English

FUJITSU Software BS2000

AID V3.4B

Core Manual

User Guide

Edition June 2018

Comments… Suggestions… Corrections…

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Documentation creation 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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Contents

1 Preface

AID (Advanced Interactive Debugger) is a powerful interactive debugging aid which runs under the operating system BS2000. AID V2.0A can be used as of BS2000 V9.5. Error diagnosis, debugging and preliminary recovery for all programs created under BS2000 are much shorter and easier with AID compared to other techniques, such as the insertion of debugging statements in the program. AID is permanently available and can be easily adapted to the relevant programming language. A program that has been tested by means of AID does not always have to be recompiled but can be used immediately in a production run. The functionality of AID and its test language, the AID commands, are primarily geared to interactive applications. It is quite possible, however, to employ AID in batch mode as well. AID offers comprehensive options for monitoring, runtime control, output and modification of memory contents. Users are also able to access information on program execution and on AID operation.

AID permits debugging both on the symbolic level of the appropriate programming language and on machine code level. During "symbolic debugging" of a program it is possible to reference data, statement labels and program segments with the names declared in the source code, and the statements without names can be referenced with the source reference generated by the compiler.

1.1 Objectives and target groups of the AID documentation

AID is intended for all software developers working under BS2000 with one of the programming languages COBOL, FORTRAN, C, C++, PL/I and ASSEMBH or wishing to test and/or correct the programs on machine code level.

1.2 Structure of the AID documentation

The AID documentation consists of a core manual and the language-specific manuals for symbolic debugging plus the manual for debugging on machine code level. For experience AID users there is an additional reference work, a Ready Reference [7], containing the syntax of all commands and also the operands, with brief explanations. The Reference Guide also contains the %SET tables. The manual for the language selected, together with the core manual, should provide all the information needed for testing. The manual for debugging on machine code level may be used in place of or in addition to any of the language-specific manuals.

AID Core Manual

The core manual provides an overview of AID and deals with facts and operands which are the same in all programming languages. The AID overview describes the BS2000 environment, explains basic concepts and presents the AID command set. The other chapters discuss preparations for testing; command input; the subcommand; addressing in AID; the operand *medium-a-quantity*; AID literals; and keywords. The manual also contains BS2000 commands invalid in command sequences.

AID manuals

The manuals contain lists of the commands in alphabetical order. All simple memory references are described in the manuals.
AID - Debugging of COBOL Programs [2]
AID - Debugging of FORTRAN Programs [3]
AID - Debugging under POSIX [4]
AID - Debugging of ASSEMBH Programs [5]
AID - Debugging of C/C++ Programs [6]
In the language-specific manuals, the description of the operands is tailored to the programming language involved. The user is expected to be familiar with the relevant language elements and operation of the corresponding compiler.

The additional possibilities of machine-oriented debugging are described in **Debugging on Machine Code Level [1]**.

The manual for debugging on machine code level can be used for programs for which no LSD records exist or for which the information from symbolic debugging does not suffice for error diagnosis. Testing on machine code level means that the user can employ the AID commands regardless of the programming language in which the program was written.

Readme file

The functional changes to the current product version and revisions to this manual are described in the product-specific Readme file.

Readme files are available to you online in addition to the product manuals under the various products at *http://manuals.ts.fujitsu.com*. You will also find the Readme files on the Softbook DVD.

Information under BS2000

When a Readme file exists for a product version, you will find the following file on the BS2000 system:

`SYSRME.<product>.<version>.<lang>`

This file contains brief information on the Readme file in English or German (<lang>=E/D). You can view this information on screen using the `SHOW-FILE` command or an editor. The `/SHOW-INSTALLATION-PATH INSTALLATION-UNIT=<product>` command shows the user ID under which the product's files are stored.

Additional product information

Current information, version and hardware dependencies, and instructions for installing and using a product version are contained in the associated Release Notice. These Release Notices are available online at *http://manuals.ts.fujitsu.com.*

1.3 Changes since the last edition of this manual

AID V3.4B30 offers the following new functions compared to version V3.4B10:

- Extension of the %AID command: new *LEV* operand. This operand can expand the output of the AID command %SDUMP %NEST by the levels within the call hierarchy.
- New qualification *NESTLEV* in the %DISPLAY, %MOVE, %SDUMP and %SET commands designated to qualify all instances of recursive data.
- Enhancement of the %FIND command that enables searching the *find area* for characters from a coded character set (CCS) supported by XHCS.

1.4 Notational conventions

italics Within the text, operands are shown in *italic lowercase*.

This symbol marks points in the text to which particular attention should be paid.

2 Metasyntax

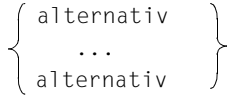
The following metasyntax is used for representing commands and their operands. The symbols used are listed below, together with a description of their meaning.

UPPERCASE

Character sequence which must be used in precisely this form when a function is selected.

lowercase

Character string representing a variable. It must be replaced by one of the permitted operand values.



{alternative | ... | alternative}

Alternatives between which a choice must be made. Both formats are equivalent.

[optional]

Specifications enclosed between square brackets may be omitted.

In the case of AID command names the part shown between square brackets must be omitted in full if it is omitted; any other abbreviations result in a syntax error.

[...]

Repeatability of an optional syntactical unit. If a separator, for example a comma, has to be placed before each repetition, it is shown before the dots representing repetition.

{...}

Repetition of a syntactical unit which must be specified once. If a separator, for example a comma, has to be placed before each repetition, it is shown before the dots representing repetition.

Underscore

The underscore identifies the default value that is used by AID if the user does not specify a value for an operand.

-

  The heavy-type period has a number of roles: it separates qualifications, or it stands for a *prequalification* (see %QUALIFY), or it is the operator for a byte offset, or it is part of the execution counter or subcommand name. The period is entered in the normal way with the period on the keyboard. It is shown here in heavier type merely to improve readability.

3 BS2000 environment, basic concepts and command set

3.1 AID in BS2000

The AID test system consists of two components:

– the user interface AID and
– the system interface AIDSYS.

This splitting makes the AID user interface independent of the BS2000 versions. All necessary system functions are implemented via AIDSYS. This independence from BS2000 versions is important if, for example, one of the available system tables is to be output in edited form from a dump generated on another system with a different BS2000 version. Version-dependent editing is performed via AIDSYS, which recognizes which BS2000 version was used to generate the dump, edits the required system table accordingly and then passes it to AID for output.

Input of AID commands and output of AID messages are effected via the system files SYSCMD and SYSOUT in the same way as for BS2000 commands (see Commands [8]).

3.1.1 Loading AID

AID is not loaded by the non-privileged user but by the system support with the /START-SUBSYSTEM AID command (see BS2000 manual Commands [8]). AID is then available to all users without any additional intervention.

3.1.2 Using AID

An AID debugging session may be started in one of two ways:

1. Load and start the program. If the program run is interrupted by an error and symbolic testing is desired, load the LSD records with the %SYMLIB command for the compilation unit in which the error has occurred. AID commands can then be entered.

```
/START-EXECUTABLE-PROGRAM FROM-FILE=...
...
%  IDAON51 PROGRAM INTERRUPT AT LOCATION '000B62 (MOBS), (CDUMP), EC=58'
%  IDAON45 DUMP DESIRED? REPLY (Y = USER/AREA DUMP; Y,SYSTEM = SYSTEM DUMP;
N = NO)
...
/%SYMLIB ...
/%SDUMP %NEST
...
```

2. Load the program. If symbolic testing is desired, specify the parameter which loads the LSD records together with the program. Enter AID monitoring commands and then start the program with an AID command.

```
/LOAD-EXECUTABLE-PROGRAM FROM-FILE=..., TEST-OPTIONS=AID
/%INSERT ...
/%R
...
```

3.1.3 AID and the BS2000 command interpreter

The AID functions are called via AID commands. An AID command starts with a

% character immediately followed by the command name:

```
%DISPLAY ARRAY1
```

AID commands can be entered whenever the task is in command mode. The AID commands are accepted by the BS2000 command interpreter like normal BS2000 commands. The command interpreter identifies the AID commands on the basis of the % character and passes them to AID for execution.

AID commands may be entered in interactive mode or in procedure files. The CMD macro permits AID commands to be called from a program (see Executive Macros [10]).
AID commands can coexist with BS2000 commands in command sequences.

3.1.4 AID and SDF

SDF (System Dialog Facility) is the interactive interface to BS2000. SDF has its own command language. The command language in ISP (Interactive String Processor) was used before SDF. In the AID core manual and the language-specific manuals, BS2000 commands are always described in the EXPERT form of the SDF format (see SDF Dialog Interface [14]). In some cases a comparison with the corresponding ISP commands is contained in the appendix; references to this are included where appropriate.

SDF notation is not available for AID commands.

3.1.5 AID link names

Dump files can be referenced with AID via link names D0 through D7.

Data output, trace listings and REPs may be written to output files. AID output files have the format `FCBTYPE=SAM, RECFORM=V, OPEN=EXTEND`. AID output files are assigned via link names F0 through F7.

3.1.6 XS programming

On all BS2000 versions programs can use the extended address space from over 16 Mbytes to 2 Gbytes. As a consequence, AID can also be used to test programs in the extended address space.

AID automatically adjusts to the addressing mode of the test object and works with both 24-bit (lower address space) and 31-bit (extended address space) addresses.

If for instance the program linkage of modules with different addressing modes is to be tested, AID offers the following functions (see Debugging on Machine Code Level [1]):

– keyword for the AMODE system information (%AMODE)
– displaying the current addressing mode (%DISPLAY)
– switching the addressing mode for the test object (%MOVE)
– switching the address interpretation for indirect addressing (%AINT)

3.1.7 Programs in AR mode

Application programs can use not only the program space, which corresponds to the previous address space, but also other address spaces for data, the data spaces. Data spaces can only contain data; program code cannot be executed in a data space. They can be uniquely addressed via the SPID (space identification) or via one or more ALETs (access list entry tokens). To allow addressing with ALETs the access registers were introduced as an additional register record in parallel with the general registers. The ALETs are contained in the access registers. When AR (access register) mode is activated, the access registers are also analyzed during address translation in a machine instruction, and in that way data is addressed in a data space. See Executive Macros [10] manual for details.

AID provides the following functions for programs running in AR mode (see Debugging on Machine Code Level [1]):

– keyword for the ASC mode system information (%ASC) for interrogating AR mode.
– keywords for the access registers (%nAR, %AR)
– ALET and SPID qualification for the unique referencing of virtual addresses in data spaces
– keywords for the system information about the active data spaces (%DS[(ALET/SPID-qua)])
– identification of virtual addresses from data spaces with an asterisk **"*"** in the event of output with %DISPLAY and in the %TRACE log.

Data in data spaces can only be referenced via its virtual address. If it is intended to edit the data symbolically, this can be done with the aid of subsequent type modification.

3.1.8 Test privileges

AID users must be prevented from accessing and/or modifying arbitrary data sets and memory areas within the system. Each user entry therefore contains a "test privilege" entry to control read/write access rights for testing. This entry is made by the system administrator (see Introduction to System Administration [9]).

When a task is started, the lowest privileges (1,1) are assigned. They allow usage of the complete AID function range as described in the documentation.

If files or libraries have been protected by means of a read or execute password, access under AID is not possible unless the correct password is entered.
If memory areas are to be accessed which require higher privileges, the /MODIFY-TEST-OPTIONS command can be used to change privileges, provided this is permitted in the entry in the user catalog. This entry may be viewed via the /SHOW-USER-ATTRIBUTES command (see the Commands [8]).

AID also offers keywords for access to protected areas such as registers.

3.2 Basic concepts

3.2.1 Test object

The program to be processed by means of AID is known as the test object. It may be loaded under the relevant user ID or may be present in the form of a memory dump in a dump file. Within a test session, switchover between these two options is possible, for example to compare data in the loaded program with data in a dump file or to compare dumps from different versions of the same object.

The program can always be tested on machine code level. Testing on the symbolic level is possible if LSD records have been created during compilation. The program to be tested need not be recompiled or relinked. As the program can be loaded without the symbolic information, further compiler or linkage editor runs after an error-free test run can be dispensed with. The program can be immediately employed for productive use.

3.2.2 Object structure list and LSD

AID works with two lists that contain information on the program.

When linking is performed with the linkage editor, the corresponding list is the ESV (External Symbols Vector)(default case). Among other things, the object structure list contains information on the CSECTs, DSECTs and COMMONs of a program. If this list is available, it is possible to use the name of a CSECT or a COMMON to access the associated address, content and length.

The LSD (List for Symbolic Debugging) is the directory of the data names, statement names and program segment names defined in the module. It also contains the source references created by the compiler. LSD records are generated by the compiler, provided the appropriate compiler option is specified. If LSD records have been created, the names defined in the source program can be used to access the address, content, length and type of the relevant memory objects. The compiler-generated statement names permit access to the executable part of the program.

The class-5 memory requirements of a program with LSD records may reach a multiple of the actual program size, depending on the amount of symbolic definitions involved. If the object modules are stored in a PLAM library, the program may be loaded and started without LSD records, and the PLAM library that contains the LSD records can be opened with the %SYMLIB command. AID then loads the LSD records from the assigned library whenever they are required.

3.2.3 Symbolic versus machine code)

AID knows two debugging levels.

On the symbolic level, the compiler-generated symbolic addresses from the LSD records are used. Memory locations are referenced via the names assigned in the source program. AID output comprises program, data and statement names as well as source references. The keyword %HLLOC (High-Level LOCation), the operand of the %DISPLAY AID command, displays the symbolic localization information. This information comprises the context name, the name of the compilation unit, the name of the current main program or subprogram, and the name of the source reference to which the address is assigned. The AID commands %JUMP, %SDUMP and %SYMLIB can only be used at the symbolic level, i.e. if LSD records exist for the referenced program segment. For the %CONTROLn and %TRACE commands, the keyword for *criterion* decides whether tracing/monitoring takes place on the symbolic level. If AID is to calculate an address (complex memory reference), switchover from the symbolic to the machine code level is possible at any point. Use of address selection and the pointer operator (%@(name)->) enables the referenced memory object to be used with all its machine-oriented attributes.

On the machine code level, only the CSECT and COMMON information from the object structure list is used. AID output comprises virtual addresses and CSECT and COMMON names. The keyword %LOC (low-level LOCation), the operand of the AID command %DISPLAY, displays the localization information at the machine code level. This information comprises the context name, the name of the load unit, the name of the object module, the name of the CSECT and COMMON, and the CSECT-relative and COMMON-relative address. For the %CONTROLn and %TRACE commands, the keyword for *criterion* decides whether tracing/monitoring takes place on the machine code level. In a complex memory reference it is possible to link symbolic addresses and elements of addressing on the machine code level and therefore to continue to use all attributes of symbolic addressing.

3.2.4 AID work area

The AID work area is the address space in which memory objects can be referenced without a base qualification.
It comprises the non-privileged part of the virtual memory of the relevant task occupied by the program, including the connected subsystems, or the corresponding area in a memory dump.
Whether debugging is performed in a loaded program or in a memory dump can be determined by the %BASE command. If %BASE is not specified, the AID work area is in the loaded program. This is referred to as the AID default work area.
It is also possible to deviate from the currently set work area within a command by specifying a corresponding base qualification {E=VM | Dn} in an address operand.

If the AID work area is in a dump file, the commands for monitoring and runtime control cannot be used. Nor is it possible to modify a dump file with AID commands. Data can be output from a dump file, however, the call hierarchy can be traced back to the time of the program interrupt, machine code translated back to symbolic assembler notation, and character strings can be located in a dump file. In addition, data from a dump file can be used to overwrite the memory contents of a loaded program.

3.2.5 Memory objects and memory references

A set of contiguous bytes extending from a specific address in the memory area of the program is known as a memory object. This includes the data of a program as well as the instruction code. The registers outside the program memory and the program counter are likewise memory objects; they are referenced by AID via keywords.

Constants are not regarded as memory objects. This category includes all the constants defined in the program as well as the statement names, the source references, the results of address/length selection and of the length function, and the AID literals. All of these represent a value that cannot be changed and are lacking an address attribute.

A memory reference addresses a memory object. There are two kinds of memory reference: simple and complex. Simple memory references are virtual addresses, names whose address AID can fetch from the LSD records, and keywords.
In a complex memory reference, AID calculates an address on the basis of user specifications which also include information on the type and length of the memory object identified by this address. The following operations may occur in a complex memory reference: byte offset, indirect addressing, type/length modification, address selection.

If a memory reference is not in the currently valid AID work area or is outside the current main program or subprogram, or if it is not unique in that area, qualifications can be used to define the path to the desired memory reference.

3.2.6 Naming conventions in AID

All names used in AID commands to address programs or program segments, data or statements or to define subcommands can make use of the following character set, regardless of the programming language used:
a-z, A-Z, 0-9, $, #, @, underscore "_" or hyphen "-".

The hyphen is not permitted as the first character and also is only allowed as part of the name if SYMCHARS=STD has been set (%AID command).
If a hyphen is the last character of a name, the name can only be specified with N'...'.

It is generally necessary for all names which contain special characters or which can be ambigoues for AID to be set in N'...'. Labels with special characters and labels that are the starting address for a complex memory reference must be written in L'...'.

To ensure that AID differentiates between uppercase and lowercase notation, it is first necessary to enter the %AID LOW[=ON] command. In the case of BLS names, however, in other words names that are known to the binderloader-starter such as names of CSECTs, COMMONs or entries, and in the case of names of compilation units (or in Fortran: program units), account will only be taken of uppercase and lowercase notation if you enter the %AID LOW=ALL command.

The permissible length for BLS names and names of compilation units is 32 characters; names of data and program segments such as functions, procedures or subprograms may be up to 255 characters long. Names of subcommands may be up to 32 characters long including the prefixed characters "%•".

Overview

Names	Length (max.)	%AID LOW=ON active	%AID LOW=ALL active
BLS names and names of compilation units	32	no	yes
Date and program names	255	yes	yes
Names of labels	255	yes	yes
Subcommand names	32 incl. %•	no	no

3.2.7 Character representation

AID supports the representation of Unicode characters (UTF16 / UTFE), as well as interpretation of character data in accordance with any coded character set (CCS) that is supported by XHCS.

3.2.7.1 Character representation using UTF16 / UTFE

The support of Unicode means that the data type %UTF16 is provided in AID to represent strings. With this data type each character has 2-byte encoding. The data type for representing strings which was supported by AID to date has 1-byte EBCDIC encoding.

AID supports UTFE character encoding for input and output media. This encoding is the EBCDIC variant of UTF8, which supports multibyte encoding with a variable byte length.

Setting an EBCDIC encoding table via %AID

The EBCDIC operand of the %AID command enables EBCDIC encoding of a C string to be specified which AID uses when conversion is to be carried out between a UTFE/%UTF16 string and a 1-byte C string.

AID supports all 1-byte EBCDIC encodings which the XHCS-SYS subsystem offers. You can use the %SHOW %CCSN command to diaplay the current names of the encoding tables.

The new functions %C(...) and %UTF16(...) allow you, for example, to convert the literal encoding into a different encoding.

3.2.7.2 Character representation in coded character sets (CCS) that are supported by XHCS

With the *CCS* operand of the %AID command, you specify a CCS supported by XHCS for interpreting characters if no CCS is explicitly indicated in the %DISPLAY command. Unicode character sets are not allowed.

3.3 AID commands

AID features a wide variety of functions, which are invoked via AID commands. This section provides an overview of the AID functionality. The complete command descriptions can be found in the language-specific manuals or in the manual for debugging on machine code level.
The AID command set can be divided into four function groups, whose commands and operands are shown in the summary below. Commands which can only be used for debugging on the symbolic level are identified by 'SY' in the second column.

Monitoring

Command name		Operands
%C[ONTROL]n		[criterion][,...] [IN control-area] <subcmd>
%IN[SERT]		test-point [<subcmd>] [control]
%ON		{write-event | event} [<subcmd>]
%REM[OVE]		target

Runtime control and logging

Command name		Operands
%CONT[INUE]		
%JUMP	SY	continuation
%R[ESUME]		
%STOP		
%T[RACE]		[number] [criterion][,...] [IN trace-area]

Output and modification of memory contents

Command name		Operands
%D[IS]A[SSEMBLE]		[output-quantity] [FROM start]
%D[ISPLAY]		{data} {,...} [medium-a-quantity][,...]
%F[IND]		[[ALL] search-criterion] [IN find-area] [alignment]
%M[OVE]		sender INTO receiver [REP]
%SD[UMP]	SY	[dump-area][,...] [medium-a-quantity][,...]
%SET		sender INTO receiver

Administration

Command name		Operands
%AID		[CHECK] [REP] [SYMCHARS] [OV] [LOW] [DELIM] [EXEC] [FORK] [LANG] [EBCDIC] [CCS] [LEV]
%AINT		[aid-mode] [,...]
%BASE		[base]
%D[UMP]F[ILE]		[link [= file]]
%H[ELP]		[info-target] [medium-a-quantity][,...]
%OUT		[target-command [medium-a-quantity][,...]]
%OUTFILE		[link [=file]]
%Q[UALIFY]		[prequalification]
%SYMLIB	SY	[qua-a-lib]
%SHOW		[show-target]
%TITLE		[page-header]

3.3.1 Monitoring

The commands %CONTROLn, %INSERT and %ON support dynamic monitoring of program execution. They can be used to define monitoring conditions and subcommands (see chapter “Subcommand” on page 51). If the monitoring condition is satisfied, the related subcommand is processed. Each of the three commands specifies a different type of monitoring condition, which can be canceled with %REMOVE.

%CONTROLn *criterion*

criterion designates the type of source statements or machine instructions to be monitored.

%INSERT *test-point*

test-point designates an address in the executable part of the program.

%ON {*write-event* | *event*}

write-event activates write monitoring. *event* designates an event during program execution, such as an addressing error, a supervisor call (SVC), or dynamic loading of a module.

%REMOVE *target*

This command enables monitoring conditions to be canceled. *target* designates the condition to be canceled.

The user chooses the appropriate command for the desired monitoring job and can selectively control program execution via the associated subcommand. A subcommand specifies a command or sequence of commands and possibly a condition. Moreover, the subcommand may be given a name which serves to address its execution counter or to delete the subcommand. The appropriate AID commands can be used within the subcommand to define whether the program is to be interrupted or continued. It is thus possible to prepare an automatic test run. To do this it is essential, however, that all the necessary information for determining the further course of action upon occurrence of the monitoring condition is already available before input of the monitoring command. If the relevant commands are stored in the subcommand, the input of commands at the terminal during testing (for instance to change current memory or register states) is therefore no longer required.

3.3.2 Runtime control

The commands %CONTINUE, %RESUME, %STOP and %TRACE change the status of a loaded program. %JUMP can be used for FOR1 and COBOL85 programs to specify a continuation address that deviates from the coded program sequence. A loaded program can be in any of three defined program states:

1. The program has stopped.

   %STOP, actuation of the K2 key or termination of a %TRACE have interrupted the running program. The task is in command mode. Commands can be entered.

2. The program is running without tracing.

   %RESUME has started or continued the program. %CONTINUE has the same effect; if a %TRACE is still being processed, however, %CONTINUE resumes the program *with* tracing.

3. The program is running with tracing.

   %TRACE has started or continued the program. Program execution is logged as specified in %TRACE. %CONTINUE has the same effect if a %TRACE is still active.

If no other continuation address has been declared, program execution is continued at the interrupt point. By issuing %JUMP (FOR1 and COBOL85 only) or by altering the program counter (%PC) with %MOVE or %SET a different continuation address can be defined. In either intervention in the program sequence it is the user's responsibility to ensure that memory contents, register states and file statuses/contents are compatible with the specified continuation address.

%CONTINUE and %RESUME start or resume a loaded program. The difference between the two commands lies in the fact that %RESUME deletes any active %TRACE, whereas %CONTINUE does not.

%STOP suspends the program and issues a STOP message which contains information on the current interrupt point.

%TRACE activates the trace function. The program is running and the selected commands are logged. The %TRACE terminates when the specified number of commands have been logged or the program is continued with %RESUME after an interrupt. If the %TRACE is only interrupted because a subcommand containing a %STOP has been executed or one of the *control* operands KEEP or STOP has been executed or the K2 key has been depressed, the %TRACE can be resumed with %CONTINUE.
With the *continue* operand of the %TRACE command you can control whether the program should stop (default value) or continue to run without logging, after %TRACE terminates.

3.3.3 Output and modification of memory contents

The commands %DISPLAY, %SDUMP and %DISASSEMBLE can be used to output memory contents and information on the program.
The commands %MOVE and %SET serve to modify memory contents in the loaded program.

%FIND searches for character strings.

%DISPLAY outputs the current content of memory objects, their addresses/lengths or the values of constants, statement names and source references. %DISPLAY can also be used to query system information, control the SYSLST feed or output AID literals, e.g. to annotate the test run. Output is effected via SYSOUT, SYSLST or to a cataloged file.
If a memory object is referenced with its name, AID outputs it in the data type and length specified in the source program. A different editing format can be defined via type/length modification.

%SDUMP outputs a symbolic dump. Output may include either data of the current call hierarchy, or the call hierarchy itself. The current call hierarchy ranges from the subprogram level where the program was interrupted to the subprograms invoked by CALL statements to the main module.
%SDUMP %NEST outputs the names of all program segments of the current call hierarchy as far as the linkage conventions are known to AID. Data or data areas can then be output from the program segments of this hierarchy.

%DISASSEMBLE "retranslates" memory contents from the executable part of a program, i.e. this command causes AID to display these memory contents edited in symbolic Assembler notation. Any memory contents which cannot be interpreted as a command are displayed in the form of an output line which contains the memory contents in hexadecimal notation as well as the note INVALID OPCODE.

%MOVE changes memory contents in the loaded program. %MOVE transfers a sender to a receiver, left-justified and in the length of the sender, without checking whether the storage types of sender and receiver are compatible and without matching the respective types. AID merely checks that the right-hand limit (= end address) of the receiver is not exceeded. Activation of the update dialog and creation of REP records are supported for %MOVE.

