` in C11 and the keyword `alignas` in C++17. These can be used to increase the alignment for struct members only. There is no effect on variables.

### Declarations without type

In language mode C11, each declaration must have an explicit type. The type could be missing in C89, then `int` was assumed. If the type is missing, an error occurs in mode C11 that can be downgraded to a warning.

#### Example

```
% CFE1260[*ERROR]: x.c /      3: explicit type is missing ("int" assumed)
  const var1 = 7;
      ^
% CFE1077[*ERROR]: x.c /      5: this declaration has no storage class or type
specifier
  var2;
  ^
% CFE1260[*ERROR]: x.c /      7: explicit type is missing ("int" assumed)
  extern function (int a);
      ^
% CFE1260[*ERROR]: x.c /      9: explicit type is missing ("int" assumed)
  function2 (int a);
  ^
```

### Unicode

The term Unicode means a standard that specifies a binary representation for many characters in the world. The standard specifies more than 100,000 different characters. The standard defines several representations, the best known are UTF-8 and UTF-16. In these representations, most characters are represented by more than 1 byte. The C11 standard has created language elements to describe these characters in the source code: characters with `\u`, types for Unicode characters and literals in Unicode. These language resources are supported by the C/C++ 4.0 compiler.

However, it should be noted that the functions of the CRTE only support characters and strings from normal EBCDIC or ASCII. It is assumed that each character is represented in a byte. This means that the CRTE functions are not suitable for processing Unicode strings.

### Floating point format IEEE

The compiler does not support the IEC 60559 standard. The compiler allows you to store float constants in the IEEE format, however, some configuration functions are missing. The values infinity and NaN are also not supported meaningfully. Using these values can lead to strange behavior.

---

## Thread support

The C/C++ compiler does not support a specific thread package. In detail, this means that the headers `<threads.h>` and `<stdatomic.h>` are not available. The keywords `_Thread_local` and `_Atomic` lead to an error message in mode C11. The predefines `__STDC_NO_THREADS__` and `__STDC_NO_ATOMICS__` are set.

## Complex numbers

The C/C++ compiler does not support the complex numbers mentioned in the C11 standard. In detail, this means that the header `<complex.h>` is not supported. The `<complex.h>` header in the CRTE is used for complex numbers in C++, its use in C leads to an error message. The keywords `_Complex` and `_Imaginary` lead to an error message in mode C11. The predefine `__STDC_NO_COMPLEX__` is set.

## C11 Appendix K

The C11 standard, Appendix K, describes functions that fall under the term "Bounds-checking interfaces". These functions are not offered.

## C11 Appendix L

The C11 standard, Appendix L, describes functions that fall under the term "Analyzability". These functions are not offered.

---

## 6.4 Pragma

This section describes the `#pragma` directives which are defined as implementation dependent in the ANSI/ISO standard and which are accepted by the compiler:

- `aligned pragma`
- `pack pragma`
- `ETPND pragma`
- `Pragmas to control the layout of listings`
  - `LISTING pragma`
  - `PAGE pragma`
  - `SPACE pragma`
  - `TITLE pragma`
- `inline pragma`
- `int_to_unsigned pragma`
- `weak pragma`
- `ident pragma`
- `VIRTUAL_FUNCTION_TAB pragma`
- `instantiate_inline pragma`
- `instantiate_mangled_id pragma`
- `Pragmas to control template instantiation`
- `deprecated pragma`
- `STDC pragma`
- `__printf_args pragma`
- `__scanf_args pragma`

---

## 6.4.1 aligned pragma

The `aligned` pragma can be used to align data elements within classes, structures and unions on a larger number of bytes than the default minimum alignment set for the compiler.

This pragma can be used in all language modes of the compiler.

---

```
#pragma aligned n
```

---

*n* is a number of bytes, which is specified in steps to the power of 2 up to a maximum of 8, and optionally entered in decimal, octal or hexadecimal notation. The permitted values (in decimal notation) are 1, 2, 4, 8 and 16 (still permitted by the syntax).

### Notes

For the sake of simplicity, the following notes only refer to structures, but are also analogously applicable to classes and unions.

- Pragmas that specify fewer bytes than the minimum alignment intended for the corresponding data type (see table below) are not permitted and are ignored.

Data type	Minimum alignment (number of bytes)
char	1
short	2
int	4
long	4
long long	8
float	4
pointer	4
double	8
long double	8

- The data element to be aligned may also be a bitfield, in which case the bitfield is created in a new base field with the required alignment.
- In the case of `static` elements, the pragma is ignored.
- The pragma must be placed in the structure definition immediately before the data element to be aligned. Otherwise, it will be ignored.
- If multiple pragmas precede a data element, the one with the largest alignment specification is considered.
- If a pragma precedes the declaration of several structure elements, it is applied to only the first declared element.
- The alignment of a structure is based on the maximum alignment of its elements.
- If a structure appears as an element in another structure, the pragma preceding it applies to the alignment of the entire structure, and not the alignment of its elements.

- A pragma that precedes a structure element that represents an array applies to the alignment of the entire array (i.e. the first array element), and not the remaining array elements.
- Aligned pragmas and pack pragmas (see "[pack pragma](#)") can be active at the same time for a specified structure element. In this case, the aligned pragmas take precedence.

### Example

```

...
class bsp1
{
    int a;                // Aligned on 4 bytes.
#pragma aligned 8
    int b,c;              // b is aligned on 8 bytes.
                        // c is aligned on 4 bytes!
                        // The maximum alignment of an element
                        // of class bsp1 is thus equal to 8 bytes.
                        // Class bsp1 is therefore aligned on
                        // 8 bytes.
    int d;                // Aligned on 4 bytes.
};
class bsp2
{
public:
double dens;             // Aligned on 8 bytes.
#pragma aligned 4        // Is ignored. Since the maximum alignment
                        // of an element of the structure stru1 is
                        // 8 bytes, stru1 is also aligned on 8 bytes.
                        // A corresponding warning is issued.

    struct
    {
        int istru1;      // Aligned on 4 bytes.
        double dstru12; // Aligned on 8 bytes.
    } stru1;             // Aligned on 8 bytes (see above).

    struct
    {
        short s1;        // Aligned on 2 bytes.
        short s2;        // Aligned on 2 bytes.
    } stru2;             // Aligned on 2 bytes, since the maximum
                        // alignment of an element equals 2 bytes.

#pragma aligned 4
    char c;              // Aligned on 4 bytes.
    char c1;             // Aligned on 1 byte.
#pragma aligned 8
    short ar1[16];       // The array is aligned on 8 bytes,
                        // but not the individual array elements.

    ...
}
...

```

---

## 6.4.2 pack pragma

This pragma controls structure layout. The alignment of the structural elements in all structures is reduced to the number specified in the pragma. This has the effect of reducing the size of the structure. The scope of a pack pragma extends as far as the next pack pragma..

---

```
#pragma pack ([n])
```

---

*n* can be specified as a decimal, octal or hexadecimal number. The permitted values (in decimal notation) are 1, 2, 4 and 8.

Default value: 8

### **Attention!**

Using pack pragmas has the effect of increasing run time since accessing unaligned structure elements takes longer than accessing aligned structure elements.

You should note that using the address of a structure element is not without risks. Attempting to access a structure element by using its address can cause a dump.

---

### 6.4.3 ETPND pragma

This pragma can be used to create a documentation area in each module (code and data CSECT) of the generated LLM. This area contains general information on the translation unit (e.g. the version number or creation date), but no data on the function of the module. If desired, a patch area can be reserved for corrections that may be required at a later stage.

#### Format:

---

```
#pragma ETPND { CODE | DATA }
             [ ,VER= version ]
             [ ,DATE= datum ]
             [ ,COMPNR= compnr ]
             [ ,PATCH= anzahl ]
             [ ,MODULLENGTH= länge ]CODE
```

---

**CODE** The ETPND area is created in the code or data module.  
**DATA**

*version* Module version as a decimal value in the range [0..999]. If this entry is omitted, 0 is assumed.

*date* Date of creation, in the form *yyyymmdd*, *yyyy-mm-dd* or *yymmdd*.  
If the six-digit format is specified, the year must be between 1960 and 2059.  
The two missing digits for the year (19 or 20) are added as appropriate.  
The date must lie between 1.1.1905 and 1.1.2035.  
  
Overflows in months or days, if present, are converted to the canonical form. An entry of 19961335 (35.13.1996), for example, would thus correspond to 19970204 (4.2.1997).

If no creation date is specified, the compiler uses the date of compilation.

*compno* Component number as a decimal value in the range [0..99999999]. If this entry is omitted, 0 is assumed.

*number* Size of the patch area in bytes. The value must not exceed 4294967295 (0xFFFFFFFF). If this entry is omitted, an area of 200 bytes is reserved in the code module, and no area (0) is reserved in the data module.  
If PATCH=0 is specified, no patch area is reserved in the code module either. The value may be specified as a decimal, octal or hexadecimal number.

*length* Length of the module including that of the ETPND area (24+7 bytes due to alignment on a double-word boundary) in bytes; this operand can be used to terminate a module on a page boundary. The value must not exceed 4294967295 (0xFFFFFFFF). If the value specified for *length* is less than the actual length of the module; the operand will be ignored. The value may be specified as a decimal, octal or hexadecimal number.

#### Notes

- 
- An ETPND pragma cannot be used to specify values for both MODULLENGTH and PATCH at the same time. If the ETPND pragma contains both entries, MODULLENTGH is ignored.
  - Only one ETPND pragma may be specified per module (i.e. per code and data CSECT). If multiple ETPND pragmas are specified for the same module, only the last pragma specified is used.

---

#### 6.4.4 Pragmas to control the layout of listings

The layout of source, error, and preprocessor listings can be controlled from within the source text by means of `#pragma` directives. Other listings generated by the compiler cannot be controlled by pragmas.

The `-K pragmas_interpreted`, `-K pragmas_ignored` and `LISTING-PRAGMAS=...` options can be used to globally specify which of the pragmas that appear in the source text are to be interpreted or ignored.

---

### 6.4.4.1 LISTING pragma

The LISTING pragma can be used to suppress the output of source text lines.

---

```
#pragma LIST[ING] { OFF | ON }
```

---

If LIST OFF is specified, all source text lines that follow this directive are suppressed in the listing.

LIST ON cancels the effect of LIST OFF, i.e. all subsequent source text lines are shown in the listing.

Source text lines in a header file are not shown in the listing if the corresponding #include directives are enclosed within #pragma LIST OFF and #pragma LIST ON directives.

Error messages of the compiler that are related to source text lines for which output has been suppressed are inserted at the point at which the source text in question would normally appear. In such cases, the appropriate line number and the file or element name are also shown.

#### Example

Source text:

```
98     ...
99     ...                <-- Message related to line 99
100    ...
101    #pragma LIST OFF
102    #include "msg.h"
     1    ...
...                <-- Messages related to suppressed lines
     45    ...
103    #pragma LIST ON
104    ...
```

Source/Error listing::

```
98     ...
99     ...
****> CFE2234 [ERROR]      : ...
100    ...
101    #pragma LIST OFF
****> CFE1004 [NOTE]       : msg.h / 13: ...
****> CFE1386 [WARNING]   : msg.h / 37: ...
103    #pragma LIST ON
104    ...
```

---

#### 6.4.4.2 PAGE pragma

The PAGE pragma generates a page feed and can optionally be used like the TITLE pragma to define an additional line of text to be entered in the header of the listing.

---

```
#pragma PAGE[ text]
```

---

*text* Any string that is enclosed within quotes and consists of printable characters. Control characters such as \n, \t, etc. are not permitted.

The #pragma PAGE directive without *text* generates a page feed.

The directive #pragma PAGE *text* generates a page feed with the line specified by *text* appearing as an additional line in the header of the listing. All other conditions for the output of text lines are the same as those for the TITLE pragma.

---

### 6.4.4.3 SPACE pragma

The SPACE pragma can be used to generate blank lines in the listing.

---

```
#pragma SPACE[ n]
```

---

*n* is a non-negative integer. The above directive inserts *n* blank lines into the listing. *n* can be specified as a decimal, octal or hexadecimal number.

If *n* is omitted, one blank line is inserted.

---

#### 6.4.4.4 TITLE pragma

The TITLE pragma can be used to define additional text to be included in the default header generated for the listing.

---

```
#pragma TITLE text
```

---

*text* Any string that is enclosed within quotes and consists of printable characters. Control characters such as `\n`, `\t`, etc. are not permitted.

If the text to be added exceeds the maximum line length defined with the `-N output` or `LINE-SIZE=...` options, it is split into multiple lines of appropriate length.

The text in the TITLE pragma appears only as of the second page in the header of the listing and overwrites any text defined with the INITIAL-TITLE-TEXT option. The first page of the listing contains either a blank line or the text defined with the INITIAL-TITLE-TEXT option.

The defined text remains in effect until the next TITLE or PAGE pragma or until the end of the file.

Invalid characters (e.g. control characters) also result in a warning and are replaced by blanks.

If the generation of multiple additional text lines in the header of a listing makes the minimum prescribed number of 11 lines per page (see the options `-N output` and `LINES-PER-PAGE`) insufficient for the output of at least one line of source text in addition to the header and footer, the listing generator issues a warning and selects a correspondingly higher number of lines.

---

## 6.4.5 inline pragma

The inline pragma is used to specify the names of the user-defined C functions to be substituted inline by the compiler.

---

```
#pragma inline name
```

---

*name* Name of a C function to be substituted inline.

The given C functions are substituted inline only if the following options are specified:

-F *inline\_by\_source* or -F *i* in POSIX and INLINING=\*YES in SDF. The inline pragma is not supported in the C++ modes, since C++ has built-in mechanisms for inlining functions.

---

## 6.4.6 int\_to\_unsigned pragma

---

```
#pragma int_to_unsigned name
```

---

The pragma is supported because it may be contained in older C sources, typically those ported from a UNIX system. It only works in K&R mode and instructs the compiler to treat a function *name* with the result type unsigned as if its result type were still int.

The declaration of the function *name* with the result type unsigned must appear before the #pragma directive, e.g.:

```
unsigned int function(const char*);  
  
#pragma int_to_unsigned function
```

---

## 6.4.7 weak pragma

---

```
#pragma weak name
```

---

This pragma declares *name* as a global symbol with the linkage attribute “weak external reference” (WXTRN). For more information on WXTRNs, see the manual “BINDER” [14]. Symbols that are declared as `weak` may remain unresolved at linkage. This means that if a reference to *name* cannot be resolved, BINDER will only issue an information message. Weak external references are resolved only on explicit inclusion (INCLUDE-MODULES). They are not resolved when modules are included with the autolink mechanism (RESOLVE-BY-AUTOLINK). Note that external C++ names cannot be declared as `weak`.

---

## 6.4.8 ident pragma

---

```
#pragma ident "string"
```

---

This pragma is only accepted syntactically by the compiler, since it may be contained in older C sources, typically those ported from a UNIX system.

---

## 6.4.9 VIRTUAL\_FUNCTION\_TAB pragma

---

```
#pragma VIRTUAL_FUNCTION_TAB = {GLOBALLY_DEFINED | EXTERNALLY_DECLARED}
```

---

This pragma can be used to control the generation of the virtual function table in C++ mode. This table is generated implicitly if a class has at least one virtual function.

Usually the compiler determines a module which contains the definition of the table. In other modules only an external reference is generated. For this, it is checked whether the class has a virtual function that is neither inline nor a pure virtual function. The module in which the first of these functions is defined is then taken.

However, there are classes for which this heuristic fails. This pragma works for these classes:

- If the pragma is not specified, the table is created as a static variable.
- If GLOBALLY-DEFINED is specified, the table is defined as an external variable in this module.
- If EXTERNALLY-DECLARED is specified, only an external reference to the table is generated. It must then be defined in another module.

---

## 6.4.10 instantiate\_inline pragma

---

`#pragma instantiate_inline argument`

---

Extern inline functions and inline variables must be assigned to a module. The source gives no hint on which module to use. So the compiler chooses one. With this pragma the programmer can choose the module.

The external entry for the symbol will be placed in this module. For extern inline functions it will be needed when the address is taken or when the optimizer decides not to do inline expansion.

For inline variables the current module will contain the memory for the variable.

The following arguments can be specified with the pragma:

<i>Argument</i>	<i>Examples</i>
a function name	f
a member function name	A::f
a variable name	i
a static data member name	A::i
a function declaration	void f(int, char)
a member function declaration	void A::f(int, char)
a variable declaration	int i
a static data member declaration	int A::i
a class specifier	class A

When a class name is specified as an argument, the net effect is the same as if the pragma were specified for each member function and for each static data member of that class.

If a function name or member function name (e.g. A::f) is specified as a pragma argument, it must not be an overloaded function. Overloaded functions or member functions can be specified by providing the complete function declaration, as in `#pragma instantiate_inline char * A::f(int, char *)`.

The argument to an instantiation pragma may not be a compiler-generated function or a pure virtual function.

The argument may not be a template. For templates use an explicit instantiation or the `#pragma instantiate`.

This pragma is available in C/C++ version 4.0A20 or later.

---

## 6.4.11 instantiate\_mangled\_id pragma

---

```
#pragma instantiate_mangled_id external-link-name
```

---

This pragma triggers the instantiation of the named entity in the current translation unit. The entity will be named with its external link name, which is a mangled name. For an example: the template function `template <class T> void foo(T t);` instantiated with `int` could be named with `#pragma instantiate_mangled_id __1foo_tm_2_i_FZ1Z_v&_.`

The pragma can be placed anywhere in the source file. It will be evaluated at the end of the source file when all templates and their uses have been seen. In some situations, the pragma will have no effect. In this case a warning will be issued. Possible causes are:

- wrong syntax, the argument of the pragma is no valid external name
- the argument does not name a template instance (or extern inline instance)
- the instance was not used in this translation unit
- the instance cannot be generated in this translation unit (missing definition of the template or one of its arguments)

This pragma is available in C/C++ version 4.0B04 or later.

---

## 6.4.12 Pragmas to control template instantiation

---

```
#pragma { instantiate | do_not_instantiate | can_instantiate } argument
```

---

With C++ translations, the instantiation of individual templates or even a group of templates can be controlled with the following pragmas:

- The `instantiate` pragma causes the template entity that is specified as an argument to be created. This pragma can be used in all instantiation modes.
- The `do_not_instantiate` pragma suppresses the instantiation of the template entity specified as an argument. The typical candidates for this pragma are template entities for which specific definitions (specializations) have been provided. This pragma can be used in all instantiation modes.
- The `can_instantiate` pragma is a hint to the compiler that the template entity specified as an argument can, but need not, be created in the compilation unit. This pragma is required in connection with libraries and is only evaluated in automatic instantiation mode.

The following arguments can be specified with the pragmas:

<i>Argument</i>	<i>Examples</i>
a template class name	<code>A&lt;int&gt;</code>
a member function name	<code>A&lt;int&gt;::f</code>
a static data member name	<code>A&lt;int&gt;::i</code>
a member function declaration	<code>void A&lt;int&gt;::f(int, char)</code>
a template function declaration	<code>char * f(int, float)</code>

When a template class name is specified as an argument (e.g. `A<int>`), the net effect is the same as if the pragma were specified for each member function and for each static data member of that template class. When instantiating an entire class, individual member functions or static data members can be excluded from the instantiation process by using the `do_not_instantiate` pragma.

### *Example*

```
#pragma instantiate A<int>
#pragma do_not_instantiate A<int>::f
```

In order to instantiate templates, the appropriate template definitions must be available in the current compilation unit. If an instantiation is requested explicitly with the `instantiate` pragma, and no template definition or only a specific definition (specialization) is available, an error message (ERROR) is issued.

