File No. S360-33
GC28-6543-5

OS

IBM Systems Reference Library

IBM System/360 Operating System

Sort/Merge

Program Number 360S-SM-023

This publication describes the use of the IBM System/360 Operating System Sort/Merge Program. It discusses:

- Program capabilities.
- Sorting and merging techniques.
- Sort/merge program control statements.
- Intermediate storage requirements.
- Job control language requirements.
- Program initiation.
- Program modification.
- Efficient program use.
- Standard operating system collating sequence.
- Sort/merge program messages.

The program has generalized sorting and merging capabilities that can be tailored to the needs of a particular installation and application.

Sixth Edition (November 1968)

This is a major revision of, and obsoletes C28-6543-4 and Technical Newsletter N28-2323. This revision adds discussions of sequence distribution techniques in general, balanced direct access sequence distribution technique on the 2314, spanned records for sort input and output, blocked input on SYSIN, advanced checkpoint/restart, and standard System/360 Operating System collating sequence. A flow chart describing how to set up a simple sort or merge is also included. Other changes to the text, and small changes to illustrations, are indicated by a vertical line to the left of the change; changed or added illustrations are denoted by the symbol • to the left of the caption.

This edition applies to release 17 of the IBM System/360 Operating System, and to all subsequent releases until otherwise indicated in new editions or Technical Newsletters. Changes are continually being made to the specifications herein; before using this publication in connection with the operation of IBM systems, consult the latest IBM 360 SRL Newsletter, Form N20-0360, for the editions that are applicable and current.

Requests for copies of IBM publications should be made to your IBM representative or to the IBM branch office serving your locality.

A form is provided at the back of this publication for readers' comments. If the form has been removed, comments may be addressed to IBM Nordic Laboratory, Technical Communications, Vesslevagen 3, Lidingö, Sweden.

Preface

This publication is a guide for users of the System/360 Operating System Sort/Merge program. It contains a general description of the program and specific information about control statement formats, program operation, the inclusion of user-written routines, efficient use of the program, and program generated messages. Merging techniques used by the program are briefly described. General information about basic sorting and merging methods is contained in the IBM publication Sorting Techniques, Form C20-1639.

ORGANIZATION AND USE OF THIS PUBLICATION

If you want to set up a simple sort or merge quickly, fold out the chart in Appendix A at the back of the book and refer to Section 2 for details as you follow the chart. Eventually, however, you should plan to read the entire publication, which is organized as follows:

Section 1: Sort/Merge Program -- This section describes sorting and merging specifications, control fields, sorting and merging techniques used by the program, and error correction facilities.

Section 2: How to Use Sort/Merge -- This section is divided into four main topics: "Defining the Sort or Merge" which describes the format and use of sort/merge control statements and contains a number of complete sorting and merging examples; "Determining Intermediate Storage Requirements" which describes how to calculate the amount of intermediate storage for a given application; "Required Job Control Language Statements" which describes the JOB, EXEC, and DD statements necessary for sort/merge execution and contains a number of complete JCL and sort/merge statement examples; and "Invoking the Sort/Merge Program" which describes initiating sort/merge via the system input stream and via a macro instruction in another program.

Section 3: Program Modification -- This section describes sort/merge program exits and the requirements for user-written routines that use them. Users who do not include their own routines to modify records or handle errors during sort/merge program execution can skip this section.

Section 4: Efficient Program Use -- This section describes the factors that contribute to efficient use of the sort/merge program.

Appendixes -- These sections contain a flow chart summary of how to use the sort/merge program, a summary of considerations for MVT users, the standard operating system collating sequence, and sort/merge messages.

PREREQUISITE PUBLICATIONS

IBM System/360 Operating System:

Introduction, Form C28-6534

Concepts and Facilities, Form C28-6535

SUGGESTED READING

IBM System/360 Operating System:

Sort/Merge Timing Estimates, Form C28-6662 for information about sorting speeds with a variety of work devices, input data set sizes, main storage sizes, blocking factors, etc.

Supervisor and Data Management Services, Form C28-6646 for descriptions of linkage conventions, program and task management, data organization and access features, and the use of macro instructions.

Job control Language, Form C28-6539 for a thorough discussion of job control language statements.

Checkpoint/Restart Planning Guide, Form C28-6708.

The following additional publications are referred to in text:

IBM System/360 Operating System:

Linkage Editor, Form C28-6538

Storage Estimates, Form C28-6551

Supervisor and Data Management Macro Instructions, Form C28-6647

System Generation, Form C28-6554

Sort/Merge Control Statements

Intermediate Storage Assignment

JCL Statements

Examples

Initiating Sort/Merge

Modifying the Program

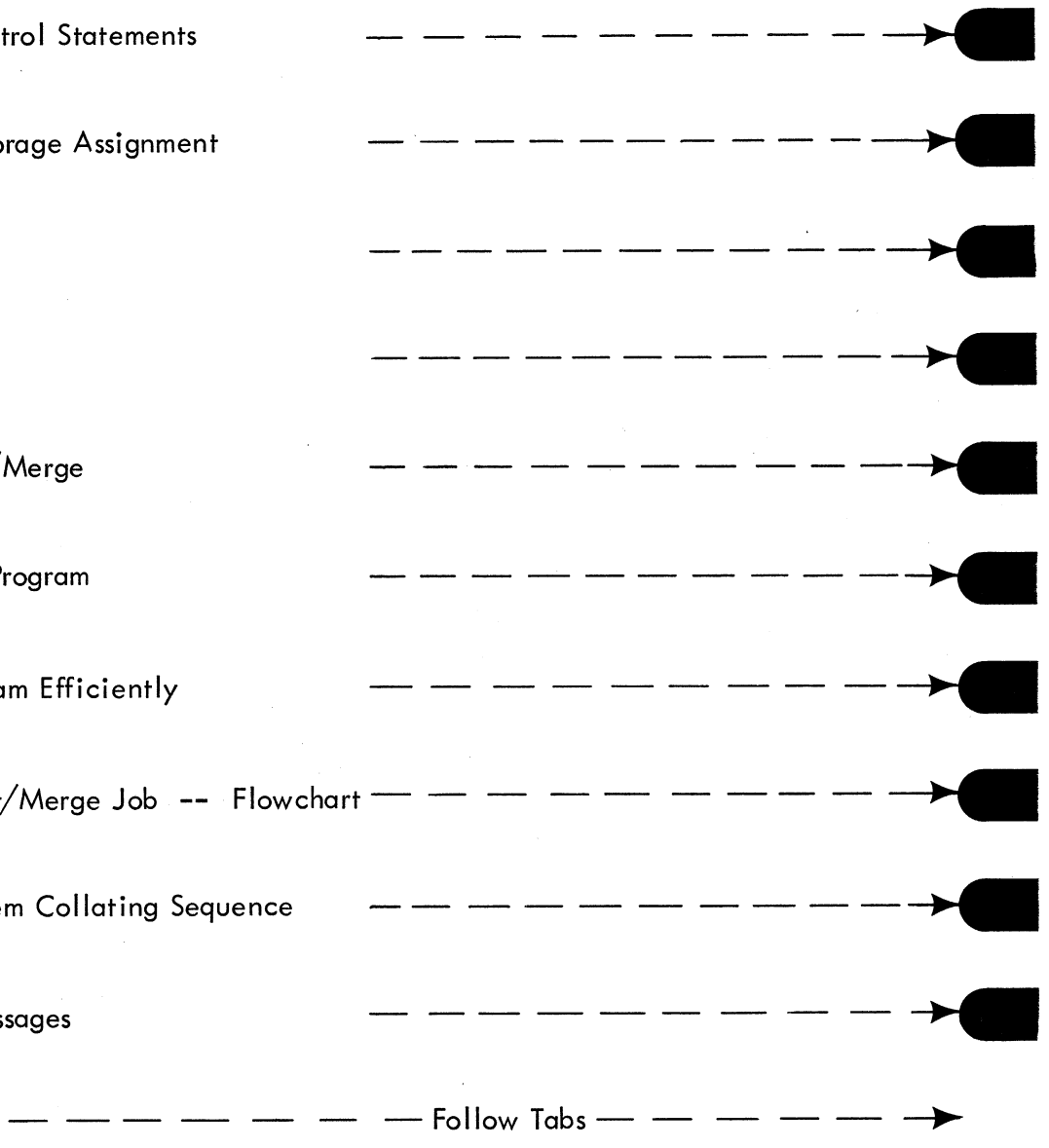
Using the Program Efficiently

Preparing a Sort/Merge Job -- Flowchart

Operating System Collating Sequence

Sort/Merge Messages

Follow Tabs



Contents

Illustrations

Figures

Tables

Introduction

This publication explains how to use the System/360 Operating System Sort/Merge Program to fulfill the sorting and merging requirements of System/360 installations that use magnetic tape and direct access input and output devices.

The sort/merge program can arrange data sets into a predesignated order. The program places the records of a data set in sequence according to the contents of a control word which is contained in each record. The program is generalized to perform a variety of sorts and merges. Because of this ability, the sort/merge program can simplify many data processing applications that require the sequential updating of previously created data sets.

Input to and output from the program can be any data set that consists of fixed-length or variable-length, blocked or unblocked records (except U format) and can be accessed by the queued sequential access method (QSAM). Any I/O device that operates with QSAM can be used for input and output.

The program uses sorting and merging techniques that take advantage of machine configurations and data set sizes. These techniques are designed to provide efficient operation for a great variety of sorts and merges. The technique used by sort/merge depends upon information supplied to the program through control statements which define the application to be performed. These statements can be supplied to the program in the operating system input stream or as parameters passed by another program.

User-written routines can operate in conjunction with the sort/merge program to perform many functions during sort/merge execution. The program gives control to user-written routines at various exits in the program. When they receive control, the routines can insert, summarize, delete, and alter the records being sorted or merged.

Relationship to the Operating System

The sort/merge program is part of the System/360 Operating System and operates under the supervisory control of the operating system control program. Sort/merge execution must be initiated according to operating system conventions, and any data sets used by the program must be defined according to operating system standards. At the user's option, the checkpoint and label checking (standard and nonstandard) facilities of the operating system can be used during a sort/merge program execution. Information about operating system label checking facilities can be found in the publication IBM System/360 Operating System: Supervisor and Data Management Services, Form C28-6646.

The sort/merge program also makes extensive use of the operating system data management facilities. All data sets necessary for program operation must be defined in data definition statements; these statements must be placed in the operating system input stream with the job step that initiates sort/merge execution. DD statements are described in the publication IBM System/360 Operating System: Job Control Language, Form C28-6539.

The sort/merge program can be tailored to the needs of a particular installation when the operating system for that installation is generated.

Minimum Machine Requirements

The sort/merge program requires:

- For main storage, a System/360 model that is large enough to use the operating system and provide at least 15,500 bytes of main storage for sort/merge execution. (Sort/merge uses 12,000 bytes; system functions use 3,500 bytes.)
- At least one selector channel or one multiplexor channel.
- For intermediate storage, at least one IBM 2311 Disk Storage Drive, or one IBM 2301 Drum Storage Drive, or one drive of an IBM 2314 Direct Access Storage Facility or three magnetic tape units.

MAIN STORAGE REQUIREMENTS

Sort/merge performance usually improves as the amount of main storage available to the program increases. Approximately 44K bytes of main storage are required for efficient operation. Refer to "Section 4: Efficient Program Use" for more information about main storage requirements.

Determining Region Size

Use the following formula to estimate the region size required when the sort/merge program is run under MVT:

Region size = 1.2(sort size) + 8K

Sort size is the amount of main storage assigned to the sort/merge program at system generation time. If the user overrides the SYSGEN value at execution time, then the overriding value is used for sort size. The constant 1.2 provides for space lost through fragmentation, and the additional 8K is used by the system.

If the formula yields a region size less than the minimum allowed, use the minimum. If calculated region size is not a multiple of 2K, round up to the nearest 2K multiple.

INTERMEDIATE STORAGE REQUIREMENTS

The amount of intermediate storage needed to perform sorting applications depends upon the size of the input data set. This storage may be allocated on either magnetic tape or direct access devices. The program needs at least three magnetic tape units or one direct access device for intermediate storage.

The amount of main storage available to the sort/merge program affects the size of records that the program can handle. Figure 1 shows the maximum record size that the program will accept for a given amount of main storage when fixed- or variable-length unspanned records are used. Figure 2 gives sizes for variable-length spanned records. (Spanned records, also referred to as VRE records, are records that can have fractional blocking factors such as one third, two and one half, etc. Thus a record may "span" blocks and/or direct access tracks.)

Figures 1 and 2 assume that the minimum number of intermediate storage data sets are assigned, and no control fields are to be extracted (placed in a work area and modified by user-written routines). Minimum record size is 18 bytes. Conditions such as control field extraction, or large numbers of intermediate storage data sets require additional main storage. Since a work area is used for VRE records, the available storage space for buffers and sorting is decreased and therefore, the maximum record lengths for VRE records are somewhat smaller than for unspanned records.

Main Storage Available to the Sort	Maximum Record Size for Input and Output Records				
	Intermediate Storage Device				
	Tape (Bytes)	IBM 2311 Disk (Bytes)	IBM 2301 Drum (Bytes)	IBM 2314 Facility (Bytes)	
				3 workareas	6 workareas
18K[1] (18,432)	1,100	1,300	1,300	1,300	---
44K (45,056)	5,500	3,600	6,600	6,600	3,500
100K (102,400)	14,900	3,600	18,000	7,272	7,272
200K (and up) (204,800)	32,000	3,600	20,458	7,272	7,272

[1]The value of K is 1,024 bytes.

• Figure 1. Estimated Maximum Record Sizes for Input and Output with Fixed-Length or Variable-length Records

Main Storage Available to the Sort	Maximum Record Size for Input and Output Records				
	Intermediate Storage Device				
	Tape (Bytes)	IBM 2311 Disk (Bytes)	IBM 2301 Drum (Bytes)	IBM 2314 Facility (Bytes)	
				3 Workareas	6 Workareas
18K[1] (18,423)	800	900	1,100	900	---
44K (45,056)	4,600	3,600	5,100	5,100	3,100
100K (102,400)	12,800	3,600	12,900	7,272	7,272
200K (and up) (204,800)	27,400	3,600	20,458	7,272	7,272

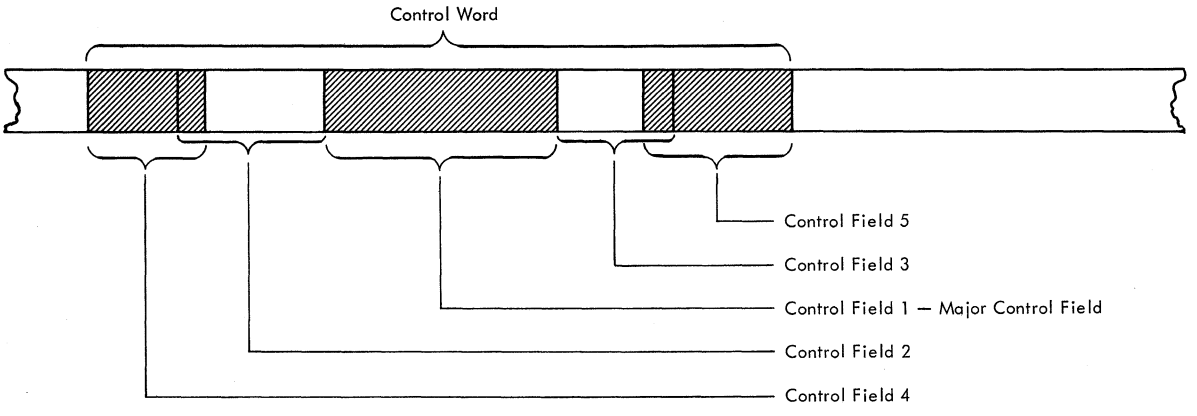
[1]The value of K is 1,024 bytes.

• Figure 2. Estimated Maximum Record Sizes for Input and Output with Variable-Length Spanned Records (VRE)

This section discusses control fields, sort and merge requirements, the sorting technique used by sort/merge, the sort/merge sequence distribution techniques, and error correction facilities.

Control Fields

Each record in a data set is sorted or merged on the basis of control information contained in the record's control word. A control word, which can be up to 256 bytes long, has from 1 to 64 control fields. Control fields can overlap; the end of one control field can share data with the beginning of another control field. Figure 3 shows a control word with five control fields.



• Figure 3. Control Word With Five Fields

Each control word, along with the record in which it appears, is sorted into either ascending or descending order, using standard IBM System/360 collating sequences.[1]

Nonstandard collating can be achieved without physically changing the control fields. A user-written routine can modify one or more of the control fields each time the sort/merge program collates a record. The modified control fields are used for collating purposes only; they do not replace the fields in the records. User-written routines can be entered at sort/merge program exits. (These exits and the requirements for user-written routines that use them are discussed in "Section 3: Program Modification.")

The maximum control field lengths for the various control field data formats accepted by the sort/merge program are:

- Character, fixed-point, or normalized floating point data -- 1 through 256 bytes.
- Packed or zoned decimal data -- 1 through 16 bytes.
- Binary data -- 1 bit through 256 bytes.

Control fields must be contained within the first 4,092 bytes of a record.

---

[1]The collating sequence for character data and binary data is absolute; that is, character and binary fields are not interpreted as having signs. (Refer to Appendix C: Collating Sequence.) For packed decimal, zoned decimal, fixed point, and normalized floating-point data, collating is algebraic; that is, each quantity is interpreted as having an algebraic sign.

Sort Requirements

Control fields for a sorting application are defined in a SORT control statement such as

```
SORT FIELDS=(10,30,A),FORMAT=CH
```

(described in "Defining the Sort or Merge" in Section 2). Input, output, and intermediate storage data sets are defined on standard job control language DD statements such as

```
//SORTOUT  DD  DSNAME=OUTPUT,UNIT=2400,DISP=(NEW,CATLG),                X
//             DCB=(RECFM=FB,LRECL=90,BLKSIZE=900)
```

(described in "Job Control Language for Sort/Merge" in Section 2).

INPUT: Sort input can be a blocked or unblocked sequential data set containing fixed- or variable-length records on any I/O device that can be used with QSAM.

OUTPUT: Output from the sort can be a blocked or unblocked sequential data set containing fixed- or variable-length records. The output device can be any device that can be used with QSAM. It need not be related in any way to the input device.

INTERMEDIATE STORAGE: All intermediate storage for a particular sort/merge application must be on the same type of device. Up to 32 tape units, 17 modules of a 2314 storage facility, six 2311 disk storage drives, or six 2301 drum storage devices can be used for intermediate storage. The amount of intermediate storage required is based primarily on the size of the input data set. The amount of main storage available to sort/merge is also a factor in determining intermediate storage requirements. Intermediate storage is discussed in greater detail and formulas for the amount of storage needed are given in "Determining Intermediate Storage Requirements" in Section 2.

USER MODIFICATIONS: User-written routines can summarize, insert, delete, shorten, lengthen, or otherwise alter records while they are being sorted. A detailed discussion of exits in the sort/merge program that permit control to be transferred to user-written routines is given in "Section 3: Program Modification."

INVOKING THE SORT: Execution of the sort is initiated by control statements in the operating system input stream, or by another program through the use of an ATTACH, LINK, or XCTL macro instruction.

Merge Requirements

Control fields for a merging application are defined in a MERGE control statement such as

```
MERGE  FIELDS=(10,30,A),FORMAT=CH
```

(described in "Defining the Sort or Merge" in Section 2). Input and output data sets are defined on standard job control language statements such as

```
//SORTIN01  DD DSNAME=MERGE1,VOLUME=SER=000111,DISP=CLD,                X
//             LABEL=(,NL),UNIT=2400,DCB=(RECFM=FB,                     X
//             LRECL=80,BLKSIZE=240)
```

(described in "Job Control Language for Sort/Merge" in Section 2).

INPUT: Input to the merge can be up to 16 blocked or unblocked sequential data sets containing fixed- or variable-length records. For a given application, all records must be of the same format (only blocking factors may differ). The records in the input data sets must be in proper sequence. The input devices must be acceptable for use with QSAM.

OUTPUT: Output from the merge can be a blocked or unblocked sequential data set containing fixed- or variable-length records. The output device must be acceptable for use with QSAM. It need not be related in any way to the input device type.

INTERMEDIATE STORAGE: Not needed for a merge-only operation.

USER MODIFICATION: The merge provides exits for user-written routines to summarize, insert, delete, lengthen, shorten, or otherwise alter output records. A detailed discussion of these exits and the requirements for routines that use them is given in "Section 3: Program Modification."

INVOKING THE MERGE: Execution of the merge can only be initiated by control statements in the operating system input stream.

Sorting Technique

The sort/merge program uses the replacement selection technique to sort records. Figure 4 shows in general how this technique works.

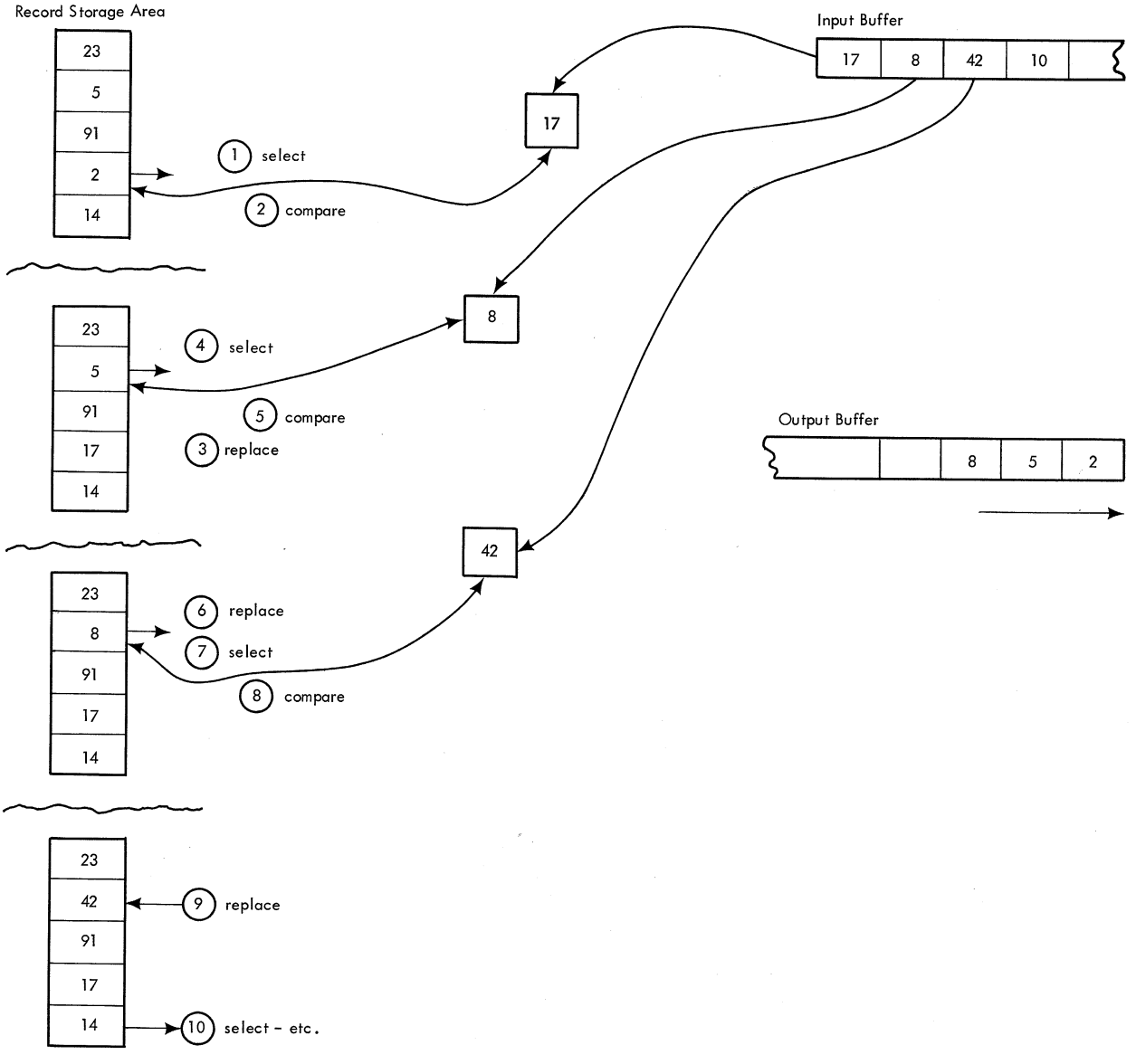


Figure 4. Replacement Selection Sorting Technique

The input data set is almost always too large to be brought into main storage and sorted all at once. Instead, it is broken up into sections. Each section is placed in sequence and stored on an intermediate storage device. The sorted sections of the input data set are called sequences.

Sequence Distribution Techniques

The sort/merge program selects one of five sequence distribution techniques based on information it has about a specific sorting application. The object of all five techniques is to enable the intermediate merge phase of the program to combine the many small sequences of records produced by the sort phase into a few longer sequences. The number of sequences must be reduced to the point where the final merge phase of the sort/merge program can combine them into a single sequence in one pass.

TAPE TECHNIQUES

If the intermediate storage medium is tape, the program chooses the balanced tape technique, the polyphase tape technique, or the oscillating tape technique.

DIRECT ACCESS TECHNIQUES

If the intermediate storage medium is direct access, the program chooses either the balanced direct access technique or the crisscross direct access technique.

Table 1 lists the basic requirements for the five sequence distribution techniques and their major advantages and disadvantages.

FORCING A TECHNIQUE

If you find that for a particular sort/merge application, the sort/merge program does not choose the most efficient technique, you can request sort to use another technique. The program will comply if you provide enough main storage and work areas to meet the technique's requirements (see Table 1). If the requirements cannot be met, sort will use another technique rather than terminate the program.

Caution: Be extremely cautious about forcing a technique. The sort/merge program attempts to choose the most efficient technique for a given application. If it is forced to use another technique, performance is usually not as efficient.

Refer to the discussion of the EXEC statement PARM field in "Job Control Language Statements for Sort/Merge" in Section 2 for information on how to force a sequence distribution technique.

• Table 1. Sequence Distribution Technique Requirements

Technique	Minimum Main Storage For Sort/ Merge	Maximum Input	Minimum Intermediate Storage Areas Required	Maximum Intermediate Storage Areas Permitted	Comments
Balanced Tape BALN	12,000 bytes	15 reels	2(x+1), where x is the number of input volumes	32 tape units	Always used if more than three intermediate storage tapes are available and input data set size is not specified or estimated.
Polyphase Tape POLY	12,000 bytes	1 reel	3 reels	17 tape units	Always used if only three intermediate storage tapes are available.
Oscillating Tape OSCL	21,000 bytes	15 reels	x+2 or 4, whichever is greater, where x is the number of input volumes	17 tape units	Input data set size must be given or closely estimated. The tape drive containing SORTIN, the input data set cannot be assigned as an intermediate storage unit.
Balanced Direct Access BALN	13,000 bytes	No fixed maximum, depends on available main storage and available intermediate storage	3 areas	6 areas	The only technique available for the 2301 and 2311. Always used on 2314 when less than six work areas are available. Used on 2314 when six areas are available unless CRCX is forced.
Crisscross Direct Access CRCX	24,000 bytes		6 areas	17 areas	Always used on 2314 when more than six work areas are available. Used on 2314 when six areas are available but must be forced. Not used on 2301 or 2311.

Error Correction Facilities

The sort/merge program provides exits where control can be transferred to user-written error routines. (Refer to "Section 3: Program Modification.") These routines may be able to correct:

- I/O errors that cannot be corrected by the operating system.
- Errors that arise because the input data set is larger than the intermediate storage capacity estimated by the program for a given application.

I/O ERRORS

The sort/merge program passes control to a user-written I/O error routine only when the operating system cannot correct the error condition. In the case of a permanent read error the user-written routine can accept the block as is, attempt to correct the error, skip the block, or request termination. For an uncorrectable write error, the user-written routine can perform any necessary abnormal end-of-task operations before the program is terminated.

If no user-written routines are supplied, the sort/merge program issues the message IER061A-I/O ERR xxx, where xxx represents the number of the unit on which the error occurred. Then the program terminates.

EXCEEDING INTERMEDIATE STORAGE CAPACITY

The sort/merge program estimates a maximum intermediate storage capacity (Nmax) from the information supplied to it at the beginning of the sorting operation.

You can supply an actual or an estimated input data set size to the program. (This is done via the SIZE parameter on a SORT control statement described in "Defining the Sort or Merge" in Section 2.) If you supply an actual data set size, and the size is larger than Nmax, the program terminates before starting to sort. If you supply an estimated data set size, or if you do not give a data set size, and the number of records processed while sorting reaches Nmax, the program gives control to a user-written Nmax routine, if one is supplied. The Nmax routine can take one of the following actions:

- Indicate to sort/merge that it should continue sorting the entire input data set with available intermediate storage. (If the estimated input data set size was high, there may be enough intermediate storage left to complete the application.)
- Direct sort/merge to continue sorting with only part of the input data set. (The remainder of the data set could be sorted later and the two results merged to complete the application.)
- Terminate the program without any further processing.

If an Nmax routine is not supplied, sort/merge continues to process records beyond Nmax. If the intermediate storage capacity is sufficient to contain all the records in the input data set, the sort completes normally; when intermediate storage is not sufficient, the program terminates.

The sort generates a separate message for each of the three possible error conditions. These messages are:

IER041A-N GT NMAX: Generated before sorting begins when the exact data set size supplied on a SORT control statement is greater than Nmax.

IER046A-SORT CAPACITY EXCEEDED: Generated when the sort has used all available intermediate storage while processing.

IER048I-NMAX EXCEEDED: Generated when the sort has exceeded Nmax and has transferred control to a user-written Nmax routine for further action.

(A full description of all program messages is contained in Appendix D.)

Section 2: How to Use the Sort/Merge Program

There are three basic things you must do to use the sort/merge program:

1. Define your sorting or merging job with sort/merge control statements. (See "Defining the Sort or Merge" in this section.)

2. If your job is a sort, determine the amount of intermediate storage your data will require while it is being sorted and merged. (See "Determining Intermediate Storage Requirements" in this section.)

