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OPERATIONAL SPECIFICATIONS FOR FIXED BLOCK ROTATING MASS STORAGE SUBSYSTEMS

CATEGORY: HARDWARE STANDARD
SUBCATEGORY: INTERFACE

U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

Foreword

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Abstract

This specification is intended for use in the acquisition of Fixed Block Rotating Mass Storage (FBRMS) Subsystems (e.g., magnetic disk devices with fixed sized blocks and their controllers), and is a companion to the I/O Channel Interface Standard, FIPS 60. This standard defines the command repertory for FBRMS subsystems, sense information supplied by FBRMS subsystems for error recovery purposes and error recovery procedures for both FBRMS subsystems and attached computers. This standard does not specify recording technology or the internal implementation of subsystems; consequently, storage geometries, recording formats, physical addressing, and hardware diagnostic sense information are not specified.

Key words: computers; FBRMS; Federal Information Processing Standard; fixed block; I/O channel interface; magnetic disk controller; magnetic disks; mass storage subsystems; sense information.

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ANNOUNCING THE STANDARD FOR

OPERATIONAL SPECIFICATIONS FOR FIXED BLOCK ROTATING MASS STORAGE SUBSYSTEMS

Federal Information Processing Standards Publications are issued by the National Bureau of Standards pursuant to section 111(f)(2) of the Federal Property and Administrative Services Act of 1949, as amended, Public Law 89-306 (79 Stat. 1127), Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 Code of Federal Regulations (CFR).

Name of Standard. Operational Specifications for Fixed Block Rotating Mass Storage Subsystems (FIPS PUB 97).

Category of Standard. Hardware Standard, Interface.

Explanation. This standard defines the peripheral device dependent operational interface specifications for connecting fixed block rotating mass storage equipment as a part of automatic data processing (ADP) systems. It is to be used together with the latest versions of FIPS PUB 60, I/O Channel Interface, and FIPS PUB 61, Channel Level Power Control Interface. This standard, together with these two referenced standards, provides for full plug-to-plug interchangeability of fixed block rotating mass storage equipment as a part of ADP systems. FIPS PUB 63, Operational Specifications for Rotating Mass Storage Subsystems, provides, together with FIPS PUB 60 and FIPS PUB 61, for plug-to-plug interchangeability of variable block rotating mass storage equipment as a part of ADP systems. This standard serves the same purpose as FIPS PUB 63; it specifies the operational characteristics of a particular type of rotating mass storage subsystem. The two standards are alternatives to each other. If either standard is used, the other is not required.

The Government's intent in employing this standard for Fixed Block Operational Specifications for Rotating Mass Storage Subsystems is to reduce the cost of satisfying its data processing requirements through increasing its available alternative sources of supply for computer systems components at the time of initial system acquisition, as well as in system augmentation and in system component replacement. This standard is also expected to lead to improved reutilization of system components.

When acquiring ADP systems and system components, Federal agencies shall cite this standard in specifying the interface for connecting fixed block rotating mass storage peripheral equipment as a part of ADP systems.

Approving Authority. Secretary of Commerce.

Maintenance Agency. Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Cross Index. Not applicable.

Applicability. In the acquisition or operation of rotating mass storage equipment under circumstances where the use of Federal Information Processing Standard I/O Channel Interface (FIPS PUB 60) is required, each item of rotating mass storage equipment must conform to either this standard or FIPS PUB 63.

Verification of the correct operation of all interfaces that are required to conform to this standard shall be provided in accordance with the verification procedures established for FIPS 60 through 63 prior to the acceptance of all applicable ADP equipment.

Specifications. This standard incorporates by reference the technical specifications of the following NBS document: Operational Specifications for Fixed Block Rotating Mass Storage Subsystems.

Implementation. The provisions of this standard are effective February 4, 1983.

All applicable equipment ordered on or after the effective date may conform to the provisions of this standard rather than the provisions of FIPS PUB 63. (The provisions of FIPS PUB 63 have been in effect since June 23, 1980.) Such equipment or actions must conform to the provisions of this standard, or FIPS PUB 63, unless a waiver has been granted in accordance with the procedures described elsewhere in this publication.

This standard shall be reviewed by NBS within three years after its effective date, taking into account technological trends and other factors, to determine whether the standard should be affirmed, revised, or withdrawn.

Waivers. Heads of agencies desiring a waiver from the requirements stated in this publication, so as to acquire ADP equipment that does not conform to this standard, shall submit a request for such a waiver to the Secretary of Commerce for review and approval. Approval will be granted if, in the judgment of the Secretary based on all available information, including that provided in the waiver request, a major adverse economic or operational impact would occur through conformance with this standard.

A request for waiver shall include: (1) a description of the existing or planned ADP system for which the waiver is being requested, (2) a description of the system configuration, identifying those items for which the waiver is being requested, and including a description of planned expansion of the system configuration at any time during its life cycle, and (3) a justification for the waiver, including a description and discussion of the major adverse economic or operational impact that would result through conformance to this standard as compared to the alternative for which the waiver is requested.

The request for waiver shall be submitted to the Secretary of Commerce, Washington, D. C. 20230, and labeled as a Request for Waiver to a Federal Information Processing Standard. Waiver requests will normally be processed within 45 days of receipt by the Secretary. No action shall be taken to issue solicitation documents or to order equipment for which this standard is applicable and which does not conform to this standard prior to receipt of a waiver approval response from the Secretary.

Where to Obtain Copies. Either paper or microfiche copies of this Federal Information Processing Standard, including the technical specifications, may be purchased from the National Technical Information Service (NTIS) by ordering Federal Information Processing Standard Publication 97 (FIPS-PUB-97), Operational Specifications for Fixed Block Rotating Mass Storage Subsystems. Ordering information, including prices and delivery alternatives, may be obtained by contacting the National Technical Information Service (NTIS), U. S. Department of Commerce, Springfield, VA 22161, telephone: (703) 487-4650. Payment may be made by check, money order, or deposit account.

U.S. DEPARTMENT OF COMMERCE

National Bureau of Standards

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Operational Specifications for

Fixed Block Rotating Mass Storage Subsystems

ABSTRACT

This specification is intended for use in the acquisition of Fixed Block Rotating Mass Storage (FBRMS) Subsystems (e.g., magnetic disk devices with fixed sized blocks and their controllers), and is a companion to the I/O Channel Interface Standard, FIPS 60. This standard defines the command repertory for FBRMS subsystems, sense information supplied by FBRMS subsystems for error recovery purposes and error recovery procedures for both FBRMS subsystems and attached computers. This standard does not specify recording technology or the internal implementation of subsystems; consequently, storage geometries, recording formats, physical addressing, and hardware diagnostic sense information are not specified.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Scope

This specification defines the operational characteristics of Fixed Block Rotating Mass Storage Subsystems (FBRMS) which attach to the I/O channel interface specified in FIPS 60.* Operational characteristics are defined as those properties of the subsystem which are "apparent" to any level of program which controls the subsystem through the I/O channel interface. This specification in conjunction with FIPS 60 and FIPS 61* specifies the mechanical, electrical, and functional characteristics necessary to facilitate plug-to-plug compatibility and interchangeability of fixed block rotating mass storage subsystems used on I/O channels of general purpose computer systems. Use of a specific computer system with a specific FBRMS subsystem requires an appropriate match of the system requirements with the subsystem characteristics such as allowable logical block size, the operational characteristics of the READ IPL command, and channel data transfer rates. Nothing in this specification is intended to specify any recording mechanism or implementation technology.

1.2 Editorial Conventions

Certain terms used in this standard and FIPS 60, which are proper names of commands, status conditions, or sense conditions are printed in upper case to avoid possible confusion with other uses of the same words. Any lower case uses of these words have the normal English meaning.

1.2.1 Command and Subcommand Names

The following names of FBRMS commands are always printed in all upper case letters: NO-OPERATION (NO-OP), DEFINE EXTENT, LOCATE, READ, READ INITIAL PROGRAM LOAD (READ IPL), WRITE, SENSE INPUT/OUTPUT, SENSE INPUT/OUTPUT TYPE, READ AND RESET BUFFERED LOG, READ DEVICE CHARACTERISTICS, DEVICE RESERVE, DEVICE RELEASE, UNCONDITIONAL RESERVE, DIAGNOSTIC CONTROL, DIAGNOSTIC SENSE/READ, SET DIAGNOSE, and READ DIAGNOSTIC STATUS.

A number of commands have subcommands or other named parameters. The first letter of each word in a subcommand or parameter name is capitalized. Examples are: Mask, Block Size, Extent-Offset.

1.2.2 Status Conditions

FIPS 60 defines eight status conditions which are used frequently in this standard. They are printed in upper case as follows: ATTENTION, STATUS MODIFIER, CONTROL UNIT END, BUSY, CHANNEL END, DEVICE END, UNIT CHECK, and UNIT EXCEPTION.

*Throughout this publication, all references to FIPS 60 and 61 refer to the latest effective version of the I/O Channel Interface Standard, FIPS 60-1, 60-2, etc.

1.2.3 I/O Channel Signals

The I/O Channel sequence control STOP, defined in FIPS 60, is printed in upper case.

1.2.4 Sense Information

Section 5 of this standard defines a large number of Sense Conditions and Fields. Most of these fields are never referenced in other sections, and the first letter of each word in their name is capitalized; for example: File Protected, Cylinder High.

Some sense fields or conditions, however, are widely used throughout the standard and are printed in upper case. They are: COMMAND REJECT, INTERVENTION REQUIRED, BUS OUT PARITY, EQUIPMENT CHECK, DATA CHECK, OPERATION INCOMPLETE, OVERRUN, PERMANENT ERROR, and CORRECTABLE.

1.3 Use of Terms

1.3.1 Use of "shall," "will," "should," and "may"

In this standard, the word "shall" is always used to express binding requirements.

"Will" is used where the future tense is required, or to express an expected action outside the scope of the specification. For example, since conformance of control units and devices to this standard is determined before installation, when addresses are assigned, "Each control unit and device will be assigned an address at installation time."

The use of "should" is advisory. For example, users can write channel programs for FBRMS devices. This standard cannot specify those programs; however, it does warn that, "A UNIT CHECK should always be followed by a SENSE I/O command to retrieve the sense data from the control unit, whether or not the sense data is used."

"May" is used to express something which is allowed, but not required. For example, "Each control unit may be optionally accessed via more than one I/O channel."

1.3.2 Use of "vendor"

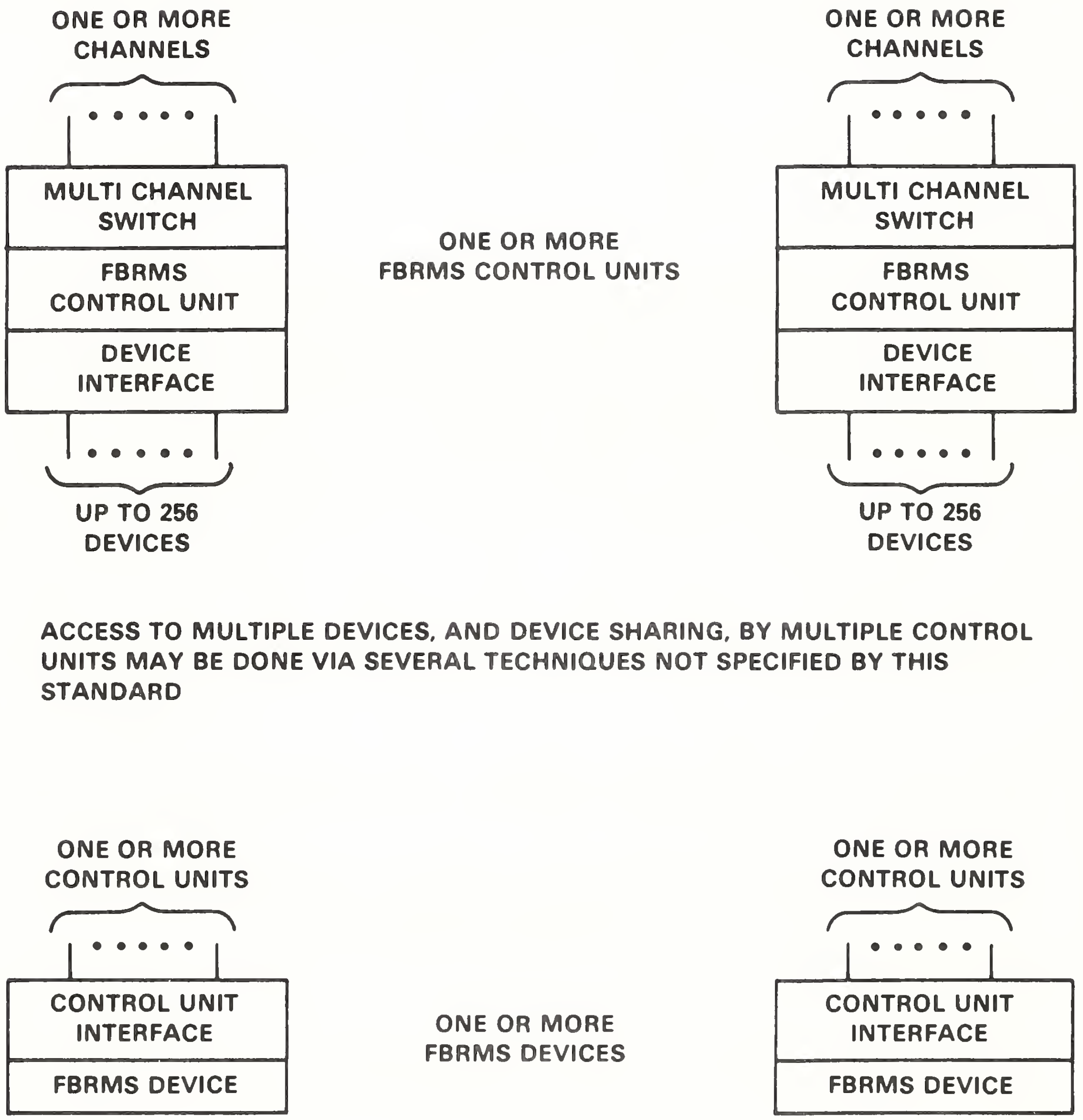
The term "vendor" denotes the supplier of the FBRMS subsystem.

1.4 I/O Channel Interface

FIPS 60 specifies the functional, electrical, and mechanical characteristics of the interface which serves as the communication link between the general purpose computer system's I/O channel and the fixed block rotating mass storage subsystem. The channel provides a mechanism for the computer to address subsystems and devices, to transfer the commands specified herein to the subsystem, to read and write data from and to the subsystem, and to receive the status indications and sense information specified herein from the subsystem. Since neither FIPS 60, nor this specification, specify performance (that is speed or bandwidth) requirements, and since fixed block rotating mass storage subsystems may be subject to overrun conditions, conformance to FIPS 60 does not guarantee that specific I/O channels have the performance capability to support specific storage subsystems.

1.5 Power Control Interface

FIPS 61 specifies the Power Control Interface used by FBRMS subsystems.



ACCESS TO MULTIPLE DEVICES, AND DEVICE SHARING, BY MULTIPLE CONTROL UNITS MAY BE DONE VIA SEVERAL TECHNIQUES NOT SPECIFIED BY THIS STANDARD

FBRMS SUBSYSTEM CONFIGURATION

FIGURE 1

1.6 Subsystem Organization

An FBRMS subsystem consists of one or more control units connected to one or more channels, and controlling one or more FBRMS storage devices. The range of possible configurations is illustrated in Figure 1, which illustrates the connection of multiple channels to a single control unit, and multiple control units to a single device.

1.6.1 Control Units

A basic FBRMS subsystem consists of a single control unit and one attached FBRMS device. Multiple control units and devices may be interconnected, limited only by the addressable range limits of each.

1.6.2 Multi-Channel Switch

Each control unit may be optionally accessed via more than one I/O channel interface. This permits programming control (within the computing system) over the sharing of FBRMS control units. The additional channel interface(s) may be for the same computer system or for different computer systems.

If a control unit is selected on channel x when it is already in use by channel y, and therefore cannot be used by channel x, the control unit shall present busy status to channel x. If the control unit is selected on two channels simultaneously, it may delay the selection sequence on one channel until it determines what is required on the other channel, and then either continue the selection sequence or indicate BUSY on the channel which was delayed.

1.6.3 Devices

An FBRMS "device" is whatever is "viewed" by the channel as a separately addressable device. For example, single "device" could span several disk spindles, or a single spindle could contain several devices. A single spindle may have more than one access mechanism; each access mechanism may be presented to the channel as a separate device, or the control unit may logically combine several access mechanisms to make a single device.

1.6.4 Device Sharing

A subsystem with multiple FBRMS control units may allow shared access of multiple FBRMS devices by any of several shared access techniques. This allows for fully shared access of attached rotating mass storage devices by two or more control units.

The device sharing may be accomplished by a dynamic switch, multiple sub-control-units each supporting one or more devices, multiple control unit access at the device level, any combination of the above, or any other technique effecting device sharing.

It is not the intention of this standard to specify the architecture or the technique used to accomplish device sharing, only its externally observable (outside of the rotating mass storage subsystem) characteristics.

1.6.5 Number of Devices

Although a channel may address up to 256 FBRMS devices, there is no requirement that a FBRMS control unit be physically capable of controlling more than one FBRMS device.

1.6.6 Device Addressing

Each control unit and device will be assigned an address at installation time. The control unit address is concatenated to the device address to form the 8-bit address used by the channel for initial selection (see FIPS 60). No fixed number of bits is allocated for control unit and device addresses for FBRMS subsystems. However, the concatenated control unit and device address shall be 8 bits, and the control unit address shall be the most significant portion of the address.