%SET changes memory contents in the loaded program. %SET transfers a sender to a receiver and checks, prior to the transfer, whether the storage types of sender and receiver are compatible. The transfer is effected in the length of the receiver and in accordance with the appropriate type; truncation, padding or type matching takes place as required. The rules for transfer with %SET are closely related to the relevant programming language. The %SET description in the language-specific manuals contains a table listing the permissible storage type combinations. Activation of the update dialog is supported for %SET.

%FIND locates a character string in specific data sets or in the entire user address space of the loaded program or in a dump file and displays the hits on the terminal (SYSOUT). For a hit, AID outputs the address at which the string was found and, if possible, the name of the associated CSECT or of the COMMON and the distance to the start address of CSECT or COMMON. To do that, the memory contents are output from the hit address up to the end of the search range, but to a length of no more than 12 bytes. In addition, AID stores the hit address in AID register %0G and the continuation address (hit address + search string length) in AID register %1G.

3.3.4 Administration functions

The commands %DUMPFILE, %SYMLIB and %OUTFILE support the administration of AID input and output files. The files can be assigned link names and opened or closed.
%OUT controls AID output, %TITLE specifies a header line for output to SYSLST.
%AID, %AINT, %BASE and %QUALIFY define global presettings.
%HELP displays help texts.
%SHOW calls up information about the currently valid default settings and about the AID commands which have been entered in the debugging run so far and which are still active.

%DUMPFILE helps administrate dump files, which are assigned via the AID link names D0 through D7. AID may be caused to open or close a dump file. The dump files contain memory dumps to be used for debugging.

%SYMLIB opens PLAM libraries in which the OMs or LLMs of the program have been stored with the LSD records.

AID accesses open PLAM libraries when a command references symbolic names that are contained in a compilation unit (in Fortran: program unit) for which no LSD records have been loaded. A base qualification can be used to assign a PLAM library to a specific AID work area.
Upon %SYMLIB declaration, AID merely checks whether the specified library can be opened; AID does not check whether the library contents match the program being processed. This makes it possible to declare libraries in advance which may be needed in the course of the debugging run. If several libraries are declared for a base qualification, AID searches them in the sequence in which they were specified in the %SYMLIB command.
AID can manage up to 14 PLAM libraries in parallel.

%OUTFILE administrates AID output files, to which the outputs of the commands %DISASSEMBLE, %DISPLAY, %HELP, %SDUMP and %TRACE or the REPs of the %MOVE command are written. These files are assigned via the AID link names F0 through F7. If a file does not yet exist, AID catalogs and opens it. Conversely, open output files can be closed with this command.

%OUT defines the output media for the commands %DISASSEMBLE, %DISPLAY, %HELP, %SDUMP and %TRACE and specifies whether the output of additional information is desired. Possible output media are the terminal (SYSOUT), SYSLST or an AID output file that can be assigned previously via %OUTFILE.
The commands %DISPLAY, %HELP and %SDUMP support a separate, local *medium-a-quantity* operand which temporarily overrides the definitions made for these commands in the %OUT command. The commands %DISASSEMBLE and %TRACE do not offer this operand.

%TITLE permits a specific page header text to be defined for SYSLST output and controls the page counter. Output to SYSLST is specified via %OUT or with the *medium-a-quantity* operand of an output command.

%AID is used to activate the update dialog, to create REPs for memory modifications with %MOVE, to control interpretation of the hyphen in names, to take account of the overlay structure of a program, to activate uppercase/lowercase interpretation for user inputs, to define other delimiters for character-type outputs, to define an EBCDIC character set for conversions from or to UTF16/UTFE or interpret and display characters, and to switch from German to English help texts or vice versa.

%AINT switches the interpretation of indirect address specifications in AID commands. This determines whether an address preceding a pointer operator (->) is to be interpreted by AID as a 24-bit or 31-bit address. This does not affect the addressing mode of the test object. A base qualification can be used to specify the area to which the address interpretation definition is to apply.

%BASE defines the base qualification, which applies to all subsequent commands in which no explicit base qualification is specified. %BASE specifies whether the AID work area is to be in the loaded program or in a dump file. A dump file used as a base qualification must have been assigned via %DUMPFILE.

%QUALIFY identifies qualifications or an address to be referenced in the address operand of another command by prefixing a period. This abbreviation is expedient when making multiple references to addresses which require the same qualifications or which are calculated on the basis of the same start address.

%HELP provides information on AID commands. The following can be output to the selected medium: either all AID commands or the specified command with its operands. The HELP information pool comprises information for both symbolic debugging and debugging on machine code level.

%SHOW provides information on the AID commands of the previous debugging run, about the currently valid global settings, or about the currently valid operand values of the commands.
%SHOW without an operand displays the AID command that was entered last.

With regard to the monitoring commands (%CONTROLn, %INSERT and %ON) %SHOW outputs a list of the original input strings of all active %CONTROLn or %ON commands or the list of set test points with the context, virtual address, CSECT or COMMON and distance from the start of the CSECT or COMMON. The original input string for a certain test point is obtained with %SHOW %INSERT *test-point*. If more than one %INSERTs are active at the test point, the commands are output in reverse order, i.e. the %INSERT that was entered last is listed first.
%SHOW %TRACE causes AID to output the %TRACE command that was entered last, the %TRACE steps that have been processed, and the currently valid operand values.
%SHOW %DISASSEMBLE outputs the currently valid operand values, while %SHOW %FIND outputs the command that was entered last and the last hit.
In relation to the commands that manage AID input or output files, %SHOW outputs all explicitly or implicitly opened files and various additional information. %SHOW %OUT displays the current output declarations of the commands whose output is controlled via %OUT. %SHOW %AID, %SHOW %BASE and %SHOW %QUALIFY each output the declarations that have been made with these commands.

3.3.5 Overview of the scope of validity of the commands

When working with AID it is important to know which commands, operand values or declarations are valid until the next command of the same type is entered or until the end of the program or task. This is the purpose of the following overview:

Command	Operand	Scope of validity
%AID	all	Valid until a new %AID is entered with a corresponding operand or until /EXIT-JOB.
%AINT	aid-mode	Valid until a new %AINT is entered for the same base qualification or until /EXIT-JOB or until the associated dump file is closed.
%BASE	base	Valid until a new %BASE is entered or until /EXIT-JOB or until the dump file declared as the *base* is closed.
%CONTROLn	criterion/ control-area	Can be taken over by the next %CONTROLn, otherwise valid until the %CONTROLn is deleted or until the end of the program.
	subcmd	Must always be specified.
%DISASSEMBLE	number	Can be taken over by a new %DISASSEMBLE; this option is available until the end of the program.
	start	The address following the instruction that was translated back last can be taken over as the *start* value; this option is available until the end of the program.
%DISPLAY	all	All operands must always be specified.
%DUMPFILE	link=file	The file assigned via *link* remains open until /EXIT-JOB unless it is explicitly closed.
%FIND	search-criterion	Can be taken over from a previous %FIND until the search through *find-area* has been completed. This option is available until /EXIT-JOB.
	find-area/ alignment	If no *search-criterion* is specified, *find-area/alignment* is taken over from the previous %FIND until the search through *find-area* has completed.
%INSERT	test-point	The test-point remains entered until it has been deleted with %REMOVE, until all %INSERTs have been deleted, or until the end of the program. For programs that are linked as overlays the test point remains entered in the module in which it was set, even if a different module has been loaded at the same point in the meantime.
	subcmd	The subcommand remains entered until it is deleted with %REMOVE, until the associated test is deleted or until the end of the program.
%MOVE	all	All operands must always be specified.

continued...

continued...

Command	Operand	Scope of validity
%ON	event/ write-event	The *event* remains entered until it has been deleted with %REMOVE, until all %ONs are deleted or until the end of the program. One exception is %ON %WRITE: a new *write-event* overwrites one that is already entered.
	subcmd	The subcommand remains entered until it has been deleted with %REMOVE, until the associated *event* is deleted, until all %ONs are deleted or until the end of the program.
%OUT	all	Valid until a new %OUT is entered with a corresponding operand or until /EXIT-JOB.
%OUTFILE	link=file	If *file* is not explicitly closed, it remains open until /EXIT-JOB.
%QUALIFY	prequalification	*prequalification* applies until it is overwritten by a new %QUALIFY, until it is canceled by a %QUALIFY without an operand, or until /EXIT-JOB.
%REMOVE	target	*target* must always be specified.
%SDUMP	all	Nothing can be taken over from a previous %SDUMP.
%SET	all	All operands must always be specified.
%SHOW	info-target	Nothing can be taken over from a previous %SHOW.
%SYMLIB	qual-a-lib	A library remains open until the next %SYMLIB for the same base qualification, until the next %SYMLIB without an operand, until /EXIT-JOB, or until the associated dump file is closed.
%TITLE	page-header	Valid until the next %TITLE or until the end of the program.
%TRACE	all	All operands continue to apply until they are overwritten by corresponding specifications in a new %TRACE or until the end of the program. *trace-area* will not be taken over if a %TRACE is entered without a *trace-area* and the interrupt point is not in *trace-area*.

4 Prerequisites for debugging with AID

Testing with AID is subdivided into symbolic debugging (where the names assigned in the source program are used for addressing) and debugging on machine code level (where virtual addresses are used). For symbolic debugging to be performed, the compiler must be caused to generate LSD records during compilation. Inclusion of the LSD records in the linkage and loading process can be controlled via corresponding operands. If no LSD records have been included, they can still be dynamically loaded by AID from a PLAM library.
Debugging on machine code level does not require any preparatory action.

If CSECTs are renamed with the LMS statement MODIFY-ELEMENT (substatement RENAME-SYMBOLS), symbolic debugging is no longer possible. If an LLM has been generated directly by the compiler and the LLM contains the LSD records, CSECTs can be renamed with BINDER (MODIFY-MODULE-ATTRIBUTES statement). The compiler versions for which this possibility is available are shown in the respective user guide for each compiler.

Debugging on machine code level is not affected by the renaming of CSECTs. The CSECTs in the program can be referenced with the new names.

4.1 Debugging on machine code level

Debugging on machine code level requires no extra operands during compilation, linkage or loading. All the functions described in the manual Debugging on Machine Code Level [1] can be used without preliminary measures.

Within the process of linking by default an object structure list is generated from the external references (see Dynamic Binder Loader / Starter in BS2000 [13]). When linking with BINDER it is the ESV (External Symbols Vector).

However, no object structure list will be created if the PROGRAM operand SYMBOL-DICTIONARY=NO is written in the SAVE-LLM statement during linkage with BINDER or if the operand SYMTEST=NO is specified during program linkage. The following functions cannot be performed in that case:

– Output a list of all CSECTs and COMMONs of the application program (%D %SORTEDMAP or %D %MAP)

– Output localization information for a memory reference (%D %LOC(memref))
– Specify a CSECT/COMMON qualification in a memory reference
– Trace by means of the %CONTROLn and %TRACE commands, if these are to be explicitly or implicitly restricted to one CSECT
– Create REPs for corrections

In addition, in this case AID cannot output any CSECT-relative or COMMON-relative addresses with %TRACE, %DISASSEMBLE, %FIND or in the STOP message.

Caution is required in the case of LLMs or contexts which contain CSECTs of the same name: in this case it cannot be foreseen which CSECT will be referenced with AID.

4.2 Symbolic debugging

Symbolic debugging with AID enables data to be addressed with user-defined names from the source program and permits statements to be referenced through the input of statement names or source references. For this purpose AID needs information on the names used in the source programs of which the program to be tested is made up. This information is in two parts:

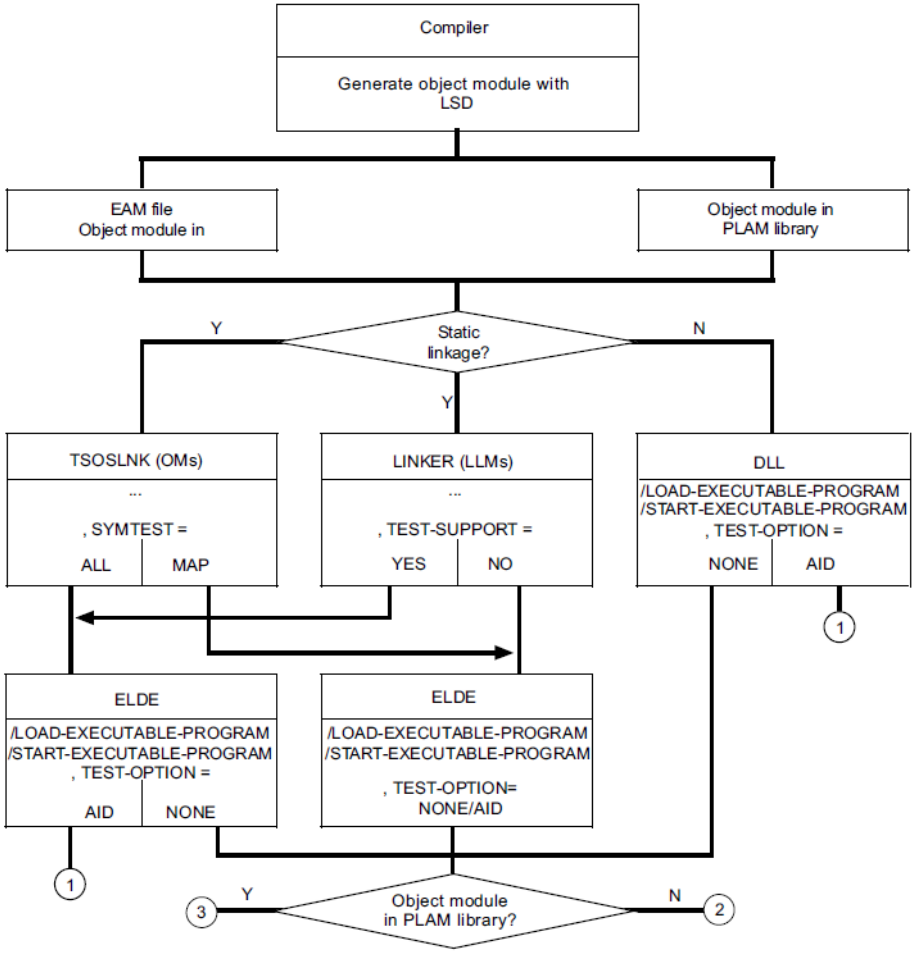
1. LSD (List for Symbolic Debugging): directory of the names and source references defined in the module.
2. ESD (External Symbol Dictionary): ESV (External Symbols Vector) when linking with BINDER.

The following sections deal with the various processing options for ESD/ESV and LSD records for each of the following steps in the software engineering cycle:

– source program compilation
– linkage and loading with DBL or
– linkage with BINDER

In addition AID offers the %SYMLIB command, which can be used to open PLAM libraries (see the "LMS (BS2000) [11]) from which AID dynamically loads the missing LSD records as required.

The following diagram outlines the options regarding the inclusion or non-inclusion of the compiler-generated LSD records during linkage and loading.



(1) The program may be tested symbolically without restrictions.

(2) The program may be tested symbolically with restrictions, i.e. names of program segments can be referenced and call hierarchies traced.

(3) The program may not be tested symbolically until the PLAM library containing the OMs or LLMs has been assigned using the %SYMLIB command.

There are thus different ways of supplying AID with LSD information. The prerequisite is always that the LSD records are passed to the generated object module (OM) or link and load module (LLM) during compilation. If the OM or LLM is stored in a PLAM library, the LSD records can either be included in linkage and loading or dynamically loaded by AID when required.

Dynamic loading of LSD records is especially useful for programs which are the result of multiple compilation runs and for which only certain modules are to be symbolically tested. The LSD that is to be dynamically loaded must have been created in the same compilation run as the module.

AID cannot perform dynamic loading from the temporary object module file (*OMF file).

4.2.1 Compilation

A compiler option is used to control generation of LSD records by the compiler. A detailed description of the relevant operands can be found in the language-specific manuals for AID (see [2] - [6]). Essentially there are two possibilities:

– Only the ESD/ESV is created, but no LSD records (default value). The program can only be tested on the machine code level.

– The compiler generates both LSD records and the ESD/ESV. The program can be tested symbolically under AID.

4.2.2 Linkage using BINDER

When linking using BINDER, LSD records can be incorporated in all linkage processes. In the BINDER statements which control the creation, modification or storage of an LLM, the TEST-SUPPORT operand determines whether the LSD records from link and load modules (LLMs) will be incorporated or not (see Binder in BS2000 [12]). Statements which require the same operand values are summarized in the table below, shown with the syntax of the TEST-SUPPORT operand. A description of the operand values follows below the table of statements and the associated TEST-SUPPORT syntax options.

Statement	Meaning	TEST-SUPPORT operand values
START-LLM-CREATION	Creation of an LLM	TEST-SUPPORT= 
START-LLM-UPDATE MODIFY-LLM-ATTRIBUTES	Update an LLM Modify the physical structure of an LLM	TEST-SUPPORT= 
MODIFY-MODULE-ATTRIBUTES	Modify the logical structure of an LLM	TEST-SUPPORT= 
SAVE-LLM	Save an LLM	TEST-SUPPORT= 
INCLUDE-MODULES REPLACE-MODULES RESOLVE-BY-AUTOLINK	Insertion of modules Replacement of modules Resolution of external references by Autolink	TEST-SUPPORT= 

*YES The LSD records are taken over. The linkage editor does check, however, whether the object module (OM) or link and load module (LLM) being processed actually contains LSD records.

*NO The LSD records are not taken over. If SYMBOL-DICTIONARY=YES has been set in the SAVE-LLM statement, however, i.e. the ESV has been included, it is possible to track back through call hierarchies. If LSD records have been created additionally during compilation and written to a PLAM library with the OM or LLM, the LSD can be dynamically loaded for symbolic debugging when required.

*UNCHANGED The currently applying specification depending on the prompted commands before is kept.

*INCLUSION-DEFAULT

The values of the TEST-SUPPORT operand, which is a suboperand of the INCLUSION-DEFAULT operand, from the START-LLM-CREATION, START-LLM-UPDATE, or MODIFY-LLM-ATTRIBUTES statements from the same edit run are transferred.

*LAST-SAVE The linkage editor takes over the values from the last SAVE-LLM statement in the same edit run. If no SAVE-LLM has previously been specified, the linkage editor inserts YES.

The BINDER allows CSECTs of the same name to be incorporated more than once in an LLM. During debugging with AID, however, this leads to unforeseeable results.

4.2.3 Linkage and loading via DBL

A program to be tested is called by means of the BS2000 command LOAD-EXECUTABLE-PROGRAM, whereupon AID commands can be entered.
A program to be processed by AID only in the event of an error can be loaded and started by means of START-EXECUTABLE-PROGRAM. A load unit included with the BIND macro call can also be tested with AID.

A program in the form of object modules (OMs) or link and load modules (LLMs) is loaded by the Dynamic Linking Loader DBL (see Dynamic Binder Loader / Starter in BS2000 [13]).

– Loading or loading and starting with the DBL called by SDF commands:

```
/LOAD-EXECUTABLE-PROGRAM  }
                          } .....,TEST-OPTIONS = { *DBL-DEFAULT }
/START-EXECUTABLE-PROGRAM }                      { *NONE        }
                                                 { *AID         }
```

*DBL-DEFAULT
The value of the operand is taken from the last call of the MODIFY-DBL-DEFAULTS command. If no value was specified for the corresponding operand by MODIFY-DBL-DEFAULTS, TEST-OPTIONS=*NONE applies.

*NONE The program is loaded without LSD records. Symbolic testing is possible only if the PLAM library containing the relevant object modules is made available to AID for dynamic loading of the LSD records.

*AID The program is loaded with the LSD records. If no LSD records exist, the program is loaded nonetheless. If DBL-PARAMETERS:LOADING was specified at the same time, it must be ensured that the associated LOAD-INFORMATION operand, which controls loading of the ESV, is set to DEFINITIONS (default value) or to REFERENCES.

– Integration of an additional load unit with the DBL via the BIND macro call:

```
BIND      .....,TSTOPT = { *DBLOPT }
                         { NONE    }
                         { AID     }
```

*DBLOPT The value of the operand is taken from the last call of the MODIFY-DBL-DEFAULTS command. If no value was specified for the corresponding operand by MODIFY-DBL-DEFAULTS, TEST-OPTIONS=*NONE applies.

NONE Same meaning as above

AID The program is loaded with the LSD records. It will also be loaded even if it does not contain any LSD records. At the same time the LDINFO operand must be set to DEF or REF to ensure that the ESV is loaded.

Examples

1. `/LOAD-EXECUTABLE-PROGRAM FROM-FILE=*OMF,TEST-OPTIONS=*AID`

   DLL loads an object module with LSD records from the *OMF file.

2. `/LOAD-EXECUTABLE-PROGRAM FROM-FILE=*LIBRARY-ELEMENT(LIBRARY=PROGRAMLIB,ELEMENT-OR-SYMBOL=ROOTMOD)`

   ROOTMOD is loaded from the PLAM library PROGRAMLIB.

The examples apply analogously for the START-EXECUTABLE-PROGRAM command.

4.2.4 Dynamic loading of LSD records by AID

AID can dynamically load LSD records for a program from a PLAM library if the library contains the associated OMs or LLMs with the LSD records. The %SYMLIB command instructs AID to open the specified library. If AID processes a command with symbolic operands and recognizes that the related LSD records are not available in memory, AID accesses any libraries assigned and opened via %SYMLIB. AID checks whether the dynamically loaded LSD records are derived from the same compilation run as the module for which they are loaded.

If no library has been assigned or the assigned libraries do not contain the desired OM or LLM, or if they do not contain any LSD records, AID reports the LSD records to be missing. The required library can be assigned with a new %SYMLIB command. If the AID command for which the LSD records were missing is then repeated, AID will process it.

In the case of LLMs it is possible to mask CSECTs contained in them with the BINDER

statement MODIFY-SYMBOL-VISIBILITY. AID cannot dynamically load any LSD information for such CSECTs. The same applies to CSECTs for which the

RUN-TIME-VISIBILITY operand was set to YES, because this includes masking of the CSECT. This operand can be specified with the following BINDER statements:

– INCLUDE-MODULES
– MODIFY-MODULE-ATTRIBUTES
– REPLACE-MODULES
– RESOLVE-BY-AUTOLINK

Programs which contain masked CSECTs can only be put through symbolic debugging with AID if the LSD is loaded together with the program. Dynamic loading is only possible if the masking has been reset in a separate BINDER run.

It should be pointed out that AID terminates the LSD search in an LLM when it finds the first CSECT of the required name, even if the LSD for that CSECT is inconsistent, for example because the LSD has not come from the same compilation as the CSECT. It is therefore of no benefit if there is another CSECT of the same name with a consistent LSD contained in the same LLM.

Examples

1. ```
   /LOAD-EXECUTABLE-PROGRAM FROM-FILE=*LIBRARY-
   ELEMENT(LIBRARY=PROGRAMLIB,ELEMENT-OR-SYMBOL=ROOTMOD)
   ```

   The linked FORTRAN program ROOTMOD is loaded without LSD records from the PLAM library PROGRAMLIB.

   After input of the following AID command with which the statement with label 10 is referenced:

   ```
   %INSERT L'10'
   ```

   the following error message is issued:

   ```
   AID0378       Symbolic information missing
   ```

   If the PROGRAMLIB library contains the object module for this program with the associated LSD information, the command

   ```
   %SYMLIB      PROGRAMLIB
   ```

   can be used to assign the appropriate PLAM library. The %INSERT command can then be repeated and will be processed by AID. The object module and the load unit may be contained in different libraries, but the load unit must have been linked from the object module version from which the LSD records are dynamically loaded. If this is not the case, AID displays the following error message:

   ```
   AID0377       Symbolic information inconsistent for (&00)
                 &00 = programname
   ```

2. ```
   %SYMLIB E=D1.OBJMOD.LIB1,E=D1.OBJMOD.LIB2
   ```

   The PLAM libraries OBJMOD.LIB1 and OBJMOD.LIB2 are available for dynamic loading of the LSD records for the dump file with link name D1.

3. ```
   %QUALIFYE=D2
   %SYMLIB E=D3.LIB1,.LIB2,LIB3
   ```

   The PLAM library LIB1 is defined and opened for the dump file with link name D3.
   Library LIB2 is defined and opened for the dump file with link name D2.
   The PLAM library LIB3 is defined and opened for the current AID work area.

   If no %BASE command has been issued, the current AID work area is the virtual memory area of the loaded program. Following a %BASE command, the AID work area is the one specified in %BASE.
   ```

5 Command input

5.1 Command format

Every AID command starts with the percent character (%), immediately followed by the command name.
Operands may follow after at least one blank.
If operands and/or keywords are entered in succession without a predefined delimiter, they must be separated by at least one blank.
Operands must be entered in the sequence in which they appear in the format descriptions.

Command names

An AID command can be assigned a name like a BS2000 command:

– 1st character: A-Z, $, # or @

– all subsequent characters: A-Z, 0-9, $, #, @ or -,
where the hyphen (-) must not be the last character of the name.

Names which are branched to with SKIP-COMMANDS begin with a period and may comprise up to 8 characters; names from S-procedures to which the process branches with GOTO may comprise up to 255 characters and are concluded with a colon.
The name follows the slash which is output by the system in interactive mode and entered by the user in procedure files. This name and the % character of the AID command must be separated by at least one blank.
Example: /.START %AID CHECK=NO

The BS2000 command names serve as branch destinations in procedures; they are not relevant for testing with AID.

Continuation of input lines

If an AID command overflows into the next line, the same continuation mechanism applies as for BS2000 commands. In interactive mode, an input may extend over several lines. Alternatively each line may be concluded with a hyphen and sent off separately. The continuation line then starts after the prompt sent by the system.

In procedure files, a continuation line must be announced by a hyphen, which may be followed only by blanks up to the end of the line.
The continuation line must begin with a slash.

The length of an AID command must not exceed 1000 characters.

As there is only a limited area in memory which can be used for the interpretation of a command, the number of operands in a command is restricted. The individual command descriptions contain information on how many operands can be specified in each case.

Use of blanks and comments

Blanks and comments may be used to make AID commands clearer and easier to read. Just like in the BS2000 command language, comments must be enclosed in double quotes ("). Blanks and comments can be inserted whenever one of the following characters occurs:

```
–         Blank
.         Period
,         Comma
=         Equal sign
'...'     Apostrophe
(...)     Opening and closing parentheses
<...>     Opening and closing angle brackets
[...]     Opening and closing square brackets
;         Semicolon
+ – * /   Arithmetic operators
->        Pointer operator
```

When using the minus sign or hyphen "-" the presetting of the *SYMCHARS* operand in the %AID command must be taken into account.