3. Prepare job control language statements for the job and combine them in proper order with the sort/merge control statements. (See "Job Control Language for Sort/Merge" in this section.)

Defining the Sort or Merge

The sort/merge program must know what to do with your input data. The program needs a general description of the input data, information about the control fields in the input records, and a description of your modification routines, if any, that will be used during sort/merge execution. Sort/merge control statements supply this information to the program.

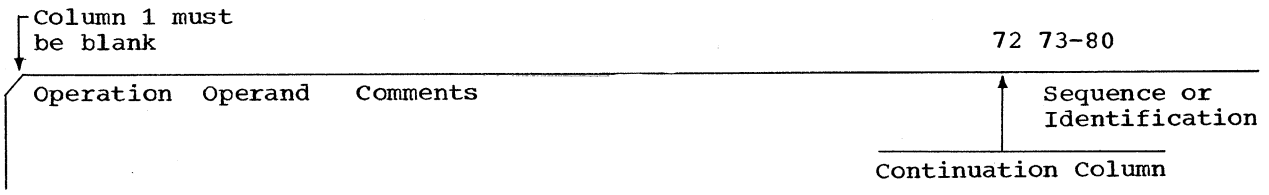
Control statement formats for all System/360 sort/merge programs are constant even though operating environments and data descriptions are different. Compatibility of control statements among System/360 sort/merge programs is discussed later in this section. The five control statements that are acted upon by the operating system sort/merge program are:

SORT Statement	Provides information about control fields and data set size. Use this statement if your job is a sort. Do not use this statement for a merge-only job.
MERGE Statement	Provides the same information as a SORT statement. Use this statement if your job is a merge. Do not use this statement for a sort operation.
RECORD Statement	Provides record length and type information. This statement is required only when your modification routines change record lengths during sort/merge execution.
MODS Statement	Associates your modification routines with particular sort/merge program exits. This statement is required only when you supply modification routines to be executed at sort/merge exits. ("Section 3: Program Modification," describes these exits and the requirements for routines that use them.)
END Statement	Signifies the end of a related group of sort/merge control statements. This statement is required when sort/merge statements are not followed immediately in the input stream by a /* statement.

Each statement is checked for validity before it is acted upon by the sort/merge program. If the program finds an error, it issues a diagnostic message. (See Appendix D for descriptions of messages.) However, the program may not be able to detect all errors or inconsistent combinations of entries so you should be very careful in preparing control statements.

CONTROL STATEMENT FORMAT

All sort/merge control statements have the same general format:



The control statements are free-form; that is, the operation definer, operand(s), and comments may appear anywhere in a statement, as long as they appear in the proper order, and are separated by one or more blank characters. Column 1 of each control statement must be blank.

Operation Field: This field must appear first on the card. It must not extend beyond column 71 of the first card. It contains a word (SORT, MERGE, RECORD, MODS, or END) that identifies the statement type to the sort/merge program. In Figure 5, the operation definer SORT is in the operation field of the sample control statement.

Operand Field: The operand field is made up of one or more operands separated by commas. This field must be the second field on the card and be separated from the operation field by at least one blank. If the statement occupies more than one card, this field must begin on the first card. Operands supply parameters to the sort/merge program. Each operand is made up of an operand definer, or keyword (a group of characters that identifies the operand type to the sort/merge program). A value or values may be associated with a keyword. The three possible operand formats are:

- keyword=(value$_1$,value$_2$,...,value$_n$)
- keyword=value
- keyword

Figure 5 contains an example of each of these formats.

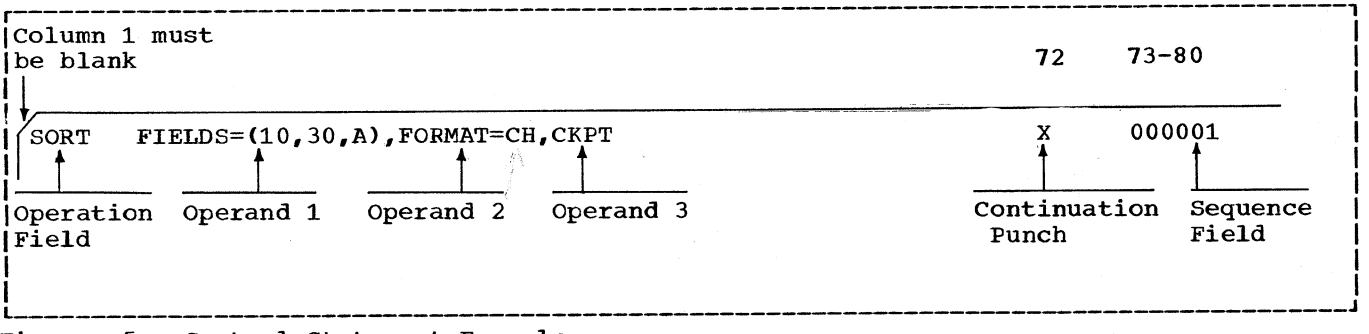


Figure 5. Control Statement Example

Comments Field: This field may contain any information you desire. It is not required, but if it is present, it must be separated from the operand field by at least one blank. Message IER009I appears for each statement containing comments.

Continuation Column (72): Any character other than a blank in this column indicates that the present statement is continued on the next card. In Figure 5 , X is used to specify that the next card contains more information pertaining to this SORT control statement.

Columns 73-80: This field may be used for any purpose you desire. It may be used for identification, or as shown in Figure 5, for sequencing.

Continuation Cards

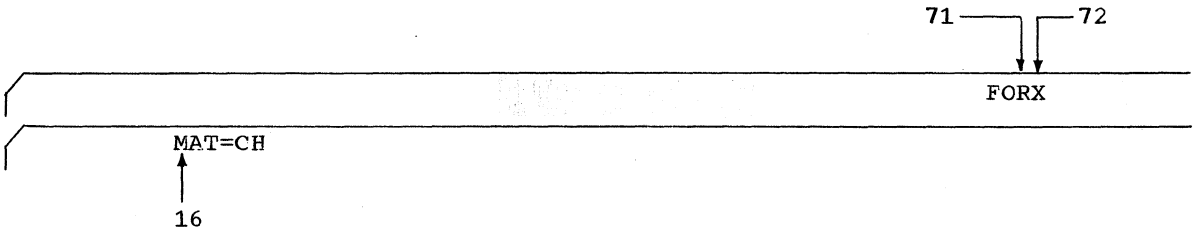
The format of the sort/merge continuation card is:

The continuation column and columns 73-80 of a continuation card fulfill the same purpose as they do on the first card of a control statement. Columns 1 through 15 of a continuation card must be blank. The maximum number of continuation cards allowed for each type of control statement is shown in the following table:

Control Statement Type	Maximum Number of Continuation Cards
SORT	19
MERGE	19
RECORD	5
MODS	19
END	none allowed

A continuation card is treated as a logical extension of the preceding card. Either an operand or a comments field may begin on one card and continue on the next. The following rules apply to continuing operands or comments fields:

- If an operand is continued through column 71, the next character of the operand must appear in column 16 of the continuation card. Columns 1-15 must be left blank. For example:



- If an operand field is broken between two cards without filling the first card through column 71, it must be done in either of two ways:

  1. At the end of a complete operand followed by a comma and a blank (or blanks). For example:

```
SORT  FIELDS=(10,30,A),                                        X
              FORMAT=CH,CKPT
```

  2. At the end of any of the values in an operand of the type keyword=($value_1$, $value_2$,...,$value_n$), followed by a comma and a blank. For example:

```
SORT  FIELDS=(10,                                              X
              30,A),FORMAT=CH,CKPT
```

The following rules apply to control statement preparation:

- Column 1 of each control statement must be blank.
- The operation field must be the first field on the first card of a control statement and may not be carried over onto a continuation card.
- The operand field, if present, must begin on the first card of a control statement. The last operand in a statement must be followed by at least one blank.
- Embedded blanks are not allowed in operands. Anything following a blank is considered part of the comments field.
- Values may contain no more than eight alphameric characters.
- Commas and blanks can be used only as field delimiters. They must not be used in values.
- Each type of sort/merge control statement may appear only once for each execution of the sort/merge program.
- No more than 33 control statement cards, including continuation cards, are allowed for a sort/merge program execution.

SORT CONTROL STATEMENT

The SORT control statement must be used when a sorting application is to be performed. It describes the control fields on which the program will sort.

The format of the SORT statement is shown in Figure 6. The first field in the statement must be the operation definer SORT, followed by at least one blank.

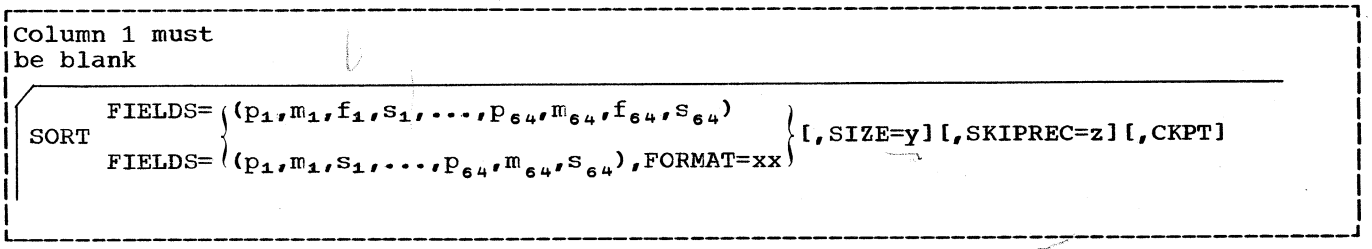


Figure 6. SORT Control Statement Format

Parameters

The FIELDS operand describes control fields. As shown in Figure 6, it can be written in two ways. Use the FIELDS format shown at the top of Figure 6 to describe control fields that contain different data formats. Use the format at the bottom of the figure to describe control fields that contain data of the same format. The format at the bottom of the figure is optional; you can always use the top format if you prefer.

The sort/merge program requires four facts about each control field in the input records: the position of the field within the record, the length of the field, the format of the data in the field, and the sequence into which the field is to be sorted. These facts are communicated to the program by the values of the FIELDS operand which are represented by p, m, f, and s in Figure 6.

The major control field, the one sort examines first, is specified first. Successive minor control fields are specified following the major control field. Up to 64 control fields can be used. In Figure 6, p_1,m_1,f_1,s_1 describe the major control field. $p_2,m_2,f_2,s_2,\ldots,p_{64},m_{64},f_{64},s_{64}$ describe the successive minor control fields.

p

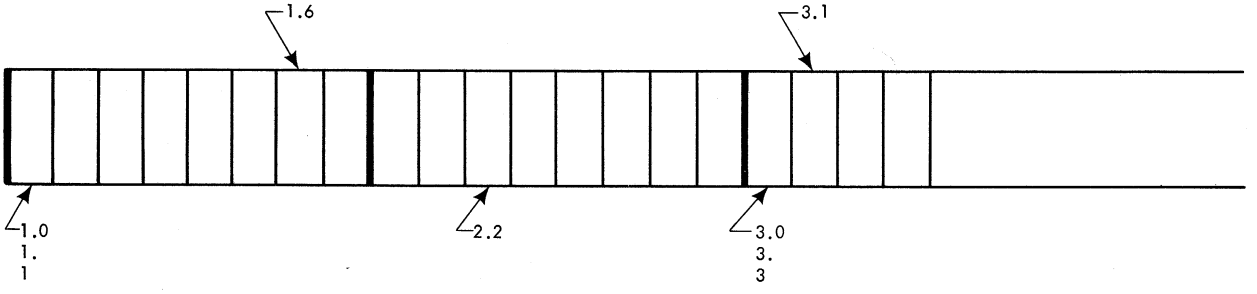
specifies the beginning (high-order location) of a control field relative to the beginning of the record which contains the control field. (For variable-length records, the logical record includes the four-byte record length indicator.) The first (high-order) byte in a record is byte 1, the second is byte 2, etc. All control fields, except binary, must begin on a byte boundary. Fields containing binary values are described in bytes and bits as follows:

First give the byte location relative to the beginning of the record and follow it with a period. Then give the bit location relative to the beginning of that byte. The resulting notation is then -- bytes.bits. The first (high-order) bit of a byte is bit 0; the remaining bits are numbered 1 through 7.

Thus, 1.0 represents the beginning of a record. A binary field beginning on the third bit of the third byte of a record is represented as 3.2. When the beginning of a field falls on a byte boundary, (say, for example, the fourth byte) you can write it in one of three ways:

```
4.0
4.
4
```

Other examples of this notation are:



m

specifies the length of the control field. All control fields except binary must be a whole number of bytes long. The length of a control field that is a whole number (d) bytes long can be expressed in one of three ways:

```
d.0
d.
d
```

Binary fields are expressed in the notation -- bytes.bits. The number of bits specified must not exceed 7. A control field two bits long would be represented as 0.2.

f

specifies the format of the data in the control field. f can be any one of the following two-character abbreviations:

```
CH -- Character
ZD -- Zoned decimal
PD -- Packed decimal
FI -- Fixed-point
BI -- Binary
FL -- Floating-point
```

If all the control fields contain the same type of data, you can omit the f parameters and use the optional FORMAT=xx operand.

The table below contains the data formats, indicates whether or not they are signed, and shows the maximum control field length for each format.

FORMAT	SIGNED	NUMBER OF BYTES
CH	NO	1-256
ZD	YES	1-16
PD	YES	1-16
FI	YES	1-256
BI	NO	1 bit - 256 bytes
FL	YES	1-256

s

specifies how the control field is to be ordered. One of the following one-character codes must be used for s:

A -- Ascending sequence
D -- Descending sequence
E -- User modification

If you are including your own routine to modify control fields before the sort/merge program sequences them, use E. After your program has modified the control fields, the sort/merge program orders the fields in absolute ascending sequence. (See "Exit E61", described in "Section 3: Program Modification," for further information about modifying control fields.)

Options

You can use the following optional operands with the SORT control statement.

FORMAT=xx: If all the control fields contain the same type of data, you can use this operand instead of the f parameter of the FIELDS operand to specify the data format. If all the control fields are not of the same type, you must use the f parameter of the FIELDS operand. The possible values for xx are the same as those for the f parameter.

SIZE=y: This operand specifies the number of records in the input data set. The value y can be either the actual data set size or an estimate of the size.

If you give an actual data set size, do not include any records inserted in the input data set by one of your routines. If the number of records in the input data set, as counted by the sort/merge program, does not agree with the value of the SIZE parameter, the sort terminates. The value specified in the SIZE parameter is placed in the IN field of message IER047A or IER054I. If you give an estimated data set size, precede the value by E (for example, E5000).

If you omit the SIZE operand, the sort/merge program assumes that:

- If intermediate storage is tape, the input data set can be contained on one volume at the blocking factor used by the sort.
- If intermediate storage is direct access, the input data set will fit into the space you have allocated.

SKIPREC=z: If you want the sort to skip a certain number of records before starting to process the input data set, use this operand. Substitute the number of records you want skipped for z. On a preceding sort/merge program execution you may have exceeded storage capacity and only part of your input data was sorted. (The program prints a message specifying the number of records sorted in a partial run.) Using this operand, you could request that sort skip over the records it processed in the preceding run and sort the remaining records. You could then merge the output from the two sort runs to complete the sort/merge operation.

If you were using a routine to insert or delete records in a run during which sort capacity was exceeded, you will have to provide a routine that will reposition the modified data set before the second part of the data set can be sorted.

CKPT: This operand tells the sort/merge program to activate the checkpoint facility of the operating system. The program takes checkpoints at the start of the sort phase and at the start of the final merge phase. In addition when the balanced or polyphase tape techniques are used, the program takes a checkpoint at the start of each intermediate merge phase pass. If the oscillating tape technique is used, the program takes checkpoints at intervals during the intermediate merge phase.

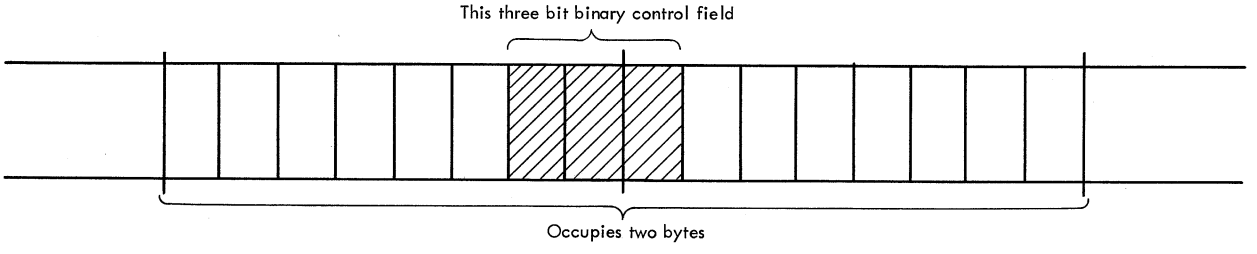
In addition to those taken at the beginning of each pass, the balanced direct access technique takes checkpoints at selected intervals during the intermediate merge phase.

You can have the program restart from the last checkpoint taken or from the checkpoint written at the start of the sort phase.

When you use the checkpoint/restart facility, you must define a data set for the checkpoint records. The data set is described further in this section under "Job Control Language for Sort/Merge".

The following rules apply to the control fields described on a SORT control statement:

- All control fields must be located within the first 4,092 bytes of a record.
- The first byte of a floating-point field is interpreted as a signed exponent. The rest of the field is interpreted as the fraction.
- All floating-point data must be normalized before the sort/merge program can collate it properly. You can use your own routine to do this at execution time. (See "Exit E61" in "Section 3: Program Modification.") Specify the E option for the value of s in the FIELDS operand for each control field you are going to modify.
- The total number of bytes occupied by all control fields must not exceed 256. A binary field is considered to occupy an entire byte if it occupies any part of it. For example, a binary field that begins on byte 2.6 and is 3 bits long occupies two bytes.



SORT Statement Examples

```
Column 1
must be blank

 SORT  FIELDS=(2.0,5.0,CH,A),SIZE=29483
```

SORT Statement Example 1. One Control Field and Size Option.

FIELDS operand
- 2.0 means that the control field begins on the second byte of each record in the input data set.
- 5.0 means the control field is five bytes long.
- CH means the control field contains character data.
- A instructs the program to sort the fields into ascending order.

SIZE operand
The input data set contains exactly 29,483 records.

```
Column 1 must                                          Column 72
be blank

 SORT FIELDS=(7.0,3.0,CH,D,1.0,5.0,FI,A,398.4,7.6,BI,D,99.0,230.2,BI,A,X

              Column 16
              ↓
              452.0,8.0,FL,A),SIZE=10693,CKPT
```

SORT Statement Example 2. Five Control Fields, Size and Checkpoint Options

FIELDS operand — The first four values describe the major control field. It begins on byte 7 of each record, is 3 bytes long, contains character data, and is to be sorted into descending sequence.
The next four values describe the second control field. It begins on byte 1, is 5 bytes long, contains fixed-point data, and is to be sorted into ascending sequence.
The third control field begins on bit 5 (bits are numbered 0 through 7) of byte 398. The field is 7 bytes and 6 bits long (occupies 9 bytes), and contains binary data to be placed in descending order.
The fourth control field begins on byte 99, is 230 bytes and 2 bits long, contains binary data, and should be sorted into ascending order.
The fifth control field begins on byte 452, is 8 bytes long, contains normalized floating-point data which is to be sorted into ascending order. If the data in this field was not normalized, you would specify E instead of A and include your own routine to normalize the field, before sort/merge examines them.

SIZE operand — The input data set contains exactly 10693 records.

CKPT operand — Instructs the sort/merge program to take checkpoints during this run.

```
Column 1 must
be blank

 SORT FIELDS=(3.0,8.0,ZD,E,40.0,6.0,CH,D),SIZE=E30000
```

SORT Example 3. Two Control Fields, User Modification, Size Option

FIELDS operand — The first four values describe the major control field. It begins on byte 3 of each record, is 8 bytes long, contains zoned decimal data that will be modified by your routine before sort examines the field.
The second field begins on byte 40, is 6 bytes long, contains character data and will be sorted into descending sequence.

SIZE operand — The input data set contains approximately 30,000 records.

```
Column 1 must
be blank

 SORT FIELDS=(25,4,A,48,8,A),FORMAT=ZD
```

SORT Statement Example 4. Two Control Fields, Format Option

FIELDS operand — The major control field begins on byte 25 of each record, is 4 bytes long, contains zoned decimal data (FORMAT=ZD), and is to be sorted into ascending sequence.
The second control field begins on byte 48, is 8 bytes long, has the same data format as the first field, and is also to be sorted into ascending order.
The FORMAT=xx option can be used because both control fields have the same data format. It would also be correct to write this SORT statement as follows:

```
Column 1 must
be blank

 SORT FIELDS=(25,4,ZD,A,48,8,ZD,A)
```

MERGE CONTROL STATEMENT

The MERGE control statement must be used when a merge-only operation is to be performed. It provides essentially the same information to the sort/merge program for a merge as the SORT statement does for a sort. As you can see from Figure 7, the format of the MERGE statement is very much like that of the SORT statement. There are the following differences:

- The operation definer is MERGE.
- The SKIPREC and CKPT options are not used.
- The value of the SIZE operand is the total number of records in all the input data sets.

```
Column 1 must
be blank

 MERGE {FIELDS=(p1,m1,f1,s1,p2,m2,f2,s2,...,p64,m64,f64,s64)} [,SIZE=y]
       {FIELDS=(p1,m1,s1,p2,m2,s2,...,p64,m64,s64),FORMAT=xx}
```

Figure 7. MERGE Control Statement Format

Parameters

The FIELDS operand is written exactly the same way for a merge as it is for a sort. The meanings of p, m, f, and s were described previously in the discussion of the SORT statement.

The SIZE operand is optional. Its value can be either exact or estimated. The value refers to the total number of records in all the input data sets to be merged.

MERGE Statement Examples

```
Column 1 must
be blank

 MERGE FIELDS=(2.0,5.0,CH,A),SIZE=29483
```

MERGE Statement Example 1. One Control Field, Size Option

FIELDS operand — The control field begins on byte 2 of each record in the input data sets. The field is 5 bytes long, and contains character data that has been presorted into ascending order.

SIZE operand — The input data sets contain exactly 29,483 records.

```
Column 1 must
be blank

 MERGE FIELDS=(3.0,8.0,ZD,E,40.0,6.0,CH,D),SIZE=E30000
```

MERGE Statement Example 2. Two Control Fields, User Modification, Size Estimate

FIELDS operand — The major control field begins on byte 3 of each record, is 8 bytes long, and contains zoned decimal data that will be modified by your routine before the merge examines it.

The second control field begins on byte 40, is 6 bytes long, and contains character data that is in descending order.

SIZE operand — The input data sets contain approximately 30,000 records.

```
Column 1 must
be blank

 MERGE FIELDS=(25,4,A,48,8,A),FORMAT=ZD
```

MERGE Statement Example 3. Two Control Fields, Format Option

FIELDS operand — The major control field begins on byte 25 of each record, is 4 bytes long, and contains zoned decimal data that has been placed in ascending sequence.
The second control field begins on byte 48, is 8 bytes long, is also in zoned decimal format, and is also in ascending sequence. The FORMAT=xx option can be used because both control fields have the same data format.

RECORD CONTROL STATEMENT

The RECORD statement is required only when your routines change record lengths during a sort/merge program run. The statement describes the format and lengths of the records being sorted or merged. The format of the RECORD statement is shown in Figure 8.

Parameters

The RECORD statement has two operands, TYPE and LENGTH. Both are required when the RECORD statement is used.

TYPE: The TYPE operand specifies whether the input records to sort/merge are fixed- or variable-length format.

TYPE=F indicates fixed-length records.
TYPE=V indicates variable-length records.

LENGTH: The LENGTH operand specifies the length in bytes of the input records, the length in bytes of the records that enter the sort phase of the sort/merge program, (you can include your own routine to change record lengths before the records are sorted), and the length in bytes of the records in the output data set. (You can change record lengths during the final merge phase of the program.)

The value l_1 is required whenever the RECORD statement is used. The values l_2 and l_3 are required only when your routines change record lengths before the sort or during the final merge. The values l_4 and l_5 are used only for variable-length records.

```
Column 1 must
be blank

 RECORD {TYPE=F,LENGTH=(l1,l2,l3)                }
        {TYPE=V,LENGTH=(L1,l2,l3,l4,l5)          }
```

Figure 8. RECORD Control Statement Format

Defining Fixed-Length Records

If your input records are fixed-length, use 1_1, 1_2, and 1_3 as follows:

1_1
is the length of each record in the input data set. If you use the RECORD control statement, you must include this value. The value should be the same as the value you specified in the LRECL subparameter of the DCB parameter on the SORTIN DD statement (discussed later in this section.) If the values are not the same, sort/merge uses the value specified on the DD statement.

1_2
is the length of each record handled by the sort phase. If you do not specify a value for 1_2, the program assumes that it is equal to 1_1. If you are going to change record lengths in the sort phase, you must include a value for 1_2. You do not need 1_2 for a merging application.

1_3
is the length of each record in the output data set. If you do not specify a value for 1_3, the program assumes that 1_3=1_2 for a sorting application and that 1_3=1_1 for a merging application. If your routines change record lengths during the final merge phase of the program, you must specify a value for 1_3. This value should be the same as the value you specified for the LRECL subparameter of the DCB parameter on the SORTOUT DD statement (discussed later in this section). If the values are different, the sort/merge program uses the value given on the DD statement.

Defining Variable-Length Records

If your input records are variable-length, use 1_1, 1_2, 1_3, 1_4, and 1_5 as follows:

1_1
is the maximum length of the records in the input data set. If you use the RECORD statement, you must specify a value for 1_1. The value should be the same as the value you specified in the LRECL subparameter of the DCB parameter on the SORTIN DD statement (discussed later in this section). If the values are not the same, the program uses the LRECL value.

1_2
is the maximum length of the records handled by the sort phase. If you do not specify a value for 1_2, the program assumes it is equal to 1_1. If you change record lengths in the sort phase, you must provide a value for 1_2. You do not need 1_2 for a merging application.

1_3
is the maximum length of each record in the output data set. If you do not specify a value for 1_3, the program assumes 1_3=1_2 for a sort and 1_3=1_1 for a merge. If you include a routine that changes record lengths in the final merge phase, you must specify a value for 1_3. The value should be the same as the value you provided for the LRECL subparameter of the DCB parameter on the SORTOUT DD statement. If it is not, the program uses the LRECL value.

1_4
is the minimum length of records in the input data set. If you do not specify a value for 1_4, the program assumes it is equal to the minimum record size necessary to contain the control fields defined on the SORT or MERGE control statement, or the minimum record length allowed by the operating system, whichever is greater. You need not specify this value for a merge.

1_5
is the record length that occurs most frequently in the input data set (modal length). You should use this value to help define a data set biased toward a particular length. If you do not specify a value for 1_5, the program assumes it is equal to the average of the maximum and minimum record lengths in the input data set. If, for example, your data set contains mostly small records

and just a few long records, the program would assume a high modal length and would allocate a larger record storage area than necessary. Conversely, if your data set contains just a few short records and many long records, the program would assume a low modal length and might not allocate a large enough record storage area to sort your data.

When you use the RECORD statement, consider the following:

- The lengths you specify for variable length records must include the 4-byte count field that the operating system places at the beginning of each record.
- When you use a direct access device for intermediate storage, record length cannot exceed the capacity of one track.
- The minimum record length of records in the input data set is 18 bytes.
- The record format you specify in the TYPE operand must be the same as the format you used in the RECFM subparameter of the DCB parameter on the SORTIN and SORTOUT DD statements (described later in this section.) If the formats are not the same, the program uses the one you specified in the DD statement.
- When you use an operand like the LENGTH operand of the type, keyword=(value$_1$, value$_2$,...,value$_n$), you can omit values that are equal to those assumed by the program. The following rules apply to omitting values from the LENGTH operand:

  1. You can drop values from right to left. If all the values after 1_2 are equal to the values assumed by the program, you could write -- LENGTH=(1_1,1_2).
  2. If you drop values from the middle or from left to right, you must use commas to indicate their omission. If 1_2 is equal to the value assumed by the program, you could write -- LENGTH=(1_1,,1_3).

RECORD Statement Examples

```
Column 1 must
be blank

 RECORD TYPE=F,LENGTH=(60,40,50)
```

RECORD Statement Example 1. Fixed-length, Three Length Values

TYPE operand — The input records are fixed-length.

LENGTH operand — The records in the input data set are each 60 bytes long. You change the records to 40 bytes in the sort phase and to 50 bytes in the final merge phase.

```
Column 1 must
be blank

 RECORD TYPE=V,LENGTH=(200,175,180,50,100)
```

RECORD Statement Example 2. Variable-length, Five Length Values

TYPE operand — The records in the input data set are variable-length.

LENGTH operand — The maximum length of the records in the input data set is 200 bytes. In the sort phase, you reduce the maximum record length to 175 bytes. You add five bytes to each record in the final merge phase, making the maximum record length in the output data set 180 bytes. The minimum record length in the input data set is 50 bytes and the most frequent record length in the input data set is 100 bytes.

```
Column 1 must
be blank
 RECORD TYPE=F,LENGTH=(76,,50)
```

RECORD Statement Example 3. Fixed-length, Two Length Values

TYPE operand — The records in the input data set are fixed-length.

LENGTH operand — The input records are 76 bytes long. You do not change record length in the sort phase so you omit 1_2 because sort/merge will assume the proper value for it. In the final merge phase, you change the record length to 50 bytes.

MODS CONTROL STATEMENT

The MODS statement is required only if you want the sort/merge program to transfer control to your routine(s) at various points during sort/merge execution. The statement associates your routines with specific exits in the sort/merge program and provides the program with basic descriptions of your routines. For details about exits in the sort/merge program and how to use them, refer to "Section 3: Program Modification."