1.7 FBRMS Classes and Options

1.7.1 Classes

Two classes of FBRMS subsystems are defined:

a) Class A - This class of FBRMS subsystem shall use only 512 byte logical blocks.

b) Class B - All FBRMS subsystems shall support Class A operation. Class B operation is optional. This class of FBRMS subsystem shall be capable of being reformatted at user installations, if needed, and used at a vendor-defined allowable logical block size within the range from 1 to 65,535 bytes. Vendors may support for Class B devices one specific block size, a selection of block sizes, or a range of block sizes. Allowable logical block sizes and the corresponding physical block sizes shall be defined in the vendor's documentation. This standard does not specify the relationship of logical blocks to physical blocks written upon the recording medium. All Class B subsystems shall be capable of being set to operate as Class A subsystems with appropriate software or microcode changes. Formatting may be performed in either of two ways according to the method specified in the vendor's documentation:

(1) by use of the Format ID subcommand of the DIAGNOSTIC CONTROL command and the Format Defective Block subcommand of the LOCATE command, or

(2) internally within the subsystem (for example, many subsystems load the microstore of the control unit from a floppy disk; it is acceptable for the vendor to supply a special floppy disk for reformatting the subsystem to new block sizes).

There is no requirement that Class B control units be capable of concurrently supporting FBRMS devices with different block sizes; only one block size need be supported at any one time within a Class B FBRMS subsystem.

1.7.2 Optional Features

Optional features are allowed for FBRMS devices. These options are independent of device classes. Such features may be used to improve performance or maintainability or for some other type of enhancement. They are:

a) Untagged DEVICE END Feature - This optional feature of the LOCATE command allows a device, which is attached to two or more control units, to respond with device end through a control unit other than the control unit through which the original command was made. For example, a device shared by control units A and B may be given a LOCATE command through control unit A. When the access operation is complete, that device would ordinarily signal DEVICE END through control unit A. If A were busy, an access latency might be lost. However, with the untagged Device End feature, DEVICE END could be presented through control unit B. DEVICE END for a command might then be returned via a channel and control unit other than the channel and control unit for which the command was originally issued. The method for routing DEVICE END back to the appropriate computer system is vendor-specified and may be dependent on the configuration of channel connections. In general, the use of this feature is not practical with existing I/O channels which have not been specifically designed to support it. The I/O channel to CPU interface (which is vendor unique and is not specified in FIPS 60) of most existing I/O channels will not support the optional Untagged Device End Feature. Channels which do support the Untagged Device End feature will operate properly with subsystems which do not support this feature. The feature may be disabled if implemented for use with channels which do not support it.

b) Indefinite Transfer Feature - This optional feature is intended to facilitate use of FBRMS subsystems with computer systems whose software-I/O interfaces do not provide an indication of the total number of blocks to be processed in advance of initiating read or write operations. If implemented, its use is controlled by the Operation Byte of the LOCATE command. Only the operation of the READ and WRITE commands are affected when this feature is invoked. The effect of invoking this feature is to cause READ and WRITE operations to continue through successive blocks until the channel signals STOP (see FIPS 60). When the Indefinite Transfer Feature is not implemented or not specifically invoked, READ and WRITE operations are normally terminated under control of a Block Count passed as parameter to the LOCATE command.

1.8 Device Characteristics

The FBRMS subsystem includes one or more fixed block rotating mass storage devices, drives, or units that store and read back information on a medium not defined in this standard.

1.8.1 Logical Storage Organization

With the exception of certain class specific commands (READ DEVICE CHARACTERISTICS, DIAGNOSTIC CONTROL, and DIAGNOSTIC SENSE/READ), storage shall logically be considered to be a contiguous extent of directly addressable logical blocks of fixed size, beginning with block zero and ending with the greatest block address supported by the device. Class A FBRMS devices shall use a logical block size of 512 8-bit bytes, while Class B FBRMS Devices shall use a vendor-defined allowable logical block size within the range from 1 to 65,535 eight-bit bytes. Vendors may support for Class B devices one specific block size, a selection of block sizes, or a range of block sizes. Allowable logical block sizes, the corresponding logical to physical relationships, and the resulting device capacities shall be defined in the vendor's documentation and are not specified herein.

1.8.1.1 Identification Area

An Identification (ID) area shall be associated with each logical or physical block and shall be defined in detail accordingly in the vendor's documentation. The ID area typically contains device specific address and control information and may be protected by error detection or correction codes. The ID area is normally used by the control unit and is not ordinarily read or written over the channel interface. The ID area may be written using the Format Defective Block subcommand of the LOCATE command, which uses logical block addressing, and may also be written using the Format ID subcommand of the DIAGNOSTIC CONTROL command. The ID area may be read using the Read ID subcommand of the DIAGNOSTIC CONTROL command in conjunction with the DIAGNOSTIC SENSE/READ command. The use of these commands to read and write ID areas and the number of logical and/or physical blocks affected shall be defined in detail in the vendor's documentation. See Physical Storage Organization below.

1.8.1.2 Data Area

A data area shall be associated with each logical block and accordingly shall be defined in detail in the vendor's documentation. In addition to containing a fixed length of data, the data area may contain error detection or correction codes. Data areas are normally read and written using the READ and WRITE commands and are logically addressed with the DEFINE EXTENT and LOCATE commands. The logical to physical relationships shall be defined in the vendor's documentation.

1.8.2 Physical Storage Organization

Two kinds of blocks, "logical" and "physical" blocks may be associated with FBRMS devices. When the term "block" alone is used in this standard, it means logical block. All the control, read and write commands operate on logical blocks. FBRMS devices may, however, have an underlining organization of physical blocks which need not map one to one into logical blocks. A physical block is the smallest unit of data storage which may physically be independently written in an FBRMS device. In magnetic disk devices, physical blocks are separated by "gaps" which allow each block to be independently written.

Physical blocks may be smaller than logical blocks, in which case the logical block spans two or more physical blocks. Physical blocks may also contain part or all of several logical blocks. The principal reason for introducing physical blocks in this standard is their importance when there are defects in the recording medium. Since a physical block is the smallest unit of data storage which may be independently written on an FBRMS device, any medium defect which causes an uncorrecable error generally makes the entire physical block unusable. An Identification Area or ID field typically precedes the physical block, and may be separated from it by a gap which allows the ID field to be written independently of the physical data block. This ID Field is typically used for three purposes: to find or verify the location of the desired block, to flag a defective block as defective and, in some cases, to point to an alternate location which contains the desired data. ID fields are typically protected by error detection or correction codes which are independent of the codes used to protect data areas.

Logical blocks are identified by a logical address as indicated under Logical Storage Organization above and in the sections which describe the DEFINE EXTENT and LOCATE commands. Physical Blocks have physical addresses (typically Cylinder, Track, and position on a track) which are not specified in this standard and which are only of concern in the Format ID, Read ID and Space ID, and Read Data subcommands of the DIAGNOSTIC CONTROL command. These commands are primarily concerned with the recovery of recorded data in the presence of uncorrectable errors, and the determination and flagging of blocks with a defect in the recording medium.

The physical organization of FBRMS subsystems is not specified. The physical organization and its relationship to logical block addresses shall be defined in the vendor's documentation. Subsystems may transparently pad and discard bits within physical blocks when operating on logical blocks.

1.8.3 Error Detection/Correction

Both the ID areas and data areas shall be protected by error detection codes and may optionally be protected by correction codes. The detection and correction of errors, however, is considered to be an internal subsystem function and the error detection/correction mechanism itself is not specified. The control unit shall detect errors and generate appropriate responses to the channel as defined for each command. For correctable errors which are not corrected in the control unit before data is passed to the channels, the control unit shall provide the necessary correction information as defined in Section 5 of this specification.

No provision of this specification is intended to prevent correction of errors within the control unit before data is passed to the channel, nor is any provision of this standard intended to require the inclusion of an error correcting capability in FBRMS subsystems. Although no particular code is specified, FBRMS subsystems are required to implement an error detecting capability appropriate to the recording technology employed.

Error detecting or correcting codes may be associated with the logical block, the ID and data areas, or the physical block or some physical sub-block, at the discretion of the vendor.

1.8.4 Basic Information Unit

The basic information unit of all FBRMS commands, parameters, and sense information is a byte, consisting of eight (8) binary digits (bits). The most significant bit of each byte is bit position zero, and the least significant is bit seven. Commands, parameters, and sense information are transmitted across the channel interface in one byte units, and multiple byte fields are transmitted in order of decreasing significance.

1.9 Status Presentation

Status shall be presented to the channel as specified in FIPS 60. Presentation of an initial status byte of zero for any command except TEST I/O or NO-OP shall cause all sense information to be reset to zero.

Except for CONTROL UNIT END, all status conditions shall be associated with a specific device address. However, during a contingent connection, CONTROL UNIT END shall be associated with the specific device address for which the contingent connection is maintained, and be cleared only when that device is addressed or the contingent connection is cleared as specified in Contingent Connection. When there is no contingent connection, CONTROL UNIT END shall be cleared whenever any device attached to the control unit is addressed. The device address accompanying CONTROL UNIT END is specified in FIPS 60, section 2.6.5.

1.9.1 Initial Status

Initial status shall be presented as specified in FIPS 60 to the channel whenever a command is issued by the channel. The initial status byte for TEST I/O (see FIPS 60 for a description of TEST I/O) and all non-immediate commands shall be zero unless one or more of the following are true:

a. The device or control unit is busy to the channel. The control unit normally signals BUSY whenever contention with another path blocks access to the selected device or whenever a previously initiated action is still incomplete at either the device or the control unit. The BUSY Status paragraph below lists specific causes of busy status.

b. Status is pending at the control unit or the device. In this case, the pending status shall be presented as initial status, and BUSY shall also be indicated for all operations except TEST I/O. The pending status shall then be cleared unless it is stacked (see FIPS 60 for the definition of stacked status) by the channel. After the status is cleared, the device must be reselected to determine its availability. The Pending Status section below lists specific causes of pending status.

c. The control unit indicates initial status of command retry (CHANNEL END with STATUS MODIFIER and UNIT CHECK). Note: This would be unusual since command retry is usually indicated only in ending status.

d. A UNIT CHECK condition exists at either the control unit or device. In this case, UNIT CHECK shall be presented for all commands except the SENSE INPUT/OUTPUT (I/O) command which shall present zero status.

e. A command code parity error is detected by the control unit on Bus Out.

1.9.1.1 BUSY Status

BUSY indicates that the control unit or device cannot execute a command because of a condition at either the control unit or device.

1.9.1.1.1 Control Unit Busy

Both BUSY and STATUS MODIFIER shall occur together to indicate a control unit busy condition. Control unit busy shall be indicated in response to an initial selection whenever:

a) The control unit is performing an operation which issues CHANNEL END after parameters or data are transferred, but before command processing is complete. The LOCATE, WRITE, and DIAGNOSTIC CONTROL commands all may cause the control unit to issue CHANNEL END before completion of command processing by the the control unit.

b) A write operation is still in progress after termination of command chaining.

c) The control unit is unable to execute the command because a control unit error recovery or diagnostic procedure is in progress.

d) Status is pending in the control unit for some device other than the addressed device.

e) A contingent connection is established by the control unit for some device other than the addressed device.

f) Another channel attached to a multichannel subsystem is using the addressed control unit.

g) A system reset is in progress at the control unit.

h) A control unit initiated connection is preferred over a channel initiated connection.

1.9.1.1.2 Device Busy

Device busy shall be indicated by BUSY without STATUS MODIFIER. Device Busy shall be presented whenever:

a) DEVICE END status is pending for the selected device.

b) The device is reserved for another channel or control unit.

c) CHANNEL END has been presented without DEVICE END for the device and DEVICE END has not been presented.

1.9.2 Ending Status

Ending status shall be presented to the I/O channel as part of the Ending Procedure specified in FIPS 60. An Ending Procedure may be initiated by either the Control Unit or the I/O channel. In some cases, the I/O channel may initiate an Ending Procedure before the control unit or device reaches its normal end point. Immediate commands normally present CHANNEL END and DEVICE END in the initial status. A valid LOCATE command may cause ending status to be presented to the channel twice; CHANNEL END is presented to the channel after parameters have been transferred and checked for validity and a DEVICE END status is presented again when the LOCATE is completed and the control unit is able to accept another command for the device. Similarly, a WRITE command, when Write and Check Data has been specified shall cause ending status to be presented to the channel twice; CHANNEL END is presented when data transfer is complete and DEVICE END is presented after the the data has been checked by the control unit.

When the optional Untagged DEVICE END feature is implemented and selected (see the description of LOCATE command modifier bits), DEVICE END status for a LOCATE command may be presented via a path (control unit and channel) other than that used to issue the command.

1.9.3 Pending Status

Pending status is status which has been generated by the device or control unit, but has not yet been presented to the channel. Pending status is distinct from stacked status, which has been presented to but not accepted by the channel.

When a status condition other than CONTROL UNIT END is pending at the control unit, the control unit may present control unit busy status if any device except the device for which status is pending is selected.

Whenever status is pending for a control unit or for any device attached to that control unit, the control unit shall begin a Control Unit Initiated Sequence (see FIPS 60) and present the pending status as soon as the channel, control unit, and, where status is pending for the device itself, the device is not busy. The pending status shall be cleared whenever it is presented to and accepted by the channel.

1.9.3.1 Status Pending at Control Unit

Status shall be pending at the control unit whenever:

a. BUSY, CHANNEL END, or UNIT CHECK status was stacked.

b. A Test I/O command results in a zero status indication, which is then stacked by the channel.

c. Control unit busy status was presented to the channel and CONTROL UNIT END is pending.

d. An interface disconnect occurs after a command is issued, but before CHANNEL END status is accepted. Ending status shall then remain pending at the control unit after the operation is complete.

e. An interface disconnect occurs after issuing a TEST I/O command but before accepting the status indication. The status remains pending at the control unit for the addressed device.

f. Status may be pending at the control unit whenever DEVICE END status from a LOCATE or DIAGNOSTIC CONTROL command is stacked.

1.9.3.2 Status Pending at the Device

DEVICE END status shall be pending for the device whenever:

a. CHANNEL END was presented without DEVICE END and the operation is now complete at the device.

b. BUSY status was presented for the device and the device is no longer busy.

c. The device condition changes from not ready to ready.

d. DEVICE END status from a LOCATE or DIAGNOSTIC CONTROL COMMAND is stacked, and status is not held pending at the control unit.

1.9.3.3 Pending Status in a Control Unit-Initiated Sequence

When pending status is presented by a control unit-initiated sequence, several separate pending status conditions may exist within the control unit and attached devices. Pending status shall be presented in the following priority order:

a. Highest priority is any status pending at the control unit except CONTROL UNIT END. Exception: During a contingent connection, CONTROL UNIT END has highest priority.

b. Unsuppressible status.

c. Suppressible DEVICE END status.

d. CONTROL UNIT END status.

Whenever status is presented by a control unit-initiated sequence, the address shall be the address of a not busy device within the range of addresses of the control unit.

1.9.4 Suppressible Status

Status conditions specified to be suppressible in FIPS 60 shall be suppressible except (1) DEVICE END status associated with CHANNEL END for which chaining has been indicated and (2) the DEVICE END status associated with unchained LOCATE or DIAGNOSTIC CONTROL commands.

1.9.5 Contingent Connection

A contingent connection shall be established in the control unit after the channel accepts a status byte containing UNIT CHECK. It shall last until a command other than Test I/O or NO-OPERATION receives an initial status byte of zero for the control unit and device address that generated the UNIT CHECK or a selective or system reset occurs. However, to allow for a non-responsive system, a control unit may break the contingent connection based on a vendor-specified timeout of one second or greater.

During the contingent connection state, the control unit shall be busy to all addresses other than the address for which the contingent connection state was established.

1.9.6 Multiple Status Indications

In many cases, several different status indications are specified for a particular condition. All these indications need not be presented together at one time. For example, where this specification calls for a condition to cause status indications of CHANNEL END, DEVICE END, and UNIT CHECK status, it is acceptable for the control unit to first present CHANNEL END alone, and then later present DEVICE END and UNIT CHECK.

2.0 COMMAND DESCRIPTIONS

Commands executed by FBRMS subsystems fall into one of the following categories:

1) Control Commands

2) Read Commands

3) Write Commands

4) Sense Commands

5) Diagnostic Commands

Table 1 lists the commands which shall be recognized and executed by an FBRMS subsystem. There shall be no other valid commands and any invalid command shall be recognized by the subsystem and shall cause the generation of a status indication of UNIT CHECK with a sense indication of COMMAND REJECT.

Two optional commands, SET DIAGNOSE and READ DIAGNOSTIC STATUS, are allowed. These may be used to provide additional model dependent diagnostic functions at the discretion of the vendor. If used, they shall be fully defined in the vendor's documentation. These commands shall not be used to implement features used during ordinary operation of FBRMS devices, but may be used for special diagnostic purposes, or for logging or saving device dependent information.

The sense commands for device allocation (DEVICE RESERVE, DEVICE RELEASE, and UNCONDITIONAL RELEASE) are implemented only if the subsystem implements optional device sharing or a multichannel switch (see section 1.6). If these features are not implemented, then the sense commands for device reservation are treated as NO-OP's.

Unless otherwise noted, numeric parameters use unsigned binary representation. Unless otherwise noted, values expressed in the text of this standard use decimal notation.

Command	Command Code	
	Hexadecimal	Binary
Control		
NO-OPERATION (NO-OP)	'03'	0000 0011
TEST I/O	'00'	0000 0000
DEFINE EXTENT	'63'	0110 0011
LOCATE	'43'	0100 0011
Read		
READ	'42'	0100 0010
READ INITIAL PROGRAM LOAD	'02'	0000 0010
Write		
WRITE	'41'	0100 0001
Sense		
SENSE INPUT/OUTPUT	'04'	0000 0100
SENSE INPUT/OUTPUT TYPE	'E4'	1110 0100
READ AND RESET BUFFERED LOG	'A4'	1010 0100
READ DEVICE CHARACTERISTICS	'64'	0110 0100
DEVICE RESERVE*	'B4'	1011 0100
DEVICE RELEASE*	'94'	1001 0100
UNCONDITIONAL RESERVE*	'14'	0001 0100
Diagnostic		
DIAGNOSTIC CONTROL	'F3'	1111 0011
DIAGNOSTIC SENSE/READ	'C4'	1100 0100
Model Dependent Diagnostic		
SET DIAGNOSE	'4B'	0100 1011
READ DIAGNOSTIC STATUS	'44'	0100 0100

Table 1. Summary of the Command Set

*Note: Sense commands for device allocation are implemented only in subsystems which allow sharing of control units by two or more channels or sharing of devices by two or more control units. Otherwise, these commands are treated as NO-OP's.

