INTERNATIONAL STANDARD

ISO/IEC 14776-321

First edition
2002-08

Information technology –
Small computer system interface-3 (SCSI-3) –

Part 321:
Block commands (SBC)

Reference number
ISO/IEC 14776-321:2002(E)

INTERNATIONAL STANDARD

ISO/IEC 14776-321

First edition
2002-08

Information technology – Small computer system interface-3 (SCSI-3) –

Part 321: Block commands (SBC)

PRICE CODE XB

For price, see current catalogue

CONTENTS

INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE-3 (SCSI-3) –

Part 321: Block commands (SBC)

FOREWORD

1) ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

2) In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

3) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 14776-321 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

ISO/IEC 14776-321 is to be read in conjunction with ISO/IEC 14776-411, ISO/IEC 14776-311 and ISO/IEC 14776-351.[1)]

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

1) For details, see clause 2.

INTRODUCTION

The SCSI command set described in this document is designed to provide efficient peer-to-peer operation of input/output logical units by an operating system using block transfers. The SCSI command set assumes an underlying command-response protocol.

This SCSI command set provides multiple operating systems concurrent control over one or more input/output logical units. However, the multiple operating systems are assumed to coordinate their actions properly to prevent data corruption. This SCSI standard provides commands that assist with coordination between multiple operating systems. However, details of the coordination are beyond the scope of the SCSI command set.

At the time this standard was developed SCSI included the following:

- physical interconnects;
- transport protocols;
- shared command set;
- architecture model;
- common access method.

Please refer to the bibliography for examples of international standards referring to the above items.

INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE-3 (SCSI-3) –

Part 321: Block commands (SBC)

1 Scope

This part of ISO/IEC 14776 defines the command set extensions to facilitate operation of SCSI block devices.

It specifies the functional requirements for the SCSI-Block Command set (SBC). SBC permits that SCSI block logical units, such as flexible disks, rigid disks, optical disks, etc. be attached to computers, and it provides the definition for their use.

This standard defines a logical unit model for SCSI block logical units. Also defined are SCSI commands that apply to SCSI block logical units.

The clause(s) of this standard pertaining to the SCSI block device class, implemented in conjunction with the applicable clauses of ISO/IEC 14776-311, fully specify the standard command set for SCSI block devices.

The objectives of this standard are the following:

a) permit an application client to communicate with a logical unit that declares itself to be a direct-access device, write-once device and optical memory device in the device type field of the INQUIRY command response data over an SCSI service delivery subsystem;

b) define commands unique to the type of SCSI block devices;

c) define commands to manage the operation of SCSI block devices;

d) define the differences between types of SCSI block devices.

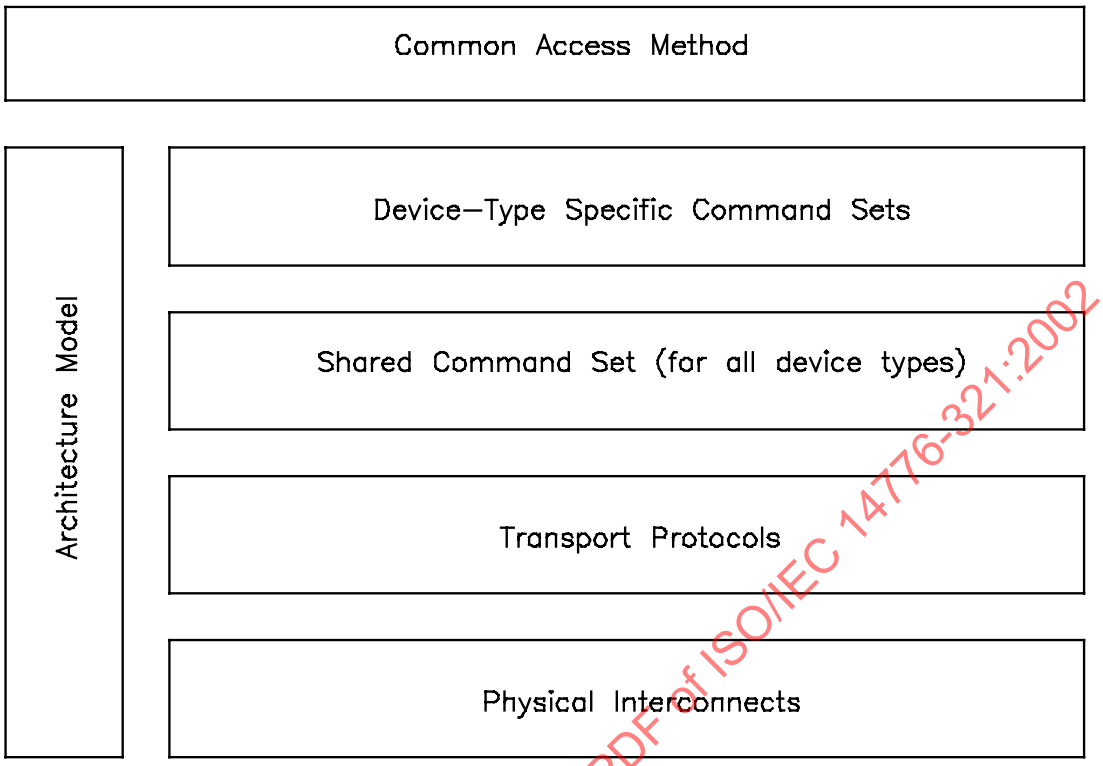


Figure 1 – SCSI standards – General structure

Figure 1 shows the general structure of SCSI standards. The figure does not imply a relationship such as a hierarchy, protocol stack, or system architecture. It indicates the applicability of a standard to the implementation of a given transport.