Figure 9 shows the format of the MODS statement.

```
Column 1 must
be blank
 MODS exit=(n1,m1,s1[,{N}]),...,exit=(n17,m17,s17[,{N}])
                      {S}                          {S}
```

Figure 9. MODS Control Statement Format

Parameters

The sort/merge program provides seventeen exits at which control can be transferred to your routines. These exits are described in detail in "Section 3: Program Modification." The exits have three-character names such as E11, E15, E16, E28, etc. To use one of these exits, you substitute its three-character name for the word "exit" in the MODS statement format example. The values associated with the three-character name describe your routine. These values are:

n
: the name of your routine (member name if your routine is in a library). If your routine has been link edited previously and you do not want to have it link edited again, its name must be the same as the three-character exit name with which it is associated.

m

the number of bytes, exact or approximate, of main storage that your routine occupies.

s

either the name of the DD statement in your sort/merge job step that defines the partitioned data set in which your routine is located, or SYSIN if your routine is in the input stream. If your routines are in a concatenated data set the value of s for all the routines must be the ddname of the data set.

N
S

indicates the linkage editor requirements of your routine.

N means that your routine has already been link edited and can be used in the sort/merge run without further link editing.

S means that your routine requires link editing but that it can be link edited separately from the other routines you are using in a particular sort/merge program phase. Only routines at exits E11, E21, and E31 are eligible for separate link editing; see Section 3.

Absence of these parameters means that your routine must be link edited together with the other routines you are using in a particular sort/merge program phase.

Refer to the topic "Bypassing the Linkage Editor" in "Section 3: Program Modification" for details on how to design your routines.

When you are preparing your MODS statement, consider the following:

- The sort/merge program must know the amount of main storage your routine needs so that it can allocate main storage properly for its own use. If you do not know the exact number of bytes your program requires, make a slightly high estimate. The value of m in the MODS statement is written the same whether it is an exact figure or an estimate. In other words, you do not precede the value by E for an estimate as you did on the SORT or MERGE statement.
- If the routines you are using for a particular sort/merge run are in several system libraries, you need a DD statement for each library. DD statements required for sort/merge are described later in this section.
- If your routines are in the system input stream (SYSIN), you must arrange them in numerical order (the E11 routine before the E15 routine, etc.). If you use the same routine in several sort/merge program phases, you must provide a separate copy of the routine for each use.
- Your routines can also reside in private libraries. The use of private libraries is described in the publication IBM System/360 Operating System: Job Control Language, Form C28-6539.

MODS Statement Examples

```
Column 1 must
be blank

 MODS E15=(E15,554,MODLIB,N),E35=(E35,11032,MODLIB,N)
```

MODS Statement Example 1. Two Routines in a Library, No Link Editing

E15 At exit E15, the sort/merge program will transfer control to your routine. Your routine is in the library defined by the MODLIB DD statement. Its member name is E15, it is 554 bytes long, and has been link edited previously, and does not require further link editing.

E35 At exit E35, the program will transfer control to your routine. Your routine is in the library defined by the MODLIB DD statement, its member name is E35, it is 11032 bytes long and has been link edited previously.

```
Column 1 must
be blank

 MODS E17=(CLSE,348,SYSIN)
```

MODS Statement Example 2. One Routine in SYSIN, Link Editing is Needed

E17 At exit E17, the sort/merge program will transfer control to your routine which is named CLSE. Your routine is in object form in the system input stream and will be link edited together with other routines in the sort phase of the sort/merge program.

```
Column 1 must
be blank                                          Column 72 ——┐
                                                              ↓
 MODS E16=(NMAXERR,1000,MYLIB),E21=(E21,550,MODLIB,N),                X
                E31=(E31,450,MODLIB,N),E35=(SUMUP,5000,SYSIN)
```

MODS Statement Example 3. Four Routines

E16 The sort/merge program will transfer control to your routine at exit E16. Your routine is named NMAXERR, is located in the library defined by the MYLIB DD statement, and is approximately 1000 bytes long.

E21 At exit E21, the program will transfer control to your routine which resides in the library defined by the MODLIB DD statement under the member name E21. Your routine is 550 bytes long and does not require additional link editing.

E31 Another of your routines in the library defined by the MODLIB DD statement will gain control at exit E31. Its member name is E31, it is 450 bytes long and does not require additional link editing.

E35 You have placed a routine named SUMUP in object form in the input stream. It is approximately 5000 bytes long, must be link edited together with other routines in its phase, and will receive control at exit E35.

```
Column 1 must
be blank

 MODS   E11=(E11,500,MYLIB,S)
```

MODS Statement Example 4. One Routine, Separate Link Editing

E11 At exit E11 on the sort phase, the sort/merge program will transfer control to your routines. Your routine, named E11, is located in a library defined on a statement with the ddname MYLIB, is 500 bytes long, and can be link edited separately from other routines in the sort phase. After the sort phase is initialized, your E11 routine will be overlaid. Becuase you have specified S for separate link editing, your routine can have no external references.

END CONTROL STATEMENT

The END statement marks the end of all sort/merge control statements and continuation statements for a particular sort/merge run. The END statement must be used whenever the sort/merge control statements are not immediately followed in the input stream by a /* statement. For example, if you include you own routines in the input stream, they are placed between the sort/merge control statements and the /* statement, so you must use an END statement.

The format of the END statement is shown in Figure 10. The statement has no operands.

```
Column 1 must
be blank

 END
```

Figure 10. END Control Statement Format

CONTROL STATEMENT COMPATIBILITY

There are eight control statement types used by System/360 sort/merge programs. The System/360 Operating System sort/merge program acts upon the SORT, MERGE, RECORD, MODS, and END statements described above. The three remaining control statement types, INPFIL, OUTFIL, and OPTICN, are used only by other System/360 sort/merge programs. The operating system sort/merge program recognizes INPFIL, OUTFIL, and OPTION as valid control statements, but does not act upon them.

The information contained in INPFIL and OUTFIL statements is supplied to the operating system sort/merge program in DD statements. The information contained in the OPTION statement is specified at system generation time.

The operating system sort/merge program accepts SORT, MERGE, RECORD, and END statements used by other System/360 sort/merge programs. If these statements contain parameters not recognized by the operating system sort/merge program, the program ignores those parameters. However, because of differences in the way parameters are specified, the operating system sort/merge program will not accept MODS statements used by other System/360 sort/merge programs.

Summary of Sort/Merge Control Statements

```
SORT   { FIELDS = (p1, m1, f1, s1, p2, m2, f2, s2, . . ., p64, m64, f64, s64)          }
       { FIELDS = (p1, m1, s1, p2, m2, s2, . . ., p64, m64, s64), FORMAT = xx          }
                                                                  [, SIZE = y][, SKIPREC = z][, CKPT]
```

```
MERGE  { FIELDS = (p1, m1, f1, s1, p2, m2, f2, s2, . . ., p64, m64, f64, s64)          }
       { FIELDS = (p1, m1, s1, p2, m2, s2, . . ., p64, m64, s64), FORMAT = xx          }
                                                                  [, SIZE = y]
```

SORT and MERGE Statement Parameters

PARAMETER	EXPLANATION	LIMITATIONS	EXAMPLE	DEFAULT
p	Control field position within record.	All fields except binary must start on a byte boundary. No field may extend past byte 4092.	4.2 - a binary field starting on the 3rd bit of the 4th byte.	
m	Control field length.	Character 1 - 256 bytes Zoned Decimal 1 - 256 bytes Packed Decimal 1 - 16 bytes Fixed - Point 1 - 256 bytes Floating - Point 1 - 256 bytes Binary - 1 bit - 256 bytes	16 - a maximum length packed decimal field	
f	Control field data format.	Must be one of the following: CH, ZD, PD, FI, FL, or BI.	ZD - the code for a zoned decimal field	
s	Sequencing desired	Must be one of the following: A - ascending D - descending E - user modification then absolute ascending	E - exit E61 will modify the control field to achieve a unique sequencing.	
FORMAT = xx	Optional. Used when all control field data formats are the same.	XX must be CH, ZD, PD, FI, FL, or BI.	FORMAT = PD - all control fields are packed decimal.	
SIZE = y	Optional. The number of records in the input data set. May be an estimate.	If y is an estimate, precede value with the character E.	E40200 - an estimate of 40200 records.	
SKIPREC = z	Optional. Program will skip z records before sorting.	Not valid for a merge.	SKIPREC = 900 - the first 900 input records are ignored.	
CKPT	Optional. Checkpoints are taken.	Not valid for a merge.	CKPT	

END

The END statement must be used when user routines or data are in the input stream. The statement has no parameters.

RECORD TYPE = x, LENGTH = $\left(\ell_1, \ell_2, \ell_3, \ell_4, \ell_5\right)$

RECORD Statement Parameters

PARAMETER	EXPLANATION		LIMITATIONS	EXAMPLE	DEFAULT
TYPE =x	Tells program whether input records are fixed or variable length.		x must be F or V	TYPE = V - input is variable - length	
ℓ_1	Fixed: Input record length	Variable: Maximum input record length	ℓ_1 may not be less than 18 bytes See Figures 1 & 2 for maximum.	80 - fixed - length input records are 80 bytes, or maximum variable - length input record is 80.	
ℓ_2	Length of input to sort phase	Maximum record length of input to sort phase	ℓ_2 is not used for a merge.	60 - input to sort phase is 60, or a maximum of 60. User routine has modified original input record length.	$\ell_2 = \ell_1$
ℓ_3	Record length of output records	Maximum record length of output records.	If specified, must be same as LRECL for output, or else LRECL is used.	90 - output records are all 90 bytes or a maximum of 90.	$\ell_3 = \ell_2$ for a sort $\ell_3 = \ell_1$ for a merge
ℓ_4		Minimum input record length.	Not used for fixed - length records.	30 - minimum variable - length record is 30 bytes	ℓ_4 = sum of control field lengths, or 18 bytes, whichever is greater.
ℓ_5		Modal input record length	Not used for fixed - length records.	50 - in a variable-length input data set, 50 bytes is the most frequently occurring length.	$\ell_5 = \frac{\ell_1 + \ell_4}{2}$

MODS exit = $\left(n_1, m_1, s_1 \left[, \begin{Bmatrix} N \\ S \end{Bmatrix}\right]\right)$, . . . , exit = $\left(n_{17}, m_{17}, s_{17} \left[, \begin{Bmatrix} N \\ S \end{Bmatrix}\right]\right)$

MODS Statement Parameters

PARAMETER	EXPLANATION	LIMITATIONS	EXAMPLE	DEFAULT
exit = xx	The name of an exit to be activated.	Must be a valid exit name.	E28	
n	Name of the routine. Member name if routine is in a library.		CHANGE1	
m	Size, in bytes, of the routine.		514	
s	Location of the routine.	Either the ddname of data set containing routines, or SYSIN.	USERLIB - the routine is in a data set defined by the DD statement named USERLIB.	
N	Tells if no additional link editing or separate link editing is required.	Must be the character N or S.	N - no additional link editing is required.	If not used, assumes link editing together.

Sort/Merge Control Statement Examples

Following are a number of examples showing groups of sort/merge control statements. Each example shows all the sort/merge control statements that are necessary to accomplish a particular job. However, these control statements must be accompanied by job control language statements before the job can be run. Later in this section the JCL required for sort/merge execution is discussed. At the end of that discussion is a group of complete JCL and sort/merge control statement examples. The operands and values of the sort/merge control statements shown there are the same as the ones in these examples.

Example 1 - Simple Sort

This example shows a simple sorting application. No modification routines are included so neither the RECORD nor the MODS statement is required.

```
SORT FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000
END
```

SORT statement — The FIELDS operand describes two fields. The first begins on byte 1 of each record, is 6 bytes long, contains character data, and is to be sorted into ascending order. The second field begins on byte 28, is 5 bytes long, contains character data, and is to be sorted into descending order. The optional FORMAT operand is used because both fields contain data of the same format.

END statement — This statement is shown for completeness. It is not necessary since no modification routines which would come between the SORT statement and the /* statement are included.

Example 2 -- Simple Merge

This example shows a simple merge application. The values of the FIELDS operand are the same as those on the SORT statement in Example 1. No modification routines are included in this application.

```
MERGE FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000
END
```

Example 3 -- Sorting With Modification Routines

This example shows a more complicated sorting application. Modification routines are included, therefore a MODS statement is required. Some of the modification routines change record lengths during sort/merge program execution, therefore a RECORD statement is required.

```
SORT FIELDS=(3.0,8.0,ZD,E,40.0,6.0,CH,D),SIZE=E30000

RECORD TYPE=F,LENGTH=(120,100,80)

MODS E15=(E15,780,MODLIB,N),E16=(E16,1024,MODLIB,N),                X
            E35=(ADDUP,912,SYSIN),E61=(CHGE,1000,SYSIN)

END
```

SORT Statement — The FIELDS operand describes two control fields. The first will be changed by a modification routine (at exit E61, see the MODS statement) before sort/merge orders it into absolute ascending sequence. The second control field will not be modified and will be placed in descending sequence.

RECORD Statement The fixed-length records in the input data set are 120 bytes long. A modification routine (at exit E15) changes them to 100 bytes during the sort phase. A modification routine at exit E35) changes them again during the final merge phase (to 80 bytes each).

MODS Statement The statement describes four modification routines. The first two are in a library that is defined on the MODLIB DD statement with member names of E15 and E16 respectively. Neither routine requires additional link editing. The next two routines are in object form in the input stream. Their names are ADDUP and CHGE, respectively. They must be link edited together with other routines in their phases that require link editing.

END Statement This statement is required because of the modification routines in the input stream.

Example 4 - Merging With Modification Routines

This example is a merging application. Modification routines that change record lengths and control fields are included.

```
MERGE FIELDS=(1,6,CH,E),SIZE=8150
RECORD TYPE=V,LENGTH=(240,,200,,160)
MODS E35=(CALC,800,USERLIB),E61=(E61,450,MODLIB,N)
END
```

MERGE Statement The FIELDS operand describes one control field that will be modified (by the routine at exit E61) before it is examined by the merge. The exact size of the input data sets is given.

RECORD Statement All the records in the input data sets are variable-length. The maximum record length in the input data sets is 240. A modification routine (at exit E35) shortens all records by 40 bytes making the maximum record length in the output data set 200 bytes. The most frequent record length in the input data set is 160 bytes.

MODS Statement A routine named CALC receives control at exit E35. CALC is approximately 800 bytes long, resides in the library defined on the USERLIB DD statement and must be link edited together with other routines in its phase which require link editing. At exit E61, the sort/merge program transfers control to a routine from the library defined by the MODLIB DD statement. The member name of this routine is E61. This routine is 450 bytes long and does not need further link editing.

END Statement The END statement is not required because there are no modification routines in the input stream, but it is shown here for completeness.

Example 5 - Sort

This example shows a one-field sort with fixed-length records whose length is changed during the course of sort/merge execution by a routine at exit E35.

```
SORT FIELDS=(10,5,CH,A),SIZE=10000

RECORD TYPE=F,LENGTH=(80,,50)

MODS E35=(E35,534,SYSIN)

END
```

SORT Statement — The FIELDS operand describes one control field that begins on byte 10 of each record, is 5 bytes long, contains character data, and is to be sorted into ascending order. The optional SIZE operand indicates that there are exactly 10,000 records in the input data set.

RECORD Statement — This statement indicates that the input data set contains 80-byte fixed-length records and that the records will be shortened to 50 bytes each as they leave the final merge.

MODS Statement — The statement describes a modification routine that will receive control at sort/merge program exit E35. The name of the routine is E35, it is 534 bytes long, appears in object form in SYSIN, and must be link edited together with other routines in its phase which require link editing.

END Statement — This statement is required because the sort/merge control statements are not followed immediately by a /* statement. (The E35 object deck follows the END statement in the input stream.)

Example 6 - Sort

This example shows a one-field sort with variable-length records. Modification routines receive control at exits E11 and E16.

```
SORT FIELDS=(20,5,CH,A),SIZE=E25500

RECORD TYPE=V,LENGTH=(120,,,60,80)

MODS E11=(E11,500,USERLIB,S),E16=(E16,554,USERLIB,N)

END
```

SORT Statement — The FIELDS operand describes one control field that begins on byte 20 of each record, is 5 bytes long, contains character data, and is to be sorted into ascending order. The optional SIZE operand indicates that there are approximately 25,500 records in the input data set.

RECORD Statement — This statement indicates that the input data set contains variable-length records with a maximum record length of 120 bytes, a minimum record length of 60 bytes and a modal (most frequent) length of 80 bytes. The RECORD statement is not required for this example, but without it, sort/merge would assume a minimum record length of 24 bytes (large enough to contain the specified control field) and a modal length of 72 bytes (the average of maximum and minimum lengths).

MODS Statement — The statement describes two modification routines. One will receive control at exit E11. It is named E11, is 500 bytes long and can be link edited separately. (See "Bypassing the Linkage Editor" in "Section 3: Program Modification," for a description of the requirements for separate link editing.) The E11 routine

is in a library described on a DD statement with the ddname USERLIB. The other modification routine, named E16 will receive control at exit E16. The routine is 554 bytes long and the library in which it resides is described on the DD statement USERLIB. The E16 routine has been link edited previously and does not require further link editing prior to its use in this application.

END statement — This statement is not required in this example. It is shown for completeness only.

Example 7 - Sort

This example shows a two-field sort. A modification routine at E35 places part of the output data set on a device other than SORTOUT.

```
SORT FIELDS=(1,10,CH,A,11,6,PD,D),SIZE=E15000

MODS E35=(SUBSET,1024,SYSIN)

END
```

SORT Statement — The FIELDS operand describes two control fields. The first is a 10-byte field beginning on byte 1. It contains character data which is to be sorted into ascending order. The second is a 6-byte field which begins on byte 11 and contains packed decimal data to be placed in descending order. The input data set contains approximately 15,000 records.

MODS Statement — A routine named SUBSET will receive control at sort/merge exit E35. The routine is 1024 bytes long, must be link edited together with other routines in the final merge phase of the program, and will appear in object form in SYSIN.

END Statement — This statement is required for this example because the SUBSET routine will appear in the input stream between the sort/merge control statements and the /* statement.

Determining Intermediate Storage Requirements

If you are performing a sorting application, you must calculate the amount of intermediate storage the sort/merge program needs to sort your data. The basic factors to consider are the type of device on which you assign intermediate storage and the number of records in your input data set. Another factor which must sometimes be weighed is the amount of main storage assigned to the sort/merge program. In general, the less main storage sort/merge has to operate in, the more intermediate storage it needs to complete a sorting application.

INTERMEDIATE STORAGE DEVICES

You can assign intermediate storage either on magnetic tape or direct access devices, but not on a mixture of both.

IBM 2400 Series Magnetic Tape Units can be used for intermediate storage. The sort/merge program can operate with a mixture of 7-track and 9-track tapes. If the sort input data set is on 7-track tape, you can use any combination of 7-track and 9-track tapes for intermediate storage and output, or intermediate storage and output can be on 2311 disks, 2314 storage facilities, or 2301 drums. However, if 7-track tape is not used for input, it cannot be used for intermediate storage or output. When 7-track tape is used for intermediate storage, variable length records cannot be handled.

If you assign 7-track tapes for input, you can use the data converter. If you assign 7-track tape for intermediate storage, you cannot use the data converter, nor can you use the translation feature for anything but character data.

If you use direct access devices for intermediate storage, use only one type of direct access device as intermediate storage for a given sorting application. The types of direct access devices available for intermediate storage are:

- IBM 2311 Disk Storage Drive.
- IBM 2301 Drum Storage Drive.
- IBM 2314 Direct Access Storage Facility.

INTERMEDIATE STORAGE SPACE REQUIREMENTS

Use the following formulas to calculate the amount of intermediate storage necessary for a given sorting application, device type, and sequence distribution technique. Unless you force a sequence distribution technique, you do not know which one sort will use. This causes no difficulty, however. The amount of intermediate storage you assign may affect the sort/merge program's choice of a technique. In other words, you may implicitly rule out one technique by not providing enough intermediate storage for its use. To avoid this possibility, calculate the intermediate storage required by all the techniques and provide the largest amount needed.

Tape Intermediate Storage

If you use tape for intermediate storage, the following formulas give the number of tapes needed to complete a tape sort for a given data set size and sequence distribution technique:

Formula 1 n = 2(x+1) -- balanced tape technique -- maximum input is 15 reels.

Formula 2 n = x+2 -- oscillating tape technique -- maximum input is 15 reels.

Formula 3 n = 3 reels -- polyphase tape technique -- maximum input is 1 reel.

The x represents the number of volumes required to contain the input data set with a blocking factor equal to that used for intermediate storage by the sort/merge program. For an approximate sort blocking figure refer to the publication IBM System/360 Operating System: Sort/Merge Timing Estimates, Form C28-6662, under your particular configuration and record length.

The maximum number of tape units that can be used for intermediate storage are:

32 for the balanced technique.

17 for the oscillating technique.

17 for the polyphase technique.

These maximums permit the sorting of 15 reels of input with the balanced and oscillating techniques. The polyphase technique allows only one reel of input.

2311, 2301, and 2314 (Balanced Technique) Intermediate Storage

Use the following formula to calculate the approximate number of tracks (T) required to complete a direct access sort for a given data set size when intermediate storage is on 2311 or 2314 disk or 2301 drum. If the data set tends to be ordered in reverse of the sequence you want the output to be in, more intermediate storage may be necessary. Conversely, if the input data set tends to be ordered in the desired sequence, less intermediate storage is necessary.

Formula 4 $$T = \frac{S(N)}{k(N-1)} + 2N$$

where:

N is the number of intermediate storage areas. You must have at least three, but no more than six.

S is the number of records in the input data set, exact or approximate.

$$k = \frac{B}{L}$$

where:

B is 3,400 for the 2311
18,000 for the 2301
7,000 for the 2314

L is the length in bytes of each record in the input data set. For variable-length records, L is the maximum length.

Only the integer portion of k is used for calculating T. Disregard the remainder, whatever its value. If the formula yields k = 0, use the value 1.

You must make at least three intermediate storage areas available to the sort and define each as a separate data set. Assign at least three tracks to the smallest area (five for the 2314). All tracks in an area must be contiguous. You can use up to six areas. Divide the number of tracks (T) among the areas you select. The formula is based on areas of equal size. More tracks will be needed if T is not divided equally.

Intermediate Storage Assignment Example

Determine T for 2301 using 4 intermediate storage data sets, variable-length records; maximum length 120, estimated input data set size 25500 records.

$$T = \frac{25500(4)}{\frac{18000(3)}{120}} + 8 = \frac{102008}{450} = 227$$

Divide T among the 4 data sets: 57, 57, 57, 56.

If the sort/merge program has less than 44K bytes of main storage to execute in, you may have to increase the value of T. If sort/merge has 12K bytes of main storage, you should increase T by about 50%. If main storage is between 12K and 44K, the percentage of increase is correspondingly less.

For information on assigning intermediate storage for efficient program operation, refer to "Section 4: Efficient Program Use."

2314 (Crisscross Technique) Intermediate Storage

Use the following formula to calculate the approximate total number of tracks (T) required to complete a sort when intermediate storage is on a 2314 and the crisscross sequence distribution technique is used:

Formula 5 $$T = \frac{1.25S}{k}$$

where:

S is the number of records in the input data set, either actual or approximate.

$$k = \frac{B}{L}$$

where:

B is 7,000

L is the number of bytes in each record in the input data set.

For variable-length records, L is the maximum record length. Use only the integer portion of k. Disregard the remainder, whatever its value. If the formula yields k=0, use the value 1.

When the input data set is on 2314, and you know how much space it occupies, you do not need to use the above formula to determine intermediate storage space. Assign intermediate storage space that is at least 25% larger than the space occupied by the input data set.

If the data set tends to be ordered in reverse of the desired output sequence, more intermediate storage space is necessary. Conversely, if the data set tends to be ordered in the desired sequence, less space is required. Also, if the sort/merge program is assigned less than 44K bytes of main storage in which to execute, you may have to increase the value of T. If sort/merge has 24K bytes of main storage, you should increase T by about 50%. If main storage is between 24K and 44K, the percentage of increase is correspondingly less.

The sort/merge program requires a minimum of six 2314 areas when the crisscross technique is used and permits a maximum of 17. (When the balanced technique is used, the minimum number of 2314 areas is three.) Each area must contain at least five tracks. All tracks in an area must be contiguous.

Efficient assignment of 2314 space is discussed in "Section 4: Efficient Program Use."

Intermediate Storage Assignment Formulas—Summary

Device Types for Intermediate Storage

INPUT	INTERMEDIATE STORAGE
7-track tape	7- and/or 9-track tape or 2311 disk or 2301 drum or 2314 facility
Any device but 7-track tape	9-track tape or 2311 disk or 2301 drum or 2314 facility

NUMBER OF TAPES REQUIRED FOR INTERMEDIATE STORAGE (N)

Formula 1 $n = 2(x+1)$ -- for the balanced technique, maximum n=32, maximum input 15 reels.
Formula 2 $n = x+2$ -- for the oscillating technique, maximum n=17, maximum input 15 reels.
Formula 3 $n = 3$ -- for the polyphase technique, maximum n=17, maximum input 1 reel.

where:

x is the number of tapes that would be required to contain the input data set at sort blocking.

TOTAL NUMBER OF TRACKS REQUIRED FOR DIRECT ACCESS INTERMEDIATE STORAGE

Formula for 2301, 2311 and 2314 with balanced technique

Formula 4 $T = \frac{S(N)}{k(N-1)} + 2N$

Formula for 2314 with crisscross technique

Formula 5 $T = \frac{1.25S}{k}$

where:

N is the number of intermediate storage areas
$3 \leq N \leq 6$ for 2311, 2301 and 2314 with the balanced technique
$6 \leq N \leq 17$ for 2314 with crisscross technique

S is the number of input records

$k = \frac{B}{L}$

B is 3,400 for the 2311
18,000 for the 2301
7,000 for the 2314
L is the input record length (maximum length for variable-length records)

Note: Use only the integer portion of k. Never round upwards. If k = 0, use 1.

Job Control Language for Sort/Merge

When the sort/merge program is initiated via the system input stream, it requires a JOB statement, an EXEC statement, and DD statements.

JOB STATEMENT

The JOB statement for a sort/merge job is a standard System/360 Operating System JOB statement.

```
//jobname  JOB  accounting info,programmer name, etc.
```

EXEC STATEMENT

The EXEC statement identifies either a sort/merge cataloged procedure or the sort/merge program. The statement

```
//stepname  EXEC  { PGM=SORT     }  [ ,PARM=optional parameters ]
                  { PGM=IERRCO00 }  [       discussed later    ]
```

identifies the sort/merge program. The statement

```
//stepname  EXEC  { PROC=SORT  }
                  { PROC=SORTD }  [ , PARM=optional parameters discussed ]
                  { SORT       }  [       later                         ]
                  { SORTD      }
```

identifies a sort/merge cataloged procedure. The procedures, SORT and SORTD are shown later in this section under "Initiating Sort/Merge." The PROC= notation merely serves as a reminder that a cataloged procedure is being used.

PARM Field Options

```
PARM= [ { BALN } ] [ ,CORE=xxxxxx an optional main storage value ] [ ,MSG={ NO } ]
      [ { OSCL } ]                                                 [       { CC } ]
      [ { POLY } ]                                                 [       { CP } ]
      [ { CRCX } ]                                                 [       { AC } ]
                                                                   [       { AP } ]
```

The first PARM field option specifies a sequence distribution technique to be used by the sort/merge program. If the intermediate storage medium is tape, BALN means use the balanced tape technique, OSCL means use the oscillating tape technique, and POLY means use the polyphase tape technique. If the intermediate storage medium is on a 2314 storage facility, BALN means use the balanced direct access technique, CRCX means use the crisscross direct access technique.

Note: You cannot choose a sequence distribution technique if intermediate storage is on 2311 or 2301; sort/merge always uses the balanced technique. There are certain restrictions on your choice of a technique for the 2314:

- If less than six work areas are provided, the sort/merge program always uses the balanced technique.
- If more than six work areas are provided, the program uses the crisscross technique.
- If exactly six work areas are provided, the program uses the balanced technique unless CRCX is specified in the PARM field.

You should be extremely cautious when forcing the sort/merge program to use a specific technique. The program tries to select the most efficient technique for a given application. If it is forced to use another, performance may not be as efficient. Refer to Table 1 in Section 1 for information about the requirements of the sequence distribution techniques.

The second PARM field option is an optional main storage value which will temporarily override the sort/merge storage allocation set up at system generation time. Refer to "Altering the Main Storage Allocation" in Section 4.

You can use the third PARM field option to temporarily override the message option specified at system generation time. The option is requested by MSG=xx. Valid entries for xx are:

- NO - no messages are printed.
- CC - critical messages only are printed. They appear on the system console.
- CP - critical messages only are printed. They appear on the printer.
- AC - all messages are printed. They appear on the system console.
- AP - all messages are printed. They appear on the printer.

DD STATEMENTS

If you do not use a sort/merge cataloged procedure to invoke the sort/merge program, you must include system DD statements in the input stream. These are the DD statements that would be contained in the cataloged procedure. They are:

//SYSPRINT	DD	used by the linkage editor. Include this statement when your routines that require link editing are included in the application.
//SYSLMOD	DD	defines a data set that contains output from the linkage editor. Include this statement when your routines that need link editing are included in the application.
//SYSUT1	DD	used as a work area by the linkage editor. Use this statement when your routines that must be link edited are included.
//SYSLIN	DD	defines a data set that contains input to the linkage editor. Use this statement when your routines that require link editing are included.
//SORTLIB	DD	defines a data set that contains load modules for the sort/merge program. Always include this statement.
//SYSOUT	DD	used as the system output data set. Always use this statement.

The following DD statements are required whether sort is initiated directly or through a cataloged procedure:

//SORTIN	DD	defines the input data set for a sorting application. Not required for a merge-only application.

//SORTIN01
---------- 	
---------- 	
//SORTIN16
	DD	define the input data sets for a merging application. Not required for a sorting application.

//SORTWK01
---------- 	
---------- 	
//SORTWK32
	DD	define intermediate storage data sets for a sorting application. Not required for a merging application.

//SORTOUT	DD	defines the output data set for sorting and merging applications.
//SORTMODS	DD	defines a temporary partitioned data set large enough to contain all of your modification routines that appear in the input stream for a given application. If your routines are not in the input stream, this statement is not required. If your routines are on libraries, DD statements defining the libraries must be included.
//SORTCKPT	DD	defines a data set for checkpoint records. If you are not using the checkpoint facility this statement is not required.