2.1 Control Commands

Control commands do not transfer recorded data to or from the FBRMS subsystem. Control commands may transfer control information to the subsystem, which may include subcommands specifying certain actions to be performed by the subsystem or device, or parameters to be employed by the subsystem in subsequent operations.

2.1.1 NO-OPERATION

COMMAND CODE 0000 0011 binary, 03 hexadecimal

NO-OP is an immediate command; it shall cause no action at the addressed device. It may be used to maintain the channel connection during I/O operations.

PARAMETERS

No parameters are passed as a result of a NO-OP.

CHAINING REQUIREMENTS

None.

STATUS INDICATIONS

CHANNEL END and DEVICE END shall be presented in initial status.

2.1.2 TEST I/O

COMMAND CODE 0000 0000 binary, 00 hexadecimal

This command is used to relieve the addressed I/O path of pending status information. It shall operate as defined in FIPS 60.

PARAMETERS

No parameters are passed as a result of Test I/O.

CHAINING REQUIREMENTS

None.

STATUS INDICATIONS

Shall be as defined in FIPS 60.

2.1.3 DEFINE EXTENT

COMMAND CODE 0110 0011 binary, 63 hexadecimal

The DEFINE EXTENT command performs the following functions:

a. Defines the operations which will be allowed by the following chained commands.

b. Defines the size of logical data blocks.

c. Defines an extent of data blocks which may be accessed by subsequent chained commands. An extent is a set of data blocks with contiguous logical addresses, which are contained on a single logical device.

d. Defines a relative displacement in data blocks, from the start of a data set to the extent which may be accessed by subsequent chained commands. A data set is a set of one or more extents which need not be contiguous. The first block of a data set has a relative displacement of zero and the last block has a displacement of n-1, where n is the sum of the blocks in each of the extents of the data set. The extents of a data set need not be contained on the same logical device.

PARAMETERS

Sixteen bytes of parameters shall be transferred from the channel to the FBRMS subsystem. The parameter bytes have the following format:

Byte	Use
0	Mask byte
1	Must be zero
2 and 3	Blocksize
4 through 7	ExtentOffset
8 through 11	ExtentFirstDisplacement
12 through 15	ExtentLastDisplacement

BYTE 0: Mask Byte

Byte 0 is a mask byte that shall determine which operations will be inhibited in subsequent chained commands. The function of the bits are:

Bits	
0 and 1	
00	Format write operations shall be inhibited, but non-formatting writes are allowed.
01	All write operations shall be inhibited.
10	Invalid, must not be used.
11	All write operations shall be permitted.
2 and 3	Reserved, if not 00 parameters shall be invalid.
4	Zero indicates data area and one indicates an area reserved for maintenance purposes only.

5 Zero indicates diagnostic commands shall be inhibited while one indicates Diagnostic commands shall be allowed.

6 and 7 Reserved, if not zero parameters shall be invalid.

BYTE 1: Reserved

Byte 1 is reserved and if not zero the parameters shall be invalid.

BYTES 2 and 3: Blocksize

Bytes 2 and 3 define the logical block size. For Class A devices, the block size is always 512 bytes and the Blocksize parameter may be zero for 512 bytes. For Class B devices, this value may be a vendor-defined allowable number within the range from 1 to 65,535 and indicates the block size in bytes. For Class B devices, zero shall be interpreted as a 512 byte block size.

BYTES 4 through 7: ExtentOffset

Bytes 4 through 7 define the offset, from block zero of the logical device, of the first block of the extent to which access shall be permitted by subsequent chained LOCATE commands.

BYTES 8 through 11: ExtentFirstDisplacement

Bytes 8 through 11 define the relative displacement, in blocks, from the beginning of the data set, to the first blook of the extent, to which access shall be permitted by subsequent chained commands. A data set is a set of one or more extents. Although the blocks within an extent have contiguous logical block addresses, the extents within a data set need not be physically contiguous.

BYTES 12 through 15: ExtentLastDisplacement

Bytes 12 through 15 define the relative displacement, in blocks, from the beginning of the data set to the last block of the extent to which access shall be permitted by subsequent chained commands. The extent then begins at the ExtentFirstDisplacement and ends at the ExtentLastDisplacement.

CHAINING REQUIREMENTS

A DEFINE EXTENT Command which is preceded in the same chain by another DEFINE EXTENT Command shall be rejected by the subsystem. See FIPS 60 for the definition of command chaining.

STATUS INDICATIONS

Initial status is normally zero.* CHANNEL END and DEVICE END shall be presented after the parameters have been transferred to the control unit and checked for validity. Invalid parameters shall cause the command to be terminated with the presentation of CHANNEL END, DEVICE END, and UNIT CHECK status, and a sense indication of command reject. A DEFINE EXTENT command which is preceded by another DEFINE EXTENT command in the same chain shall cause the command to be terminated with the presentation of CHANNEL END, DEVICE END, and UNIT CHECK status, and a sense indication of COMMAND REJECT.

2.1.4 LOCATE

COMMAND CODE 0100 0011 binary, 43 hexadecimal

The LOCATE command defines the location and amount of data to be processed by an immediately following chained READ or WRITE Command, and positions the device to the first data block to be processed. Recorded data is not transferred by this command.

PARAMETERS

Eight bytes of parameters are transferred from the channel to the FBRMS subsystem. The parameter bytes have the following format:

Byte	Use
0	Operation byte
1	Replication Count
2 and 3	Block Count
4 through 7	RelativeDisplacement

Byte 0: Operation Byte

Byte 0 is the operation byte that specifies the type of operation to be performed when the desired storage blocks are accessed. The format of Byte 0 shall be as follows:

*Note: Zero initial status means that the command has been accepted by the control unit. Other initial status values, such as BUSY or UNIT CHECK are possible.

Bits	Use
0-3	Modifier Bits
4-7	Operation Code Bits

Modifier Bits (0-3): Bits 0 and 1 are reserved and must be zero or the command shall be terminated with DEVICE END and UNIT CHECK status and a sense indication of Command Reject.

Bit 3 controls the use of the optional Untagged DEVIDE END feature. When bit 3 is set to one, the feature is enabled and DEVICE END may be returned via an alternate control unit and channel. When bit 3 is set to zero, the Untagged DEVICE END feature is disabled and DEVICE END shall be returned via the original control unit and channel. If the Untagged DEVICE END Feature is not implemented, then bit 3 is not used and shall be ignored by the control unit.

Bit 2 controls the use of the optional Indefinite Transfer feature. When bit 2 is set and the Indefinite Transfer feature is implemented, then the operation of the Write Data, Write and Check Data and Read operations, selected by the Operation Code Bits (4-7), is altered. If the Indefinite Transfer feature is not implemented, then bit 2 is reserved and if bit 2 is one, the command shall be terminated with DEVICE END and UNIT CHECK status and a sense indication of COMMAND REJECT.

Operation Code Bits (4-7): These four bits define the following operations:

Value	Operation
0100	Format Defective Block
0001	Write Data
0101	Write and Check Data
0110	Read
0010	Read Replicated Data

Any other values shall be invalid and cause the command to terminate with DEVICE END and UNIT CHECK status.

Data transfers between the channel and subsystem associated with these operations do not occur during the execution of the LOCATE command but are initiated by an immediately following chained READ or WRITE command.

Format Defective Block (0100): This operation code shall cause the control unit to flag the logical or physical block at the logical block address specified by bytes 4 through 7 as defective. The control unit shall assign an alternate logical or physical block and establish appropriate pointers so that the specified alternate block will be accessed whenever subsequent commands attempt to access the block specified by bytes 4 through 7. The algorithm for assigning alternate blocks and maintaining their pointers is considered an internal FBRMS subsystem function and is not herein specified. The algorithm shall be defined in the vendor's documentation. If all alternate space has been used, the control unit shall signal UNIT CHECK, DEVICE END, and, if it has not already been presented, CHANNEL END status.

If the mask specified in the DEFINE EXTENT command inhibits format write operations, or if the device is set by local switches in read-only mode, the LOCATE command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

If an unused alternate block is located, the control unit shall save the alternate block pointer and initiate an access to the defective block specified in bytes 4 through 7 of the parameters, verify the correct positioning, and format the block identification (ID) with the defective flag bit on and the appropriate block pointer.

Format Defective Block shall specify parameters for only one logical block but the operation may affect more than one logical block or more than one physical block depending on the relationship of logical to physical blocks and the use of this command as defined in the vendor's documentation. If the Format Defective Block operation affects more than the specified logical block, and those other logical blocks are readable, then the data they contain shall be preserved through the reformatting operation. Future references to the defective block or any other affected logical block shall cause the control unit to access the assigned alternate block.

There shall be no data transfer between the channel and the control unit during the Format Defective Block operation. All data written shall be generated internally by the control unit. Only the ID areas of the defective and alternate logical or physical blocks are written. A LOCATE command specifying Write Data should be issued after the Format Defective Block to write the data field of the logical block or logical blocks of the physical block as defined in the vendor's documentation.

If the LOCATE command was preceded by a DIAGNOSTIC CONTROL command with a subcommand of Displace ID, the control unit shall write the block ID in its normal, displaced, or extended-displaced position according to the Displace ID subcommand. The control unit shall then perform a readback check on the block ID just written. If it is unreadable due to data errors, the operation shall be terminated with DEVICE END and UNIT CHECK status.

If the LOCATE was not preceded by a DIAGNOSTIC CONTROL command, the control unit shall write the block ID in its normal position and perform a readback check on the block ID. If it is unreadable due to data errors, the control unit may rewrite the block ID at a displaced position and perform another readback check. If the data is still unreadable, the operation shall be terminated with DEVICE END and UNIT CHECK status.

In either case (with or without a preceding DIAGNOSTIC CONTROL command) if the readback check is successful, the control unit shall initiate an access to the alternate block, verify proper location, format the alternate block ID with the appropriate flag byte and backward pointer, and present DEVICE END status.

Write Data (0001): This operation code shall prepare the control unit to write one or more blocks of data. The number of blocks to be written is specified in the block count parameters of the LOCATE command (bytes 2 and 3). If the mask specified in the DEFINE EXTENT command inhibits all write operations, or if the device is locally set in read-only mode, the LOCATE command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

The Write Data operation shall establish write orientation in the control unit for the addressed device.

Write Data shall cause the control unit to initiate an access to the first block to be processed. The Relative-Displacement of the first block specified by bytes 4 through 7 of the parameters shall be converted to the appropriate physical values for the addressed device. When the access to the block is complete, the device shall present DEVICE END status.

If the Indefinite Transfer Feature is implemented and Modifier Bit 2 is a one, the Block Count parameters shall be ignored.

Write and Check Data (0101): The control unit shall perform the same functions as described for the Write Data operation code, and in addition, shall prepare to perform a readback check on the data written during the chained WRITE command.

Read Replicated Data (0010): This operation code shall prepare the control unit to read one or more blocks of data from a range of replicated data. The number of blocks to be read is specified in the Block Count parameters (bytes 2 and 3). This operation shall establish read orientation in the control unit for the addressed device.

Read Replicated Data causes the control unit to initiate an access to the first block of any unit of replicated data. DEVICE END status shall be presented when the access is complete.

Read Data (0110): This operation code shall prepare the control unit to read one or more blocks of data. The number of blocks to be read is specified in the Block Count parameters (bytes 2 and 3).

Read Data shall cause the control unit to initiate an access to the first block of data to be processed. The relative displacement of the first block specified by bytes 4 through 7 of the parameters shall be converted to the appropriate physical values for the addressed device. DEVICE END shall be presented when the access is complete.

If the Indefinite Transfer feature is implemented and Modifier Bit 2 is a one, the Block Count parameter shall be ignored.

BYTE 1: Replication Count

Byte 1 is the Replication Count. This byte shall be ignored unless byte 0 specifies Read Replicated Data (bits 4 through 7 = 0010). It specifies a range of blocks containing replicated data. The first block of this range is specified by the Relative-Displacement.

The control unit shall position the storage medium to the beginning of a unit of replicated data to minimize rotational delay.

The Block Count (bytes 2 and 3 of the parameters) specifies the number of blocks in a unit of replicated data. For example, if the Block Count is two and this two-block unit is replicated five times, the Replication Count is ten.

If the Replication Count is less than the Block Count or if the Replication Count is not a mulitple of the Block Count, the LOCATE command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

If the Replicated Count equals the Block Count, the control unit shall treat the read replicated data operation as a Read Data operation.

BYTES 2 and 3: Block Count

Bytes 2 and 3 are the Block Count. Unless the optional Indefinite Transfer Feature is implemented and selected, they specify the number of sequential blocks to be processed by the command immediately following the LOCATE command. These bytes must not be zero or the LOCATE command shall terminate with CHANNEL END, DEVICE END, and UNIT CHECK status. The FBRMS subsystem shall transfer the number of blocks specified in this parameter during execution of the immediately following command.

If the optional Indefinite Transfer Feature is implemented and selected (Operation Byte 2 is one), then the Block Count Parameter shall be ignored.

BYTES 4 through 7: RelativeDisplacement

Bytes 4 through 7 specify the displacement, in blocks, from the beginning of the data set to the first block to be processed. The offset, from block zero of the logical device of the first block to be accessed shall be computed by the control unit as follows:

FirstBlockAccessed = RelativeDisplacement - ExtentFirstDisplacement + Extent Offset

The control unit shall compare the relative displacement of the blocks to be processed to the valid extent range determined by the ExtentFirstDisplacement and the ExtentLastDisplacement (see Figure 2). If the blocks are within the valid extent, the control unit shall process the LOCATE command and position the device to the first block to be processed. If any block is not within the valid extent range, the LOCATE command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status. Figure 2 illustrates the FBRMS address translation process.

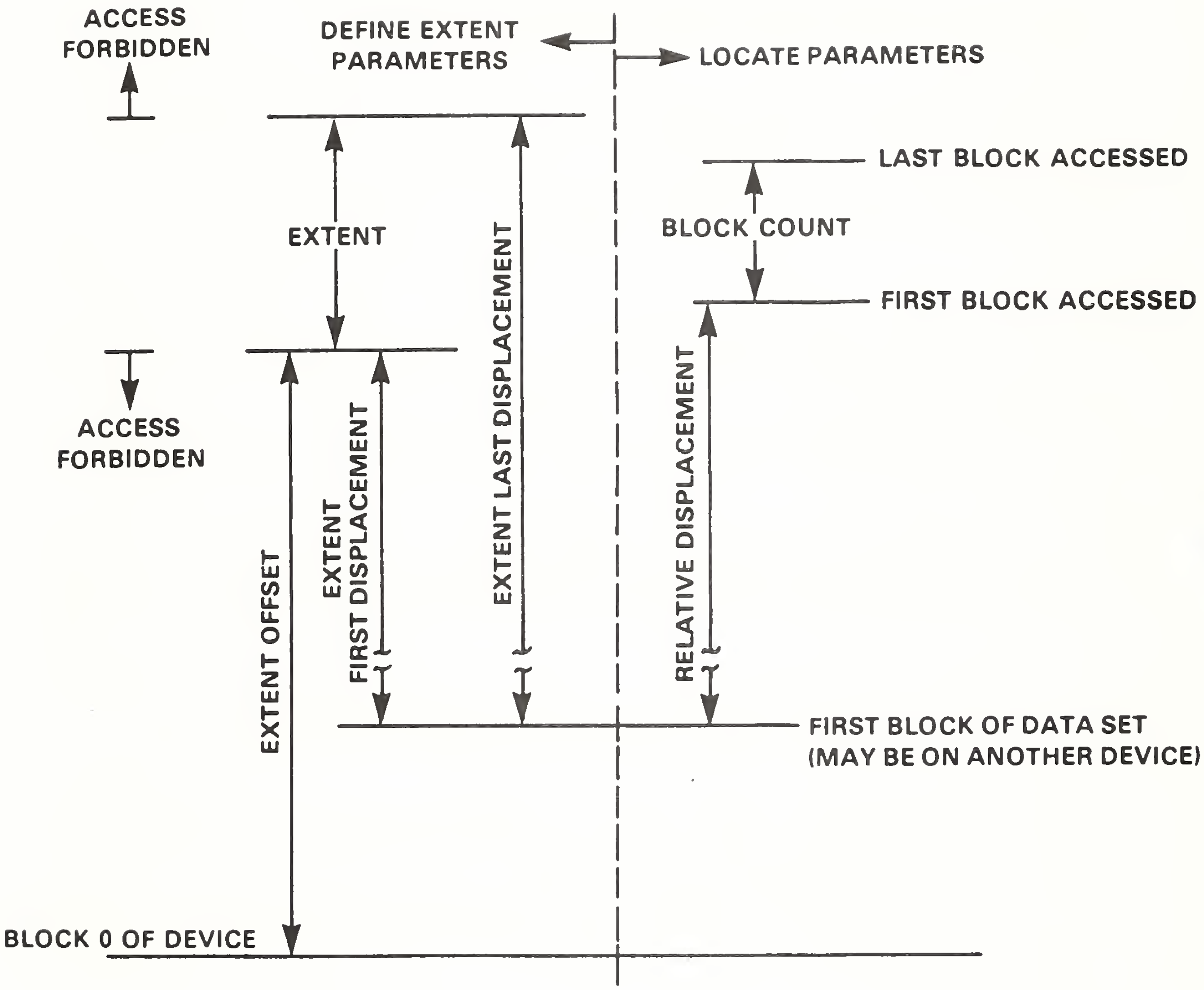
Note: ExtentFirstDisplacement, ExtentOffset, and ExtentLastDisplacement are parameters of the DEFINE EXTENT command.