2 Normative references

2.1 Normative reference overview

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE The term SCSI is used wherever it is not necessary to distinguish between the different types of SCSI.

2.2 Approved references

ISO/IEC 9316:1995, *Information technology – Small Computer System Interface-2*

NOTE ISO/IEC 9316 is referred to herein as SCSI-2. The term SCSI-3 in this standard refers to different versions of SCSI defined since SCSI-2.

ISO/IEC 13614:1995, *Information technology – Interchange on 300 mm optical disk cartridges of the write once read multiple (WORM) type using the SSF method*

ISO/IEC 14776-341:2000, *Information technology – Small Computer System Interface-3 (SCSI-3) – Part 341: Controller Commands (SCC)*

ISO/IEC 14776-411:1999, *Information technology – Small Computer System Interface (SCSI-3) – Part 411: SCSI-3 Architecture Model (SCSI-3 SAM)*

ISO/IEC 10090:1992, *Information technology – 90 mm optical disk cartridges, rewritable and read only, for data interchange*

2.3 References under development

At the time of publication, the following referenced standards were still under development.

ISO/IEC 14776-311, – *Information technology – Small Computer System Interface-3 (SCSI-3) – Part 311: Primary Commands*

ISO/IEC 14776-351, – *Information technology – Small Computer System Interface-3 (SCSI-3) – Part 351: Medium Changer Commands*

ISO/IEC 14776-362, – *Information technology – Small Computer System Interface (SCSI 3) – Part 362: Multimedia commands-2 (MMC-2)*

3 Definitions, symbols and abbreviations

3.1 Definitions

3.1.1 Definitions specific to direct access devices

3.1.1.1
block device
a device that is capable of containing data stored in blocks that have a unique logical block address

3.1.1.2
cache memory
a temporary (and often volatile) data storage area outside the user-accessible area that may contain a subset of the data stored in the non-volatile data storage area

A cache memory is usually faster to access than the medium and thus has the effect of increasing data throughput by reducing the number of accesses to the medium.

3.1.1.3
check data
information contained within a redundancy group that allows lost or destroyed user data to be recreated

3.1.1.4
data-in buffer
buffer identified by the application client to receive data from the device server during the execution of a command

3.1.1.5
data-out buffer
buffer identified by the application client to supply data that is sent from the application client to the device server during the execution of a command

3.1.1.6
domain
an I/O system consisting of a set of SCSI devices that interact with one another by means of a service delivery subsystem

3.1.1.7
exclusive-or
logical function that combines two logical inputs producing a logical output true state if one but not both inputs are true

This function is used in error correction algorithms. In this standard the term encompasses the entire algorithm but does not define the specific polynomial. The exclusive-or operation may be performed by the storage array controller or by the storage device.

3.1.1.8
extent
an extent is a specified number of logical blocks and all or part of a block device

3.1.1.9
host
any combination of initiators and application clients that form a device managing one or more peripheral devices

3.1.1.10
logical block
unit of data supplied or requested by an initiator

3.1.1.11
non-volatile medium
physical storage medium that retains data written to it for a subsequent read operation through power off/on cycles

An example of a non-volatile medium is a disk within a device that stores data as magnetic field changes which do not require device power to exist.

3.1.1.12
notch
all or part of the medium having a consistent set of geometry parameters

Notches are used to increase storage capacity by optimizing the number of bytes per track between the inner and outer tracks.

3.1.1.13
redundancy group
grouping of protected space and associated check data into a single type of data redundancy

This standard only supports the exclusive-or type of redundancy.

[see ISO/IEC 14776-341:2000]

3.1.1.14
storage array controller
any combination of an initiator and application clients that originates SCSI command descriptor blocks and performs the services of a SACL

A storage array controller organizes a group of storage devices into various objects (for example, redundancy groups, volume sets, etc.).

[see ISO/IEC 14776-411:1999]

3.1.1.15
storage array conversion layer (SACL)
converts input logical unit numbers to output logical unit numbers and may convert input logical block addresses to output logical block addresses

3.1.1.16
third party
when used in conjunction with exclusive-or operations refers to the operations performed by a primary target with a secondary target on behalf of the host storage array controller

3.1.1.17
user-accessible
the area of the medium that can be read from or written to by READ and WRITE commands

3.1.1.18
user data
the addressable logical blocks that are input to the SACL

Check data is not part of the addressable logical blocks.

3.1.1.19
volatile medium
medium that does not retain data written to it for a subsequent read operation through power off/on cycles

An example of volatile medium is a silicon memory device that loses data written to it if device power is lost.