Example

```
%CONTROL1    %CALL   "SORT CALL"   <%DISPLAY 'CALL'; %STOP>
```

5.2 Individual commands

AID commands may be entered in BS2000 command mode or called via the CMD macro interface. AID commands are accepted by BS2000 like BS2000 commands and passed to AID after they have been identified as AID commands on the basis of the % character. If the BS2000 command interpreter determines during input that an AID command is too long, it rejects it with an error message and the user can reenter the corrected command.

AID checks the command syntax and semantics and determines whether the operand values can be processed in the current test situation. An error message is issued, for example, if a symbolic address is referenced which is not stored in the available LSD records (see section “Basic concepts” on page 20).

If a syntactically invalid command is entered, AID issues an appropriate error message and marks the location where it detected the error. The corrected command can then be entered once more.

Once AID has accepted and executed a command, the type of command involved determines whether the program is started or further commands can be entered.

5.3 Command sequences and subcommands

Command sequences can be formed to combine a number of AID and/or BS2000 commands. Successive commands must be separated by semicolons.
A command sequence must not be longer than 1000 characters (same limit as for a single AID command).
Command sequences are executed immediately. They are processed from left to right.

All commands in a command sequence which start with % are identified by AID as AID commands and immediately checked for errors. If AID senses a syntax error, the entire command sequence is rejected during input. AID interprets commands without a leading % character as BS2000 commands and accepts them without any further check. Errored or illegal BS2000 commands are thus not recognized until command execution and lead to abortion of the command sequence. Processing of the command sequence is also aborted in the case of serious errors in AID commands, such as address overflow. The system is then in command mode, i.e. the user may enter further commands.
If an AID command cannot be executed because a specified name is not stored in the LSD records or no LSD records are loaded, AID issues an appropriate error message for this command and continues processing of any subsequent commands.
Since the entire command sequence must be reentered after certain errors, lengthy command sequences should be used in completely tested procedure files only.

Command sequences may include all those BS2000 commands which are permitted in the CMD macro (see Executive Macros [10]) and nearly all AID commands.

The following commands are illegal in command sequences:

AID commands: %AID, %ALIAS, %BASE, %DUMPFILE, %HELP, %OUT, %QUALIFY, %?

BS2000 commands: See list in appendix.

SDF-P control flow commands are likewise illegal in command sequences.

Moreover, some BS2000 commands that are permitted in command sequences terminate a loaded program, i.e. the program can then no longer be processed with AID commands (see the description of the CMD macro in the „Executive Macros“ manual [10]).

The commands %TRACE, %RESUME, %CONTINUE and %STOP terminate a command sequence. After %STOP the system is in command mode, whereas the commands %TRACE, %RESUME and %CONTINUE start or continue the program. This is why all of these commands should only occur as the last item in a command sequence.

A subcommand is not a command in its own right but an operand of the monitoring commands %CONTROLn, %INSERT and %ON.
The subcommand is not processed until the monitoring condition has been satisfied.
The command section of subcommands is subject to the same rules as command sequences, with the following exceptions:

– The length of monitoring command plus subcommand must not exceed 1000 characters.
– Like %CONTINUE, %RESUME, %TRACE and %STOP, a %REMOVE for the subcommand just executed makes sense as the final command only, since any ensuing commands of the subcommand will not be executed.
– In the subcommand of a %CONTROLn it is not permitted to specify another %CONTROLn command or an %INSERT, %JUMP (COBOL85, FOR1) or %ON.

Examples

1. `%INSERT S'20' <%DISPLAY A,B;%SET A INTO B;ADD-FILE-LINK...;%REM %•>`

   When the running program arrives at statement 20, AID outputs the contents of variables A and B, assigns the value of A to variable B, and calls the SDF command ADD-FILE-LINK. Since the subcommand also contains a %REMOVE %• it is deleted following execution.

2. `%ON %LPOV <%DISPLAY %LINK>`

   Whenever a module is dynamically loaded during a program run, AID outputs its name. The program run is continued.

5.4 Command files

AID commands may also be contained in BS2000 procedure files and ENTER jobs. If an input record is to begin with an AID command, the first character must be a slash followed by the % character of the AID command. Any label for /SKIP-COMMANDS or /GOTO must precede the % character however.

If a BS2000 procedure contains an AID command requiring an acknowledgment (see /%AID CHECK=ALL.../%SET...), AID inserts Y as an answer in batch mode.

Example

```
/LOAD-EXECUTABLE-PROGRAM *LIB-ELEM(TESTLIB,TESTLLM), TEST-OPT=AID
/BEG: %SET 17 INTO SLF
/%INSERT S'71'  <%DISPLAY I,J,K>
.
.
.
/GOTO BEG
/END: EXIT-PROC
```

6 Subcommand

6.1 Description

A subcommand is an operand of one of the monitoring commands %CONTROLn, %INSERT and %ON. These commands define a monitoring condition which must be satisfied for the related subcommand to be processed. This offers the option of effectively controlling the debugging run and of setting up automated test sequences where, for instance, current data statuses are written to logging files or contents of data fields or registers are modified at predefined points in the program.

```
subcmd-OPERAND  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

                                  ⎧AID-command   ⎫
<[subcmdname:] [(condition):] [   ⎨              ⎬ {;...}]>
                                  ⎩BS2000-command⎭

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

The subcommand name can be used in the course of the debugging run to reference the subcommand, for example to interrogate the subcommand execution counter or to delete the subcommand. Execution of the subcommand may depend on a condition, which must be situated between the subcommand name and the command section. The command section may consist of a single command or a command sequence and may contain both AID and BS2000 commands (see also section “Command sequences and subcommands” on page 47).

In %INSERT, %CONTROLn and %ON, AID inserts <%STOP> as a subcommand if no subcommand is specified by the user. If, however, a *subcmdname* or *condition* is specified and just the command section is omitted, AID does not add a %STOP but behaves (at the test point or on occurrence of the defined event) as if a %CONTINUE were inserted:

– the execution counter is incremented (can be queried via %•*subcmdname*)

– the program continues

– any %TRACE is resumed.

Address operands in the command section of a subcommand which do not contain a complete explicit qualification are complemented during input in accordance with the currently valid definitions for the base qualification (see %BASE) and for *prequalification*

(see %QUALIFY). Only the syntax of a subcommand is checked during input. Whether the specified symbolic addresses are contained in the LSD records or whether LSD records for a program segment that is referenced via a qualification are loaded at all is not checked by AID until subcommand execution. This means the corresponding LSD records need not yet be loaded when the subcommand is entered. Likewise, when qualifications are used there is no check at subcommand input as to whether the program segments identified in that way exist or have been loaded.

The subcommands of %INSERT or %ON can be chained according to the LIFO principle, i.e. subcommands may be modified/updated later as a function of the test results. Detailed information can be found in section “Chaining” on page 62.
In the subcommands for %INSERT and %ON, further %INSERT and %ON commands may be defined. This is described in section “Nesting” on page 64.
Some commands are not permitted in subcommands and/or abort the subcommand, the program, or even the task. chapter “Command input” on page 45 contains complete information on this topic as well as a description of error handling in subcommands.

Examples

1. `%CONTROL1 %STMT IN (S'20':S'27') <%DISPLAY A_ARR>`

   The contents of all elements of field A_ARR are output before statements 20 through 27 are processed.

2. `%INSERT INPUT <%DISPLAY INDAT;%SET KEY INTO I-KEY>`

   Every time the running program reaches the paragraph with the name INPUT the input record INDAT is output and the contents of key field KEY are transferred to I-KEY.

3. `%ON %LPOV <%SDUMP %NEST>`

   The current call hierarchy is displayed every time a new segment has been loaded.

4. `%INSERT V'2C' <%SET #2C'INTO%5;%DISPLAY'INS_2C!!!'>'`

   Prior to execution of the instruction with address V’2C’ AID loads register 5 with the value #2C’anddisplaysthetext"INS_2C!!!".'

5. `%ON %SVC <%C1 %INSTR <%R>; %C2 %INSTR <%REM %C>; %T 2 %INSTR>; %R`

   All SVCs from input of the above %ON command onwards are logged.

   Firstly, %ON %SVC specifies that the subsequent subcommand is executed before execution of an SVC. The subcommand contains two %CONTROL commands and one %TRACE, each with the %INSTR criterion. The %TRACE executes the next instruction, which is the SVC, and logs it. Execution of the next instruction triggers processing of the two subcommands for %CONTROL1 and %CONTROL2: program execution is continued with %RESUME, until the next SVC is detected; the second subcommand (%REMOVE %CONTROL) immediately resets the %CONTROL because otherwise a %RESUME would be executed for each subsequent instruction, which would greatly reduce the speed of program execution.

6.2 Name and execution counter

A subcommand name comprises up to 30 characters; the first character may be A-Z, $, @ or underscore "_", the subsequent characters may also include the digits 0-9 and the hyphen (-). A hyphen at the end of a command line is always interpreted as a continuation character in interactive mode. The subcommand name is concluded with a colon, which is not part of the name however.
The name must follow the opening angle bracket and must be unique: identical subcommand names are rejected by AID with an error message. In the case of nested subcommands AID checks the name not during input but only at subcommand execution. In particular, internal subcommands from nesting which are executed more than once can be given a name only if they are explicitly deleted after every time of their execution.
Up to 256 different subcommand names may be assigned.
If the subcommand contains a %STOP, the subcommand name is included in the STOP message.
The subcommand name must be preceded by the string %• if it is to be used as a general AID operand. This results in the AID keyword %•*subcmdname* which can be used in the course of the test run to reference the subcommand and its execution counter.
All subcommands, even those which do not have a name, can be referenced within the subcommand by means of the %• string. Outside the subcommand it is not possible to reference the execution counter and subcommand with the %• string.

The execution counter is directly connected with the subcommand name, because it can be referenced via that name. AID also has an execution counter for subcommands which do not have a name, however; this counter can only be interrogated within the associated subcommand with the %• string.
The execution counter is a numerical value which is incremented by one each time the subcommand is processed. The counter is also incremented if the subcommand contains

a condition whose result is FALSE (preventing execution of the associated command section). The user may modify the execution counter via %MOVE or %SET. It is possible for the execution counter to assume a negative value.
The current status of the execution counter can be queried via %DISPLAY %•*subcmdname* (or %DISPLAY %.z for the subcommand about to be executed).

Examples

1. `%CONTROL1 %IO <IO: %CONTINUE>`

   The %•IO execution counter is incremented by 1 on each input/output operation of the program.

2. `%IN L'200' <L200: %DISPLAY %•IO; %STOP>`

   The program stops at label 200 and AID outputs the status of the execution counter belonging to the subcommand with the name %•IO from example 1.

3. `%CONTROL2 %CALL <PAR: %D %•,PAR1,PAR2,PAR3 P=MAX>`

   This command monitors the subprogram calls. The execution counter reflects the number of CALL statements that have already been issued. Parameters PAR1, PAR2 and PAR3 are additionally logged on SYSLST.
   As the subcommand has the name PAR, %DISPLAY %•PAR can be entered at any point during further testing to determine how many CALL statements have been executed by the program.

6.3 Conditional execution

AID offers the possibility of making the execution of a subcommand dependent on a condition. The condition must be enclosed in parentheses and concluded by a colon; it is situated immediately before the command section of the subcommand.

AID checks the condition and assigns the value TRUE or FALSE to it. Only in the case of TRUE is the command section executed; in the event of FALSE it is skipped.

```
condition OPERAND - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

                          ⎡AND⎤
([NOT] comparison1 [⎨OR ⎬ [NOT] comparison2⎦ [...]):
                          ⎣XOR⎦

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Operands can be formed and used for *comparison*$_n$ in accordance with the following syntax:

```
comparison OPERAND - - - - - - - - - - - - - - - - - - - - - - - - - - - -

⎧      ⎧dataname          ⎫⎫             ⎧      ⎧dataname          ⎫⎫
⎪      ⎪statementname     ⎪⎪             ⎪      ⎪statementname     ⎪⎪
⎪      ⎪S'...'            ⎪⎪             ⎪      ⎪S'...'            ⎪⎪
⎪      ⎪compl-memref      ⎪⎪             ⎪      ⎪compl-memref      ⎪⎪
⎪[qua]⎨                   ⎬⎪ ⎧EQ ⎪ NE⎫ ⎪[qua]⎨                   ⎬⎪
⎪      ⎪V'f...f'          ⎪⎪ ⎪GE ⎪ LE⎪ ⎪      ⎪V'f...f'          ⎪⎪
⎨      ⎪C=csect           ⎬⎨ ⎨        ⎬ ⎨      ⎪C=csect           ⎬⎨
⎪      ⎪COM=common        ⎪⎪ ⎪GT ⎪ LT⎪ ⎪      ⎪COM=common        ⎪⎪
⎪      ⎪keyword           ⎪⎪ ⎩NG ⎪ NL⎭ ⎪      ⎪keyword           ⎪⎪
⎪%@(...)                  ⎪⎪            ⎪%@(...)                  ⎪⎪
⎪%L(...)                  ⎪⎪            ⎪%L(...)                  ⎪⎪
⎪%L=(expression)           ⎪⎪            ⎪%L=(expression)           ⎪⎪
⎩AID-literal               ⎭⎭            ⎩AID-literal               ⎭⎭

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Summary of relational and Boolean operators:

Relational operators		Boolean operators	
EQ	equal	NOT	logical negation
NE	not equal	AND	logical AND
LE	less or equal	OR	logical OR (inclusive)
LT	less than	XOR	logical OR (exclusive)
NL	not less than		
GE	greater or equal		
GT	greater than		
NG	not greater		

The relational operators are all of the same precedence and are processed before the Boolean operators.

The Boolean operators are subject to the following order of precedence:

NOT highest precedence

AND second-highest precedence

OR/XOR lowest precedence

Operators of the same precedence are processed from left to right. Appropriate parentheses must be used if the operators are to be processed in an order other than their predefined precedence.

Examples

```
(I EQ J AND VAR EQ 'A' OR VAR EQ 'B'):
corresponds to:
(((I EQ J) AND (VAR EQ 'A')) OR (VAR EQ 'B')):

(NOT VAR EQ 'A' OR ADR NE %OG):
corresponds to:
((NOT (VAR EQ 'A')) OR (ADR NE %OG)):
```

Parentheses must also be used if the relational operators or Boolean operators can be confused with variable names and consequently might be rejected as faulty syntax.

The only unary operator is NOT, i.e. it refers to one operand only. All the other Boolean operators and all relational operators are binary, i.e. they link two operands with each other.

The relational operators support the comparison of precisely two operands in each case; chaining is not possible. If, for instance, the condition `(A EQ B EQ C):` is specified, AID rejects it during input with the message `AID0271 Syntax error`. Instead the condition should be
represented by `(A EQ B AND B EQ C):`.

Any memory reference permitted for AID (see section “Memory references” on page 76) can be used as an operand for relational operators. If data items from the user program are employed, they are assigned one of the following storage types:

– binary string (≙ %X)

– character (≙ %C)

– numeric (≙ %A, %F, %P, %D).

Character-type memory contents of up to 1000 bytes can be compared in a condition. Logical variables may be compared if a type modification is used to define a different storage type (e.g. `(ALOG%X EQ X'FF'):`). Among the keywords the subcommand execution counters, the AID registers, all program registers and the program counter (%PC) can be used for comparisons.

AID literals are likewise permitted as comparison operands. For character literals (C'x...x') AID always uses the code of the input mediums, that means the coded character set ot the terminal or the prozedure file with AID commands. If character-type memory contents are to be compared in ASCII, the comparison text must be converted into a hexadecimal literal, e.g. C'Hugo' has the hexadecimal value X'4875676F' in ASCII.

When a condition is formulated, the operand types must be compatible. The table on the next page shows which comparisons are permitted and how the comparison takes place. The permissibility of a comparison is not checked until the monitoring event has occurred. In the case of an error, AID issues an appropriate message and sets the comparison result to FALSE, i.e. the command section of the subcommand is not executed.

AID distinguishes between binary, character and numerical comparisons. AID derives the type of comparison from the type of the operands involved. AID converts and compares the operands of a condition according to a specific, language-independent algorithm because it is quite possible for a user to compare data items from modules that are written in different programming languages. Therefore the result of an AID comparison will not necessarily match the result of a similar comparison in a particular programming language:

– In the case of a character comparison the shorter operand is logically blank-filled, and AID compares two operands of the same length, whereas Fortran for example always evaluates the result of the comparison as FALSE if the operands involved are of different lengths.

– In the case of a binary comparison, the operand is padded with X'00' to the right and the subsequent procedure is the same as for character comparison.

– In the case of numeric comparisons, different results may arise from the fact that AID does not work to the same degree of precision as the respective programming language during the conversion of the operands.

– COBOL assigns the numerically edited variables to the numerical operands; for AID, these variables belong to the character memory type.

Particular attention must be paid to this situation if it is intended to compare operands from various different programming languages.

The comparisons that are made using the relational operators serve as operands for the Boolean operators. Logical variable such as those used in Fortran cannot be used in this case.
Boolean operators also enable more than two comparisons to be linked with each other: the upper limit is determined by the complexity of the comparison operands and the size of the internal AID input buffer.

The following table shows how the various operand types are compared with each other and which comparisons are not permitted.

storage type 1st operand	storage type 2nd operand					
	%X X' f...f' B' b...b'	numeric	%C C' x...x' U' x...x'	%UTF16/ NATIONAL	numeric Literal	Pointer
%X X' f...f' B' b...b'	bin	bin	bin	bin	–	bin
numeric	bin	num	num(1)	numchar UTF16-chr	num	–
%C C' x...x' U' x...x'	bin	num(1)	char	UTF16-conv UTF16-chr	num(1)	–
%UTF16/ NATIONAL	bin	numchar UTF16-chr	UTF16-conv UTF16-chr	UTF16-chr	numchar UTF16-chr	–
numeric Literal	–	num	num(1)	numchar UTF16-chr	num	–
Pointer	bin	–	–	–	–	bin

bin: Binary comparison
Comparison takes place bitwise from left to right. The shorter operand is padded with zeros (B'0') to the right.

char: Character comparison
Comparison takes place bytewise from left to right. The shorter operand is padded with blanks (X'40') to the right.

num: Numerical comparison
The arithmetical values of the two operands are compared.

numchar
The printable numeric string in UTF16 encoding from the integer numeric field is used for the comparison.

UTF16-chr
Character comparison in UTF16 encoding
Comparison takes place bytewise from left to right. However, UTF16 characters are used for padding and truncation (blanks in 2-byte encoding).

Ordering relations which are used in EBCDIC encoding are no longer supported by AID for the bytewise UTF16 comparison.

UTF16-conv
: If an operand is of the type %UTF16 and the operand to be compared is of the type %C or a C/U literal, it is converted to %UTF16 by UTF16-conv. The comparison can then take place as with UTF16-chr.

num(1)
: If a character-type operand contains only digits and is no more than 19 characters in length, it is compared numerically, provided the second operand is of the numeric type.
All other character-type operands cannot be compared with numeric storage types or numeric literals.

–
: Comparison not possible

  An attempted comparison is rejected with an error message and the result is set to FALSE.

Numeric storage types:

%A, %Y (corresponds to %AL2)	unsigned integer
%F, %H (corresponds to %FL2)	signed integer
%P	packed number
%D	floating-point number
%PC	program counter
all registers	
%•[*subkdoname*]	execution counter

and all symbolically addressed numeric-type data items.

Not all data items treated numerically in the various programming languages have a numeric storage type in AID; for details see the language-specific AID manuals (%SET table).

Numeric literals:

```
[{±}]n                          integer
#f...f'hexadecimalnumber'
[{±}]n.m                        decimal number
[{±}]mantissaE[{±}]exponent     floating-point number
```

Storage types %S and %SX are not very useful for comparisons and are therefore not listed in the above table. %S is treated like %XL2 and %SX like %XL4.

Further information on storage types and literals can be found in chapter “AID literals” on page 109 and chapter “Keywords” on page 121.

Examples

1. `%IN S'18' <(%• LT 10): %D I,J; %MOVE X'58' INTO V'348'>`

   When the program reaches statement 18, AID interrupts the program run and checks the subcommand condition. On the first nine times the command section is executed, i.e. AID outputs the values for variables I and J on the screen and sets the content of virtual address V'348' to X'58'. As the subcommand does not contain a %STOP the program run is resumed at statement 18.
   On each further pass of test point S'18' the command section of the subcommand is skipped.

2. `%IN S'25' <INS25: (ACHAR EQ 'END'): %D ISUM,JSUM; %STOP>`

   The subcommand of test point S'25' is not executed until the field with the symbolic address ACHAR has the content 'END'. AID then displays the contents of the sum fields ISUM and JSUM on the screen and the program switches to command mode.

3. `%CONTROL1 %IO <OUTPUT: (SLF NE 200): %D %•, OUTDAT, SLF P=MAX>`

   On testing a program which is supposed to output records with a length of 200 the record length is found to be incorrect at times. The command %CONTROL1 can be used to monitor the record length field SLF. Every time a record is output and SLF does not contain the value 200, AID writes the contents of the execution counter and of the fields OUTDAT and SLF to SYSLST.

4. `%INSERT S'18' <IN1:(I EQ 15): %SET 1 INTO J; %D ARRAY(K),K;%STOP>`

   A test point is set for statement number 18. A subcommand with the name IN1 is entered for this test point: whenever index I has the value 15, index J is set to 1 and the vector element ARRAY(K) is output with the associated index K. The program is then suspended.

5. `%SET 0 INTO %0G`

```
%INSERT S'25'      <CN1: (CODGT NE '3'): %SET %L=(1 + %0G) INTO
%0G;-
                     %D %•, %0G, CNO, OUTDAT P=MAX>
```

   The %SET sets AID register %0G to 0. The %INSERT sets a test point for statement 25 and defines a subcommand with the name CN1. Whenever the test point is reached, AID increments the counter %•CN1 by 1. Only if the code digit CNO at the test point is '3' will register %0G be incremented by 1, with AID writing the counter statuses, the contents of the code digit CNO and the output record OUTDAT to SYSLST (P=MAX).

In other words, the content of %•CN1 shows how often the program executes statement 25, and %0G counts how often the code digit CNO at the test point is not equal to 3.

6. `%IN PROC <(%3 GT 4096 AND %5->%L1 EQ 'A'): %SET %L=(%5 + 2) INTO %5>`

   Prior to execution of the PROC statement, AID checks whether register %3 contains a value > 4096 and whether the memory location referenced by register %5 contains an ’A’ at the same time. If so, the content of register %5 is incremented by 2 and program execution continues.

6.4 Chaining

On input of several %INSERTs for the same *test-point* or several %ONs for the same *event* AID prefixes the last subcommand to the preceding one (LIFO principle). One exception is the *write-event* with %ON. Chaining is not possible in this case; the command that is entered last overwrites the previous one. AID draws attention to this with warning AID0496. Commands are also chained if the newer command does not have an explicit subcommand; in this case the implicitly generated <%STOP> command is prefixed to the subcommand already entered, i.e. the older subcommand is not executed any more. It is expedient, however, to first delete the subcommand no longer required, for otherwise AID has to administrate a "deadwood" entry throughout the remaining debugging sequence.

If a chained subcommand contains a condition, this condition applies for the associated command section only. The subcommands ensuing in the chain are handled in one of two ways:

– The conditional command section is concluded with %CONTINUE, %RESUME, %TRACE or %STOP. Ensuing subcommands are processed only if the condition result is FALSE.

– The conditional command section does not contain any %CONTINUE, %RESUME, %TRACE or %STOP. Ensuing subcommands are always processed regardless of whether the condition result is TRUE or FALSE.

Subcommand chaining for %CONTROLn is not possible. A new %CONTROLn overwrites all operand values of an earlier %CONTROLn for the same number n with entries from the new command.

Examples

1. The following commands are entered in the test run:

```
%ON %LPOV(SUBTOT)
          .
          .
          .
%ON %LPOV(SUBTOT)      <%DISPLAY S=B1@.PROC=B1.CHAR_DAT>
```

   On input of the first %ON, AID adds <%STOP> as a subcommand, because no subcommand has been explicitly specified. Chaining after input of the second %ON results in the following subcommand for the %LPOV(SUBTOT) event, i.e. after the SUBTOT module has been loaded:

```
<%DISPLAY S=B1@.PROC=B1.CHAR_DAT; %STOP>
```

2. The following example shows the effect of LIFO chaining with a <%STOP> command inserted by default (implicit subcommand).

```
%INSERT ST4  <%D TEXTDAT>
                      .
                      .
                      .
%INSERT ST4
```

The second %INSERT contains no subcommand, therefore AID adds a <%STOP> command. Since the second %INSERT designates the same test point as the previous one, it is prefixed and leads to the following chained subcommand sequence:
`<%STOP;%DISPLAY TEXTDAT>`

As the execution of a subcommand is aborted by %STOP, the `%DISPLAY TEXTDAT` command will never be executed; but it remains registered as a subcommand for test point ST4 and cannot be deleted from the chain either, because it has no name. It is best to assign a name to each subcommand so that there is always the possibility of deleting a subcommand from the chain via its name in the event of chaining being incorrect by mistake.
In the above example it would have been better to delete the first %INSERT via

```
%REMOVE ST4
```

and then enter

```
%INSERT ST4
```

3. The following %INSERTs can be used in a procedure in order to search for a character literal. In the event of a hit, the located address is stored in AID register %0G and the length of the desired string is stored in %2G (see %FIND).