CHAINING REQUIREMENTS

A LOCATE command must be preceded by a READ IPL or a DEFINE EXTENT command in the same command chain or the LOCATE command shall be rejected with a status indication of CHANNEL END, DEVICE END, and UNIT CHECK, and a SENSE indication of COMMAND REJECT.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END status shall be presented after the parameters have been transferred and checked for validity. Invalid parameters shall cause the command to be terminated with the presentation of CHANNEL END, DEVICE END, and UNIT CHECK status, and a sense indication of COMMAND REJECT. A LOCATE command with valid parameters and an Operation Code parameter of 0100 (Format Defective Block) shall return DEVICE END status after completion of the format operation. A LOCATE command with valid parameters and an Operation Code parameters of 0001, 0101, 0110, or 0010 (Write Data, Write and Check Data, Read or Read Replicated Data) shall cause the subsystem to return DEVICE END status after the device is properly positioned to begin processing the first data record.



NOTE: "OFFSET" IS THE FIRST BLOCK OF THE DEVICE
"DISPLACEMENT" IS FROM THE FIRST BLOCK OF THE DATA SET

FBRMS ADDRESS TRANSLATION

FIGURE 2

2.2 Read Commands

2.2.1 READ

COMMAND CODE 0100 0010 binary, 42 hexadecimal

The READ command causes recorded data to be transferred from the subsystem to the I/O channel. A READ command shall be immediately preceded by and chained from a LOCATE command which has specified an Operation Code of Read Data or Read Replicated Data, as well as the location of the first data block to be read, and the number of blocks to be read. The READ command itself is then initiated when DEVICE END status is returned for the LOCATE command, signifying that the device is properly positioned to read the first data block.

When the READ command is executed, the control unit shall read the block ID and verify the correct positioning. After verification of correct positioning, the following data block shall be read and transferred to the channel. The subsystem shall continue reading and transferring data to the channel including data from subsequent blocks until one of three events occurs:

(1) An error is detected by the subsystem.

(2) If the Indefinite Transfer feature is not implemented or if the LOCATE Operation Byte Bit 2 is zero, the number of blocks specified in the Block Count parameter of the preceding LOCATE command have been transferred to the Channel.

(3) The Channel signals STOP (see FIPS 60).

PARAMETERS

The READ command does not pass parameters to the control unit.

ERROR CONDITIONS

Command overrun, service overrun, data errors, and access errors are all possible during the execution of READ commands. They shall be detected by the subsystem. The control unit shall then perform the appropriate error recovery specified in the Control Unit Error Recovery section of this specification.

CHAINING REQUIREMENTS

If the READ command is not immediately chained from a LOCATE command which specifies an Operation Code parameter of Read or Read Replicated Data, then the READ command shall be terminated CHANNEL END, DEVICE END, and UNIT CHECK.

STATUS INDICATIONS

Initital status is normally zero. CHANNEL END and DEVICE END status shall be presented after completion of data transfer. Status indications for overrun, data errors, and access errors shall be as specified in the CONTROL UNIT ERROR RECOVERY section of this specification.

2.2.2 READ INITIAL PROGRAM LOAD

COMMAND CODE 0000 0010 binary, 02 hexadecimal

2.2.2.1 Class A Operation

The READ INITIAL PROGRAM LOAD (READ IPL) command shall cause the control unit to access and read block 0. The READ IPL command must be the first command in its chain or must be chained from another READ IPL command.

The READ IPL command shall first cause the control unit to establish an extent of maximum allowable size with an ExtentOffset of zero and a mask byte of zero (see the DEFINE EXTENT command for the definition of these parameters). The control unit shall then orient to block zero of the selected device and read the entire block. Only block zero shall be read.

PARAMETERS

No parameters are passed to the control unit by the READ IPL command; however, several parameters normally passed by DEFINE EXTENT commands are implicitly set by the READ IPL Command (see above).

ERROR CONDITIONS

Service overrun and data errors are possible during the execution of a READ IPL command. They shall be detected by the subsystem. The control unit shall then perform the appropriate error recovery actions specified in the CONTROL UNIT ERROR RECOVERY section of this specification.

CHAINING REQUIREMENTS

The READ IPL Command must be the first command in a chain or must be chained from another READ IPL command or the READ IPL command shall be rejected with a status indication of CHANNEL END, DEVICE END, and UNIT CHECK and a sense indication of COMMAND REJECT.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after completion of the data transfer. Status indications for overrun and data errors shall be as specified in the CONTROL UNIT ERROR RECOVERY section of this specification.

2.2.2.2 Class B Operation

Class B operation is identical to Class A except that the starting block and number of blocks transferred shall be defined in the vendor's documentation. Any additional error recovery procedures used by the control unit shall also be defined in the vendor's documentation.

2.3 WRITE

COMMAND CODE 0100 0001 binary, 41 hexadecimal

The WRITE command causes data to be transferred from the channel to the subsystem and recorded in one or more data blocks selected by an immediately preceding, chained LOCATE command. The WRITE command is initiated when DEVICE END status is returned for the LOCATE command, signifying that the addressed device is properly positioned to write the first data block.

A WRITE command shall be immediately preceded by and chained from a LOCATE command which specifies an Operation Code parameter of Write Data or Write and Check Data.

When the WRITE command is executed, the control unit shall read the block ID and verify the correct positioning. After verification of correct positioning, the following data block shall be written with data transferred from the channel. The subsystem shall continue to write subsequent data blocks until one of three events occurs:

(1) An error is detected by the subsystem.

(2) If the Indefinite Transfer feature is not implemented or if the LOCATE Operation Byte Bit 2 was zero, the number of blocks specified in the Block Count parameter of the preceding LOCATE command have been written.

(3) The channel signals STOP (see FIPS 60).

If the Indefinite Transfer feature is not implemented or if the LOCATE Operation Byte Bit 2 was zero and the channel signals STOP before all of the data blocks specified by the preceding LOCATE command are written, the remainder of the current data block, and the following blocks specified in the Block Count of the preceding LOCATE command shall be filled with zeros by the control unit.

If the Indefinite Transfer feature is implemented and was selected by the previous LOCATE command (Operation Byte Bit 2 is a one), then when the channel signals STOP or an error is detected by the subsystem causing it to halt the write operation, the remainder, if any, of the current block only shall be filled with zeros by the subsystem.

If access boundaries are encountered during data transfer, the control unit shall perform the appropriate access movement.

If an Operation Code of Write and Check Data is specified in the preceding LOCATE command, the control unit shall, after recording all specified data blocks, initiate an access back to the first block written and present CHANNEL END status. When the access is complete, the control unit shall read the block ID and verify correct positioning. All data blocks written during execution of the command shall then be read by the control unit, but data is not transferred to the channel. The validity of each recorded data block shall be verified by the control unit. After all blocks are verified, the control unit shall present DEVICE END status.

PARAMETERS

No parameters are passed to the control unit by a WRITE command.

ERROR CONDITIONS

Command overrun, service overrun, data errors, and access errors are all possible during the execution of WRITE command. They shall be detected by the subsystem. The control unit shall then perform the appropriate error recovery specified in the CONTROL UNIT ERROR RECOVERY Section of this specification.

CHAINING REQUIREMENTS

If the WRITE command is not immediately chained from a LOCATE command which specifies an Operation Code parameter of Write Data or Write and Check Data, or if the device is set in read only mode by operator switch action, then the WRITE command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status and a Sense Indication of COMMAND REJECT.

STATUS INDICATIONS

Initial status is normally zero. If an operation of Write Data is specified by the preceding LOCATE command, CHANNEL END and DEVICE END shall be presented after data has been transferred to the control unit. If an operation of Write and Check Data is specified by the preceding LOCATE command, CHANNEL END shall be presented after all data has been transferred to the control unit, and DEVICE END shall be presented after all blocks have been read and checked. If Write Data or Write and Check Data were not specified, the status response shall be as indicated under Chaining Requirements above (see 2.2.2.1). Status indications for error conditions shall be as specified in the CONTROL UNIT ERROR RECOVERY section of this specification.

2.4 Sense Commands

2.4.1 SENSE INPUT/OUTPUT

COMMAND CODE 0000 0100 binary, 04 hexadecimal

The SENSE INPUT/OUTPUT command shall cause the transfer of sense information from the control unit to the channel. The number of bytes and meaning of the sense information shall be as defined in the SENSE INFORMATION section of this specification.

Sense information describes the reason for UNIT CHECK status, the current status of the device which performed an operation, and system error recovery information.

A contingent connection state is established in the control unit after the channel accepts a status byte containing a UNIT CHECK (see the Contingent Connection subsection of the INTRODUCTION section of this specification). A UNIT CHECK should always be followed by a SENSE INPUT/OUTPUT command to reset the contingent connection state of the control unit, whether or not the sense data is used.

Sense information shall be reset to zero after the sense data transfer is complete, or when an initial status byte of zero is given to any command except TEST I/O or NO-OPERATION.

PARAMETERS

The SENSE INPUT/OUTPUT command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

None.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after the sense bytes are transferred.

2.4.2 SENSE INPUT/OUTPUT TYPE

COMMAND CODE 1110 0100 binary, E4 hexadecimal

The SENSE INPUT/OUTPUT TYPE command shall transfer a minimum of seven bytes of information from the control unit to the channel. This information identifies the type of control unit and device. The format shall be as follows:

Byte	Description
0	Always FF hexadecimal
1 to 3	Control unit type (model dependent)
4 to 6	Device type (model dependent)
7 to n	Additional model dependent information (if any).

The presence of and interpretation of the model dependent fields shall be defined in the vendor's documentation. If the device is available and not busy, the SENSE INPUT/OUTPUT TYPE command shall be executed even if the device is not ready.

The sense information shall be reset to zero after execution of this command.

PARAMETERS

The SENSE INPUT/OUTPUT TYPE command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

None.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END status shall be presented after completion of information transfer.

2.4.3 READ AND RESET BUFFERED LOG

COMMAND CODE 1010 0100 binary, A4 hexadecimal

The READ AND RESET BUFFERED LOG command shall cause the control unit to transfer usage and/or error information to the channel. The first eight bytes shall be sense bytes 0 through 7. The remaining bytes shall be as specified in Format 6 sense information (see the SENSE INFORMATION section of this specification).

The usage/error information pertains to the logical device addressed. The information is reset to zero after data transfer is complete.

PARAMETERS

The READ AND RESET BUFFERED LOG command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

None.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after the information bytes are transferred.

2.4.4 READ DEVICE CHARACTERISTICS

COMMAND CODE 0110 0100 binary, 64 hexadecimal

The READ DEVICE CHARACTERISTICS command shall cause 32 bytes of information to be transferred from the control unit to the channel. The information transferred defines the characteristics of the addressed device. The device characteristics shall have the following format:

Byte	Bits	Description
0		Operation modes (if the bit is one, the mode applies)
	0	Reserved
	1	Overrunable
	2	One indicates burst mode and zero indicates byte mode
	3	Data reconnection
	4-7	Reserved
1		Features (if the bit is one, the feature applies)
	0	Reserved
	1	Removable device
	2	Shared device
	3	Reserved
	4	Movable access mechanism
	5-7	Reserved
2		Device class
	0	Zero indicates Class A; one indicates Class B
	1-7	Model dependent; if used, shall be defined in the vendor's documentation
3		Unit type - model dependent
4,5		Physical block size in bytes
6-9		Number of primary physical blocks per cyclical group (quotient from dividing number of primary physical blocks per access position by number of moving heads). "Primary" means not reserved for reassignment of bad blocks or other maintenance procedures.
10-13		Number of primary physical blocks per access position
14-17		Number of primary physical blocks under movable access mechanism
18,19		Number of primary physical blocks under fixed heads
20,21		If non-zero, indicates Class B logical block size in bytes. If zero, indicates logical block size equals physical block size.
22,23		If non-zero, indicates Class B logical blocking factors; i.e., number of logical blocks per physical block. If zero, indicates block size equals physical block size.
24,25		Number of primary physical blocks in the maintenance area. The maintenance area is that portion of the recording surface not normally available for data storage, but reserved for maintenance purposes, reassignment of bad blocks and the like.

26		Optional Features (if the bit is one, the optional feature is present)
	0	Untagged DEVICE END feature
	1	Indefinite Transfer Feature
	2-7	Reserved, shall be zero
27		Model dependent - If used, the interpretation of this field shall be defined in the vendor's documentation
28-31		Primary physical block number, relative to physical block zero of the device, of the first block under fixed heads

PARAMETERS

The READ DEVICE CHARACTERISTICS command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

None.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after the information bytes are transferrred. If the addressed device is available and not busy but in the not-ready state, the command shall not be executed and UNIT CHECK shall be presented in initial status.

2.4.5 Sense Commands for Device Allocation

The purpose of these commands is to reserve or release a specific access path to the device. These commands are useful for reserving connection paths when recovering from hardware malfunctions and for blocking access to a device via other paths.

These commands shall be implemented if the subsystem allows sharing of control units by two or more channels or sharing of devices by two or more control units. When a device has been reserved for one access path, all attempts to access it by any other path (except via the UNCONDITIONAL RESERVE command) shall be rejected with some type of BUSY status. If sharing is not implemented, these commands may be treated as NO-OP's or by issuing COMMAND REJECT.

2.4.5.1 DEVICE RESERVE

COMMAND CODE 1011 0100 binary, B4 hexadecimal

The DEVICE RESERVE command shall reserve the addressed device to the channel that issued the command.

In addition to reserving the addressed device, the DEVICE RESERVE command shall transfer all the sense bytes to the channel as with the SENSE I/O command.

A DEVICE RESERVE command shall be executed regardless of device status conditions.

Device reservation shall be maintained until the reserving channel successfully completes a DEVICE RELEASE command addressed to the reserved device. While a device reservation is in effect for a channel, BUSY status shall be used to reject access to the reserved device from a different channel access path. If two DEVICE RESERVE commands are issued for a device by the same channel, without an intervening DEVICE RELEASE command, then the second DEVICE RESERVE shall be rejected with a status indication of CHANNEL END, DEVICE END, and UNIT CHECK and a sense indication of COMMAND REJECT.

Note: A system reset shall cancel reservation of a device to the resetting channel only.

PARAMETERS

The DEVICE RESERVE command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

The DEVICE RESERVE command must not be preceded by a DEFINE EXTENT command in the same chain, or the command shall be rejected with a CHANNEL END, DEVICE END, and UNIT CHECK status and a sense indication of COMMAND REJECT.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after the sense bytes have been transferred. Error status conditions are defined above.

2.4.5.2 DEVICE RELEASE

COMMAND CODE 1001 0100 binary, 94 hexadecimal

When a DEVICE RELEASE command is issued by a channel which had previously issued a DEVICE RESERVE command to the same device, the reservation established by the DEVICE RESERVE command shall be terminated. A DEVICE RELEASE issued for a device which is not reserved shall be treated as a NO-OP command.

In addition to terminating the reservation of the addressed device, the DEVICE RELEASE command shall transfer the sense bytes to the channel as with the SENSE I/O command.

A DEVICE RELEASE command shall be executed regardless of device status conditions.

PARAMETERS

The DEVICE RELEASE command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

The DEVICE RELEASE command must not be preceded by a DEFINE EXTENT command in the same chain, or the command shall be rejected with CHANNEL END, DEVICE END, and UNIT CHECK status and a sense indication of COMMAND REJECT.

STATUS INDICATIONS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after the sense bytes have been transferred. Error status conditions are defined above.

2.4.5.3 UNCONDITIONAL RESERVE

COMMAND CODE 0001 0100 binary, 14 hexadecimal

This command is ordinarily used to recover from hardware malfunctions, where a reservation has been established by a channel which then "fails" to subsequently release the reservation with a DEVICE RELEASE command.

The UNCONDITIONAL RESERVE command shall break any existing device allocation to the original primary (failing) path and reserve the device to the current alternate path in the same system if there are multiple access paths to the same device. This command shall reserve the device to the alternate path even if the device was previously reserved or in use by the primary path. The reservation and pending status or sense information in the primary path shall be reset in the device and control unit through which the command was issued. Information in any control units not in the alternate connection path shall not be reset.

This command is ordinarily used only with devices reserved by the same computer system. If this command is used with a device shared with another system, then the effects of issuing this command upon the other system, which has reserved the device, is unpredictable.

Device reservations established by the UNCONDITIONAL RESERVE command may be released by the DEVICE RELEASE command.

PARAMETERS

The UNCONDITIONAL RESERVE command does not pass parameters to the control unit.

CHAINING REQUIREMENTS

The UNCONDITIONAL RESERVE command must be the first command in a chain or the command shall be rejected with CHANNEL END, DEVICE END, and UNIT CHECK status and a sense indication of COMMAND REJECT.

STATUS

Initial status is normally zero. CHANNEL END and DEVICE END shall be presented after the sense bytes have been transferred. Error status conditions are defined above.

2.5 Diagnostic Commands

2.5.1 Diagnostic Control

COMMAND CODE 1111 0011 binary, F3 hexadecimal

The DIAGNOSTIC CONTROL command shall cause at least four, and sometimes more than four, bytes of DIAGNOSTIC CONTROL parameters to be transferred from the channel to the control unit. These parameters are used to perform diagnostic, data recovery, or block reformatting functions and are not ordinarily used by applications programs. Their specific meanings are defined below.

PARAMETERS

The first four bytes of DIAGNOSTIC CONTROL parameters transferred by this command shall have the following format:

Byte	Description
0	Subcommand identification
1	Subcommand identification modifier bits
2 and 3	Additional number of bytes to be transferred (N)

After the first four bytes have been transferred, the control unit shall check the validity of the subcommand identification code and verify that bytes 2 and 3 specify the correct number of additional bytes required for that subcommand. If an invalid parameter is detected, the DIAGNOSTIC CONTROL command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

If the parameters are valid, the channel shall transfer the additional number of bytes (specified in bytes 2 and 3) to the control unit.