3.1.2 Definitions specific to optical memory block devices and to write-once block devices

3.1.2.1
blank
the logical block contains no information detectable by the block device, or is written with a pattern that appears to the block device as no data present. The logical block is considered ready for a write operation

3.1.2.2
generation
indicates a relative revision level of a logical block that has been updated via the UPDATE BLOCK command

A logical block that has never been updated has only one generation associated with it.

3.1.2.3
read-only medium
medium which is not to be written by the application client

The medium contains data prepared in a manner not defined by this standard.

3.1.2.4
update
to write new data to a logical block without destroying the previous data

After a block has been updated, a normal read returns the most recent generation of the data. Earlier generations are still available after the update.

3.1.2.5
write-once medium
medium which is to be written only once by any application client

Logical blocks on write-once media that have not been written are considered blank. Logical blocks on write-once media that have been written are not to be written again.

3.2 Symbols and abbreviations

CDB	command descriptor block
I/O	input/output
ID	identifier
LSB	least significant bit
MMC-2	SCSI-3 Multimedia Command Set-2 [see ISO/IEC 14776-362]
MSB	most significant bit
SAM	SCSI-3 Architecture Model [see ISO/IEC 14776-411]
SCC	SCSI-3 Controller Commands [see ISO/IEC 14776-341]
SCSI	either SCSI-2 or SCSI-3
SCSI-2	the Small Computer System Interface-2 [see ISO/IEC 9316:1996]
SCSI-3	the Small Computer System Interface-3
SPC	SCSI-3 Primary Command Set standard [see ISO/IEC 14776-311]
XOR	exclusive-or

3.3 Keywords

Several keywords are used to differentiate between different levels of requirements and optionality, as follows:

3.3.1
expected
used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented

3.3.2
mandatory
indicates items required to be implemented as defined by this standard

3.3.3
may
indicates flexibility of choice with no implied preference

3.3.4
obsolete
indicates items that were defined in prior SCSI standards but have been removed from this standard

3.3.5
optional
describes features that are not required to be implemented by this standard

However, if any optional feature defined by the standard is implemented, it shall be implemented as defined by this standard.

3.3.6
reserved
refers to bits, bytes, words, fields and code values that are set aside for future standardization

Their use and interpretation may be specified by future extensions to this or other standards. A reserved bit, byte, word or field shall be set to zero, or in accordance with a future extension to this standard. The recipient may not check reserved bits, bytes, words or fields. Receipt of reserved code values in defined fields shall be treated as an error.

3.3.7
shall
indicates a mandatory requirement

Designers are required to implement all such mandatory requirements to ensure interoperability with other standard conformant products.

3.3.8
should
indicates flexibility of choice with a strongly preferred alternative

Equivalent to the phrase “it is recommended”.

3.3.9
vendor-specific
items (e.g., a bit, field, code value, etc.) that are not defined by this standard and may be vendor defined.

3.4 Conventions

Lower case is used for words having the normal English meaning. Certain words and terms used in this standard have a specific meaning beyond the normal English meaning. These words and terms are defined either in clause 3 or in the text where they first appear.

Listed items in this standard do not represent any priority. Any priority is explicitly indicated. Formal lists (for example, (a) red; (b) blue; (c) green) connoted by letters are in an arbitrary order. Formal lists (for example, (1) red; (2) blue; (3) green) connoted by numbers are in a required sequential order.

If a conflict arises between text, tables, or figures, the order of precedence to resolve conflicts is text; then tables and finally figures. Not all tables or figures are fully described in text. Tables show data format and values.

The ISO/IEC convention of numbering is used (for example, the thousands and higher multiples are separated by a space, and a decimal comma is used instead of the decimal point, as shown in the following examples: 65 536 or 0,5).

The additional conventions are:

a) the names of abbreviations, commands and acronyms used as signal names are in uppercase (for example, IDENTIFY DEVICE);

b) fields containing only one bit are referred to as the "NAME" bit instead of the "NAME" field;

c) field names are in SMALL CAPS to distinguish them from normal English;

d) numbers that are not immediately followed by lower-case b or h are decimal values;

e) numbers immediately followed by lower-case b (xxb) are binary values;

f) numbers immediately followed by lower-case h (xxh) are hexadecimal values;

g) the most significant bit of a binary quantity is shown on the left side and represents the highest algebraic value position in the quantity;

h) if a field is specified as not meaningful or to be ignored, the entity that receives the field shall not check that field.

4 General

SCSI devices that conform to this standard are referred to as SCSI block devices. This includes the category of logical units commonly referred to as flexible disks, rigid disks, removable rigid disks, erasable optical discs, write once optical discs and read only optical discs. The ISO/IEC 14776-362, SCSI-3 Multimedia Command Set - 2 standard is typically used by CD-ROM devices.

The common attribute of block devices is that they are block addressable (i.e. the data are addressed on the block device in groups referred to as logical blocks). The number of bytes of data contained in a single logical block is the block length. The block length is almost always greater than one byte and may be a multiple of 512 bytes. In addition, a logical block is not required to bear any relation to the physical block size of the storage medium.

Each logical block has a block length associated with it. This means that the block length for the medium can change from logical block to logical block. However, for simplicity the block length typically remains constant over the entire capacity of the medium.