REQUIRED DD STATEMENT PARAMETERS

The sort/merge program requires that certain parameters be included in the DD statements described above. These parameters, the conditions under which they are required, a summary of the information contained in them, and the value assumed (default) if the parameter is not included are shown in Table 2. The parameters and subparameters which are not required are not discussed

• Table 2. Summary of DD Statement Parameters Required by the Sort/Merge Program

PARAMETER	CONDITION UNDER WHICH REQUIRED	SUMMARY OF PARAMETER VALUE	DEFAULT VALUE
DSNAME	When the DD statement defines a labeled input data set (e.g., SORTIN), or when the data set being created is to be kept or cataloged (e.g., SORTOUT), or passed to another step.	Specifies the fully qualified name or the temporary name of the data set.	The system assigns a unique name.
DCB	When tape is used for the input or output data set, or when 7-track tape is used for intermediate storage.	Specifies information used to fill the data control block (DCB) associated with the data set.	----
UNIT	When the input data set is neither cataloged nor passed, or when the data set is being created.	Specifies (symbolically or actually) the type and quantity of I/O units required by the data set.	----
SPACE	When the DD statement defines a new direct access data set.	Specifies the amount of space needed to contain the data set.	----
VOLUME	When the input data set is neither cataloged nor passed, for multi-reel input, or when the output data set is on direct access and is to be kept or cataloged.	Specifies information used to identify the volume or volumes occupied by the data set.	----
LABEL	When the default value is not applicable.	Specifies information about labeling and retention for the data set.	The system assumes standard labeling.
DISP	When the default value is not applicable.	Indicates the status and disposition of the data set.	The system assumes (NEW, DELETE)

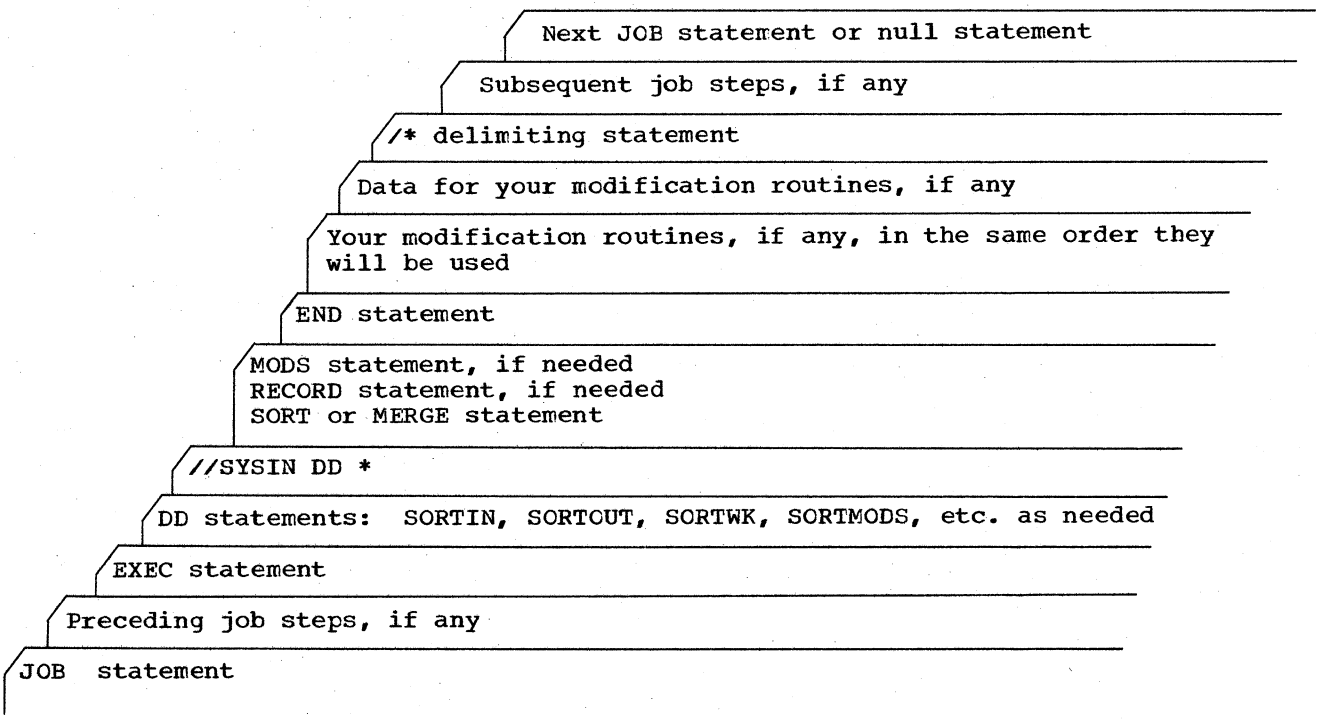
A full description of other DD statement parameters and subparameters is contained in the publication IBM System/360 Operating System: Job Control Language, Form C28-6539.

Table 3 is a summary of the DCB subparameters that are required by the sort/merge program if the DCB parameter is used. A more detailed discussion of these and other DCB subparameters is contained in the publication IBM System/360 Operating System: Supervisor and Data Management Macro Instructions, Form C28-6647.

• Table 3. Summary of DCB Subparameters Required by the Sort/Merge Program

SUBPARAMETER	CONDITION UNDER WHICH REQUIRED	SUMMARY OF SUBPARAMETER VALUE	DEFAULT VALUE
DEN	When the data set is located on a 7-track 2400-series tape unit.	Specifies the density at which the tape was recorded.	200 bpi
TRTCH	When the data set is located on a 7-track 2400-series tape unit.	Specifies the technique used to record 8-bit bytes on a 7-track tape.	Converter not used, translator not used, odd parity.
RECFM	When the DCB parameter is required, except on SORTWK statements.	Specifies the format of the records in the data set.	----
LRECL	When the DCB parameter is required, except on SORTWK statements. Not required for fixed-length unblocked records.	Specifies the maximum length (in bytes) of the logical records in the data set.	----
BLKSIZE	When the DCB parameter is required, except on SORTWK statements.	Specifies the maximum length (in bytes) of the physical records in the data set.	----

Figure 11 illustrates the order in which control statements must be placed in the input stream.



• Figure 11. Arrangement of Statements for Sort/Merge Execution

Each of the DD statement types required by the sort/merge program are discussed in the following text. Examples of the statements are included.

SORTIN DD Statement

For a sort, the SORTIN data set may be cataloged or uncataloged, or it may be inserted by your routine at exit E15 (see "Section 3: Program Modification"). The SORTIN data set may not be a DD DUMMY.

DD Example 1: SORTIN DD Statement

```
This example shows DD statement parameters that define a previously cataloged
input data set:

//SORTIN      DD  DSNAME=INPUT,DISP=(OLD,DELETE),                    X
//                DCB=(RECFM=FB,BLKSIZE=800,LRECL=80)
```

DSNAME — causes the system to search the catalog for a data set with the name INPUT. When the data set is found, it is associated with the ddname SORTIN. The control program obtains the unit assignment and volume serial number from the catalog and types a mounting message to the operator if the volume is not already mounted.

DISP — indicates that the data set is passed or cataloged (OLD) and that it should be deleted (DELETE) after the current job step.

DCB — indicates that the data set contains fixed-length blocked records (RECFM=FB) with a block size of 800 bytes and a record length of 80 bytes.

If the input data set is contained on more than one reel of magnetic tape, the VOLUME parameter must be included on the SORTIN DD statement to indicate the serial numbers of the tape reels. In the following volume parameter example, the input data set is on three reels that have serial numbers 75836, 79661, and 72945.

DD Example 2: Volume Parameter on SORTIN DD

```
VOLUME=SER=(75836,79661,72945)
```

When input to the sort/merge program is a concatenated data set, all data sets in the concatenation must have identical attributes. If they do not, results are unpredictable. This causes sort to terminate if an actual data set size appears in in the SIZE parameter of the SORT control card because of the ensuing record count off condition.

SORTIN01 -- SORTIN16 DD Statements

These DD statements define the input data sets for a merge operation. They must be numbered in ascending sequence. SORTIN01 is the name of the first DD statement; SORTIN02 is the name of the second DD statement, etc. No numbers can be skipped. The maximum block size and the maximum record length of all the data sets to be merged must be defined in the SORTIN01 DD statement. RECFM and LRECL must be the same for all input data sets. Mixtures of fixed- and variable-length records are not allowed. Fixed-length records must all be of the same length.

DD Example 3: SORTIN01 -- SORTIN03 DD Statements for a Merge

```
//SORTIN01    DD  DSNAME=MERGE1,VOLUME=SER=000111,DISP=CLD,          X
//                LABEL=(,NL),UNIT=2400,                            X
//                DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)
//SORTIN02    DD  DSNAME=MERGE2,VOLUME=SER=000121,DISP=OLD          X
//                LABEL=(,NL),UNIT=2400,                            X
//                DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)
//SORTIN03    DD  DSNAME=MERGE3,VOLUME=SER=000131,DISP=OLD,         X
//                LABEL=(,NL),UNIT=2400,                            X
//                DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)
```

DD Example 4: SORTIN01 and SORTIN02 DD Statements for a Merge

```
//SORTIN01    DD  DSNAME=INPUT1,VOLUME=SER=000101,                  X
//                UNIT=2301,DISP=OLD,DCB=(RECFM=VB,                 X
//                LRECL=240,BLKSIZE=2400)
//SORTIN02    DD  DSNAME=INPUT2,VOLUME=SER=000201,                  X
//                UNIT=2301,DISP=OLD,DCB=(RECFM=VB,                 X
//                LRECL=240,BLKSIZE=2400)
```

SORTWK01 -- SORTWK32 DD Statements

These statements define the intermediate storage data sets for a sort operation. For a merge-only operation, these statements are not required. Intermediate storage data sets can be on tape or direct access devices but not on a mixture of both. Your selection of an intermediate storage device type is not related to the device types used for input or output with one exception: seven-track tape cannot be used for intermediate storage unless the input device is also 7-track tape. Refer to "Intermediate Storage Space Requirements" in this section for information about how much intermediate storage is required for a particular application.

If you are using the checkpoint/restart facility and may be making a deferred restart, you must make the following two additions to each of your SORTWK DD statements so that the sort work data sets will not be lost:

```
DSNAME=anyname
DISP=(NEW,DELETE,KEEP)
```

Thus a complete SORTWK DD statement for deferred restart might be:

```
//SORTWK01    DD  DSNAME=WORK1,UNIT=2311,SPACE(TRK,(20),,CONTIG),     X
//                DISP=(NEW,DELETE,KEEP)
```

With this DD statement, the data set will be kept, if the job step aborts, and will be in the system until the step has been successfully rerun or until the data set has been deleted by some other means.

When the intermediate storage data sets are on direct access devices, only the primary space allocation is used by sort/merge and the space must be contiguous.

The ddnames for intermediate storage data sets must be numbered in ascending sequence. SORTWK01 must be the first, SORTWK02, the second, etc., and no numbers can be skipped.

DD Example 5: SORTWK01 DD Statement Defining a Tape Intermediate Storage Data Set

```
//SORTWK01    DD  UNIT=2400,LABEL=(,NL)
```

These parameters specify an unlabeled data set on a 2400 series tape unit. The system assigns a unique name to the data set because the DSNAME parameter is omitted. Because the DISP parameter is omitted, the system assumes DISP=(NEW, DELETE); the data set has not been previously cataloged and it will be deleted at the end of the current job step. The disposition PASS is not allowed for a SORTWK data set.

DD Example 6: SORTWK01 DD Statement Defining a Direct Access Data Set for Intermediate Storage

```
//SORTWK01    DD  UNIT=2311,SPACE=(TRK,(200),,CONTIG)
```

UNIT specifies a 2311 disk. The LABEL parameter is omitted. The default is standard labels.

SPACE specifies 200 contiguous tracks for the data set.

The omission of the DSNAME parameter causes the system to assign a unique name to the data set. The DISP parameter is omitted; the system assumes NEW, DELETE.

SORTOUT DD Statement

This DD statement is used to define all the characteristics of the output data set.

DD Example 7: SORTOUT DD Statement

```
//SORTOUT     DD  DSNAME=OUTPT,UNIT=2400,DISP=(NEW,CATLG),          X
//               DCB=(RECFM=FB,LRECL=90,BLKSIZE=900)
```

DSNAME The data set is to be called OUTPT.

DISP The data set is unknown to the operating system (NEW) and it is to be cataloged (CATLG) under the name OUTPT.

UNIT indicates that the data set is on a 2400 series tape unit.

DCB specifies a fixed-length blocked data set with a record length of 90 bytes and a block size of 900 bytes.

SORTMODS DD Statement

This statement is required if your routines are included in the system input stream. It must define a temporary partitioned data set large enough to hold all your routines that appear in the input stream. The sort/merge program transfers your routines to the SORTMODS data set before they are link edited for execution. If all your routines are located in libraries, the SORTMODS DD statement is not required, but DD statements defining the libraries must be included.

DD Example 8: SORTMODS DD Statement Defining a SORTMODS Data Set on 2311

```
//SORTMODS    DD  UNIT=2311,SPACE=(TRK,(10,,3))
```

These parameters allot ten tracks of a 2311 disk to the SORTMODS data set. Space for three directory blocks is also requested.

SORTCKPT DD Statement

The SORTCKPT data set may be assigned on any device that operates with BSAM. Processing can be restarted from the last checkpoint taken. If the MOD disposition is specified for the checkpoint data set, processing can be restarted from the checkpoint taken at the start of the sort phase as well as the last checkpoint taken.

DD Example 9: SORTCKPT DD Statement

```
//SORTCKPT    DD  DSNAME=CHECK,VOLUME=SER=000123,DISP=(NEW,KEEP),    X
//               UNIT=2400,DCB=(RECFM=U,BLKSIZE=800)
```

Job Control Language Statements for Sort/Merge—Summary

Statement		Purpose	When Required
//jobname	Job	Introduces the job.	Always.
//stepname	EXEC	Introduces the step.	Always.
//SYSPRINT	DD	Used by linkage editor.	When you do not use a cataloged procedure and have modification routines that require link editing.
//SYSLMOD	DD	Defines linkage editor output data set.	Same as for SYSPRINT.
//SYSUT1	DD	Defines work area for linkage editor.	Same as for SYSPRINT.
//SYSLIN	DD	Defines input data set for linkage editor.	Same as for SYSPRINT.
//SORTLIB	DD	Defines data set that contains sort/merge program modules.	When you do not use cataloged procedures SORT or SORTD.
//SYSOUT	DD	Defines system output data set.	Same as SORTLIB.
//SORTIN	DD	Defines input data set for a sort.	For a sort, always unless LINK, ATTACH, or XCTL is used to invoke sort and the input data set is inserted by your routine at sort/merge exit E15. Not used for a merge.
//SORTIN01-16	DD	Define input data sets for a merge.	For a merge, always. Not used for a sort.
//SORTWK01-32	DD	Define intermediate storage data sets for a sort.	For a sort, always. Not used for a merge.
//SORTOUT	DD	Defines sort/merge output data set.	Always, unless LINK, ATTACH, or XCTL is used to invoke sort and your routine disposes of output via sort/merge exit E35.
//SORTMODS	DD	Defines a temporary data set for your modification routines in SYSIN.	When you supply modification routines through the system input stream.
//SORTCKPT	DD	Defines data set for checkpoint records.	When you use the checkpoint facility.
//SYSIN	DD *	Indicates that data set containing sort/merge control statements) follows in input stream.	Always.
/*		Marks the end of SYSIN data set.	Always.

Shaded statements are provided by SORT or SORTD cataloged procedure.

JCL and Sort/Merge Statement Examples

Following are a number of examples showing all the JCL and sort/merge statements necessary to accomplish a particular job. The sort/merge control statements shown have the same operands as those illustrated and explained at the end of the topic "Defining the Sort or Merge" in this section.

Example 1 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Blocked fixed-length records on 9-track tape	Blocked fixed-length records on 9-track tape	Four 9-track tapes	None	FORMAT=xx for control fields of like format. Estimated data set size.

```
//EXAMP1          JOB A402,PROGRAMMER                                    01
//STEP1          EXEC SORTD                                              02
//SORT.SORTIN     DD  DSNAME=INPUT,VOLUME=SER=000101,                X    03
//               UNIT=2400,DISP=(OLD,DELETE),                       X    04
//               DCB=(RECFM=FB,LRECL=80,                            X    05
//               BLKSIZE=800)                                            06
//SORT.SORTOUT    DD  DSNAME=OUTPUT,UNIT=2400,DISP=(NEW,             X    07
//               CATLG),VOLUME=SER=102,DCB=(RECFM=FB,               X    08
//               LRECL=80,BLKSIZE=800)                                   09
//SORT.SORTWK01   DD  UNIT=2400                                           10
//SORT.SORTWK02   DD  UNIT=2400                                           11
//SORT.SORTWK03   DD  UNIT=2400                                           12
//SORT.SORTWK04   DD  UNIT=2400                                           13
//SORT.SYSIN      DD  *                                                   14
(SORT  FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000                    15
 END                                                                      16
/*                                                                        17
```

01 The JOB statement introduces this job to the operating system. The card contains accounting information and programmer identification. Message level 0, indicating that only incorrect control statements and associated diagnostic messages are to be printed, is specified by default.

02 The EXEC statement invokes the cataloged procedure SORTD. It can be written as shown or as EXEC PROC=SORTD. The contents of the two cataloged procedures supplied by IBM for sort/merge are shown in Section 2. The SORT cataloged procedure could be used for this example, but it causes allocation of linkage editor data sets which are not needed since no user-written modification routines that require link editing are included. The SORT procedure is therefore less efficient than the SORTD procedure for this example.

The remaining DD statements are being added to the SORTD procedure for this job step only. Therefore they are qualified by the stepname (SORT) of the SORTD proceudre. The SORT procedure also has the stepname SORT.

03-06 The SORTIN DD statement describes an input data set named INPUT. The data set is on a 9-track tape that has the serial number 000101. The DISP parameter indicates that the data set is known to the operating system and that it should be deleted from the system after this job step. The DCB parameter shows that the data set consists of fixed-length records with a record size of 80 and a block size of 800.

07-09 The SORTOUT DD statement describes the output data set. OUTPUT will be recorded on a 9-track tape drive and will be cataloged after it is created. The data set will be placed on tape volume number 102. OUTPUT's format, record length and block size are the same as those for SORTIN.

10-13 These DD statements define temporary intermediate storage data sets. The three data sets are on 9-track tape drives. No other parameters are necessary since the standard system default options are acceptable for this application.

14 The SYSIN DD * statement informs the operating system that a data set follows in the input stream.

15-16 Sort/Merge control statements described in Example 1 at the end of the topic "Defining the Sort or Merge."

17 The /* delimiter statement marks the end of the SYSIN data set.

Example 2 -- Sort

Example 2 is a sorting application exactly like that shown in Example 1 except that a cataloged procedure is not used. The sort/merge program is called directly. Only the EXEC statement, which is different from Example 1, and the two extra DD statements are described. Note that the DD statements need not be qualified by the word SORT.

```
//EXAMP2      JOB  A402,PROGRAMMER
//STEP1       EXEC PGM=IERRCO00,REGION=26K                              01
//SYSOUT      DD   SYSOUT=A                                             02
//SORTLIB     DD   DSNAME=SYS1.SORTLIB,DISP=SHR                         03
//SORTIN      DD   DSNAME=INPUT,VOLUME=SER=000101,                   X
//               UNIT=2400,DISP=(OLD,DELETE),                        X
//               DCB=(RECFM=FB,LRECL=80,                             X
//               BLKSIZE=800)
//SORTOUT     DD   DSNAME=OUTPUT,UNIT=2400,DISP=(NEW,                X
//               CATLG),VOLUME=SER=102,DCB=(RECFM=FB,                X
//               LRECL=80,BLKSIZE=800)
//SORTWK01    DD   UNIT=2400
//SORTWK02    DD   UNIT=2400
//SORTWK03    DD   UNIT=2400
//SORTWK04    DD   UNIT=2400
//SYSIN       DD   *
 SORT  FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000
 END
/*
```

01 This EXEC statement initiates the sort/merge program and indicates that it needs a 26K region in which to operate.

02 This DD statement directs the system output to system output class A.

03 This DD statement defines the data set containing the sort/merge program modules.

Example 3 -- Merge

Input	Output	Intermediate Storage	User Modifications	Options
Blocked fixed-length records on four 9-track unlabeled tapes	Blocked fixed-length records on one 9-track tape	None is required for a merge	None	FORMAT=xx for control fields of like format. Estimated data set size.

```
//EXAMP3          JOB A402,PROGRAMMER                                    01
//STEP1         EXEC SORTD                                               02
//SORT.SORTIN01  DD  DSNAME=MERGIN01,VOLUME=SER=000111,              X    03
//               DISP=OLD,LABEL=(,NL),UNIT=2400,                     X    04
//               DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)                      05
//SORT.SORTIN02  DD  DSNAME=MERGIN02,VOLUME=SER=000222,              X    06
//               DISP=OLD,LABEL=(,NL),UNIT=2400,                     X    07
//               DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)                      08
//SORT.SORTIN03  DD  DSNAME=MERGIN03,VOLUME=SER=000333,              X    09
//               DISP=OLD,LABEL=(,NL),UNIT=2400,                     X    10
//               DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)                      11
//SORT.SORTIN04  DD  DSNAME=MERGIN04,VOLUME=SER=000444,              X    12
//               DISP=OLD,LABEL=(,NL),UNIT=2400,                     X    13
//               DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)                      14
//SORT.SORTOUT   DD  DSNAME=MERGOUT,VOLUME=SER=000101,               X    15
//               DISP=(NEW,KEEP),LABEL=(,NL),UNIT=2400,              X    16
//               DCB=(RECFM=FB,LRECL=80,BLKSIZE=240)                      17
//SORT.SYSIN     DD   *                                                   18
 MERGE  FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000                   19
 END                                                                      20
/*                                                                        21
```

01-02 The basic JOB and EXEC statements. The EXEC statement invokes the cataloged procedure SORTD.

03-14 These DD statements describe the merge input data sets. They are all on 9-track unlabeled tape and consist of fixed-length records with a blocking factor of three. The total number of records on all of the data sets is about 10,000 as indicated by the SIZE parameter on the MERGE statement.

15-17 The result of the merge is recorded on 9-track tape at the same blocking factor and in the same format as the input data sets.

18 A data set follows in the input stream.

19-20 Sort/Merge control statements described in Example 2 at the end of the topic "Defining the Sort or Merge."

21 Marks the end of the SYSIN data set.

Example 4 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Fixed-length blocked records on 9-track tape	Fixed-length blocked records on 9-track tape, same unit as input data set	Three 2311 areas of 540 tracks each	Four - two change record lengths, one changes control fields, one decides what to do if Nmax is exceeded	Estimated data set size

```
//EXAMP4          JOB A402,PROGRAMMER                                          01
//STEP1           EXEC SORT                                                    02
//SORT.SORTIN      DD  UNIT=2400,DSNAME=INPUT,VOLUME=SER=000101,          X     03
//                DCB=(RECFM=FB,LRECL=120,                               X     04
//                BLKSIZE=480),DISP=(OLD,DELETE)                               05
//SORT.SORTOUT     DD  UNIT=AFF=SORTIN,DSNAME=OUTPUT,                     X     06
//                VOLUME=SER=000101,DCB=(RECFM=FB,                       X     07
//                LRECL=80,BLKSIZE=320),DISP=(NEW,PASS)                        08
//SORT.SORTWK01    DD  UNIT=2311,SPACE=(TRK,(540),,CONTIG)                      09
//SORT.SORTWK02    DD  UNIT=2311,SPACE=(TRK,(540),,CONTIG)                      10
//SORT.SORTWK03    DD  UNIT=2311,SPACE=(TRK,(540),,CONTIG)                      11
//SORT.MODLIB      DD  DSNAME=YOURRTNS,DISP=OLD                                 12
//SORT.SORTMODS    DD  UNIT=2311,SPACE=(TRK,(10,,3))                            13
//SORT.SYSIN       DD  *                                                        14
 SORT  FIELDS=(3.0,8.0,ZD,E,40.0,6.0,CH,D),SIZE=E30000                          15
 RECORD  TYPE=F,LENGTH=(120,100,80)                                             16
 MODS  E15=(E15,780,MODLIB,N),E16=(E16,1024,MODLIB),                    X     17
                E35=(ADDUP,912,SYSIN),E61=(CHGE,1000,SYSIN)                     18
 END                                                                            19
Object deck for ADDUP routine
Object deck for CHGE routine
/*                                                                              20
```

01-02 The basic JOB and EXEC statements. The EXEC statement specifies the SORT cataloged procedure because user-written routines that require link editing are included in the application.

03-05 This DD statement describes an input data set that consists of fixed-length blocked records on 9-track tape. Each record is 120 bytes long and the blocking factor is 4. The data set, which is already known to the operating system, will be deleted after this job step.

06-08 This DD statement describes the output data set. UNIT=AFF=SORTIN means that the data set is to be placed on the same unit as the input data set. The output records have the same format as the input records, but they are each 40 bytes shorter. The blocking factor is the same.

09-11 The next three DD statements describe three intermediate storage areas on 2311 disk. Each area contains 540 contiguous tracks.

12 Defines the data set that contains the E15 and E16 modification routines.

13 Defines a data set on which the ADDUP and CHGE routines will be placed.

14 A data set follows in the input stream.

15-19 Sort/Merge control statements described in Example 3 at the end of the topic "Defining the Sort or Merge."

Objects decks for your modification routines must appear in the input stream in numerical exit number order. ADDUP is the routine for exit E35, so it appears first. CHGE, the routine used at exit E61, appears second.

20 Marks the end of the SYSIN data set.

Example 5 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Fixed-length blocked records on two 9-track tape volumes	Fixed-length blocked records on one 9-track tape	Four 9-track tapes	Four - two change record lengths, one changes control fields, one decides what to do if Nmax is exceeded.	Estimated data set size, Oscillating technique forced.

```
//EXAMP5       JOB  A402,PROGRAMMER                                          01
//STEP1        EXEC SORT,PARM='OSCL'                                        02
//SORT.SORTIN  DD   DSNAME=INPUT,VOLUME=SER=(000333,000343),          X     03
//                 UNIT=2400,DISP=(OLD,DELETE),                       X     04
//                 DCB=(RECFM=FB,LRECL=120,                           X     05
//                 BLKSIZE=480)                                             06
//SORT.SORTOUT DD   DSNAME=OUTPUT,UNIT=2400,DISP=(NEW,                 X     07
//                 CATLG),VOLUME=SER=456,DCB=(RECFM=FB,               X     08
//                 LRECL=80,BLKSIZE=320)                                    09
//SORT.SORTWK01  DD  UNIT=2400                                              10
//SORT.SORTWK02  DD  UNIT=2400                                              11
//SORT.SORTWK03  DD  UNIT=2400                                              12
//SORT.SORTWK04  DD  UNIT=2400                                              13
//SORT.MODLIB DD     DSNAME=YOURRTNS,DISP=OLD                               14
//SORT.SORTMODS  DD  UNIT=2311,SPACE=(TRK,(10,,3))                          15
//SORT.SYSIN   DD    *                                                      16
 SORT FIELDS=(3.0,8.0,ZD,E,40.0,6.0,CH,D),SIZE=E30000                       17
 RECORD TYPE=F,LENGTH=(120,100,80)                                          18
 MODS E15=(E15,780,MODLIB,N),E16=(E16,1024,MODLIB,N),               X     19
             E35=(ADDUP,912,SYSIN),E61=(CHGE,1000,SYSIN)                    20
 END
Object deck for ADDUP routine                                               22
Object deck for CHGE routine                                                23
/*                                                                          24
```

01 The basic JOB statement.

02 The EXEC statement specifies the cataloged procedure SORT. OSCL in the PARM field directs the sort/merge program to use the oscillating tape sequence distribution technique if it possibly can, whether or not it considers the oscillating technique most efficient for this application.

03-06 Defines the input data set. Note that the SORTIN DD statement is prefaced by the step name of the SORT cataloged procedure because it and other DD statements so prefaced are being added to the procedure for this job step. The input data set consists of fixed-length blocked records on two 9-track tape volumes numbered 000333 and 000343, respectively.

07-09 Defines the output data set. The output data set also consists of fixed-length blocked records. It is on one 9-track tape.

10-13 Defines four intermediate storage data sets on 9-track tape. Since the DSNAME parameter is omitted, the system will assign unique names to the data sets.

14 Describes a data set that contains the E15 and E16 modification routines.

15 Defines a data set on which the ADDUP and CHGE routines will be placed.

16 A data set follows in the input stream.

17-21 Sort/merge control statements described in Example 3 at the end of the topic "Defining the Sort or Merge".

22 The object deck for the ADDUP routine comes before the deck for CHGE.

23 The object deck for the CHGE routine.

24 SYSIN data set delimiter.

Example 6 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Blocked fixed-length records on 7-track unlabeled tape	Blocked fixed-length records on 7-track labeled tape	Six 7-track tapes	None	FORMAT=xx for control fields of like format, estimated data set size.

```
//EXAMP6          JOB A402,PROGRAMMER                                    01
//STEP1           EXEC SORT                                              02
//SORT.SORTIN      DD  DSNAME=INPUT,VOLUME=SER=000101,                X   03
//                UNIT=2400-2,DCB=(DEN=2,RECFM=FB,                   X   04
//                LRECL=80,BLKSIZE=800,TRTCH=ET),                    X   05
//                DISP=(OLD,PASS),LABEL=(,NL)                            06
//SORT.SORTOUT     DD  DSNAME=OUTPUT,UNIT=2400-2,DISP=(NEW,           X   07
//                CATLG),VOLUME=SER=102,DCB=(RECFM=FB,               X   08
//                LRECL=80,BLKSIZE=800,DEN=2,TRTCH=ET)                   09
//SORT.SORTWK01    DD  UNIT=2400-2,LABEL=(,NL),DCB=(DEN=2,            X   10
//                TRTCH=ET)                                              11
//SORT.SORTWK02    DD  UNIT=2400-2,LABEL=(,NL),DCB=(DEN=2,            X   12
//                TRTCH=ET)                                              13
//SORT.SORTWK03    DD  UNIT=2400-2,LABEL=(,NL),DCB=(DEN=2,            X   14
//                TRTCH=ET)                                              15
//SORT.SORTWK04    DD  UNIT=2400-2,LABEL=(,NL),DCB=(DEN=2,            X   16
//                TRTCH=ET)                                              17
//SORT.SORTWK05    DD  UNIT=2400-2,LABEL=(,NL),DCB=(DEN=2,            X   18
//                TRTCH=ET)                                              19
//SORT.SORTWK06    DD  UNIT=2400-2,LABEL=(,NL),DCB=(DEN=2,            X   20
//                TRTCH=ET)                                              21
//SORT.SYSIN       DD  *                                                  22
 SORT  FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000                    23
 END                                                                      24
/*                                                                        25
```

01-02 Standard JOB and EXEC statements. The EXEC statement invokes the SORT cataloged procedure. The SORTD procedure would be more efficient for this application since there are no modification routines that need link editing, but the SORT procedure can be used.