Let the additional bytes specified in bytes 2 and 3 be N. Then 4 + N bytes shall be transferred to the control unit. If less than 4 + N bytes are transferred by the channel, the command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

Byte 0: Subcommand

Byte 0 specifies the subcommand to be performed. The following subcommands shall be executed by the control unit:

Subcommand	Binary	Hexadecimal
Trace/Dump	0000 0000	'00'
Displace ID	0000 1111	'0F'
Format ID	0000 0100	'04'
Space ID and Read Data	0000 0110	'06'
Read ID	0000 1010	'0A'

2.5.1.1 Subcommands which do not use Physical Addresses

a. Trace/Dump Subcommand

Byte:	0	1	2 and 3
	Command Code	Modifiers	Additional Bytes Required
	'00'	'00'	'0000'

The Trace/Dump subcommand shall prepare the control unit for a subsequent DIAGNOSTIC SENSE/READ command that will transfer the contents of the trace/dump buffer to the channel.

b. Displace ID Subcommand

Byte:	0	1	2 and 3
	Command Code	Modifiers	Additional Bytes Required
	'0F'	see below	'0000'

Modifiers

'10'	Write ID of defective block in normal position.
'20'	Write ID of defective block in displaced position.
'40'	Write ID of defective block in extended displaced position.

The Displace ID subcommand is executed to prepare the control unit for a subsequent LOCATE command with an operation code specifying a Format Defective Block. During execution of the Format Defective Block operation, the ID of the defective block shall be written in the position indicated by the modifier bits in the Displace ID subcommand. Since the utility of this command is dependent upon the recording medium, the implementation of this subcommand with modifiers of '20' or '40' is optional. If these subcommand modifiers are not implemented, they shall be rejected with CHANNEL END, DEVICE END, and UNIT CHECK status and a sense indication of COMMAND REJECT.

2.5.1.2 ID Physical Address Subcommands

There are three additional DIAGNOSTIC CONTROL ID subcommands which use model dependent flags and physical addresses:

- Format ID
- Space ID and Read Data
- Read ID

In addition to the four parameter bytes specified above, these three subcommands pass a block count in bytes four and five plus flag parameters and a physical address for a block or multiple blocks in a format specified by the vendor's documentation. Since the ID fields are model dependent, their format shall be defined separately in the vendor's documentation for each device. The correlation between logical blocks, physical blocks, and physical addresses are not specified here, but shall be defined in the vendor's documentation. There is no requirement that a logical block be contained entirely within one physical block. The allowed values for the block count are also specified in the vendor's documentation.

Two conditions determined in the flag parameter, the alternate area and the defective block flags, shall be checked by the control unit while performing an ID subcommand. When the alternate area flag is set, it indicates that this block is in an alternate area. When it is reset (zero), it indicates that this block is in the primary area. When the defective block flag is set, it indicates a defective block. In addition, the flag parameter indicates whether the ID is physically displaced once, physically displaced twice, or not displaced at all, for those devices which have the capability to displace ID's.

For the Space ID and Read Data, and Read ID subcommand operations, the flag bytes shall contain the alternate area flag only. The indications of this flag shall be the same as for the Format ID subcommand.

For all three ID subcommands, the physical address specified shall be checked for consistency with bit 4 of the DEFINE EXTENT mask byte (parameter byte 0) set in the control unit by the preceding chained DEFINE EXTENT command. If they are inconsistent (that is, if bit 4 is set, indicating reserved for maintenance but the address is in the data area of the device, or if bit 4 is zero, indicating data area but the address is in the area reserved for maintenance), then the command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

For all three ID subcommands, the alternate area flag shall be checked for consistency with the physical address specified. If they are inconsistent (that is, if the flag indicates an alternate area while the physical address is in the primary area or vice versa), then the command shall be rejected with CHANNEL END, DEVICE END, and UNIT CHECK status.

The three DIAGNOSTIC CONTROL subcommands which use physical addresses are:

a. <u>Format ID Subcommand</u>

Byte:	0	1	2 and 3
	Command Code	Modifiers	Additional Bytes Required
	'04'	'00'	model dependent

Additional Bytes

4 and 5 Block Count (allowed values defined in vendor's documentation)

Additional parameters include the flags and physical address for the ID of each logical and/or physical block and optionally, the number of logical blocks to be represented within a physical block (Logical Blocking Factor). The formats of flags, physical addresses, and Logical Blocking Factor, if used, are model dependent and shall be defined in the vendor's documentation.

The Format ID subcommand shall be capable of:

(1) formatting a normal block (Note: The relationship of logical blocks to physical blocks and the use of this command shall be defined in the vendor's documentation.)

(2) flagging an alternate block as unused

(3) flagging an alternate block as defective

Execution of this subcommand shall cause the control unit to rewrite the block ID of the block or block(s) specified by the parameter list.

For Class A subsystems, the block size shall be 512 bytes. For Class A subsystems, only one block shall be affected, and the Block Count specified in bytes 4 and 5 shall be ignored.

Class B subsystems may optionally use this subcommand to format a device to a new logical or physical block size, or they may use some internal mechanism (such as loading the microstore of the control unit with a special formatting program). They may also use a combination of this subcommand and some internal subsystem procedure to reformat to a new logical or physical block size. Class B subsystems may optionally use the Block Count specified in bytes 4 and 5 to determine the number of consecutive blocks to be formatted beginning with the physical address given in the additional parameters. The vendor's documentation shall define the procedures used to reformat FBRMS devices to a new block size if more than one block size is supported.

Class B FBRMS subsystems shall be capable of using this subcommand to write a new block ID except for a defective primary block after the subsystem has been reformatted to a new logical or physical block size, regardless of whether this subcommand is used to alter block sizes. For Class B devices, the logical block size is specified in parameter bytes 2 and 3 of the preceding DEFINE EXTENT command. The same block size must be used for all blocks on a device.

At the end of data transfer, the control unit shall check the parameters for validity. The command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status if any of the following conditions are detected:

- The DEFINE EXTENT command inhibits format write operations.
- The device is in read-only mode.
- A physical address is invalid for the addressed device.
- A physical address is inconsistent with either the alternate area flag or the Mask byte of the DEFINE EXTENT command.
- A flag parameter is invalid.
- The use of the alternate area flag and the defective block flag are inconsistent, for example, if defective block and primary area are both indicated.

If all of the parameters are valid, the control unit shall initiate an access to the first block and present CHANNEL END status. When access to the block is completed, the control unit shall verify correct orientation and write the block ID for each block. (The block ID is internally generated by the control unit.)

If an addressed block is in the alternate area, the alternate flag bit shall be set in the block ID Field. If the defective-block flag bit is on, the block shall be flagged as defective with a null alternate/defective pointer and shall be written with a displacement indicated in the flag parameter. No data field shall be written for this operation and DEVICE END status shall be presented at the completion of the operation.

b. Space ID and Read Data Subcommand

Byte:	0	1	2 and 3
	Command Code	Modifiers	Additional Bytes Required
	'06'	'00'	model dependent

4 and 5 Block Count (ignored)

Additional parameters include the flags and physical address from the ID field. The format of flags and physical address are model dependent and shall be defined in the vendor's documentation.

The Space ID and Read Data subcommand can be used to recover the data field of a block when the block ID has a permanent uncorrectable DATA CHECK. Execution of this subcommand shall prepare the control unit to space over the block ID field and read the data field of the block specified in the physical address of the parameter list. Only one block shall be read and the block count in bytes 4 and 5 is ignored.

At the end of data transfer, the control unit shall check the parameters for validity. If any of the following conditions are detected, the command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

- The physical address is invalid for the addressed device.

- The physical address is inconsistent with either the alternate area flag or the Mask byte of the DEFINE EXTENT command.

If all the parameters are valid, the control unit shall initiate an access to the block and present CHANNEL END status. When access to the block is completed, DEVICE END status shall be presented.

The actual operation of spacing over the block ID field and transferring the read data is performed by a subsequent DIAGNOSTIC SENSE/READ command.

c. Read ID Subcommand

Byte:	0	1	2 and 3
	Command Code	Modifiers	Additional Bytes Required
	'0A'	'00'	class dependent

Additional Bytes

4 and 5	Block Count

Additional parameters include the flag and physical address for the first ID field. The format of flags and physical address are model dependent and shall be defined in the vendor's documentation.

The Read ID subcommand is used to generate a defective physical block map for a device. Execution of this subcommand shall prepare the control unit to read one or more block ID's. The number of block ID's to be read is determined by the block count in bytes 4 and 5.

At the end of data transfer, the control unit shall check the parameters for validity. If any of the following conditions are detected, the command shall be terminated with CHANNEL END, DEVICE END, and UNIT CHECK status.

- The physical address is invalid for the addressed device.

- The physical address is inconsistent with either the alternate area flag or the Mask byte of the DEFINE EXTENT command.

If all the parameters are valid, the control unit shall initiate an access to the block and present CHANNEL END status. When access to the block is completed, DEVICE END status shall be presented.

The actual reading of block ID's and transferring data to the channel is performed by a subsequent DIAGNOSTIC SENSE/READ command. The control unit shall transfer the ID field as data to the channel for each block ID processed. The format of the ID information transferred shall be defined for each FBRMS device in the vendor's documentation. The block ID's processed are logically continuous either in the primary area or in the alternate area.

CHAINING REQUIREMENTS

The DIAGNOSTIC CONTROL command must be preceded in the same command chain by a DEFINE EXTENT command that allows diagnostic commands or the command shall be rejected with CHANNEL END, DEVICE END, and UNIT CHECK status.

STATUS

Initial status is normally zero. Error status conditions are defined above for each subcommand.

2.5.2 DIAGNOSTIC SENSE/READ

COMMAND CODE 1100 0100 binary, C4 hexadecimal

The DIAGNOSTIC SENSE/READ command transfers diagnostic or data recovery information from the control unit to the channel. The meaning and number of bytes transferred shall be determined by the preceding DIAGNOSTIC CONTROL command as shown below:

DIAGNOSTIC CONTROL SUBCOMMAND	ACTION
Trace/Dump	The contents of the trace/dump buffer shall be transferred to the channel. CHANNEL END and DEVICE END shall be presented after transfer. The size and organization of the trace/dump buffer are model dependent and not specified here but shall be defined in the vendor's documentation.
Format ID	No data transfer shall take place on this subcommand. CHANNEL END and DEVICE END shall be presented in ending status.
Space ID and Read Data	The control unit shall verify the positioning, specified by the preceding DIAGNOSTIC CONTROL command, then shall space over the next ID field and transfer the data field to the channel. CHANNEL END shall be presented after data transfer.
Read ID	The control unit shall first verify the positioning specified by the preceding DIAGNOSTIC CONTROL command.

The ID field of the following block shall then be read and transferred to a buffer in the control unit. If no ID Field errors are detected, the block ID field shall be transferred from the control unit to the channel.

This read process shall continue until the block count specified by the preceding DIAGNOSTIC CONTROL command reaches zero. If access boundaries are encountered during data transfer, the control unit shall automatically perform the appropriate access movement. CHANNEL END and DEVICE END shall be presented after data transfer.

If an ID field error was detected, the control unit shall attempt recovery through the use of internal retry.

Displace ID

No data transfer shall take place for this subcommand. The Displace ID subcommand of the DIAGNOSTIC CONTROL command is used with a subsequent LOCATE command. A DIAGNOSTIC SENSE/READ command issued following a Displace ID is in effect a NO-OPERATION. CHANNEL END and DEVICE END are presented in ending status.

PARAMETERS

No parameters shall be passed by the DIAGNOSTIC SENSE/READ command itself; parameters passed by an immediately preceding chained DIAGNOSTIC CONTROL command shall govern the execution of the DIAGNOSTIC SENSE/READ command.

ERROR CONDITIONS

Access, overrun, and data errors may occur and shall be detected by the control unit when they occur. Control unit error recovery procedures shall be as specified in CONTROL UNIT ERROR RECOVERY section of this specification.

CHAINING REQUIREMENTS

The DIAGNOSTIC SENSE/READ command must be immediately chained from a DIAGNOSTIC CONTROL command or the command shall be rejected with CHANNEL END, DEVICE END, and UNIT CHECK status.

STATUS

Initial status is normally zero. Error status conditions are defined above under Chaining Requirements or the appropriate subcommand and in the CONTROL UNIT ERROR RECOVERY section of this specification.

2.6 Model Dependent Diagnostic Commands

These commands may be used to implement special model dependent diagnostic functions.

2.6.1 SET DIAGNOSE

COMMAND CODE 0100 1011 binary, 4B hexadecimal

This optional command is model dependent and, if used, shall be defined in the vendor's documentation. Parameter bytes may be transferred to the control unit from the channel.

2.6.2 READ DIAGNOSTIC STATUS

COMMAND CODE 0100 0100 binary, 44 hexadecimal

This optional command is model dependent and, if used, shall be defined in the vendor's documentation. Diagnostic logging or other model dependent information may be transferred from the control unit to the channel.

3.0 CONTROL UNIT ERROR RECOVERY

The control unit shall use appropriate means to detect the following kinds of errors:

a) Data Errors - Whenever the control unit reads data or ID Fields from the storage device, it shall check for data errors. Data errors are detected by use of unspecified redundancy or cyclic check bits which the control unit generates and appends to ID or data fields whenever they are written. If data errors are correctable and are not corrected before data is passed to the channel, the control unit shall generate appropriate correction patterns to correct the invalid bits, as a part of Format 5 sense information (Format 5 sense information is described in Section 5 of this specification). If data errors are corrected within the control unit before data is passed to the channel, no UNIT CHECK status or correction pattern is generated. NOTE: No practical error detecting code can detect every possible data error, and error correction may increase the possibility of accepting erroneous data as valid.

b) Service Overrun - Service overruns may occur only during the transfer of recorded data. A service overrun shall be detected whenever the channel does not respond to a control unit request for service within the time necessary for proper subsystem operation while transferring recorded data.

c) Command Overrun - A command overrun shall be detected whenever the channel fails to issue a command which transfers recorded data to or from the channel (READ, WRITE, READ IPL, and DIAGNOSTIC SENSE/READ) within the time required by the control unit for proper subsystem operation. A command overrun may occur because of a late channel reconnection. Commands which do not transfer recorded data shall not generate command overruns.

d) Access Errors - The control unit shall detect access errors which may occur during the movement of a device's access mechanism. Implicit access movements and therefore access errors may result from the multiple block transfers which cross access boundaries, or when defective blocks are encountered, as well as from explicit access movement commands.

e) Defective or Alternate Block - A defective block or alternate block shall be checked for and detected whenever the control unit reads an ID Field from the storage device in preparation for a read or write operation on the corresponding data field.

The control unit may internally retry or otherwise correct any error it is capable of internally correcting without notifying the I/O channel. The control unit shall respond to detected errors as indicated in the following Tables 3-1, 3-2, and 3-3:

Table 3-1

Control Unit Input (to Channel) Error Recovery* (Excluding Access Error)

Error Condition	Control Unit Action
Command Overrun	Signal retry status (CHANNEL END, STATUS MODIFIER, and UNIT CHECK). After positioning to the specified block, reconnect with DEVICE END status and continue.
Service Overrun on first block	Attempt recovery via retry status. If retry is unsuccessful, terminate with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 0 sense information with an indication of OVERRUN and PERMANENT ERROR.
Service Overrun on block of data other than first block	Terminate operation with retry status. UNIT CHECK status is then posted on the retried command, and Format 0 sense information is generated with an indication of OVERRUN and OPERATION INCOMPLETE.
Data Error detected while reading a block ID	Attempt recovery via internal retry, and if successful continue. If retry is unsuccessful, terminate command with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 4 sense information with an indication of DATA CHECK and PERMANENT ERROR.
Correctable Data Error detected while reading a data block	If correctable errors are not corrected internally, terminate with retry status. Post UNIT CHECK status when command is retried, and generate Format 5 sense information with an indication of DATA CHECK and CORRECTABLE. If the error did not occur in the last data block for the command, set OPERATION INCOMPLETE.** Format 5 sense information contains the data necessary to correct the error.
Uncorrectable Data Error detected in the first block	Attempt recovery via command retry. If retry is unsuccessful, terminate with CHANNEL END, DEVICE END, and UNIT CHECK status. Generate Format 4 sense information with an indication of DATA CHECK and PERMANENT ERROR.

*This table applies to Read, READ IPL, and DIAGNOSTIC SENSE/READ commands.

**This condition cannot occur with the READ IPL command or with the DIAGNOSTIC SENSE/READ command.

Uncorrectable Data Error detected in any block other than first**	Terminate with retry status. UNIT CHECK status is then posted on the retried command. Generate Format 4 sense information with indication of DATA CHECK and OPERATION INCOMPLETE.
Correctable Data Error detected and data corrected within the control unit before passing data to the channel	Command is completed normally without UNIT CHECK status. The occurrence of this condition may be recorded in the buffered log or the trace/dump buffer.
Defective or Alternate Block	Internal retry is used to access the correct position and continue the operation in progress.