### *Example*

---

```
template <class T> void f1(T); // no body provided
template <class T> void g1(T); // no body provided
template <> void f1(int) { } // specific definition
int main()
{
    int i;
    double d;
    f1(i);
    f1(d);
    g1(i);
    g1(d);
}
#pragma instantiate void f1(int) // error - specific definition
#pragma instantiate void g1(int) // error - no body provided
```

`f1(double)` and `g1(double)` will not be instantiated either (due to the missing template definitions), but no error message will be issued during the compilation in this case. The missing template definitions will, however, result in a linker error at link time.

If a member function name (e.g. `A<int>::f`) is specified as a pragma argument, it must not be an overloaded function. Overloaded member functions can be instantiated by providing the complete member function declaration, as in

```
#pragma instantiate char * A<int>::f(int, char *)
```

The argument to an instantiation pragma may not be a compiler-generated function or a pure virtual function.

When an extern inline function or an inline variable is explicitly instantiated, it is assigned to the module containing the instantiation. The extern entry will be placed in this module.

---

### 6.4.13 deprecated pragma

---

`#pragma deprecated`

---

This pragma has to be placed before a declaration. The declared symbol will be marked as deprecated. This has the same effect as the C++ attribute `[[deprecated]]`. Usage of such a symbol will result in a warning.

---

### 6.4.14 STDC pragma

The standard C11 defines 3 pragmas. They are used to control some aspects of floating point arithmetics. The C /C++ compiler accepts these pragmas syntactically in the language modes C11, C++ 2017 and C++ 2020, but they have no effect. All compilations occur as if the following values are set:

---

```
#pragma STDC CX_LIMITED_RANGE ON
```

```
#pragma STDC FENV_ACCESS OFF
```

```
#pragma STDC FP_CONTRACT ON
```

---

---

### 6.4.15 `__printf_args` pragma

This pragma can be used for additional parameter checks. As an example:

---

```
#pragma __printf_args

void my_printf(int arg1, const char *format, ...);

void foo()
{
    my_printf(5, "falsches Argument %s\n", 42);
}
```

---

The pragma must be placed directly in front of a function declaration. This function is then assumed to be like `printf`. It has to have a variable number of arguments. The last argument before the ellipsis is assumed to be a format string. That format string has the same semantics as in the function `printf`.

When a call to that function has a string literal as format string, the remaining arguments are checked against the conversion specifiers in the format string. Any mismatch is reported with a message.

The weight of the message depends on the kind of difference. When the execution of the function call only leads to strange output, the difference is marked with a warning. An example would be a floating point number for `%d`. A note is issued when `int` is mixed with `unsigned int` or `long`.

An error is issued when the execution leads to other problems. When the size of the conversion specifier and argument is different, none of the following arguments is output correctly. An error is also issued when the format specifier expects a pointer but a number was used as argument.

The example will give an error. The conversion specifier `%s` expects a `char *`, but the argument has type `int`.

This check is also done for the CRTE functions `printf`, `fprintf`, `sprintf` and `snprintf`.

---

### 6.4.16 `__scanf_args` pragma

This pragma can be used for additional parameter checks. As an example:

---

```
#pragma __scanf_args

void my_scanf(int arg1, const char *format, ...);

void foo()
{
    int i;

    my_scanf(5, "wrong argument %d\n", i);
}
```

---

The pragma must be placed directly in front of a function declaration. This function is then assumed to be like `scanf`. It has to have a variable number of arguments. The last argument before the ellipsis is assumed to be a format string. That format string has the same semantics as in the function `scanf`.

When a call to that function has a string literal as format string, the remaining arguments are checked against the conversion specifiers in the format string. Any mismatch is reported with a message.

An error is issued when the size of the conversion specifier and argument is different. In such a case either the variable would be written only partly, or the bytes after the variable are changed. An error is also issued when the argument is not a pointer.

Other differences give a warning or note.

The example will give an error. The conversion specifier `%d` expects a `int *`, but the argument has type `int`. The call is missing an address operator `&`.

This check is also done for the CRTE functions `scanf`, `fscanf` and `sscanf`.

---

## 7 C++ language support of the compiler

The compiler optionally supports the language scope compatible with the previous version C/C++ V3.2 as well as the language defined in the C++ standards ISO/IEC 14882:2017 and ISO/IEC 14882:2020.

The previous language modes are described in detail in the 2nd and 3rd edition of “The C++ Programming Language” by Bjarne Stroustrup. The current standard can be ordered from DIN (Deutsche Institut für Normung).

The following sections describe the vendor-specific and implementation-defined language features of C++. They are intended as a supplement to the C++ language definitions given in the manuals.

## 7.1 Overview of the C++ language modes

In accordance with the different language definitions for C++, the compiler supports seven C++ compilation modes:

*Cfront C++ mode (POSIX option -X V2-COMPATIBLE, SDF option MODE=\*V2-COMPATIBLE)*

The compiler accepts C++ code compatible with Cfront V3.0.3.

*extended C++ V3 mode (POSIX option -X V3-COMPATIBLE -X nostrict, SDF option MODE=\*V3-COMPATIBLE, STRICT=\*NO)*

The compiler accepts C++ code similar to the C/C++ V3 compiler in extended mode.

*strict C++ V3 mode (POSIX option -X V3-COMPATIBLE -X strict, SDF option MODE=\*V3-COMPATIBLE, STRICT=\*YES)*

The compiler accepts C++ code similar to the C/C++ V3 compiler in strict mode.

*extended C++ 2017 mode (POSIX option -X 2017 -X nostrict, SDF option MODE=\*2017, STRICT=\*NO)*

The compiler accepts C++ code in accordance with the 2017 C++ standard in extended mode.

*strict C++ 2017 mode (POSIX option -X 2017 -X strict, SDF option MODE=\*2017, STRICT=\*YES)*

The compiler accepts C++ code in accordance with the 2017 C++ standard in strict mode.

*extended C++ 2020 mode (POSIX option -X 2020 -X nostrict, SDF option MODE=\*2020, STRICT=\*NO)*

The compiler accepts C++ code in accordance with the 2020 C++ standard in extended mode.

*strict C++ 2020 mode (POSIX option -X 2020 -X strict, SDF option MODE=\*2020, STRICT=\*YES)*

The compiler accepts C++ code in accordance with the 2020 C++ standard in strict mode.

The following table contains an overview of the main differences between the various C++ language modes.

Features / Language attributes	Cfront C++	C++ V3	C++ 2017	C++ 2020
Reserved keywords <sup>1)</sup>				
overload	yes	no	no	no
Exception handling catch, throw, try	no <sup>2)</sup>	yes	yes	yes
Templates template	no <sup>2)</sup>	yes	yes	yes
Language features from C++ 1998				
Runtime type information (RTTI) typeid, dynamic_cast	no <sup>3)</sup>	yes	yes	yes
Arrays: new/delete new[], delete[]	no	yes	yes	yes

Name space namespace, using	no	yes	yes	yes
Template parameter typename	no	yes	yes	yes
Constructor type explicit	no	yes	yes	yes
Data type wchar_t	no	yes <sup>4)</sup>	yes	yes
Data type bool	no	yes <sup>5)</sup>	yes	yes
Storage class mutable	yes	yes	yes	yes
Casting keywords const_cast, reinterpret_cast, static_cast	yes	yes	yes	yes
export <sup>6)</sup>	no	no	yes	no
extern inline functions	no	no	yes	yes
Symbol search in the namespaces of an argument class (Koenig-Lookup)	no	no	yes	yes
Language features from C++ 2017				
Alignment control alignas, alignof	no	no	yes	yes
Semantic of auto	storage class	storage class	type	type
Unicode support: literals u"x", U"x", u8"x", u'x', U'x', u8'x', char16_t, char32_t	no	no	yes	yes
Computation at compile time constexpr	no	no	yes	yes
decltype	no	no	yes	yes
long long	yes	yes	yes	yes
noexcept <sup>7)</sup>	no	no	yes	yes
nullptr	no	no	yes	yes
register (was banned in C++17)	yes	yes	no	no
static_assert	no	no	yes	yes
thread_local	no	no	yes <sup>8)</sup>	yes <sup>8)</sup>
Trigraph (i.e., ??<)	yes	yes	no	no

Language features from C++ 2020				
char8_t	no	no	no	yes
extended computation at compile time constexpr, constexpr	no	no	no	yes
operator <=>	no	no	no	yes
concept, requires	no	no	no	yes
Co-routines co_await, co_return, co_yield	no	no	no	no <sup>9)</sup>
Modules	no	no	no	yes <sup>10)</sup>
predefined preprocessor names				
__STDC_VERSION__	==199409L	==199409L	==199409L	==199409L
__cplusplus	==1	==2 (extended) ==199612L (strict)	==201703L	==202002L

Overview of differences between the various C++ language modes

### 1) Reserved keywords

All keywords listed in chapter “C language support of the compiler” ([Overview of the C language modes](#)), except `restrict`, are also reserved in the C++ language modes. In addition there are the following C++-specific keywords. **Bold** keywords are not reserved in all C++ language modes (see table above).

<b>alignas</b>	<b>concept</b>	delete	new	<b>requires</b>	<b>typeid</b>
<b>alignof</b>	const_cast	dynamic_cast	<b>noexcept</b>	<b>static_assert</b>	<b>typename</b>
asm	<b>constexpr</b>	<b>explicit</b>	<b>nullptr</b>	static_cast	<b>using</b>
<b>bool</b>	<b>constexpr</b>	<b>export</b>	operator	template	virtual
catch	<b>constexpr</b>	<b>false</b>	<b>override</b>	this	<b>wchar_t</b>
<b>char8_t</b>	<b>co_await</b>	friend	private	<b>thread_local</b>	
<b>char16_t</b>	<b>co_return</b>	inline	protected	throw	
<b>char32_t</b>	<b>co_yield</b>	mutable	public	<b>true</b>	
class	<b>decltype</b>	<b>namespace</b>	reinterpret_cast	try	

Reservierte names in C++

---

The following keywords may be used as alternative tokens for C operators. They may or may not be reserved, depending on the settings of the `-K alternative_token`, `-K no_alternative_token` or `ALTERNATIVE-TOKENS=*YES/*NO` options.

By default, they are “not reserved” in the Cfront C++ mode and “reserved” in the modes C++ V3, C++ 2017 and C++ 2020.

and	&&	not_eq	!=
and_eq	&=	or	
bitand	&	or_eq	=
bitor		xor	^
compl	~	xor_eq	^=
not	!		

Keyword operators in C++

## 2) Exception handling, Templates

Exception handling and templates are not supported in the Cfront-C++ mode. However, the keywords `catch`, `throw`, `try` und `template` are not freely available and lead to an error message when used.

## 3) Runtime type information (RTTI)

In the Cfront-C++ mode the keyword `dynamic_cast` is active. It is checked whether the operation addressed in this way requires real runtime information or whether it can be done using the static type information. If the static information is sufficient, the appropriate code is generated. If dynamic information is required, an error message is issued.

## 4) Data type `wchar_t`

In the mode C++ V3 modes the keyword `wchar_t` is reserved depending on the options `-K wchar_t_keyword`, `-K no_wchar_t_keyword` resp. `KEYWORD-WCHAR=*YES/*NO` . `-K wchar_t_keyword` resp. `KEYWORD-WCHAR=*YES` is the default.

## 5) Data type `bool`

In the C++ V3 modes the keywords `bool`, `true` und `false` are reserved depending on the options `-K bool`, `-K no_bool` bzw. `KEYWORD-BOOL=*YES/*NO`. `-K bool` resp. `KEYWORD-BOOL=*YES` is the default.

## 6) `export`

The use of the word `export` leads to a message in all C++ modes. It is an error in C++ 2017, a warning in C++ V2 and in C++ V3. In C++ 2020 mode the keyword is part of the module<sup>10)</sup> syntax. The semantics behind the keyword is not offered by the C/C++ compiler.

## 7) `noexcept`: exception handling as part of a type

---

In C++ it is possible to specify for a function whether it throws exceptions or not. As of C++ 2017, only the specification yes/no is allowed, and this specification is part of the type of the function. Previously, a list of types that could be thrown could be specified. This list was checked dynamically and was not part of the type of function.

8) **thread\_local**

The standard C++ 2017 defines `thread_local` as a keyword. It can be used in the context of threads. Since the C/C++ compiler does not support thread implementation, the keyword is recognized as such and rejected with an error message.

9) **co-routines**

The feature co-routines is not implemented in the current compiler. Use of the keywords will give a warning. A used keyword will then be interpreted as an identifier.

10) **Modules**

The feature modules is not implemented in the current compiler. The syntax for modules is recognized and rejected with an error message.

---

## 7.2 Implementation-defined behavior based on the ANSI/ISO C++ standard

All of the implementation-defined features based on the ANSI/ISO C standard that have already been described in chapter “C language support of the compiler” (Implementation-defined behavior based on the ANSI/ISO C standard ) are also applicable in the C++ language modes and are therefore not listed individually here.

Only the implementation-defined C++ language features that extend beyond the scope of the C language are described below. Which C ++ language features are supported in which C++ modes can be found in the tabular overview on “Overview of the C++ language modes”.

### Identifiers with external linkage

- Compilation in the Cfront C++ mode  
External C++ names are truncated by the compiler to 32 characters. When generating shared code (with the options `-K share` or `SHAREABLE-CODE=*YES`), the maximum permissible length is restricted to 30 characters.  
Lowercase letters are converted to uppercase by default, but can be retained in external names with the option `-K llm_case_lower` or `LOWER-CASE-NAMES=*YES`.
- Compilation in the modes C++ V3, C++ 2017 or C++ 2020  
All characters are significant for the construction of external C++ names. No name truncation and no conversion from lowercase to uppercase occurs. The compiler generates entry names in the EEN format, which can have a length of up to 32000 characters. Longer names result in an error.

To enable processing by the link editor, names with external C++ linkage are transformed internally by the compiler so that they only contain permitted characters and are unique (name mangling). This internal name mangling process differs in the Cfront C++ mode and in the other C++ modes. A list of the originally used external C++ names and those which were generated internally by the compiler for the linkage editor can be obtained with the option `-N project` or `PROJECT-INFORMATION=*YES`.

### Linkage of the main function

The `main` function has external C linkage.

### Data type `bool`

The size of type `bool` is defined as `sizeof(bool) == 1`.

### `reinterpret_cast`

The destination object contains the same bit pattern as the expression evaluated by `reinterpret_cast`, but might not be a valid object of the desired type (e.g. `reinterpret_cast<float>(int)`).

The following conversions are possible:

1. A pointer can be explicitly converted to an integral type that is large enough to hold it. Depending on whether the destination type is `signed` or `unsigned`, the value of the result obtained from the conversion may or may not be signed.
2. The value of an integral type can be explicitly converted to a pointer.

---

## Allocation overhead for new arrays

For each allocated array, a structure is reserved at the start of the memory block allocated for that array. This structure contains two `size_t` members, one for the size of the array (in bytes) and one for the number of elements in the array (this field is encoded in order to detect whether the structure has been overwritten).

## The `asm` keyword

The `asm` keyword is an extension to the ANSI/ISO C standard, but is defined as a normal reserved keyword in the ANSI C++ standard. However, since the inline substitution of assembler code is not supported, any attempt to use this keyword will result in an error message.

## Linkage specification

The supported linkage specifications are “C++” and “C”.

The default linkage specification is “C++”. Names with external C++ linkage are transformed internally by the compiler to enable processing by the linkage editor (name mangling). This internal name transformation is done differently in the different C++ modes.

In the case of names with external C linkage, no internal name mangling is performed. C linkage can be used to link and call functions written in C or in a language that behaves like C on its name mangling interface.

A pointer to a C function is compatible with a pointer to a C++ function of the same type if the argument types are C-compatible PODs. In C++ 2017, these are two different types. In the extended C++ 2017 mode there is an implicit conversion between two function types that only differ in the linkage.

## Linkage of templates

Only templates with C++ linkage are supported.

## Template instantiation

See "[Template instantiation](#)".

## Reference types

The reference for an value is bound to a temporary object created by the compiler. Internally, the C++ data type `reference` is treated as a pointer (see "[Implementation-defined behavior based on the ANSI/ISO C standard \(C/C++-Compiler, #89\)](#)").

## Allocation of non-static data elements of a class

The allocation of memory for these data elements occurs in the strict order of their declarations, i.e. without taking the access specifiers `public`, `private` or `protected` into account.

## Bitfields within classes

Bitfields within classes are handled in the same way as bitfields within structures. This applies to the allocation and alignment as well as the handling of “plain” bitfields without the `signed` or `unsigned` attribute.

---

## Constructors and destructors for global and local static objects

C++ supports the initialization and finalization of objects with constructors and destructors. Constructor and destructor calls can be applied on both dynamic as well as global and local static objects.

### *Constructors and destructors for dynamic objects*

Constructors for dynamic objects are called when objects are created with the `new` operator, on entering functions or local blocks, on processing actual parameters, and when temporary objects are created.

Destructors for dynamic objects are called in the reverse order of their construction, e.g. on exiting a function ( `return`, `exit`), block, etc.

If temporary objects are created for an expression, the destructors are called at the end of the expression. This applies in particular to function parameters.

### *Constructors and destructors for global and local static objects*

The type and order of constructor and destructor calls for global and local static objects is “implementation-defined”. Seen from a technical viewpoint, this means the following:

Constructor calls are collected in one function per compilation unit, and the address of each such function is stored in a specially marked variable in the data section of the program. During the initialization of the runtime system, a list of these variables is generated, and the constructors are called before the `main` function. Destructors are called on exiting a program normally, i.e. on calling `exit`, `_exit`, `bs2exit` or `return` from the `main` function, but not on calling `abort`.

Seen from the user's perspective, the following points must be observed when using global and local static objects with constructors and destructors:

- The redirection of standard I/O files (see "[Redirecting standard I/O files \(C/C++-Compiler, #72\)](#)") has no effect within global and local static objects.
- The order in which constructors are called is totally undefined and may actually vary even when running the same program. It is therefore crucial to ensure that no dependencies between the individual constructor calls exist.
- The names of the special variables for constructor function addresses (see above) begin with ICP. This prefix and the initial letter `I` in general must not be used when constructing user-defined external names, since this produces errors in constructor handling.
- ESD information must not be suppressed when linking.
- The data of the program must be in class-6 memory.
- In the case of shared code, all code segments to call constructors are loaded dynamically.
- No inter-language linkage is permitted within a destructor (only linkage to other languages).
- No code may be “unloaded”; otherwise, on exiting the program, this would result in destructors being called for code that no longer exists.
- In the case of true subsystems for which data and code are loaded dynamically with an explicit call, the runtime system must be reinitialized. During this process, the table of constructors is extended, and the new constructors are called.

## Exception handling

### *Thrown exceptions*

---

The memory for exception objects is taken from a preallocated storage, which can be extended by calls to `malloc`.

### *Handling of exceptions*

In some situations, the `terminate()` function is called implicitly. The C++ standard leaves open the question in two situations whether destructors are called for automatic objects:

If no suitable exception handler is found, the destructors are not called.

If there is a function on the stack that specifies `noexcept(true)`, only some of the destructors are called.

These destructors could be executed with the function `unwind_exit()`, (see ["Additional runtime functions"](#)).

### *The `unexpected()` function*

The thrown exception object which causes the `unexpected()` function to fail is destroyed by calling a destructor and is replaced by a new `bad_exception` object.

More details on exception handling can be found on ["Exception handling"](#).

## **Return type of `operator->`**

The return type of `operator->()` is not checked any more at the point where the function is declared, but is now only checked at the point where it is used as a “->” operator. (This check was performed later on just for elements of class templates in versions up to V3.0C.)