```
%INSERT V'1648' <(%0G NE -1): %SET %L=(%1G - %0G) INTO %2G>
%INSERT V'1648' <%FIND C'x...x'>
```

Chaining is necessary because a condition can only be stated at the beginning of a subcommand. It is only through LIFO chaining that the required subcommand is generated for test point V’1648’:

```
<%FIND C'x...x'; (%0G NE -1): %SET %L=(%1G - %0G) INTO %2G>
```

4. `%INSERT S'50' <%D NO,INDAT; %STOP>`

   `%INSERT S'50' <(ISW EQ X'FF'): %SET X'00' INTO ISW; %CONT>`

   The two %INSERTs for the same source reference, i.e. statement 50, result in the following conditional subcommand with a THEN and an ELSE branch at test point S'50' (the various parts of the construct are marked with IF, THEN and ELSE to make it easier to read):

```
(ISWITCH EQ X'FF'): %S X'00' INTO ISWITCH; %CONT; %D NUMBER, INDAT; %STOP#1
┐                  ┐                        ┐
IF                 THEN                     ELSE
```

   Whenever statement S'50' is about to be executed, AID interrupts the program sequence and checks the content of switch ISW. If the switch contains the value X'FF', it is reset to X'00' and the program is resumed. Otherwise AID outputs the contents of NO and INDAT and halts the program.

6.5 Nesting

The subcommand of an %INSERT or %ON may contain another %INSERT or %ON. This phenomenon is known as subcommand nesting and is supported by AID over several subcommand levels. The depth to which subcommands can be nested is dependent on their complexity and on the size of the internal input buffer for AID.
Nested subcommands take effect step by step. While the monitoring condition of the first generation (outer level) is immediately entered by AID and can thus cause an interrupt already in the ensuing program sequence, AID does not enter the *test-point* (%INSERT) or *write-event* or *event* (%ON) in more recent subcommands until the monitoring condition of the immediately preceding generation has triggered an interrupt. If another, different command occurs within %INSERT or %ON nesting for a monitoring condition already entered, the new subcommand is additionally prefixed to the older one (LIFO principle). In contrast, a subcommand for a test point or an event of an inner nesting structure will not be chained if the test point of the next higher level of nesting is passed through several times because of a program loop or if the event in the outer nesting structure occurs more than once.

Subcommands for a %CONTROLn cannot be nested, which is why the commands %CONTROLn, %INSERT and %ON are illegal in the subcommand of a %CONTROLn (apart from the commands that are never allowed in any subcommand). In addition, it is not permitted to specify a %JUMP (COBOL85, FOR1) in subcommands of a %CONTROLn.

Examples

1. `%IN ST3 <%DISPLAY 'INSERT1', TEXTDAT;%IN OUTPUT <%D 'INSERT2', I,J,K,-`
   `NUM-TAB; %ON %SVC(186) <%D 'OPEN DAT1',I,J>>>`

   The example relates to a COBOL program. %INSERT ST3 defines paragraph ST3 as a test point; this %INSERT contains another %INSERT nested within it, which in turn contains a %ON command. The test point OUTPUT and the event %SVC(186) (≙OPEN) do not yet affect program execution. They are not activated until the test point of the %INSERT is reached in whose subcommand they are defined. When symbolic address ST3 is encountered in the program, the related *subcmd* is executed, i.e. the literal 'INSERT1' and the content of output record TEXTDAT are output and the test point OUTPUT is set. The subcommand for test point OUTPUT is not yet effective. The test points ST3 and OUTPUT have thus been set so far in the program to be tested.

   As the subcommand for test point ST3 does not contain a %STOP command, the program is resumed. When the address OUTPUT is reached in the program, `%DISPLAY 'INSERT2',I,J,K, NUM-TAB` is executed. In addition to this command, the subcommand contains a %ON for the event %SVC(186). If AID subsequently recognizes a SVC for opening a file, it executes the subcommand defined in the %ON: the literal 'OPEN DAT1' and the contents of indexes I and J are output.

2. `%IN ST4 <%D TEXTDAT>`
   `%ON %LPOV (SUBTOT) <%REMOVE ST4; %IN ST4 <%D 'SUBTOT LOADED'; %STOP >>`
   `%RESUME`

   Whenever test point ST4 is reached, AID outputs the memory contents of data field TEXTDAT. If the declared event %LPOV (SUBTOT) occurs, i.e. when the SUBTOT module is loaded, AID executes the subcommand in the %ON command. Test point ST4 is deleted, but a new subcommand is immediately entered for this test point:

   `<%DISPLAY 'SUBTOT LOADED'; %STOP>`

   When ST4 is encountered the next time, AID displays the text 'SUBTOT LOADED' and interrupts the program sequence; new commands can then be entered.

6.6 Deletion

The %REMOVE command is available for the deletion of subcommands. A subcommand is implicitly deleted when the associated monitoring command is deleted or, in the case of %INSERT, the associated test point or, in the case of %ON, the associated event.
A subcommand can be explicitly deleted via its name. This option only applies to subcommands of a %CONTROLn or %INSERT. As it is not possible to chain subcommands for a %CONTROLn, the effect of a %REMOVE %•*subcmdname* is the same as %REMOVE %CONTROL*n*. With %INSERT, however, it is possible to chain a whole series of subcommands consecutively for a certain test point. In this case %REMOVE %•*subcmdname* removes a single subcommand from the chain via its name. If the subcommand does not have a name, it can only be deleted together with the entire test point. It is therefore always advisable to assign a name to subcommands.

In the case of nested subcommands it is not possible to remove inner subcommands (not even via their names) from the nesting structure if they have not yet been entered at the associated test point. Such subcommands can only be deleted together with the entire %INSERT (%REMOVE %INSERT) or with the test point (%REMOVE *test-point*).

The current subcommand can be deleted immediately after it has been executed if %REMOVE %• is written as the last command in the command section. The %REMOVE %• is executed immediately; this has the effect that any commands which follow will also be deleted and therefore can no longer be executed.

7 Addressing in AID

The commands for execution monitoring, the %JUMP command (specifying a continuation address) and the commands for the output and modification of memory contents require operands which identify an address or a specific area in the memory. An address must be specified in the executable part of the program for %DISASSEMBLE, %INSERT, %JUMP and %REMOVE. %CONTROLn and %TRACE each require an operand which is a memory area in the executable part of the program, whereas in the case of the %DISPLAY, %FIND, %MOVE and %SET commands the specified memory area may also be in the data section of the program.

In AID, an address is designated by an address constant or by a complex memory reference. A memory area can be specified by a qualification or a memory reference, dependent on the command, or an area can be defined by two addresses; the area then lies between the first and second address. A detailed description of the operands that have to be specified is given in the descriptions of commands in the language-specific manuals and in the manual for debugging on machine code level.
The %SDUMP command has a special status; its associated operand *dump-area* designates either a name range, which can be specified with a qualification, or a single data item.
The following sections contain descriptions of all terms that can be used to designate an address in AID, the various qualifications, and the simple and complex memory references.

7.1 Qualifications

Qualifications define the path to a memory object which is outside the currently valid AID work area or which is not within the current main program or subprogram, or which is not unique there. In some cases addressing may end with a qualification, i.e. the qualification can reference the memory object itself. There is a distinction between the base qualification and area qualifications. Qualifications are always specified in the order from the higher-ranking to the lower-ranking qualification, and only to the extent that is necessary for unique path identification. Redundant qualifications are ignored by AID.

Successive qualifications are separated by periods. A period must also be placed between the last qualification and the ensuing address section.

%QUALIFY is used for predefining qualifications. A prefixed period in an address operand will fetch these predefined qualifications.

7.1.1 Base qualification

The base qualification identifies the environment, i.e. it determines whether an ensuing address is to be located in virtual memory or in a dump file. The base qualification is equally applicable for symbolic and machine-oriented debugging.

AID does not support basic qualifications (E=...) inside an operand, only at the beginning. Thus, basic qualification must be specified before functions like addressing %@(...) or length functions %L(), %L=(), ...

E=VM Default value; designates the virtual memory area of the loaded program.

E=Dn Designates a memory dump in a dump file with a link name from the range D0 - D7; the dump file must have been assigned via %DUMPFILE.

The base qualification can be globally defined with %BASE or specified in the address operand for an individual memory reference. The base qualification is permitted as the only operand in the %BASE, %QUALIFY and %SDUMP commands. In all other address or area operands a base qualification must be followed by one of the following terms:

– area qualification
– data name
– statement name
– source reference
– virtual address
– keyword

7.1.2 Area qualifications

An area qualification designates a certain subarea of a program. The various program subareas are defined/named during programming, compilation or linkage. Area qualifications are specified when an address does not reside in the program segment which is being executed. There are different area qualifications for debugging on machine code level and for the various programming languages. The area qualifications for symbolic debugging are determined by the structure of the relevant language; chapter “Prerequisites for debugging with AID” on page 35 of the language-specific manuals describes which program segments are referenced by which qualifications.

SPID=X’f...f’	machine code (AR mode)
ALET={X’f...f’|%nAR|%nG}	machine code (AR mode)
CTX=context	symbolic and machine code
L=loadunit	machine code
O=objectmodule	machine code
C=csect/segmentname/sharename	machine code / COBOL
COM=common	symbolic and machine code
S=srcname	all programming languages
PROC=name	all programming languages
PROG=name	Assembler, COBOL, FORTRAN
ONUNIT=’onunitname’	PL/I
BLK=’blkname’	C++/C, PL/I
NESTLEV=level-number	all programming languages

Area qualifications are specified in the address operand for a memory reference, where they are used for path description. Only those qualifications which are required for unique referencing need be specified. However, if the interrupt point is in the routines of the runtime system, data and statements can only be referenced in their own program via the full qualification.
In commands which require an area operand it is permissible to use any area qualifications apart from SPID and ALET in order to designate an area. C=*csect* and COM=*common* can also be used as the start address. All area qualifications can be declared as prequalifications with %QUALIFY.

In a complex memory reference it is essential that the subsequent operations do not exceed the area limits. Although the length attribute of an area qualification cannot be accessed, a check is made as to whether the result of a byte offset or a length modification is still within the area specified in the qualification.

The **ALET and SPID qualifications** identify a data space, and can only be used before a virtual address or a complex memory reference which is formed without symbolic components.

The **context qualification** identifies the context in which the memory areas or addresses referenced by subsequent qualifications or address data are supposed to lie. It is only necessary if a CSECT, COMMON or compilation unit is contained in a number of contexts and the current interrupt point is not located in the CSECT, COMMON or compilation unit in which the memory object selected by the address operand is contained.

The context qualification is specified by CTX=context. Here, *context* is the name assigned explicitly in the BIND macro with the LNKCTX[@] operand, or the implicit name LOCAL#DEFAULT if LNKCTX[@] has not been specified. Programs loaded dynamically with the DBL are given the same context name, assigned as the default: LOCAL#DEFAULT. Other contexts of program may result from connection to a shared code program (for example to a DSSM subsystem or to a program in a COMMON MEMORY POOL).
The *prequalification* operand of the %QUALIFY command and the *dump-area* operand in the %SDUMP may end with CTX=*context*. In all other address or area operands a CTX qualification must always be followed by one of the following:

– another area qualification

– data name

– statement name

– source reference

The **L and O qualifications** are specified when it is necessary to describe the path to one of several CSECTs or COMMONs of the same name. All that need be specified is the L and/or O qualification that is sufficient to provide unique reference. An L and/or O qualification must always be followed by a C or COM qualification.

The **C and COM qualifications** can be used as area specifications in the %CONTROLn and %TRACE commands. If the C qualification is used to designate a CSECT or the COM qualification to designate a COMMON, only a machine code criterion may be specified. The specification C=*sharename/segmentname*, which can be used when debugging COBOL programs, may only be combined with a symbolic criterion. However, a C qualification can never be followed by a symbolic memory reference, not even in COBOL.

In the %DISASSEMBLE, %INSERT and %REMOVE commands the start address of the CSECT or COMMON is specified with the C or COM qualification respectively. Similarly, in the %DISPLAY, %FIND, %MOVE, %ON %WRITE(...) and %SET commands the address operand can end with C=*csect*/COM=*common*. The effect of this is to reference the entire CSECT or COMMON. In these commands the CSECT or COMMON is used as a machine-code memory reference. The C/COM qualification can also be used as a memory reference within a complex memory reference (see section “Machine code memory references” on page 77).

The **S, PROC, BLK, ONUNIT and PROG qualifications** can be used to identify a memory area in %CONTROLn and %TRACE or the name range in %SDUMP. These qualifications stand for the entire program segment specified; they cannot be used as memory references however.

An S qualification can be followed by a:

– PROC, BLK or ONUNIT qualification
– data name
– statement name
– source reference

A PROC, BLK or ONUNIT qualification can be followed by a:

– data name
– statement name
– source reference

The **PROG qualification** is a combination of S=srcname•PROC=name if *srcname* and *name* are identical. It can be used in Assembler, COBOL and Fortran and can be employed for the Assembler, COBOL and Fortran languages.

The **NESTLEV qualification** can be used in the commands %DISPLAY, %MOVE, %SDUMP and %SET. In these commands, the qualification `NESTLEV=`*level-number* denotes that level in the call hierarchy that is created with the AID command %SDUMP %NEST. For an example for the usage of the NESTLEVqualification, see page 72.

Examples

1.
```
%BASE E=VM
%DUMPFILE D1=M.DUMP
%DISPLAY V'10A', E=D1.V'10A'
```

   %BASE defines the virtual memory area of the loaded program as the base qualification. %DUMPFILE assigns the link name D1 to the file M.DUMP.
   As the base qualification E=VM applies, AID outputs four bytes as of address V'10A' of the loaded program for the first entry in the %DISPLAY command and four bytes as of address V'10A' from a dump for the second entry. This dump resides in a file that was assigned to link name D1 via %DUMPFILE.
   Four bytes constitute the implicit length of a V address.

2.
```
%DISPLAY S=COMPUTE@.PROC=COMPUTE.SUM
```

   AID outputs the contents of the variable SUM from the program unit COMPUTE@ of a Fortran program. The S and PROC qualifications are necessary if the program has been interrupted in different program unit.

3. `%QUALIFY E=D1.S=COMPUTE@.PROC=COMPUTE`
   `%DISPLAY .SUM`

   AID prefixes the defined prequalification to the period preceding SUM. This results in the command: `%DISPLAY E=D1.S=COMPUTE@.PROC=COMPUTE.SUM`
   AID outputs the data field SUM from program unit COMPUTE@ residing in the dump file assigned to link name D1.

4. `%DISPLAY E=D2.S=TEST@.BLK='23'.var`

   The dump file with the link name D2, which contains the memory dump of a C program, and within that the compilation unit with the code module name TEST@, contains the local variable var, in the block starting in line 23. AID outputs the contents of the variable.

5. `%MOVE L=LAD1.C=CS1.(%L(L=LAD1.C=CS1) - 4) INTO %2G`

   AID transfers the last four bytes of CSECT CS1 from load unit LAD1 to AID register %2G.
   The L qualification is necessary because CS1 is not the current CSECT and the name CS1 is not unique within the program system.

6. `%INSERT S=COMPUTE@.PROC=COMPUTE.S'16' <%DISPLAY %•>`

   AID sets a test point for statement 16 in program unit COMPUTE@. When this test point is reached in the program sequence, the execution counter is output and the program continues.

7. Example for the usage of the NESTLEV qualification

   The following program is to be debugged:

```
#include <stdio.h>

int main(void) {
    int arr[6] = {0, 0, 0, 0, 0, 0};
    int i = 0;
    proca(i, arr);
}

int proca(int i, int arr[])
{
        int testVar;
        testVar = 10 + i;
        arr[i] = i;
   stop: ;
        if (i < 4)
            procb(i + 1, arr);
        arr[5] = arr[5] + testVar;
        return 0;
```

```
}

int procb(int i, int arr[])
{
        int testVar;
        testVar = 20 + i;
        arr[i] = i;
        if (i < 4)
           {  proca(i + 1, arr);  }
        arr[5] = arr[5] + testVar;
        return 0;
}
```

After the C program has been loaded, the following AID commands are entered:

```
%AID C=YES
%INSERT stop
%RESUME
%RESUME
```

The current call hierarchy:

```
/%SD %NEST
SRC_REF: 15  SOURCE: CREC  PROC: proca  **********************************
SRC_REF: 27  SOURCE: CREC  BLK : 27  ************************************
SRC_REF: 28  SOURCE: CREC  PROC: procb  **********************************
SRC_REF: 16  SOURCE: CREC  PROC: proca  **********************************
SRC_REF: 6  SOURCE: CREC  PROC: main  ************************************
ABSOLUT: V'1019108'   SOURCE: ICS$MAI@  PROC: ICS$MAI@  ******************
ABSOLUT: V'10020D8'   SOURCE: IC@MAIN@  PROC: IC@MAIN@  ******************
```

The current call hierarchy with levels:

The number in column 3 shows the nest level (NESTLEV). The value in RLEV: shows the recursion level. This value is of informational nature only and cannot be used for operating AID.

```
/%AID LEV=ON
/%SD %NEST
# 1 SRC_REF: 15  SOURCE: CREC  RLEV: 0  PROC: proca  **********************
# 2 SRC_REF: 27  SOURCE: CREC  RLEV: 0  BLK : 27  ************************
# 3 SRC_REF: 28  SOURCE: CREC  RLEV: 0  PROC: procb  **********************
# 4 SRC_REF: 16  SOURCE: CREC  RLEV: 1  PROC: proca  **********************
# 5 SRC_REF: 6  SOURCE: CREC  RLEV: 0  PROC: main  ************************
# 6 ABSOLUT: V'1019108'   SOURCE: ICS$MAI@  PROC: ICS$MAI@  **************
# 7 ABSOLUT: V'10020D8'   SOURCE: IC@MAIN@  PROC: IC@MAIN@  **************
```

The data of recursive `proca` at different levels:

```
/%SD NESTLEV=1
# 1 SRC_REF: 15  SOURCE: CREC  RLEV: 0  PROC: proca  *********************
stop            = 010001CA
i               =          2
arr             = 010E181C
testVar          =          12

/%SD NESTLEV=4
# 4 SRC_REF: 16  SOURCE: CREC  RLEV: 1  PROC: proca  *********************
stop            = 010001CA
i               =          0
arr             = 010E181C
testVar         =         10
```

`NESTLEV` combined with the base qualification `E=VM`:

```
/%D  E=VM.NESTLEV=4.testVar
testVar         =         10
```

To change a variable at certain level use %SET or %MOVE:

```
/%MOVE X'00000064' INTO NESTLEV=4.testVar
/%D NESTLEV=4.testVar %X
V'010E18C8' = testVar  + #'00000000'
010E18C8 (00000000) 00000064                                  ...
```

NESTLEV can be used both for the sender and the receiver:

```
/%SD testVar
# 1 SRC_REF: 15  SOURCE: CREC  RLEV: 0  PROC: proca  *****************
testVar         =          12
# 3 SRC_REF: 28  SOURCE: CREC  RLEV: 0  PROC: procb  *****************
testVar         =          21
# 4 SRC_REF: 16  SOURCE: CREC  RLEV: 1  PROC: proca  *****************
testVar         =         100

/%SET NESTLEV=4.testVar INTO NESTLEV=3.testVar
/%D NESTLEV=3.testVar
testVar         =         100
```

After execution of %RESUME, the current call hierarchy looks as follows:

```
/%R
/%SD %NEST
# 1 SRC_REF: 15  SOURCE: CREC  RLEV: 0  PROC: proca  *****************
# 2 SRC_REF: 27  SOURCE: CREC  RLEV: 0  BLK : 27  ******************
# 3 SRC_REF: 28  SOURCE: CREC  RLEV: 0  PROC: procb  *****************
# 4 SRC_REF: 16  SOURCE: CREC  RLEV: 1  PROC: proca  *****************
# 5 SRC_REF: 27  SOURCE: CREC  RLEV: 1  BLK : 27  ******************
# 6 SRC_REF: 28  SOURCE: CREC  RLEV: 1  PROC: procb  *****************
# 7 SRC_REF: 16  SOURCE: CREC  RLEV: 2  PROC: proca  *****************
# 8 SRC_REF: 6  SOURCE: CREC  RLEV: 0  PROC: main  ******************
# 9 ABSOLUT: V'1019108'   SOURCE: ICS$MAI@  PROC: ICS$MAI@  **********
#10 ABSOLUT: V'10020D8'   SOURCE: IC@MAIN@  PROC: IC@MAIN@  **********
```

The recursive function `proca` shows the following instances of `testVar`:

```
/%SD PROC='proca'.testVar
# 1 SRC_REF: 15  SOURCE: CREC  RLEV: 0  PROC: proca  *****************
testVar     =     14
# 4 SRC_REF: 16  SOURCE: CREC  RLEV: 1  PROC: proca  *****************
testVar     =     12
# 7 SRC_REF: 16  SOURCE: CREC  RLEV: 2  PROC: proca  *****************
testVar         =         100
```

7.2 Memory references

A memory reference can be used in an AID command to address a memory object. If the memory reference defines a string, e.g. of the type %C or %UTF16, the character conversion function %C() or %UTF16() can be applied to the memory reference.
AID distinguishes between simple and complex memory references.
Example of simple memory references include:

– virtual addresses: V'f...f'
– data names: VAR1, FIELD(I)
– keywords: %14, %2D, %PC, %CLASS6
– C qualifications: C=CS1
– COM qualifications: COM=CB
– statement names: L'20', COMPUTE1
– source references: S'133', S'44ADD'

Examples of complex memory references are:

– %@(VAR1)->.(%L=(I+5))%XL20
– C=CS1.#100'%SX->%CL8'

The simple memory references (i.e. the machine code and symbolic memory references and the keywords), together with their attributes and characteristics, are described in section "Machine code memory references" on page 77.

A complex memory reference is an instruction to be used by AID for calculating an address or by the user for modifying the attributes of a memory object. In a complex memory reference the user may incorporate symbolic and machine code memory references, keywords, constants and AID literals for byte offset, indirect addressing, type/length modification and address selection operations in order to determine the type and length of a memory reference or to cause AID to compute an address required in a particular test situation. Information on complex memory references and their associated operations is given in section "Symbolic memory references" on page 79.

Attributes

Attributes describe the characteristics of a memory object or of a constant.
Memory objects have up to six attributes:

– name (optional)
– address
– content
– length
– storage type
– output type

Selectors can be used to access the address, length and storage type attributes. Modification is used to alter the length or storage type. The length attribute also defines the relevant area: address to address + (length - 1). The limits of this area are checked in the case of length modification and byte offset operations. During a transfer with %MOVE, a check is made to see whether *sender* fits in the area limits of *receiver*. An exception is the virtual address, which is assigned the entire user address space as its area although the length attribute is only 4 bytes.

The manner in which AID takes account of the attributes in the individual commands and the checks performed on this occasion are described for the respective commands in the language-specific manuals and the manual for debugging on machine code level.
The AID mechanism for incorporating these attributes in the calculation of a complex memory reference is described under the various operations in the present chapter.

Constants do not have an address attribute and can thus be used in special cases only; in particular they cannot be subjected to address selection.

7.2.1 Machine code memory references

The CSECTs, COMMONs and virtual addresses are machine code memory references.

The **CSECTs and COMMONs** are specified in the form of a C or COM qualification with C=*csect* and COM=*common* respectively. As the CSECTs/COMMONs are specified in the same way as qualifications and can also be used in the same way as qualifications in certain commands, they are also described in section “Area qualifications” on page 69.

As a memory reference, the C/COM qualification has the following attributes:

```
Name
Address
Content
Length (length of CSECT/COMMON)
Storage type (%X)
Output type (dump)
```

The area limits are defined by the start address and the length of the CSECT/COMMON.

The following operations can be used on a C/COM qualification:

– address selector
– length selector
– byte offset
– type modification
– length modification

A **virtual address** is specified in the following format:
V'f...f', where *'f...f'* is a hexadecimal number of up to 8 digits between '0' and '7FFFFFFF'.
A virtual address directly references a memory location in the loaded program or in a dump file. In AR mode it is therefore also possible to reference a memory location in a data space, for which it is necessary to specify an ALET/SPID qualification before the virtual address. Otherwise the only meaningful entry before a virtual address is a base qualification.

The result of a byte offset or of indirect addressing is also a virtual address, and therefore also has its attributes.

The attributes of a virtual address are as follows:

```
Address (f...f)
Content
Length (4 bytes)
Storage type (%X)
Output type (dump)
```

The area limits extend from V'0' to V'7FFFFFFF'.
Unlike all other memory objects, for which address and length at the same time define the area limits, virtual address operations have the entire user address space at their disposal, the only restriction being that the lowest address V'0' and the highest possible address V'7FFFFFFF' must not be exceeded.

A virtual address may be followed by:
– byte offset (•)
– indirect addressing (->)
– type modification
– length modification

Examples

1. `%DISPLAY V'100'->->->%C`

   The four bytes as of address V'100' have the content X'00000A1A'. Address V'A1A' has the content X'0000000F' (first pointer operator). Address V'F' has the content X'0000B001' (second pointer operator). Address V'B001' has the content X'F1F2F3F4' (third pointer operator). AID interprets this as characters and outputs '1234'.

2. `%MOVE E=D1.V'206'.(%1)->.(%2-5) INTO %2G`

   In dump file D1, address V’206’ is the starting point for a byte offset expressed in terms of the content of register %1 (X’00000004’). The memory contents (X’0000B111’) there (V’20A’) are used as the address for a pointer operation. From this new address (V’B111’) an offset expressed by the content of register %2 (X’00000008’) minus 5 is made, and from the address thus obtained (V’B114’) four bytes are transferred to AID register %2G.

7.2.2 Symbolic memory references

Symbolic memory references are the symbolic addresses which the compiler stores in the LSD records in the course of compilation. They include the names of data and statements assigned by the user in the program, in other words labels, entries or function names, and the source references generated by the compiler, via which every executable statement of a program can be referenced, regardless of whether the statement has a label or not. If LSD records have been created and are available, therefore, AID is able to access the associated addresses and the attributes linked to the addresses via data names or statement names or via source references.

Statement names and source references are address constants and only become a memory referenced when they are followed by a pointer operator. Without a pointer operator they can only be used in those commands which require an address as an operand. However, if it is intended to reference the instruction code that is at the corresponding address in the memory, the pointer operator must be added.

7.2.2.1 Data names

Data names are names of variables, data structures, fields, matrixes or vectors, depending on the language tools and terminology of the programming language involved. The items of tables or structures can be accessed in AID just like in a programming language statement, i.e. by placing the requisite identifiers, indexes or subscripts after the data name. For any exceptions see the command descriptions in the language-specific manuals.

Constants defined in the source program are likewise regarded as data names. They are specified, for instance, via EQU (Assembler), via *literal* and *symbolic character* in the SPECIAL NAMES paragraph (COBOL), or via PARAMETER (FORTRAN). As they do not occupy memory space, however, they cannot be used in the same way as all the other data. They have no address attribute; only the value of the constant is available to AID. The remaining attributes cannot be used.

The attributes of data names are defined in the source program, except for the output type, which AID determines on the basis of the storage/output type assignment (see section “General storage types” on page 121).

Data names have the following attributes:

```
Name
Address
Content
Length
Storage type
Output type
```

The area limits are defined by the address and the length.

Data names can be used in all commands addressing the data section. Selectors support access to the address, length and storage type attributes so that results can be output, transferred or modified or switchover to the machine code level can take place.

A data name may be subjected to or followed by:

– address selector
– length selector
– type selector
– character conversion function
– byte offset (•)
– length modification
– type modification
– indirect addressing (->), provided the data name is of type %A

A type modification serves to alter the storage type or the associated output type.
For the %DISPLAY and %SET commands, the memory contents must match the storage type defined in the type modification.

A length modification serves to alter the length associated with a data name. The data type is not retained, AID assumes storage type %X.
Length modification must not lead to a transgression of the area limits, i.e. the modified length must not exceed the implicit length from the length attribute.

If a deviation from the implicit attributes of a data name is desired, the address selector can be applied to the data name followed by a pointer operator. %@(dataname)-> then references the virtual address of a data name, which means the attributes of a virtual address take effect.

Indexes and subscripts

If a data name is the name of a tabular structure, it may be indexed in the same way as in a programming language statement. COBOL distinguishes between indexing and subscripting, although subscripting corresponds to indexing in other programming languages. Special features of how COBOL indexes are handled by AID are described in the User Guide "Debugging of COBOL Programs".

The index can be specified as follows:

```
⎧n                   ⎫
⎨dataname            ⎬
⎩arithmetic expression⎭
```

n

Integer with a value $-2^{31} \leq n \leq 2^{31}-1$.

dataname

Index defined for the vector, or numeric variable situated in the same program segment as the vector; i.e. the qualification of the vector is taken over for the index.

arithmetic expression

The value for *index* is calculated by AID. Permissible are the arithmetic operators (+, -, /, *) and the above-mentioned operands *n* and *dataname*. For COBOL it is the case that only the subscript, not the index, can be used in an arithmetic expression.

You can specify a range of indexes:

index1:*index2*

This designates the range between *index1* and *index2*. Both must lie within the index limits, and *index1* must be less than or equal to *index2*.

Examples

1. `%DISPLAY V'10A'%T(SYMBOL)`

   The memory contents as of address V'10A' are interpreted with the storage type of SYMBOL and are output in the associated output type and length of SYMBOL. AID checks that the memory contents of V'10A' and the storage type of SYMBOL are compatible.

2. `%DISPLAY %@(DATARECORD)->.4%T(INPUT)`

   DATARECORD has no data structure description; however, the structure of INPUT corresponds to that of DATARECORD with the restriction that a 4-byte number is situated at the beginning of DATARECORD. The address selector and subsequent pointer operator reference the virtual address of DATARECORD, i.e. the area limits

are no longer binding. A byte offset skips the first four bytes of DATARECORD. The type selector defines the storage type and the length of INPUT, and the memory contents as of the calculated address are output accordingly.

7.2.2.2 Statement names and source references

Statement names are names assigned in the source program to labels, sections, paragraphs or label/entry constants/variables, depending on the language tools and terminology of the programming language involved.

Statement names stand for the address of the instruction code generated for the first statement following the label. They are specified in the following format:

L'number'	Label (Fortran)
L'name'	Label (all programming languages); in %DISASSEMBLE, %INSERT, %REMOVE possible without L'...' if not followed by address computation.
name	Function (C++/C), program name (COBOL, Fortran, Assembler; can only be used in the %DISASSEMBLE, %INSERT and %REMOVE commands for identifying the program start), entry constant or variable (PL/I)

Source references are the numbers or names of statements, generated by the compiler, which are stored in the LSD records and via which the statements can be referenced which are neither at the start of a main program or subprogram nor have a label. The compiler-oriented statement designations and compiler listing entries can be found in the language-specific manuals.
Source references stand for the address of the instruction code generated for a statement. Source references are specified in the format S'number/name'.

Characteristics

Source references and statement names are address constants. They occupy no memory space, i.e. they have no address attribute and cannot be changed. Entry and label variables in PL/I are an exception; memory space is created for these as for all other data, and they can be overwritten via %SET.

If LSD records have been generated and are available, AID can use statement names and source references to access the instruction code.

Statement names and source references can be used as simple memory references in the commands %DISASSEMBLE, %JUMP, %INSERT and %REMOVE. Source references can also be used to specify a memory area in the %CONTROLn and %TRACE commands.

In %DISPLAY, %MOVE and %SET the value of the address constant is referenced, but can only be used as *sender*. An exception are the section and paragraph names in COBOL. Here, AID knows not only the address of the first command but also the end of the section or paragraph. Section and paragraph names can thus also be used as an area specification in the %CONTROLn and %TRACE commands.

Otherwise statement names and source references to be used for referencing a memory location must be followed by a pointer operator. Only the address constant is available to AID; the remaining attributes cannot be used.

A statement name may only be followed by indirect addressing (->).

Examples

1.
```
%DISPLAY L'TOTAL'
%DISPLAY L'TOTAL'->
```

   The first %DISPLAY outputs the address of the instruction code generated for the first statement following the label TOTAL.
   The second %DISPLAY outputs four bytes of memory contents as of this address.

2.
```
%INSERT S'123'
%INSERT S'123'->.(-6)
```

   The first %INSERT sets a test point for the address of the instruction code generated for statement 123. The source reference S’123’ is used as a simple memory reference here.
   The second %INSERT sets a test point for the address of the instruction code which is located six bytes before the test point of the first %INSERT. This time, the source reference S’123’ is used in a complex memory reference and therefore its function as an address constant must be observed and the pointer operator placed accordingly.

3.
```
%MOVE L'123' INTO %2G
%MOVE X'D2' INTO L'123'->
```

   The address V’A1A’ is stored in the LSD records for label 123 in a Fortran program. The first %MOVE transfers this address to AID register %2G. The second %MOVE transfers the hexadecimal literal X’D2’ to the memory location with the address V’A1A’.

7.2.3 Keywords

Memory objects outside the program memory which are used by AID or by the program can be referenced by AID via keywords. This applies to general registers

%0 - %15, floating-point registers %nE, %nD and %nQ, the access register %nAR, the program counter %PC, AID registers %0G - %15G and %nGD, as well as the execution counter %•subcmdname. Class 5 and class 6 memories can also be addressed with the keywords %CLASS5, -ABOVE and -BELOW and %CLASS6, -ABOVE and -BELOW. All other keywords cannot be used as memory references. Only a base qualification can be specified before a keyword.
All keywords which can be used in AID are described in chapter “Keywords” on page 121.

Keywords have the following attributes:

```
Name (%name)
Address
Content
Length
Storage type
Output type
```

The area limits are defined by the start address and the length.

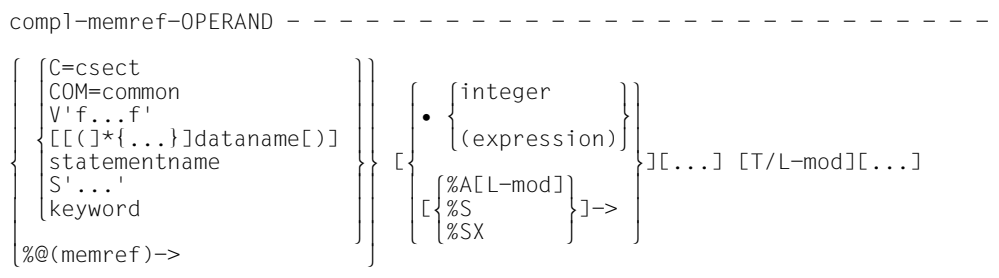
A keyword may be subjected to or followed by:

– address selector (the result is unusable if the address is located outside the user area)
– length selector
– byte offset (•)
– indirect addressing (->)
– length modification
– type modification

In the case of byte offset and length modification, AID checks the area limits. General registers may be used without type modification before a pointer operator, even though they are of type %F.

7.2.4 Complex memory references

A complex memory reference is where an address computation is carried out, on the basis of a symbolic or machine code memory reference or of a keyword. The result of a complex memory reference, without a final type and length modification, is a virtual address with storage type %XL4. The calculated address can, however, be assigned to the required storage type via a type modification or length modification or both.



C=csect	C qualification
COM=common	Common qualification
V'f...f'	virtual address
dataname	Data names
statementname	Statement names
S'...'	Source references
keyword	Keywords
%@(memref)	Address selector
T/L-mod	Type and/or length modification
%A, %S, %SX	Storage types for address interpretation
• {...}	Byte offset
->	Indirect addressing (pointer operator)
*	Indirect addressing (content operator, C++/C only)
(expression)	Arithmetic expression

Byte offset, indirect addressing, type and length modification, arithmetic expression and the address selector are described in the following sections. All other terms are explained at the start of this chapter.

7.2.4.1 Byte offset "•"

Byte offset enables byte-by-byte positioning forwards or backwards from a particular address. A byte offset always results in a virtual address. A byte offset must not exceed the area limits of the memory object involved.

```
byte-offset - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

             ⎧number       ⎫
memref  •   ⎨             ⎬
             ⎩(expression) ⎭
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

• Offset operator

memref

May be any memory location referenced in any manner:

virtual address, data name, keyword, C qualification or complex memory reference.

number

Positive integer (decimal or hexadecimal) between 0 and 2^{31}-1.

expression

Value between -2^{31} and 2^{31}-1 that is calculated by AID.

expression is described in section “Address, type and length selectors” on page 98. It may comprise numbers, numerical contents of memory references, the result of address/length selector and length function, and the arithmetic operators (+ - * /).

Byte offset can only be effected within the area limits of the relevant memory object and results in a virtual address with a length of 4. These four bytes must fit within the area limits of the memory object. If these limits are violated, AID issues an error message.

Except for virtual addresses, the area limits are determined by the start address and the length attribute. For a virtual address the entire virtual memory area (V’0’ through V’7FFFFFFF’) can be used. In the case of data names, the keywords %CLASS6, -ABOVE, -BELOW and the C qualification, the symbolic level may be left via address selection followed by a pointer operator: %@(...)-> thus switches to the area limits of a virtual address.

A byte offset may be followed by:

- byte offset (•)
- indirect addressing (->)
- length modification
- type modification

Examples

1. `%DISPLAY SYMBOL.10`
   `%DISPLAY %@(SYMBOL)->.10`

   SYMBOL has a length of 10. An offset by 10 bytes cannot be executed by AID since this would reference the first four bytes after SYMBOL and thus violate the area limits of SYMBOL. AID issues an error message.

   Address selection followed by a pointer operator switches to machine code level, where the area limits of a virtual address apply. A byte offset positions to the first byte after SYMBOL, as in the first %DISPLAY. AID can now execute this %DISPLAY and outputs the first four bytes after SYMBOL.

2. `%D %@(VAR)->.(%L(ELEM(1))*5)%T(ELEM(1))`

   Let it be assumed that a COBOL program contains a vector ELEM with 10 elements ELEM(1) to ELEM(10). Variable VAR is to be redefined as a vector in the structure of ELEM, and its 6th element is to be output. The length of element ELEM from a table called TAB is to apply. From the start address of VAR, AID positions forwards via a byte offset using the value derived by multiplying the length of ELEM by 5. The consequence of subsequent type modification is that the contents are output at the calculated address in the type and length of an element of ELEM.
   If ELEM were specified without an index, AID would assume the type and length of the entire vector ELEM.

3. `%D %5->.(%L(INDEX)*%L(ADDRESS))%CL=(%L(ADDRESS)+50)`

   The content of register 5 (X’00000A00’) is used as an address. As of address V’A00’ an offset derived by multiplying the length of INDEX (2) by the length of ADDRESS (7) is effected. The memory contents at address V’A0E’ (#A00’+(2*7)<String#A0E’)areoutputincharacterformatwitha'length of 57 (7+50).

4. `%D S'123COMP'->.8%S->%L10`

   Address ’1B0’ is stored in the LSD records for the COBOL source reference S’123COMP’. The pointer operator positions to the memory location with the address V’1B0’. An offset of 8 bytes is effected. The content X’600F0130’ at the new location, i.e. at address V’1B8’, is interpreted with %S. Base register 6 (content X’000B010’) plus displacement #00F’resultintheaddressV’B01F’,whichisreferenced'with the pointer operator. 10 bytes as of this address are output in dump format.

5. `%D C=CS1.(%L(C=CS1))`
   `%D C=CS1.(%L(C=CS1)-4)`

   The first %DISPLAY is rejected since a byte offset with the length of CS1 would reference the first byte after CS1 and thus exceed the area limits of CS1.
   The second %DISPLAY reduces the offset by four bytes. The area limits of CS1 are not violated, and AID outputs the last four bytes of CS1.

6. `%D V'4'.(-5).4`
   `%D V'4'.(4-5)`
   `%D V'4'.4.(-5)`

   The byte offset in the first %DISPLAY is rejected since (-5) would violate the lower area limit of virtual addresses (V'0'), although the final result would be within the permissible range due to the second offset.
   In the second and third %DISPLAYs, no offset exceeds the area limits and AID outputs four bytes as of address V'3'.

7. `%D V'100' .(%1 + %2)`

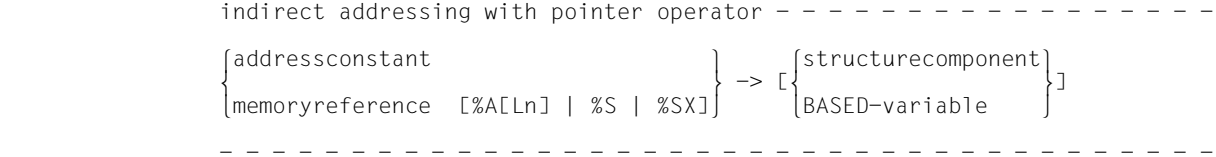
   Address V'100' is incremented by the sum of the contents of registers 1 and 2.

7.2.4.2 Indirect addressing "->" / "*"

In indirect addressing AID uses an address constant or a memory content as an address for another memory location. If the pointer operator is used as a unary operator, the result is a virtual address. The pointer operation therefore causes transition to machine code level. If indirect addressing is carried out with the pointer operator as a binary operator or if the content operator is used, the user remains on the symbolic level even after indirect addressing, and the result is edited in accordance with the corresponding data definition from the source program.

In any 4-byte address used for indirect addressing, AID takes the current addressing mode of the test object into account. It can be interrogated with %DISPLAY %AMODE. A different address interpretation can be declared for the pointer operation with %AINT.

Pointer operator



-> Pointer operator

addressconstant

Address constant (statement name, source reference, or result of an address selection). Names of labels must be set before "->" in L'...'.

memoryreference

May be any memory location containing an address. Address-type data can be used without type modification.

[%A[Ln] | %S | %SX]

Type modification enabling a memory location to be interpreted as an address. %S and %SX simulate addressing as carried out by machine instructions. AID thus calculates addresses in the same way as the hardware, either from base register and displacement (%S) or from index register, base register and displacement (%SX). For details see section "Storage types for interpreting machine instructions" on page 124.

```
┌structurecomponent┐
├BASED-variable    ┐
```

In both of these cases the pointer operator is used in order to reconstruct indirect addressing which forms part of the language elements of the programming language, i.e. in order to reference a structure component in C++/C via a pointer or in order to reference a BASED variable via the associated pointer in PL/I The attributes of the structure components or BASED variables as defined in the source program apply to the result of the indirect addressing.

The content operator "*"

In C++/C it is also possible to use the content operator for dereferencing instead of the pointer operator.

The address referenced with the content operator is interpreted in accordance with its data type, declared in the program. There is no switch to machine code level as happens in the case of unary dereferencing by the pointer operator.
In contrast with C++/C, where the content operator can also be applied to vectors, the content operator in AID is only allowed for pointers.

```
indirect-addressing with content operator - - - - - - - - - - - - - - - - -

[(]* {...} pointer-variable[)]

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

* Content operator

pointer-variable

type-specific pointer of a C++/C program

The content operator can be repeated several times. It may be necessary to define the order of processing by bracketing. The content operator is evaluated at a lower priority after the pointer operator, byte offset and indexing.

Indirect addressing may be followed by:

– byte offset (•)
– indirect addressing (->)
– length modification
– type modification

Examples

1. `%DISPLAY V'10A', V'10A'->`

   AID output

```
/%DISPLAY V'10A', V'10A'->
 V'0000010A' = ABSOLUT  + #0000010A''
 0000010A (0000010A) 00000478                                    ....

 V'00000478' = ABSOLUT  + #00000478''
 00000478 (00000478) E3C5E7E3                                    TEXT
```

   AID outputs four bytes as of address V’10A’ in dump format. For the second operand, AID uses this memory content (X’00000478’) as the address in a pointer operation and outputs four bytes as of address V’478’ in dump format.

2. `%FIND C'***'`

   `%DISPLAY %1G->`

   %FIND searches the memory for the string ’***’. If AID locates the string, AID register %1G holds the continuation address, i.e. the address of the first byte following the located string. %DISPLAY outputs the memory contents following the search criterion.

3. `%SET %7 INTO V'14C0'%SX->`

```
Content of general register 4:X'00000100'
Content of general register 6:X'00004000'
Memory contents as of address V'14C0':X'50746B00' ≙ ST
                                          R7,X'B00'(R4,R6)
```

AID simulates transfer using the 'store' instruction (ST, instruction code X'50') and transfers the content of general register 7 as of address V'4C00'. AID calculates the address from memory content X'50746B00' as follows:

```
X'507' is ignored
X'4' use content of register 4:      '00000100'
X'6' add content of register 6:      '00004000'
X'B00' add displacement:                  'B00'
_____________________________________________
results in the address                   '4C00'
```

4. `%SET X'C1C2C3C4' INTO V'14C2'%S->`

The register and memory contents are the same as in example 3.

This %SET transfers the hexadecimal literal X'C1C2C3C4' to the memory location with the address V'4B00'. AID calculates the address from memory content X'6B00' as follows:

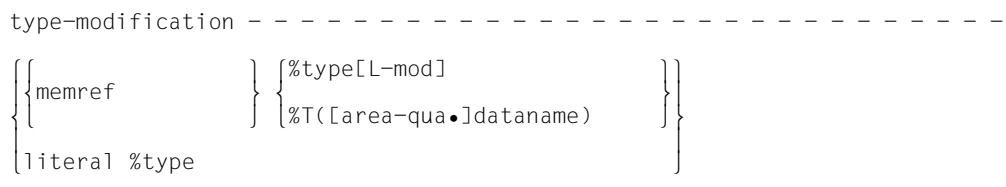
```
X'6' use content of register 6:   '00004000'
X'B00' add displacement:               'B00'
_____________________________________________
results in the address                  '4B00'
```

7.2.4.3 Type modification

Type modification is used to give a memory content an interpretation other than suggested by its storage type attribute. This may be necessary in the following cases:

- type matching for %SET
- differing output format for %DISPLAY
- conversion of a literal (only allowed for %DISPLAY)
- interpretation as an address before a pointer operator
- interpretation/editing in a different structure (redefinition of a memory location)
- interpretation as an integer in an expression

Type modification is only expedient before a pointer operator and at the end of a complex memory reference in order to interpret the storage content as of the calculated address) or the literal in the required storage type.



memref

May designate any memory location referenced in any manner:

virtual address, data name, keyword, C qualification

literal

The AID literals are described in chapter “AID literals” on page 109.

%type[L-mod]

Keyword for storage types with optional length specification:
%X, %C, %E, %P, %D, %F, %A and %UTF16 (see chapter “Keywords” on page 121).
The length can be specified via all length modification options. If no length is specified, the length attribute of the modified memory object is retained.
The storage types %H, %Y, %S and %SX have a fixed length and cannot therefore be used with a length specification.
In the case of storage type %UTF16, the length must be a multiple of 2.
Length modification is not permitted for literals.

%T([area-qua•]dataname)

The type selector interprets a memory location with the storage type and length of other data definitions. This implies that the rules of length modification must be observed (e.g. no transgression of area limits).
dataname may be qualified, i.e. derived from a different program segment; no base qualification is permitted however.

During type modification AID checks whether the memory contents match the selected storage type. If this is not the case, AID issues an error message.

Each storage type is assigned to an output type (see chapter “Keywords” on page 121). This means the type modification can be used to change the output type.

The storage types %D, %P, %F and %A have only certain permissible lengths (see chapter “Keywords” on page 121). If they are used without a length specification, the length of the modified memory object must match one of the lengths permitted for the storage type. Otherwise AID rejects the type modification and reports a length error.

The storage types %S, %H and %Y have a fixed length of 2 bytes, %SX has a fixed length of 4 bytes. They effect an implicit length modification, which must be able to take place within the defined area limits.

The type modification with storage type %UTF16 is permitted if the (implicit) length of the memory location is a multiple of 2.
The type modification %UTF16 is permitted for X literals but forbidden for C and U literals.

As the %SET command takes type and length into account during transfer and converts the storage type of the send field into that of the receive field prior to a numerical transfer if necessary, the data types of the send and receive fields must be compatible (see the table in the %SET description of the language-specific manuals [2] - [6]). If the data types are not compatible, a storage type matching the memory contents and compatible with the receive field can be specified.
The following restriction applies with regard to the %SET command for programming languages that allow the definition of structures: structures can only be modified using a %SET command if the send and receive fields have the same structure. If one of the addresses was not described as a structure during programming, it can be assigned the required structure by means of type selection. In that case, however, the current memory contents must match the definition of the structure.

Examples

1. `%DISPLAY V'10A'%F`

   The memory content as of address V’10A’ is interpreted as a signed binary value and output as a signed integer. Without type modification, the virtual address would have a hexadecimal storage type (%X) with a length of four bytes, i.e. output type DUMP.

2. `%INSERT V'4710'%SX->`

   The memory content of address V’4710’ is evaluated for test point calculation in accordance with the %SX format.

3. `%SET RECORD.10%PL5 INTO AMOUNT`

   A COBOL program contains a data item, RECORD, with a length of 45 bytes, which contains a sequence of packed numbers, each 5 bytes long. AMOUNT is a numeric unpacked data element. The first two numbers are skipped with the byte offset. As a result of type and length modification, the third packed number is unpacked from RECORD and transferred right-justified to AMOUNT.

4. `%D V'134'.(INDEX * 4)%T(LINE)`

   The number of bytes from the contents of INDEX multiplied by 4 are added to virtual address V’134’ by byte offset. The memory content at the calculated address is edited in accordance with the type and length of the data definition for LINE and then output.

5. `%DISPLAY %1%F`

   Without type modification, AID would output the content of register 1 as a hexadecimal number. Type modification %F causes AID to edit the register content before output as a signed integer.

6. `%DISPLAY X'20AC'%UTF16`
   As a result of the type modification the output takes place in dump format, i.e. not only the hexadecimal code 20AC is output but also the interpretation as UTF16 code, in this case the Euro symbol.

7.2.4.4 Length modification

A length modification permits a deviation from the predefined length of a memory reference. AID then uses the specified length instead of the length stored in the length attribute. The value of a length modification must be between 1 and 65535.

If *type* is not specified, length modification implies a type modification into storage type %X.

A length modification must not violate the area limits of the modified memory object, i.e. the new length cannot exceed the end address.

```
length-modification - - - - - - - - - - - - - - - - - - - - - - - - - - - -

                    ⎧Ln              ⎫
memref %[type]      ⎨L(memref)       ⎬
                    ⎩L=(expression)  ⎭

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

memref

May designate any memory location referenced in any manner:

virtual address, data name, keyword, C qualification or complex memory reference.

type

If type and length modification are to be effected, a storage type keyword must be entered (%X, %C, %P, %D, %F, %A, %UTF16) followed by L without another % character.
Example:
VAR1%L5 or VAR1%CL5

%Ln

A length modification beginning with %L implies a type modification into the default storage type %X.

n is a positive integer or hexadecimal number, where: $0 \leq n \leq 65535$
in accordance with the permissible value for a length modification.

%L(memref)

The length selector uses the length attribute of a different memory reference for length modification. The length selector is applied to data names, C qualifications and COM qualifications.

%L=(expression)

The length function causes AID to calculate the length. *expression* is described in section “Address, type and length selectors” on page 98. It is formed from integers, contents of memory references with type ’integer’ (%F or %A) and a length ≤ 8, the result of address selector, length selector and length function, and the arithmetic operators (+ - * /).
The operands involved and the result must be in the value range of a %FL8 field. If the *expression* of a length function contains only a memory reference, AID assumes the content (instead of the length) as the value for length modification.

The value range $-2^{63} \leq n < +2^{64}$ is supported. This enables data types %FL8 with values $-2^{63} \leq n < +2^{63}$ and %AL8 with values $0 \leq n < +2^{64}$ to be represented correctly. If the result does not comply with the value range, error message AID0470 is issued.

If a length selector is used for a vector but no index is specified, the length of the entire vector is selected. It is only through specification of an index that AID can access the length of an element of the vector.

Examples

1. `%DISPLAY V'10A'%L=(VAR1)`

   VAR1 is of type ’integer’ and contains the value 23. 23 bytes in dump format are output as of address V’10A’.

2. `%SET CVAR1%CL(CVAR) INTO CVAR`

   If it is assumed that CVAR1 and CVAR are two character variables in a Fortran program and that CVAR1 is longer than CVAR, the length modification makes it possible to transfer CVAR1 left-justified with the same length as CVAR.

3. `%SET %L(CVAR) INTO %2G`

   The length of variable CVAR is transferred to AID register %2G.

4. `%DISPLAY V'10A'%AL3->`

   The contents of three bytes as of address V’10A’ are interpreted as an address, and AID outputs four bytes in dump format (%XL4) as of the memory location thus referenced.

5. `%D V'10A'%L=(INDEX*12-%L(NAME))`

   Here, the length is derived from multiplying the content of INDEX by 12 and subtracting the length of NAME.

6. `%D V'4700'%L=(%L(C=CS1)-%L(INDAT))`

   The length is calculated from the length of CSECT CS1 minus the length of INDAT.