03-06 The SORTIN DD statement defines the input data set. The data set is named INPUT, it is on an unlabeled 7-track tape with a serial number 000101. The DCB subparameters indicate that the tape was recorded at 800 bpi, is composed of fixed-length blocked records. The TRTCH=ET subparameter indicates that the tape was recorded with even parity and that BCDIC to EBCDIC translation is required. The DISP parameter shows that the data set is in existence and that it should be retained after this job step. The data set is the first one or only one of this unlabeled volume.

07-09 The SORTOUT DD statement defines the output data set. It is named OUTPUT, and is recorded on 7-track tape on a volume that has the serial number 102. The other parameters on this statement are the same as those on SORTIN, with the exception of DISP. DISP indicates that this data set will be created in this job step and will be cataloged for future reference by another job.

10-21 These DD statements define intermediate storage for the sort/merge program. The storage is on six 7-track unlabeled tapes. These tapes are to be recorded with even parity and BCDIC to EBCDIC translation.

22 A data set follows in the input stream

23-24 Sort/Merge control statements described in Example 1 at the end of the topic "Defining the Sort or Merge."

25 Delimiter statement marks the end of the SYSIN data set.

Example 7 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Fixed-length unblocked records on 2311 disk	Fixed-length blocked records on 2311 disk	Three 2311 areas, 120 tracks each	Exit E35 routine shortens each record by 30 bytes as it leaves the merge	Exact data set size, message option

```
//EXAMP7          JOB A402,PROGRAMMER                                    01
//STEP1         EXEC PROC=SORT,PARM='MSG=CC'                             02
//SORT.SORTIN     DD  DSNAME=INFILE,VOLUME=SER=INP214,                X  03
//               UNIT=2311,DCB=(RECFM=F,LRECL=80,                     X  04
//               BLKSIZE=80),DISP=(OLD,DELETE)                           05
//SORT.SORTOUT    DD  DSNAME=OUTFILE,VOLUME=SER=DLIB02,               X  06
//               UNIT=2311,DCB=(RECFM=FB,LRECL=50,                    X  07
//               BLKSIZE=500),DISP=(NEW,KEEP),                        X  08
//               SPACE=(TRK,(500,5))                                     09
//SORT.SORTWK01   DD  UNIT=2311,SPACE=(TRK,(120),,CONTIG)                 10
//SORT.SORTWK02   DD  UNIT=2311,SPACE=(TRK,(120),,CONTIG)                 11
//SORT.SORTWK03   DD  UNIT=2311,SPACE=(TRK,(120),,CONTIG)                 12
//SORT.SORTMODS   DD  UNIT=2311,SPACE=(TRK,(10,,3))                       13
//SORT.SYSIN      DD  *                                                   14
 SORT  FIELDS=(10,5,CH,A),SIZE=10000                                      15
 RECORD  TYPE=F,LENGTH=(80,,50)                                           16
 MODS    E35=(E35,534,SYSIN)                                              17
 END                                                                      18
Object deck for E35
/*                                                                        19
```

01 Standard JOB statement

02 The EXEC statement invokes the SORT cataloged procedure and specifies that critical messages only are to be printed and they are to appear on the console typewriter.

03-05 The input data set consists of fixed-length unblocked records on volume INP214 on a 2311 disk storage drive. The data set will be deleted after this job step.

06-09 The output data set is composed of fixed-length blocked records that will require 500 tracks of 2311 disk. Each time space is exhausted, 5 additional tracks will be allotted. The data set will be retained for future reference.

10-12 Intermediate storage consists of three 2311 areas of 120 contiguous tracks each.

13 This DD statement defines a data set large enough to contain the E35 routine which appears in object form in SYSIN. Ten disk tracks are reserved for the partitioned data set plus three blocks of the directory.

14 A data set follows in the input stream.

15-18 Sort/Merge control statements described in Example 5 at the end of the topic "Defining the Sort Merge."

19 Delimiter statement marks the end of the SYSIN data set.

Example 8 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Variable-length blocked records on 2314	Variable-length blocked records on 2314	Six 2314 areas	Initialization routine at exit E11 and an Nmax error routine at E16	Crisscross technique forced, Message option, estimated data set size.

```
//EXAMP8          JOB A402,PROGRAMMER                                    01
//STEPONE        EXEC SORT,PARM='CRCX,MSG=CP'                            02
//SORT.SORTIN     DD  UNIT=2314,DSNAME=PAY413,                      X     03
//               VOLUME=SER=231401,DCB=(RECFM=VB,                  X     04
//               LRECL=120,BLKSIZE=840),DISP=(OLD,KEEP)                  05
//SORT.SORTOUT    DD  UNIT=2314,DSNAME=PAY414,                      X     06
//               VOLUME=SER=231404,DCB=(RECFM=VB,                  X     07
//               LRECL=120,BLKSIZE=840),DISP=(NEW,KEEP)                  08
//SORT.SORTWK01   DD  UNIT=2314,SPACE=(TRK,(100),,CONTIG)                 09
//SORT.SORTWK02   DD  UNIT=2314,SPACE=(TRK,(100),,CONTIG)                 10
//SORT.SORTWK03   DD  UNIT=2314,SPACE=(TRK,(100),,CONTIG)                 11
//SORT.SORTWK04   DD  UNIT=2314,SPACE=(TRK,(100),,CONTIG)                 12
//SORT.SORTWK05   DD  UNIT=2314,SPACE=(TRK,(100),,CONTIG)                 13
//SORT.SORTWK06   DD  UNIT=2314,SPACE=(TRK,(100),,CONTIG)                 14
//SORT.USERLIB    DD  DSNAME=JIMSMODS,DISP=OLD                            15
//SORT.SYSIN      DD  *                                                   16
 SORT  FIELDS(20,5,CH,A),SIZE=E25500                                      17
 MODS  E11=(E11,500,USERLIB,S),E16=(E16,554,USERLIB,N)                    18
 RECORD  TYPE=V,LENGTH=(120,,,60,80)                                      19
 END                                                                      20
/*                                                                        21
```

01 The standard JOB statement.

02 The EXEC statement specifies the SORT cataloged procedure. The options in the PARM field indicate that the program is to use the crisscross sequence distribution technique if possible, that critical messages only are to be printed and that they are to appear on the printer.

03-05 The SORTIN DD statement describes the input data set. Its name is PAY413, it is on volume 231401 on a 2314, and consists of variable length blocked records. The data set is known to the operating system and is to be retained after use.

06-08 This statement describes the output data set. The data set, named PAY414, will be on volume 231404 of a 2314, will consist of variable length blocked records, is being created in this job step, and is to be retained in the system.

09-14 These statements define intermediate storage data sets. There are six data sets of 100 contiguous tracks each and they are on 2314. Six data sets is the minimum required for the crisscross technique.

15 Defines a data set called JIMSMODS which contains the E11 and E16 modification routines described on the MODS statement. The data set is known to the operating system and is not to be deleted after this job step.

16 A data set follows in the input stream.

17-20 Sort/merge control statements described in Example 6 at the end of topic "Defining the Sort or Merge."

21 Delimiter statement marking the end of the SYSIN data set.

Example 9 -- Merge

Input	Output	Intermediate Storage	User Modifications	Options
Variable-length blocked records on 2301	Variable-length blocked records on 2301	None	E35 routine shortens records and E61 routine modifies control field	Exact input data set size

```
//EXAMP9          JOB A402,PROGRAMMER                                    01
//STEP1          EXEC SORT                                               02
//SORT.SORTIN01   DD  DSNAME=WEEKLY,VOLUME=SER=000101,                X  03
//                UNIT=2301,DISP=OLD,DCB=(RECFM=VB,                    X  04
//                LRECL=240,BLKSIZE=2400)                                 05
//SORT.SORTIN02   DD  DSNAME=DAILY,VOLUME=SER=000113,                  X  06
//                UNIT=2301,DISP=(OLD,DELETE),                         X  07
//                DCB=(RECFM=VB,LRECL=240,BLKSIZE=2400)                   08
//SORT.SORTOUT    DD  DSNAME=WEEKA,VOLUME=SER=000111,                  X  09
//                UNIT=2301,DISP=(NEW,KEEP),                           X  10
//                SPACE=(TRK,(75,10)),DCB=(RECFM=VB,                   X  11
//                LRECL=200,BLKSIZE=2000)                                 12
//SORT.USERLIB    DD  DSNAME=MYMODS,DISP=OLD                              13
//SORT.MODLIB     DD  DSNAME=XYZ,DISP=OLD                                 14
//SORT.SYSIN      DD  *                                                   15
 MERGE  FIELDS=(1,6,CH,E),SIZE=8150                                       16
 RECORD  TYPE=V,LENGTH=(240,,200,,160)                                    17
 MODS  E35=(CALC,800,USERLIB),E61=(E61,450,MCDLIB,N)                      18
 END                                                                      19
/*                                                                        20
```

01-02 The basic JOB and EXEC statements.

03-05 The SORTIN01 DD statement describes one of two input data sets for the merge. The data set, named WEEKLY, is on volume 000101 of a 2301. The data set is known to the operating system and is to be retained. It contains variable length blocked records with a maximum record length of 240 bytes and a blocksize of 2400.

06-08 The SORTIN02 DD statement describes the second of two inputs to the merge. It is named DAILY, is on volume 000113 of a 2301, is old and will be deleted after this job step, and contains records of the same format, length and block size as the WEEKLY data set.

09-12 The output from the merge will be a data set named WEEKA. It is new and will be retained in the system on volume 000111 of a 2301. The data set will be recorded on 75 drum tracks. If this space is not sufficient, additional space will be allotted in blocks of ten tracks. The data set consists of variable-length blocked records with a maximum record length of 200 (see 1_3 on the RECORD statement) and a block size of 2000.

13 Defines the library on which the CALC routine for exit E35 resides.

14 Defines the library on which the E61 routine for exit E61 resides.

15 A data set follows in the input stream.

16-19 Sort/merge control statements described in Example 4 at the end of the topic "Defining the Sort or Merge."

20 Standard delimiter statement.

Example 10 -- Simple Merge

Input	Output	Intermediate Storage	User Modifications	Options
Blocked fixed-length records on 3 7-track tapes	Blocked fixed-length records on one 7-track tape	None	None	Estimated input data set size

```
//EXAMP10        JOB A714,PROGRAMMER                                    01
//STEPA          EXEC SORTD                                             02
//SORT.SORTIN01   DD  DSNAME=FILE1,VOLUME=SER=000123,                X  03
//               UNIT=2400-2,DCB=(DEN=2,RECFM=FB,                    X  04
//               LRECL=80,BLKSIZE=800,TRTCH=ET),                     X  05
//               DISP=(OLD,DELETE)                                      06
//SORT.SORTIN02   DD  DSNAME=FILE2,VOLUME=SER=000225,                X  07
//               UNIT=2400-2,DCB=(DEN=2,RECFM=FB,                    X  08
//               LRECL=80,BLKSIZE=800,TRTCH=ET),                     X  09
//               DISP=(OLD,DELETE)                                      10
//SORT.SORTIN03   DD  DSNAME=FILE3,VOLUME=SER=000179,                X  11
//               UNIT=2400-2,DCB=(DEN=2,RECFM=FB,                    X  12
//               LRECL=80,BLKSIZE=800,TRTCH=ET),                     X  13
//               DISP=(OLD,DELETE)                                      14
//SORT.SORTOUT    DD  DSNAME=FILE123,VOLUME=SER=000111,              X  15
//               UNIT=2400-2,DCB=(DEN=2,RECFM=FB,                    X  16
//               LRECL=80,BLKSIZE=800,TRTCH=ET),                     X  17
//               DISP=(NEW,KEEP)                                        18
//SORT.SYSIN      DD  *                                                  19
 MERGE  FIELDS=(1.0,6.0,A,28,5,D),FORMAT=CH,SIZE=E10000                 20
 END                                                                    21
/*                                                                      22
```

01-02 Standard JOB and EXEC statements.

03-06 Defines one of three inputs to the merge. The data set's name is FILE1. It is on 7-track tape with a serial number of 000123, and consists of fixed-length blocked records. The TRTCH=ET DCB subparameter indicates that the tape was recorded with even parity and that BCDIC to EBCDIC translation is required.

07-10 Defines another of the inputs to the merge, a data set named FILE2.

11-14 Defines FILE3, the third input to the merge.

15-18 Defines the output data set which is named FILE123. The data set is to be recorded on 7-track tape, volume 000111. The other parameters are the same as those for SORTIN01, with the exception of DISP, which indicates that the data set is new and is to be retained for future reference.

19 Data set follows in the input stream.

20-21 Sort/merge control statements described in Example 2 at the end of the topic "Defining the Sort or Merge."

22 Delimiter statement.

Example 11 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Fixed-length blocked records on 2314	Fixed-length blocked records on 2314	Eight 2314 areas of 20 tracks each	One routine shortens records as they leave the final merge phase	Exact data set size

```
//EXAMP11        JOB B600,PROGRAMMER                                          01
//STEPI          EXEC PROC=SORT                                               02
//SORT.SORTIN     DD  DSNAME=INPUT,UNIT=2314,VOLUME=SER=231401,          X     03
//                DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),                   X     04
//                DISP=(OLD,DELETE)                                            05
//SORT.SORTWK01   DD  UNIT=2314,VOLUME=SER=231402,                       X     06
//                SPACE=(TRK,(20),,CONTIG)                                     07
//SORT.SORTWK02   DD  UNIT=2314,VOLUME=SER=231403,                       X     08
//                SPACE=(TRK,(20),,CONTIG)                                     09
//SORT.SORTWK03   DD  UNIT=2314,VOLUME=SER=231404,                       X     10
//                SPACE=(TRK,(20),,CONTIG)                                     11
//SORT.SORTWK04   DD  UNIT=2314,VOLUME=SER=231405,                       X     12
//                SPACE=(TRK,(20),,CONTIG)                                     13
//SORT.SORTWK05   DD  UNIT=2314,VOLUME=SER=231406,                       X     14
//                SPACE=(TRK,(20),,CONTIG)                                     15
//SORT.SORTWK06   DD  UNIT=2314,VOLUME=SER=231407,                       X     16
//                SPACE=(TRK,(20),,CONTIG)                                     17
//SORT.SORTWK07   DD  UNIT=2314,VOLUME=SER=231408,                       X     18
//                SPACE=(TRK,(20),,CONTIG)                                     19
//SORT.SORTWK08   DD  UNIT=2314,VOLUME=SER=231409,                       X     20
//                SPACE=(TRK,(20),,CONTIG)                                     21
//SORT.SORTOUT    DD  DSNAME=OUTPUT,UNIT=2314,                           X     22
//                VOLUME=SER=231410,DCB=(RECFM=FB,                       X     23
//                LRECL=50,BLKSIZE=500),DISP=(NEW,KEEP),                 X     24
//                SPACE=(TRK,(200,10),RLSE)                                    25
//SORT.SORTMODS   DD  UNIT=2314,SPACE=(TRK,(10,,2))                            26
//SORT.SYSIN      DD  *                                                        27
 SORT  FIELDS=(10,5,CH,A),SIZE=10000                                           28
 RECORD  TYPE=F,LENGTH=(80,,50)                                                29
 MODS  E35=(E35,534,SYSIN)                                                     30
 END                                                                           31
Object deck for E35 routine
/*
```

01-02 Standard JOB and EXEC statements.

03-05 Defines the input data set. It is named INPUT, is on 2314 volume 231401, consists of fixed-length, blocked records with a length of 80 bytes and a blocking factor of 10.

06-21 These statements describe eight 2314 work areas. Each area consists of 20 contiguous tracks.

22-25 Defines the output data set. The data set, named OUTPUT, will be on volume 231410 of a 2314 and will contain fixed-length blocked records. Two hundred tracks are requested for the data set; if the space is exhausted, additional tracks are to be assigned in blocks of ten. When the output data set is closed, unused tracks are to be released.

26 Defines a temporary data set on 2314 for the E35 routine.

27 A data set follows in the input stream.

28-31 Sort/merge control statements described in Example 5 at the end of the topic "Defining the Sort or Merge."

32 Delimiter statement.

Example 12 -- Sort

Input	Output	Intermediate Storage	User Modifications	Options
Variable-length records on 2301	Variable-length records on 2301	Four 2301 areas of 60 tracks each	E11 routine performs initialization for the E16 NMAX routine	Estimated data set size

```
//EXAMP12        JOB B999,PROGRAMMER                                    01
//STEP0         EXEC SORT                                               02
//SORT.SORTIN    DD  DSNAME=XFILE,VOLUME=SER=000230,                X   03
//              UNIT=2301,DISP=OLD,DCB=(RECFM=V,                   X   04
//              LRECL=120,BLKSIZE=124)                                  05
//SORT.SORTWK01  DD  UNIT=2301,VOLUME=SER=230102,                   X   06
//              SPACE=(TRK,(60),,CONTIG)                                07
//SORT.SORTWK02  DD  UNIT=2301,VOLUME=SER=230197,                   X   08
//              SPACE=(TRK,(60),,CONTIG)                                09
//SORT.SORTWK03  DD  UNIT=2301,VOLUME=SER=000106,                   X   10
//              SPACE=(TRK,(60),,CONTIG)                                11
//SORT.SORTWK04  DD  UNIT=2301,VOLUME=SER=000145,                   X   12
//              SPACE=(TRK,(60),,CONTIG)                                13
//SORT.SORTOUT   DD  DSNAME=YFILE,VOLUME=SER=230198,                X   14
//              UNIT=2301,DCB=(RECFM=V,LRECL=120,                  X   15
//              BLKSIZE=124),SPACE=(TRK,(170,10),RLSE),            X   16
//              DISP=(NEW,CATLG)                                        17
//SORT.USERLIB   DD  DSNAME=MYRTNS,DISP=OLD                             18
//SORT.SYSIN     DD  *                                                  19
 SORT  FIELDS=(20,5,CH,A),SIZE=E25500                                   20
 MODS  E11=(E11,500,USERLIB,S),E16=(E16,554,USERLIB,N)                  21
 RECORD  TYPE=V,LENGTH=(120,,,60,80)                                    22
 END                                                                    23
/*                                                                      24
```

01-02 Standard JOB and EXEC statements.

03-05 Defines the input data set. It is named XFILE, resides on volume 000230 of a 2301, is known to the operating system and is not to be deleted, and consists of variable-length unblocked records.

06-13 Define four intermediate storage areas on 2301. Each area consists of 60 contiguous tracks.

14-17 Defines the output data set. It is named YFILE, and is to be placed on volume 230198 of a 2301. It will contain records of the same format as the input data set. One hundred seventy tracks are requested for the data set. If they are not sufficient to contain it, additional tracks are requested in blocks of ten. The data set is being created in this job step and is to be cataloged.

18 Defines the library that contains the E11 and E16 modification routines.

19 A data set follows.

20-23 Sort/merge control statements described in Example 6 at the end of the topic "Defining the Sort or Merge."

24 Delimiter statement.

Initiating Sort/Merge

There are two ways to initiate a sorting operation:

- By including sort/merge control statements and job control language statements in the input stream. You can use a cataloged procedure to supply some of the job control language statements.
- By using ATTACH, LINK, or XCTL macro instructions issued by another program.

There is only one way to initiate a merging operation: by placing sort/merge control statements and JCL statements in the input stream. As with a sort, a cataloged procedure can be used to supply some of the JCL.

USING THE SYSTEM INPUT STREAM

When sort/merge program execution is initiated by control statements in the input stream, it is treated as an ordinary task being executed under operating system control. You must provide a JOB statement, an EXEC statement and several DD statements to communicate with the operating system and the sort/merge program.

The job that initiates sort/merge requires a JOB statement. Each job step within that job requires an EXEC statement. (Other job steps may precede and follow the sort/merge job step.) The EXEC statement that introduces the sort/merge job step can initiate execution either directly or through a cataloged procedure. DD statements are required to define data sets used by the sort/merge program, the system, and, if necessary, the linkage editor.

Cataloged Procedure SORT

The SORT cataloged procedure is designed to be used in sorting and merging applications that have modification routines that require link editing. You can use this procedure for all sort/merge applications, but it is inefficient for those that do not have modification routines that require link editing, because it causes unnecessary linkage editor data sets to be allocated.

The SORT cataloged procedure is:

```
//SORT        EXEC  PGM=IERRCO00,REGION=98K                          01
//SYSOUT      DD    SYSOUT=A                                         02
//SYSPRINT    DD    DUMMY                                            03
//SYSLMOD     DD    UNIT=SYSDA,SPACE=(3600,(20,20,1))                04
//SYSLIN      DD    UNIT=SYSDA,SPACE=(80,(10,10))                    05
//SORTLIB     DD    DSNAME=SYS1.SORTLIB,DISP=SHR                     06
//SYSUT1      DD    UNIT=(SYSDA,SEP=(SORTLIB,SYSLMOD,SYSLIN)),     X 07
//                  SPACE=(1000,(60,20))                             08
```

01 The stepname of the procedure is SORT. This EXEC statement initiates the sort/merge program, which is named IERRCO00. A 98K region, large enough to contain the largest linkage editor, is requested.

02 This DD statement defines an output data set for system use (messages). It is directed to system output class A.

03 SYSPRINT is defined as a dummy data set because linkage editor diagnostic output is not required.

04 This DD statement defines a data set for linkage editor output. Any system direct access device is acceptable for the output. Space for 20 records that have an average length of 3,600 bytes is requested; this is the primary allocation. Space for 20 more records is requested if the primary space allocation is not sufficient; this is the secondary allocation, which is requested each time space is exhausted. The last value is space for a directory, which is required because SYSLMOD is a new partitioned data set.

05 The SYSLIN data set is used by the sort/merge program to describe pre-edited input to the linkage editor. It is created on any system direct access device, and it has space for 10 records with an average length of 80 bytes. If the primary space allocation is exhausted, additional space is requested in blocks large enough to contain 10 records. No directory space is necessary.

06 The SORTLIB DD statement defines the data set that contains the sort/merge program modules. It has the qualified name SYS1.SORTLIB, and it is cataloged.

07-08 The SYSUT1 DD statement defines a work data set for the linkage editor.

Cataloged Procedure SORTD

The SORTD cataloged procedure is designed for sorting and merging applications that have no modification routines, or have modification routines that do not require link editing. It cannot be used for applications having modification routines that need link editing.

The SORTD cataloged procedure is:

```
//SORT       EXEC  PGM=IERRCO00,REGION=26K                    01
//SYSOUT     DD    SYSOUT=A                                    02
//SORTLIB    DD    DSNAME=SYS1.SORTLIB,DISP=SHR                03
```

01 The stepname of the SORTD procedure is SORT. A 26K region is the smallest in which the program can operate.

02 Sort output is directed to system output class A.

03 This DD statement defines the data set containing sort/merge program modules.

USING ATTACH, LINK OR XCTL

You can use ATTACH, LINK, or XCTL macro instructions in another program to initiate operation of a sorting application (but not a merging application). (For a full description of ATTACH, LINK, and XCTL, see the publication IBM System/360 Operating System: Supervisor and Data Management Macro Instructions, Form C28-6647.)

There are four differences between initiating sort in the input stream and initiating it by a macro instruction:

1. Sort DD statements must be placed in the input stream with the job step that issues the macro instruction.
2. Information normally contained on sort/merge control statements must be passed to the sort/merge program in a parameter list.
3. Only two sort/merge program exits for modification routines (E15 and E35, see "Section 3: Program Modification") can be used when the sort is initiated by a macro instruction.
4. If ATTACH is used, checkpoints cannot be taken.

Supplying the Needed DD Statements

When you ATTACH, LINK, or XCTL to the sort/merge program, you must supply the following DD statements in the input stream with the job step that issues the macro instruction:

```
//SORTLIB      DD  DSNAME=SYS1.SORTLIB,DISP=SHR
```

to define the data set that contains sort/merge program modules.

```
//SORTIN       DD  with appropriate parameters
```

(See the examples at the end of "Job Control Language for Sort/Merge") to define the data set(s) to be sorted.

```
//SORTWK01     DD  with appropriate parameters
.
.
.
//SORTWK32     DD  with appropriate parameters
```

to define the intermediate storage data sets required by the sort.

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

to define an output data set (messages) for system use.

```
//SORTOUT      DD  with appropriate parameters
```

to define the sort/merge output data set.

Note: If you activate sort/merge exit E15, the SORTIN DD statement is not necessary because your routine will supply all input for the sort. If you activate exit E35, the SORTOUT DD statement is not necessary because your routine will handle output from the sort. You may need DD statements to describe your sort input and to set up a data set for your output, but they need not be called SORTIN or SORTOUT.

Passing Parameters to the Sort

The parameters you pass to sort/merge consist of two control statement images -- SORT and RECORD -- in main storage, and the entry point addresses of your modification routines (E15 and E35). These are the only modification routines permitted when sort/merge is initiated by ATTACH, LINK, and XCTL, and they are optional. You need not use any modification routines.

Your routine must construct the following parameter list and place a pointer to it in general register 1 before issuing the control-passing macro instruction:

X'80'	Pointer to list of addresses and options

The format of the address list is:

Unused	Number of bytes in the following list
Starting address of the SORT statement	
Ending address of the SORT statement	
Starting address of the RECORD statement	
Ending address of the RECORD statement	
Address of the E15 routine or zeros if no routine is provided	
Address of the E35 routine or zeros if no routine is provided	
Optional characters for ddnames	
X'00'	Optional main storage value
Optional sequence distribution techniques	
X'FF'	Unused	Message option

The address list is variable in length. The first halfword shown in the above illustration is not considered part of the list. The next halfword, which is pointed to by the parameter list pointer, contains the number of bytes in the parameter list excluding the two bytes occupied by the number itself. The list must contain at least 24 bytes because none of the addresses can be omitted. (The E15 and E35 routine addresses are zeros if the routines are not used.) The list can be as long as 40 bytes if all the options are included.

The first address in the address list must begin on a fullword boundary. Each address is contained in the low order three bytes of a fullword.

The following rules apply to the SORT and RECORD statement images whose starting and ending addresses appear in the address list:

- The first and last bytes of each statement image must contain a blank, and a blank (one only) must follow SORT and RECORD. No other blanks are allowed.
- The contents and formats of the SORT and RECORD statements are the same as those described in Section 2 under "Defining the Sort or Merge" except that continuation characters are not allowed. In other words, the statement images are not set up in card image format. Each statement image can be up to 1,100 bytes long.
- No comments are permitted.

The six addresses (or four addresses and two words of zeros) must appear in the order shown in the list. The options following the addresses can appear in any order and any of them can be omitted. For example, to specify only the optional main storage value, construct the list as follows:

Unused	Count
Address	
Address	
Address	
Address	
Address or zeros	
Address or zeros	
X'00'	Optional Main Storage Value

To specify only the balanced sequence distribution technique, construct:

Unused	Count		
Address			
Address			
Address			
Address			
Address or zeros			
Address or zeros			
B	A	L	N

OPTIONAL CHARACTERS FOR DDNAMES: You must select this option if you are operating in a multiprogramming environment and your task initiates two or more sort applications via ATTACH, LINK, or XCTL. The four characters you place in this word of the address list will replace the characters "SORT" in the DD names of the standard DD statements that define input, intermediate storage, and output. For the four characters, you can use any alphameric characters and the special characters $, #, and @, but the first must be alphabetic. If it is not, the characters are ignored. For example, if you use the characters ABC# as replacement characters, the statements SORTIN, SORTWK01 - SORTWK32, and SORTOUT from the input stream will be converted internally to ABC#IN, ABC#WK01 - ABC#WK32, and ABC#OUT.

Caution: Do not use characters that conflict with other ddnames; do not use the characters BALN, OSCL, POLY, CRCX, or DIAG.

OPTIONAL MAIN STORAGE VALUE: This parameter serves the same purpose as the CORE parameter in the EXEC statement PARM field. With it, you can specify the amount of main storage sort/merge can use for this application. The value you specify temporarily overrides the main storage assigned to the sort at system generation. The value must be a binary number and must appear right justified in the last three bytes of the field. As shown in the address list format, the high-order byte must contain zeros. The new value must not be less than 12,000, the minimum number of bytes needed for sort/merge operation. If it is, the number 12,000 is chosen by default. Refer to the topic "Altering the Main Storage Allocation" in Section 4 for further information.

OPTIONAL SEQUENCE DISTRIBUTION TECHNIQUES: This parameter takes the place of another PARM field option. With it you can force the sort/merge program to choose the balanced, oscillating, or polyphase technique for tape intermediate storage or the balanced or crisscross technique for disk. The four valid entries for this parameter are BALN, OSCL, POLY, and CRCX. Refer to the topic "Sequence Distribution Techniques" in Section 1 for further information.

This parameter may be ignored under the following conditions:

Tape Sorting

- Only three intermediate storage tape drives are assigned. With only three drives, the polyphase technique is always used.
- No input data set size, exact or estimated, is specified on the SORT statement. When the sort/merge program is not given an input data set size, it always uses the balanced technique if more than three work tapes are available.
- The tape drive containing the input data set is also specified as an intermediate storage unit. In this case, the oscillating technique cannot be used, so the sort/merge program chooses either the balanced or polyphase technique.