5 SCSI block device models

5.1 Direct-access device type model

5.1.0 General

Direct-access block devices store blocks of data for later retrieval. Each block of data is stored at a unique logical block address. An application client issues WRITE commands to store the blocks of data (write operations) and READ commands to retrieve the blocks of data (read operations). Other commands issued by the application client may also cause write and read operations to occur. A write operation causes one or more blocks of data to be written on the medium. A read operation causes one or more blocks of data to be read from the medium. A verify operation confirms that one or more blocks of data were correctly written and can be read without error from the medium.

Blocks of data are stored by a process that causes localized changes or transitions within the medium. The changes made to the medium to store the blocks of data may be volatile (i.e., not retained through off/on power cycles) or non-volatile (i.e., retained through power off/on cycles). The medium may be divided in parts that are used for data blocks, parts that are reserved for defect management and parts that are reserved for use by the controller for the management of the block device.

5.1.1 Removable medium

5.1.1.0 General

The medium may be removable (for example, used in a floppy disk device) or non-removable (for example, used in a fixed disk device). The removable medium may be contained within a cartridge (or jacket) to prevent damage to the recording surfaces. The combination of medium and cartridge is often called a removable volume.

A removable volume has an attribute of being mounted or de-mounted on a suitable transport mechanism. A removable volume is mounted when the direct access block device is capable of performing write or read operations to the medium. A mounted removable volume may not be accessible by an initiator if it is reserved by another initiator. A removable volume is de-mounted at any other time (for example, during loading, unloading or storage).

An application client may check whether a removable volume is mounted by issuing a TEST UNIT READY command. A volume that is loaded may need a START STOP UNIT command issued to become accessible for write or read operations.

The PREVENT ALLOW MEDIUM REMOVAL command allows an application client to restrict the demounting of the removable volume. This is useful in maintaining system integrity. If the direct-access block device implements cache memory, it ensures that all logical blocks of the medium contain the most recent data prior to permitting demounting of the removable volume. If the application client issues a START STOP UNIT command to eject the removable volume, and the direct-access block device is prevented from demounting by the PREVENT ALLOW MEDIUM REMOVAL command, the START STOP UNIT command is rejected by the device server.

5.1.1.1 Removable medium with an attached medium changer

When a block device is served by a medium changer, control over a media transport element may be done using media changer commands sent to the logical unit.

The block device indicates its ability to support these commands by setting the MCHNGR bit to one in its standard INQUIRY data. An MCHNGR bit of one indicates that the MOVE MEDIA and READ ELEMENT STATUS commands are supported. Only one medium transport element is permitted (element 0) and only one data transfer element is permitted.

5.1.2 Logical blocks

Blocks of data are stored on the medium along with additional information that the medium controller uses to manage the storage and retrieval. The format of the additional information is defined by other standards or is vendor-specific and is hidden from the application client during normal read or write operations. This additional information may be used to identify the physical location of the blocks of data and the address of the logical block, and to provide protection against the loss of user data.

The address of the first logical block is zero. The address of the last logical block is [$n - 1$], where [n] is the number of logical blocks available to the application client on the medium. A READ CAPACITY command may be issued to determine the value of [$n - 1$]. If a command is issued that requests access to a logical block not within the capacity of the medium, the command is terminated with CHECK CONDITION status and the additional sense key shall be set to LOGICAL BLOCK ADDRESS OUT OF RANGE with the additional sense code set to ILLEGAL REQUEST.

The number of bytes of data contained in a logical block is the block length. Each logical block has a block length associated with it. The block descriptor in the MODE SENSE data describes the block lengths that are used on the medium. The FORMAT UNIT command may be required to change the block length of block devices that support variable block lengths.

The location of a logical block on the medium is not required to have a relationship to the location of any other logical block. However, in a typical block device the logical blocks are located in an ascending order. The time to access the logical block at address [x] and then the logical block at address [$x + 1$] need not be less than time to access [x] and then [$x + 100$]. The READ CAPACITY issued with a PMI bit of one may be useful in determining where longer access times occur.

5.1.3 Ready state

A direct-access block device is ready when medium access commands can be executed. A block device using removable media is not ready until a volume is mounted. Such a block device, with a volume not mounted, shall terminate medium access commands with CHECK CONDITION status and the sense key shall be set to NOT READY with the appropriate additional sense code for the condition.

Some direct-access block devices may be switched from being ready to being not ready by using the START STOP UNIT command. An application client may need to issue a START STOP UNIT command with a START bit set to bring a block device ready.

5.1.4 Power conditions

The optional power conditions permit the application client to modify the behavior of a block device in a manner that may reduce the required power. There is no notification to the application client that a block device has entered one of the power conditions. The power conditions may be controlled by the START STOP UNIT command or the power condition page of the MODE SELECT command. If both methods are being used on the same target/logical unit combination then any START STOP UNIT commands power condition request shall override the power condition page's power control. See the START STOP UNIT command description and the MODE SELECT power condition page description for more information. (See 6.1.15 and 7.1.3.6.)

No power condition shall affect the SCSI bus.

The lowest power consumption, with power applied, occurs in the Sleep condition. When in the Sleep condition a block device requires a WAKEUP task management function to be activated.