7.2.4.5 Arithmetic expression

In a byte offset, length function or index, an arithmetic expression can be specified for calculation of the requisite value by AID. An expression may thus be used wherever an integer value is required.
AID processes the arithmetic operators according to the mathematical rules for the resolution of an arithmetic expression. The order of processing can be changed by inserting parentheses. It is advisable to insert a blank before and after a minus sign "-" so that no misinterpretation can occur in the %AID SYMCHARS[=STD] setting.

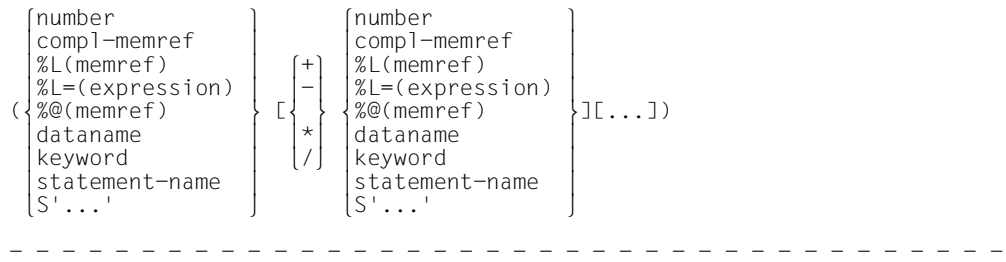
The following applies for each processing step of *expression*:

$-2^{63} \leq$ intermediate result $\leq 2^{63}-1$.

The following applies for a byte offset: $-2^{31} \leq$ end result $\leq 2^{31}-1$

The following applies for the length function: $0 \leq$ end result ≤ 65535

For the index, the limits defined in the source program apply. Moreover, only the operands *number* and *dataname* may be used (see section “Data names” on page 79).



number

Integer or hexadecimal number between -2^{63} and $2^{63}-1$.

compl-memref

May designate any memory location referenced in any manner. Its content must be an integer, i.e. of type %F or %A with a length ≤ 8.

The content of a memory reference can thus be used for a byte offset, for length modification, or as an index/subscript.

%L(memref)

The length selector is used to access the length attribute of a memory reference. The result is an integer. Length selectors are only applied to data names, C qualifications and COM qualifications, since the length of other memory references such as keywords is known anyhow.

%L=(expression)

AID calculates an integer value via the length function.
expression corresponds to the rules described here.

%@(memref)

The address selector is used to access the address attribute of a memory reference. The result is an address constant (%AL4).

dataname

Must be defined in the source program with type 'integer' or 'address' and a length ≤ 8.
The contents of *dataname* are used for calculating the arithmetic expression.

keyword

The contents of *keyword* are used for calculating the arithmetic expression. The following keywords may be specified (see chapter "Keywords" on page 121):

```
%n                  General register, 0 ≤ n ≤ 15
%nG                 AID general register, 0 ≤ n ≤ 15
%PC                 Program counter
%•[subcmdname]      Execution counter; the abbreviation %• designates
                    the execution counter of the currently active
                    subcommand
```

statement-name

As statement names are address constants, they can be used in expressions.

S'...'

Source references are likewise address constants and can thus be used in expressions.

Examples

1. `%D %L=(%1+5)`

   The length derived from the content of register %1 plus 5 is output.

2. `%D V'0'.(V'100'%AL2 + %L(C=CSECT))`

   As of address V'0', a byte offset is effected with the length of the expression specified in parentheses. First the contents of the two bytes with addresses V'100' and V'101' are interpreted as positive integers with a length of 2. The length of CSECT is then added to than. AID outputs 4 bytes in dump format as of the memory location thus calculated.

3. `%S %L=((V'0'%AL4 + V'4'%AL1) * NUM1) INTO %2G`

   The value calculated by the length function is transferred to AID register %2G. V'0' contains X'00000005', V'4' contains X'FFF5003A' and NUM1 contains the value. After the type and length modifications, this results in (5 + 255) * 3 = 780. The value 780 is thus transferred to %2G.

7.2.4.6 Address, type and length selectors

The selectors support access to the attributes of a memory reference.

```
selectors - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

%@(memref)
%T([area-qua•]dataname)
%L(memref)

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

%@(memref)

The address selector accesses the address attribute of a memory reference. The result is an address constant (%AL4). An address selector may be employed before a pointer operator to access a memory location, or as an unsigned binary number in an expression. %DISPLAY can be used to output the result of an address selection.
The address selector is applied to data names, C qualifications and COM qualifications. The addresses of keywords outside the user area can be output via %DISPLAY but cannot be used as a memory reference with a subsequent pointer operator.

%T([area-qua•]dataname)

The type selector accesses the type attribute and length attribute of a memory reference. The selected data type can only be used for type modification. *dataname* may be qualified.

%L(memref)

The length selector accesses the length attribute of a memory reference. The result is a positive integer. Length selectors may be employed for length modification or in expressions. %DISPLAY can be used to output the result of a length selection. The length selector is applied to data names, C qualifications and COM qualifications only, since the length of other memory references such as keywords and virtual addresses is known anyhow.

Examples

1.
```
%D %@(VAR)
%D %@(VAR)->.8
%S V'2E'.(%@(VAR))%CL2 INTO X
%D V'A1A'%XL=(2+@(VAR))
```

Use of the address selector:

The first %DISPLAY outputs an address.

The second %DISPLAY switches to machine code level (address selection and pointer operator) so that the byte offset operation is not impeded by the area limits of VAR.
%SET uses the address of VAR as a value for a byte offset.
The last %DISPLAY uses the value of the address of VAR in order to calculate the length.

2.
```
%D V'100'%T(VAR)
%S V'100'%T(INT) INTO NUM1
```

Use of the type selector:

%DISPLAY outputs the content of a virtual address with the type and length of VAR (redefinition). %SET interprets the content of a virtual address with the type and length of integer variable INT so that its value is retained during transfer to the numeric variable NUM1.

3.
```
%D %L(VAR)
%S %L(VAR) INTO NUM1
%D V'A1A'.(2+%L(VAR))
%D V'A1A'%L=(%L(VAR)*5)
```

   Use of the length selector:

   The first %DISPLAY outputs the length of VAR.

   %SET transfers the value of the length of VAR to the numeric variable NUM1.
   The second %DISPLAY uses the length of VAR as a value in a byte offset expression.
   The last %DISPLAY uses the value of the length of VAR in a length modification.

7.2.4.7 Special features of the interaction of various components

If a complex memory reference begins with an address constant (for example

with a source reference or a label), the pointer operator must be written next. Names of labels must always be set in L'...'.

Without the pointer operator, address constants may be positioned anywhere within the *compl-memref* where hexadecimal numbers can be written.

After a byte offset of pointer operation (exceptions apply to C++/C and PL/I, see section "Byte offset "•"" on page 86 and section "Indirect addressing "->" / "*"" on page 88), the implicit storage type and implicit length of the start address are lost. If no other storage type and length are explicitly defined, storage type %X with a length of 4 applies at the calculated location, unless the complex memory reference is used as the receiver in the %MOVE command. In this case the area that may be overwritten with %MOVE extends from the start address of *compl-memref* to the end of the memory occupied by the program.

The memory area assigned for an operand in a complex memory reference must not be exceeded by a byte offset or a length modification, otherwise AID issues an error message. However, if it is intended to use the start address of
a memory object without having to pay attention to the area boundaries, address selection should be used in conjunction with the pointer operator (%@(...)->). This takes the user away from the symbolic level, which at the same time means that the type attribute and length attribute of the referenced object can then only be accessed via the corresponding selectors.

Some compilers, such as C++/C and PL/I, generate a prologue for each program or subprogram during compilation. *function* (C++/C) or *entry* (PL/I) without a subsequent pointer operator designate the first executable statement of the corresponding function or procedure. However, if *function* or *entry* is followed by the pointer operator in order to move to a further position starting from the start of the function or procedure, it must be ensured that address calculation begins at the start address of the prologue.

Character encoding of a string

The interpretation of the string encoding can be changed using the conversion functions %C() and %UTF16(). The memory reference must be of the type “string”, i.e. of the type %C or %UTF16.

The conversion functions have an effect only when %C() is applied to the type %UTF16 or %UTF16() to the type %C. The memory locations remain unchanged here. AID continues to work implicitly with the converted memory location.

The CCSN for type %C from the %AID EBCDIC setting is used. The settings that are currently applicable can be displayed with the %SHOW %AID command.

Example:

The byte X'BB' is contained at memory location V'00'.

1. `%AID EBCDIC=EDF03IRV`
   The byte X'BB' consequently defines the character '[' in CCSN EDF03IRV.
   %UTF16(V'00' %CL1) results in the hexadecimal value X'005B'.
2. `%AID EBCDIC=EDF03DRV`
   The byte X'BB' X'BB' defines the character C'Ä' in CCSN EDF03DRV.
   %UTF16(V'00' %CL1) results in the hexadecimal value X'00C4'.

8 Medium-a-quantity operand

The *medium-a-quantity* operand defines the output medium to be used by AID and whether additional information apart from the contents of the specified memory area (data) is to be output.
This operand may be output more than once, separated by commas; for example, T=MIN,P=MAX can be used to output minimum information at the terminal and maximum information at SYSLST.

The *medium-a-quantity* operand may be specified in the following commands:

%DISPLAY
%HELP
%SDUMP
%OUT

The *medium-a-quantity* operand of the %OUT command also affects:

%DISASSEMBLE
%TRACE

The %OUT command can be used to predefine *medium-a-quantity* for %DISASSEMBLE, %DISPLAY, %HELP, %SDUMP and %TRACE. This presetting applies throughout the debugging session until a new definition is made or termination is initiated with /EXIT-JOB.

A local *medium-a-quantity* specification in %DISPLAY, %SDUMP and %HELP applies for the current command only; afterwards the *medium-a-quantity* value of the %OUT command or the default value T=MAX takes effect again. If no *medium-a-quantity* is specified in %DISPLAY, %SDUMP or %HELP the *medium-a-quantity* value of the %OUT command applies. If %OUT contains no *medium-a-quantity* declaration either, the default value T=MAX is assumed.

AID takes the coded character set name (CCSN) asigned into account for all output media whenever UTF16/UTFE characters are to be output to the output medium.

T Terminal output via SYSOUT.

H Hardcopy output (includes terminal output and cannot be specified together with *T*)

Fn File output. Fn designates the link name for the output file.

n is a number with a value $0 \leq n \leq 7$.

There are three ways of creating the associated file or assigning the output file:

1. %OUTFILE command with link name and file name.
2. ADD-FILE-LINK command for Fn.
3. For a link name with no file name assignment, AID issues a FILE macro with the file name AID.OUTFILE.Fn in accordance with the link name Fn. The file is created with `FCBTYPE=SAM, OPEN=EXTEND, RECFORM=V`.

When using the link name F6, remember that F6 is the default link name for REP files.

P Output to SYSLST.

MAX

The data is output with a maximum of additional information.

This includes information on the AID work area and on the interrupt point, but also information on the data to be output.

For %HELP the {MIN | MAX} specification has no effect, but one of the two entries is mandatory for syntactical reasons.
If output with the operand value MAX is effected for an output medium for the first time, or if the line contents have changed as compared with a previous output, up to three lines appear before the actual output:

– task line: provides information on the current AID work area and contains the task identifier (TID) and the task sequence number (TSN) or the link name of the dump file.

– header line: contains information on the interrupt point, i.e. the address at which the program stopped at the time of output.

– target line: contains information on the address to be output, i.e. the CSECT/COMMON containing the address and the displacement to the beginning of CSECT/COMMON.

The following is output for each data area:

– data name and, in the case of vectors, the index boundary list

– content (plus the associated index in the case of vectors);

in the case of identical lines the text "repeated lines: n" is output.

– virtual address of the first byte of each data line in the case of output on machine code level

– displacement of the first byte of each data line to the beginning of a CSECT if the address can be assigned to a CSECT; otherwise the address of the first byte of each data line relative to the beginning of the data area

MIN

No additional information is output with the data.

XMAX The data output with the %SDUMP command is nearly identical to the data output with the default value MAX with the following difference: Each data element is preceded by a type tag which defined the type, size and output format of this data element.

In the %DISPLAY, %DISASSEMBLE, %HELP, and %TRACE commands the operand value XMAX is not taken into account. The default MAX value is generated.

XFLAT The data output with the %SDUMP command is nearly identical to the data output with the value XMAX with the following difference: Only the topmost structural level is output for structured data types. In the case of long data (e.g. long strings or arrays), only the first elements are output.

In the %DISPLAY, %DISASSEMBLE, %HELP, and %TRACE commands the operand value XFLAT is not taken into account. The default MAX value is generated.

Examples

```
%OUT %DA T=MIN
%C1 %IO <%DA FROM %PC->;%STOP>
%R
00000BB6  L     R1,A8(R0,R11)
00000BBA  L     R15,98(R0,R11)
00000BBE  BALR  R14,R15
00000BC0  DC    X'0001'  INVALID OPCODE
00000BC2  CLI   396(R12),X'F0'
00000BC6  L     R13,B4(R0,R2)
00000BCA  BC    B'1100',E0(R0,R13)
00000BCE  L     R15,A4(R0,R11)
00000BD2  BAL   R14,4(R0,R15)
00000BD6  DC    X'0000'  INVALID OPCODE
STOPPED AT SRC_REF: 540PE, SOURCE: TEST, PROC: TEST
```

The data retrieved by the %DISASSEMBLE command is output without any additional information. The virtual addresses of the respective commands are prefixed in the form of 8-digit hexadecimal numbers.

```
%OUT %DA T=MAX
%C1 %IO <%DA FROM %PC->;%STOP>
%R
TEST+C22          L     R1,A8(R0,R11)          58 10 B0A8
TEST+C26          L     R15,9C(R0,R11)         58 F0 B09C
TEST+C2A          BALR  R14,R15                05 EF
TEST+C2C          CLI   396(R12),X'F2'         95 F2 C396
TEST+C30          L     R13,B4(R0,R2)          58 D0 20B4
TEST+C34          BC    B'1100',14A(R0,R13)    47 C0 D14A
TEST+C38          L     R15,A4(R0,R11)         58 F0 B0A4
TEST+C3C          BAL   R14,4(R0,R15)          45 E0 F004
TEST+C40          DC    X'0000'  INVALID OPCODE 00 00
TEST+C42          CLI   396(R12),X'F0'         95 F0 C396
STOPPED AT SRC_REF: 58REA, SOURCE: TEST, PROC: TEST
```

The data retrieved by the %DISASSEMBLE command is output with additional information. The command addresses are stated in the form of relative addresses, i.e. as program names plus displacement to the beginning of the program. The disassembled commands are followed by the memory contents in hexadecimal format.

```
%OUT %D T=MIN
%D ABC-TAB
01          ABC-TAB
 02         CHARS( 1: 26)
            |A|  |B|  |C|  |D|  |E|  |F|  |G|  |H|  |I|  |J|  |K|  |L|  |M|
            |N|  |O|  |P|  |Q|  |R|  |S|  |T|  |U|  |V|  |W|  |X|  |Y|  |Z|
```

The table ABC-TAB from a COBOL program is output via %DISPLAY without any additional information. The level numbers and the contents of the table items are output.

```
%D ABC-TAB T=MAX
*** TID: 000000D1 *** TSN: 8438 ***********************************************
SRC_REF:     58ADD   SOURCE: MOBS      PROC: MOBS  ****************************
01          ABC-TAB
 02         CHARS( 1: 26)
            (  1) |A|  (  2) |B|  (  3) |C|  (  4) |D|  (  5) |E|  (  6) |F|
            (  7) |G|  (  8) |H|  (  9) |I|  ( 10) |J|  ( 11) |K|  ( 12) |L|
            ( 13) |M|  ( 14) |N|  ( 15) |O|  ( 16) |P|  ( 17) |Q|  ( 18) |R|
            ( 19) |S|  ( 20) |T|  ( 21) |U|  ( 22) |V|  ( 23) |W|  ( 24) |X|
            ( 25) |Y|  ( 26) |Z|
```

The table ABC-TAB from a COBOL program is output via %DISPLAY with additional information. The actual output is preceded by a task line and a header line. The level numbers, the contents of the table items and the associated indexes are output.

9 AID literals

An AID literal can be specified as an operand in the AID commands %DISPLAY, %FIND, %MOVE and %SET.

9.1 Alphanumeric literals

9.1.1 Character literal

9.1.1.1 Input formats

{C'x...x' | 'x...x'C | 'x...x'| U'x...x'}

Maximum length: 80 characters.
Character set for *x*: any character which can be entered at the terminal.

If the coded character set for the input medium is not UTFE, a UTFE character string can be specified with the aid of the U literal.

Lowercase letters can be entered as such only if %AID LOW[=ON] has been specified. Normally (default setting) lowercase letters are converted into uppercase (see %AID); lowercase letters can then only be specified in the form of hexadecimal literals.

Apostrophes which are to be included in the literal must be duplicated (").

%DISPLAY
The literal is output. It may be converted using a type modification.

%FIND
x may also be the wildcard symbol '%', which stands for an arbitrary character and is always reported as a hit by %FIND.
When %C() and %UTF16() are applied to the search literal, '%' is no longer supported as a wildcard symbol.

%MOVE
The literal is transferred to the receive field left-justified and in the length of the literal. If the literal is longer than the receive field, the transfer is rejected with an appropriate message.

%SET
If the literal consists of numerals only, has a length ≤ 18 and is to be transferred to a numeric field, it is converted like a numeric literal and transferred retaining its correct value.

If its content is not purely numeric or its length > 18, the literal can be transferred in alphanumeric form to a character field (%C), or in binary form to a field with type modification %X, where it is stored left-justified. If the receive field is longer than the literal, the literal is padded on the right, with blanks (C'␣' ≙ X'40') in the case of alphanumeric transfer or with X'00' in the case of binary transfer. If the literal is longer than the receive field, it is truncated on the right and a warning issued.

9.1.1.2 Character encoding

Following the introduction of Unicode, AID supports the **c**oded **c**haracter **s**et **n**ame (CCSN) assigned to input and output media.
A CCSN can be assigned to a file using the CODED-CHARACTER-SET operand in the MODIFY-FILE-ATTRIBUTES command.

In the case of the input medium TERMINAL, AID uses the CCSN which was set using the BS2000 command MODIFY-TERMINAL-OPTIONS. Here AID knows none of the settings which were made directly in the terminal emulation but were not made known via the MODIFY-TERMINAL-OPTIONS command.

If no CCSNs were defined for input and output media, AID uses the CCSN of the user ID's entry in the user catalog as the default CCSN. This setting can be modified using the %AID EBCDIC= … command.

For input and output media, AID supports only those CCSNs which are also supported by XHCS and, except for UTFE, represent a 1-byte EBCDIC code.

The AID command %SHOW %CCSN enables the CCSNs currently supported by XHCS-SYS to be displayed.

9.1.1.3 Conversion functions %C() and %UTF16()

These functions can be used to modify the type of character encoding of a character literal.

%UTF16() converts the literal into a UTF16 string.
%C() converts a UTF16 literal into a 1-byte EBCDIC encoding which was defined by the %AID EBCDIC command.

If the literal is available in 1-byte EBCDIC encoding, %C() has no effect.

During conversion a character is replaced by the substitute character '.' if it is not available in UTF16 or the 1-byte EBCDIC character set. In this case AID issues a message.

9.1.1.4 Searching for character literals with %FIND

For the %FIND command to properly find character data, the CCS of *find-area* has to agree with the CCS of the input media (SYSCMD). Be sure to specify the CCS of *find-area* before looking for some character data in *find-area*:

`%AID CCS=` *CCS-name*

Usually, the default value for CCS is set to EDF03IRV, but any other EBCDIC character set defined in the attributes of the user account is also possible, e.g. EDF04F.

Be aware that since V3.4B11 the %DISPLAY command refers to the CCS value of `%AID` as to the default (implicit) CCS of character data to be displayed.

Example:

The CCS of SYSOUT is set to Unicode:

```
/MODIFY-TERM-OPTION CODED=UTFE
```

```
FTEST: PROC OPTIONS(MAIN);
           /* UTFE  */
  DCL  UTFED  BIT(200) INIT('D49EB7D5C3C8C5D56DC4C5'X);  :* DE
  DCL  UTFEB  BIT(200)                                   :* BY
   INIT('4541B745B0AF45AAB845B0B245AAA045AAB86DC2E8'X);  :* 21
  DCL  CED   CHAR(11) DEFINED UTFED;
  DCL  CEB   CHAR(21) DEFINED UTFEB;
  DCL  CE    CHAR(9)  INIT('Munich_EN');
  DCL  SE    CHAR(47);
           /* UTF-8 */
  DCL  UTF8D  BIT(200) INIT('4DC3BC6E6368656E2D4445'X);  :* DE  11
  DCL  UTF8B  BIT(200) INIT('D09CD18ED0BDD185D0B5D0BD2D4259'X); :* BY
  DCL  ISO    BIT(200) INIT('4D756E6963682D454E'X);      :* EN  9
  DCL  B8     BIT(16)  INIT('2020'X);
  DCL  C8D    CHAR(11) DEFINED UTF8D;
  DCL  C8B    CHAR(15) DEFINED UTF8B;
  DCL  C8     CHAR(9)  DEFINED ISO;
  DCL  BL     CHAR(2)  DEFINED B8;
  DCL  S8     CHAR(41);
           /* 8-bit ISO8859x */
  DCL  ISO8D  BIT(200) INIT('4DFC6E6368656E2D4445'X);    :* DE  10
  DCL  ISO8B  BIT(200) INIT('BCEEDDE5D5DD2D4259'X);      :* BY  9
  DCL  C7D    CHAR(10) DEFINED ISO8D;
  DCL  C7B    CHAR(9)  DEFINED ISO8B;
  DCL  S7     CHAR(34);
           /* UTF-16 */
  DCL U16D BIT(200) INIT('004D00FC006E00630068006500
  DCL U16B BIT(200) INIT('041C042E041D04250415041D003D00420059'X);
```

```
  DCL U16  BIT(200) INIT('004D0075006E00690063006800 3D0045004E'X);
  DCL B16  BIT(32)  INIT('00200020'X);
  DCL  C16D   CHAR(20) DEFINED U16D;
  DCL  C16B   CHAR(18) DEFINED U16B;
  DCL  C16    CHAR(18) DEFINED U16;
  DCL  BB     CHAR(4)  DEFINED B16;
  DCL  S16    CHAR(68);

  SE= CED ||'  '|| CEB ||'  '|| CE ||'  ';
  S8= C8D || BL || C8B || BL || C8 || BL ;
  S7= C7D || BL || C7B || BL || C8 || BL ;
  S16= C16D || BB || C16B || BB || C16 || BB;
  STOP: ;
END FTEST;
```

After loading the program:

```
%AID LOW=ON
%INSERT S=FTEST.STOP
%RESUME
```

The UTFE data output using %DISPLAY:

```
/%D SE %X 'UTFE'
V'01028290' = SE       + #'00000000'
01028290 (00000000) D49EB7D5 C3C8C5D5 6DC4C540 404541B7    MÜNCHEN_DE  ?
010282A0 (00000010) 45B0AF45 AAB845B0 B245AAA0 45AAB86D    Мюнхен_
010282B0 (00000020) C2E84040 D4A49589 83886DC5 D54040      BY  Munich_EN
```

The search with %FIND for ‘Мюнхен’ in the UTFE-area does not find a match:

```
/%FIND 'Мюнхен' IN SE
%  AID0351 No match in range
```

Use %SHOW to output the CCS of *find-area* (EDF03IRV):

```
/%SH %AID
%AID CHECK      =   NO
%AID REP        =   NO
%AID SYMCHARS   =   STD
%AID OV         =   NO
%AID LOW        =   ON
%AID DELIM      =   '|'
%AID LANG       =   D
%AID FORK       =   NOT_USED
%AID EXEC       =   OFF
%AID C          =   NO
```

```
%AID EBCDIC     =   EDF03IRV
%AID CCS        =   EDF03IRV
%AID LEV        =   OFF
```

Assign UTFE to the CCS of *find-area*:

```
/%AID CCS=UTFE
```

The search with %FIND in the UTFE-area now finds matches:

```
/%FIND Мюнхен' IN SE
ABSOLUT +0102829D=0102829D : 4541B745 B0AF45AA B845B0B2 Мюнхен_

/%FIND 'E' IN SE
ABSOLUT +01028296=01028296 : C5D56DC4 C5404045 41B7  EN_DE M

/%F
ABSOLUT +0102829A=0102829A : C5404045 41B745B0 AF45AAB8  E Мюн
```

Assign UTF8 to the CCS of *find-area*:

```
/%AID CCS=UTF8
```

UTF8 has been assigned to the CCS of *find-area*, but %FIND without parameters proceeds with CCS=UTFE:

```
/%F
ABSOLUT +010282BB=010282BB : C5D54040  EN
/%F
%  AID0352 No additional match in range
```

The output of data with %DISPLAY with the implicit UTF8 interpretation:

```
/%D S8 %X
V'010282BF' = S8       + #'00000000'
010282BF (00000000) 4DC3BC6E 6368656E 2D444520 20D09C      München-DE  ?
010282CE (0000000F) D18ED0BD D185D0B5 D0BD2D42 5920204D    юнхен-BY  M
010282DE (0000001F) 756E6963 682D454E 2020                 unich-EN
```

Using the wildcard symbol % in *'string'* to search in the UTF8-area now:

```
/%F '%E' IN S8
ABSOLUT +010282C8=010282C8 : 44452020 D09CD18E D0BDD185  DE юнх
/%F
ABSOLUT +010282E3=010282E3 : 2D454E20 20  -EN

/%AID CCS=UTF16
```

```
/%D S16 %X
V'0102830A' = S16      + #'00000000'
0102830A (00000000) 004D00FC 006E0063 00680065 006E003D    München=
0102831A (00000010) 00440045 00200020 041C042E 041D0425    DE юнх
0102832A (00000020) 0415041D 003D0042 00590020 0020004D    EH=BY  M
0102833A (00000030) 0075006E 00690063 0068003D 0045004E    unich=EN
0102834A (00000040) 00200020
```

The keyword ALL involved:

```
/%F ALL '%%%ch%%' IN S16

ABSOLUT +0102830A=0102830A : 004D00FC 006E0063 00680065  Münche
ABSOLUT +0102833A=0102833A : 0075006E 00690063 0068003D  unich=

/%AID CCS=ISO88591
/%F ALL 'M%n' IN C=FTEST@@@
FTEST@@@+000001BD=010011BD : 4D756E69 63682D45 4E000000  Munich-EN...
FTEST@@@+000001D8=010011D8 : 4DFC6E63 68656E2D 44450000  München-D..?
```

AID functions %C() and %UTF16():

```
/%F %C('M') IN SE
ABSOLUT +01028290=01028290 : D49EB7D5 C3C8C5D5 6DC4C540  M..NCHEN_DE
```

When using %C(), %FIND interprets *find-area* as encoded in the CCS that was defined by the %AID EBCDIC command (=EDF03IRV).