Disk sorting

- Technique forcing can occur only on a 2314 facility. All direct access sorting on 2311 disks and 2301 drums uses the balanced technique.
- Whenever less than six work areas are available, only the balanced technique can be used on the 2314.
- Whenever more than six work areas are available, only the crisscross technique can be used on the 2314.

MESSAGE OPTION: This parameter takes the place of the third EXEC statement PARM field option, MSG. The parameter temporarily overrides the message option selected at system generation.

The high-order byte of this parameter must be X'FF'. The next byte is unused. The last two bytes must contain one of the following codes:

NO -- no messages printed
CC -- critical messages only, printed on the system console
CP -- critical messages only, printed on the printer
AC -- all messages, printed on the system console
AP -- all messages, printed on the printer

Considerations When Using XCTL

When you initiate sort/merge via XCTL, you must give special consideration to the area where the parameter list, address list, and optional parameters, and modification routines (if you use them) are stored. This information must not reside in the module that issues the XCTL because the module is frequently overlaid by the sort/merge program.

There are two ways to overcome this problem. First, the control information can reside in a task that attaches the module that issues the XCTL. Second, the module issuing the XCTL can first issue a GETMAIN macro instruction and place the control information in the main storage area it obtains. This area is not overlaid when the XCTL is issued. The address of the control information in the area must be passed to the sort/merge program in general register 1.

The following text contains two examples. The first illustrates passing parameters to the sort. The second is an assembler language coding example that shows how to set up the parameter list, address list, and optional fields.

Example 1

Figure 12 shows how the parameter list, address list, and optional fields might appear in main storage.

General register 1 contains a pointer to the parameter list, which is at location 1000. The parameter list points to the address list which begins at location 1006. The first halfword of the address list contains, right adjusted, in hexadecimal, the number of bytes in the list (40 decimal).

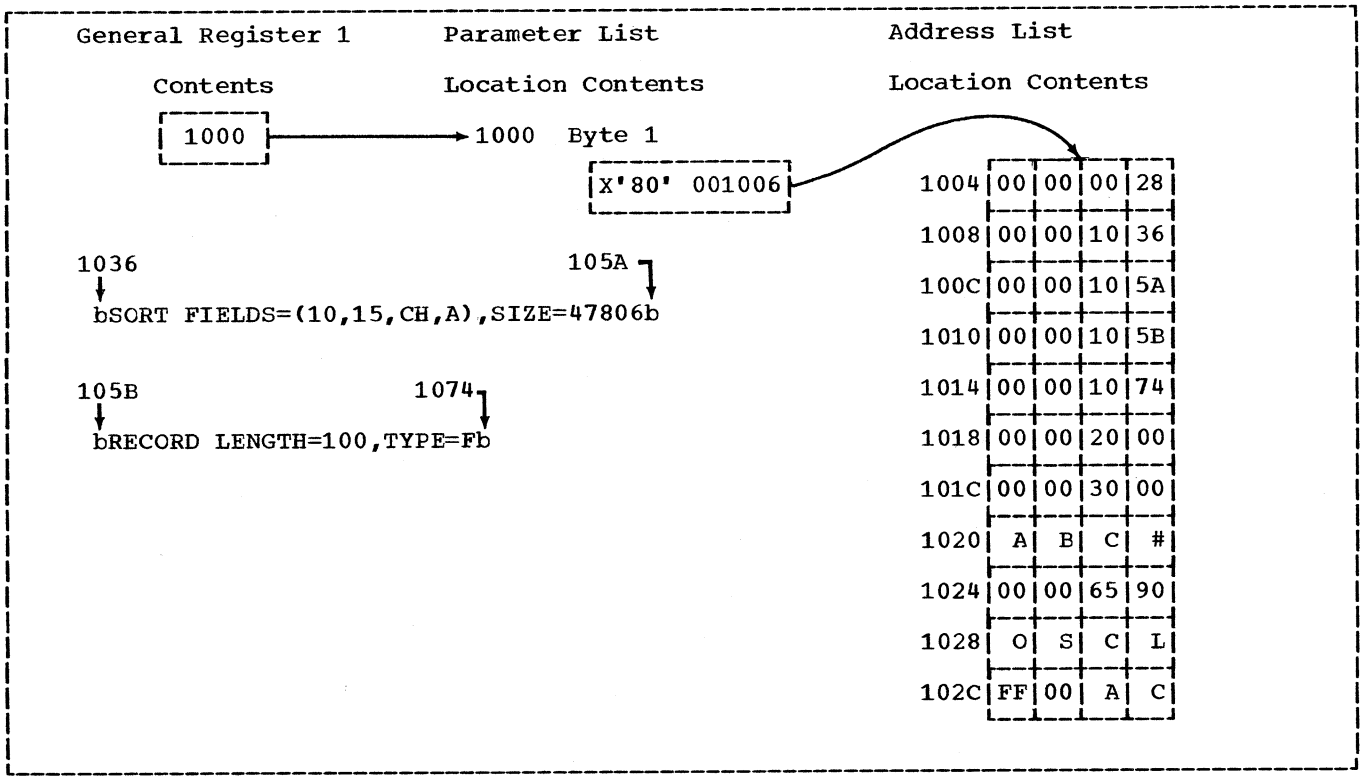
The first two fullwords in the address list point to the beginning (location 1036) and end (location 105A) of the SORT control statement. The next two fullwords point to the beginning (location 105B) and end (location 1074) of the RECORD statement.

The fourth and fifth fullwords in the list contain the entry point addresses of modification routines for exit E15 (2000) and exit E35 (3000).

The next fullword in the list contains four characters to replace the letters "SORT" in the DD names of standard DD statements.

The next three fullwords in the list specify a main storage value for this application, a sequence distribution technique, and a message option.

The control statement images must be represented in EBCDIC. The symbol b in the figure stands for a blank character.



• Figure 12. Passing Parameters to the Sort

Example 2

The following example shows, in assembler language coding, how to set up the parameters and card images in Example 1, and how to pass control to the sort/merge program.

```
        LA      1,PARLST
        ATTACH  EP=SORT,MF=(E,(1))
        .
        .
        .
        CNOP    0,8
PARLST  DC      X'80'
        DC      AL3(ADLST)
        DC      X'0000'
ADLST   DC      X'0020'
        DC      A(SORTCD)
        DC      A(STCDED)
        DC      A(RCDCD)
        DC      A(RDCDED)
        DC      A(MOD1)
        DC      A(MOD2)
        DC      C'ABC#'
        DC      X'0000'
        DC      X'6590'
        DC      C'OSCL'
        DC      X'FF00'
        DC      C'AC'
SORTCD  DC      C' SORT FIELDS=(10,15,CH,A),'
        DC      C'SIZE=4780'
STCDED  DC      C' '
RCDCD   DC      C' RECORD LENGTH=100,TYPE=F'
RDCDED  DC      C' '
        CNOP    0,8
        USING   *,15
MOD1    routine for exit E15
        .
        .
        CNOP    0,8
        USING   *,15
MOD2    routine for exit E35
```

Further Considerations When Using ATTACH, LINK, or XCTL

If you provide a modification routine for exit E15, sort/merge ignores the SORTIN data set. Your E15 routine must pass all input records to the sort/merge program. This means that your routine can only issue a return code of 12 (insert record) until the input data set is completed and then a return code of 8 (do not return).

Similarly, sort/merge ignores the SORTOUT data set if you provide a modification routine for exit E35. Your routine is responsible for disposing of all output records. Your routine must issue a return code of 4 (delete record) for each record in the output data set. When sort/merge has deleted all the records, your routine issues RC = 8 (do not return).

When sort/merge completes execution, it passes control back to the routine that invoked it or to the operating system.

Section 3: Program Modification

User-written routines can be used during a sort/merge program execution to perform a variety of functions, such as deleting, inserting, altering, and summarizing records.

Control is passed to your routines at predesignated places in the executable code of the sort/merge program called sort/merge program exits. Because these exits are located in particular program phases (and in one case, in a particular module), a general understanding of how the sort/merge program operates is necessary to understand sort/merge program exits.

Program Description

The sort/merge program is a segmented program; that is, it is composed of parts that can operate independently. Generally, there are two levels of segmentation:

1. Phases -- large program components that accomplish a certain task.
2. Modules -- the independent routines of which phases are composed.

The sort/merge program is composed of five phases. All five phases are used for sorting applications, but only the first two and the last phases of the program are used for merging applications. The first two phases -- the definition and optimization phases -- are strictly initialization phases. Each of the remaining three phases -- the sort, intermediate merge, and final merge -- is divided into two components:

1. An assignment component that initializes for the operation of the phase.
2. A running component that performs the actual sorting or merging.

Figure 13 is a phase-level flowchart of the program. Each phase is explained in the following text.

DEFINITION PHASE

The definition phase reads and interprets sort/merge control statements and decides which phases, and which modules of each phase, should be used. This phase also decides which of your routines, if any, must be link edited. This phase has no exits for passing control to your routines.

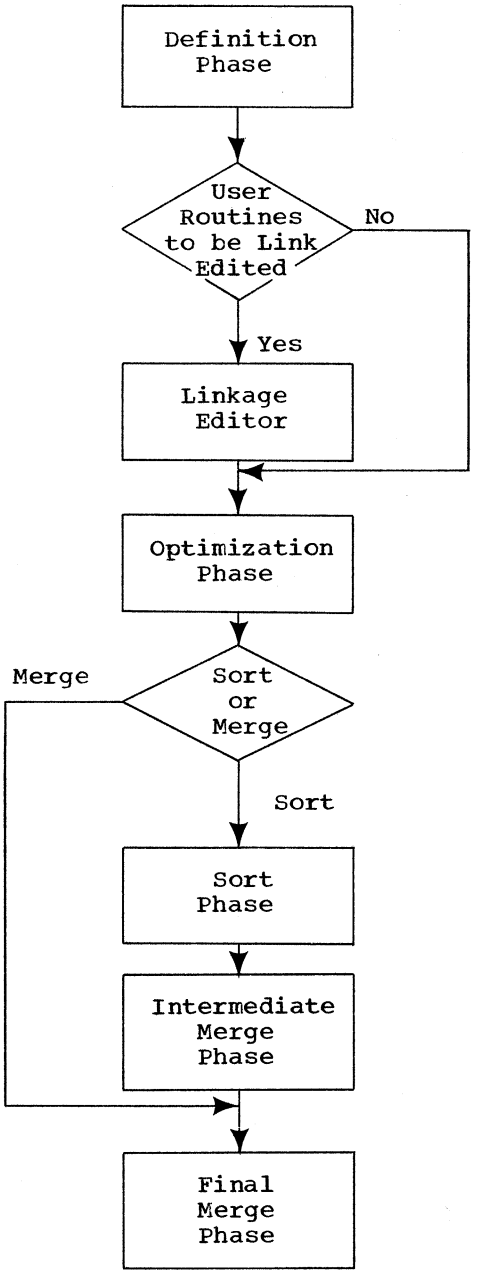


Figure 13. Phase-level Flowchart

OPTIMIZATION PHASE

The optimization phase, using information obtained from the operating system and from DD statements, determines the optimum method of using the CPU and I/O configuration available.

This phase also generates special routines, if necessary, to perform record comparisons. One of two routines -- the equals module or the extract module -- may be generated to make record comparisons. (Neither routine is used when sorting or merging is based on a single control field containing character data or binary data beginning and ending on a byte boundary.) If one of these routines is used, it remains in main storage throughout execution of the program.

Equals Module

The equals module is used when there are from two to twelve control fields and all control fields contain character data or binary data beginning and ending on a byte boundary. It is executed to resolve the collating of records when an equal comparison arises between two major control fields. This is done by comparing successive minor control fields until an unequal compare is made, thus determining the proper order of the two records. If all control fields are equal, the records are taken in the order which requires the least internal processing time.

Extract Module

The function of the extract module is to extract and group all of the control fields into one field so that a single compare instruction can be executed to collate the record.

The extract module is loaded for one of two reasons:

1. If more than one control field is used and the equals module cannot be used to resolve collating.

2. If specified by the user in either the SORT or MERGE control statement. (User specification is accomplished by taking the E option for the S parameters of the FIELDS operand. See the topic "Defining the Sort or Merge" in Section 2 for further information.)

When the extract module is used, it is executed each time a logical record is processed. This is done to avoid carrying the extracted information with the records, which would increase I/O time and, therefore, total sort or merge time.

SORT PHASE

The job of the sort phase is to order the input data set into sequences and distribute these sequences onto intermediate storage data sets. The method of distribution is determined by the sequence distribution technique being used.

If tape is being used as intermediate storage, the sequences may be put out in both ascending and descending order. This enables the intermediate merge phase, using the read-backward feature, to merge the sequences without rewinding tapes.

If direct access intermediate storage is used, the sequences are distributed among the areas assigned to the program so that they may be merged in a minimum number of passes.

This phase has a number of exits at which control can be passed to your routines.

INTERMEDIATE MERGE PHASE

The intermediate merge phase is loaded and executed following completion of the sort phase. It performs successive merges of the strings produced by the sort phase. The merges are carried out from intermediate storage device to intermediate storage device, each successive merge decreasing the number of strings and increasing the average string length. When one more merge is required to create one long string (the output data set), control is given to the final merge phase. There are several exits in this phase at which your routines can receive control.

FINAL MERGE PHASE

The final merge phase has two uses:

1. It makes the final merge pass of a sorting application, thus creating the output data set.

2. It merges the input data sets for a merging application to create the output data set.

Output from this phase can be on any output device supported by QSAM. After the execution of this phase, the sort system control component returns control to the operating system via the RETURN macro instruction. Your routines can receive control at a number of exits in this phase.

General Information

There are two types of exits available with the sort/merge program.

1. Assignment component exits, one each for the sort, intermediate merge, and final merge phases.

2. Running component exits, a number of which are associated with the running component of each program phase.

You can use assignment component exits to initialize your routines in each phase or to open data sets needed by your routines. The sort/merge assignment components are overlaid and used as buffer areas by the running components. Your routines at assignment component exits are also overlaid unless you link edit them together with the other routines in the phase.

You can use running component exits for a variety of purposes including the deletion, summarization, insertion, or any other alteration of the records coming into or out of the phase. You can also use running component exit routines to correct some of the errors that may occur during sort/merge execution, including I/O errors and exceeding Nmax. These exits also give you an opportunity to provide a routine that will close any data sets used by your other routines. You can use a running component extract module exit (E61) to alter control fields before the program collates them. This is the exit you would use to normalize floating-point control fields.

Figure 14 is a summary of the sort/merge program exits and their uses. The first digit of the exit number represents the phase in which the exit is located -- 1 for the sort phase, 2 for the intermediate merge phase, and 3 for the final merge phase. The second digit represents the type of function your routine can perform at the exit.

EFFICIENCY CONSIDERATIONS

When you consider using sort/merge program exits, you should weigh the following factors:

- Your modification routines occupy main storage that would otherwise be available to the sort/merge program. Because its main storage is restricted, the program may need to execute extra intermediate merge phase passes. This, of course, increases sorting time.

- The execution of your routines adds time to the overall sort/merge program execution time. Later, in the descriptions of exits, you will note that most of the exits give your routine(s) control once for each record until you pass a "do not return" return code to the program. You should design your modification routines with this in mind.

To use sort/merge program exits, you must associate your routines with the appropriate exits using the MODS control statement. (Refer to the topic "Defining the Sort or Merge" in Section 2.)

Note: If you use the 18K linkage editor with the minimum amount of sort/merge main storage, your routines are limited to 10 external references.

Possible Use for Exit	Sort						Intermediate Merge					Final Merge					Extract
	E11	E15	E16	E17	E18	E19	E21	E25	E27	E28	E29	E31	E35	E37	E38	E39	E61
Assignment	X						X					X					
Nmax Error			X														
Logical Record Change		X						X					X				
Control Field Change																	X
Opening Data Sets	X						X					X					
Closing Data Sets				X					X					X			
Read Error Routine					X					X					X		
Write Error Routine						X					X					X	

Figure 14. Summary of Functions Permitted at Sort/Merge Program Exits

BYPASSING THE LINKAGE EDITOR

To save execution time, you should design your routines so that they do not require link editing each time they are used in a sort/merge application. To avoid use of the linkage editor at sort/merge execution time, your routines must meet the following requirements:

- Each routine must be a load module on a partitioned data set (library). Its member name must be the same as its exit number. e.g., E16. The value s on the MODS statement that defines the routine must be the name of the DD statement that defines the library. e.g.,

```
 MODS E16=(E16,500,MYLIB,N)
//MYLIB DD DSNAME=MYRTN,etc.
```

- Each routine must have only one entry point which is the module name.
- The routines cannot have external references.
- All routines must be on the same library or must be defined as a concatenated data set with one ddname.

You should code the parameter N on the MODS statement for each routine that meets the above requirements. This indicates that the routine was previously link edited and does not require further link editing.

If you use routines at assignment exits (E11, E21, and E31) that do not meet the requirements for bypassing the linkage editor, you can still save execution time by designing them for separate link editing. To be eligible for separate link editing, your assignment component routines must meet the following requirements:

- Each routine must be separate.
- The routines cannot contain external references.
- The routines can have several entry points, but one entry point must be the same as the exit number e.g., E11.
- The routine must be designed so that it can be overlaid after assignment time.

To indicate that the routine is eligible for separate link editing, code the parameter S for that routine on the MODS statement. If your routine opens data sets or communicates with running component routines, it will contain external references and therefore cannot be link edited separately.

When your routine does not meet the requirements for bypassing the linkage editor or for separate link editing, do not code a fourth parameter for that routine on the MODS statement. The routine is then link edited together with all other routines in its phase which do not meet the requirements. In any phase, you can mix routines that do not require additional link editing, routines that can be link edited separately, and routines that must be link edited together.

OPERATING CONSIDERATIONS

Each of your routines must be assembled or compiled as a separate program and placed in either a partitioned data set (library) or in the system input stream. The sort/merge general assignment phase includes the names and locations of your routines in the list of modules to be executed during each program phase. Your routines are loaded and executed with their associated program phase.

None of your routines can appear more than once in a program phase, but the same routine can appear in several phases. For example, you can use the same read error routine in all three phases, but not twice in any one phase. If a routine is to be used more than once and the routines are on SYSIN, you must supply a copy of the routine for each use.

Only one load module is allowed at each sort/merge program exit. If you need more than one routine at an exit, the routines must be assembled, compiled, or link edited as one load module.

All your routines in a phase that require link editing can be placed in one partitioned data set member. The member must have an entry point for each of the routines you use. When the routines are arranged in one member, their individual lengths specified on a MODS statement are not important, but the sum of the lengths must be the total length of the module. All but one length can be specified as zero, with the total member length specified for the remaining routine.

ROUTINES IN THE SYSTEM INPUT STREAM

The routines that you place in the system input stream are copied into the SORTMODS data set; they then become input to the linkage editor. Under the MVT configuration, the entire contents of SYSIN, including control statements, is first moved to a system direct access data set. Sort/merge strips away the sort control cards and then copies your routines on SORTMODS.

When data follows your routines, it is also written on the system data set. When one of your routines opens SYSIN to read the data, it will start reading from the beginning of the SYSIN data set.

LINKAGE CONSIDERATIONS

Your routine must save and restore all general registers it uses at the modification exit. The general registers used by the sort/merge program for linkage and communication of parameters follow operating system conventions. The registers used are:

- General register 1 -- used to pass the address of a parameter list to the called routine.
- General register 13 -- contains the address of an area, set aside by the sort/merge program, in which your routine may save the contents of any general registers it needs for operation.
- General register 14 -- This register contains the address of the sort/merge program return point.
- General register 15 -- contains the address of your routine. your routine can use it as a base register. General register 15 is also used as a return-code register whereby your routine communicates information to the sort/merge program.

The sort/merge program uses a CALL macro instruction expansion to enter your routines. You can return control to the sort/merge program with a RETURN macro instruction. You can also use the RETURN macro instruction to set return codes when multiple actions are available at an exit. You can use the SAVE macro instruction to save all general registers that the routine uses. If you save registers, you must also restore them. You can do this with the RETURN macro instruction.

All of your routines must contain an entry point defined by an ENTRY or CSECT statement. The name of the entry point must be the number of the associated sort/merge program exit.

Linkage Examples

The CALL macro instruction used by the sort/merge program to link to your routines is written as follows:

```
     CALL    E11
```

This macro instruction is expanded to form assembler language instructions and, when executed, places the return address in general register 14 and your routine's entry point address in general register 15. The sort/merge program has already placed the register save area address in general register 13.

Your routine for the sort phase assignment component exit could incorporate the following instructions:

```
       ENTRY    E11
       .
       .
       .
E11    SAVE     (5,9)
       .
       .
       .
       RETURN   (5,9)
```

This coding saves and restores the contents of general registers 5 through 9. The macro instructions are expanded into the following assembler language code:

```
        ENTRY    E11
        .
        .
        .
E11     STM      5,9,40(13)
        .
        .
        .
        LM       5,9,40(13)
        BR       14
```

If multiple actions are available at a sort/merge program exit, your routine sets a return code in general register 15 to inform the sort/merge program of the action it is to take. The following macro instruction could be used to return to the sort/merge program with a return code of 12 in general register 15:

```
        RETURN RC=12
```

(A full explanation of linkage conventions and the macroinstructions discussed in this section can be found in the publication IBM System/360 Operating System: Supervisor and Data Management Macro Instructions, Form C28-6647.)

Assignment Component Exits (E11, E21, E31)

PHASE IN WHICH USED:

E11 -- Sort phase
E21 -- Intermediate merge phase
E31 -- Final merge phase

POSSIBLE USES OF ROUTINES: You might use routines at these exits to open data sets needed by your other routines in the associated phases, or to initialize your other routines.

RETURN CODES: None.

LINKAGE CONVENTIONS:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
CALL E11	ENTRY E11 . . E11 SAVE (5,9)[1] . . RETURN (5,9)[1]
[1]This coding saves and restores the contents of registers 5 through 9. You would save and restore whatever registers you use.	

FURTHER CONSIDERATIONS: These are the only three routines you can design for separate link editing. Refer to the topic "Bypassing the Linkage Editor" earlier in this section.

Running Component Exits

Each sort/merge program phase has a number of running component exits associated with it. Many of these exits perform the same function in each of the program's three phases. They are explained in the following text according to exit function.

RECORD CHANGE EXITS (E15, E25, E35)

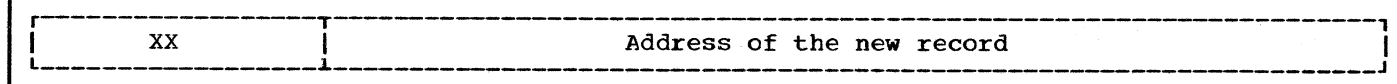
The record change exits can be used to insert, delete, alter, or summarize records.

Exit E15

PHASE IN WHICH USED: Sort phase before any records are sorted.

POSSIBLE USES OF ROUTINE: Add records to the input data set, create the entire input data set, delete records from the input data set, change records in the input data set (except control fields). Use exit E61 for control field change.

INFORMATION SUPPLIED TO YOUR ROUTINE BY SORT/MERGE: Your routine at exit E15 is executed each time a new record is brought into the sort phase. Sort/merge places the address of a parameter list in general register 1. The parameter list contains the address of the new record. The parameter list starts on a fullword boundary and is one fullword long. The high order byte of the word is not used; it is represented by xx in the figure below. The format of the parameter list is:



When sort/merge reaches the end of the input data set, it passes an address of zero in the parameter list. If there are no records in the input data set, sort/merge passes a zero address the first time it uses exit E15.

RETURN CODES: Your routine must pass one of the following return codes to the sort merge program informing it what to do with the record you have been examining or changing:

0 -- Alter or no action
4 -- Delete record
8 -- Do not return
12 -- Insert record

0 - No Action: If you want sort/merge to retain the record as is, place the address of the record in general register 1 and return to sort/merge with a zero return code.

0 - Alter Record: If you want to change the record before passing it back to sort/merge, your routine must move the record into a work area, perform whatever modification you desire, place the address of the modified record in general register 1, and return to sort/merge with a zero return code. If your routine changes record size, you must communicate that fact to the program on a RECORD statement. (See "Defining the Sort or Merge" in Section 2 and the publication IBM System/360 Operating System: Supervisor and Data Management Services for further information about the length indicator and the Record Descriptor Word.)

4 - Delete Record: If you want sort/merge to delete the record from the input data set, return with a return code of 4. You need not place the address of the record in general register 1.

8 -- Do Not Return: Sort/merge keeps returning to your routine until you pass a return code of 8. After that, the exit is closed and not used again during the sort/merge application. You need not place an address in general register 1 when you return with RC = 8. Unless you are inserting records after end-of-data set, you must pass a return code of 8 when sort/merge indicates end-of-data set by passing your routine a zero address in the parameter list.

12 -- Insert Record: If you want sort/merge to add a record to the input data set, before the record whose address was just passed to your routine, place the address of the record to be added in general register 1 and return to sort/merge with a return code of 12. Sort/merge then returns to your routine with the same record address as before so that your routine can insert more records at that point or alter the current record. You can make insertions after the last record in the input data set (after sort places a zero address in the parameter list). Sort/merge keeps returning to your routine until you pass a return code of 8.

LINKAGE CONVENTIONS: Linkage conventions for exit E15 are shown in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
LA 1,param CALL E15 . . param DC A(radrs)	ENTRY E15 . . E15 SAVE (5,9) . . LA 1,nwrec RETURN (5,9), RC=x
radrs refers to the record passed by the sort nwrec refers to the record returned to the sort x is the return code	

RESTRICTIONS: If you ATTACH, LINK, or XCTL to the sort/merge program, and use exit E15, the sort/merge program ignores the SORTIN data set. Your E15 routine must pass all input records to the program by placing their addresses one by one into general register 1 and returning to sort/merge with RC = 12. When sort/merge returns to your routine after you have passed the last record, return to sort with RC = 8 indicating "do not return." Since exit E15 is associated with the sort phase, it cannot be used during a merge-only operation.

Exit E25

PHASE IN WHICH USED: Intermediate merge phase, after the records have been merged.

POSSIBLE USES OF ROUTINE: Change (except control fields) or delete records leaving the intermediate merge phase.

INFORMATION SUPPLIED TO YOUR ROUTINE BY SORT/MERGE: Your E25 routine is executed each time sort/merge prepares to place a record (except the first record in each sequence) in an intermediate merge output sequence. Sort/merge passes two record addresses to your routine. These are:

- The address of the record leaving the merge, which would normally follow the record in the output area.
- The address of a record in the output area.

In general register 1, sort/merge places the address of a parameter list that contains these two record addresses. The parameter list starts on a full word boundary and is two fullwords long. The high order bytes of both words are not used (contain zeros). The format of the parameter list is:

XX	Address of Record Leaving Merge
XX	Address of Record in Output Area

RETURN CODES: Your routine must pass one of the following return codes to the sort/merge program informing it what to do with the record leaving the merge:

0 -- Alter or no action
4 -- Delete record or summarize and delete

0 - No Action: If you want sort/merge to retain the record as is in the intermediate merge sequence, load the address of the record leaving the merge into general register 1 and return to sort/merge with a zero return code. The next time sort/merge transfers control to your routine, the record whose address you just passed will be the record in the output area.

0 - Alter Record: If you want to change the record (except its control field) before passing it back to sort/merge, move the record to a work area, make the change, place the address of the modified record in general register 1, and return to sort/merge with a zero return code.

4 - Delete Record: If you want to delete the record leaving the merge, return to sort/merge with a return code of 4. You need not place an address in register 1.

4 - Summarize and Delete: You can summarize records by changing the record in the output area and then deleting the record leaving the merge. Sort/merge then returns to your routine with a new record (leaving the same record in the output area so that you can summarize further.) If you want to perform summarization without deletion, you should do it at exit E35 rather the E25 because it is more efficient. The sort/merge program does not test for equal control fields before taking exit E25. If you want to summarize records with equal control fields, you must test the fields.

LINKAGE CONVENTIONS: Linkage conventions for exit E25 are shown in the following

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
LA 1,param CALL E25 . . param DC A(rcara) DC A(otara)	ENTRY E25 . . E25 SAVE (5,9) . . LA 1,modrc RETURN (5,9), RC=x
rcara refers to the record leaving the merge otara refers to the record in the output area modrc refers to the record returned to the merge x is the return code	

RESTRICTIONS: You must not retain status information in the exit routine; you must carry it in the records being merged. The entire intermediate merge phase (including your E25 exit routine) is reloaded into main storage for each intermediate merge phase pass when the balanced tape or balanced direct access sequence distribution techniques are used by the program. Your routine would not work properly when sort/merge chooses either of the balanced techniques, if it depended upon status information saved within it. Since exit E25 is associated with the intermediate merge phase, it cannot be used during a merge-only operation.

Exit E35

PHASE IN WHICH USED: Final merge phase after the records have been merged.

POSSIBLE USES OF ROUTINE: Add records to, delete records from, or change records in the output data set.

INFORMATION SUPPLIED TO YOUR ROUTINE BY SORT/MERGE: Your E35 exit routine is executed each time sort/merge prepares to place a record (including the first record) in the output area after the final merge. Sort/merge passes two record addresses to your routine. These are:

- The address of the record leaving the merge which would normally follow the record in the output area. (This address is zero at end-of-data set.)
- The address of a record in the output area. (This address is zero the first time your routine is entered because there is no record in the output area at that time.)

Sort/merge also passes your routine a third parameter which is used to control sequence checking. In general register 1, sort/merge places the address of a parameter list that contains the two record addresses and the sequence check switch. The list is three full-words long and begins on a full-word boundary. The high order bytes of the first two words are not used. The format of the parameter list is:

XX	Address of Record Leaving Merge		
XX	Address of Record in Output Area		
	00	00	Sequence Check Switch - 00 or 04

The sort/merge program tests the sequence check switch before each record is written on the output data set. If the word contains all zeros, sort/merge performs a sequence check. If the low order byte of the word contains a 4, sort/merge does not perform a sequence check. This switch is initially set to zero. Your routine can set it and reset it as necessary. If your routine is altering control fields which would not collate properly in the output data set, it should set the low order byte of the switch to 0100 to eliminate the sequence check for the records whose control fields have been changed.