## **Classes and Ellipsis**

Functions can be declared with variable argument lists (e.g. `int foo(int, ...);`). An object of a class can be a parameter if the appropriate argument is the ellipsis. In this case the object is copied byte by byte. Any constructor that may exist is ignored. Any existing destructor is not called for the parameter.

---

## 7.3 Template instantiation

This section provides information concerning the following topics:

- [Fundamentals](#)
- [Automatic instantiation](#)
- [Generating explicit template instantiation statements \(ETR files\)](#)
- [Implicit inclusion](#)
- [extern inline functions](#)

---

## 7.3.1 Fundamentals

The C++ language includes the concept of templates. A template is a description of a class or function that serves as a model for a family of derived classes or functions. For example, one can write a template for a `Stack` class, and then use a stack of integers, a stack of floats, or a stack of any user-defined type. These stacks could then be typically written in the source as `Stack<int>`, `Stack<float>` and `Stack<X>`. From a single source description of the template for a stack, the compiler can create instantiations of the template for each of the types required.

The instantiation of a class template is always created as soon as it is required during compilation. The instantiations of template functions and member functions or static data members of a class template (referred to as **template entities** below), by contrast, need not be created immediately. This is due to the following reasons:

- In the case of template entities with external linkage (functions and static data members), it is important to have only one copy of the instantiated template entity throughout the program.
- The C++ standard allows to write a specialization for a template entity, which means that the programmer can supply a specific version to be used instead of the instantiation generated from the template for a specific data type.  
Since the compiler cannot know, when compiling a reference to a template entity in mode C++ V3, if a specialization for that entity is available in another compilation unit, it cannot create the instantiation immediately.
- The C++ standard dictates that template functions which are not referenced should not be compiled and should be checked for errors. Consequently, a reference to a template class should not automatically instantiate all the member functions of that class.

Note that some template entities such as inline functions are always instantiated when used.

From the requirements listed above, it is evident that if the compiler is responsible for the entire instantiation (i.e. if the instantiation is done “automatically”), these instantiations can only be performed meaningfully on a program-wide basis. In other words, the compiler cannot make decisions about the instantiation of template entities until it has seen the source code of all compilation units in the program.

The C/C++ compiler provides an instantiation mechanism by which automatic instantiation is carried out at link time (with the aid of a “prelinker”). This mechanism is discussed in detail in section [“Automatic instantiation”](#).

More explicit control over the instantiation process is available to the programmer via different instantiation modes that can be selected using options and by means of `#pragma` directives.

- The options to select instantiation modes are:  
`MODIFY-SOURCE-PROP INSTANTIATION=*NONE / *AUTO / *LOCAL / *ALL`(see [“MODIFY-SOURCE-PROPERTIES”](#)).
- The instantiation of individual templates or even a template group can be controlled with the pragmas:  
`instantiate`, `do_not_instantiate` and `can_instantiate` (see [“Pragmas to control template instantiation”](#)).

### *Important notes*

The default template instantiation method of this compiler (i.e. automatic instantiation by the prelinker and implicit inclusion) is also the recommended method and should generally be used. Deviations from this default method via control options should be restricted to exceptional cases and should only be attempted if the entire application is known in detail, including every template that is defined and used.

Implicit inclusion must not be disabled (with `IMPLICIT-INCLUDE=*NO`) when using templates from the C++ V3 library (`SYSLNK.CRTE.STDCPP`). Otherwise, the required definitions will not be found.

---

Instantiation modes  $\neq$  INSTANTIATION= $\ast$ AUTO: In this case, there is a high risk that unresolved external references ( $\ast$ NONE), duplicates ( $\ast$ ALL) or runtime errors ( $\ast$ LOCAL) may occur.

---

## 7.3.2 Automatic instantiation

The C/C++ compiler supports automatic instantiation (`INTEGRATION=*AUTO`) by default in the language modes C++ V3, C++ 2017 and C++ 2020. This enables you to compile source code and link the generated objects without being concerned about any required instantiations.

Note that the discussion which follows refers to the automatic instantiation of template entities for which there is no explicit instantiation request (`template declaration`) and no `instantiate` pragma.

### Requirements

For each instantiation, the compiler expects a source file that contains both a reference to the required instantiation and the definition of the template entity as well as all types required for the instantiation of that template entity. The latter two requirements can be satisfied by the following methods:

- Each `.h` file that declares a template entity also contains either the definition of the entity or includes another file containing the definition.
- Implicit inclusion  
When the compiler sees a template declaration in a `.h` file and discovers a need to instantiate that entity, it looks for a source file with the same base name as the `.h` file and a suffix that satisfies the conventions for C++ source file names (`.C`, `.CPP`, `.CXX` or `.CC`). This file is then implicitly included by the compiler on instantiation at the end of each compilation unit without a message being issued. Further details see the [section "Implicit inclusion"](#).
- The programmer makes sure that the files that define template entities also contain the definitions of all required types and adds C++ code or instantiation pragmas in those files to request the instantiation of the template entities therein.

### First instantiation without a definition list

The definition list method can also be used as an alternative to the following procedure (see ["First instantiation with the help of the definition list \(temporary repository\)"](#)).

The following steps are performed internally during automatic instantiation:

1. Create instantiation information files  
The first time that one or more source files are compiled with the `COMPILE` statement, no template entities are instantiated. For each source file that makes use of a template, an associated instantiation information file is created if no such file exists. This instantiation information file is placed in the PLAM library of the module to be generated and is assigned the base name of the module with the suffix `.II` by default (see the [section "Rules for constructing module names"](#)). For example, if a source program named `ABC.CC` were to be compiled (without explicitly specifying a module name), the file `ABC.II` would be generated as the instantiation information file. This file must not be modified by the user.
2. Create modules  
The created modules contain information on which instantiations could have been created and on those possibly required when compiling a source file.
3. Assign template instantiations  
When the modules are linked with the `BIND` statement, the prelinker is called before the actual linking takes place. The prelinker examines the modules, looking for references and definitions of template entities and for additional information about entities that could be instantiated. If the prelinker cannot find a definition for a required template entity, it looks for a module that indicates that it could instantiate that template entity. When it finds such a module, it assigns the instantiation to it.

- 
4. Update the instantiation information file  
All instantiations that were assigned to a given module are recorded by name in the associated instantiation information file.
  5. Recompile  
The compiler is internally called again to recompile each file for which the instantiation information file was changed.
  6. Create new modules  
When the compiler compiles a file, it reads the instantiation information file for that compilation unit and generates a new module with the required instantiations (i.e. template definitions).
  7. Repetition Steps 3 to 6 are repeated until all instantiations which are required and which can be generated have been created.
  8. Linkage  
The modules are linked together.

### First instantiation with the help of the definition list (temporary repository)

Since the method above (see ["First instantiation without a definition list"](#)) needs to recompile some files more than once, an option was added to accelerate the entire process.

When this option is used, the files are generally only recompiled once. Most of the instantiations are assigned to the first few files to be recompiled in this process. This results in disadvantages in some cases since the object size increases due to this (although other objects decrease in size to balance this out).

Steps 3-5 above are modified. The resulting algorithm appears as follows:

1. Create instantiation information files  
The first time that one or more source files are compiled with the COMPILER statement, no template entities are instantiated. For each source file that makes use of a template, an associated instantiation information file is created if no such file exists. This instantiation information file is placed in the PLAM library of the module to be generated and is assigned the base name of the module with the suffix `.II` by default (see the [section "Rules for constructing module names"](#)). For example, if a source program named `ABC.CC` were to be compiled (without explicitly specifying a module name), the file `ABC.II` would be generated as the instantiation information file. This file must not be modified by the user.
2. Create modules  
The created modules contain information on which instantiations could have been created and on those possibly required when compiling a source file.
3. Assign template instantiations to a source file  
If there are references for template entities for which there are no definitions in the set of modules, then a file that could instantiate one of the template entities is selected. All template entities that can be instantiated in this file are assigned to the file.
4. Update the instantiation information file  
The set of instantiations that were assigned to the file are recorded by name in the associated instantiation file.
5. Store the definition list  
A definition list is stored internally in memory. It contains a list of all definitions found in all modules that relate to templates. This list can be read in and changed during recompilation.  
*Note*This list is not stored in a file.
6. Recompile  
The compiler is internally called again to recompile the corresponding source files.

---

7. Create new modulesWhen the compiler recompiles a file, it reads the instantiation information file for that compilation unit and generates a new module with the required instantiations.When the compiler obtains an opportunity during compilation to instantiate additional template entities that are not mentioned in the definition list and were not found in the libraries resolved, then it will also instantiate these (e.g. for templates that are contained in templates). It sends the list of instantiations that it obtained during recompilation to the prelinker so that the prelinker can assign it to the file.

This process results in faster instantiations and reduces the necessity of recompiling an existing file more than once during the prelinking process.

8. Repetition Steps 3 to 7 are repeated until all instantiations that are required and can be generated have been created.

9. LinkageThe modules are linked together.

## Further development

Once a program has been correctly linked, the associated instantiation information files contain all the names of the defined and required instantiations. From then on, whenever source files are compiled, the compiler will consult the instantiation information file and do the instantiations therein as in a normal compilation run. In other words, except in cases where the set of required instantiations changes, the prelinker will find all required instantiations stored in the modules, so no further instantiation adjustments are needed. This applies even if the entire program is recompiled.

If a specialization of a template entity has been provided somewhere in the program, the prelinker will treat it as a definition. Since this definition will satisfy any references to the template entity, the prelinker will see no need to request an instantiation for that template entity. If a specialization is added to a program that has already been compiled, the prelinker will remove the assignment of the instantiation from the corresponding instantiation information file.

The instantiation information file must not be modified (e.g. renamed or deleted) by the user, except in the following case: if a source file in which a definition was changed and another source file in which a specialization was added are being compiled in sequence in the same compiler run, and the compilation of the first file (with the changed definition) has aborted with an error, the associated instantiation information file must be deleted manually to allow the prelinker to regenerate it.

## Interaction between the compilation and prelinker runs

Since the automatic template instantiation by the prelinker can, among other things, also involve subsequent compilations, the conditions under which the compilation occurs (COMPILE) play an important role in the prelinker run (BIND ACTION=\*PRELINK,...) as well. Technically speaking, all options relevant for the compilation, code generation and compiler outputs are entered in the corresponding instantiation information files and interpreted during the automatic template instantiation. In order to ensure that the follow-up compilations and other updates function correctly during instantiation, the following points, in particular, must be observed:

- The input of source programs via SYSDTA and the output of listings to SYSLST or SYSOUT are not supported and are rejected with a corresponding error message.
- All I/O files and libraries of the compilation run must also be locatable and accessible in the prelinker run and should hence be neither renamed nor deleted. If the prelinker run occurs in some other environment (e.g. user ID), fully-qualified file names must be used in the compilation, i.e., names including the <cat-id> and <user-id> for BS2000 files and PLAM libraries, and absolute path names (beginning with /) for POSIX files.

- The `*INCREMENT` option is not permitted for the following output files:
  - module element name
  - cif element name
  - listing element name

**Warning:** Compilation is aborted in this case.

- When you specify an explicit version string for 'module name', an ii-element file with the same version string is searched for, read in and written. (If an existing ii-element with a different version string is to be used, then this element must be copied and stored under a new name before it can be linked and before the template instantiation starts.) This behavior is not compatible with the C++ Compiler V3.0.

## Prelinking and dynamic linkage

The prelinker does the automatic instantiation only in the individual modules generated by the compiler, since it requires the unique assignment between the module and the instantiation file (. I I file) for this purpose. The prelinker is activated only with the BIND statement of the compiler (ACTION=\*PRELINK). If only ACTION=\*MODULE-GENERATION is specified in the BIND statement, no template instantiation is performed.

When generating the finished program (via static or dynamic linkage), all "prelinked modules" of the the BIND statement and all dynamically linked modules that require instances of template entities must either

- already contain these instances (which may be achieved by explicit instantiation and/or the preinstantiation of modules with the BIND statement (ACTION=\*PRELINK)
- or provide appropriate headers with `can_instantiate` pragmas.

During the preinstantiation with the BIND statement, it is absolutely essential to ensure that the C++ libraries and C++ runtime systems of the CRTE (standard C++ library, C++ runtime system, Tools.h++ library) are also considered by the prelinker, since duplicate definitions may otherwise be created. The libraries are automatically taken into account if the STDLIB option of the MODIFY-BIND-PROPERTIES statement is set to \*DYNAMIC or \*STATIC and the TOOLSLIB option is set to \*YES. If the CRTE libraries are to be linked in dynamically themselves, duplicate definitions can be prevented as follows:

1. The first step is to preinstantiate the modules, taking the used CRTE libraries into account:

```
//MODIFY-BIND-PROPERTIES STDLIB=*DYNAMIC / *STATIC [,TOOLSLIB=*YES], ...//BIND
ACTION=*PRELINK, ...
```

2. All modules with unresolved external references to the used CRTE libraries can then be linked in a second step:

```
//MODIFY-BIND-PROPERTIES STDLIB=*NONE [,TOOLSLIB=*NO], ...//BIND ACTION=*MODULE-
GENERATION, ...
```

If the prelinker and linkage runs are to be executed concurrently, the ADD-PRELINK-FILES option must be used. The main disadvantage of this method is that the names of the CRTE libraries would then need to be specified explicitly.

In the case of a standard installation of the CRTE and in mode C++ V3, for example, this is achieved as follows:

```
//MODIFY-BIND-PROPERTIES ADD-PRELINK-FILES=( *LIB(LIB=$.SYSLNK.CRTE.STDCPP) , *LIB
(LIB=$.SYSLNK.CRTE.RTSCPP)

[ , *LIB(LIB=$.SYSLNK.CRTE.TOOLS) ] ) , - STDLIB=*NONE, ...//BIND ACTION=( *PRELINK,
*MODULE-GENERATION) , ...
```

---

### 7.3.3 Generating explicit template instantiation statements (ETR files)

In some cases, for example, when automatic instantiation cannot be used effectively, the programmer has the option of using explicit (manual) instantiation in order to extend the sources as required.

To make this process easier, it is possible to create an ETR file (ETR - Explicit Template Request) which contains the instantiation statements for the templates used and which can be incorporated into a source.

The options for creating this ETR file can be specified with the GENERATE-ETR-FILE operand of the SDF statement MODIFY-DIAGNOSTIC-PROPERTIES (see "[MODIFY-DIAGNOSTIC-PROPERTIES](#)").

The important options are **\*ALL...**, which outputs all relevant information and **\*ASSIGNED...**, which only outputs part of this information.

The templates taken into account during the ETR analysis can be divided into the following classes:

- Templates that are instantiated explicitly in the compilation unit. These are output with "ALL".
- Templates that are assigned by the prelinker to the compilation unit and then instantiated within the compilation unit. These can be output using both "ALL" and "ASSIGNED".
- Templates that are used in the compilation unit and that can be instantiated here. These are output with "ALL".
- Templates that are used in the compilation unit, but cannot be instantiated here. These are output with "ALL".

The contents of an ETR file have the following format:

- Comments in the header will indicate that the file is a generated file.
- Three logical lines are created for each template (see the example below):
  - a comment line containing the text 'The following template was'
  - a comment line containing the type of the instance (for example, 'explicitly instantiated')
  - a line which describes the explicit instantiation for this instance. This line contains the external name of the instance. This name is the same as the entry in the ii file (see section "[The II-UPDATE tool](#)") and can also be obtained from the binder listing or the binder error listing

#### Notes

- If the lines described above are too long, they will be wrapped in the usual C++ fashion using "*Backslash newline*".
- The sequence of the output templates is not defined. If recompilation takes place or a source is modified, the sequence may change.
- The third logical line is particularly interesting when copying to a source.
- The comments are always in English.

The following two scenarios describe sensible uses of an ETR file:

1. The compiler is called during development using the INSTANTIATION=\*AUTO option of the SDF statement MODIFY-SOURCE-PROPERTIES and the GENERATE-ETR-FILE=\*ASSIGNED option of the SDF statement MODIFY-DIAGNOSTIC-PROPERTIES.

The instantiation statements output to the ETR files are incorporated into the appropriate sources. Productive operation is then activated using the INSTANTIATION=\*NONE or \*AUTO option in the SDF statement MODIFY-SOURCE-PROPERTIES the next time the compiler is called.

The advantage of this method is the considerable reduction in the time it takes to complete prelinking during productive operation.

- 
2. The compiler is called during development using the `INSTANTIATION=*NONE` and `GENERATE-ETR-FILE=*ALL-INSTANTIATIONS` option (of the SDF statements as described above).

After linking the developer checks each unresolved external reference to see whether it is a template, and if it is a template, when it can be instantiated. Particularly helpful in this case are the output external names. Then, the developer selects a source for the instantiation and inserts the instantiation statements there. In addition, the correct header files must also be included.

This method requires a considerable amount of manual work. But you do not subsequently need to call the prelinker.

This procedure offers you precise control over the placing of instances (which is important when using components with high performance requirements).

## Example 1

For a single ETR file compiled using two files, **x.c** and **y.c**:

The following statements are used for compilation:

```
//MOD-DIAG GEN-ETR=ALL
//COMPILE (*LIB(OLIB,X.C), *LIB(OLIB,Y.C)), MODULE-OUTPUT=*SOURCE-LOCATION
```

### Source x.c:

```
template <class T> void f(T) {}
template <class T> void g(T);
template void f(long);
void foo()
{
    f(5);
    f('a');
    g(5);
}
```

### Source y.c:

```
template <class T> void f(T) {}
void bar()
{
    f(5);
}
```

**ETR-File x.etr** (is in the OLIB library as a type S member):

```

// This file is generated and will be changed when the module is compiled

// The following template was
// explicitly instantiated
#pragma instantiate_mangled_id __1f_tm_2_l_FZ1Z_v&_

// The following template was
// used in this module and can be instantiated here
#pragma instantiate_mangled_id __1f_tm_2_i_FZ1Z_v&_

// The following template was
// used in this module and can be instantiated here
#pragma instantiate_mangled_id __1f_tm_2_c_FZ1Z_v&_

// The following template was
// used in this module
#pragma instantiate_mangled_id __1g_tm_2_i_FZ1Z_v&_

```

**ETR-File y.etr** (is in the OLIB library as a type S member):

```

// This file is generated and will be changed when the module is compiled

// The following template was
// used in this module and can be instantiated here
#pragma instantiate_mangled_id __1f_tm_2_i_FZ1Z_v&_

```

The user can now decide in which source they wish to make explicit instantiations (this decision must always be made for entries with “used in this module and can be instantiated here”), see Example 2. Then you will subsequently not need to use automatic template instantiation.

## Example 2

This example uses two file **x.c** and **y.c** in a library called **test**.