**This condition cannot occur with the READ IPL command or with the DIAGNOSTIC SENSE/READ command.

Table 3-2

Control Unit WRITE Command Error Recovery (Excluding Access Error)

Error Condition	Control Unit Action
Command Overrun	Signal retry status (CHANNEL END, STATUS MODIFIER, and UNIT CHECK). After reorientation to the specified block, reconnect with DEVICE END status and continue.
Service Overrun in first block for Write Data subcommand or in any block for Write and Check data	Fill remainder of data block with zeros and issue retry status. If the retry fails, terminate with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 0 sense information with an indication of OVERRUN and PERMANENT ERROR.
Service Overrun in any block other than first for Write Data subcommand	Fill remainder of data block with zeros and terminate operation with retry status. When command is retried, issue UNIT CHECK status and generate Format 0 sense information with an indication of OVERRUN and OPERATION INCOMPLETE.
Data Error while reading a block ID	Attempt recovery via internal retry, and if successful continue. If retry is unsuccessful, terminate command with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 4 sense information with an indication of DATA CHECK and PERMANENT ERROR.
Uncorrectable Data while reading a data block during a Write and Check Data operation	Terminate with UNIT CHECK and DEVICE END status and generate Format 4 sense information with an indication of Check Data Error.
Correctable Data Error while reading a data block during a Write and Check Data operation	Continue to operate until all blocks written have been checked.
Defective or Alternate Block	Internal retry is used to access the correct position and continue the operation in progress.

Table 3-3

Control Unit Access Error Recovery

Error Condition	Control Unit Action
Access Error detected before data transfer is initiated for all read or update write operations except a WRITE with a Write and Check Data subcommand	Attempt recovery via command retry. If retry is unsuccessful, terminate with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 1 sense information as an indication of EQUIPMENT CHECK and PERMANENT ERROR and a message table indication of the type of access error.
Access Error detected after data transfer has begun for all read or update write operations except a WRITE with a Write and Check Data subcommand	Terminate with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 1 sense information with an indication of OPERATION INCOMPLETE and a message table indication of the type of access error.
Access Error detected during write operation of WRITE command, with Write and Check Data subcommand specified	Attempt recovery through command retry. If retry is unsuccessful, terminate with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 1 sense information with an indication of EQUIPMENT CHECK and PERMANENT ERROR and a message table indication of the type of access error.
Access Error detected during readback operation of WRITE command, with Write and Check Data subcommand specified or during execution of a Format Defective Block subcommand of a LOCATE command or during execution of a Format ID subcommand of a DIAGNOSTIC CONTROL command	Attempt recovery via internal retry. If recovery is unsuccessful, terminate with CHANNEL END, DEVICE END, and UNIT CHECK status, and generate Format 1 sense information with an indication of EQUIPMENT CHECK and PERMANENT ERROR and a message table indication of the type of access error.

4.0 COMPUTER SYSTEM REQUIREMENTS

The requirements of this section, unlike the other sections of this specification, apply to the lumped combination of I/O channel, CPU and operating system, referred to herein as the computer system.

4.1 Device Specific Parameters

The computer system shall not depend, for its normal (that is other than diagnostic) operation upon prior knowledge of any device parameters which are not specified herein (e.g., records per track, tracks per cylinder, device capacity). The READ DEVICE CHARACTERISTICS command or operator input may be used by the computer system to determine needed device characteristics at system initialization time. Default parameters are allowed if they can be overridden by operator action. Operator input for this purpose includes machine readable files of initialization parameters, provided such files can be readily modified to accommodate new device parameters.

4.2 Response to Unit Check

Whenever a UNIT CHECK status is accepted by the computer system, it shall use the SENSE INPUT/OUTPUT command to read the sense information generated by the FBRMS control unit. Appendix A contains recommended computer system error recovery procedures which are not a part of this standard but which may be separately invoked.

5.0 SENSE INFORMATION

The primary purpose of the FBRMS sense information is to identify the conditions that caused the last UNIT CHECK to be generated. The sense information also provides secondary information for system error recovery and may provide vendor specific information for diagnosing and isolating device and control unit malfunctions.

There are 16 possible formats for sense information. The format used is identified by byte 7, bits 0-3. All formats shall present a minimum of 24 bytes of information but the use or interpretation of these 24 bytes is not necessarily specified. No provision of this specification is intended to prevent the generation of more than 24 bytes of model dependent sense information, provided the meaning of the additional model dependent information is defined in the vendor's documentation.

The first eight bytes of sense information have a common interpretation. Formats 0, 1, 4, 5, and 6 are defined, and the interpretations of most of their fields are specified below. The use of Formats 2 and 3 are specified, but the specific fields and information associated with these formats is model dependent and shall be defined in the vendor's documentation. Formats 7, 8, 9, and A are model dependent, and neither their use nor their interpretation are defined in this specification, but shall be defined, if they are used, in the vendor's documentation. Formats B, C, D, E, and F are reserved and shall not be used.

The intent of this document is to specify only that sense information which is useful for software or device driver error recovery purposes, and not to specify that sense information which is only used to assist in the identification and isolation of specific hardware faults. Since the internal hardware design of FBRMS subsystems is not specified, hardware fault diagnostics cannot be specified. Moreover, the precise format of certain information, primarily physical addresses, which may be needed to flag or correct defective recording media, are not specified, although the mechanisms for passing and using this information are specified. This is done to avoid unnecessary constraints on recording technology or access mechanism design. Physical addresses shall be fully defined in the vendor's documentation for the FBRMS subsystem or device.

No violation of this specification shall occur if new meanings or conditions are assigned by vendors to sense bits defined below, provided only that the error recovery procedures described in Appendix A remain appropriate for the redefined sense indications, and that the assignment of these conditions is identified in the vendor's documentation.

In the following section, some sense bits are designated as reserved. These bits shall not be used and must always be zero. The reservation of these bits provides previously unused code points for later uniform extensions to the FBRMS Operational Specifications. Certain other bits or bytes are designated as model dependent. These bits or bytes may be used at the discretion of vendors of FBRMS subsystems, provided only that the interpretation of these bits shall be defined in the vendor's documentation.

5.1 First Eight Bytes

The first eight bytes of sense information are common to all sense formats. They shall have the information specified below:

Sense Byte 0

Byte 0, Bit 0
COMMAND REJECT

Bit 0 shall be set by:

- An invalid command code.
- An invalid command sequence.
- An invalid or incomplete argument transferred by a control command.
- A WRITE command issued when writing is inhibited by local switch settings. Sense byte 1, bit 6 (Write Inhibited) is also set.
- A WRITE command that violates the DEFINE EXTENT Mask.
- A LOCATE command with a format defective block specified in the operation byte, and space in the alternate area has been exhausted. Byte 1, bit 7 (OPERATION INCOMPLETE) is also set.
- A LOCATE command with Write Data specified in the operation byte and the DEFINE EXTENT Mask byte inhibits all write operations.
- An invalid or incomplete argument transferred by a DIAGNOSTIC CONTROL command.

Byte 0, Bit 1
INTERVENTION REQUIRED

Bit 1 shall be set by:

- Addressing a device that is not attached to the system.
- Addressing a device that is not ready.

Byte 0, Bit 2
BUS OUT PARITY

Bit 2 shall be set when a parity error is detected during the transfer of data from the channel to the control unit.

Byte 0, Bit 3
EQUIPMENT CHECK

Bit 3 shall be set when an unusual hardware condition occurs in the channel, control unit, or drive. The condition is further defined in sense bytes 7 through 23.

Byte 0, Bit 4
DATA CHECK

Bit 4 shall be set when the control unit detects a data error in the information received from the drive. If byte 2, bit 1 (CORRECTABLE) is also set, the data error is correctable and bytes 16 through 23 shall provide correction information. If the data error is uncorrectable, sense byte 7 defines the specific nature of the condition.

Byte 0, Bit 5
OVERRUN

Bit 5 is set when the control unit does not receive a response from the channel to a data request within the required period of time. Detection of an overrun terminates data transmission. When writing, the remaining portion of the record area shall be padded with zeros. Either byte 1, bit 7 (OPERATION INCOMPLETE) or byte 1, bit 0 (PERMANENT ERROR) is also set.

Byte 0, Bit 6

Bit 6 is reserved. It shall be set to zero.

Byte 0, Bit 7

Bit 7 is reserved. It shall be set to zero.

Sense Byte 1

Byte 1, Bit 0
PERMANENT ERROR

Bit 0 shall be set when internal error recovery has been exhausted and was unsuccessful, or when internal error recovery was not possible or desirable.

This bit overrides any other bit settings and indicates that system error recovery procedures may not be feasible.

Byte 1, Bit 1
Block Size Exception

Bit 1 shall be set when an invalid block size is specified in bytes 2 and 3 of a DEFINE EXTENT command.

Byte 1, Bit 2

Bit 2 is reserved. It shall be set to zero.

Byte 1, Bit 3
Operator Message

Bit 3 shall be set in conjunction with byte 0, bit 3 (EQUIPMENT CHECK) to indicate a permanent failure in an alternate control unit or a state save operation in the reporting control unit.

Byte 1, Bit 4

Bit 4 is reserved. It shall be set to zero.

Byte 1, Bit 5
File Protected

Bit 5 shall be set when a DIAGNOSTIC CONTROL or LOCATE command violates the logical extent limits established by a DEFINE EXTENT command.

Byte 1, Bit 6
Write Inhibited

Bit 6 shall be set when a write operation is attempted on a device that has its Write Inhibit switch in the Read-Only position. Byte 0, bit 0 (COMMAND REJECT) is also set.

Byte 1, Bit 7
OPERATION INCOMPLETE

Bit 7 shall be set when:

- A correctable data check is detected in the data area of any block other than the last block. Byte 0, bit 4 (DATA CHECK) and byte 2, bit 1 (CORRECTABLE) are also set.

- An uncorrectable data check is detected in the data area of any block other than the first block. Byte 0, bit 4 (DATA CHECK) is also set.
- A service overrun is detected in a data area of any block other than the first during a read or update-write operation. Byte 0, bit 5 (OVERRUN) is also set.
- A LOCATE command has been issued with a Format Defective Block specified in the operation byte, and space in the alternate area is exhausted. Byte 0, bit 0 (COMMAND REJECT) is also set.
- An access error is detected after the start of data transfer during a multitrack read or write operation.

<u>Sense Byte 2</u>

Byte 2, Bit 0
Check Data Error

Bit 0 shall be set when an uncorrectable data check is detected during the read-back verification phase of a WRITE command with Write and Check Data specified in the preceding LOCATE command.

Byte 2, Bit 1
CORRECTABLE

Bit 1 shall be set when the data check condition indicated by byte 0, bit 4 (DATA CHECK) is correctable.

Byte 2, Bit 2

Bit 2 is reserved. It shall be set to zero.

Byte 2, Bit 3
Environmental Data
Present

Bit 3 shall be set when:

- An error counter overflows.
- The usage statistics require off-loading.
- A READ AND RESET BUFFERED LOG command is executed.

Byte 2, Bits 4
Through 7

Bits 4 through 7 are model dependent. If used, the interpretation of these bytes shall be defined in the vendor's documentation.

<u>Sense Byte 3</u>

Bits 0 Through 7
Cylinder High

Bits 0 through 7 shall identify the high-order physical address of the most recent access operation. The interpretation of this operation is model dependent and shall be defined in the vendor's documentation.

Sense Byte 4

Bits 0 Through 7
Cylinder Low

Bits 0 through 7 shall identify the second highest order physical address byte of the most recent access operation. The interpretation of this address is model dependent and shall be defined in the vendor's documentation.

Sense Byte 5

Bits 0 Through 7
Head Address

Bits 0 through 7 identify the third highest order address bytes of the most recent access operation when Formats 1, 2, 4, or 5 are used. The interpretation of this address is model dependent and shall be defined in the vendor's documentation. When Formats 3 or 6 are used, the interpretation of this byte is model dependent and shall be defined in the vendor's documentation.

Sense Byte 6

Bits 0 Through 7
Block Number

When Formats 4 or 5 are generated, or when Format 0 is generated and byte 1, bit 7 (OPERATION INCOMPLETE) is set, bits 0-7 of this byte shall specify the least significant portion of the physical address of the more recently accessed block. The interpretation of this address is model dependent and shall be defined in the vendor's documentation. When Format 6 is generated, this byte shall contain the control unit ID. The ID is vendor specific. For all other cases, the use of this sense byte is model dependent and shall be defined in the vendor's documentation.

Sense Byte 7

Bits 0 Through 3
Format

Bits 0 through 3 shall specify the format of sense bytes 8 through 23 as follows:

0000 = Format 0 - program or system check
0001 = Format 1 - device equipment check (hardware diagnostic information)
0010 = Format 2 - control unit equipment check (hardware diagnostic information)
0011 = Format 3 - control unit control check (hardware diagnostic information)
0100 = Format 4 - data check without displacement (UNCORRECTABLE DATA CHECK)
0101 = Format 5 - data check with displacement information (CORRECTABLE DATA CHECK)

0110 = Format 6 - usage statistics/overrun errors
0111 = Format 7 - model dependent; if used, shall be defined in the vendor's documentation
1000 = Format 8 - model dependent; if used, shall be defined in the vendor's documentation
1001 = Format 9 - model dependent; if used, shall be defined in the vendor's documentation
1010 = Format A - model dependent; if used, shall be defined in the vendor's documentation
1011 through 1111 = Formats B through F - reserved; shall not be used

Byte 7, Bits 4 Through 7 Message Code

Bits 4 through 7 describe the specific nature of the error conditions for each of the formats as specified in sections 5.2 through 5.9 below. The message table that accompanies the format descriptions identifies the function of the message bits for the format.

5.2 Format 0 - Program or System Check

Format 0 shall be used when sense bytes 0 through 7 completely describe an error or unusual condition caused by a program or system error. For Format 0, the Message Table contained in bits 4-7 of sense byte 7 shall be set as follows:

Message Table - Format 0

Sense Byte 7, Bits 4-7 =	Message Code	Message
0000	0	No message. No additional information required.
0001	1	The control unit received an invalid command.
0010	2	The control unit received an invalid sequence of commands.
0011	3	The bytes of data transferred from the channel was less than required.
0100	4	The data argument of the command was invalid.
0101	5	A DIAGNOSTIC CONTROL command was issued when prohibited by the DEFINE EXTENT mask.
0110	6	The channel did not indicate chaining when retry status was presented.
0111	7	The command that was returned after a command retry sequence did not match the command for which retry was signalled.
1000-1011	8-B	Reserved
1100	C	A LOCATE command with a Format Defective Block specified in the operation

		byte was issued when the alternate space was exhausted.
1101	D	A service overrun occurred in the data area.
1110	E	Model dependent. If used, shall be defined in the vendor's documentation
1111	F	Model dependent. If used, shall be defined in the vendor's documentation.

Bytes 8 Through 15 - LOCATE Parameters

When byte 1, bit 7 (OPERATION INCOMPLETE) is set and the error was not detected on a DIAGNOSTIC SENSE command, bytes 8 through 15 shall contain the updated LOCATE parameters. Otherwise, these bytes shall be set to zero.

Bytes 16 and 17 - Number of Blocks Transferred

When byte 1, bit 7 (OPERATION INCOMPLETE) is set and the error was not detected on a DIAGNOSTIC SENSE command, bytes 16 and 17 shall contain the number of blocks transferred to the system (excluding the error block). Otherwise, these bytes shall be set to zero.

Bytes 18 Through 20

Bytes 18 through 20 are reserved and shall be set to zero.

Byte 21

Byte 21 shall contain the control unit ID. The ID is vendor specific.

Bytes 22 and 23

Model dependent. If used, the vendor's documentation shall define their meaning.

5.3 Format 1 - Device Equipment Check

Format 1 shall be generated when:

- A device, device interface, or a controller equipment check is detected. Byte 0, bit 3 (EQUIPMENT CHECK) is also set.

- A permanent device seek check is detected. Byte 0, bit 3 (EQUIPMENT CHECK) and byte 1, bit 0 (PERMANENT ERROR) are also set.

- Error log information is off-loaded after a successful retried seek that occurred during error logging. Byte 2, bit 3 (Environmental Data Present) is also set. The message bits in sense byte 7 indicate a seek error.

- Device status shows not on line. Byte 0, bit 1 (INTERVENTION REQUIRED) is also set.

The information contained in bytes 8 through 23 is model dependent and is not described in this standard, but, if used, shall be described in the vendor's documentation.

5.4 Format 2 - Control Unit Equipment Check

Format 2 shall be reserved for use when a control unit equipment check is detected. The information contained in bytes 8 through 23 is model dependent and is not described in this standard, but, if used, shall be defined in the vendor's documentation.

5.5 Format 3 - Control Unit Control Check

Format 3 shall be reserved for use when a control unit control check is detected. The information contained in bytes 8 through 23 is model dependent and is not described in this standard, but, if used, shall be defined in the vendor's documentation.

5.6 Format 4 - Data Checks Without Displacement Information

Format 4 shall be generated when:

- Errors that were not correctable by the error correcting code were detected in the ID or data field. The message code in sense byte 7 identifies the field.

- Error log information is off-loaded after an error correcting code uncorrectable error occurred during error logging. The information was recovered through use of command retry. Byte 2, bit 3 (Environmental Data Present) is also set.

Message Table - Format 4

Sense Byte 7, Bits 4-7 =	Message Code	Message
0000	0	The check byte detected a data error in the ID field.
0001	1	An error occurred in the data area and could not be corrected by the error correcting code.
0010 & 0011	2, 3	Reserved. Shall not be used.
0100	4	Data synchronization on the ID field was unsuccessful.
0101	5	Data synchronization on the data area was unsuccessful.

0110-1000	6-8	Model dependent. If used, its interpretation shall be defined in the vendor's documentation.
1001	9	An error occurred in the data read during a read-back check of a Write and Check Data operation and it could not be corrected by the error correcting code.
1010-1100	A-C	Reserved. Shall not be used.
1101	D	Data synchronization on the data area was unsuccessful and the error occurred during a read-back check of a Write and Check Data operation.
1110 & 1111	E, F	Model dependent. If used, the interpretation shall be defined in the vendor's documentation.

Bytes 8 Through 15 - LOCATE Parameters

If byte 1, bit 7 (OPERATION INCOMPLETE) is set, bytes 8 through 15 shall contain the LOCATE parameters. If byte 1, bit 7 is not set or the error was detected during a DIAGNOSTIC SENSE command, these bytes shall be zero.