RETURN CODES: Your routine must pass one of the following return codes to sort/merge informing it what to do with the record leaving the merge:

```
 0 -- Alter or no action
 4 -- Delete record
 8 -- Do not return
12 -- Insert record
```

0 -- No Action: If you want the program to retain the record as is in the output data set, load the address of the record leaving the merge into general register 1 and return to sort/merge with a zero return code.

0 -- Alter Record: If you want to change the record before having it placed in the output data set, move the record to a work area, make the change, load the address of the modified record into general register 1, and return to sort/merge with a zero return code. If you change record size, you must communicate that fact to sort/merge on a RECORD statement.

4 -- Delete Record: Your routine can delete the record leaving the merge by returning to sort/merge with a return code of 4. You need not place an address in general register 1.

8 -- Do Not Return: Sort/merge keeps returning to your routine until you pass a return code of 8. After that, the exit is closed and not used again during the sort/merge application. When you return with RC = 8, you need not place an address in general register 1. Unless you are inserting records after end-of-data set, you must pass RC = 8 when sort/merge indicates end-of-data set by passing your routine zero as the address of the record leaving the merge.

12 -- Insert Record: If you want to add a record to the output data set before the record leaving the merge, place the address of the new record in general register 1 and return to sort/merge with a return code of 12. Sort/merge returns to your routine with the same addresses as before so that you can make more insertions at that point, or delete the record leaving the merge, etc. Sort/merge does not perform a sequence check on records that you insert unless you delete the

record leaving the merge and insert a record to replace it. If your new record will not collate properly, set the sequence check switch to 0100 to eliminate the sequence check for that record.

Summarize Records: You can summarize records in the output data set by changing the record in the output area and then, if you desire, deleting the record leaving the merge. Sort/merge returns to your routine with the address of a new record leaving the merge and leaves the same record in the output area, so that you can summarize further. If you do not delete the record leaving the merge, that record takes the place of the record in the output area and sort/merge returns with the address of a new record leaving the merge. As with exit E25, sort/merge does not check for equal control fields.

LINKAGE CONVENTIONS: Linkage conventions for exit E35 are shown in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
LA 1,param CALL E35 . . param DC A(rcara) DC A(otara) DC A(0)	ENTRY E35 E35 SAVE (5,9) . . E35 MVI 11(1), . X'04' . LA 1,nwrec RETURN (5,9), RC=x
rcara refers to the record leaving the merge otara refers to the record in the output area nwrec refers to the record returned to the merge x is the return code	

RESTRICTIONS: If you ATTACH, LINK, or XCTL to the sort/merge program and use exit E35, the sort/merge program ignores the SORTOUT data set. Your E35 routine must dispose of all the output records by writing them out on a data set (you must supply a DD statement defining that data set,) and returning to sort/merge with RC = 4. When sort/merge returns to your routine after you have disposed of the last record, return to sort with RC = 8 indicating "do not return."

NMAX EXIT (E16)

PHASE IN WHICH USED: Sort phase.

POSSIBLE USES OF ROUTINE: You would use a routine at this exit to decide what to do if sort exceeds its calculated estimate of the number of records it can handle for a given amount of main storage and intermediate storage.

RETURN CODES: Your routine can choose among three actions, and must use one of the following return codes to communicate its choice to sort/merge:

0 -- Sort current records only.
4 -- Try to sort additional records.
8 -- Terminate the program.

0 -- Sort Current Records Only: If you want sort/merge to continue with only that part of the input data set it estimates it can handle, return with RC = 0. (Message IER054I contains the number of records that sort is continuing with. You can sort the remainder of the data set on another run, using the SKIPREC operand on the SORT statement to skip over the records already sorted. Then you can merge the two sort outputs to complete the operation.)

4 -- Try to Sort Additional Records: If you want sort/merge to continue with all of the input data set, return with RC = 4. (Enough space may be available for the program to complete processing. If enough is not available, the program generates a message and terminates. Refer to "Further Considerations" below.)

8 -- Terminate the Program: If you want sort/merge to terminate, return with RC = 8. The job steps following the sort step are executed.

LINKAGE CONVENTIONS: Linkage conventions for this exit appear in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
CALL E16	ENTRY E16 . . E16 RETURN RC=x
x is the return code	

FURTHER CONSIDERATIONS: For variable-length input records, sort/merge calculates Nmax using the maximum record length. Therefore, Nmax tends to be lower than the actual number of records the program can handle. If the maximum record length is much larger than the average record length, Nmax is considerably lower than the number of records the program can handle.

Sort/merge can calculate Nmax very accurately for fixed-length records. When Nmax is reached, usually little additional space remains.

If the input data set has no natural ordering, and if direct access devices (balanced technique only) are used for intermediate storage, Nmax tends to be larger than the number of records the program can handle.

Nmax is recalculated during the sort phase (balanced direct access technique only) and the final value may be less than the original estimate.

EXITS FOR CLOSING DATA SETS (E17, E27, E37)

Your routines at these exits are executed once at the end of the phase with which they are associated. They can be used to close data sets used by your other routines in the phase or to perform any housekeeping functions for your routines.

PHASE IN WHICH USED:

E17 Sort phase
E27 Intermediate merge phase
E37 Final merge phase

LINKAGE CONVENTIONS: The linkage conventions used with these exits appear in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
CALL E17	ENTRY E17 . . E17 CLOSE . . RETURN

READ/WRITE ERROR ROUTINES

You can use the six read/write error exits to incorporate your own or your installation's I/O error recovery routines into the sort/merge program. When the sort/merge program encounters an uncorrectable I/O error, it passes the same parameters as those passed by QSAM. The following information is passed to your synchronous error routine:

General Register 0: This register always contains X'10' in the high-order byte. The remaining three bytes contain the address of the input/output block (IOB) associated with the error, as follows:

X'10'	IOB address

General Register 1: The high-order byte of this register always contains zeros. The remaining three bytes contain the address of the data control block (DCB) associated with the error, as follows:

00	DCB address

General Register 14: This register contains the return address of the sort/merge program.

General Register 15: This register contains the address of your error routine.

Your read and write error routines can reside on a library, or can be placed in SYSIN. Your library or SYSIN routines are brought into main storage with their associated phases. (The E28 and E29 routines are reloaded for each pass of the intermediate merge phase.)

Read Error Exits (E18, E28, E38)

PHASE IN WHICH USED:

E18 -- Sort phase
E28 -- Intermediate merge phase
E38 -- Final Merge phase

POSSIBLE USE OF ROUTINES: Your routines at these exits can pass a parameter list containing the specifications for three data control block fields -- SYNAD, EXLST, and EROPT -- to the sort/merge program. Your E18 exit routine can pass a fourth DCB field -- EODAD -- to sort/merge.

Your routines are entered first during the assignment component of each phase so that the sort/merge program can obtain the parameter lists. The routines are entered again during the running components at the points indicated in the parameter lists. For example, if you choose the EXIST option for your E18 routine, sort/merge enters your E18 routine during the execution of the sort phase assignment component. Sort picks up the parameter list, including the EXLST address. During the running component, sort/merge enters your routine at the EXLST address when the data set is opened.

INFORMATION YOUR ROUTINE PASSES TO SORT/MERGE: Your routine passes the DCB fields to sort/merge in a parameter list, the address of which it places in general register 1 before returning to the sort/merge program. The parameter list must begin on a fullword boundary and be a whole number of fullwords long. The high order byte of each word must contain a character code that identifies the parameter. One or more of the words can be omitted. A word of all zeros marks the end of the list. The format of the list is:

Byte 1	Byte 2	Byte 3	Byte 4
01	SYNAD field		
02	EXLST field		
03	0	0	EROPT code
04	EODAD field		
00	0	0	0

A full description of these DCB fields is in the publication IBM System/360 Operating System: Supervisor and Data Management Macro Instructions. A brief description of these fields follows:

SYNAD: This field contains the location of your read synchronous error routine. This routine is entered only after the operating system has tried unsuccessfully to correct the error. The routine must be assembled as part of your E18, E28, or E38 exit routine. When the routine receives control, it must not store registers in the save area pointed to by general register 13.

EXLST: This field contains the location of a list which contains pointers to your routines that you want used to check labels and perform other functions not done by data management. The list and the routines to which it points should be included in your read error routine.

EROPT: The EROPT code is a means whereby you can specify what action sort/merge should take if an uncorrectable read error is encountered. The three possible actions and the codes associated with them are:

X'80' -- Accept the record (block) as is
X'40' -- Skip the record (block)
X'20' -- Terminate the program

If you include this parameter in the DCB field list, you must place one of the above codes in the low-order byte of the word. Bytes 2 and 3 of the word must contain zeros.

When you use the EROPT option, the SYNAD field (and the EODAD field of exit E18) must contain either of the following:

- The address of your read synchronous error routine (or end-of-file routine in the EODAD field). These must be addresses within your exit routine.
- If you do not provide a read synchronous error routine or an end-of-file routine, the fields must contain X'01' in byte 4; bytes 2 and 3 must contain zeros. You can use the instruction DC AL3(1) to set up the field.

EODAD: This field is the address of your end-of-file routine. You can specify this parameter at exit E18 only. If you specify it, your end-of-file routine must be included in your exit routine. The end-of-file routine is used only for the SORTIN data set.

LINKAGE CONVENTIONS: Linkage conventions for these exits are shown in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
CALL E18	ENTRY E18 . . E18 LA 1,parm RETURN CNOP 0,4 parm DC X'01' DC AL3(ser) DC X'02' DC AL3(lst) DC X'03' DC XL3(x) DC A(0) . . ser error routine . . lst address list
ser refers to the read synchronous error routine lst refers to the EXLST address list x is EROPT code	

Write Error Exits (E19, E29, E39)

PHASE IN WHICH USED:

E19 -- Sort phase
E29 -- Intermediate merge phase
E39 -- Final merge phase

POSSIBLE USES OF ROUTINE: Your routines at these exits can pass a parameter list containing the specifications for two DCB fields -- SYNAD and EXLST -- to the sort/merge program.

Your routines are entered first during the assignment component of each phase so that the sort/merge program can obtain the parameter lists. The routines are entered again during the running components at the points indicated by the options in the parameter lists.

INFORMATION YOUR ROUTINE PASSES TO SORT/MERGE: Your routine passes the DCB fields to sort/merge in a parameter list, the address of which it places in general register 1 before returning to the sort. The list must begin on a fullword boundary and must be a whole number of fullwords long. The high-order byte of each word must contain a character code that identifies the parameter. Either word can be omitted. A word of all zeros indicates the end of the list. The format of the list is:

Byte 1	Byte 2	Byte 3	Byte 4
01	SYNAD field		
02	EXLST field		
00	0	0	0

A full description of these DCB fields can be found in the publication IBM System/360 Operating System: Supervisor and Data Management Macro Instructions. A brief description follows:

SYNAD: This field contains the location of your write synchronous error routine. This routine is entered only after the operating system has unsuccessfully tried to correct the error. It must be assembled as part of your exit routine.

EXLST: The EXLST field contains the location of a list that contains pointers to your routines that you want used to check labels and perform other functions not done by data management. This list and the routines to which it points must be included as part of your exit routine.

LINKAGE CONVENTIONS: Linkage conventions for these exits are shown in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
CALL E19	ENTRY E19 . . E19 LA 1,parm RETURN CNOP 0,4 parm DC x'01' DC AL3(ser) DC x'02' DC AL3(lst) DC A(0) . . ser error routine . . lst address list
ser refers to the write synchronous error routine lst refers to the EXLST address list	

CONTROL FIELD MODIFICATION EXIT (E61)

You can use a routine at this exit to lengthen, shorten, or alter any control field within a record. The E option for the s parameters on the SORT or MERGE control statement must be specified for control fields changed by this routine. (Refer to the topic "Defining the Sort or Merge in Section 2.")

PHASE IN WHICH USED: Your routine is loaded with the running portion of each phase and is executed whenever sort/merge encounters a control field specified by the E option.

POSSIBLE USES OF ROUTINE: Your routine can normalize floating point control fields or change any other type of control field in any way that you desire. You should be familiar with the standard data formats used in System/360 before modifying control fields.

INFORMATION SUPPLIED TO YOUR ROUTINE BY SORT/MERGE: Sort/merge places the address of a parameter list in general register 1. The list begins on a fullword boundary and is two fullwords long. It contains the number (in hexadecimal) of the control field in the low-order byte of the first word, and the address of the control field in the three low-order bytes of the second word as follows:

Byte 1	Byte 2	Byte 3	Byte 4
00	00	00	01-40
00	Control Field Address		

Before it passes your routine the control field address, sort/merge moves the control field to an extract area, an area apart from the record. Your routine, in effect, changes an image of the control field and not the control field itself. Because of internal manipulation by sort/merge, the control fields appear in the extract area in the following format:

Binary: Unchanged.

Character: Unchanged.

Fixed-point: The sign bit is inverted.

Positive floating-point: The sign bit is inverted.

Negative floating-point: The sign bit is inverted and the numeric portion of the number is in one's complement notation; that is, zeros become ones and ones become zeros.

Packed decimal: The sign is considered a separate control field. It is inverted and placed before the numeric portion of the number. If the records are to be ordered in descending sequence, the numeric portion appears in one's complement notation. For ascending sequence, the numeric portion is unchanged.

Zoned decimal: The control field is converted to packed decimal and treated as above.

For all fields except binary, the number of bytes sort/merge passes to your routine is equal to the length specified in the m parameters of the SORT or MERGE statement. The field your routine returns to sort/merge must contain the same number of bytes.

All binary fields passed to your routine contain a whole number of bytes. If a binary field does not begin and end on a byte boundary, sort/merge pads it with zeros at beginning and/or end.

Your routine cannot physically change the length of the control field. If you must increase the length for collating purposes, you must specify that length in the m parameter of the SORT or MERGE statement. If you must shorten the control field, you must pad the field to the specified length before returning it to sort/merge.

Sort/merge collates the modified control field in absolute ascending order.

LINKAGE CONVENTIONS: Linkage conventions for exit E61 are shown in the following table:

Code Sort/Merge Uses to Enter Your Routine	Code Your Routine Uses to Return to Sort/Merge
CALL E61	ENTRY E61 . . E61 SAVE (5,9) . . RETURN (5,9)

EXIT	USE	PHASE
E11	Assignment Opening Data Sets	Sort
E15	Record Change	Sort
E16	NMAX	Sort
E17	Closing data sets	Sort
E18	Read Error Routine	Sort
E19	Write Error Routine	Sort
E21	Assignment Opening Data Sets	Int. Merge
E25	Record Change	Int. Merge
E27	Closing Data Sets	Int. Merge
E28	Read Error Routine	Int. Merge
E29	Write Error Routine	Int. Merge
E31	Assignment Opening Data Sets	Final Merge
E35	Record Change	Final Merge
E37	Closing Data Sets	Final Merge
E38	Read Error Routine	Final Merge
E39	Write Error Routine	Final Merge
E61	Change Control Field Contents	All Phases

Register Conventions

REGISTER	USE
1	Sort/Merge places address of parameter list in this register.
13	Sort/Merge places address of a save area in this register. Area may be used to save contents of registers used by routine.
14	Contains address of sort/merge return point.
15	Contains address of your routine. May be used as base register for routine. This register is also used by routine to pass return codes to sort/merge.

Section 4: Efficient Program Use

Once you become familiar with the basic functions of the sort/merge program, you will be concerned with program efficiency -- how to get a faster sort or merge. In this section the following subjects involving program efficiency are discussed:

- Information you can supply to the sort/merge program to optimize its operation.
- Intermediate storage assignment for optimum performance.
- Multiprogramming efficiency considerations.
- System generation options and requirements.

Supplying Information to the Program

The information you give the sort/merge program about the application it is to perform helps the sort and merge phases to produce a fast, efficient sort or merge. When you do not supply information such as data set size and record format, the program must make assumptions, which, if incorrect, lead to inefficiency.

DATA SET SIZE

The most important information you can give the program is an accurate data set size using the SIZE parameter of the SORT or MERGE statement. If you know the exact number of records in the input data set, use that number as the value of the SIZE parameter. If you do not know the exact number, estimate it as closely as you can.

When the sort/merge program has accurate information about data set size, it can make the most efficient use of both main storage and intermediate storage.

BLOCKING INPUT RECORDS

Sort performance is improved if you block input records. Ideally, you should use the same blocking factor that the sort/merge program uses internally. If your machine configuration, main storage allotted to the program, and record size are the same as one of those listed in the publication IBM System/360 Operating Systems: Sort/Merge Timing Estimates, Form C28-6662, use the figure given in the sort block column. Otherwise, use the sort block figure corresponding to entries that most closely describe your configuration.

RECORD FORMAT

When your input data set consists of variable length records, use the RECORD statement to supply maximum, minimum, and modal (most frequent) lengths to the sort/merge program. This information allows the program to calculate the optimum sort.

Intermediate Storage Assignment

If you can, avoid assigning the bare minimum amount of intermediate storage for a given application. When a small amount of intermediate storage is assigned to the program, more intermediate merge phase passes are necessary because only a small number of record sequences can be merged at one time. Naturally, these extra passes increase sorting time.

Likewise, when the program has only a small amount of main storage to operate in, more intermediate merge phase passes are necessary because only a small number of records can be sorted internally and more sequences are produced.

The sort/merge program operates efficiently when at least two selector channels are available. A tape switching device also improves program performance, if the device is connected so that two channel paths exist between each device and the central processing unit that is running the sort/merge program.

ASSIGNING DIRECT ACCESS INTERMEDIATE STORAGE

Program performance is improved if you use devices, storage areas, and channels efficiently. If you use UNIT=2311, 2314, or 2301 on the DD statements that define intermediate storage data sets, the program assigns areas, and some optimization occurs automatically. But maximum performance is achieved if you follow these recommendations:

- Use as many physical devices as you have available. (If you place more than one intermediate storage data set on a disk, place them as close together as possible to minimize access arm movement.)
- Use channel overlap whenever you can.
- On 2311 and 2301, assign as few data sets as possible. (You need at least three. Three large data sets are more efficient than six smaller ones.) On 2314, assign as many data sets as possible, (17 maximum) but not more than one for each device.
- Assign data sets of similar sizes.

Assigning more than three intermediate storage data sets (the minimum number) on a 2311 disk or a 2301 drum decreases program efficiency unless you assign the data sets to different devices. Sometimes you may need the maximum (six for the 2311 and 2301) number of data sets to handle a large input data set. To preserve efficiency, assign them on separate physical devices.

For example, if a 100-track area is available on each of three 2311 disk drives, you can handle more records if you define six data sets, each 50 tracks long, two on each device, but you decrease efficiency. If the size of the input data set permits, you can increase efficiency by defining fewer areas. For maximum efficiency, define three 100-track areas, each on a different device.

If your intermediate storage is on 2314, you can obtain maximum efficiency by assigning one data set per access arm. Also, efficiency decreases as the size of your input data set approaches sort capacity.

If you use channel overlap program performance is improved because the program can read input while writing output, etc.

Figure 15 shows a method for specifying channel overlap. The SEP parameter on the SORTWK01 DD statement requests that the operating system assign that data set to a channel other than the channel assigned to the SORTIN data set. The AFF parameter on the SORTWK03 and SORTOUT DD statements requests that the SORTWK03, and SORTOUT data sets, also be on a channel that is different from SORTIN. The channel assigned to SORTWK02 and SORTWK04 is not necessarily the same as the one assigned to SORTIN.

The operating system will honor your channel assignment requests when the necessary channel and device resources are available. If the requests cannot be filled, the system assigns channels according to the resources it has. Therefore, specifying channel overlap will never impair performance.

```
//SORTIN   DD   DSNAME=INPUT,VOLUME=SER=000001,UNIT=2311,DISP=(OLD,KEEP),    X
//              DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//SORTWK01 DD   DSNAME=WORK1,VOLUME=SER=000002,UNIT=2311,                    X
//              SEP=SORTIN,SPACE=(TRK,(15),,CONTIG)
//SORTWK02 DD   DSNAME=WORK2,VOLUME=SER=000003,UNIT=2311,                    X
//               SPACE=(TRK,(15),,CONTIG)
//SORTWK03 DD   DSNAME=WORK3,VOLUME=SER=000004,UNIT=2311,                    X
//              AFF=SORTWK01,SPACE=(TRK,(15),,CONTIG)
//SORTWK04 DD   DSNAME=WORK4,VOLUME=SER=000005,UNIT=2311,                    X
//               SPACE=(TRK,(15),,CONTIG)
//SORTOUT  DD   DSNAME=OUTPUT,VOLUME=SER=000006,UNIT=2311,DISP=(NEW,KEEP),   X
//              DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200),                        X
//              AFF=SORTWK01,SPACE=(TRK,(50),,CONTIG)
```

Figure 15. DD Statements Illustrating Channel Overlap

ASSIGNING TAPE INTERMEDIATE STORAGE

You can use the timing tables in the publication IBM System/360 Operating System Sort/Merge Timing Estimates, Form C28-6662 as guide lines for assigning tape intermediate storage.

Multiprogramming the Sort/Merge Program

You should consider the following factors when you execute the sort/merge program with other programs:

- The sort/merge program may use many I/O devices for input, output, and intermediate storage. You should assign it a relatively high priority to be sure that it gets control of the central processing unit frequently and does not tie up the I/O devices while it waits for CPU time.
- The sort/merge program tends to be I/O limited. Therefore, you should multiprogram the sort with programs that are process limited.
- When a single task attaches two or more sort applications by ATTACH, LINK, or XCTL, you must modify the standard DD names (SORTIN, SORTOUT, etc.) so that they are unique. Do this by specifying four letters in the parameter list passed to the sort/merge program. These characters replace the letters SORT in the references to standard DD names in sort/merge program modules. (For more information, see the topic "Passing Parameters to the Sort" in Section 2.)

System Generation Options and Requirements

When the operating system for your installation is generated, certain sort/merge facilities may be included; others may not be. You should be aware of what is available at your installation. The following list is a summary of the sort/merge facilities that can be included when the program is generated:

- Sort or merge fixed-length records.
- Sort or merge variable-length records.
- Sort or merge records over 256 bytes long.
- Operate with any or all allowable intermediate storage devices. (Only one type can be used for a specific sort run.)

- Sort or merge multiple control fields.
- Use sort/merge program exits.
- Print non-critical program-generated messages.
- Use (a specific number) of bytes of main storage as a maximum for sort/merge execution.

Selecting only the required program facilities conserves library space. If you attempt to execute an option that was not selected, the program terminates abnormally. System generation is described in the publication IBM System/360 Operating System: System Generation, Form C28-6554.

LIMITING MAIN STORAGE

If the maximum amount of main storage to be used by the sort/merge program was not specified at system generation time, the program assumes a maximum of 15,500 bytes. The program requests 12,000 bytes leaving 3,500 bytes for system functions, Performance usually improves as the program is given more main storage. Approximately 44K bytes of main storage are needed for efficient execution of the sort/merge program, and performance usually increases as more main storage is made available.

The maximum amount of main storage that can be made available to the program can be determined by subtracting the amount of storage required by system functions from the total amount available. The amount of main storage required for the execution of various operating components is given in the publication IBM System/360 Operating System: Storage Estimates, Form C28-6551. The publication IBM System/360 Operating System: System Generation, Form C28-6554, gives a formula for calculating the maximum amount of main storage.

On an execution by execution basis, you can change two of the system generation specifications: main storage size and types of messages printed.

ALTERING THE MAIN STORAGE ALLOCATION

You can override the amount of main storage specified at system generation time by using the PARM field of the EXEC statement. Write the field as follows:

```
PARM='CORE=xxxxxx'
```

where xxxxxx is the amount of main storage in bytes that you want to operate with. xxxxxx cannot be less than 12,000, and at this value, some combinations of I/O devices and record lengths make a successful sort impossible. For MVT, the region size must be bigger than the sort size. Region size should be approximately 1.2 times the sort size + 8K. The main storage value is changed only for the current job step; afterwards, the value reverts to the one specified at system generation time.

Changing the main storage allocation is useful when you are running a sort/merge application in a multiprogramming environment. By reducing the amount of main storage allocated, you impair sort/merge performance so that other programs can have the storage they need to operate simultaneously. By increasing the allocation, you can run large sort/merge applications efficiently at the expense of other jobs sharing the multiprogramming environment.

ALTERING THE MESSAGE SPECIFICATION

You can override the message option selected at system generation by using the PARM field of the EXEC statement. Write the field as follows:

```
PARM='MSG=xx'
```

where xx is a two-character code that specifies what kind of messages you want printed and where you want them to appear.

NO means that you want no messages to be printed.

CC means that you want critical messages only to be printed and you want them to appear on the console.

CP means critical messages only and that you want them to appear on the printer.

AC means that you want all messages (critical and informational) printed on the console.

AP means that all messages are to be printed on the printer.

The time factor involved in printing messages is relatively small. The printer is slightly faster that the console so you probably could save a few seconds by specifying CP or AP rather than CC or AC.

Glossary

The following terms and phrases are defined as they are used in this publication.

ascending sequence: A sequence of records such that the control word of each successive record collates equal to or greater than that of the preceding record.

assignment component: A sort/merge program component that establishes the basic constants needed for program execution and initializes running components for a specific application.

block: A group of contiguous data read or recorded by an I/O device as one unit.

collating sequence: A predetermined sequence into which data can be sorted or merged.

control field: A group of contiguous data within a record that forms all or part of a control word.

control word: A group of control fields used to order records according to the collating sequence during a sort or merge.

descending sequence: A sequence of records such that the control word of each successive record collates equal to or less than that of the preceding record.

input data set: The data set (or data sets) used as input to the sort/merge program.

intermediate storage data set: A partially sequenced data set that is either input to or output from an intermediate merge phase pass.

major control field: The control field that is most significant in determining the collating sequence of a record.

merge: The process used to form one sorted sequence of records from two or more previously sorted sequences. Also, a program or routine that performs this function.

merge pass: The passing of all the records used as input to the sort/merge through a program phase which merges previously sorted sequences into fewer, longer sequences.

minor control field: A control field which is less significant than the major control field in determining the collating sequence of a record. Successive minor control fields are considered to be in decreasing order of significance.

modal length: The record length that occurs most frequently in a variable-length record data set used as input to the sort/merge program.

nmax: The estimated maximum number of records of a given length that can be sorted using a given amount of intermediate storage.

output data set: The sequenced data set which is produced by a sort/merge program execution.

phase: A portion of the sort/merge program that is designed to perform one of the following functions: definition, optimization, sorting, intermediate merging, or final merging.

program exit: A place in the executable code of the sort/merge program component at which a user-written routine may be given control to perform various functions.

record: A group of contiguous characters which is processed as a unit by the sort/merge program.

running component: A sort/merge program component that performs a sorting or merging operation on the data set used as input to the program. Running components are initialized by assignment components.

sequence: A group of records that have been collated into a predesignated order.

sequence distribution technique: One of several methods used by the sort/merge program to combine previously sorted sequences of records into fewer, longer sequences.

sort: The process used to collate the records in a data set of unknown order. Also, a program or routine that performs this function.

sort blocking factor: The blocking factor used by the sort/merge program for intermediate storage data sets.

user-written routine: A routine written by the user to perform various functions at a sort/merge program exit.

Appendix A: Summary of How to Use the Sort/Merge Program

The following is a summary of what you need to do to use the sort/merge program:

- Prepare sort/merge control statements defining the sorting or merging application. (Refer to the topic "Defining the Sort or Merge" in Section 2).
- For a sorting application, determine the amount of intermediate storage the sort/merge program will need for your data set. (Refer to the topic "Determining Intermediate Storage Requirements" in Section 2.)
- Prepare job control language statements to accompany the sort/merge statements. (Refer to the topic "Required Job Control Language Statements" in Section 2.)

The following chart shows the three points mentioned above in greater detail.

The chart does not cover the following points:

- EXEC statement PARM field options: forcing a sequence distribution technique (Refer to "Sequence Distribution Techniques" in Section 1 for descriptions of the techniques; and "Job Control Language for Sort/Merge" in Section 2 for how to code the option), message option (refer to "Job Control Language for Sort/Merge" in Section 2), core value option (refer to "Job Control Language for Sort/Merge" in Section 2.)
- The checkpoint option. (Refer to "Defining the Sort or Merge" in Section 2 for how to select the option, and "Job Control Language for Sort/Merge" for information on the required SORTCKPT DD statement.)
- Achieving maximum sort/merge efficiency. (Refer to "Section 4: Efficient Program Use.")

Appendix B: Considerations for MVT Users—Summary

REGION SIZE

The SORT cataloged procedure requests a region size of 98K. The SORTD cataloged procedure requests 26K.

A formula for determining region size is given in Section 1: "Determing Region Size."

OPTIONAL CHARACTERS FOR DD NAMES

If a task initiates two or more sort/merge applications via ATTACH, LINK, or XCTL, this option must be selected. It is discussed in the topic "Passing Parameters to the Sort" in Section 2.

ALTERING THE MAIN STORAGE ALLOCATION

The amount of main storage assigned to sort/merge at system generation can be changed. It can be temporarily increased to improve sort/merge performance or temporarily decreased to permit other programs to obtain main storage. Refer to "Altering the Main Storage Allocation" in Section 4 for further details.

OTHER

Refer to "Multiprogramming the Sort/Merge Program" in Section 4.

Appendix C: Standard System/360 Operating System Collating Sequence

The following table shows the collating sequence for character and unsigned decimal data. The bit configuration shown is EBCDIC. The collating sequence is based on the EBCDIC representation of the graphic and ranges from low (00000000) to high (11111111). The bit configurations which do not correspond to graphics (e.g., 0 - 73, 81 - 89, etc.) are not shown. Some of these correspond to control commands for the printer and other devices.

Packed decimal, zoned decimal, fixed-point, and normalized floating-point data is collated algebraically; i.e., each quantity is interpreted as having a sign.