```
/%F %UTF16('M') IN S16
ABSOLUT +0102830A=0102830A : 004D00FC 006E0063 00680065  Münche
```

When using %UTF16(), %FIND interprets *find-area* as UTF16-encoded.

9.1.2 Hexadecimal literal

{X'f...f' | 'f...f'X}

Maximum length: 80 hexadecimal digits (equals 40 bytes).
A literal with an odd number of digits is complemented with X'0' on the right.
Character set for *f*: any character in the range 0-9 and A-F.

The type modification %UTF16 is permissible for a hexadecimal literal. As a result of this type modification, the literal is treated like a character literal (see section "Character literal" on page 109).

%DISPLAY
The literal is output. It may be converted using a type modification.

%FIND
f may also be the wildcard symbol '%', which stands for an arbitrary character and is always reported as a hit by %FIND.

%MOVE
The literal is transferred to the receive field left-justified and in the length of the literal. If the literal is longer than the receive field, the transfer is rejected with an appropriate message.

%SET
The literal is transferred left-justified. If the receive field is longer than the literal, padding with X'00' occurs on the right. If the literal is longer than the receive field, it is truncated on the right.
This literal can be used for transfer to a receive field with any data type definition.

9.1.3 Binary literal

{B'b...b' | 'b...b'B}

Maximum length: 80 binary digits (equals 10 bytes).

Padding with binary zeros (B'0') occurs on the right up to byte length (8 binary digits).
Character set for *b*: characters 0 and 1.

%DISPLAY
The literal is output. It may be converted using a type modification.

%FIND
B'b...b' cannot be specified.

%MOVE
The literal is transferred to the receive field left-justified and in the length of the literal. If the literal is longer than the receive field, the transfer is rejected with an appropriate message.

%SET
The literal is transferred left-justified. If the receive field is longer than the literal, padding with binary zeros occurs on the right. If the literal is longer than the receive field, it is truncated on the right.
This literal can be transferred to a receive field with any data type definition.

9.2 Numeric literals

9.2.1 Integer

[{±}]n

Maximum length:20 digits
Value range: $-10^{21} \leq n \leq +10^{21}$

For the user the internal representation of an integer is undefinded, i.e. if the user references to the internal representation within a AID command, the result is also undefined.
Example: `%D 12345 %X / %M 123456789 INTO V'xxxx'`

For compatibility reasons, the internal representation in the range $2^{31} \leq n \leq +2^{31}-1$ is like %FL4.

%DISPLAY
The literal is output. It may be converted using a type modification.

%FIND
An integer cannot be specified.

%MOVE
The integer is edited as a one-word hexadecimal value (4 bytes) and stored left-justified in the receive field. If the receive field is too short, the transfer is rejected with an appropriate message.

%SET
The integer can be transferred to any numeric receive field; it is adapted to the type of the receive field if necessary and transferred so that its value is retained.

9.2.2 Hexadecimal number

#'x...x'

Maximum length: 16 hexadecimal digits (corresponds to storage type %FL8, signed integer).

Value range:
With a max. length of 8 hexadecimal digits: $-2^{31} \leq$ #'x...x' $\leq +2^{31}-1$ (%FL4)
With a max. length of at least 9 hexadecimal digits: $-2^{63} \leq$ #'x...x' $\leq +2^{63}-1$ (%FL8)

Character set for *x*:

Negative hexadecimal number:
32-bit numbers:
have precisely 8 hexadecimal digits, the first bit in the leftmost digit defining the sign. In order to define a negative value, this digit must come from the range X'8' , X'9', ..., X'F'.

64-bit numbers:
have precisely 16 hexadecimal digits; as with a 32-bit hexadecimal number, the leftmost digit must come from the range X'8' , X'9', ..., X'F'.

Example:
#'FFFFFFFF' defines a 32-bit hexadecimal number with the value -1;
#'0FFFFFFFF' defines a 64-bit hexadecimal number with the value +2**32-1;

Consequently the behavior of older AID versions in the case of 32-bit hexadecimal numbers is retained.

%DISPLAY
The literal is output. It may be converted using a type modification.

%FIND
A hexadecimal number cannot be specified.

%MOVE
The hexadecimal number is edited in word length (4 bytes) and stored in the receive field left-justified. If the receive field is too short, the transfer is rejected with an appropriate message.

%SET
The hexadecimal number can be transferred to any numeric receive field; it is adapted to the type of the receive field if necessary and transferred so that its value is retained.

9.2.3 Decimal number

[{±}]n.m

Maximum length: 18 digits, decimal point and sign

The leftmost digit may be preceded by a sign. A decimal point may be located at any position within the digit sequence. If it is to occupy the leftmost position, it must be preceded by a zero.

%DISPLAY
The literal is output.

%FIND/%MOVE
A decimal number cannot be specified.

%SET
The decimal number can be transferred to any numeric receive field; it is adapted to the type of the receive field if necessary and transferred so that its value is retained.

9.2.4 Floating-point number

[{±}]mantissaE[{±}]exponent

The floating-point number is set up internally with double precision (8 bytes). If *mantissa* and/or *exponent* are unsigned, they are assumed to be positive. No blanks are allowed within the floating-point number.

mantissa

Maximum length: 16 significant digits, decimal point and sign.

mantissa must contain a decimal point, which may be located at any position within. If it is to occupy the leftmost position, it must be preceded by a zero.

exponent

Maximum length: 2 digits and sign.

Value range: $-75 \leq exponent \leq 76$.

%DISPLAY
The literal is output.

%FIND/%MOVE
A floating-point number cannot be specified.

%SET
The floating-point number can be transferred to any numeric receive field; it is adapted to the type of the receive field if necessary and transferred so that its value is retained.

10 Keywords

Keywords are predefined declarations for AID and start with the % character. They stand for storage types, registers, program counter, memory areas, system information, execution counters, logical values, feed control, address switchover, output of the current call hierarchy, instruction types, and events.
In a complex memory reference, keywords for memory areas, program registers, program counter, AID registers and execution counters can be used. The implicit storage types and lengths are stated below in the respective sections.

10.1 General storage types

The keywords for storage types can be used to change the interpretation of a memory location or of a literal (see section “Type modification” on page 91). This may be necessary or expedient, for instance, for the %SET command (when the storage types of *sender* and *receiver* are incompatible) or for %DISPLAY (if a memory location or a literal is to be output after conversion; each storage type is implicitly assigned an output type which defines how the memory contents are to be output) or when a memory location is to be included in the address calculation.

The optional length specification *L-mod* also permits a length modification (see section “Length modification” on page 94). This is not permitted in the case of literals. No blank is allowed between the type and length entries. The length entry may assume any form of length modification.

```
%X[L-mod]   Hexadecimal, length 1 ≤ n ≤ 65.535
            The default storage type for a virtual address is %XL4
            Output type: dump (hexadecimal and character)

%C[L-mod]   Character, length 1 ≤ n ≤ 65.535
            Output type: character

%UTF16[L-mod]
            Unicode character, length 2 ≤ n ≤ 65.534,
            The length must be a multiple of 2.
            Output type: dump (hexadecimal and character)

%P[L-mod]   Packed, length 1 ≤ n ≤ 9, can only contain the sign
            (last half-byte) and digits.
            Output type: numeric (signed integer)
            Not permitted for literals.
```

```
%D[L-mod]   Floating-point, length n = 4, 8 or 16 bytes
            Output type: numeric (floating-point)
            Not permitted for literals.

%F[L-mod]   Binary, signed integer, length n = 1..8 bytes
%H          Corresponds to %FL2
            Output type: numeric (signed integer)
            %H is not permitted for literals.

%A[L-mod]   Address, length n = 1..8 bytes
%Y          Corresponds to %AL2
            Output type: numeric (unsigned integer)
            Not permitted for literals.
```

10.1.1 Storage types for inverting the endianness of data item

Type modification %E is used to invert endianness of a memory content.

It works with:

%n	General registers
%nG	AID general registers
%MR	All 16 general registers in tabular form
%nQ	Floating-point register, n = 0,4
%nD|E	Floating-point register, n = 0,2,4,6
%FR	All 4 floating-point registers with double precision edited in tabular form
%PC	Program counter
%PCB	Process control block
%nAR	Access register
field	Data from loaded program
%TCB	
%CLASS6	Length must be less than 1024
%CLASS6ABOVE	Length must be less than 1024
%CLASS6BELOW	Length must be less than 1024
%CLASS5	Length must be less than 1024
V'xxxxxxxx'	virtual adress

%E type modification can be used with commands %MOVE, %SET, %DISPLAY. After applying a type modification %E to an operand, the operand has hexadecimal storage type (%X),i.e. output type Dump.

Examples

1. %E inverts the memory content of the register

```
/%DISPLAY %4
 %4              = 01001444
```

   With %E:

```
/%DISPLAY %4%E
 %4              = 44140001
```

2. %E inverts the memory content of address V'00000066'

```
/%DISPLAY V'00000066'
 V'00000066' = SEND2    + #'00000066'
 00000066 (00000066) 11223344
```

   With %E:

```
/%DISPLAY V'00000066'%E
 V'00000066' = SEND2    + #'00000066'
 00000066 (00000066) 44332211
```

You can use %E with length modification: %ELn, but the length cannot exceed 1024.Keyword %CLASSx%E must be used with length modification and length must be less than 1024.

Examples

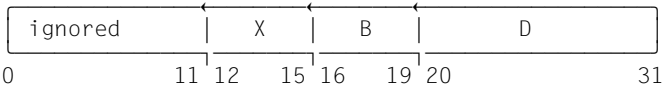
```
1. /%DISPLAY %5
             %5              = 12345678
   /%MOVE %5%E INTO %10
   /%DISPLAY %10
              %10             = 78563412

2. /%DISPLAY %5
             %5              = 12345678
   /%SET %5%EL2 INTO %10
             %10             = 34120000
```

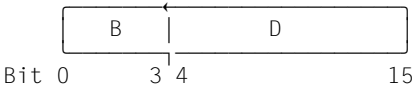
10.2 Storage types for interpreting machine instructions

These storage types are used to calculate an address expressed in the memory operands of machine instructions in the form of base register and displacement or index register, base register and displacement. Only a subsequent pointer operator (->) actually initiates address calculation. Without such a pointer operator, %SX equals %XL4 and %S equals %XL2. Examples are given in section “Indirect addressing "->" / "*"” on page 88.

```
%SX     SX address, length 4 bytes, index-base-displacement (X-B-D),
        corresponds to a machine instruction in SX format
        The index register number X is only evaluated if it is  0.
        Output type: HEX
```




```
%S      S address, length 2 bytes, base-displacement (B-D)
        The base register number B is only evaluated if it is | 0.
        Output type: HEX
```



10.3 Program registers and program counter

The program registers (general and floating-point registers) and the program counter are addressed by AID via keywords. Their contents can be output (%DISPLAY), modified (%MOVE, %SET) or used for addressing. The program registers are located in the privileged area and cannot be referenced by their virtual addresses. The floating-point registers occupy common memory space:
%0Q overwrites %0D and %2D; %4Q overwrites %4D and %6D.

AID handles the contents of general registers in subcommand conditions and in arithmetic expressions as signed numeric values in accordance with the type %FL4.
Before a pointer operator, however, AID assumes the type %AL4 and the register contents can be used as an address without type modification. A register is output with output type 'dump'. If numeric values are to be signed, a type modification with %F must be effected prior to output.

In ASSEMBH the program registers have the symbolic name _Rn, which can only be used for the symbolic debugging of Assembler programs however.

```
%PC   Program counter, type %AL4
%n    General register 0 ≤ n ≤ 15, storage type %FL4, output as hex. number
%nE   Floating-point register with single precision n = {0,2,4,6}, type %DL4
%nD   Floating-point register with double precision n = {0,2,4,6}, type %DL8
%nQ   Floating-point register with quadruple precision n = {0,4}, type %DL16

%MR   All 16 general registers edited in tabular form
%FR   All 4 floating-point registers with double precision
      edited in tabular form

%nAR  Access register 0 ≤ n ≤ 15, storage type %FL4, output as
      hexadecimal number (AR mode)
%AR   All 16 access registers edited in tabular form (AR mode)
```

The keyword %PC and the registers may be indexed if required. This is only necessary in the case of a program which has defined contingency processes or which was interrupted by AID during STXIT processing: if information other than on the interrupted contingency or STXIT process is desired (e.g. on the base process) the index of the appropriate process level must be specified. This index may be queried with %DISPLAY %PCBLST (see Executive Macros [10]).

The index is specified in the format: keyword(index).

10.4 AID registers

The AID registers are located in the memory area reserved for AID and can thus be referenced from any AID work area without a new work area declaration. The type and length of AID registers are the same as for program registers.
There are no keywords for addressing all AID registers collectively.

```
%nG     AID general register 0 ≤ n ≤ 15, storage type %FL4, output as hex. no.
%nGD    AID floating-point register with double precision n = {0,2,4,6},
        type %DL8
```

10.5 Memory classes

The keywords listed below are used to reference memory classes. They can be specified in %CONTROLn, %DISASSEMBLE, %DISPLAY, %FIND and %TRACE. In a complex memory reference, keywords for memory classes can be used with all attributes, i.e. name, address, content, length and type.

In class 5 memory the program occupies privileged and non-privileged areas. Both areas can be accessed with the keyword %CLASS5, but the privileged area can only be accessed with a higher test privilege.

The keywords %CLASS5 and %CLASS5BELOW designate the same address space. The same is true of %CLASS6 and %CLASS6BELOW.

```
%CLASS5             Class 5 memory, type %X
%CLASS6             Class 6 memory, type %X
```

In addition, there are the following keywords (all of type %X) for debugging a program or for processing a dump:

```
%CLASS5BELOW        Class 5 memory below the 16-Mb boundary (≙%CLASS5)
%CLASS5ABOVE        Class 5 memory above the 16-Mb boundary
%CLASS6BELOW        Class 6 memory below the 16-Mb boundary (≙%CLASS6)
%CLASS6ABOVE        Class 6 memory above the 16-Mb boundary
```

10.6 System information

The keywords for system information support the output of information on a particular task via %DISPLAY. If a given keyword returns more than one value, AID edits the values and outputs an appropriate table.

```
%CC                    Condition code
%PCB                   Process control block
%PCBLST                List of all process control blocks
%LINK                  Name of the segment last loaded, which was determined
                       with %ON %LPOV
%PM                    Program mask
%AUD1                  Hardware audit table, starting with the oldest
                       entry (only if created at system generation)
%AMODE                 System information field for addressing mode
                       (can be modified with %MODE24 or %MODE31 only)
%ASC                   ASC mode
                       (with regard to AR mode: X'00' = off; X'01' = on)
%DS[(ALET/SPID-qua)]   Information about SPIDs and/or ALETs of the active
                       data spaces

%LOC(memref)           Machine-oriented localization information for
                       an address in the executable part
%HLLOC(memref)         Symbolic localization information for an address
                       in the executable part

%SORTEDMAP             List of all CSECTs and COMMONs of the user program
                       (sorted by names and addresses)
```

```
        ⎧ CTX=context [•L=loadunit]    ⎫
        ⎪ L=loadunit                   ⎪
%MAP [(⎨          ⎧USER⎫               ⎬)]
        ⎪ SCOPE = ⎨    ⎬               ⎪
        ⎩         ⎩ALL ⎭               ⎭
```

`{CTX=context | L=loadunit}#1`
When a path is specified, all CSECTs/COMMONs of the specified context or load unit are listed.

`SCOPE=USER` CSECTs/COMMONs of the default contexts CTXPHASE or LOCAL#DEFAULT and of the contexts formed by the BIND macro with operand LNKCTX[@] are listed.

`SCOPE=ALL` In addition to the CSECTs/COMMONs of the user-defined contexts, the map of all contexts is output to which the program has connected, e.g. DSSM subsystems or user pool contexts.

All BLS names (context, load unit, CSECT and COMMON) are output unabbreviated. Within the contexts and load units, the output list is sorted according to CSECT name.

Examples

1. `/%D %HLLOC(PROG=UPRONUM.S'22DIS'->)`

   AID output

```
 V'000083EC' = CONTEXT  : LOCAL#DEFAULT
               SMOD     :  UPRONUM
               PROC     :  UPRONUM
               PARAGRAPH:  UNPCK
               SRC-REF  :     21
               LABEL    :  UNPCK
```

2. `/%D %LOC(PROG=UPRONUM.S'22DIS'->)`

   AID output

```
 V'000083EC' = CONTEXT  :  LOCAL#DEFAULT
               LMOD     :  %UNIT
               SMOD     :  UPRONUM
               OMOD     :  UPRONUM
               CSECT    :  UPRONUM (00008018) + 000003D4
```

3. `/%D %MAP`

   AID output

```
*** TID: 00230056 *** TSN: OFZB ********************************************
CURRENT PC: 00002000    CSECT: LLMTEST2  ***************************************
**CSECT-LISTING(MAP) OF CONTEXT : LOCAL#DEFAULT
**MAP OF LOAD UNIT             : %UNIT
  CSECT-NAME                       START     SIZE    VER/DATE_OF_MOD
  ASSTEST                          00000150  000830   ............
  ASS2                             00000980  000008   ............
  COMM1                            00001000  00012C   %COMMON.....
  LLMTEST1                         00000000  000150   ............
**CSECT-LISTING(MAP) OF CONTEXT : CTX2
**MAP OF LOAD UNIT             : LLMTEST2
  CSECT-NAME                       START     SIZE    VER/DATE_OF_MOD
  ASSTEST                          00002078  000650   ............
  ASS2                             000026C8  000008   ............
  COMM1                            FFFFFFFF  000000   %COMMON.....
  LLMTEST2                         00002000  000078   ............
```

10.7 Execution counter

An execution counter is set up for each subcommand. It counts the number of times the subcommand is executed. The subcommand's own execution counter may be addressed with %• within the subcommand. If the subcommand is assigned a name, the execution counter receives the same name and can then be referenced with %•subcmdname outside the subcommand. Execution of a subcommand may be made dependent on the status of the execution counter by querying %•subcmdname in a condition (see chapter "Subcommand" on page 51).

A numeric value may be assigned to the counter via %SET. The content of an execution counter can be read via %DISPLAY. The counter is incremented every time the associated subcommand is encountered in the program sequence. Execution counters can be used wherever a numeric value is permissible.

```
%•[subcmdname]   Variable of type %FL4
                 subcmdname is the name of the associated subcommand.
                 The abbreviation %• designates the execution counter of
                 the currently active subcommand.
```

10.8 Logical values

The two keywords listed below can be used to assign values to logical variables from Fortran programs via %SET.

```
%TRUE
%FALSE
```

10.9 Feed control

The two keywords for feed control are only effective for the output medium SYSLST and can only be specified in %DISPLAY.

```
%NP              Beginning of a new page
%NL[(n)]         Output of n blank lines, 1 ≤ n ≤ 255
                 The default value for n is 1.
```

10.10 Address switchover

XS programming uses 31-bit addresses instead of the customary 24-bit addresses. The two keywords listed below serve to change the addressing mode for the test object or the address interpretation in indirect addressing.

`%MOVE %MODE31 INTO %AMODE` changes the addressing mode

`%AINT %MODE24` changes the AID address interpretation in indirect addressing

```
%MODE24  24-bit addressing
%MODE31  31-bit addressing
```

10.11 Current call hierarchy

In %SDUMP the keyword %NEST causes the current call hierarchy to be output.