### Source x.c

```

template <class T> void f(T){}
template <class T> void g(T);
template void f(long);
void foo()
{
    f(5);
    f('a');
    g(5);
}

```

### Source y.c:

```
template <class T> void f(T) {}
void bar()
{
    f(5);
}
```

These programs are compiled using the following statements and the prelinking carried out:

```
//mod-source-prop instantiation=*auto
//mod-diagnostic-prop generate-etr-file=*assigned-instantiations
//compile *lib-elem(test, X.C), module-output=*source-location
//compile *lib-elem(test, Y.C), module-output=*source-location
//mod-bind-prop start-llm-creation=*yes
//mod-bind-prop include=*lib-elem(test,X)
//mod-bind-prop include=*lib-elem(test,Y)
//bind action=*prelink
```

This creates a file called **x.etr** in the library **test**:

```
// This file is generated and will be changed when the module is compiled

// The following template was
// instantiated automatically by the compiler
#pragma instantiate_mangled_id __1f_tm_2_i_FZ1Z_v&_

// The following template was
// instantiated automatically by the compiler
#pragma instantiate_mangled_id __1f_tm_2_c_FZ1Z_v&_
```

The important lines are inserted in the file **x.c**, which creates the file **x1.c**:

```
template <class T> void f(T){}
template <class T> void g(T);
template void f(long);
void foo()
{
    f(5);
    f('a');
    g(5);
}
#pragma instantiate_mangled_id __1f_tm_2_i_FZ1Z_v&_
#pragma instantiate_mangled_id __1f_tm_2_c_FZ1Z_v&_
```

Then you can carry out production using the following commands:

```
//mod-source-prop instantiation=*none
//mod-diagnostic-prop generate-etr-file=*no
//compile *lib-elem(test,X1.C), module-output=*source-location
//compile *lib-elem(test,Y.C), module-output=*source-location
```

---

### Example 3

The following example shows the four classes of template that can be output. The same assumptions are made as for example 1.

The following commands are input:

```
//mod-source-prop instantiation=*auto
//mod-diagnostic-prop generate-etr-file=*no
//compile *lib-elem(test,Y.C), module-output=*source-location
//mod-bind-prop start-llm-creation=*yes
//mod-bind-prop include=*lib-elem(test,y)
//bind action=*prelink (this will assign y to f(int))
//mod-diagnostic-prop generate-etr-file=*all-instantiations
//compile *lib-elem(test,X.C), module-output=*source-location
//mod-bind-prop start-llm-creation=*yes
//mod-bind-prop include=*lib-elem(test,X)
//mod-bind-prop include=*lib-elem(test,Y)
//bind action=*prelink
```

This creates an ETR file **x.etr** in the library called **test**:

```
// This file is generated and will be changed when the module is compiled

// The following template was
// explicitly instantiated
#pragma instantiate_mangled_id __1f_tm_2_l_FZ1Z_v&_

// The following template was
// used in this module and can be instantiated here
#pragma instantiate_mangled_id __1f_tm_2_i_FZ1Z_v&_

// The following template was
// instantiated automatically by the compiler
#pragma instantiate_mangled_id __1f_tm_2_c_FZ1Z_v&_

// The following template was
// used in this module
#pragma instantiate_mangled_id __1g_tm_2_i_FZ1Z_v&_
```

---

### 7.3.4 Implicit inclusion

The implicit inclusion of source files is a method of finding definitions of template entities. This method is enabled for the compiler by default (see also the option `IMPLICIT-INCLUDE` on "[MODIFY-SOURCE-PROPERTIES](#)") and can be disabled with `IMPLICIT-INCLUDE=*NO`. When disabling implicit inclusion please check the notes in section "[Fundamentals](#)".

When implicit inclusion is enabled, the compiler looks for the definition of a template entity in accordance with the following principle:

If a template entity is declared in a header file named *basename.H* and no definition for it is available in the compiled source code, the compiler will assume that the definition for that template entity is contained in a source file

- which is located as a source program element in the same PLAM library as the header file and
- which has the same base name as the header file and a standard suffix that is valid for C++ source files, i.e.: `.C`, `.CPP`, `.CXX` or `.CC` (e.g. *basename.CC*).

Let us assume, for example, that a template entity `ABC::f` is declared in the header file `XYZ.H` in the library `PLAM.T`. If the instantiation of `ABC::f` is requested on compilation, but no definition of `ABC::f` exists in the compiled source code, the compiler will search the library `PLAM.T` for a source file with the base name `XYZ` and a standard suffix that applies to C++ source files, i.e.: `.C`, `.CPP`, `.CXX` or `.CC` (e.g. `XYZ.CC`). If such a file exists, it will be treated as if it were included at the end of the source file.

---

### 7.3.5 extern inline functions

The language modes C++ 2017 and C++ 2020 support *extern inline* functions (see "[extern inline vs. static inline](#)"). They have a similar problem as template units: a single address. The function must be assigned to a single module.

Extern inline functions are handled mostly like template units. They will get an entry in the instantiation information file. The automatic instantiation assigns the function to a module.

The effect is that automatic instantiation has to be performed even when no template is used.

Inline expansion is still possible, see "[Inline substitution of user-defined functions](#)" ([The optimization process](#)). This optimization is possible in all modules.

Extern inline functions differ from template units:

- The pragmas `instantiate`, `do_not_instantiate` and `can_instantiate` may not be used for non-template extern inline functions.
- The pragma `instantiate_inline` can be used to assign an extern inline function to a specific module.
- Implicit inclusion is not relevant. All types used in an extern inline function must have been declared. This is the same as for other functions.
- An extern inline function is checked in each module where it is defined.
- The current compiler (version 4.0B03) does not put extern inline functions into ETR files.

---

## 7.4 Deviations from ANSI/ISO C++

This section provides information concerning the following topics:

- [Extensions to ANSI-/ISO-C++](#)
- [Restrictions to ANSI-/ISO-C++](#)
- [extern inline vs. static inline](#)

---

## 7.4.1 Extensions to ANSI-/ISO-C++

The extensions described below are accepted in the C++ 2017 and C++ 2020 language modes, except when the option `-R strict_errors` or `ANSI-VIOLATIONS=*ERROR` has been set in strict mode. Note that all extensions to ANSI/ISO C (see section “[Extensions to ANSI/ISO C](#)”) are also supported in the C++ modes.

- A qualified name may be used in the declaration of a class member:

```
struct A {
    int A::f(); // ANSI requires int f();
};
```

- In extended C++ 2017 mode and in extended C++ 2020 mode an implicit conversion between functions with "C" und "C++" linkage exists:

```
extern "C" void f();
void (*pf)() = &f;
```

- In extended C++ 2017 mode and in extended C++ 2020 mode an implicit conversion from string literals to the type `char*` exists (in C++ 2017 string literals are of type `const char *`):

```
char *p1 = "abc";
char *p2 = x ? "abc" : "def";
```

- The preprocessor macro `cplusplus` is defined in addition to the standard-compliant macro `__cplusplus`. No warning is issued.

---

## 7.4.2 Restrictions to ANSI-/ISO-C++

Some language features are not supported. The restrictions regarding `long long`, alignment, unicode and the float format IEEE described in [restrictions to ANSI/ISO C](#) are also restrictions in C++.

### Thread support

The C/C++ compiler does not support a specific thread package. In detail, this means that the headers `<thread>`, `<mutex>`, `<shared_mutex>`, `<condition_variable>` and `<future>` are not available. The Keyword `thread_local` leads to an error message in mode C++2017 or C++ 2020. The predefine `__STDCPP_THREADS__` is not set.

### Atomics

C/C++ 4.0 does not support the atomic types. Some of their usage has to have support in the thread library. Using the keywords associated with atomic types will give an error message. The header file `<atomic>` is not available. C/C++ 4.0 does have support for some essential atomic features. Details are available on special request.

### Header `<execution>`

The C/C++ compiler 4.0 does not support the header `<execution>`. The classes which should be declared in those headers are not supported.

### Mathematical special functions

The mathematical special functions (C++ 2017 standard, chapter 29.9.5) are not supported. These are some advanced mathematical functions, for example Laguerre and Legendre.

### Co-Routines

The co-routines from C++ 2020 are not supported. Use of the reserved words will lead to a specific warning.

### Modules

The modules from C++ 2020 are not supported. The syntax will be recognized and will cause an error message.

### Library of C++ 2020

The library of C++ 2020 is not supported. The library of C++ 2017 is available in language mode C++ 2020.

---

### 7.4.3 extern inline vs. static inline

An inline function can be interpreted as *static inline* or *extern inline*. This question is important when local static variables are used in the function or when the address of such a function is used in a comparison.

*Examples 1* and *2* at the end of this section illustrate the problem.

From the programmer's viewpoint, a static inline function behaves in exactly the same way as a static function. The function itself and all the elements declared in the function are local to the current compilation unit. The function itself does not interact in any way with elements of other compilation units; these must be produced by other (external) functions.

An extern inline function behaves like a normal external function. The body of the function must occur in every compilation unit which uses it. It must, however, always be identical. The behavior can be described by means of a comparison: it is as if the body were the only definition in an additional compilation unit and this function were called in all the other compilation units.

In addition to the definition above, the optimizer is also informed that an inline expansion is desirable. However, the meaning must be retained when this optimization is implemented.

#### The view of the C++ standard

If a function is declared with the keyword `inline`, it is implicitly regarded as extern inline. A static inline must be declared with the keywords `static` and `inline`.

A member function which is defined within a class is implicitly regarded as extern inline.

#### Implementation in language mode C++ 2017 or C++ 2020

The language modes C++ 2017 and C++ 2020 support extern inline functions as required by the standard, see "[extern inline functions](#)".

#### Implementation in language modes Cfront C++ and C++ V3

In the language modes Cfront C++ and C++ V3 the compiler does not know the concept of an extern inline function. It interprets all inline functions as static inline.

This affects both the functions declared with the keyword `inline` and also the member functions defined within a class.

The following sections apply only to the language modes Cfront-C ++ and C ++ V3.

#### The problematical constructs

In many cases it is irrelevant whether a function is interpreted as static inline or extern inline. To permit this, one of three constructs must be used. The situation is problematical only when the function is used in multiple compilation units.

The functions affected are those which are conceived as extern inline (see *Example 3*). These functions are almost always contained in a header file, together with a body. Templates or member functions can be concerned here.

In the case of templates it must be borne in mind that the C/C++ compiler includes other sources if this function is not disabled. In this context, see the options `//MODIFY-SOURCE-PROPERTIES IMPLICIT-INCLUDE =` and `-K implicit_include` which are active in the default case (see *Example 4*).

---

- Local static variables

In such a situation a local `static` variable exists several times over in the compiler implementation, while the standard requires a single occurrence. Whether this leads to a problem depends on the reason why the variable was defined as local `static` (see *EExample 5*).

If a single occurrence is indeed expected, a problem exists. Whether this will result in runtime errors depends very much on the actual usage.

The situation is different if the reason is the lifetime of the memory. A great deal of code sets up a string internally in order to return it as the return value. No `auto` variable can be used here because the memory is released when the value is returned. However, a local `static` remains valid until the function is called again. This is frequently used when texts are edited for output. In this case the variable is duplicated, but this has practically no effect on the program run.

- Comparison of addresses

An extern inline function has an unambiguous address, a static inline function one address per compilation unit. This is not relevant as long as the addresses are only used to call the function.

Things become critical when such addresses are compared with each other. However, this tends to happen only rarely. It would be conceivable when registering callback functions in which each function should only be entered once.

- String literal

This construct only returns a problem in exceptional cases. The standard does not define whether string literals with the same content also have the same address. It is also very unusual to use the address of a string literal in comparisons or similar functions.

*Example 1: A problematical situation*

```

// file bsp.h
#include <stdio.h>
class BSP {
public:
    inline int mf1(void);
};
inline int BSP::mf1(void)
{
    static int i = 1;
    return i++;
}
extern void f();
// file bsp1.c
#include "bsp.h"
void f()
{
    BSP bsp;
    printf ("Value 1: %d\n", bsp.mf1() );
}
// file bsp2.c
#include "bsp.h"
void g()
{
    BSP bsp;
    printf ("Value 2: %d\n", bsp.mf1() );
}
int main()
{
    f();
    g();
    return 0;
}

```

### *Explanation*

The function `mf1` is critical, as is the variable `i` which it contains. According to the standard this should only exist once. The two calls in `bsp1.c` and `bsp2.c` should therefore apply to the same variable. The required output is

Value 1: 1

Value 2: 2

However, in the implementation of the C/C++ compiler the function is processed separately in `bsp1.c` and `bsp2.c`. A different variable is addressed with the call in `bsp2.c` from the call in `bsp1.c`. Both variants are initialized with 1.

The output is then

Value 1: 1

Value 2: 1

*Example 2: A problematical situation with templates*

```

// file tmpl.h
#include <stdio.h>
template <class T>
inline int tmpl(T t)
{
    static int i = 1;
    return i++;
}
extern void f();
// file tmpl1.c
#include "tmpl.h"
void f()
{
    printf ("Value 1: %d\n", tmpl(5) );
}
// file tmpl2.c
#include "tmpl.h"
void g()
{
    printf ("Value 2: %d\n", tmpl(7) );
}
int main()
{
    f();
    g();
    return 0;
}

```

### *Explanation*

The same notes apply as for *Example 1*, but a template is involved here rather than a member function. The output expected by the standard is

Value 1: 1

Value 2: 2

The output supplied by the C/C++ compiler is

Value 1: 1

Value 2: 1

### *Example 3: Functions affected*

```

// file bf.h
inline int f1(T) { } // affected
int f2(T); // not affected
static inline int f3(T) { } // not affected
// as explicitly static

template <class T> inline int tf1(T) { } // affected
template <class T> int tf2(T); // not affected
template <class T> static inline int tf3(T) { } // not affected
// as explicitly static

class BSP {
public:
    inline int mf1(void); // affected
    int mf2(void) { } // affected
    int mf3(void); // not affected
};
inline int BSP::mf1(void) { }

```

#### Example 4: Implicit include

```

// file ii.h
template <class T> inline int ii(T);
// file ii.c
template <class T> inline int ii(T) // this function is affected,
// although it is contained in a
// .c file

{
    static int i;
    return i++;
}

```

#### Example 5: Problematical static variables

Usage is only presented as problematical/not problematical here. To become a real problem, the function must be a problematical inline function.

```

inline void no_recursion (void)
{
    static int active = 0; // problematical
    active ++;
    if (active > 1)
    {
        illegal_recursion ();
    } else {
        do_something ();
    }
    active --;
}

```

This is problematical because the recursion is not reliably detected.

---

```
inline char * debug_text ()
{
    static char buffer [200];          // not problematical
    sprintf (buffer, "...", ...);
    return buffer;
}
```

This is not problematical because the content of the buffer is always used before the next call. There is normally nobody who saves and accepts the address, which means that its content changes reliably.

```
inline void f (void)
{
    static int actions = 0;           // (see below)
    actions++;
    if (actions > 200)
    {
        actions = 0;
        optimize_datastructures (); // Only cleaning up, no relevant
                                   // change
    }
    do_something ();
}
```

Whether this is problematical depends very much on the `optimize_datastructures` function. If it is really the case that only optimization is being performed there, the program runs correctly despite actions being duplicated. However, the performance is different because `optimize_datastructures` is no longer called on a regular basis.

---

## 7.5 Variations in the Cfront C++ mode

The behavior of the compiler in the Cfront C++ mode is compatible with Cfront C++ V3.0, i.e. the compiler supports many of the corresponding function attributes and specific features. The Cfront C++ mode is supported so that existing code containing extensions to Cfront version V3.0 can be compiled without manual intervention. It does not guarantee full compatibility with the C++ compiler V2.2.

Consequently, note that if a program produces an error when compiled with the C++ V2.2 compiler, it is possible that the C/C++ V4.0 compiler may produce a different error or no error at all in the Cfront C++ mode. Some of the special aspects to be noted for the Cfront C++ mode are described below.

- `const` qualifiers on the `this` parameter may be dropped in some contexts, as in this example:

```
struct A {
    void f() const;
};
void (A::*fp)() = &A::f;
```

This is actually a safe operation. A pointer to a function of type `const` may be put into a pointer to a non-`const` type, since a call using the pointer is permitted to modify the object, and the function pointed to will actually not modify the object. An assignment in the reverse direction would not be safe.

- Conversion operators specifying conversion to `void` are allowed.
- A `friend` declaration may introduce a new type. A `friend` declaration that omits the elaborated type specifier is allowed in the C++ mode, but is also allowed to introduce a new type name in the Cfront mode.

```
struct A {
    friend B;
};
```

- The third operator of the `?:` operator is a conditional expression instead of an assignment expression.
- A reference to a pointer type may be initialized from a pointer value without using a temporary variable even if the reference pointer type has supplementary type qualifiers in addition to those present in the pointer value. For example:  

```
int *p;
const int *&r = p; // No temporary used
```
- A reference variable may be initialized with 0.
- Since the accessibility of types is not checked in the Cfront mode, access errors for types are issued as warnings instead of errors.
- When calling overloaded functions, a null pointer must be written as a string in the form "0". Other notations such as `const` variables with the value 0 or constants in the form `\0` are not interpreted as a null pointer by the compiler in the case of overloaded functions.
- No warning is issued when an `operator()()` function has default argument expressions.

- An alternate form of declaring pointer-to-member-function variables is supported. This is illustrated in the example below:

```
struct A {
    void f(int);
    static void sf(int);
    typedef void A::T3(int);    // nonstd typedef decl
    typedef void T2(int);      // std typedef
};
typedef void A::T(int);        // nonstd typedef decl
T* pmf = &A::f;                // nonstd ptr-to-member decl
A::T2* pf = A::sf;            // std ptr to static mem decl
A::T3* pmf2 = &A::f;          // nonstd ptr-to-member decl
```

In this example, `T` names a routine type for a nonstatic member function of class `A` that takes an `int` argument and returns `void`. The use of such types is restricted to nonstandard pointer-to-member declarations. The declarations of `T` and `pmf` in combination are equivalent to a single standard pointer-to-member declaration in the form:

```
void (A::* pmf)(int) = &A::f;
```

A non-standard pointer-to-member declaration that appears outside of a class declaration, such as the declaration of `T`, is normally invalid and would cause an error to be issued. For declarations that appear within a class declaration, such as `A::T3`, this feature changes the meaning of a valid declaration.

- `protected`

class members are not checked when the address of a `protected` member is specified.

```
class B { protected: inti; };
class D : public B {void mf(); };
void D::mf() {
    int B::* pm1 = &B::i;    // Error except in Cfront mode
    int D::* pm2 = &D::i;    // OK
}
```

Note that the checking of `protected` class members for other operations (i.e. everything except the declaration of pointer-to-member addresses) is handled as defined by the standard in Cfront mode.

- The destructor of a derived class may implicitly call the `private` constructor of a base class.

```
class A {
    ~A();
};
class B : public A {
    ~B();
};
B::~~B(){}    // Error except in Cfront mode
```

- When disambiguation requires deciding whether something is a parameter declaration or an argument expression, the pattern *type-name-or-keyword (identifier...)* is treated as an argument. For example:

```
class A { A(); };
double d;
A x(int(d));
A(x2);
```

According to the standard, `int(d)` is interpreted as a parameter declaration (with redundant parentheses), which means that `x` is a function. In the Cfront C++ mode, `int(d)` is interpreted as an argument, so `x` is a variable.

Note that the declaration `A(x2);` is also interpreted differently in the Cfront C++ mode as compared to the standard. The standard dictates that it should be interpreted as the declaration of an object named `x2`, but in the Cfront C++ mode it is interpreted as a `cast` of `x2` to type `A`.

A similar deviation from the standard can be seen in the interpretation of the following declaration:

```
int xyz(int());
```

According to the standard, this declares the function `xyz`, which takes a parameter that is a function without arguments and returns an `int`. In the Cfront mode, this is interpreted as the declaration of an object that is initialized with the value 0.

- Bitfields

A named bitfield may have a size of 0. The declaration is treated as if no name were declared.

Plain bitfields, i.e. bitfields declared with the type `int`, are always `unsigned`.