In the Standby condition a block device is capable of accepting commands, but media is not immediately accessible (for example, the spindle is stopped).

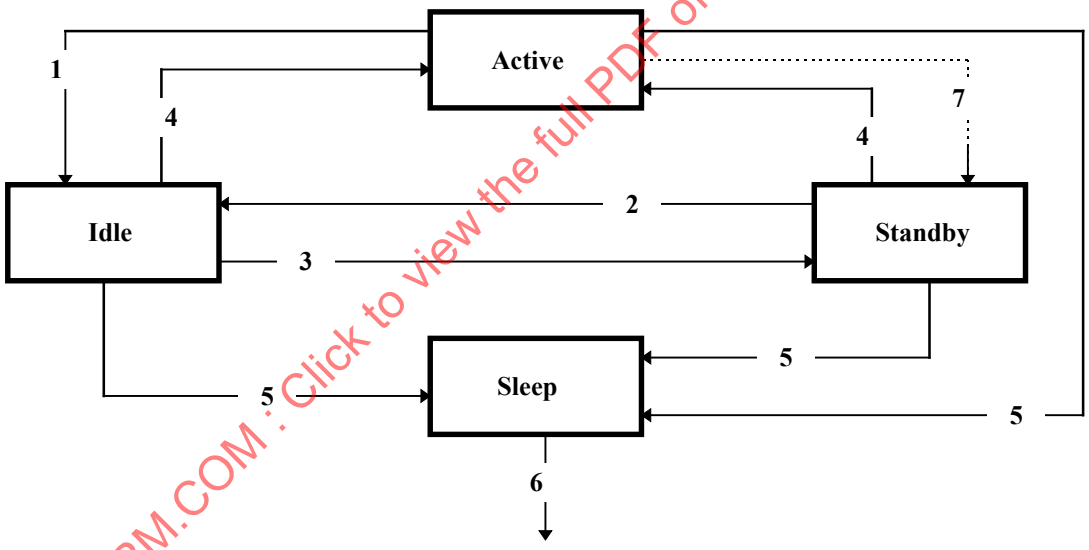
In the Idle condition, a block device is capable of responding quickly to media access requests. However, a block device in the idle condition may take longer than in the active condition, to complete the execution of a command because it may have to activate some circuitry.

In the Active condition a block device is capable of responding immediately to media access requests, and operations complete execution in the shortest time compared to the other power conditions.

Block devices that contain cache memory shall implicitly perform a SYNCHRONIZE CACHE command for the entire medium prior to entering any power condition that prevents access the media (for example, the spindle being stopped).

If implemented, the block device shall use the optional power condition page to control the power conditions after a power on or a WAKEUP task management function until a START STOP UNIT command is received with the POWER CONDITIONS field set to a value other than 0h or 7h. See 6.1.15 and 7.1.3.6.

Figure 2 shows the flow control between the different power conditions in a device that is setup to adjust itself automatically to the power condition that allows any command to execute.



NOTE For Active, Idle or Standby, see f).

a) Path 1: An idle time-out or a START STOP UNIT command with a power condition code of Ah.

b) Path 2: Any command that can be executed within the power constraints of the Idle power condition.

c) Path 3: A standby time-out or a START STOP UNIT command with a power condition code of Bh.

d) Path 4: Any command that exceeds the power constraints of the Idle power condition.

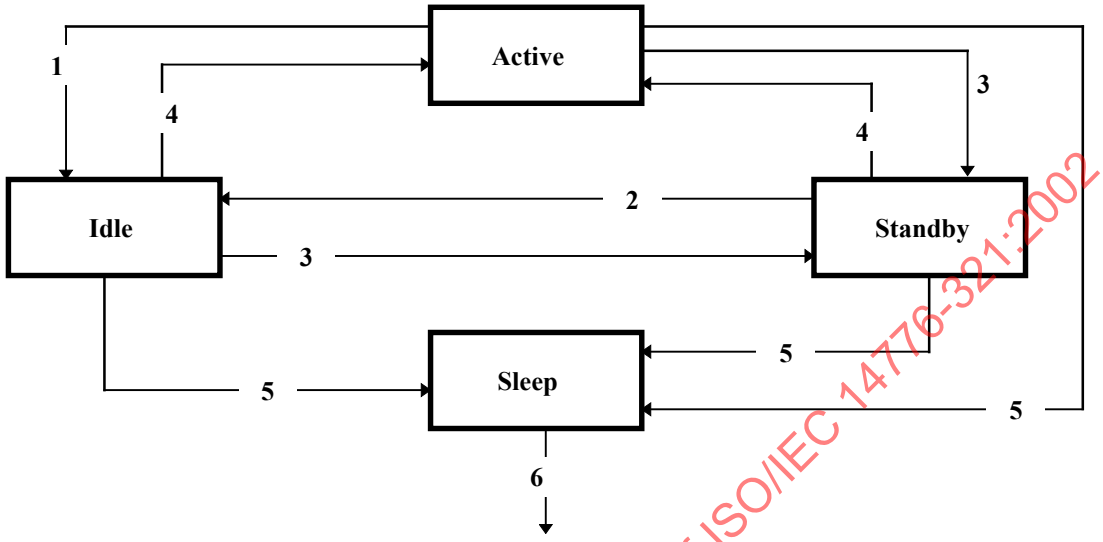
e) Path 5: A START STOP UNIT command with a power condition code 5h.

f) Path 6: A WAKEUP task management function returns the device to the state defined by the saved power mode page parameters.

g) Path 7: This path only occurs if the idle bit is set equal to zero.