Bytes 16 and 17 - Blocks Transferred

Bytes 16 and 17 shall contain the number of blocks transferred to the channel (excluding the error block).

Bytes 18 Through 21 - Offset

Bytes 18 through 21 shall specify, in blocks, the offset of the error block from the beginning of the data set.

Bytes 22 and 23

Bytes 22 and 23 are model dependent and are not defined in this standard. If used, these bytes shall be defined in the vendor's documentation.

5.7 Format 5 - Data Checks With Displacement Information

Format 5 shall be generated when:

- Data checks that are correctable by the error correcting code are detected in the data area of a record.

- Error log information is off-loaded after an error correcting code correctable error occurred during error logging. Byte 2, bit 3 (Environmental Data Present) is also set.

Message Table - Format 5

Sense Byte 7, Bits 4-7 =	Message Code	Message
0000	0	Used for all format 5 data checks.
0001-1111	1-F	Reserved, shall not be used.

Bytes 8 Through 15 - LOCATE Parameters

If byte 1, bit 7 (OPERATION INCOMPLETE) is set, bytes 8 through 15 shall contain the LOCATE parameters. If byte 1, bit 7 is not set or if the error occurred during a DIAGNOSTIC SENSE command, these bytes shall be zero.

Bytes 16 and 17 - Blocks Transferred

Bytes 16 and 17 shall contain the number of blocks transferred to the system (inculding the error block).

Bytes 18 and 19 - Error Displacement

Bytes 18 and 19 shall specify the location of the first data byte in error in the data field. The location is relative to the end of the data field.

Bytes 20 Through 23 - Error Pattern

These bytes shall identify the bits in error when the data check is correctable. A 1 in the bit position shall represent an incorrect bit.

Bytes 24 and Greater

These bytes may optionally be used to extend the length of the Error Pattern.

5.8 Format 6 - Usage Statistics/Overrun Errors

Format 6 shall be generated when:

- A READ AND RESET BUFFERED LOG command is executed.
- Usage/error statistics require off-loading due to counter overflow.

Message Table - Format 6

Sense Byte 7, Bits 4-7 =	Message Code	Message
0000-0111	0-7	Reserved, shall not be used.
1000	8	Indicates that the information in bytes 22 and 23 applies to channel A.*
1001	9	Indicates that the information in bytes 22 and 23 applies to channel B.*
1010	A	Indicates that the information in bytes 22 and 23 applies to channel C.*
1011	B	Indicates that the information in bytes 22 and 23 applies to channel D.*
1100-1111	C-F	Model dependent. If used, the interpretation of these codes shall be defined in the vendor's documentation.

5.8.1 Use of Format 6, Bytes 8 Through 23 for Message - Codes 8 Through B

Bytes 8 Through 10 - Blocks Read

Bytes 8 through 10 shall contain an accumulated count of the number of blocks read during read operations.

Bytes 11 and 12 - Correctable Data Checks

Bytes 11 and 12 shall contain an accumulated count of the number of Error Correcting Code (ECC) correctable data checks detected by the control unit.

Byte 13 - Uncorrectable Data Checks

Byte 13 shall contain the number of ECC uncorrectable data checks retried by the control unit.

Byte 14 - Access Offset Involved

Byte 14 shall contain the number of ECC uncorrectable data checks retried by the control unit that involved access offset.

Bytes 15 Through 17 - Blocks Written With Verify

Bytes 15 through 17 shall contain the number of blocks written by the FBRMS subsystem with the check data option specified.

*Note: A, B, C, and D are used here to designate separate channels attached to one control unit. See Section 1.6.

Byte 18

Byte 18 is reserved and shall not be used.

Bytes 19 and 20 - Access Movements

Bytes 19 and 20 shall contain the number of access movements processed by the FBRMS subsystem.

Byte 21 - Access Errors

Byte 21 shall contain the number of access errors that were retried by the control unit.

Byte 22 - Service Overruns

Byte 22 shall contain the number of service overruns that occurred.

Byte 23 - Command Overruns

Byte 23 shall contain the number of command overruns that were retried by the control unit.

Byte 24-n - Model dependent. If used, the interpretation of these bytes shall be defined in the vendor's documentation.

5.9 Formats 7 Through F

Formats 7, 8, 9 and A are model dependent. If used, they shall be defined in the vendor's documentation. Formats B, C, D, E, and F are reserved and shall not be used.

APPENDIX A

RECOMMENDED COMPUTER SYSTEM ERROR RECOVERY PROCEDURES FOR FIXED BLOCK ROTATING MASS STORAGE SUBSYSTEMS

A.0 General

This appendix is a companion to but is not a part of the Operational Specifications for Fixed Block Rotating Mass Storage Subsystems. This appendix specifies procedures which may be executed by the lumped combination of the I/O channel, I/O channel adaptor (if any), and host computer system software to attempt recovery from FBRMS subsystem errors which are not resolved internally within the subsystem.

These procedures are all applicable to recovery after the presentation of UNIT CHECK status. The proper recovery procedure is identified by unique combinations of the following sense indications:

Sense Byte	Bit	Name
0	0	COMMAND REJECT
0	1	INTERVENTION REQUIRED
0	2	BUS OUT PARITY
0	3	EQUIPMENT CHECK
0	4	DATA CHECK
0	5	OVERRUN
1	0	PERMANENT ERROR
1	1	Block Size Exception
1	3	Operator Message
1	5	File Protected
1	6	Write Inhibited
1	7	OPERATION INCOMPLETE
2	0	Data Check Error
2	1	CORRECTABLE
2	3	Environmental Data Present

When Appendix A is invoked and the FBRMS subsystem generates UNIT CHECK status, the computer system shall issue a SENSE INPUT/OUTPUT command and then perform the appropriate recovery action specified in Tables A-1 through A-10. Table A-11 .is a more concise summary of these sense conditions and recovery actions.

A.1 Error Correction Function

The system recovery action procedures use the error correction function as a step in recovering from correctable data errors that may occur in the data area of a block.

When the DATA CHECK and CORRECTABLE (and possibly also OPERATION INCOMPLETE) sense bits are posted in the sense information, sense bytes 18 through 23 provide error pattern and displacement information. Error correction shall be accomplished by aligning the error pattern in sense bytes 20 through 23 with the erroneous data in main storage and performing a bit-by-bit Exclusive Or of the data with the error pattern.

The location of the erroneous data in main storage shall be determined by the displacement information in sense bytes 18 and 19, and by the counts provided in the interrupted channel program. For Class A devices, the displacement between the first byte transferred in the operation and the first byte in error is calculated by multiplying the number of blocks transferred (sense bytes 16 and 17) by the block size (512 bytes) to obtain the restart displacement and subtracting the error displacement provided in sense bytes 18 and 19. For Class B devices, the displacement between the first byte transferred in the operation and the first byte in error is calculated in a similar manner but using the appropriate block size. The result is the forward error displacement which is used, in conjunction with the counts specified in the interrupted channel program, to locate the erroneous data in main storage.

The error correction function is bypassed for bytes that were not transferred to main storage.

A.2 ERROR LOG

In each of the tables which follow, there is a column with the heading Log. To log an error simply means to write a record of its occurrence on an appropriate medium or file. Logging is not the same as operator notification. Errors are logged because the history of their occurrence may be of diagnostic value to maintenance personnel. However, a record of the occurrence of certain errors, for example, most errors resulting from invalid channel programs, has no diagnostic value, and those errors need not be logged.

A.3 Operator or Console Message

Many large scale computer systems are controlled by an operator who is provided with an operator's console. Other systems, particularly terminal-oriented systems, may not require an "operator," or may simply be started by a "privileged user." In some cases, any operator or a user may be able to take action to clear a disk error condition, for example, by turning a needed device on. In other cases, an operator or user may wish or need to explicitly abort or cancel a program as a result of an I/O error, particularly a programming error. The following error recovery procedures frequently state "print operator error message." This action should be implemented in light of the normal facilities and concepts of the computer system as appropriate. In some systems, it may be appropriate to write messages to users, in others, it may be appropriate to notify an operator, and in other systems there may not be any useful action to be taken.

TABLE A-1

COMPUTER SYSTEM ERROR RECOVERY ACTION 1: PRINT CONSOLE ERROR MESSAGE

Error Conditions Requiring Action 1:

Sense Byte	Bit	Name	Description	Log
0 1	0 6	COMMAND REJECT Write Inhibited	Write command received with the Write Inhibit switch in the Read-Only position.	No
0 1	0 7	COMMAND REJECT OPERATION INCOMPLETE	Alternate space exhausted.	No
0 1	3 0	EQUIPMENT CHECK PERMANENT ERROR	Equipment malfunction and retry exhausted or undesirable.	Yes
0 1	4 0	DATA CHECK PERMANENT ERROR	Uncorrectable data check and command retry exhausted.	Yes
0 1	5 0	OVERRUN PERMANENT ERROR	Command retry exhausted on a service overrun.	Yes

Description of Action 1:

For all of the above cases, since the error is not recoverable using the recovery procedures described in this document, an operator error message should be printed for operator and/or customer engineer notification. Alternatively, additional system recovery procedures not specified in this document could be used, if available.

TABLE A-2

COMPUTER SYSTEM ERROR RECOVERY ACTION 2: EXIT WITH PROGRAMMING ERROR OR UNUSUAL CONDITION INDICATION

Error Conditions Requiring Action 2:

Sense Byte	Bit	Name	Description	Log
0	0	COMMAND REJECT	Programming error occurred.	No
1	1	Block Size Exception	Invalid block size specified.	No

Description of Action 2:

Since this error is a programming or unusual error and is not recoverable using the recovery procedures described in this document, the operation cannot be completed. Program abnormal exit routines could be used, if available. Alternatively, additional system recovery procedures not specified in this document could be used, if available.

TABLE A-3

COMPUTER SYSTEM ERROR RECOVERY ACTION 3: REPEAT OPERATION ONCE AND PRINT CONSOLE ERROR MESSAGE IF ERROR PERSISTS

Error Conditions Requiring Action 3:

Sense Byte	Bit	Name	Description	Log
0	1	INTERVENTION REQUIRED	Drive offline or not on system.	No
0	2	BUS OUT PARITY	Bus out parity error occurred.	Yes
2	3	Environmental Data Present	Statistical usage and/or error log information present.	Yes

Description of Action 3:

For these reported error conditions, recovery should be attempted by repeating the operation once because the condition that caused the error is of a type that may clear after one occurrence. If the error condition persists, then refer to action 1 for the remaining procedure.

TABLE A-4

COMPUTER SYSTEM ERROR RECOVERY ACTION 4: PRINT CONSOLE ERROR MESSAGE AND RETRY

Error Condition Requiring Action 4:

Sense Byte	Bit	Name	Description	Log
0	3	EQUIPMENT CHECK	Permanent equipment malfunction of alternate control unit or state save operation in reporting control unit.	Yes
1	3	Operator Message		

Description of Action 4:

An operator error message should be printed to immediately notify the operator or maintenance personnel of this type of error condition. Refer to action 5 for the remaining procedure.

TABLE A-5

COMPUTER SYSTEM ERROR RECOVERY ACTION 5: REPEAT OPERATION UP TO 10 TIMES AND PRINT ERROR MESSAGE IF ERROR PERSISTS

Error Conditions Requiring Action 5:

Sense Byte	Bit	Name	Description	Log
0	3	EQUIPMENT CHECK	Equipment malfunction.	Yes
2	0	Check Data Error	Uncorrectable data check during a check data operation.	Yes

Description of Action 5:

For either of these error conditions, recovery should be attempted by repeating the operation up to 10 times because the condition that caused the error is of a type that may be intermittent. If the error condition persists, then refer to action 1 for the remaining procedure.

TABLE A-6

COMPUTER SYSTEM ERROR RECOVERY ACTION 6: CORRECT LAST BLOCK AND CONTINUE COMMAND CHAIN

Error Condition Requiring Action 6:

Sense Byte	Bit	Name	Description	Log
0 2	4 1	DATA CHECK CORRECTABLE	Correctable data check in the last data area during a read operation.	No

Description of Action 6:

First, perform the error correction function as described in Table A-1.

Second, simulate normal ending status for the channel command that is logically completed when the error correction function is done.

Third, if the channel program (refer to FIPS 60 for definition of channel program) has also been logically completed, the user program should be notified of the completion status. Otherwise, the channel program should be continued by issuing a DEFINE EXTENT command the same as the one in the interrupted channel program and command chained to the next appropriate channel command in the interrupted channel program as determined from the simulated status.

TABLE A-7

COMPUTER SYSTEM ERROR RECOVERY ACTION 7: CORRECT BLOCK (NOT LAST) AND RESUME OPERATION

Error Condition Requiring Action 7:

Sense Byte	Bit	Name	Description	Log
0	4	DATA CHECK	Correctable data check in the data area of any block except the last during a read operation.	No
2	1	CORRECTABLE		
1	7	OPERATION INCOMPLETE		

Description of Action 7:

First, perform the error correction function as described in Table A-1.

Second, construct an appropriate READ restart channel command to be used to resume the operation beginning with the block after the one in which the erroneous data was corrected. The channel program interrupt status, the number of blocks transferred including the error block (from sense bytes 16 and 17), and other information from the interrupted channel program is used in the construction of the restart channel command. Since the software to I/O channel interface is not defined in this appendix, the details of the construction of the restart channel command are also not defined.

Third, complete the interrupted operation and continue the channel program by issuing a DEFINE EXTENT command the same as the one in the interrupted channel program. The DEFINE EXTENT is command chained to a LOCATE command with parameters obtained from sense bytes 8 through 15. The LOCATE is in turn command chained to the restart channel command that was constructed as described above. If it was determined during construction of the restart channel command that the channel program continues beyond the interrupted operation, then the restart channel command is in turn command chained to the next appropriate channel command in the interrupted channel program as determined during construction of the restart channel command.

TABLE A-8

COMPUTER SYSTEM ERROR RECOVERY ACTION 8: RETRY BLOCK (NOT FIRST) AND RESUME OPERATION

Error Conditions Requiring Action 8:

Sense Byte	Bit	Name	Description	Log
0 1	4 7	DATA CHECK OPERATION INCOMPLETE	Uncorrectable data check in a data area of any block except the first during a read operation.	No
0 1	5 7	OVERRUN OPERATION INCOMPLETE	Service overrun in a data area of any block except the first during a read or write operation with the check data modifier bit off.	No

Description of Action 8:

First, construct an appropriate READ or WRITE restart channel command to be used to retry the operation beginning with the block in which the error occurred. If sense byte 8, bit 7 equals 0, then set the restart command code to a READ command; otherwise, set it to a WRITE command. The channel program interrupt status, the number of blocks transferred excluding the error block (from sense bytes 16 and 17), and other information from the interrupted channel program is used in the construction of the restart channel command. Since the software to I/O channel interface is not defined in this appendix, the details of the construction of the restart channel command are also not defined.

Second, complete the interrupted operation and continue the channel program by issuing a DEFINE EXTENT command the same as the one in the interrupted channel program. The DEFINE EXTENT is command chained to a LOCATE command with parameters obtained from sense bytes 8 through 15. The LOCATE is in turn command chained to the restart channel command that was constructed as described above. If it was determined during construction of the restart channel command that the channel program continues beyond the interrupted operation, then the restart channel command is in turn command chained to the next appropriate channel command in the interrupted channel program as determined during construction of the restart channel command.

TABLE A-9

COMPUTER SYSTEM ERROR RECOVERY 9:
RESUME OPERATION

Error Condition Requiring Action 9:

Sense Byte	Bit	Name	Description	Log
1	7	OPERATION INCOMPLETE	Seek error after the start of data transfer during a read or update write with check data modifier bit off.	No

Description of Action 9:

First, construct an appropriate READ or WRITE restart channel command to be used to resume the operation beginning with the block after the point of interruption. If sense byte 8, bit 7 equals 0, then set the restart command code to a READ command; otherwise, set it to a WRITE command. The channel program interrupt status and other information from the interrupted channel program are all else that is needed to construct the restart channel command. Since the software to I/O channel interface is not defined in this appendix, the details of the construction of the restart channel command are also not defined.

Second, complete the interrupted operation and continue the channel program by issuing a DEFINE EXTENT command the same as the one in the interrupted channel program. The DEFINE EXTENT is command chained to a LOCATE command with parameters obtained from sense bytes 8 through 15. The LOCATE is in turn command chained to the restart channel command that was constructed as described above. If it is determined from the channel program interrupt status that the channel program continues beyond the interrupted operation, then the restart channel command is in turn command chained to the next appropriate channel command in the interrupted channel program as determined from the interrupt status.

TABLE A-10

COMPUTER SYSTEM ERROR RECOVERY ACTION 10: EXIT WITH PROGRAMMING ERROR OR CORRECT EXTENT LIMITS AND RETRY

Error Condition Requiring Action 10:

Sense Byte	Bit	Name	Description	Log
1	5	File Protected	Locate argument violated the Define Extent specifications.	No

Description of Action 10:

If the blocks specified by the LOCATE command are not in the user's data set, perform action 2. Otherwise, the computer system software may supply the correct extent limits, complete the operation and continue the channel program by issuing a DEFINE EXTENT command with the modified extent limit parameters and command chained to the LOCATE channel command in the interrupted channel program as determined from the interrupt status.