- The name for a type specifier may be a `typedef` name that is a synonym for a class name:

```
typedef class A T;
class T *pa; // No error in Cfront mode
```

- No warning is issued on duplicate size and sign (`signed` or `unsigned`) type specifiers:

```
short short int i; // No warning in Cfront mode
```

- An extra comma is allowed after the last argument in an argument list:

```
f(1,2,);
```

- A constant pointer-to-member function may be cast to a pointer-to-function. Only a warning is issued:

```
struct A {int f();};
main() {
    int (*p)();
    p = (int (*)())A::f;    // OK, with warning
}
```

- Arguments of class types that allow bitwise copy construction but also have destructors are passed by value (like C structures), and the destructor is not called on the “copy”. In the other modes, the class object is copied to a temporary object; the address of the temporary object is passed as the argument, and the destructor is called on the temporary object after the call returns. In practice, this is not much of a problem, since classes that allow bitwise copying usually do not have destructors.

- If an unnamed class appears in a typedef declaration, the typedef name may be used as the class name.

```
typedef struct {int i, j; } S;  
struct S x; // No error in Cfront mode
```

- A typedef name may be used in an explicit destructor call:

```
struct A { ~A(); };  
typedef A B;  
int main() {  
    A *a;  
    a->~B();           // Permitted in Cfront mode  
}
```

- Two member functions may be declared with the same parameter types when one is static and the other is nonstatic with a function qualifier. For example:

```
class A {  
    void f(int) const;  
    static void f(int);    // no error in Cfront mode  
}
```

- When two functions have the same name and very similar parameter types, they cannot be used together. This is the case when the parameter types differ only in the following aspects:

- char vs. signed char;

```
f(char);  
f(signed char);
```

- Array limits

```
f(char(*x)[15]);  
f(char(*x)[18]);
```

- A const qualification of a typedef

```
typedef char c;  
f(const c*);  
f(c*);
```

- Indirect or combined use of these aspects

```
f(char*,int);  
f(signed char*,int);  
typedef char c;  
g(char,c*);  
g(signed char,const c*);
```

If both functions are defined nevertheless, this is interpreted as a duplicate. No message is issued during compilation.

---

## 8 The C++ libraries and C++ runtime system

The following C++ libraries are provided with CRTE:

- a C++ library for the language modes C++ 2017 and C++ 2020
- a C++ library for the language mode C++ V3
- a C++ library for the Cfront C++ language mode C++ V2
- a C++ V3 library Tools.h++ V7.0
- the C++ runtime system

---

## 8.1 The C++ library for the language modes C++ 2017 and C++ 2020

The library for the language modes C++ 2017 and C++ 2020 is available in two versions. Some classes have small differences in their layout. The two versions are not compatible with each other.

To avoid an accidental combination the implementation was done in two different namespaces. The user interface is in namespace `std`, but the implementation is in namespace `std::__CXX01` or `std::__CXX02`.

Version 1 was published with C/C++ 4.0A00 in the year 2019.

Version 2 was published with C/C++ 4.0B03 in the year 2023.

A program has to use either version 1 or version 2. When both versions are used, the result would be unresolved external references.

The version can be specified with the statement `//MODIFY_LIBRARY_VERSION` or with the posix option `-K library_version`. The default is version 1.

Both versions can be used with the language modes C++ 2017 and C++ 2020.

Some classes in the C++ library use functions which require the posix subsystem. So we strongly recommend to install and activate the posix subsystem on every machine where a program using this library is running.

When a critical function is used and the posix subsystem is not available, the program will terminate at the point of use.

---

### 8.1.1 Reasons for the versioning of the C++ library

The language C++ and its library is still developing. C/C++ supports two modern language standards (C++ 2017 and C++ 2020). The next standard version will be published soon.

In the code generation of the compiler we were able to maintain compatibility. A module produced with C++ 2017 can be linked with a module produced with C++ 2020.

Binary compatibility in the library was not possible. To support standard C++2020 we had to change the layout of a few classes. The next C++ standard may need further changes.

So we decided to deliver two versions of the modern C++ library. Version 1 corresponds to the library of the C++ 2017 standard. It is compatible with the library delivered with previous compiler versions.

Library version 2 contains some features from C++ 2020. This version was added in C/C++ V4.0B03.

Both library versions will continue to be maintained. Both library versions will be delivered in future versions of C/C++ and CRTE.

The versioning is restricted to modern C++. The libraries for language modes V2-COMPATIBLE and V3-COMPATIBLE are not affected.

---

## 8.1.2 The modern C++ library in version 1

This C++ library can only be used in the language modes C++ 2017 and C++ 2020. This library includes the following interfaces (based on the chapters of the C++ standard of 2017):

- Some auxiliary classes (Chapter 23), i.a. Allocator, function objects, smart pointer, pairs, tuples and more.
- String classes (Chapter 24), especially a string of char elements that can handle EBCDIC well,
- Classes for treatment of `locale` (Chapter 25),
- Container classes (Chapter 26), especially `bitset`, `deque`, `queue`, `vector`, `list`, `map`, `multimap`, `set`,
- Iterators (chapter 27),
- generic algorithms (Chapter 28), i.a. `search`, `sort`, `minimum`, `maximum`, `partition`, `permute`,
- numeric classes (Chapter 29), including complex numbers or arithmetic-value arrays,
- Input and Output (Chapter 30), in this library the implementation is template-based,
- regular expressions (chapter 31).

The classes for atomic operations (Chapter 32) and threads (Chapter 33) are not offered.

The include files for the interfaces mentioned above are contained in the library `SYSLIB.CRTE.CXX01`, the modules in the library `SYSLNK.CRTE.CXX01`.

The interface of the C++ library is defined in namespace `std`. References to the library should use this namespace. The implementation is in namespace `std::__CXX01`.

Another component of the C++ library are the include files listed below (also contained in `SYSLIB.CRTE.CXX01`), in which all ANSI C library functions are defined in the namespace `std`.

The names of these include files are derived from the names of the ANSI C include files as follows: The name is preceded by the letter `c`, the suffix `.h` is omitted.

<code>&lt;cassert&gt;</code>	<code>&lt;cinttypes&gt;</code>	<code>&lt;csetjmp&gt;</code>	<code>&lt;cstddef&gt;</code>	<code>&lt;ctgmath&gt;</code>
<code>&lt;cctype&gt;</code>	<code>&lt;ciso646&gt;</code>	<code>&lt;csignal&gt;</code>	<code>&lt;cstdint&gt;</code>	<code>&lt;ctime&gt;</code>
<code>&lt;cerrno&gt;</code>	<code>&lt;climits&gt;</code>	<code>&lt;cstdalign&gt;</code>	<code>&lt;cstdio&gt;</code>	<code>&lt;cuchar&gt;</code>
<code>&lt;cfenv&gt;</code>	<code>&lt;locale&gt;</code>	<code>&lt;cstdlibarg&gt;</code>	<code>&lt;cstdliblib&gt;</code>	<code>&lt;wchar&gt;</code>
<code>&lt;cfloat&gt;</code>	<code>&lt;cmath&gt;</code>	<code>&lt;stdbool&gt;</code>	<code>&lt;cstring&gt;</code>	<code>&lt;wctype&gt;</code>

### Using the library

*Program development in BS2000 environment (SDF)*

The library version 1 has to be selected (default).

During compilation, the library `SYSLIB.CRTE.CXX01` must be searched for standard includes. This is ensured if the option `STD-INCLUDE-LIBRARY=*STANDARD-LIBRARY` is specified in the `MODIFY-INCLUDE-LIBRARY` statement for the search for the standard includes (default).

The program must be linked with the `BIND` statement of the compiler. The specification `RUNTIME-LANGUAGE = *CPLUSPLUS (MODE= *LATEST/*2017/*2020)` is required in the `MODIFY-BIND-PROPERTIES` statement. The default specification is `*LATEST`.

---

For more details see ["MODIFY-BIND-PROPERTIES"](#).

*Program development in POSIX environment*

To insert the include files and bind the modules, the `cc` command must specify the C++ 2017 mode or the C++ 2020 mode. C++ 2020 mode is the default for the `cc` command. The library version 1 has to be selected (default). For further details see the manual "POSIX Commands of the C/C++ Compiler" [1].

## **Documentation**

The standard C++ library is documented in the common C++ literature.

---

### 8.1.3 The modern C++ library in version 2

This C++ library can only be used in the language modes C++ 2017 and C++ 2020. This library includes the following interfaces (based on the chapters of the C++ standard of 2020):

- some `concept` declarations (Chapter 18),
- Some auxiliary classes (Chapter 20), i.a. Allocator, function objects, smart pointer, pairs, tuples and more.
- String classes (Chapter 21), especially a string of char elements that can handle EBCDIC well,
- Container classes (Chapter 22), especially `bitset`, `deque`, `queue`, `vector`, `list`, `map`, `multimap`, `set`,
- Iterators (chapter 23),
- range classes (Chapter 24),
- generic algorithms (Chapter 25), i.a. `search`, `sort`, `minimum`, `maximum`, `partition`, `permute`,
- numeric classes (Chapter 26), including complex numbers or arithmetic-value arrays,
- classes for time and calendar (Chapter 27),
- Classes for treatment of `locale` (Chapter 28),
- Input and Output (Chapter 29), in this library the implementation is template-based,
- regular expressions (chapter 30).

The classes for atomic operations (Chapter 31) and threads (Chapter 32) are not offered.

The include files for the interfaces mentioned above are contained in the library `SYSLIB.CRTE.CXX02`, the modules in the library `SYSLNK.CRTE.CXX02`.

The interface of the C++ library is defined in namespace `std`. References to the library should use this namespace. The implementation is in namespace `std::__CXX02`.

Another component of the C++ library are the include files listed below (also contained in `SYSLIB.CRTE.CXX02`), in which all ANSI C library functions are defined in the namespace `std`.

The names of these include files are derived from the names of the ANSI C include files as follows: The name is preceded by the letter `c`, the suffix `.h` is omitted.

<code>&lt;cassert&gt;</code>	<code>&lt;cinttypes&gt;</code>	<code>&lt;csetjmp&gt;</code>	<code>&lt;cstddef&gt;</code>	<code>&lt;ctgmath&gt;</code>
<code>&lt;cctype&gt;</code>	<code>&lt;ciso646&gt;</code>	<code>&lt;csignal&gt;</code>	<code>&lt;cstdlib&gt;</code>	<code>&lt;ctime&gt;</code>
<code>&lt;cerrno&gt;</code>	<code>&lt;climits&gt;</code>	<code>&lt;cstdlibalign&gt;</code>	<code>&lt;cstdio&gt;</code>	<code>&lt;cuchar&gt;</code>
<code>&lt;cfenv&gt;</code>	<code>&lt;clocale&gt;</code>	<code>&lt;cstdlibarg&gt;</code>	<code>&lt;cstdliblib&gt;</code>	<code>&lt;wchar&gt;</code>
<code>&lt;cfloat&gt;</code>	<code>&lt;cmath&gt;</code>	<code>&lt;stdbool&gt;</code>	<code>&lt;cstring&gt;</code>	<code>&lt;wctype&gt;</code>

### Using the library

*Program development in BS2000 environment (SDF)*

The library version 2 has to be selected with the `MODIFY-LIBRARY-VERSION` statement.

During compilation, the library `SYSLIB.CRTE.CXX02` must be searched for standard includes. This is ensured if the option `STD-INCLUDE-LIBRARY=*STANDARD-LIBRARY` is specified in the `MODIFY-INCLUDE-LIBRARY` statement for the search for the standard includes (default).

---

The program must be linked with the BIND statement of the compiler. The specification `RUNTIME-LANGUAGE = *CPLUSPLUS (MODE= *LATEST/*2017/*2020)` is required in the `MODIFY-BIND-PROPERTIES` statement. The default specification is `*LATEST`.

For more details see "[MODIFY-BIND-PROPERTIES](#)".

### *Program development in POSIX environment*

To insert the include files and bind the modules, the `CC` command must specify the C++ 2017 mode or the C++ 2020 mode. C++ 2020 mode is the default for the `CC` command. The library version 2 has to be selected. For further details see the manual "POSIX Commands of the C/C++ Compiler" [1].

## **Documentation**

The standard C++ library is documented in the common C++ literature.

---

## 8.2 The C++ library for the language mode C++ V3

This C++ library can only be used in the C++ V3 mode of the compiler. This library includes the following interfaces:

- A string class  
`<string>`
- Container classes  
`<bitset>`  
`<deque>`  
`<list>`  
`<map>`  
`<queue>`  
`<set>`  
`<stack>`  
`<vector>`
- Iterators  
`<iterator>`
- Generic algorithms  
`<algorithm>`
- Numeric classes and operations  
`<complex>`  
`<numeric>`
- I/O classes  
`<iostream.h>`  
`<fstream.h>`  
`<strstream.h>`  
`<stdiostream.h>`  
`<iomanip.h>`

The I/O classes are not standard-compliant and correspond to the Cfront V3.0.3-compatible I/O library `iostream`.

The header files for the above interfaces are contained in the library `SYSLIB.CRTE`, and the modules are contained in the library `SYSLNK.CRTE.STDCPP`.

All names of the C++ library, except for the I/O classes, are available in the `std` namespace.

The following header files (also contained in `SYSLIB.CRTE`), in which all ANSI C library functions are defined in the `std` namespace, constitute a further component of the C++ library. The names of these header files are derived from the names of the corresponding C headers as follows: each name is preceded by the letter `c`, and the `.h` suffix is dropped.

<code>&lt;cassert&gt;</code>	<code>&lt;ciso646&gt;</code>	<code>&lt;csetjmp&gt;</code>	<code>&lt;cstdio&gt;</code>	<code>&lt;ctime&gt;</code>
<code>&lt;cctype&gt;</code>	<code>&lt;climits&gt;</code>	<code>&lt;csignal&gt;</code>	<code>&lt;cstdlib&gt;</code>	<code>&lt;cwchar&gt;</code>
<code>&lt;cerrno&gt;</code>	<code>&lt;locale&gt;</code>	<code>&lt;cstdlibarg&gt;</code>	<code>&lt;cstring&gt;</code>	<code>&lt;cwctype&gt;</code>
<code>&lt;cfloat&gt;</code>	<code>&lt;cmath&gt;</code>	<code>&lt;stddef&gt;</code>		

### Using the library

---

*Program development in the BS2000 environment (SDF)*

The library SYSLIB.CRTE must be searched for standard headers at compilation. This can be ensured by specifying the search for standard headers with the option `STD-INCLUDE-LIBRARY= *STANDARD-LIBRARY` (default) in the `MODIFY-INCLUDE-LIBRARY` statement.

The program must be linked with the `BIND` statement of the compiler, and the entry `RUNTIME-LANGUAGE=*CPLUSPLUS(MODE=*V3-COMPATIBLE)` must be specified in the `MODIFY-BIND-PROPERTIES` statement.

For further details see "[MODIFY-BIND-PROPERTIES](#)".

*Program development in the POSIX environment*

In order to include header files and link in the required modules, the C++ V3 mode (`-x V3-COMPATIBLE`) must be specified in the `CC` command. For more details, see also the manual "POSIX Commands of the C/C++ Compiler".

## **Documentation**

This C++ library is described in detail in the following manual: "Standard C++ Library V1.2, User's Guide and Reference" [6] (one volume).

A description of the I/O classes compatible with Cfront V3.0.3 can be found in the "Cfront C++ Library", Reference Manual [5].

---

## 8.3 The C++ library for the Cfront C++ language mode C++ V2

The C++ library compatible with Cfront V3.0.3 can only be used in the Cfront C++ mode of the compiler. This library includes the following interfaces:

- A class for complex math  
`<complex.h>`
- Classes for stream-oriented I/O  
`<iostream.h>`  
`<fstream.h>`  
`<strstream.h>`  
`<stdiostream.h>`  
`<iomanip.h>`  
`<generic.h>`  
`<new.h>`

The header files for the above interfaces are contained in the library SYSLIB.CRTE.CPP, and the modules are located in the library SYSLNK.CRTE.CPP.

### Using the library

*Program development in the BS2000 environment (SDF)*

**i** The headers of the Cfront C++ library contain declarations which use the "at" sign (@). You should note that it will not be possible to use the Cfront C++ library where \*NO is specified in the option AT-ALLOWED=... in the MODIFY-SOURCE-PROPERTIES statement.

In the search for standard headers at compilation, the library SYSLIB.CRTE.CPP must be searched before the library SYSLIB.CRTE. This can be ensured by specifying the search for standard headers with the option STD-INCLUDE-LIBRARY= \*STANDARD-LIBRARY (default) in the MODIFY-INCLUDE-LIBRARY statement.

When linking with the BIND statement of the compiler, only the following entry must be specified in the MODIFY-BIND-PROPERTIES statement:

```
RUNTIME-LANGUAGE=*CPLUSPLUS(MODE=*V2-COMPATIBLE).
```

*Program development in the POSIX environment*

**i** If you use the Cfront C++ library, you cannot use the option `-K no_at`.

In order to include header files and link in the required modules, only the language mode option `-X V2-COMPATIBLE` needs to be specified in the `CC` command. Note, however, that this option must be specified for both compilation and linkage:

```
CC -X V2-COMPATIBLE -c x.C y.C # Compilation
CC -X V2-COMPATIBLE x.o y.o # Linkage
```

---

## Documentation

The Cfront C++ library is described in detail in the following manual:  
“C++ V2.1 (BS2000) C++ Library Functions” [\[5\]](#).

---

## 8.4 The C++ V3 library Tools.h++

The Tools.h++ V7.0 library can only be used in the C++ V3 mode of the compiler.

This library offers a broad spectrum of “foundation classes”, i.e.:

- string classes with pattern-matching mechanisms
- classes to handle the date and time
- virtual streams
- file and file manager classes
- container classes (collectable) with the option of implementing persistence and associated iterator classes:
  - Smalltalk-like container classes (without template usage)
  - template container classes to store values (RWTVal...)
  - template container classes to store pointers (RWTPtr...)
- classes for internationalization

The header files for the above interfaces are contained in the library SYSLIB.CRTE, and the modules are contained in the libraries SYSLNK.CRTE.TOOLS.

### Using the library

*Program development in the BS2000 environment (SDF)*

The library SYSLIB.CRTE must be searched for standard headers at compilation. This can be ensured by specifying the search for standard headers with the option `STD-INCLUDE-LIBRARY= *STANDARD-LIBRARY` (default) in the `MODIFY-INCLUDE-LIBRARY` statement.

The program must be linked with the `BIND` statement of the compiler, and the following options must be specified in the `MODIFY-BIND-PROPERTIES` statement:

`RUNTIME-LANGUAGE=*CPLUSPLUS(MODE=*V3-COMPATIBLE)` and `TOOLS_LIB=*YES`.

For further details see "[MODIFY-BIND-PROPERTIES](#)".

*Program development in the POSIX environment*

In order to include header files and link in the required modules, the C++ V3 mode (`-X V3-COMPATIBLE`) must be specified in the `CC` command.

Furthermore, when linking the program, the option `-l RWtools` must also be specified. For more details, see also the manual “POSIX Commands of the C/C++ Compiler” [1].

### Documentation

The C++ V3 library Tools.h++ is described in detail in the following manuals:

“Tools.h++ V7.0, User s Guide” and

“Tools.h++ V7.0, Class Reference”

---

## Information on the documentation

In order to make the *tools.h++* library independent of incompatible future versions of the standard library, it is not based on the standard library (i.e. the `RW_NO_STL` directive has been placed in the central configuration header `w/compiler.h`).

Certain classes are therefore not available or only available with restrictions. These are identified accordingly in the “Tools.h++ Class Reference” manual [8], e.g.

“RWTVaIMap requires the Standard C++ Library.”