Collating Sequence	Bit Configuration	Graphic	Meaning
	00000000		
.			
.			
74	01001010	¢	Cent sign
75	01001011	.	Period, decimal point
76	01001100	<	Less than sign
77	01001101	(	Left parenthesis
78	01001110	+	Plus sign
79	01001111	|	Vertical bar, Logical OR
80	01010000	&	Ampersand
.			
.			
90	01011010	!	Exclamation point
91	01011011	$	Dollar sign
92	01011100	*	Asterisk
93	01011101	)	Right parenthesis
94	01011110	;	Semi colon
95	01011111	¬	Logical not
96	01100000	-	Minus, hyphen
97	01100001	/	Slash
.			
.			
107	01101011	,	Comma
108	01101100	%	Percent sign
109	01101101	_	Underscore
110	01101110	>	Greater than sign
111	01101111	?	Question mark
.			
.			
122	01111010	:	Colon
123	01111011	#	Number sign
124	01111100	@	At sign
125	01111101	'	Apostrophe, prime
126	01111110	=	Equals sign
127	01111111	"	Quotation marks
.			
129	10000001	a	
130	10000010	b	
131	10000011	c	
132	10000100	d	
133	10000101	e	
134	10000110	f	
135	10000111	g	
136	10001000	h	
137	10001001	i	
.			
.			
145	10010001	j	
146	10010010	k	

147	10010011	l
148	10010100	m
149	10010101	n
150	10010110	o
151	10010111	p
152	10011000	q
153	10011001	r
.		
.		
162	10100010	s
163	10100011	t
164	10100100	u
165	10100101	v
166	10100110	w
167	10100111	x
168	10101000	y
169	10101001	z
.		
.		
193	11000001	A
194	11000010	B
195	11000011	C
196	11000100	D
197	11000101	E
198	11000110	F
199	11000111	G
200	11001000	H
201	11001001	I
.		
.		
209	11010001	J
210	11010010	K
211	11010011	L
212	11010100	M
213	11010101	N
214	11010110	O
215	11010111	P
216	11011000	Q
217	11011001	R
.		
.		
226	11100010	S
227	11100011	T
228	11100100	U
229	11100101	V
230	11100110	W
231	11100111	X
232	11101000	Y
233	11101001	Z
.		
.		
240	11110000	0
241	11110001	1
242	11110010	2
243	11110011	3
244	11110100	4
245	11110101	5
246	11110110	6
247	11110111	7
248	11111000	8
249	11111001	9

Appendix D: Sort/Merge Messages

The sort/merge program generates two kinds of messages -- those which result from critical error conditions and those which give information about the program's operation. The printing of either all messages or only critical messages can be specified at system generation. The messages can either be printed on a printer or at the operator's console.

The message options set up at system generation can be overridden on a job step by jobstep basis by coding the MSG parameter in the PARM field of the EXEC statement. Refer to the topic "EXEC Statement" in "Section 2: How To Use The Sort/Merge Program," for a complete discussion of the MSG parameter.

The sort/merge program analyzes control statements in two stages. Stage 1 analyzes the general format of control statements. Stage 2 analyzes the information contained in the sort/merge control statements and job control language statements. Stage 2 checks for sort syntax and contents errors. Each statement is scanned for errors. The first error detected stops the scan for that statement. The program prints a message and continues the scan on successive statements.

When the program encounters a critical error in either stage, it prints a message and continues to analyze control information until the current stage is completed, then the program terminates. Thus, if a critical error is found in Stage 1, the program terminates at the end of Stage 1; if the error is encountered in Stage 2, the program terminates at the end of Stage 2. The system action that results from encountering a critical control information error is described in the messages as either "Stage 1 termination" or "Stage 2 termination."

The messages are listed and explained in message code order, from IER001 to to IER068. The last character of each message (A or I) indicates the severity of the message. A means that programmer action is required. I means that the message is an informational one and no action is required. The explanations of all critical messages begin with "Critical."

IER001A - COL 1 OR 1-15 NOT BLANK

Explanation: Critical. Column 1 of a sort/merge control statement is not blank, or columns 1 through 15 of a sort/merge continuation card are not blank.

System Action: Stage 1 termination.

User Response: Check control statements for nonblank characters in column 1, and continuation cards for nonblank characters in columns 1 through 15.

IER002A - EXCESS CARDS

Explanation: Critical. This message is generated for one of four reasons:

- More than 33 control cards are supplied to the sort/ merge program.
- A sort/merge control statement type appears more than once. (For example, there is more than one SORT statement.)
- The control statements passed to the sort/merge program during an ATTACH, LINK, or XCTL operation contain more information than is allowed for the statements passed.
- A control statement occupies more than the allowable number of cards.

System Action: Stage 1 termination. The program does not analyze control cards above the 33 limit or duplicate type statements. If the sort was activated by an ATTACH, LINK, or XCTL, no information is processed.

User Response: Check for too many control cards, duplicate statement types, and, if the sort was activated by an ATTACH, LINK, or XCTL, more information than allowed.

IER003A - NO CONTIN CARD

Explanation: Critical. A continuation card has been indicated by a nonblank character in column 72 of the previous card and no card follows.

System Action: Stage 1 termination.

User Response: Check for a keypunching error, an overflow of parameters into column 72, or a missing continuation card.

IER004A - INVALID OP DELIMITER

Explanation: Critical. A control statement ends with a comma or other incorrect delimiter.

System Action: Stage 1 termination.

User Response: Check for operands that are incorrectly split between control and continuation cards. Refer to the topic "Continuation Cards" in Section 2.

IER005A - STMT DEFINER ERR

Explanation: Critical. A control statement that should contain an operation definer (SORT, MERGE, RECORD, MODS, or END) does not contain an acceptable one.

System Action: Stage 1 termination.

User Response: Check all statements for incorrect, misplaced, or misspelled operation definers.

IER006A - OP DEFINER ERR

Explanation: Critical. The first operand of a control statement does not begin on the same statement as the operation definer.

System Accion: Stage 1 termination.

User Response: Check for statements that contain only the operation definer.

IER007A - SYNTAX ERR - xxx

Explanation: Critical. A control statement contains an error in syntax. xxx is a 3-character code ("S/M," "REC," or "MOD") that indicates the control statement in which the error occurred.

System Action: Stage 2 termination.

User Response: Check the control statements for syntax errors. Some of the more common syntax errors are:

- Unbalanced parentheses.
- Missing commas.
- Embedded blanks.

IER008A - FLD OR VALUE GT 8 CHAR - xxx

Explanation: Critical. A parameter greater than 8 characters has been specified. xxx is a 3-character code ("S/M," "REC," or "MOD") that indicates the control statement in which the error occurred.

System Action: Stage 2 termination.

User Response: Check control statements for parameters with more than eight characters.

IER009I - EXCESS INFO ON CARD - xxx

Explanation: More information than necessary appears in a control statement. This could possibly be caused by a syntax error which cannot be diagnosed by the program. xxx is a 3-character code ("S/M," "REC," or "MOD") that indicates the control statement in which the error occurred. This message is also printed when comments appear on a card.

System Action: The excess information is treated as a comment.

User Response: Check control statements, unless comments are intended.

IER010A - NO S/M CARD

Explanation: Critical. All control statements have been processed and no SORT or MERGE control statement has been found.

System Action: Stage 2 termination.

User Response: Supply a SORT or MERGE control statement.

IER011A - TOO MANY S/M KEYWORDS

Explanation: Critical. More than the maximum of 5 keyword operands are defined on a SORT or MERGE control statement.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement for too many keyword operands.

IER012A - NO FLD DEFINER

Explanation: Critical. A SORT or MERGE control statement does not contain a control field definition.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement for lack of a control field definition (FIELD operand).

IER013A - INVALID S/M KEYWORD

Explanation: Critical. An invalid keyword operand has been detected on a SORT or MERGE control statement.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement for invalid keyword operand.

IER014A - DUPLICATE S/M KEYWORD

Explanation: Critical. A keyword operand is defined twice on a SORT or MERGE control statement.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement for a multiply defined keyword operand.

IER015A - TOO MANY PARAMETERS

Explanation: Critical. Too many parameters are associated with a keyword operand on a SORT or MERGE control statement.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement keyword operands for too many parameters.

IER016A - INVALID VALUES IN FLD

Explanation: Critical. An invalid number of values is specified with a FIELDS operand on a SORT or MERGE control statement.

System Action: Stage 2 termination.

User Response: Check values in control field definitions on SORT or MERGE control statement.

IER017A - ERR IN DISP LENGTH VALUE

Explanation: Critical. An invalid length or displacement (position) value is specified in a control field definition on a SORT or MERGE control statement.

System Action: Stage 2 termination.

User Response: Check length and position values specified in the FIELDS operand on a SORT or MERGE control statement.

IER018A - CTL FLD ERR

Explanation: Critical. An error in specifying the type of control field defined in a SORT or MERGE control statement has been detected.

System Action: Stage 2 termination.

User Response: Check control field types on SORT or MERGE control statement for keypunching or other errors in specification.

IER019A - SIZE/SKIPREC ERR

Explanation: Critical. An error in specifying the SIZE operand in either a SORT or MERGE control statement, or the SKIPREC operand in a SORT control statement, has been detected.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement for invalid SIZE or SKIPREC operand.

IER020A - INVALID REC KEYWORD

Explanation: Critical. An invalid keyword operand has been found in a RECORD control statement.

System Action: Stage 2 termination.

User Response: Check RECORD control statement for keypunching or other error in a keyword operand.

IER021A - NO TYPE DEFINER

Explanation: Critical. A RECORD control statement has been found without a TYPE operand.

System Action: Stage 2 termination.

User Response: Check RECORD control statement for lack of TYPE operand.

IER022A - RCD FORMAT NOT F/V

Explanation: Critical. An error in specifying the value associated with the TYPE operand of a RECORD control statement has been detected.

System Action: Stage 2 termination.

User Response: Check the RECORD control statement for keypunching or other errors resulting in TYPE operand value being some character other than F (fixed-length records) or V (variable-length records).

IER023A - NO LENGTH DEFINER

Explanation: Critical. The LENGTH operand of a RECORD control statement is not present.

System Action: Stage 2 termination.

User Response: Check RECORD control statement for lack of LENGTH operand.

IER024A - ERR IN LENGTH VALUE

Explanation: Critical. An incorrect value is associated with the LENGTH parameter of a RECORD control statement.

System Action: Stage 2 termination.

User Response: Check RECORD control statement for incorrectly specified length value.

IER025A - RCD SIZE GT MAX

Explanation: Critical. The record size specified on a RECORD control statement is greater than the maximum allowed by the program.

System Action: Stage 2 termination.

User Response: Check RECORD control statement for incorrectly specified record length.

IER026A - L1 NOT GIVEN

Explanation: Critical. The LENGTH operand of a RECORD control statement lacks an l_1 value.

System Action: Stage 2 termination.

User Response: Check RECORD control statement for lack of l_1 value in LENGTH operand.

IER027A - CF BEYOND RCD

Explanation: Critical. A control field has been defined as extending beyond the minimum record length specified in a RECORD control statement.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statement for incorrectly specified control field displacement. Check RECORD control statement for incorrectly specified maximum record length (l_2).

IER028A - TOO MANY EXITS

Explanation: Critical. An attempt has been made to activate more than the maximum number of program exits allowed by the program (17).

System Action: Stage 2 termination.

User Response: Reduce the number of exits specified in the MODS control statement.

IER029A - IMPROPER EXIT

Explanation: Critical. This message is generated for one of two reasons:

- An exit other than the 17 allowed by the program has been specified on a MODS control statement.
- An exit in the sort or intermediate merge phase of the program has been activated during a merge application.

System Action: Stage 2 termination.

User Response: Check MODS control statement for keypunching error or other error resulting in specification of invalid program exit number. If a merge is being performed, check MODS control statement for exit numbers which refer only to sort or intermediate merge phase exits.

IER030A - MULTIPLY DEFINED EXIT

Explanation: Critical. A program exit has been defined twice in MODS control statement.

System Action: Stage 2 termination.

User Response: Check MODS control statement for multiply defined exits.

IER031A - INVALID MODS OP CHAR

Explanation: Critical. An invalid character in a parameter of a MODS control statement has been found.

System Action: Stage 2 termination.

User Response: Check the parameters of a MODS control statement for a length field containing something other than numeric data, a source or name field beginning with something other than an alphabetic character, or a source or length field containing a special character other than $, @, or #.

IER032A - EXIT E61 REQUIRED

Explanation: Critical. A SORT or MERGE control statement defines a control field calling for user-written routine (this is done by specifying E for the control field sequence indicator), and exit E61 is not activated by a MODS control statement.

System Action: Stage 2 termination.

User Response: Check SORT or MERGE control statements for keypunching errors resulting in the specification of an E type parameter. Check the MODS control statement, for lack of an E61 specification.

IER033A - CF SEQ INDIC E REQUIRED

Explanation: Critical. Program exit E61 is activated and no control fields have been specified for user modification (E control field sequence parameter missing on SORT or MERGE control statement).

System Action: Stage 2 termination.

User Response: Check MODS, and SORT or MERGE control statements for keypunching errors resulting in the activation of exit E61 and the lack of an E type parameter on the SORT or MERGE control statement.

IER034A - PARAM ERR FOR MODS

Explanation: Critical. An incorrect number of parameters follow an operand definer on a MODS control statement, or SYSIN is specified on the MODS statement as the source for user-written routines, and no //SORTMODS DD statement is present.

System Action: Stage 2 termination.

User Response: Check MODS control statement for parameter specification error.

IER035A - DUPLICATE MOD RTN IN PHASE

Explanation: Critical. The same user-written routine is being used for more than one exit in a sort/merge program phase, or two or more routines have the same name.

System Action: Stage 2 termination.

User Response: Check the MODS control statement for improper use of duplicate names. Duplicate names within a phase may be used only when the user-written routines are to be link edited together, and they are in one load module.

IER036I - B = xxxxxx

Explanation: This message communicates the blocking used by the sort for intermediate storage records. For fixed-length records, the blocking factor is substituted for xxxxxx in the message text. For variable-length records, the size of the buffer area is substituted for xxxxxx in the message text.

System Action: None.

User Response: None.

IER037I - G = xxxxxx

Explanation: This message communicates the number of records that can fit into the program's record storage area at one time during a sort. The number of records is substituted for the xxxxxx in the text of the message as shown above.

System Action: None.

User Response: None.

IER038I - NMAX = xxxxxx

Explanation: This message communicates an estimate of the maximum number of records that can be sorted using the intermediate storage and main storage available to the sort for the current application. The number replaces the xxxxxx in the text of the message as shown above.

System Action: None.

User Response: None.

IER039A - INSUFFICIENT CORE

Explanation: Critical. There is not enough main storage available to the sort to allow program execution.

System Action: The program terminates.

User Response: The sort requests main storage from 12,000 bytes to the maximum amount specified by the user at system generation. For any given execution, the minimum amount required depends upon the number of intermediate storage data sets, the record length, and the block size. Reducing the number of intermediate storage data sets reduces the amount of main storage required for buffer areas. If the number of intermediate storage data sets is at the minimum allowed for the application, reducing the block size may also reduce the amount of main storage needed for buffer areas. If such corrective action is not possible, the user-specified maximum must be increased using the CORE parameter in the PARM field of the EXEC statement.

IER040A - INSUFFICIENT WORK UNITS

Explanation: Critical. There is not enough intermediate storage available to the sort to allow program execution.

System Action: Stage 2 termination.

User Response: Check DD statements for errors. Check to see if less than three intermediate storage units were assigned. Assign more intermediate storage to sort. If 2311 disks or 2301 drums are assigned, check to be sure that at least three areas of at least three tracks each are specified on the DD statements. With the 2314 facility, three data sets of at least five tracks each must be assigned.

IER041A - N GT NMAX

Explanation: Critical. The number of records specified in the SIZE operand of a SORT control statement is greater than the maximum sort capacity calculated by the program.

System Action: The program terminates unless data set size was estimated or not given; then sort continues.

User Response: Check SIZE operand of SORT control statement for error. If SIZE operand is correct, check DD statements for an error in assigning intermediate storage. If DD statements are correct, assign more intermediate storage to the program and rerun.

IER042A - UNITS ASGN ERROR

Explanation: Critical. A. Different types of intermediate storage devices, or an invalid combination of input, work, and output devices have been assigned to the sort. B. Duplicate ddnames have been specified.

System Action: Stage 2 termination.

User Response: A. Assign intermediate storage so that all units are of the same type, i.e., all are either direct-access units or tape units. Only when 7-track tape is used for the input unit may it be used for the intermediate storage units and the output units. B. Check DD statements for duplication.

IER043A - DATA SET ATTRIBUTES NOT SPECIFIED

Explanation: Critical. DD statements that define the input and output data sets conflict with each other or lack any of the following information:

- Input or output blocking factor (BLKSIZE).
- Record format (RECFM).
- Record length (LRECL).

System Action: Stage 2 termination.

User Response: Correct statements and rerun job.

IER044I - EXIT Exx INVALID OPTION

Explanation: An invalid data control block field specification was passed to the sort/merge program at exit E18, E19, E28, E29, E38, or E39. The xx value in the above message text is replaced by the number of the exit at which the error occurred.

System Action: The invalid option is ignored.

User Response: Check the parameter list passed by the user-written routine against the following table before rerunning the application. An x indicates which options are allowed with the exit in question.

Option	E18	E19	E28	E29	E38	E39
SYNAD	x	x	x	x	x	x
EXLST	x	x	x	x	x	x
EROPT	x		x		x	
EODAD	x					

IER045I - END SORT PH

Explanation: The program's sort phase has been successfully executed.

System Action: None.

User Response: None.

IER046A - SORT CAPACITY EXCEEDED

Explanation: Critical. The sort has used up all available intermediate storage and the input data set has not been exhausted.

System Action: The program terminates.

User Response: If magnetic tape is used for intermediate storage, be sure all reels contain full length tapes. (Short tapes may result from excessive write errors.) If all reels contain full length tapes, rerun the application with more intermediate storage. If a direct access device is used for intermediate storage, assign more tracks.

IER047A - RCD CNT OFF, IN xxxxxx, OUT xxxxxx

Explanation: Critical. The number of records entering and leaving a program phase are not equal; these numbers do not include records inserted or deleted by user-written routines. If an actual data set size was specified in the SIZE parameter of the SORT control statement, it is placed in the IN field of this message. This message can appear in phase 1 or phase 2. In phase 3 the message is RCD CNT OFF and message IER054I contains the count. The numbers replace the values specified as xxxxxx in the text of the message as shown above.

System Action: The program terminates.

User Response: Check for valid SIZE value. If correct, rerun the job.

IER048I - NMAX EXCEEDED

Explanation: The sort has exceeded the calculated sort capacity while processing the input data set, and exit E16 is specified.

System Action: The user-written routine at exit E16 is entered. (See the section "Program Modification," for further information.)

User Response: None. (The number of records sorted is equal to the Nmax calculated by the sort. See sort message IER038I.)

IER049I - SKIP MERGE PH

Explanation: It is not necessary to execute the intermediate merge phase to complete a sorting application because the number of sequences created by the sort phase is $\leq$ the merge order.

System Action: Control is passed directly from the sort phase to the final merge phase.

User Response: None.

IER050I - END MERGE PH

Explanation: The program's intermediate merge phase has been successfully executed.

System Action: None.

User Response: None.

IER051A - UNENDING MERGE

Explanation: Critical. There is not enough intermediate storage assigned to successfully complete the program's intermediate merge phase.

System Action: The program terminates.

User Response: Rerun the job after assigning more intermediate storage to the sort/merge program.

IER052I - EOJ

Explanation: The program's final merge phase has been successfully executed.

System Action: Return is made to the operating system for a normal end of task.

User Response: None.

IER053A - OUT OF SEQ

Explanation: Critical. The current record leaving the final merge phase is not in collating sequence with the last record blocked for output.

System Action: The program terminates.

User Response: If a user-written routine was modifying the records leaving the final merge phase at the time this message was generated, check the routine thoroughly. If not, rerun the job.

IER054I - RCD IN xxxxxx, OUT xxxxxx

Explanation: This message lists the number of records accepted by the sort as input and the number of records in the output data set. The numbers replace the xxxxxx in the text of the message as shown

above. Leading zeros are suppressed; if there were no records in the input data set, this field will be blank. In a merging application, the RECORDS IN field is blank unless an actual data set size was specified in the SIZE parameter of the MERGE control card. When an actual size is specified, it is inserted in the IN field of the message.

System Action: None.

User Response: None.

IER055I - INSERT xxxxxx, DELETE xxxxxx

Explanation: The number of records inserted and/or deleted during a sort/merge program execution replaces the values shown as xxxxxx in the above format.

System Action: None.

User Response: None.

IER056A - SORTIN/SORTOUT NOT DEFINED

Explanation: Critical. SORTIN and/or SORTOUT do not appear as ddnames on DD statements supplied to the sort/merge program. This message can also appear when DD statements are supplied for a merge, and a SORT control statement is given instead of a MERGE statement.

System Action: The program terminates.

User Response: Check DD statements for error.

IER057A - SORTIN NOT SORTWK01

Explanation: Critical. An intermediate storage data set other than SORTWK01 was assigned to the same tape drive as SORTIN.

System Action: The program terminates.

User Response: Check DD statements for error.

IER058A - SORTOUT A WORK UNIT

Explanation: Critical. SORTOUT was specified on the same tape drive as an intermediate storage data set.

System Action: The program terminates.

User Response: Check DD statements for error.

IER059A - RCD LNG INVALID FOR DEVICE

Explanation: Critical. The record length in the input data set(s) is either less than 18 bytes, or is too large for the assigned intermediate storage devices. (For example, a record which can not be contained on one disk track is too large.)

System Action: The program terminates.

User Response: If the record length is too large, assign a different type of intermediate storage device. If the length is too small, redefine the sort with a record length of at least 18 bytes.

IER060A - DSCB NOT DEFINED

Explanation: Critical. A DD statement used to define a direct access intermediate storage data set is incorrect.

System Action: The program terminates.

User Response: Check DD statements for error.

IER061A - I/O ERR xxx

Explanation: Critical. A permanent error occurred during an I/O operation on device xxx, where xxx represents the unit number of the device.

System Action: If no user options are specified, the program terminates. (For more information on user options, see the topic I/O ERRORS in the section "Sort/merge Program" and topic "Read/write Error Routines" in the section "Program Modification.")

User Response: If error persists, have the computing system checked.

IER062A - L E ERR

Explanation: Critical. The linkage editor found a serious error; execution of the sort/merge program is impossible.

System Action: The program terminates.

User Response: Check user-written modification routines for a link editing problem.

IER063A - OPEN ERR xxxxxxxx

Explanation: Critical. An error occurred during execution of the OPEN routine for data set xxxxxxxx, where xxxxxxxx represents the ddname of the data set being opened.

System Action: The program terminates.

User Response: Check for a missing DD statement.

IER064A - DELETE ERR

Explanation: Critical. The sort/merge program was unable to delete either itself or a user-written modification routine. This message should appear only when modification routines are used.

System Action: The program terminates.

User Response: Check modification routines. If no modification routines are used, and the program is running in a multiprogramming environment, rerun the job.

IER065A - PROBABLE DECK STRUCTURE ERROR

Explanation: Critical. The end of the SYSIN data set was found before all needed user modification modules were read.

System Action: The program terminates.

User Response: 1. Be sure the SYSIN data set contains all modification routines that the MODS statement specifies it will contain. 2. Check for misplaced job control language statements, especially a /* preceding a user modification module on SYSIN.

IER066A - APROX RCD CNT xxxxxx

Explanation: Critical. Sort capacity has been reached. The count xxxxxx is an approximation of the number of records the sort/merge program can handle with the assigned intermediate storage.

System Action: The program terminates.

User Response: Rerun application with more intermediate storage.

IER067I - INVALID EXEC OR ATTACH PARAMETER

Explanation: An error was found in the PARM field parameters of the EXEC statement, or in the optional parameters of the parameter list passed to a sort initiated by ATTACH, LINK, or XCTL. Invalid parameters are ignored. If a parameter is entered more than once, the last entry is used (if valid).

System Action: Processing continues. Invalid parameters are ignored.

User Response: None. For succeeding runs, check the validity of optional parameters.

IER068A - OUT OF SEQ SORTINxx

Explanation: Critical. During a merge only run, a data set was found to be out of sequence. The xx is replaced by the data set identification (01 to 16).

System Action: The program terminates.

User Response: If a user written routine was modifying the records, check it thoroughly. If not, check the data set that is in error.

Index

IBM S/360 Printed in U.S.A. GC28-6543-5

International Business Machines Corporation
Data Processing Division
112 East Post Road, White Plains, N.Y. 10601
[USA Only]

IBM World Trade Corporation
821 United Nations Plaza, New York, New York 10017
[International]

READER'S COMMENT FORM

IBM System/360 Operating System
Sort/Merge

Form GC28-6543-5

- Is the material:

	Yes	No
Easy to read?	☐	☐
Well organized?	☐	☐
Complete?	☐	☐
Well illustrated?	☐	☐
Accurate?	☐	☐
Suitable for its intended audience?	☐	☐

- How did you use this publication?
  - ☐ As an introduction to the subject
  - ☐ For additional knowledge

  Other .....

- Please check the items that describe your position:
  - ☐ Customer personnel
  - ☐ IBM personnel
  - ☐ Manager
  - ☐ Systems Analyst
  - ☐ Operator
  - ☐ Programmer
  - ☐ Customer Engineer
  - ☐ Instructor
  - ☐ Sales Representative
  - ☐ Systems Engineer
  - ☐ Trainee
  - Other .....

- Please check specific criticism(s), give page number(s), and explain below:
  - ☐ Clarification on page(s) .....
  - ☐ Addition on page(s) .....
  - ☐ Deletion on page(s) .....
  - ☐ Error on page(s) .....

Explanation:

- Thank you for your cooperation. No postage necessary if mailed in the U.S.A.

YOUR COMMENTS PLEASE . . .

This publication is one of a series which serves as reference for systems analysts, programmers and operators of IBM systems. Your answers to the questions on the back of this form, together with your comments, will help us produce better publications for your use. Each reply will be carefully reviewed by the persons responsible for writing and publishing this material. All comments and suggestions become the property of IBM.

Please note: Requests for copies of publications and for assistance in utilizing your IBM system should be directed to your IBM representative or to the IBM sales office serving your locality.

Fold Fold

FIRST CLASS
PERMIT NO. 1359
WHITE PLAINS, N. Y.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN U. S. A.

POSTAGE WILL BE PAID BY

IBM Corporation

112 East Post Road

White Plains, N. Y. 10601

Attention: Department 813 (L)

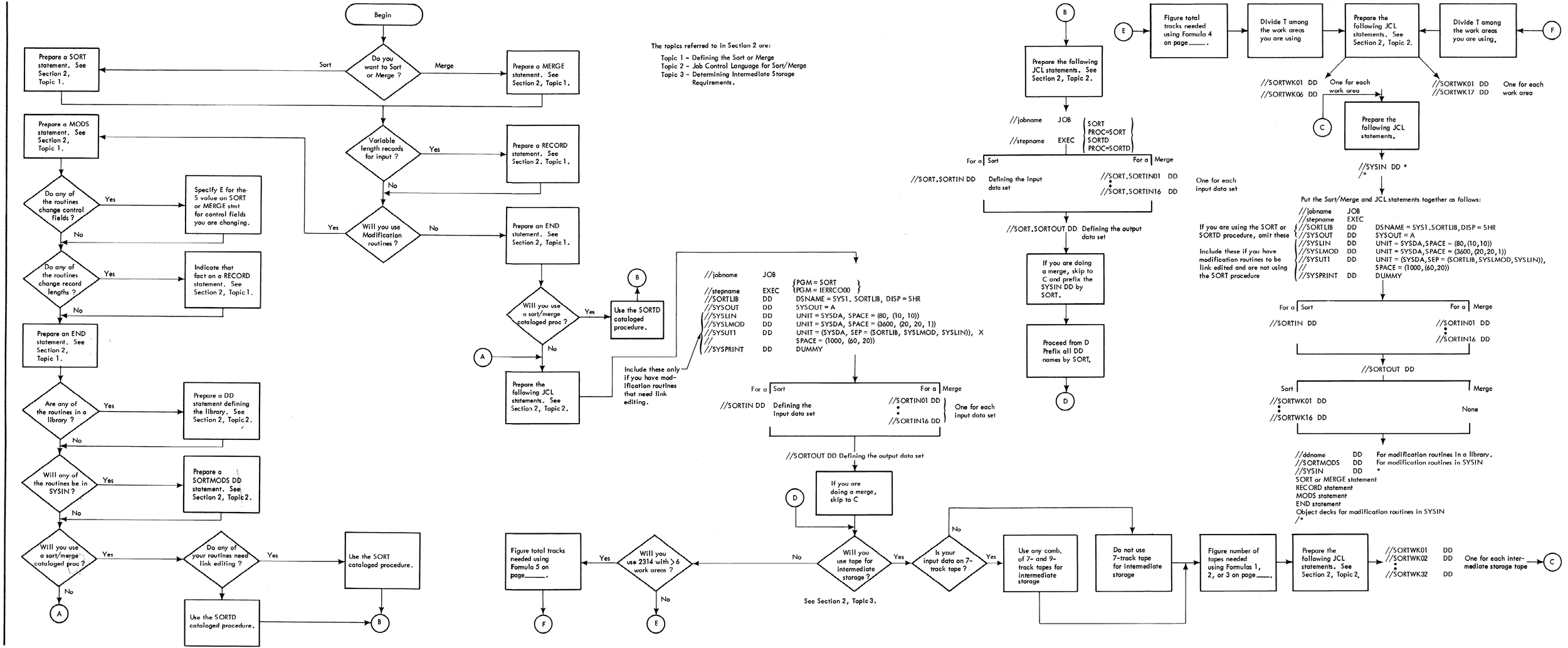
Fold Fold

IBM S/360 Printed in U.S.A. GC28-6543-5

IBM

International Business Machines Corporation
Data Processing Division
112 East Post Road, White Plains, N.Y. 10601
[USA Only]

IBM World Trade Corporation
821 United Nations Plaza, New York, New York 10017
[International]



The topics referred to in Section 2 are:

Topic 1 - Defining the Sort or Merge
Topic 2 - Job Control Language for Sort/Merge
Topic 3 - Determining Intermediate Storage Requirements.