TABLE A-11

ERROR CONDITION AND SYSTEM RECOVERY ACTION SUMMARY TABLE

Error Condition				System Logged	System Recovery Action	
Sense Byte	Bit	Name	Description		Action	Description
0	0	COMMAND REJECT	Programming error occurred	No	2	Exit with programming error or unusual condition indication
0 1	0 6	COMMAND REJECT Write Inhibited	Write command received with the Write Inhibit switch in the Read-Only position	No	1	Print operator error message
0 1	0 7	COMMAND REJECT OPERATION INCOMPLETE	Alternate space exhausted	No	1	Print operator error message
0	1	INTERVENTION REQUIRED	Drive offline or not on system	No	3	Repeat operation once and print operator error message if error persists
0	3	EQUIPMENT CHECK	Equipment malfunction	Yes	5	Repeat operation up to 10 times if needed and print operator error message if error persists
0 1	3 0	EQUIPMENT CHECK PERMANENT ERROR	Equipment malfunction and retry exhausted or undesirable	Yes	1	Print operator error message
0 1	3 3	EQUIPMENT CHECK Operator Message	Permanent equipment malfunction of alternate control unit or state save operation in reporting control unit	Yes	4	Print operator error message and repeat operation up to 10 times if needed and print operator error message if error persists
0 1	4 0	DATA CHECK PERMANENT ERROR	Uncorrectable data check and command retry exhausted	Yes	1	Print operator error message

Error Condition				System Recovery Action		
Sense Byte	Bit	Name	Description	System Logged	Action	Description
0 1	4 7	DATA CHECK OPERATION INCOMPLETE	Uncorrectable data check in a data area of any block except the first during a read operation	No	8	Retry block (not first) and resume operation
0 2	4 1	DATA CHECK CORRECTABLE	Correctable data check in the last data area during a read operation	No	6	Correct block (last) and continue chain
0 2 1	4 1 7	DATA CHECK CORRECTABLE OPERATION INCOMPLETE	Correctable data check in the data area of any block except the last during a read operation	No	7	Correct block (not last) and resume operation
0 1	5 0	OVERRUN PERMANENT ERROR	Command retry exhausted on a service overrun	Yes	1	Print operator error message
0 1	5 7	OVERRUN OPERATION INCOMPLETE	Service overrun in a data area of any block except the first during a read or write operation with the check data modifier bit off	No	8	Retry block (not first) and resume operation
1	1	Block size Exception	Invalid block size specified	No	2	Exit with programming error or unusual condition indication
1	5	File Protected	Locate argument violated the Define Extent specifications	No	10	Exit with programming error if blocks out of user's data set or else correct extent limits and retry operation
1	7	OPERATION INCOMPLETE	Seek error after the start of data transfer during a read or update write with the check data modifier bit off	No	9	Resume operation

Sense		Error Condition		System	System Recovery Action	
Byte	Bit	Name	Description	Logged	Action	Description
2	0	Check Data Error	Uncorrectable data check during a check data operation	Yes	5	Repeat operation up to 10 times if needed and print operator error message if error persists
2	3	Environmental Data Present	Statistical usage and/or error log information present	Yes	3	Repeat operation once and print operator error message if error persists

GLOSSARY

The following glossary is provided to assist in the understanding of the Operational Specifications for Fixed Block Rotating Mass Storage Devices. Many technical terms used in this standard originate in the companion I/O Channel Interface Standard, FIPS 60. Although for convenience, brief definitions or explanations of some of these terms are provided below; a detailed understanding of FIPS 60 is a necessary prerequisite for a detailed understanding of the FBRMS standard.

Access Boundary - An access boundary occurs between block n and n+1 when some process other than rotation is required to access block n+1 after accessing block n. In a magnetic disk subsystem, physical storage is typically organized into blocks, tracks, cylinders, and devices. In magnetic disks, the access boundary is considered to be between cylinders, and the process of crossing an access boundary (i.e., moving from one cylinder to another) is usually called a seek. Access boundaries are not apparent to most aspects of the FBRMS command set, and their locations are not defined in this standard, but crossing an access boundary may introduce access latencies and the possibility of the occurrence of certain positioning errors, called access errors (q. v.). This specification imposes no limit on the access error rate for magnetic disk devices, but commercial disk products usually claim less than one error per million access operations.

Access Error - An error which occurs as a result of an access movement. In magnetic disk devices, an access movement is usually called a "seek." An access error is recognized after an access movement when the block accessed does not have the expected address. This specification imposes no limit on the access error rate, but commercial magnetic disk products usually claim less than one seek error per million seek operations.

Channel Program - A sequence of chained channel commands. The channel program is ended whenever a command is terminated without indicating chaining. See Command Chaining and FIPS 60.

Command Chaining - A command is chained from its predecessor if the channel responds to the ending status of the predecessor command by raising "suppress out." The control unit maintains the connection to the device and presents busy status to other requests to access the device when chaining is indicated. See FIPS 60.

Command Retry (status) - A status indication which signals the I/O channel to retry a command without causing a CPU interrupt. Command retry status consists of either or both CHANNEL END and DEVICE END, and both STATUS MODIFIER and UNIT CHECK. See FIPS 60.

Logical Address - In an FBRMS device, each logical block is uniquely identified by a 32-bit logical address. Logically successive blocks are identified by successive logical addresses. The logical addresses of blocks processed by READ or WRITE operations are determined by parameters passed as a part of the DEFINE EXTENT and LOCATE commands. The Control Unit is responsible for mapping logical addresses into a physical address (q. v.) meaningful in terms of the physical structure of the FBRMS device. The logical to physical address mapping algorithm is not defined in this standard.

Logical Block - A block of data which is the normal unit of information read or recorded during READ or WRITE operations. For Class A operation, the size of a logical block is 512 bytes. For Class B operation, devices may be formatted to a logical block size between 1 and 65,535 bytes. The LOCATE command addresses logical blocks. See Physical Block. Whenever the term block is not preceded by the word "physical," it means "logical block."

Overrun - An overrun condition occurs when the channel is unable to service a request by the control unit within the necessary time period. Overruns which occur during the transfer of commands are command overruns, and overruns which occur during the transfer of recorded data are service overruns. Only commands which transfer recorded data are subject to service overrun.

Physical Address - The address of a block (logical or physical) which is meaningful in terms of the physical structure of an FBRMS device. For example, in magnetic disk devices, a physical address is conventionally expressed in terms of a cylinder, a track within that cylinder, and the position of a block on that track measured from an index point. The control unit is responsible for mapping logical addresses (q. v.) into physical addresses. The algorithm for performing this mapping is not defined in this standard since the physical organization of FBRMS devices is not defined.

Physical Block - The smallest unit of data which may physically be independently written on an FBRMS device. A physical block contains an ID area and a data area. The data area may be less than, equal to or more than one logical block. The mapping of logical blocks into physical blocks is not specified, but must be defined in the vendor's documentation. Physical blocks are primarily of concern when they are flagged as defective and alternate physical blocks assigned to contain a logical block or blocks. The DIAGNOSTIC CONTROL and DIAGNOSTIC SENSE/READ commands provide facilities to read and write the ID areas of physical blocks. See Logical Block.

Replicated Data - A sequence of one or more blocks which is written two or more times at successive logical addresses. It is possible to reduce rotational access latencies with replicated data.

Status - Status is a byte presented to the channel by the control unit at least once, and frequently several times, as a part of the channel protocol accompanying each channel command. Eight status conditions are defined in FIPS 60 (q. v.). See also Section 1.9.

Sense Information - Up to 24 bytes of information generated by the control unit to describe the condition of devices and the results of the last operation completed. Sense Information is read by means of the SENSE I/O command. The I/O channel is obligated to issue a SENSE I/O instruction following the occurrence of UNIT CHECK status, but may do so at other times as well. See Section 5 and FIPS 60.

STOP - A signal sequence presented to the I/O channel by the control unit or a signal sequence presented by the channel to the control unit to halt a data transfer which is in progress. The signalling of STOP does not necessarily indicate an error condition. The STOP signal sequences are fully defined in FIPS 60.

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NOTE: The principal publication outlet for the foregoing data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

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(~~REV. 10-88~~)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

FIPS PUBLICATION CHANGE NOTICE

CHANGE NUMBER 2 - FIPS 60-2 & 62
1-FIPS 61-1,63-1,97,111,130&131

DATE OF CHANGE
1990 December 26

FIPS PUBLICATION NUMBER
See above.

PUBLICATION TITLE FIPS 60-2, I/O Channel Interface; 62, Operational Specifications for Magnetic Tape Subsystems; 61-1, Channel Level Power Control Interface; 63-1, Operational Specifications for Variable Block Rotating Mass Storage Subsystems; 97, Operational Specifications for Fixed Block Rotating Mass Storage Subsystems; 111, Storage Module Interfaces (w/extens. for enhanced storage module interface); 130, Intelligent Peripheral Interface (IPI); 131, Small Computer System Interface (SCSI).

THIS OFFICE HAS A RECORD OF YOUR INTEREST IN RECEIVING CHANGES TO THE ABOVE FIPS PUBLICATION. THE CHANGE(S) INDICATED BELOW HAVE BEEN PROVIDED BY THE MAINTENANCE AGENCY FOR THIS PUBLICATION AND WILL BE INCLUDED IN THE NEXT PUBLISHED REVISION TO THIS FIPS PUBLICATION. QUESTIONS OR REQUESTS FOR ADDITIONAL INFORMATION SHOULD BE ADDRESSED TO THE MAINTENANCE AGENCY:

Department of Commerce
National Institute of Standards and Technology
National Computer Systems Laboratory
Gaithersburg, MD 20899

CHANGE ITEM(S)

Attached is a reprint from the December 18, 1990, FEDERAL REGISTER (55 FR 51941) which provides approved revisions by the Secretary of Commerce to the FIPS family of input/output interface standards, and the approved discontinuation of the Exclusion and Verification Lists for these standards.

These approved revisions became effective on December 18, 1990, and become an integral part of FIPS 60-2, 61-1, 62, 63-1, 97, 111, 130 and 131, and, as such, are considered to be included whenever reference is made to them.

These approved revisions should be filed with each FIPS listed above.

Attachment

Copies of FIPS are available from:

National Technical Information Service (NTIS)
ATTN: Sales Office, Sills Building
5285 Port Royal Road
Springfield, Virginia 22161

Phone - 703/487-4650 Office Hours - 7:45 a.m. to 4:15 p.m.

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December 18, 1990

National Institute of Standards and Technology

[Docket No. 900101-0219]

RIN 0693-AA59

Approval of Revisions to Federal Information Processing Standards (FIPS) Family of Input/Output Interface Standards

AGENCY: National Institute of Standards and Technology (NIST), Commerce.

ACTION: The purpose of this notice is to announce that the Secretary of Commerce has approved revisions to the Federal Information Processing Standards (FIPS) family of input/output interface standards, and has approved discontinuation of the exclusion and verification lists for these standards.

SUMMARY: On March 20, 1990, notice was published in the Federal Register (55 FR 10272) proposing revision of Federal Information Processing Standards (FIPS) 60-2, 61-1, 62, 63-1, 97, 111, 130, and 131 to make them non-mandatory, and discontinue the exclusion and verification lists for these standards. This proposal superseded the proposal for revision of these standards announced in the Federal Register (52 FR 44462) of November 19, 1987. Procedures for the Exclusion List for FIPS 60, 61, 62, 63, and 97 were published in the Federal Register on

September 3, 1982 (47 FR 38959–38960). Procedures for the Verification List for FIPS 60, 61, 62, 63, and 97 were published in the **Federal Register** on December 11, 1979 (44 FR 71444–71445) and on April 7, 1981 (46 FR 20719–20720).

The written comments submitted by interested parties and other material available to the Department relevant to these proposed revisions were reviewed by NIST. On the basis of this review, NIST recommended that the Secretary approve revisions to the input/output family of standards and approve discontinuation of the exclusion and verification lists for these standards. NIST prepared a detailed justification document for the Secretary's review in support of those recommendations.

This notice provides only the changes to the revised standards.

EFFECTIVE DATE: These revisions are effective December 18, 1990.

ADDRESSES: Interested parties may obtain copies of FIPS PUBS 60–2, 61–1, 62, 63–1, 97, 111, 130, and 131 from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

FOR FURTHER INFORMATION CONTACT: Ms. Shirley Radack, National Institute of Standards and Technology, Gaithersburg, MD 20899, telephone (301) 975–2833.

SUPPLEMENTARY INFORMATION: Under the provisions of 40 U.S.C. 759(d), the Secretary of Commerce is authorized to promulgate standards and guidelines for Federal computer systems, and to make such standards compulsory and binding to the extent to which the Secretary determines necessary to improve the efficiency of operation, or security and privacy of Federal computer systems.

The family of I/O interface standards currently includes:

a. FIPS 60–2, I/O Channel Interface, revised July 29, 1983.

b. FIPS 61–1, Channel Level Power Control Interface, revised July 13, 1982.

c. FIPS 62, Operational Specifications for Magnetic Tape Subsystems, revised December 30, 1980.

d. FIPS 63–1, Operational Specifications for Variable Block Rotating Mass Storage Subsystems, revised April 14, 1983; Supplement to FIPS PUB. 63–1, Additional Operational Specifications for Variable Block Rotating Mass Storage Subsystems, April 14, 1983.

e. FIPS 97, Operational Specifications for Fixed Block Rotating Mass Storage Subsystems, February 4, 1983.

f. FIPS 111, Storage Module Interfaces (with extensions for enhanced storage module interfaces), April 18, 1985.

g. FIPS 130, Intelligent Peripheral Interface (IPI), July 16, 1987.

h. FIPS 131, Small Computer System Interface (SCSI) July 16, 1987.

The following revisions are being made effective immediately upon publication. A delayed effective date is not required because these standards are exempt from the Administrative Procedure Act by U.S.C. 553(a)(2).

Revisions to Federal Information Processing Standards 60–2, 61–1, 62, 63–1, 97, 111, 130, and 131.

FIPS 60–2, I/O Channel Interface, is revised as follows:

Applicability. This standard addresses the interconnection of computer peripheral equipment as a part of ADP systems for the following types of peripherals: (1) Magnetic tape equipment employing open reel-to-reel magnetic tape storage devices, specifically excluding magnetic tape cassette and tape cartridge storage devices, (2) magnetic disk storage equipment employing disk drives each having a capacity greater than 7 megabytes per storage module, excluding flexible disk and disk cartridge devices having a smaller storage capacity per device, and (3) other peripheral equipment employing peripheral device types for which operational specifications standards have been issued as Federal Information Processing Standards. This standard is recommended for use in the acquisition of peripheral equipment for ADP systems with input/output channel interfaces as specified in the technical specifications, when it is determined that interchange of equipment between different systems is likely.

Implementation. The original version of this standard became effective December 13, 1979. The first revision became effective June 23, 1980, and the second revision became effective July 29, 1983. This revision becomes effective December 18, 1990.

Waivers. This standard is non-mandatory. No waivers are required.

FIPS 61–1, Channel Level Power Control Interface, is revised as follows:

Applicability. This standard addresses the power control interface in connecting computer peripheral equipment to ADP systems. It is w/ recommended for use hen FIPS 60–2 is used, when it is determined that interchange of equipment between different systems is likely.

Implementation. The original version of this standard became effective June 23, 1980, and the first revision became effective July 13, 1982. This revision becomes effective December 18, 1990.

Waivers. This standard is non-mandatory. No waivers are required.

FIPS 62, Operational Specifications for Magnetic Tape Subsystems, is revised as follows:

Applicability. This standard addresses magnetic tape equipment connected to ADP systems through FIPS 60 interfaces. It is recommended for use in the acquisition of such equipment, when it is determined that interchange of equipment between different systems is likely.

Implementation. The original version of this standard became effective June 23, 1980. This revision becomes effective December 18, 1990.

Waivers. This standard is non-mandatory. No waivers are required.

FIPS 63–1, Operational Specifications for Variable Block Rotating Mass Storage Subsystems, is revised as follows:

Applicability. This standard addresses peripheral device dependent operational interfaces for connecting variable block rotating mass storage equipment to ADP systems through FIPS 60 interfaces. It is recommended for use in the acquisition of such variable block rotating mass storage equipment for connection to ADP systems, when it is determined that interchange of equipment between different systems is likely.

Implementation. This standard became effective June 23, 1980, and the first revision became effective April 14, 1983. This revision becomes effective December 18, 1990.

Waivers. This standard is non-mandatory. No waivers are required.

FIPS 97, Operational Specifications for Fixed Block Rotating Mass Storage Subsystems, is revised as follows:

Applicability. This standard addresses the peripheral device dependent operational interface specifications for connecting fixed block rotating mass storage equipment to ADP systems through FIPS 60 interfaces. It is recommended for use in the acquisition of such fixed block rotating mass storage equipment for connection to ADP systems, when it is determined that interchange of equipment between different systems is likely.

Implementation. The original version of this standard became effective February 4, 1983. This revision becomes effective December 18, 1990.

Waivers. This standard is non-mandatory. No waivers are required.

FIPS 111, Storage Module Interfaces, is revised as follows:

Applicability. This standard addresses connection of a disk drive to a controller as part of an ADP system. This standard is recommended for use in the acquisition of disk systems that are

connected to small and medium sized computer systems, when it is determined that interchange of equipment between different systems is likely.

Implementation. This standard became effective May 18, 1985. This revision becomes effective December 18, 1990.

Waivers. This standard is non-mandatory. No waivers are required.

FIPS 130, Intelligent Peripheral Interface (IPI), is revised as follows:

Section 8, Applicability. This standard applies to the connection of computers to storage peripheral device controllers. This standard is recommended for use in the acquisition of magnetic disk drives, optical disk drives, and tape drives to be connected to minicomputer systems, when it is determined that interchange of equipment between different systems is likely.

Section 10, Implementation. This standard became effective December 16, 1987. This revision becomes effective December 18, 1990.

Section 11, Waivers. This standard is non-mandatory. No waivers are required.

FIPS 131, Small Computer System Interface (SCSI) is revised as follows:

Section 8, Applicability. This standard addresses the connection of small computers to peripheral devices with integral controllers. This standard is recommended for use in the acquisition of storage peripherals and small computer systems for office or laboratory use, when it is determined that interchange of equipment between different systems is likely.

Section 10, Implementation. This standard became effective December 16, 1987. This revision becomes effective December 18, 1990.

Section 11, Waivers. This standard is non-mandatory. No waivers are required.

Dated: December 12, 1990.

John W. Lyons,

Director.

[FR Doc. 90-29563 Filed 12-17-90; 8:45 am]

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