When the associated headers are used, a *#error* error message is issued, e.g.

```
“Cannot include header if RW_NO_STL macro is defined for your compiler”
```

or

```
“You must have both Standard Library and Exceptions to use this class.”
```

Some classes implement functions which are linked to particular systems:

*header rw/xdrstrea.h; class RWXDRistream and RWXDRostream*

These classes can be used in BS2000/POSIX, but not in BS2000 native.

*header rw/winstrea.h; class RWCLIPstreambuf*

The “Tools.h++ Class Reference” manual [8] contains the following information on this:

“Class RWCLIPstreambuf is a specialized streambuf that gets and puts sequences of characters to Microsoft Windows global memory. It can be used to exchange data through Windows clipboard facility.”

As neither the concept of a “Microsoft Windows global memory” nor that of a “Windows clipboard” exists in Windows, this class is not available here.

---

## 8.5 The C++ runtime system

This section provides information concerning the following topics:

- Initialization
- Exception handling
  - Additional runtime functions
  - C signal handling and C++ exception handling
  - longjmp support
  - Linking old C modules with C++ V3, C++ 2017 and C++ 2020 modules

---

## 8.5.1 Initialization

Exceptions thrown during the initialization of global objects result in a call to `terminate` and thus cause the program to abort without diagnostics. If desired, you can use `set_terminate` to specify some other exception-handling routine to be used in the event of an unforeseen program abort. This function must, however, be called before initializing the global objects.

The C++ runtime system offers the following solution to specify functions to be used as the “initial current handler”:

- You can link your own `__initial_terminate_handler` function of type `terminate_handler` into your program. This function is declared `weak` in the C++ runtime system. If `__initial_terminate_handler` is defined, the function will then be called as the “initial handler” to terminate exception processing.
- You can also use the functions `__initial_unexpected_handler` and `__initial_new_handler` with the same mechanism. These routines are of type `unexpected_handler` and `new_handler`, respectively.

You must include the header file `<exception>` for the `__initial_terminate_handler` and `__initial_unexpected_handler` interfaces and the header file `<new>` for the `__initial_new_handler`.

---

## 8.5.2 Exception handling

This section provides information concerning the following topics:

- [Additional runtime functions](#)
- [C signal handling and C++ exception handling](#)
- [longjmp support](#)
- [Linking old C modules with C++ V3, C++ 2017 and C++ 2020 modules](#)

---

### 8.5.2.1 Additional runtime functions

Besides the runtime functions defined by the language standard, the C++ runtime system offers a number of useful functions with which programs can be made more reliable. Note, however, that programs which use these functions are not ANSI C++-compliant and are hence not portable.

The following additional functions are available: `unwind_exit`, `get_caught_object_typeid`, `can_throw` and `can_rethrow`.

These functions are all part of the `_SNI_extensions` namespace.

The `EO_flag_set` data type used for the arguments is also defined in the `_SNI_extensions` namespace.

### Data Type `EO_flag_set`

The data type `EO_flag_set` is used to display properties of an exception object.

The definition of `EO_flag_set` in the language mode C++ V3 differs from the definition in language mode C++ 2017 or C++ 2020.

### `EO_flag_set` in language mode C++ 2017 or C++ 2020

In the language mode C++ 2017 or C++ 2020 `EO_flag_set` is defined as follows:

```
namespace _SNI_extensions {
    typedef unsigned int EO_flag_set;
}
```

The following flag values are defined for data items of type `EO_flag_set`:

```
EO_NO_FLAGS           : not a pointer type / no flag set
EO_IS_POINTER         : pointer type
EO_POINTER_TO_CONST   : pointer to a constant object
EO_POINTER_TO_VOLATILE : pointer to a volatile object
EO_LAST               : last element of a flag array
```

### `EO_flag_set` in language mode C++ V3

In the language mode C++ V3 `EO_flag_set` is defined as follows:

```
namespace _SNI_extensions {
    typedef unsigned char EO_flag_set;
}
```

The following flag values are defined for data items of type `EO_flag_set`:

```
EO_NO_FLAGS           : not a pointer type
EO_IS_POINTER         : pointer type
EO_POINTER_TO_CONST   : pointer to a constant object
EO_POINTER_TO_VOLATILE : pointer to a volatile object
```

---

## unwind\_exit - Unwind stack before exiting program

The `unwind_exit` function, like `exit`, is used to terminate a program. In contrast to `exit`, however, a call to `unwind_exit` causes the following additional actions to be performed before the program is exited:

- All `automatic` objects on the runtime stack that have not yet been deleted are destroyed.
- All exception objects that have not been exited are destroyed.

This is followed by the destruction of global objects as in the case of `exit`.

Note that neither `exit` nor `unwind_exit` will destroy objects on the heap that have not been released.

If a destructor called by `unwind_exit` ends with an exception, `terminate` is called implicitly. It is therefore advisable to call `unwind_exit` in the `terminate_handler` as well. This will guarantee that the destructors for all `automatic` and exception objects are eventually called in any case. This cannot result in an endless loop.

The `unwind_exit` function can be called from any part of the program (like `exit`), especially from a `terminate_handler`. Like `exit`, it is supplied with an exit status as an argument (and with the same effect).

The prototype of the `unwind_exit` function is declared in the `<exception>` header:

```
#include <exception>
namespace _SNI_extensions {
    void unwind_exit(int status);
}
```

## get\_caught\_object\_typeid - Determine type of caught exception object

The function `get_caught_object_typeid` can be used to determine the type of a caught exception object. It returns the type of the exception object that was most recently caught and was not finished. If no caught and unfinished exception object exists, an exception of type `bad_typeid` is thrown.

The function `get_caught_object_typeid` can be called in any handler (`terminate_handler`, `unexpected_handler`, `catch(...) {...}`) to obtain information about the type of the caught exception object. This can be useful in diagnosing program runtime errors.

The type of the caught exception object is returned as a reference to a `type_info` object. The class `type_info` and the prototype of the function `get_caught_object_typeid` are declared in the `<typeinfo>` header:

The definition of the function `get_caught_object_typeid` in the language mode C++ V3 differs from the definition in language mode C++ 2017 or C++ 2020.

## get\_caught\_object\_typeid in language mode C++ 2017 or C++ 2020

The prototype of the function `get_caught_object_typeid` is declared in the header file `<typeinfo>` as follows

```
#include <typeinfo>
namespace _SNI_extensions {
    const type_info &get_caught_object_typeid(EO_flag_set *pflags, EO_flag_set **ppflags);
}
```

---

If the arguments to `get_caught_object_typeid` are non-zero, they are interpreted as addresses to receive information on whether the caught object is a pointer.

The behavior depends on whether the exception object is not a pointer, a simple pointer or a pointer to a pointer.

If the exception object is not a pointer, its type is returned as a reference to a `type_info` object. `*pflags` will be set to `EO_NO_FLAGS`. `*ppflags` will be set to zero.

If the exception object is a pointer to a non-pointer, the type pointed to is returned. `*pflags` will be set to `EO_IS_POINTER`, `(EO_IS_POINTER | EO_POINTER_TO_CONST)`, `(EO_IS_POINTER | EO_POINTER_TO_VOLATILE)` or `(EO_IS_POINTER | EO_POINTER_TO_CONST | EO_POINTER_TO_VOLATILE)` depending on type attributes (`const` and/or `volatile`). `*ppflags` will be set to zero.

If the exception object is a pointer to a pointer, the first non-pointer type after the pointer chain is returned. `*pflags` will be set to `EO_NO_FLAGS`. An array is built to describe the attributes of each pointer in the chain. To indicate `const` the flag value `EO_POINTER_TO_CONST` is used, to indicate `volatile` the flag value `EO_POINTER_TO_VOLATILE` is used. The last element of the array has the additional flag value `EO_LAST`. `*ppflags` will be set to point to this array.

As an example: if the exception object is of type `"volatile char * *const *"` the array `{ EO_POINTER_TO_CONST, EO_NO_FLAGS, EO_POINTER_TO_VOLATILE|EO_LAST }` is built.

## get\_caught\_object\_typeid in language mode C++ V3

The prototype of the function `get_caught_object_typeid` is declared in the header file `<typeinfo>` as follows

```
#include <typeinfo>
namespace _SNI_extensions {
    const type_info &get_caught_object_typeid(EO_flag_set *pflags);
}
```

If the exception object is not a pointer, its type is returned as a reference to a `type_info` object. If the exception object is a pointer, the type pointed to is returned. If the argument to `get_caught_object_typeid` is non-zero, it is interpreted as an address to receive information on whether the caught object is a pointer, and if it is, also the type attributes applicable to the object pointed to ([values see above](#)). As an example: when a `const char *` was thrown, the typeid of `char` will be returned and `*pflags` will be set to `(EO_IS_POINTER | EO_POINTER_TO_CONST)`.

## can\_throw - Check for terminate or unexpected on throwing an object

The function `can_throw` (predicate) checks whether an exception of the specified type can be thrown without resulting in a call to `terminate` or `unexpected`.

```
#include <typeinfo>
namespace _SNI_extensions {
    bool can_throw(const std::type_info &typeid_to_check,
                  EO_flag_set flags = EO_NO_FLAGS);
}
```

`typeid_to_check` must be a non-pointer type of an exception object.

---

flags can be used to specify whether the type of exception to be actually checked is a pointer or whether it is a const or volatile (values see above)

If the flags argument is not specified, EO\_NO\_FLAGS (not a pointer type) is set by default.

### **can\_rethrow - Check for terminate or unexpected on rethrowing an object**

The function can\_rethrow (predicate) checks whether an exception can be rethrown (throw;) without resulting in a call to terminate or unexpected.

```
#include <typeinfo>
namespace _SNI_extensions {
    bool can_rethrow(void);
}
```

---

### 8.5.2.2 C signal handling and C++ exception handling

According to the C++ language definition, the use of C++ exception handling is not allowed in C signal routines. If a C signal routine is nonetheless reached by the runtime system during stack processing triggered by an exception, the system behaves as if the end of the stack were reached. Consequently, it is not possible to throw an exception from a signal routine or to rethrow an exception that was caught with `catch` before the signal routine was called. In such cases, `terminate` is invoked instead.

The function `unwind_exit` (see "[Additional runtime functions](#)") does not destroy all objects when called from signal routines. All `automatic` objects which were not deleted before the call to the signal routine and all exception objects that had not yet terminated are not destroyed in this case. However, the program still terminates with `exit`.

### 8.5.2.3 longjmp support

After a `longjmp` call, the following actions are performed by the C++ runtime system for each function that is skipped:

- All `automatic` objects that were constructed in the function but not deleted are destroyed.
- All exception objects which were caught in the function but which have not terminated are destroyed.

Note, however, that these destructors are not invoked for the target function of the `longjmp` call itself. Consequently, in a function containing a `setjmp` call, no object should be constructed, destroyed or caught between the `setjmp` call and the entry of the routine aborted by the `longjmp`. This can be achieved by relocating all code for constructors, destructors and catching exceptions to a separate function. Furthermore, in order to prevent this function from being inlined, it must be called via an external function pointer. Consider the following example:

#### *Example*

Instead of using the code of the function `f()` in Version 1, the code of Version 2 is to be used:

*/\* Version 1 \*/*

```
#include <setjmp>
jmp_buf target;
void g();
class X { ~X(); };
void g()
{
    longjmp(target, 1);
}
void f()
{
    if (setjmp(target) == 0)
    {
        X x;           // No destruction for longjmp call by g()
        g();
    }
}
```

*/\* Version 2 \*/*

```
void f1()
{
    X x;           // Destruction for longjmp call by g()
    g();
}
extern void (*f1p)() = f1;
void f()
{
    if (setjmp(target) == 0)
    {
        (*f1p)();   // f1() is not inlined here
    }
}
```

---

## **longjmp and signal routines**

When `longjmp` is called from a signal routine, no destructors for `automatic` and exception objects are executed in the function in which the signal occurred.

---

#### 8.5.2.4 Linking old C modules with C++ V3, C++ 2017 and C++ 2020 modules

C modules generated with the C or C++ Compiler V2.2 can be linked with C++ V3, C++ 2017 and C++ 2020 modules. Note, however, that the following restrictions apply with respect to stack handling by the C++ runtime system:

- No exception may be thrown if there is still an active C V2.2 function between the call to `throw` and the exception handler (`catch`) which catches the exception.
- No exception may be rethrown if there is still an active C V2.2 function between the call to `throw`; and the exception handler (`catch`) that has caught the rethrown exception.
- No `longjmp` across a C V2.2 function may be executed from a C++ function.

---

## 9 Appendix

This chapter provides information concerning the following topics:

- Description of listings
  - Source/error listing
  - Map listing
  - Cross-reference listing
  - Object listing
- Predefined preprocessor names
- Concept of a name adapter module in the C runtime system
- The II-UPDATE tool

---

## 9.1 Description of listings

The listing generators of the compiler produce the following listings, depending on what is requested in the MODIFY-LISTING-PROPERTIES statement:

<b>Listing</b>	<b>Options of the MODIFY-LISTING-PROPERTIES statement</b>
Option listing	OPTIONS
Source/error listing	SOURCE
Preprocessor listing	PREPROCESSING-RESULT
Map listing	DATA-ALLOCATION-MAP
Cross-reference listing	CROSS-REFERENCE
Project listing	PROJECT-INFORMATION
Object code listing	ASSEMBLER-CODE
Summary listing	SUMMARY

The following listings are described below by means of examples: source/error, map, cross-reference, and object listings.

In some listings spaces have been removed to avoid line breaks.

## 9.1.1 Source/error listing

The source/error listing is requested with the SOURCE option of the MODIFY-LISTING-PROPERTIES statement.

```
*** SOURCE - ERROR - LISTING **      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 1
                                      SOURCENAME:*BS2000(MAINPROG)          TIME=17:37:07
```

EXP	INC	FILE	SRC	BLOCK	
LIN	LEV	NO	LIN	LEV	
1	0	0	1	0	#include <stdio.h>
1746	0	0	2	0	#include "incl1.h"
1747	1	10	1	0	class A
1748	1	10	2	0	{
1749	1	10	3	0	int i;
1750	1	10	4	0	public:
1751	1	10	5	0	A(int x = 1) : i(x) {};
1752	1	10	6	0	void foo() { printf( "A::foo called\n" ); };
1753	1	10	7	0	} a;
1754	0	0	3	0	#include "incl2.h"
1755	1	11	1	0	class B : public A
1756	1	11	2	0	{
1757	1	11	3	0	int i;
1758	1	11	4	0	public:
1759	1	11	5	0	B(int x = 2) : i(x) {};
1760	1	11	6	0	void foo() { printf( "B::foo called\n" ); };
1761	1	11	7	0	} b;
1762	0	0	4	0	extern "C" int jj;
1763	0	0	5	0	extern int ii;
1764	0	0	6	0	
1765	0	0	7	0	int main(void)
1766	0	0	8	0	{
1767	0	0	9	1	char *string = "AbCdEfG";
1768	0	0	10	1	float xx = 1.0;
1769	0	0	11	1	int ii = 1;
1770	0	0	12	1	int jj = 2;
1771	0	0	13	1	A* aptr = &a;
1772	0	0	14	1	A* bptr = &b;
1773	0	0	15	1	
1774	0	0	16	1	printf("%d\n", ii);
1775	0	0	17	1	printf("%d\n", jj);
1776	0	0	18	1	printf("%s\n", string);
1777	0	0	19	1	printf("%f\n", xx);
1778	0	0	20	1	a.foo();
1779	0	0	21	1	aptr->foo();
1780	0	0	22	1	b.foo();
1781	0	0	23	1	bptr->foo();
1782	0	0	24	1	
1783	0	0	25	1	return 0;
1784	0	0	26	1	}

(1) The contents of header elements, depending on what is specified in the INCLUDE-INFORMATION option of the MODIFY-LISTING-PROPERTIES statement (only the user-defined header elements in this case).

---

## Explanation

EXP, LIN

Serial line number in the source listing, including all lines of the header elements used in the source program. The lines from the header elements are always included in the count, regardless of whether or not they are displayed in the source listing (see the INCLUDE-INFORMATION option).

INC, LEV

Nesting level of the header elements.

FILE, NO

Number of the file (source file or header element) for which the respective contents are mapped in the source listing. This number (starting with 0 for the source file) is incremented by 1 for each `#include` or `#line` directive. At the end of each header element, the number is reset to the value of the file containing the associated `#include` directive. This number is relevant for the source reference for debugging with AID if header elements contain executable statements or if `#line` directives are interspersed with executable statements in source programs. Only the user-defined header elements, i.e. `incl1.h` (10) and `incl2.h` (11), are expanded in the example. The standard header element `stdio.h` and the other `#include` directives contained in it are assigned the numbers 1 to 9 (see also the FILETABLE section in the cross-reference listing).

SCR, LIN

Original line number in the source file or header element, taking `#line` directives into account.

BLOCK, LEV

Nesting level of the statement blocks.

## 9.1.2 Map listing

The map listing is requested with the DATA-ALLOCATION-MAP option of the [MODIFY-LISTING-PROPERTIES](#) statement. It provides information on all the symbolic addresses used in the program (names of variables and functions).

```
***** MAP - LISTING *****      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 3
                                SOURCENAME:*BS2000(MAINPROG)          TIME=17:37:33
```

name	stcl/type	size	slice	offs	xoffs	enuval	stroffs	xstroffs
a	nospec class	4	1	104	0x0068	-	-	-
aptr	auto pointer to class	4	1	24	0x0018	-	-	-
b	nospec class	8	1	108	0x006C	-	-	-
bptr	auto pointer to class	4	1	28	0x001C	-	-	-
ii	extern signed int	4	-	-	-	-	-	-
ii	auto signed int	4	1	16	0x0010	-	-	-
jj	extern signed int	4	-	-	-	-	-	-
jj	auto signed int	4	1	20	0x0014	-	-	-
main	nospec entry_var	0	1	48	0x0030	-	-	-
string	auto pointer to char	4	1	8	0x0008	-	-	-
x	param signed int	4	-	-	-	-	-	-
x	param signed int	4	-	-	-	-	-	-
xx	auto float	4	1	12	0x000C	-	-	-
A	nospec class	4	-	-	-	-	-	-
B	nospec class	8	-	-	-	-	-	-

### Explanation

name    Name of the symbolic address.

---

stcl storage class: Storage class of the symbolic address.  
The following specifiers are used

- auto Variables at block level, excluding static variables
- extern External variables and functions that are defined in a different module
- member Elements of classes, structures or unions  
Enumeration values
- param Function parameters
- reg Variables declared with the keyword `register`
- static Static variables at block level, i.e. that are valid at block level
- statmem Static element of a class
- typedef typedef Name
- nospec No storage class was specified

type Data type of the symbolic address (in a separate line under the storage class).  
Most entries are obvious. Special values are:

- ass\_proc assignment Operator
- bit bitfield
- entry\_var function
- enum enumeration type
- enum\_val enumeration value
- lab\_const label
- mem\_pointer pointer to member
- opr\_func operator function
- tmpl Template
- tmpl\_inst Template Instanz
- tmpl\_par\_cl Template Parameter

size Size of the variable in memory (in bytes).

slice A slice is an area (code or data fragment) with a length of 4096 bytes that can be addressed via a base register.

The digit specifies in which slice of the data module the variable is located.

offs Relative address within a slice (decimal).

- 
- xoffs     Relative address within a slice (hexadecimal).
  - enuval   For members of an enumeration type (enum), enuval specifies the value of the member.
  - stroffs   Byte position of the symbolic address within a structure (decimal).
  - xstroffs   Byte position of the symbolic address within a structure (hexadecimal).

### 9.1.3 Cross-reference listing

The cross-reference listing is requested with the CROSS-REFERENCE option of the MODIFY-LISTING-PROPERTIES statement.