Figure 2 – SCSI power conditions flow control (automatic switching)

Figure 3 shows the flow control between the different power conditions in a device that is setup to only allow changing of the power condition by the application client. Any command received that requires more power than allowed by the most recent power condition setting shall be terminated with a sense key of ILLEGAL REQUEST and the additional sense code shall be set to LOW POWER CONDITION ACTIVE.



NOTE Active, Idle or Standby - see f).

a) Path 1: A START STOP UNIT command with a power condition code of 2h.

b) Path 2: A START STOP UNIT command with a power condition code of 2h.

c) Path 3: A START STOP UNIT command with a power condition code of 3h.

d) Path 4: A START STOP UNIT command with a power condition code of 1h.

e) Path 5: A START STOP UNIT command with a power condition code of 5h.

f) Path 6: A WAKEUP task management function returns the device to the state defined by the saved power mode parameters.

Figure 3 – SCSI power conditions flow control (controlled switching)

5.1.5 Initialization

Direct-access block devices may require initialization prior to write or read operations. This initialization is performed by a FORMAT UNIT command. Parameters related to the geometry and performance characteristics may be set with the MODE SELECT command prior to the format operation. Some block devices are initialized by means not specified in this standard. The time when the initialization occurs is specific to the implementation of the direct-access block device.

Block devices using a non-volatile medium may save the parameters and only need to be initialized once. However, some mode parameters may need to be initialized after each power-on and/or reset. A catastrophic failure of the direct-access block device may require the FORMAT UNIT command to be reissued.

Block devices that use a volatile medium may need to be initialized at each power-on and/or reset prior to the execution of read or write operations. Mode parameters may also need initialization.

5.1.6 Medium defects

Any medium has the potential for defects that can cause user data to be lost. Therefore, each logical block may contain information that allows the detection of changes to the user data caused by defects in the medium or other phenomena, and may also allow the data to be reconstructed following the detection of such a change. Some block devices provide the application client control through use of the mode parameters. Some block devices allow the application client to examine and modify the additional information by using the READ LONG and WRITE LONG commands.

Defects may also be detected and managed during execution of the FORMAT UNIT command. The FORMAT UNIT command defines four sources of defect information. These defects may be reassigned or avoided during the initialization process so that they do not appear in a logical block.

Defects may also occur after initialization. The application client issues a REASSIGN BLOCKS command to request that the specified LOGICAL BLOCK ADDRESS be reassigned to a different part of the medium. This operation may be repeated if a new defect appears at a later time. The total number of defects that may be handled in this manner can be specified in the mode parameters.

Defect management on direct-access block devices is vendor-specific. Block devices not using a removable medium may optimize the defect management for capacity or performance, or both. Some block devices that use a removable medium do not support defect management (for example, some floppy disk devices) or use defect management that does not impede the ability to interchange the medium.

5.1.7 Cache memory

Some direct-access block devices implement cache memory. A cache memory is usually an area of temporary storage in the direct-access block device with a fast access time that is used to enhance performance. It exists separately from the blocks of stored data and is not directly accessible by the application client. Use of cache memory for write or read operations may reduce the access time to a logical block and can increase the overall data throughput.

During read operations, the direct-access block device uses the cache memory to store blocks of data that the application client may request at some future time. The algorithm used to manage the cache memory is not part of this standard. However, parameters are provided to advise the device server about future requests, or to restrict the use of cache memory for a particular request.

During write operations, the direct-access block device uses the cache memory to store data that is written to the medium at a later time. This is called write-back caching. The command may complete prior to blocks of data being written to the medium. As a result of using a write-back caching there is a period of time when the data may be lost if power to the device is lost or a hardware failure occurs. There is also the possibility of an error occurring during the subsequent write operation. If an error occurred during the write, it may be reported as a deferred error on a later command. The application client may request that write-back caching be disabled to prevent detected write errors from being reported by deferred errors. Even with write-back caching disabled undetected write errors may occur. In order to detect these errors, verify commands are provided.

When the cache memory fills up with blocks of data that are being kept for possible future access, new blocks of data that are to be kept replace those currently in cache memory. The disable page out (DPO) bit allows the application client to influence the replacement of logical blocks in the cache. For write operations, setting this bit to one advises the device server to not replace existing blocks in the cache memory with the write data. For read operations, setting this bit to one causes blocks of data that are being read to not replace existing ones in the cache memory.

Sometimes the application client may want to have the blocks of data read from the medium instead of from the cache memory. The force unit access (FUA) bit is used to indicate that the device server shall access the physical medium. For a write operation, setting FUA to one causes the device server to complete the data write to the physical medium before completing the command. For a read operation, setting FUA to one causes the logical blocks to be retrieved from the physical medium.