```
%NEST    Output of the current call hierarchy
```

10.12 Criterion for %CONTROLn and %TRACE

The keywords listed below are used to group programming language commands or statements according to their type. These keywords can be specified as a monitoring criterion (*criterion* operand) in the %CONTROLn and %TRACE commands.

In the case of %CONTROLn the associated subcommand is processed when a command or statement of the group to be monitored is about to be executed.
In the case of %TRACE a log line is output when a command or statement of the group to be monitored is executed. In symbolic debugging, output occurs before statement execution; in debugging on machine code level, logging occurs after command execution.

The default value is the symbolic *criterion* %STMT. The consequence is that, in the case of a %CONTROLn or %TRACE with an area specification on machine code level, specification of a keyword for *criterion* is mandatory unless a monitoring criterion from a previous %CONTROLn or %TRACE is still valid.

criterion	Command group or statement group
Debugging on machine code level:	
%INSTR	All machine instructions being executed
%B	Branch instructions (i.e. the machine instructions BAL, BALR, BAS, BASSM, BASR, BC, BCR, BCT, BCTR, BSM, BXH and BXLE)
%BAL	Subprogram calls (using the machine instructions BAL, BALR, BAS, BASSM and BASR)
Debugging on the symbolic level:	
%STMT	All statements being executed
%ASSGN	Assignment statements
%CALL	Subroutine calls (CALL statements)
%COND	IF(...) THEN, ELSE IF(...) THEN, ELSE and IF(...) statements
%DB	Statement for calling a database
%EXCEPTION	Conditional statement branches
%GOTO	GOTO statements
%IO	Input/output statements
%LAB	Statement after label
%PROC	STOP, END, RETURN, SUBROUTINE and FUNCTION statements
%SORT	MERGE and SORT statements

10.13 Event for %ON

The keywords listed below stand for write monitoring, program errors, program termination, supervisor calls and other events during program execution. They can be specified in the %ON command (*event* operand). The *event* operand defines the occurrence upon which the program is to be interrupted so that the associated subcommand can be executed.
If several %ON commands with differing *event* declarations are active and satisfied at the same time, AID executes the related subcommands in the sequence in which the respective keywords are listed in the table below. If various %TERM events occur, the associated subcommands are processed according to the FIFO principle.

Write monitoring cannot be active for a number of different areas at the same time. A new %ON %WRITE(...) command overwrites one entered earlier (see section “%ON %WRITE with %INSERT, %CONTROLn and %TRACE” on page 135).

Further information on selecting the suitable %TERM can be found in the Executive Macros [10].

event	Subcommand is processed:
%WRITE(memref)	after overwriting the memory area identified by *memref* (as of FUJITSU Software BS2000 OSD/BC V1.0)
%ERRFLG(z)	after occurrence of an error with the specified event code and before program abortion
%INSTCHK	after occurrence of an addressing error, an invalid supervisor call (SVC), a non-decodable operation code, a paging error or a privileged operation and before program abortion
%ARTHCHK	after occurrence of a data error, a divide error, an exponent overflow or a mantissa equalling zero and before program abortion
%ABNORM	after occurrence of one of the errors covered by the above events, of a DMS error (as of BS2000 V10) or of a %ILLSTX
%ERRFLG	after occurrence of an error with any weight
%SVC(z) %SVC	before execution of the supervisor call with the specified number before execution of any supervisor call
%LPOV(name) %LPOV	after loading of the segment with the specified name after loading of any segment
%TERM(N[ORMAL]) %TERM(A[BNORMAL]) %TERM(D[UMP]) %TERM(ND|NODUMP) %TERM(P[RGR]) %TERM(S[TEP]) %TERM	before program termination with TERM MODE = NORMAL, TERM or TERMD before program termination with TERM MODE = ABNORMAL, TERMJ or TRMJD before program termination with TERM DUMP = Y, TERMD or TRMJD before program termination with TERM DUMP = NO, TERM or TERMJ before program termination with TERM UNIT = PRGR, TERM or TERMD before program termination with TERM UNIT = STEP, TERMJ or TRMJD before program termination with TERM, TERMD, TERMJ or TRMJD
%ANY	before program termination due to a program error or a TERM with any operand values or TERMJ, TERMD or TRMJD, or due to a DMS error or a %ILLSTX
%ILLSTX	before occurrence of a STXIT call during processing of a preceding STXIT call (STXIT in STXIT)

z is an integer where: $1 \leq z \leq 255$. *z* may be specified as an unsigned decimal number of up to three digits or as a two-digit hexadecimal number (#ff').'

No check is made as to whether the specified event code or the SVC number is meaningful or permissible.

11 Special applications

11.1 %ON and STXIT

There are different possible ways of responding to events which occur during execution of a program:

– STXIT routines can be assigned in the program to individual events; these routines are executed in order to process the events when they occur (see Executive Macros [10]).

– Events can be assigned via the %ON command during debugging with AID. When one of these events occurs, the subcommand specified in the %ON command is processed.

Events for which STXIT routines have been assigned in the program cannot be processed by AID: AID has no knowledge of the occurrence of such events. Any subcommands specified in the %ON command for these events will therefore not be executed.

STXIT routines are assigned among other things by the compiler runtime systems, by ILCS, openUTM and the database systems, for example for the "program error" or "unrecoverable program error" events. These STXIT events correspond to the %ERRFLG(zzz), %ERRFLG, %INSTCK, %ARTHCHK and %ABNORM events in the %ON command. These events can only be processed with AID is assignment of the STXIT routines has been suppressed.

For FOR1 programs without standard linkage, the assignment of STXIT routines is suppressed by specifying the option RUNOPT STXIT=NO.
The assignment of STXIT events cannot be prevented in the case of COBOL programs and programs that use standard linkage

(C as of V2.0A, C++ as of V2.1A, COBOL85 as of V1.1A, COBOL2000 V1.0A, FOR1 as of V2.2A, and PLI1 as of V4.1A).

However, in the event of errors which do not affect memory such as address errors or illegal operation code, ILCS offers the following approach: after the STXIT routines have been processed, ILCS restores the former program counter contents, reproduces the error and passes control to the system, thus allowing subsequent processing of the error with the %ON command. With all other errors ILCS aborts the program.
%ON %ANY or %ON %TERM can be used, however, to stop the program run before it is unloaded to investigate the cause of the error using AID command.

In the case of openUTM applications the openUTM STXIT routines can be deactivated (interactively for UTM-T and UTM-P) by specification of the option STXIT=OFF in the START parameter. If openUTM is running under ILCS (operand PROGRAM COMP=ILCS in the KDCDEF statement), the ILCS STXIT routines still remain effective even after deactivation of UTM-STXIT.

In Assembler and C++/C programs it is possible to write separate routines (in C++/C: signal handling via signal() library function, in Assembler: STXIT macro) for the purpose of error handling. In this case, too, AID has no possibility of responding via the %ON command to an error intercepted by individually programmed routines. It is possible, though, to use %INSERT to insert a test point in the error handling routines; the associated subcommand will then be executed when the error occurs.

11.2 Programs with an overlay structure

AID normally assumes that a program is linked without an overlay structure. It uses the LSD records once they are loaded without checking every time whether the CSECT that is referenced is contained in a segment that has since been dynamically loaded. However, if the program being debugged is one that was linked statically as an overlay or one that dynamically loads or unloads segments with the BIND/UNBIND macro calls, the operand OV=YES must be specified in the %AID command in order to ensure that AID checks every time the LSD is accessed whether dynamic loading has occurred in the meantime.

In programs with an overlay structure, a test point can only be set in a segment that was loaded at the time the command is entered. Similarly, a test point can only be deleted if the associated segment is loaded. If the segment is unloaded or overwritten, the test point is retained unless it has first been explicitly deleted with %REMOVE. If the segment is loaded again, the test point is also set again.

12 Restrictions and interaction

12.1 %ON %WRITE with %INSERT, %CONTROLn and %TRACE

Attention must be paid to the following interactions between %ON *write-event* and the AID commands %CONTROLn, %INSERT and %TRACE:

– If a %CONTROLn or a %TRACE with a machine-oriented *criterion* is assigned, an entry of %ON *write-event* is rejected with an error message, and vice versa.

– If a machine instruction has been overwritten by a %CONTROLn or %TRACE with a symbolic *criterion* by the internal AID label (X'0A81'), AID does not detect the write access to that instruction.

– If a machine instruction has been overwritten by the test point defined with %INSERT with the internal AID label, again AID does not detect the write access to that instruction.

To achieve continuous write monitoring it is advisable to delete all %CONTROLn and %INSERT commands using %REMOVE and to delete any %TRACE command that may still be entered by continuing with %RESUME after the %ON command.

12.2 Interaction between execution monitoring and the output or modification of memory contents

If %INSERT is used to set a test point, AID overwrites the instruction code at the address of the test point with an SVC X'81'. Similarly, AID labels the first instruction of the executable statements in *control-area* and *trace-area* (with a symbolic *criterion*) with X'0A81'. These labels can be viewed if the relevant instruction code is output using %DISPLAY. If, on the other hand, the code is disassembled using %DISASSEMBLE, AID replaces the entered SVC with the original instruction, revealing the instruction code as it was generated by the compiler. AID also falls back on the original code if an address is to be calculated from the corresponding instruction via the type modification %S or %SX, and that address is to be referenced via a pointer (->).

The labels set in the instruction code can be searched with the %FIND command by specifying X'0A81' as the search key.

In the case of the %MOVE and %SET commands, any labels that are entered are not replaced. This may have the effect when instruction code is transferred that labels disappear or new ones are set which AID is no longer able to bring into connection with its internal command management. The user must therefore personally ensure that before transfer or overwriting takes place no SVCs entered by AID are contained in the relevant instruction code. Test points and labels associated with the %CONTROLn command can be deleted with the %REMOVE command. If a %TRACE is still entered, this can be deleted by starting the program with %RESUME or by entering
%TRACE 1 %INSTR.

12.3 Test points in the common memory pools

If a test point is set in a common memory pool, it is known only to the task that set the test point. All other tasks that are also connected to the common memory pool stop at this test point.

The only way that other users of the common memory pool can avoid this is to reinsert the original code by hand. Otherwise the hung task must wait until the test point is explicitly reset using %REMOVE by the task that set it, or until the task terminates and thereby implicitly removes the test points that it set.

A further problem arises however when the task that set the test point disconnects from the common memory pool without first having removed the test point with %REMOVE. If the task is then ended, implicit resetting of the test point is not performed as there is no longer a connection between task and common memory pool. The original code can then only be recovered manually.

In order to avoid the above problems, it is advisable to run the code locally and not in a common memory pool when debugging. If, however, a test point is required in a common memory pool, it should be removed using %REMOVE once it is reached, so that other users are not prevented from using the common memory pool. During debugging, at least disconnection of the task from common memory should be suppressed so that the test points can be removed implicitly when the task terminates.

12.4 Low level trace and control in conjunction with contingencies

12.4.1 %TRACE

In tasks with event-driven processing, individual machine instructions may be logged incorrectly when running %TRACE at machine code level. If, as a result of an asynchronous event, a contingency routine is called and a low level trace is running at the same time, errors may occur when entering the contingency routine and when returning to the task interrupted by the event. Depending on the particular program and debugging constellation,

You can expect the following errors at the interface between the base process and contingency:

– an instruction is incorrectly logged, e.g. with incorrect register contents
– an instruction is lost
– an instruction is displayed twice.

12.4.2 %CONTROL

Similarly, a subcommand may be omitted or executed too many times during instruction monitoring with %CONTROL.

STXIT routines started when program errors are detected are not affected by the error conditions described above. All instructions used in conjunction with %TRACE and %CONTROL are executed correctly and completely.

13 Appendix

13.1 SDF/ISP commands illegal in command sequences and subcommands

List of BS2000 commands which must not be used in command sequences and subcommands

Command	Function
ABORT	abort procedure
ADD-CJC-ACTION	declare conditional execution of command sequence
BEGIN-PROCEDURE	define procedure file attributes
BREAK	request command mode
CATEGORY	control configuration workload
CANCEL-PROCEDURE	terminate (execution of) procedure
CHANGE-ACCOUNTING-FILE	close current accounting file and create new one
CHANGE-CONSLOG	close current logging file and create new one
CHANGE-SERSLOG	close current ISERSLOG file and create new one
DELON	delete ON command
END-CJC-ACTION	mark end of CJC command sequence
ENDON	terminate ON statement sequence
ENDP	terminate procedure file
END-PROCEDURE	terminate procedure file
EOF	mark end of file for SYSDTA
ESCAPE	Interrupt procedure run
EXIT-PROCEDURE	terminate procedure run and return control to procedure file last exited
HOLD-JOB	halt job
HOLD-PROCEDURE	halt procedure run to allow command input from display terminal

Command	Function
HOLD-SPOOLOUT	halt spoolout job
INTR	send INTR event to program
HOLD-SUBSYSTEM	place subsystem in wait state
INFORM-OPERATOR	send message to operator terminal
LOAD-EXECUTABLE-PROGRAM	load program
LOAD-PROGRAM	load program
LOGON	initiate job
MODIFY-ACCOUNTING-PARAMETERS	specify accounting records and extensions for accounting file
MODIFY-TASK-CATEGORIES	limit number of active tasks
ON	conditionally execute command sequence
PROCEDURE	specify procedure file attributes
REMOVE-CJC-ACTION	cancel effect of CJC command sequence
RESTART	restart program from checkpoint
RESUME-JOB	cancel wait state for user job
RESUME-PROCEDURE	continue interrupted procedure run
RESUME-SUBSYSTEM	cancel wait state for subsystem
RTI	return to interrupted procedure
SEND-MSG	send message to console or program (STXIT routine)
SET-JOB-STEP	terminate spin-off
SET-LOGON-PARAMETERS	initiate interactive or batch job
SET-SPACE-SATURATION-LEVEL	define storage saturation levels a pubset
SHOW-ACCOUNTING-STATUS	display information on accounting system
SHOW-FILE	display file on screen
SHOW-SERSLOG	display information on SERSLOG
SHOW-SUBSYSTEM-STATUS	display information on subsystem status
SKIP	conditional branch (task switch)
SKIP-COMMANDS	go to branch destination (depending on switches or JVs)
SKIPJV	conditional branch (job variable)
SKIPUS	conditional branch (user switch)
SPMGT	manage storage space
START-ACCOUNTING	activate accounting system
START-EXECUTABLE-PROGRAM	load and start program

Command	**Function**
START-PROGRAM	load and start program
START-SERSLOG	activate SERSLOG
START-SUBSYSTEM	load and initialize subsystem
STEP	
STOP-ACCOUNTING	deactivate accounting system
STOP-SERSLOG	terminate SERSLOG
STOP-SUBSYSTEM	terminate subsystem
WAIT	specify conditional waiting time (batch job)
WAIT-EVENT	put job on hold waiting for event
WHEN	set conditional halt for batch job (user switch)

13.2 Event codes

The assignment of interrupt events and event codes to the STXIT event classes is shown in the table below:

STXIT event class	interrupt event	Event code
Program error	illegal SVC illegal operation code Data error Exponent overflow Divide error Significance error Exponent underflow Decimal overflow Fixed-point overflow	X' 04' X' 58' X' 60' X' 64' X' 68' X' 6C' X' 70' X' 74' X' 78'
Interval timer for CPU time	"SETIC interval" expired for CPU time	X' 20'
Interval timer for CPU time	"SETIC interval" expired for real time	X' A0'
End program runtime	End of program runtime	X' 80'
unrecoverable program error	Privileged SVC Access to a non-existent memory page Privileged operation Address error XA error (incorrect addressing mode) Realtimer (Condition Error) Alignment error Validation error unrecoverable vector processor error	X' 08' X' 48' X' 54' X' 5C' X' 9C' X' A4' X' AC' X' B0' X' B4'
communication to the program	Command	X' 44'
ESCPBRK	BREAK/ESCAPE (via keys)	X' 84'
ABEND	System error, performance loss START-EXECUTABLE-PROGRAM, LOAD-EXECUTABLE-PROGRAM, ABEND, LOGOFF, CANCEL-JOB Address translation error due to hardware fault Hardware fault (CPU) forced unloading of a subsystem (system management)	X' 88' X' 8C' X' 94' X' A8' X' B8'
Program termination	TERM CMD	X' 90' X' 98'
SVC interrupt	SVC call of a specified SVCs	X' 50'
Hardware fault	Input/output error in data-in-virtual technology	X' 28'

Glossary

addressing mode

AID assumes the addressing mode of the test object (either 24-bit or 31-bit addresses). AID can also be used for testing programs that were linked from modules with differing addressing modes. The system information field %AMODE always shows the current addressing mode. The addressing mode can be changed via `%MOVE %MODE{24|31} INTO %AMODE` and queried via `%DISPLAY %AMODE`.

address operand

This is an operand used to address a memory location or a memory area. Virtual addresses, data names, statement names, source references, keywords, complex memory references, C qualifications (debugging on machine code level) or PROG qualifications (symbolic debugging) may be specified. The memory location/area is situated either in the loaded program or in a memory dump in a dump file.
If a name has been assigned more than once in a user program and thus no unique address reference is possible, area qualifications or an *identifier* (COBOL) can be used to assign the name unambiguously to the desired address.

AID default address interpretation

Indirect addresses, i.e. addresses preceding a pointer operator, are interpreted according to the currently valid addressing mode by default. %AINT can be used to deviate from the default address interpretation and to define whether AID is to use 24-bit or 31-bit addresses in indirect addressing.

AID input files

These are files required by AID for the execution of AID functions, as opposed to input files used by the program. AID processes disk files only.
AID input files include:

1. dump files containing memory dumps (%DUMPFILE)
2. PLAM libraries containing object modules; if the library has been assigned using the %SYMLIB command, AID can dynamically load the LSD records.

AID literals

AID provides the user with both alphanumeric and numeric literals (see chapter “AID literals” on page 109):

```
{C'x...x' | 'x...x'C | 'x...x'| U'x...x'}      Character literal
{X'f...f' | 'f...f'X}                         Hexadecimal literal
{B'b...b' | 'b...b'B}                         Binary literal
[{±}]n                                        Integer
#'f...f'                                      Hexadecimal number
[{±}]n.m                                      Decimal number
[{±}]mantisseE[{±}]exponent                   Floating-point number
```

AID output files

These are files to which the output of the %DISASSEMBLE, %DISPLAY, %HELP, %SDUMP and %TRACE commands may be written. The files are referenced in the output commands via their link names F0 through F7 (see %OUT and %OUTFILE).
The REP records are written to the file assigned to link name F6 (see %AID REP=YES and %MOVE).

There are three ways of creating an output file or assigning an output file:

1. %OUTFILE command with link name and file name
2. ADD-FILE-LINK command with link name and file name
3. AID issues a FILE macro with the file name AID.OUTFILE.Fn for a link name to which no file name has been assigned.

An AID output file always has the format FCBTYPE=SAM, RECFORM=V and is opened with OPEN=EXTEND.

AID standard work area

This is the non-privileged area of the virtual memory in a user task, which is occupied by the program and all its connected subsystems.
In conjunction with symbolic debugging, this is the current program segment of the program which has been loaded.
If no declaration has been made via %BASE and no base qualification has been specified, the AID standard work area applies by default.

AID work area

The AID work area is the address space in which memory references can be accessed without specification of a base qualification. It comprises the non-privileged part of virtual memory in the user task, which is occupied by the program and all its connected subsystems, or the corresponding area in a memory dump.
Using the %BASE command, you can shift the AID work area from the loaded program to a memory dump, or vice versa. You may deviate from the AID work area in a command by specifying a base qualification in the address operand.

area check

For byte offset and length modification operations and for *receiver* in the %MOVE command, AID checks whether the area limits of the referenced memory objects are exceeded, in which case an error message is issued.

area limits

Each memory object is assigned a specific area, which is defined by the address and length attributes in the case of data names and keywords. For virtual addresses, the area limits are between V'0' and the last address of the virtual memory (V'7FFFFFFF'). In area qualifications, the area limits are derived from the start and end addresses of the program segment thus identified (see chapter "Addressing in AID" on page 67).

area qualification

These qualifications are used to identify part of the work area. If an address operand ends with one of these qualifications, the command is effective only in the part that is identified by the last qualification. An area qualification delimits the active area of a command, or makes a data name or statement name unique within the work area, or allows a name to be reached that would otherwise not be addressable at the current interrupt point.

attributes

Each memory object has up to six attributes:
address, name (opt), content, length, storage type, output type.
The address, length and storage type can be accessed using selectors. AID uses the name to locate all the associated attributes in the LSD records so as to be able to correctly interpret the associated memory object.
Address constants and constants from the source program have only up to five attributes:
name (opt), value, length, storage type, output type.
They have no address. When a constant is referenced, AID does not access a memory object but merely inserts the value of the constant.

base qualification

This is the qualification designating either the loaded program or a memory dump in a dump file. It is specified via E={VM | Dn}.
The base qualification may be globally declared by means of %BASE or specified in the address operand for a single memory reference.

character conversion functions

AID provides two functions for character conversion, %C() and %UTF16(). The %UTF16() function converts strings from a 1-byte EBCDIC encoding to UTF16 encoding; the %C function performs conversion in the other direction.

command mode

The term "command mode" in the AID manuals designates the EXPERT mode of the SDF command language. Users who are working in a different mode (GUIDANCE={MAXIMUM | MEDIUM | MINIMUM | NO}) should select the EXPERT mode by issuing the command MODIFY-SDF-OPTIONS GUIDANCE=EXPERT when they wish to enter AID commands.
AID commands are not supported by SDF syntax, i.e.

– operands cannot be entered via menus and

– AID issues error messages but does not offer a correction dialog.

The system prompt for command input in EXPERT mode is "/".

command sequence

Several commands separated by semicolons (;) form a command sequence, which is processed from left to right. Like a subcommand, a command sequence may contain both AID and BS2000 commands. Certain commands are not permitted in command sequences: this refers to the AID commands %AID, %BASE, %DUMPFILE, %HELP, %OUT, %QUALIFY and the BS2000 commands listed in the appendix.
If a command sequence contains one of the commands for runtime control, the command sequence is aborted at that point and the program is started (%CONTINUE, %RESUME, %TRACE) or halted (%STOP). Any subsequent commands in the command sequence are not executed.

compilation unit

A compilation unit is part of a program that has been compiled as a unit. The term program unit is used for this in Fortran. A compilation unit can be referenced with the S qualification.

constant

A constant represents a value which is not accessible via an address in program memory.
The term "constants" includes the constants defined in the source program, the results of length selection, length function and address selection, as well as the statement names and source references.
An address constant represents an address. This subset includes statement names, source references, and address selection results. An address constant in a complex memory reference must be followed by a pointer operator (->).

CSECT information

Information contained in the object structure list.

current call hierarchy

The current call hierarchy represents the status of subprogram nesting at the interrupt point. It ranges from the subprogram level at which the program was interrupted, to the hierarchically intermediate subprograms exited by means of CALL statements, to the main program.
The hierarchy is output using the %SDUMP %NEST command.

current CSECT

This is the CSECT in which the program was interrupted. Its name is output in the STOP message.

current program

The current program is the one which is loaded in the task in which the user enters AID commands.

current program segment

This is the program segment in which the program was interrupted. Its name is output in the STOP message.

dataname

This operand stands for all names assigned for data in the source program. *dataname* can be used to address variables, constants, structures, tables and structure/table items in symbolic debugging. Items in structures/tables can be referenced just like in the relevant programming language by means of an *identifier* or an *index*.

data type

In accordance with the data type declared in the source program, AID assigns one of the following AID storage types to each data item:

– binary string (≙ %X)

– character (≙ %C or %UTF16)

– numeric (not all data types treated numerically in the relevant programming languages correspond to a numeric storage type in AID; see the individual language-specific AID manuals [2]-[6]).

The allocated storage type determines how a data item is output by %DISPLAY, transferred/overwritten by %MOVE or %SET, and compared in the condition of a subcommand.

ESD/ESV

The External Symbol Dictionary (OMs) / External Symbols Vector (LLMs) lists the external references of a module. It is generated by the compiler and contains, among other things, information on CSECTs, DSECTs and COMMONs. The linkage editor accesses the ESD when creating the object structure list.

global settings

AID offers commands which serve to adapt the behavior of AID to particular user requirements, save input efforts and facilitate addressing. The global presettings made via these commands are valid throughout the debugging session. See %AID, %AINT, %BASE and %QUALIFY.

main program

In this manual main program is used as a collective term for the program (COBOL), the function (main in C++/C) or the external procedure (PL/I) which is started by the system when the program starts.

index

An index is part of the address operand. An index defines the position of a vector element. It may be specified in the same way as in the programming language or by means of an arithmetic expression from which AID calculates the value of the index.

input buffer

AID has an internal input buffer. If this buffer cannot accommodate a command input, the command is rejected with an error message indicating that the command is too long. The required operation must be divided between two commands to enable AID to execute it.

interrupt point

The address at which a program is interrupted is known as the interrupt point. The STOP message reports the address and the program segment where the interrupt point is located. The program is then continued there. For COBOL85 and FOR1 programs a different continuation address can be specified via %JUMP.

LIFO

Last In First Out principle. If statements from different inputs concur at a test point (%INSERT) or upon occurrence of an event (%ON) the statements entered last are processed first (see section “Chaining” on page 62).

localization information

%DISPLAY %HLLOC(memref) for the symbolic level and %DISPLAY %LOC(memref) for the machine code level can be used to output the static program nesting for a specified memory location.
Conversely, %SDUMP %NEST outputs the dynamic program nesting, i.e. the call hierarchy for the current interrupt point.

LSD

The List for Symbolic Debugging (LSD) stores the data/statement names defined in the module as well as the compiler-generated source references. The LSD records are created by the compiler and used by AID to retrieve the information required for symbolic addressing.

memory object

A memory object is constituted by a certain number of bytes in memory. At the program level, this comprises the program data (provided it has been assigned a memory area) and the program code. All registers, the program counter and all other areas which can only be referenced via keywords are likewise memory objects.
Any constants defined in the program, the statement labels, source references, address selection results, length selection/function and AID literals do not constitute memory objects, however, because they represent a value which cannot be changed.

memory reference

A memory reference addresses a memory object. There are two types of memory reference: simple and complex.
Simple memory references are virtual addresses, names whose address AID can fetch from the LSD information, and keywords. Statement names and source references are allowed as memory references in the AID commands %CONTROLn, %DISASSEMBLE, %INSERT, %JUMP, %REMOVE and %TRACE although they are merely address constants.

Complex memory references constitute instructions for AID indicating how to calculate the desired address and which type and length are to apply. The following operations may occur in a complex memory reference: byte offset, indirect addressing, type/length modification and address selection.

monitoring

%CONTROLn, %INSERT and %ON are monitoring commands. When a command or statement of the selected group (%CONTROLn) or the defined program address (%INSERT) is encountered in the program sequence or if the selected event occurs (%ON), program execution is interrupted and the specified subcommand is processed by AID.

name range

Comprises all the data names stored for a program segment in the LSD records.

object structure list

The linkage editor creates the object structure list on the basis of the External Symbol Dictionary (ESD) if the default setting SYMTEST=MAP applies or SYMTEST=ALL has been specified.

output type

Attribute of a memory object; defines how the memory contents are to be output by AID. Each storage type is assigned an output type. In chapter “Keywords” on page 121 the AID-specific storage types are listed with their respective output types. A similar assignment applies for the data types in the various programming languages. A type modification in %DISPLAY and %SDUMP causes the output type to be changed.

program segment

This is a general term for any program part which can be addressed by means of an area qualification. In the various programming languages a program segment is known under different designations, which are described in the language-specific AID manuals.

program state

AID makes a distinction between three program states which the program being tested may assume:

program state

AID makes a distinction between three program states which the program being tested may assume:

1. The program has stopped.
%STOP or actuation of the K2 key interrupts a program which is executing. The program is also interrupted if a %TRACE has been fully processed. The task is in command mode, i.e. the user may enter commands.

2. The program is running without tracing.
%RESUME starts or continues a program. %CONTINUE has the same effect; but if a %TRACE has not yet finished, issuing a %CONTINUE command will continue not only the program but also tracing.

3. The program is running with tracing.
%TRACE starts or continues a program. The program sequence is logged in accordance with the declarations in the %TRACE command. %CONTINUE has the same effect if a %TRACE is still active.

program unit

This is a term used in Fortran for that which is referred to as a compilation unit in other programming languages. A program unit can be addressed with the S qualification.

qualification

A qualification addresses a memory reference which is not in the AID work area or is outside the current main program or subprogram or is not unique therein. The base qualification specifies whether the memory reference is located in the loaded program or in a dump.
An area qualification specifies the program segment containing the memory reference.
If an operand qualification is found to be superfluous or contradictory it is ignored. This is the case, for example, if an area qualification is specified for a virtual address.

source reference

A source reference designates an executable statement. It is specified as S'number/name'.
Knumber/name k is generated by the compiler and stored in the LSD records.

statement name

A statement name is a name, assigned in a source program, via which an executable statement can be referenced in AID. Such names are labels or names of main programs or subprograms. An address constant containing the address of the first statement after the label or in the main program or subprogram is

stored in the LSD records for this purpose. To be more precise it is the address of the first instruction that was generated for the first executable statement after a label or in the main program or subprogram.

storage type

This is the data type that was either defined in the source program or selected via type modification. AID knows the storage types %X, %C, %E, %P, %D, %F, %A. See %SET and chapter “Addressing in AID” on page 67 and chapter “Keywords” on page 121.

subcommand

A subcommand is an operand of the monitoring commands %CONTROLn, %INSERT and %ON. A subcommand consists of a command section which may optionally be preceded by a name and a condition. The command section may consist of a single command or a command sequence and may contain both AID and BS2000 commands. Each subcommand has an execution counter. See chapter “Subcommand” on page 51 on how an execution condition is formulated, how a name and an execution counter are assigned and referenced, and which commands are not permitted within subcommands.
The command section of a subcommand is executed if the monitoring condition (*criterion*, *test-point*, *event*) of the corresponding command is satisfied and any execution condition defined in the subcommand has been met.

subprogram

In this manual subprogram is used as a collective term for functions (C D++ d/C, Fortran, COBOL), procedures (PL/I) or programs (COBOL) which are subordinate to the main program in the call hierarchy.

tracing

%TRACE is a tracing command. It defines which and how many commands or statements are to be logged. In the default case, program execution can be viewed on the screen.

update dialog

The %AID CHECK=ALL command initiates the update dialog, which takes effect when a %MOVE or %SET is executed. AID queries during the dialog whether updating of the memory contents really is to take place. If N is entered as a response, no modification is carried out; if Y is entered, AID performs the transfer.

user area

Area in virtual memory which is occupied by the loaded program with all its connected subsystems. Corresponds to the area represented by the keywords %CLASS6, %CLASS6ABOVE and %CLASS6BELOW.

Related publications

You will find the manuals on the internet at *http://manuals.ts.fujitsu.com*. You can order printed copies of those manuals which are displayed with an order number.

[1] **AID** (BS2000)
Debugging on Machine Code Level
User Guide

[2] **AID** (BS2000)
Advanced Interactive Debugger
Debugging of COBOL Programs
User Guide

[3] **AID** (BS2000)
Advanced Interactive Debugger
Debugging of FORTRAN Programs
User Guide

[4] **AID** (BS2000)
Advanced Interactive Debugger
Debugging under POSIX
User Guide

[5] **AID** (BS2000)
Advanced Interactive Debugger
Debugging of ASSEMBH Programs
User Guide

[6] **AID** (BS2000)
Debugging of C/C++ Programs
User Guide

[7] **AID** (BS2000)
Advanced Interactive Debugger
Ready Reference

[8] **BS2000 OSD/BC**
Commands
User Guide

[9] **BS2000 OSD/BC**
Introduction to System Administration
User Guide

[10] **BS2000 OSD/BC**
Executive Macros
User Guide

[11] **LMS** (BS2000)
SDF Format
User Guide

[12] **BINDER**
Binder in BS2000
User Guide

[13] **BLSSERV**
Dynamic Binder Loader / Starter in BS2000
User Guide

[14] **SDF** (BS2000)
SDF Dialog Interface
User Guide

[15] **XHCS**
8-Bit Code and Unicode Processing in BS2000
User Guide

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