It consists of the following parts:

- The FILETABLE section contains the names of all files or libraries/elements that were used by the compiler as a source (source program or header element). A number is assigned to each of these names. These numbers are referenced in the other sections of the cross-reference listing.
- The PREPROCESSING-INFO section contains a list of the names processed by the preprocessor in #include and #define directives (macros, header element names, etc.).
- The TYPES section contains a list of the user-defined types (typedefs, classes, structure, union, and enumeration types).
- The VARIABLES section contains a list of variables.
- The FUNCTIONS section contains a list of functions.
- The LABELS section contains a list of labels.
- The TEMPLATES section contains a list of templates (in language modes C++ V3, C++ 2017 and C++ 2020 only).

The names in the individual lists are sorted in alphabetical order.

The PREPROCESSING-INFO, TYPES and TEMPLATES sections are not included in the cross-reference listing by default and must be explicitly specified with PREPROCESSING-INFO=\*YES, TYPES=\*YES or TEMPLATES=\*YES, respectively.

#### FILETABLE section of the cross-reference listing

```
***** XREF - LISTING *****      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 1
      FILETABLE          SOURCENAME:*BS2000(MAINPROG)                TIME=17:37:52

-----
SOURCE FILE      0 = *BS2000(:2OSL:$TST30B.MAINPROG)
INCLUDE FILE     1 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,STDIO.H(V04.3A10),S)
INCLUDE FILE     2 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,IOBUF.H(V04.3A10),S)
INCLUDE FILE     3 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,POSFILE.H(V04.3A10),S)
INCLUDE FILE     4 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,STDIO.BS21.H(V04.3A10),S)
INCLUDE FILE     5 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,STDIO.COMMON.H(V04.3A10),S)
INCLUDE FILE     6 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,STDIO.BS22.H(V04.3A10),S)
INCLUDE FILE     7 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,CGLOBALS.H(V04.3A10),S)
INCLUDE FILE     8 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,IOBUF.H(V04.3A10),S)
INCLUDE FILE     9 = *LIBRARY-ELEMENT(:2OSL:$TSOS.SYSLIB.CRTE,ERRNO.H(V04.3A10),S)
INCLUDE FILE    10 = *LIBRARY-ELEMENT(:2OSL:$TST30B.PLAM.INCL,INCL1.H(*UPPER-LIMIT),S)
INCLUDE FILE    11 = *LIBRARY-ELEMENT(:2OSL:$TST30B.PLAM.INCL,INCL2.H(*UPPER-LIMIT),S)
-----
```

#### *File number in global cross-reference listings*

In a cross-reference listing that was created with the global listing generator from multiple CIF files (see section [“Controlling the global listing generator”](#)), the file number is indicated in the form  $n(m)$ , where  $n$  is the sequential number of the source and header files (analogous to the local cross-reference listing; see above) used for each compilation unit (= CIF file), and  $m$  is the number of the respective compilation unit. The numbering of compilation units begins with 0.

## PREPROCESSING-INFO section in the cross-reference listing

```
***** XREF - LISTING *****      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 2
      PREPRO          SOURCENAME:*BS2000(MAINPROG)          TIME=17:37:52

56/12:5
*LIBRARY-ELEMENT(:2OSC:$TST30B.PLAM.INCL,INCL1.H(*UPPER-LIMIT),S) / include file
 2%0
*LIBRARY-ELEMENT(:2OSC:$TST30B.PLAM.INCL,INCL2.H(*UPPER-LIMIT),S) / include file
 3%0

'. 'applied ':'def ':'^'undef '%'included
```

## TYPES section in the cross-reference listing

```
***** XREF - LISTING *****      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 3
      TYPES          SOURCENAME:*BS2000(MAINPROG)          TIME=17:37:52

a0000270          / struct of size 16 (0x10)
std              / namespace
A                / class of size 4 (0x4)          ----- (1)
 1/7:10          1/18.11          13/3.0          14/3.0 ----- (2)
                public baseclass of class 'B'
  i              / member, signed int, private ----- (3)
  A              / inline constructor( signed int ), public
  foo            / member, inline function( void ) ret void, public
B                / class of size 8 (0x8)
 1/7:11
  A              / baseclass, public
  i              / member, signed int, private
  B              / inline constructor( signed int ), public
  foo            / member, inline function( void ) ret void, public

'. 'used ':'def '&'decl
```

## Explanation

- (1) Name and description of the user-defined type, possibly with a size specification (decimal and hexadecimal).
- (2) From left to right:  
source program line and column in which the type appears,  
abbreviation symbol for usage of the type,  
number of the source file or (header) element from the FILETABLE.  
  
For example, 14/3.0 means that a variable of type class A is defined in line 14, column 3 of the source program mainprog (0), and that the type is used (.).
- (3) In the case of structured types, the respective components of these types are also described (indented). The data members of structures, classes, and unions are listed only in the TYPES section (they are not variables).  
Members of functions are repeated in the FUNCTIONS section.

(3) Bei strukturierten Typen werden auch die Komponenten dieser Typen (jeweils eingerückt) beschrieben.

Die Datenelemente von Strukturen, Klassen und Unions werden ausschließlich im TYPES-Teil aufgelistet (sind keine Variablen). Die Funktionselemente erscheinen noch einmal im FUNCTIONS-Teil.

## VARIABLES section in the cross-reference listing

```
***** XREF - LISTING *****      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 4
      VARIABLES      SOURCENAME:*BS2000(MAINPROG)      TIME=17:37:52
-----
a          / class 'A'          ----- (1)
  7/3=10   7/3:10      13/14&0      20/3&0 ----- (2)
aptr      / automatic, pointer to class 'A',
          local in main( void ) ret signed int, init value = &a
  13/6=0   13/6:0      21/3.0
b          / class 'B'
  7/3=11   7/3:11      14/14&0      22/3&0
bptr      / automatic, pointer to class 'A',
          local in main( void ) ret signed int, init value = &b
  14/6=0   14/6:0      23/3.0
i          / member, signed int,
          member of class 'A'
  3/10:10  5/21=10
i          / member, signed int,
          member of class 'B'
  3/10:11  5/21=11
ii         / automatic, signed int,
          local in main( void ) ret signed int, init value = 1
  11/7=0   11/7:0      16/18.0
ii         / extern, signed int
  5/12:%0
jj         / extern, signed int
  4/16:%0
jj         / automatic, signed int,
          local in main( void ) ret signed int, init value = 2
  12/7=0   12/7:0      17/18.0
string     / automatic, pointer to char,
          local in main( void ) ret signed int, init value = "AbCdEfG"
  9/9=0    9/9:0      18/18.0
x          / param of constructor A::A, signed int
  5/12:10  5/23.10
x          / param of constructor B::B, signed int
  5/12:11  5/23.11
xx         / automatic, float,
          local in main( void ) ret signed int, init value = 1
  10/9=0   10/9:0      19/18.0
-----
'='write '.'read '*='indir-write '*.'indir-read '&'read-addr ':'def '%'decl ':%'extdecl
'%%'use
```

## Explanation

(1) Name, storage class and data type of the variables.

- 
- (2) From left to right: source program line and column in which the variable appears, abbreviation symbol for usage of the variable, and number of the source file or (header) element from the FILETABLE

For example, 7/3:10 means that the variable `a` is defined (:) in line 7, column 3 of the header element `incl1.h` (10).

## FUNCTIONS section in the cross-reference listing

```
***** XREF - LISTING *****      BS2000 C/C++ COMPILER 04.0B02      DATE:2023-04-02 PAGE: 5
          FUNCTIONS          SOURCENAME:*BS2000(MAINPROG)          TIME=17:37:52
-----
foo          / public member of class 'B', inline function( void ) ret void -- (1)
  6/11:11    22/5.0
foo          / public member of class 'A', inline function( void ) ret void -- (2)
  6/11:10    20/5.0          21/9.0          23/9.0
main         / function( void ) ret signed int
  7/5:0
A            / public member of class 'A', inline constructor( signed int )
  5/6:10     7/3.10          5/26.11
B            / public member of class 'B', inline constructor( signed int )
  5/6:11     7/3.11
-----
'. 'call ':'def '&'decl '%'extdecl ':^'forward '&.'read-addr
```

## Explanation

- (1) Name of the function, its scope, signature (type of parameters and return type), and storage class.  
For member functions, additional information on the access rights (e.g. public) and the class or union in which it is contained.
- (2) From left to right:  
source program line and column in which the function appears,  
abbreviation for usage at that position,  
number of the source file or (header) element from the FILETABLE.

For example, 6/11:11 means that the function `foo` is defined (:) in line 6, column 11 of the header element `incl2.h` (11).

---

### 9.1.4 Object listing

The object listing is requested with the ASSEMBLER-CODE option of the MODIFY-LISTING-PROPERTIES statement.

It contains

- the hexadecimal representation of object code generated by the code generator,
- the object code in Assembler notation,
- comments concerning the object code in Assembler notation,
- the source program lines in C/C++ notation as comments.

The overall listing is arranged into separate sections for code and data modules. Each module listing is divided into areas. The beginning of a given module or area listing is indicated by comment lines in the Assembler source program.

```

1 *****
2 *          CODE MODULE
3 *
4 *          OPTIMIZER:      ON
5 *          SHARED CODE:   OFF
6 *          OBJECT FORMAT: LLM
7 *****
000000 8 MAINPROG\&@ CSECT      READ
000000 9 MAINPROG\&@ AMODE      ANY
000000 10 MAINPROG\&@ RMODE     ANY
11 *****
12 *          CODE AREA (main)
13 *****
000000 14          ENTRY  MAIN
000000 15 MAIN      DS      0A
000000 16          USING *,15
000000 90 EF D00C 17          STM      14,15,12(13)
000004 90 2C D01C 18          STM      2,12,28(13)
000008 58 90 D04C 19          L        9,76(0,13)
00000C 98 AB F068 20          LM      10,11,#DC#CONT#10      104(15)
000010 58 E0 9018 21          L        14,24(0,9)
000014 41 00 E0D8 22          LA      0,216(0,14)
000018 55 00 9010 23          CL      0,16(0,9)
00001C 47 20 F044 24          BC      2,#OFLOW#10      68(0,15)
000020 50 00 9018 25          ST      0,24(0,9)
000000 00 00      26 #OFLOWOK#10 EQU *
000024 50 E0 900C 27          ST      14,12(0,9)
000028 58 00 F088 28          L        0,#DC#SAVID#10  136(0,15)
00002C 50 00 E000 29          ST      0,0(0,14)
000030 58 00 F08C 30          L        0,#DC#EHL#10     140(0,15)
000034 50 00 E050 31          ST      0,80(0,14)
000038 50 D0 E004 32          ST      13,4(0,14)
00003C 50 90 E04C 33          ST      9,76(0,14)
000040 18 DE      34          LR      13,14
000042 07 FA      35          BCR     15,10
.
.
.
000094 58 80 F084 69          L        8,132(0,15)
70 ***** LINE 7: (*BS2000(:2OSC:$TST30B.MAINPROG))
71 ***** int main(void)
000098 72 @0000001 DS      0H
73 ***** LINE 8
74 ***** {
000098 75 @0000002 DS      0H
000098 58 F0 B024 76          L        15,36(0,11)      <17>      <17>
00009C 41 00 0000 77          LA      0,0(0,0)
0000A0 0D EF      78          BASR   14,15
79 ***** LINE 16
80 ***** printf("%d\n", ii);
|          |          |          |          |
|          |          |          |          |
|          |          |          |          |
(1)      (2)      (3)      (4)      (5)

```

---

## Explanation

- (1) Location counter, in hexadecimal notation
- (2) Object code, in hexadecimal notation
- (3) Line number of the Assembler code
- (4) Assembler code (symbolic address, Assembler mnemonics, operands) and source program line as a comment
- (5) Explanation of the Assembler code

---

## 9.2 Predefined preprocessor names

When the C/C++ compiler is used for compilation in the SDF environment (COMPILE, CHECK-SYNTAX, and PREPROCESS statements), some preprocessor macros and assertions are predefined, depending on which language mode is selected and which additional options are specified.

For a few macros the value is fixed. It cannot be changed, neither on the command line nor in the source (via #define or #undef). These macros are: \_\_cplusplus, \_\_STDC\_\_, \_\_STDC\_VERSION\_\_ and \_\_SNI\_\_STDCplusplus.

### Predefined preprocessor macros (defines)

The options specified below are all part of the MODIFY-SOURCE-PROPERTIES statement:

<code>__BOOL</code>	In the language modes C++ V3, C++ 2017 and C++ 2020 with the option KEYWORD-BOOL=*YES
<code>__CGLOBALS_PRAGMA</code>	Always set
<code>__cplusplus</code>	In all C++ language modes: == 1 in Cfront C++ mode == 2 in extended C++ V3 mode == 199612L in strict C++ V3 mode == 201703L in C++ 2017 mode == 202002L in C++ 2020 mode
<code>c_plusplus</code>	In all C++ language modes
<code>__cpp_...</code>	Several defines specified in the C++ standard. They are set when the corresponding feature is supported in the current language mode.
<code>__CFRONT_V3</code>	In language mode Cfront C++
<code>__EDG_NO_IMPLICIT_INCLUSION</code>	In the modes C++ V3, C++ 2017 and C++ 2020, if implicit inclusion has been disabled with the option IMPLICIT-INCLUDE=*NO within the framework of template instantiation
<code>__EXISTCGLOB</code>	Always set
<code>__HALF_TAG_LOOKUP</code>	Always set
<code>__IEEE</code>	Option FP-ARITHMETICS=*IEEE in MODIFY-MODULE-PROPERTIES statement
<code>LANGUAGE_C</code>	Always set
<code>__LANGUAGE_C</code>	Always set
<code>__LIBCPP_STD_VER</code>	In mode C++ 2020: the compiler will set it to the value 17 In mode C++ 2017: the library headers will set it to the value 17
<code>__LITERAL_ENCODING_ASCII</code>	

---

	Option LITERAL-ENCODING=*ASCII[-FULL]
__LITERAL_ENCODING_EBCDIC	
	Option LITERAL-ENCODING=*EBCDIC[-FULL]/*NATIVE
__LONGLONG	Option LONGLONG=*YES
__OLD_SPECIALIZATION_SYNTAX	
	== 1 with the option SPECIALIZATION=*OLD
__SHORT_NAMES	Is defined, if C-NAMES=*SHORT is specified
__SIGNED_CHARS__	Option SIGNED-CHARACTER=*YES
__SMALL_VA_DCL	Always set
__SNI	In all C modes and in Cfront C++ mode
__SNI_HOST_BS2000	Always set
__SNI_HOST_BS2000_POSIX	Never set (reserved for compilation in POSIX)
__SNI_PRINTF_CHECK	Always set
__SNI__STDCplusplus	in all C++ language modes: == 0 in extended language modes (STRICT=*NO) == 1 strict language modes (STRICT=*YES)
__SNI_TARG_BS2000	Always set
__SNI_TARG_BS2000_POSIX	Never set (reserved for compilation in POSIX)
__STDC__	Always set: == 0 in extended language modes (STRICT=*NO) == 1 in strict language modes (STRICT=*YES)
__STDC_HOSTED__	Always set
__STDC_NO_ATOMICS__	Always set
__STDC_NO_COMPLEX__	Always set
__STDC_NO_THREADS__	Always set
__STDCPP_DEFAULT_NEW_ALIGNMENT__	Always set == 8U
__STDC_UTF_16__	Always set
__STDC_UTF_32__	Always set

---

---

<code>__STDC_VERS_CRTE__</code>	Undefined in K&R C mode == 199409L in language modes C89, Cfront C++ and C++ V3 == 201112L in language modes C11, C++ 2017 and C++ 2020
<code>__STDC_VERSION__</code>	Undefined in K&R C mode == 199409L in language mode C89 and in all C++ language modes == 201112L in language mode C11
<code>__STRICT_STDC</code>	in strict language modes (STRICT=*YES)
<code>_WCHAR_T</code>	Option KEYWORD-WCHAR=*YES (default in den language modes C++ V3, C++ 2017 and C++ 2020) If this option is not set (e.g. in C modes or in Cfront C++ mode), <code>_WCHAR_T</code> is defined in various standard headers to issue a <code>typedef</code> for <code>wchar_t</code> .
<code>_WCHAR_T_KEYWORD</code>	Option KEYWORD-WCHAR=*YES (default in language modes C++ V3, C++ 2017 and C++ 2020)

## Predefined preprocessor assertions (`#assert`)

The options specified below are all part of the `MODIFY-SOURCE-PROPERTIES` statement:

<code>data_model(bit32)</code>	Always set
<code>cpu(7500)</code>	On generating /390 code
<code>machine(7500)</code>	On generating /390 code
<code>system(bs2000)</code>	Always set

---

## 9.3 Concept of a name adapter module in the C runtime system

One of the problems with regard to C library functions is the fact that these functions are addressed on the source program level with predefined names (e.g. `printf`, `fopen`), while BS2000 naming conventions require entry names beginning with the prefix "IC". Furthermore, C library functions also need to be replaceable by user-defined functions, where entry names can be constructed from the function names without the prefix "IC".

Up until CRTE Version 1.0B, this problem was solved with the aid of a table that enabled the compiler to recognize the function names and convert them accordingly. Consequently, changes in the C runtime system were always associated with changes in the compiler. For reasons of compatibility, this technique has been retained for the existing C library functions in the C runtime system (functions of the C90 standard and approx. 50 BS2000-specific extensions). For all POSIX functions that were added by name as of CRTE V2.0A and all functions to be added in future, the problem is now solved on a compiler-independent basis by means of name adapter modules. These adapter modules contain the entry names derived from the function name minus the prefix "IC" and call the actual "standard" function with the entry name IC....

The following adapter modules are available for each C library function:

- An object module (OM) with the function name (possibly abbreviated to 8 characters) as an entry name in which lowercase letters have been converted to uppercase, and the underscore to a dollar character, e.g. `FPA$H$KONV` for the function `fpathkonv`.

This is only relevant when linking object modules generated with the earlier C/C++ compilers (until V2.2). As of C/C++ V3.0 and higher, only modules in LLM format are generated.

- Up to four LLMs in which the unabbreviated function name is contained as the entry name, but once in lowercase or uppercase, and once with the underscore retained or converted (cf. the `LOWER-CASE-NAMES` and `SPECIAL-CHARACTERS` options in the [MODIFY-MODULE-PROPERTIES](#) statement).

For example, two LLMs exist for the `fpathkonv` function containing the entry names `FPA$H$KONV` and `fpathkonv`, respectively.

Adapter modules belong to the non-preloadable components of the C runtime system and must consequently be linked into the application program. They are contained both in the `SYSLNK.CRTE` library and in the `SYSLNK.CRTE.PARTIAL-BIND` library.

If a user-defined function is to be called instead of the standard library function, the corresponding user module must be linked with precedence before the `SYSLNK.CRTE` or `SYSLNK.CRTE.PARTIAL-BIND` library. The user module can be either an object module or an LLM (with or without conversion of the lowercase letters and underscores).

---

## 9.4 The II-UPDATE tool

When binding or recompiling programs in C++ V3, C++ 2017 or C++ 2020 the system accesses existing ii information (ii=instantiation information). This information contains, among other things, the names of source files /libraries and source elements, of include libraries and lists or CIF files/libraries/elements. If these files, libraries and /or elements are renamed or located under a different ID (or another cat-id), then these changes **must** also be made in the ii files.

ii files, also known as ii elements, are created by the compiler from programs that contain templates. II-UPDATE is a compiler-independent tool with an SDF interface. If a source or include library has been renamed, the tool is able to make these changes automatically in the ii file without the need to recompile. It is only possible to adjust the ii elements of a **single** library per call of the tool.