When the DPO and FUA bits are both one, write and read operations, in effect, bypass the cache memory.

When a VERIFY command is executed, a forced unit access is implied, since the blocks of data stored on the medium are being verified. Furthermore, a SYNCHRONIZE CACHE operation is also implied to write unwritten blocks of data still in the cache memory. These blocks of data are stored on the medium before the verify operation begins. The DPO bit is provided since the VERIFY command may cause the replacement of blocks in the cache. The caching rules also applies to the WRITE AND VERIFY command.

Commands may be implemented by the device server that allow the application client to control other behavior of the cache memory:

a) the LOCK UNLOCK CACHE command controls whether certain logical blocks shall be held in the data cache for future use. Locking a logical block prevents its replacement by a future access. Unlocking a logical block exposes it to possible replacement by a future access (see 6.1.3);

b) the PRE-FETCH command causes a set of logical blocks requested by the application client to be read into the data cache for possible future access. The blocks fetched are subject to later replacement unless they are locked (see 6.1.4);

c) the SYNCHRONIZE CACHE command forces any pending write data in the requested set of logical blocks to be stored in the physical medium. This command may be used to ensure that the data was written and any detected errors reported (see 6.1.16);

d) the MODE SELECT command defines a page for the control of cache behavior and handles certain basic elements of cache replacement algorithms (see ISO/IEC 14776-311).

5.1.8 Reservations

The access enabled or access disabled condition determines when an application client may store or retrieve user data on all or part of the medium. Access may be restricted for read operations, write operations, or both. This attribute may be controlled by an external mechanism or by the RESERVE and RELEASE commands (see ISO/IEC 14776-311).

The RESERVE and RELEASE commands define how different types of restricted access may be achieved, and to whom the access is restricted. This subclause describes the interaction of the application client that requested the reservation, as well as the other application clients.

Reservations are further controlled by the optional PERSISTENT RESERVE IN and PERSISTENT RESERVE OUT commands. For the requirements of this standard, reservations and releases made by use of the PERSISTENT RESERVE IN and PERSISTENT RESERVE OUT commands are the same as those using the RESERVE and RELEASE commands. See ISO/IEC 14776-311 for a description and the requirements of the various reservation commands.

An application client uses reservations to gain a level of exclusivity in access to all or part of the medium for itself or another application client. It is expected that the reservation is retained until released. The device server ensures that the application client with the reservation is able to access the reserved media within the operating parameters established by that application client.

The following paragraphs explain, on a command by command basis, the appropriate device server response when a reservation exists. Unless otherwise noted, the appropriate response to an application client that issues a command to a device server that is reserved to another initiator is RESERVATION CONFLICT status.

If any initiator has an extent reservation on a logical unit, no other initiator may affect the operating definition of that initiator by use of the CHANGE DEFINITION command. If the device server allows different operating definitions for each initiator, then there is no conflict. Otherwise, a reservation conflict occurs.

The COMPARE, COPY and COPY AND VERIFY commands are evaluated for reservation conflict as if they were normal write and read operations even when a device server is requested to copy to or from itself. For example, if a COPY is issued to logical unit 0 that requests the device server to copy from logical unit 0 to logical unit 1, access to logical unit 1 is also to be evaluated for reservation conflicts.

The FORMAT UNIT, PREVENT ALLOW MEDIUM REMOVAL (with a prevent bit of one), REZERO UNIT, and START STOP UNIT commands return a RESERVATION CONFLICT status if any other initiator has an extent reservation on the device server.

The INQUIRY and REQUEST SENSE commands are not affected by any kind of reservation.

The LOG SELECT, LOG SENSE, MODE SENSE, TEST UNIT READY, READ CAPACITY (PMI equal zero), READ BUFFER, WRITE BUFFER and READ DEFECT DATA commands are not affected by extent reservations.

The SEEK, LOCK UNLOCK CACHE, PRE-FETCH and SYNCHRONIZE CACHE commands are evaluated for reservation conflict as if they were normal write or read operations.

If an initiator has an extent reservation on a device server, and another initiator attempts a MODE SELECT command, a reservation conflict occurs if the command affects the manner of accessing the extent by the first initiator. If the command does not affect access to the extent, or parameters are saved for each initiator, then a reservation conflict does not occur.

The SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS commands conflict with an extent reservation only if they affect access to the extent.

The REASSIGN BLOCKS command shall not reassign a block that is in an extent reserved to another initiator.

The SET LIMITS command generates a reservation conflict if the logical blocks specified are within an extent reserved to another initiator.

All other commands that request read or write operations are evaluated for reservation conflict as described in the reserve commands.

When a system is integrated with more than one application client, agreement is required between the application clients as to how media is reserved and released during operations. Otherwise, an application client may be locked out of access to a logical unit in the middle of an operation. For example, an application client in initiator 'A' has a write operation in progress to a direct-access logical unit that has data stored in cache memory. Then, another application client in initiator 'B' issues a RESERVE command to the direct-access block device. As a result, the application client in initiator 'A' is locked out of issuing a SYNCHRONIZE CACHE command to ensure the integrity of the data. To prevent this from happening, an application client may issue a RESERVE command prior to the WRITE command.