Entries in ii elements which contain the names of BS2000 or POSIX files or POSIX directories cannot be changed, but II-UPDATE can display these without error. This applies both for source, include, CIF and for listing entries.

The SDF syntax file of the II-UPDATE is not activated automatically. You have to activate it once per session, using the command /MODIFY-SDF-OPTIONS \*ADD(\$.SYSSDF.CPP.040.IU.USER).

START-II-UPDATE

**CONTAINER=** \*LIBRARY-ELEMENT(...)

\*LIBRARY-ELEMENT(...)

| **LIBRARY=** <filename 1..54>

| **,ELEMENT=** \*ALL / <composed-name 1..64 with-under>(...)

| <composed-name 1..64 with-under>(...)

| **VERSION=** \*HIGHEST-EXISTING / <composed-name 1..24 with-under>

**,OLD-NAME=** \*LIBRARY-ELEMENT(...) / \*LIBRARY(...)

\* LIBRARY-ELEMENT(...)

| **LIBRARY=** <filename 1..54>

| **,ELEMENT=** <composed-name 1..64 with-under>(...)

| <composed-name 1..64 with-under>(...)

| | **VERSION=** \*DEFAULT / <composed-name 1..24 with-under>

\*LIBRARY(...)

| **LIBRARY=** <filename 1..54>

**,NEW-NAME=** \*LIBRARY-ELEMENT(...) / \*LIBRARY(...)

\* LIBRARY-ELEMENT(...)

| **LIBRARY=** \*SAME / <filename 1..54>

| **,ELEMENT=** \*SAME / <composed-name 1..64 with-under>(...)

| <composed-name 1..64 with-under>(...)

| | **VERSION=** \*UNCHANGED / <composed-name 1..24 with-under>

\*LIBRARY(...)

| **LIBRARY=** <filename 1..54>

**,CONTEXT=** \*INCLUDE / \*CIF / \*SOURCE / \*LISTING / \*ALL

**,ACTION=** list-poss(2): \*REPLACE / \*SHOW

**CONTAINER = \*LIBRARY-ELEMENT(...)**

This option is used to specify which ii elements in which object library are to be adapted.

**LIBRARY = <filename 1..54>**

<filename> is the name of a PLAM library.

---

**ELEMENT = \*ALL**

All the ii elements in the PLAM library specified using LIBRARY= are to be adapted. These are elements of type S having a name with suffix ".II".

**ELEMENT = <composed-name 1..64 with-under>(…)**

<composed-name> identifies the fully qualified name of an ii element from the PLAM library specified using LIBRARY=.

**VERSION = \*HIGHEST-EXISTING**

If the ii element information does not contain a version number, II-UPDATE uses the ii element with the highest version.

**VERSION = <composed-name 1..24 with-under>**

II-UPDATE uses the ii element with the specified version.

**OLD-NAME = \*LIBRARY-ELEMENT(…) / \*LIBRARY**

This option is used to specify the original library name or original library element names (for example, from the source library elements) that is to be modified in an ii file. The name must be specified in exactly the same way as in the ii file, i.e. if required with `cat-id` and `userid` (see also example 6).

**LIBRARY-ELEMENT (…)****LIBRARY = <filename 1..54>**

<filename> is the name of the PLAM library that has changed or in which a change has been made.

**ELEMENT = <composed-name 1..64 with-under>(…)**

<composed-name> identifies the fully qualified name of an element that has changed.

**VERSION = \*DEFAULT**

Regardless of context, the version value of the ii element is accepted.

**VERSION = <composed-name 1..24 with-under>**

Identifies the version of the element that has changed.

**LIBRARY = <filename 1..54>**

<filename> is the name of a PLAM library that has changed.

**NEW-NAME = \*LIBRARY-ELEMENT(…) / \*LIBRARY**

This option is used to specify the new library or element name that is to be substituted for that specified in OLD-NAME.

**LIBRARY-ELEMENT(…)****LIBRARY = \*SAME / <filename 1..54>**

If \*SAME is specified, the name of the PLAM library as entered in the OLD-NAME parameter is used. <filename> is the new name of the PLAM library that is specified under OLD-NAME.

**ELEMENT = \*SAME / <composed-name 1..64 with-under>(…)**

---

If \*SAME is specified, the name of the element as entered in the OLD-NAME parameter is used.  
<composed-name> is the changed, fully qualified name of an element that was specified under OLD-NAME.

**VERSION = \*UNCHANGED**

The existing version of the library elements (in the ii element) should not be changed.

**VERSION = <composed-name 1..24 with-under>**

The new version name of the element.

**LIBRARY = <filename 1..54>**

<filename> is the new name of the PLAM library as specified under OLD-NAME.

*Note*

Only the same type of OLD-NAME / NEW-NAME combinations are supported, for example, OLD-NAME = \*LIBRARY / NEW-NAME = \*LIBRARY or  
OLD-NAME = \*LIBRARY-ELEMENT / NEW-NAME = \*LIBRARY-ELEMENT

**CONTEXT =**

Specify the entries of the ii information which should be handled. The entries correspond to compiler statements.

**CONTEXT = \*INCLUDE**

Handle entries corresponding to //MODIFY-INCLUDE-LIBRARIES.

If \*INCLUDE is specified, the adaption of the library is only carried out if OLD-NAME and NEW-NAME are both library names. If OLD-NAME and NEW-NAME are library element names, then adaptation would not take place for \*INCLUDE.

**CONTEXT = \*CIF**

Handle entries corresponding to //MODIFY-CIF-PROPERTIES OUTPUT=.

**CONTEXT = \*SOURCE**

Handle entries corresponding to //COMPILE SOURCE=.

**CONTEXT = \*LISTING**

Handle entries corresponding to //MODIFY-LISTING-PROPERTIES OUTPUT=.

**CONTEXT = \*ALL**

Handle all entries.

*Note*

A message is output indicating the total number of replacements carried out for the various contexts.

**ACTION =**

This option enables II-UPDATE to be instructed to replace or output all library or library element names of an ii element which can potentially be replaced.

**ACTION = \*REPLACE**

Replacements are performed. Only the replacements which are performed are output.

**ACTION = \*SHOW**

No replacements are performed. All possible replacements are output, however. The names of libraries and elements which would not be replaced are also output.

---

## **ACTION = (\*SHOW, \*REPLACE)**

Replacements are performed. In addition to the replacements which were performed, the replacements which were not performed are also output.

### *Note*

The specified context is taken into account in all cases. II-UPDATE remains compatible to older versions with regard to call, replacement and output behavior.

The following examples will provide further information about the points mentioned above.

## **Example 1**

The include library *INC-LIB-V1* has been renamed in *INC-LIB-V2*. The following statement carries out the appropriate changes to all the ii elements in the *MY-OBJ-LIB* library.

```
/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB, *ALL) ,-  
/OLD-NAME=*LIBRARY( INC-LIB-V1) ,-  
/NEW-NAME=*LIBRARY( INC-LIB-V2) ,-  
/CONTEXT=*INCLUDE
```

## **Example 2**

The source library *MY-SOURCE-LIB.V1* has been renamed in *MY-SOURCE-LIB.V2*.

The following statement makes the appropriate changes to the library element *EL.O.II* in the *MY-OBJ-LIB* library:

```
/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB, EL.O.II) ,-  
/OLD-NAME=*LIBRARY(MY-SOURCE-LIB.V1) ,-  
/NEW-NAME=*LIBRARY(MY-SOURCE-LIB.V2) ,-  
/CONTEXT=*SOURCE
```

## **Example 3**

The source libraries *MY-SOURCE-LIB1* and *MY-SOURCE-LIB2* contain a program system. The associated objects are located in the libraries *MY-OBJ-LIB1* and *MY-OBJ-LIB2*. The source libraries are to be renamed in *SOURCE-LIB1-V1* and *SOURCE-LIB2-V2*. The assumption has been made that each source library makes use of the other (include):

```
/MODIFY-FILE-ATTRIBUTES MY-SOURCE-LIB1, SOURCE-LIB1-V1  
/MODIFY-FILE-ATTRIBUTES MY-SOURCE-LIB2, SOURCE-LIB2-V1
```

The ii files/elements are adapted using the following statements:

```

/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB1, *ALL),-
/OLD-NAME=*LIBRARY(MY-SOURCE-LIB1),-
/NEW-NAME=*LIBRARY(SOURCE-LIB1-V1),-
/CONTEXT=*ALL

/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB1, *ALL),-
/OLD-NAME=*LIBRARY(MY-SOURCE-LIB2),-
/NEW-NAME=*LIBRARY(SOURCE-LIB2-V1),-
/CONTEXT=*INCLUDE

/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB2, *ALL),-
/OLD-NAME=*LIBRARY(MY-SOURCE-LIB1),-
/NEW-NAME=*LIBRARY(SOURCE-LIB1-V1),-
/CONTEXT=*INCLUDE

/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB2, *ALL),-
/OLD-NAME=*LIBRARY(MY-SOURCE-LIB2),-
/NEW-NAME=*LIBRARY(SOURCE-LIB2-V1),-
/CONTEXT=*ALL

```

## Example 4

Using the program system described in Example 3 but this time, instead of renaming the source libraries, we are going to move the source library element *MY-ELEM.C* from the *MY-SOURCE-LIB1* library to the *MY-SOURCE-LIB2* library and both the associated object *MY-ELEM.O* and the associated ii element *MY-ELEM.O.II* to the *MY-OBJ-LIB2* library:

```

/LMS
//O-L MY-SOURCE-LIB1,*U
//COP-EL (,MY-ELEM.C,S),(MY-SOURCE-LIB2,MY-ELEM.C)
//DEL-EL (,MY-ELEM.C,S)
//O-L MY-OBJ-LIB1,*U
//COP-EL (,MY-ELEM.O,L),(MY-OBJ-LIB2,MY-ELEM.O)
//COP-EL (,MY-ELEM.O.II,S),(MY-OBJ-LIB2,MY-ELEM.O.II)
//DEL-EL (,MY-ELEM.O.L)
//DEL-EL (,MY-ELEM.O.II,S)
//END

```

The ii files/elements are adapted using the following statements:

```

/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB2, MY-ELEM.O.II),-
/OLD-NAME=*LIB-ELEM(MY-SOURCE-LIB1, MY-ELEM.C),-
/NEW-NAME=*LIB-ELEM(MY-SOURCE-LIB2, MY-ELEM.C),-
/CONTEXT=*SOURCE

```

## Example 5

The source libraries *MY-SOURCE-LIB1* and *MY-SOURCE-LIB2* contain a program system (see Example 3). The associated listing libraries *MY-LISTING-LIB1* and *MY-LISTING-LIB2* are to be renamed to *LISTING-LIB1-V1* or *LISTING-LIB2-V1*:

```
/MODIFY-FILE-ATTRIBUTES MY-LISTING-LIB1, LISTING-LIB1-V1
/MODIFY-FILE-ATTRIBUTES MY-LISTING-LIB2, LISTING-LIB2-V1
```

The ii files/elements are adapted using the following statements:

```
/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB1,*ALL),-
/OLD-NAME=*LIBRARY(MY-LISTING-LIB1),-
/NEW-NAME=*LIBRARY(LISTING-LIB1-V1),-
/CONTEXT=*LISTING

/START-II-UPDATE CONTAINER=*LIB-ELEM(MY-OBJ-LIB2,*ALL),-
/OLD-NAME=*LIBRARY(MY-LISTING-LIB2),-
/NEW-NAME=*LIBRARY(LISTING-LIB2-V1),-
/CONTEXT=*LISTING
```

## Example 6

The include library *HELLO-MAP.INCLIB* was renamed *HELLO-MAP.INCLIB.NEW*. The following string of statements is initially used to determine the exact notation of the library which is to be renamed (*ACTION=\*SHOW*; in this case the values of the *old-name* and *new-name* parameters are of no significance); subsequently the replacements are performed using *ACTION=(\*SHOW, \*REPLACE)*:

```
/START-II-UPDATE CONTAINER=*LIB-ELEM(HELLO-MAP.OLIB1,*ALL),-
/OLD-NAME=*LIBRARY(OLIB),-
/NEW-NAME=*LIBRARY(NLIB),-
/CONTEXT=*ALL,-
/ACTION=*SHOW
```

*Output:*

```
% BLS0523 ELEMENT 'II-UPDATE', VERSION '04.0B02', TYPE 'L' FROM LIBRARY ': 20SG:
$TSOS.SYSLNK.CPP.040' IN PROCESS
% BLS0524 LLM 'II-UPDATE', VERSION '04.0B02' OF '2023-04-02 14:33:19' LOADED
% BLS0551 COPYRIGHT (C) 2023 Fujitsu Technology Solutions GmbH. ALL RIGHTS RESERVED
% CDR9992 BEGIN II-UPDATE VERSION 04.0B02
% CDR9810 Processing ii-element *LIBRARY-ELEMENT(:20SC:$MTZ.HELLO-MAP.OLIB1,
HELLO-MAP-HP.II(*UPPER-LIMIT),S)
% CDR9819 include lib no replacement: *LIBRARY(:20SC:$MTZ.HELLO-MAP.INCLIB)
% CDR9819 include lib no replacement: *LIBRARY(:20SC:$MTZ.HELLO-MAP.INCLIB)
% CDR9819 include lib no replacement: *LIBRARY(:20SC:$TSOS.SYSLIB.CRTE)
% CDR9819 source lib no replacement: *LIBRARY(:20SC:$MTZ.HELLO-MAP.SLIB1)
% CDR9810 Processing ii-element *LIBRARY-ELEMENT(:20SC:$MTZ.HELLO-MAP.OLIB1,
HELLO-MAP-UP.II(*UPPER-LIMIT),S)
% CDR9819 include lib no replacement: *LIBRARY(:20SC:$MTZ.HELLO-MAP.INCLIB)
% CDR9819 include lib no replacement: *LIBRARY(:20SC:$MTZ.HELLO-MAP.INCLIB)
% CDR9819 include lib no replacement: *LIBRARY(:20SC:$TSOS.SYSLIB.CRTE)
% CDR9819 source lib no replacement: *LIBRARY(:20SC:$MTZ.HELLO-MAP.SLIB1)
% CDR9814 Summary: 0 include / 0 source / 0 cif / 0 listing replaced
% CCM0998 CPU TIME USED: 0.1485 SECONDS
```

```
/START-II-UPDATE CONTAINER=*LIB-ELEM(HELLO-MAP.OLIB1,*ALL),-  
/OLD-NAME=*LIBRARY(:2OSC:$MTZ.HELLO-MAP.INCLIB),-  
/NEW-NAME=*LIBRARY(:2OSC:$MTZ.HELLO-MAP.INCLIB.NEW),-  
/CONTEXT=*ALL,-  
/ACTION=( *REPLACE, *SHOW)
```

**Output:**

```
% BLS0523 ELEMENT 'II-UPDATE', VERSION '04.0B02', TYPE 'L' FROM LIBRARY  
' :2OSG:$TSOS.SYSLNK.CPP.040' IN PROCESS  
% BLS0524 LLM 'II-UPDATE', VERSION '04.0B02' OF '2023-04-02 14:33:19' LOADED  
% BLS0551 COPYRIGHT (C) 2023 Fujitsu Technology Solutions GmbH. ALL RIGHTS RESERVED  
% CDR9992 BEGIN II-UPDATE VERSION 04.0B02  
% CDR9810 Processing ii-element *LIBRARY-ELEMENT(:2OSC:$MTZ.HELLO-MAP.OLIB1,  
HELLO-MAP-HP.II(*UPPER-LIMIT),S)  
% CDR9819 include lib no replacement: *LIBRARY(:2OSC:$TSOS.SYSLIB.CRTE)  
% CDR9811 include lib replaced: *LIBRARY(:2OSC:$MTZ.HELLO-MAP.INCLIB) -->  
*LIBRARY(:2OSC:$MTZ.HELLO-MAP.INCLIB.NEW)  
% CDR9819 source lib no replacement: *LIBRARY(:2OSC:$MTZ.HELLO-MAP.SLIB1)  
% CDR9810 Processing ii-element *LIBRARY-ELEMENT(:2OSC:$MTZ.HELLO-MAP.OLIB1,  
HELLO-MAP-UP.II(*UPPER-LIMIT),S)  
% CDR9819 include lib no replacement: *LIBRARY(:2OSC:$TSOS.SYSLIB.CRTE)  
% CDR9811 include lib replaced: *LIBRARY(:2OSC:$MTZ.HELLO-MAP.INCLIB) -->  
*LIBRARY(:2OSC:$MTZ.HELLO-MAP.INCLIB.NEW)  
% CDR9819 source lib no replacement: *LIBRARY(:2OSC:$MTZ.HELLO-MAP.SLIB1)  
% CDR9814 Summary: 2 include / 0 source / 0 cif / 0 listing replaced  
% CCM0998 CPU TIME USED: 0.2243 SECONDS
```

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## 10 Related publications

The manuals are available as online manuals, see <https://bs2manuals.ts.fujitsu.com>.

- [1] **C/C++ V4.0B03** (BS2000/OSD)  
**POSIX Commands of the C/C++ Compiler**  
User Guide
- [2] **C Library Functions** (BS2000/OSD)  
Reference Manual
- [3] **C Library Functions for POSIX Applications** (BS2000/OSD)  
Reference Manual
- [4] **CRTE** (BS2000/OSD)  
**Common RunTime Environment**  
User Guide
- [5] **C++** (BS2000)  
**C++ Library Functions**  
Reference Manual
- [6] **Standard C++ Library V1.2**  
User's Guide and Reference
- [7] **Tools.h++ V7.0**  
User's Guide
- [8] **Tools.h++ V7.0**  
Class Reference
- [9] **AID** (BS2000/OSD)  
**Debugging of C/C++ Programs**  
User Guide
- [10] **AID** (BS2000)  
**Advanced Interactive Debugger**  
**Core Manual**  
User Guide
- [11] **BS2000/OSD-BC**  
**Commands**  
User Guide
- [12] **SDF** (BS2000/OSD)  
**SDF Dialog Interface**  
User Guide
- [13] **BLSSERV**  
**Dynamic Binder Loader / Starter**  
User Guide

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- [14] **BINDER**  
**Binder in BS2000/OSD**  
User Guide
  - [15] **EDT V17.0 (BS2000/OSD)**  
**Statements**  
User Guide
  - [16] **LMS (BS2000)**  
**SDF Format**  
User Guide
  - [17] **BS2000/OSD-BC**  
**Executive Macros**  
User Guide
  - [18] **BS2000/OSD-BC**  
**Introductory Guide to DMS**  
User Guide
  - [19] **JV (BS2000/OSD)**  
**Job Variables**  
Reference Manual
  - [20] **POSIX (BS2000/OSD)**  
**POSIX Basics for Users and System Administrators**  
User Guide
  - [21] **POSIX (BS2000/OSD)**  
Commands  
User Guide

## Other reference literature and standards

- [22] The C Programming Language  
by Brian W. Kernighan und Dennis M. Ritchie
- [23] The C++ Programming Language  
(Second and Third Edition)  
by Bjarne Stroustrup
- [24] „International Standard ISO/IEC 9899 : 1990, Programming languages - C“
- [25] „International Standard ISO/IEC 9899 : 1990, Programming languages - C /  
Amendment 1 : 1994“
- [26] „International Standard ISO/IEC 9899 : 2011, Programming languages - C“
- [27] „International Standard ISO/IEC 14882 : 1998, Programming languages - C++“
- [28] „International Standard ISO/IEC 14882 : 2017, Programming languages - C++“

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[29] „International Standard ISO/IEC 14882 : 2020, Programming languages - C++“