5.1.9 Seek(10)

The SEEK(10) command provides a way for the application client to position the actuator of the block device in preparation for access to a particular logical block at some later time. Since this positioning action is implicit in other commands, the SEEK(10) command may not be useful with some direct-access block devices.

5.1.10 Notched devices

A notched (also known as zoned) device has areas of the medium with geometry changes. In the simplest case, the entire medium consists of a single notch. Multiple notches are often used to increase capacity of the device. On a disk, the inner tracks are physically shorter than the outer tracks. As a result, if each track is made to store the same number of data bits, the data is packed more densely on the inner tracks than the outer tracks. By using notches, the outer tracks may contain a different number of sectors than the inner tracks, while balancing the data density. This results in increased capacity.

The notch page is used to indicate the notch for assignment of values to the parameters in the format device page. By sequencing the notch page through each notch, the format device parameters of each notch are set. This may be done prior to initialization by the FORMAT UNIT command.

5.1.11 Rotational position locking

Rotational position locking is an optional feature implemented in some direct-access block devices to allow the synchronization of spindles between a number of logical units. The rotational position offset feature allows block devices to synchronize spindles at offsets from index. This may be useful in improving performance in systems that implement arrays of logical units.

5.1.12 Relative addressing

Relative addressing is a technique that may be useful in accessing structured data in a uniform manner. Relative addressing may be used when commands are linked.

The SET LIMITS command (see 6.1.14) is provided to define the limits of a linked chain of relative addressing commands. This protects against exceeding the specified set of blocks. The SET LIMITS command has no effect on any other initiator.

5.1.13 Error reporting

If any of the following conditions occur during the execution of a command (see Table 1), the command shall be terminated with CHECK CONDITION status and the sense key shall be set to the appropriate sense key with the appropriate additional sense code for the condition. Some errors may occur after the completion status has already been reported. For such errors, ISO/IEC 14776-311 defines a deferred error reporting mechanism. The following list illustrates some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 1 – Sample error conditions

Condition	Sense key
Invalid logical block address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Logical unit reset or medium change since last command from this application client	UNIT ATTENTION
Self-diagnostic failed	HARDWARE ERROR
Unrecovered read error	MEDIUM ERROR or HARDWARE ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to write on write protected medium	DATA PROTECT

In the case of an invalid logical block address, the SENSE DATA INFORMATION field shall be set to the logical block address of the first invalid address.

In the case of an attempt to read a blank or previously unwritten block, the INFORMATION field shall be set to the logical block address of the first blank block encountered. The data read up to that block shall be transferred (optical memory and write-once block devices only).

In the case of an attempt to write a previously written block when blank checking is enabled, the INFORMATION field shall be set to the logical block address of the first non-blank block encountered (optical memory and write-once block devices only).

5.1.14 Examples

5.1.14.0 General

The following examples show some typical variations of the direct-access block device. Other variations are possible.

5.1.14.1 Rotating media

The typical application of a direct-access block device is a disk device. The medium is a disk coated with a material that allows flux changes to be induced. The disk device allows direct and random access to the medium. This is done with an actuator that positions the read-write head and a rotating disk. Data is stored and retrieved through the interaction of the read-write head and the disk.

The disk(s) may be divided into cylinders. Each cylinder may be divided into tracks. Each track may be divided into sectors. A cylinder is a set of tracks that can be accessed without movement of the actuator. A track is a recording path that the read-write head travels over during one rotation of the disk. A sector is a part of a track that contains the stored data blocks.

A logical block is stored in one or more sectors, or a sector may store more than one logical block. A sector may be made up of a header, data and a trailer. The header, if any, may contain a preamble used to synchronize read circuits to the data, an address field to identify the sector, flags for defect management and a checksum that validates or corrects the header. The data field begins with a synchronizing field and a data area that contains user data. The trailer may contain checksum or error correction information. The checksum or the error correction information allows the correction of data for medium defects.

A disk device is ready when the disks are rotating at the correct speed and the read-write circuitry is powered and ready to access the data. Some disks, particularly removable disks, require the user to issue load or start commands to bring the disk device to the ready state.

A disk device may have to be formatted prior to the initial access. Exceptions to this are devices that are formatted at the factory and some optical devices with pre-formatted media. A disk device format may create headers for each sector and initialize the data field. The MODE SELECT command is often used prior to formatting to establish the geometry (number of heads and tracks, sectors per track, etc.) and defect management scheme. Disk devices are usually non-volatile.

The defect management scheme of a disk device may not be discernible by the user through the interface, though some aspects can be evaluated and controlled by the application client. The device server may reserve some sectors and tracks for recording defect lists and for reassigning defective blocks. The READ LONG and WRITE LONG commands may access the user data and checksum portions of the data field so that defects may be induced by the application client to test the defect detection logic of the device server. WRITE LONG commands may also be used to emulate unrecoverable logical blocks when generating “mirror copies.”

5.1.14.2 Sequential media

Some tape logical units are implemented as a direct access block device so that they may be used in disk oriented operating system environments. These logical units are sometimes referred to as random access tape or floppy tape. These logical units might be thought of as a disk device with one or more long tracks. Access time to a logical block is usually longer than for a disk device, since the tape requires that it be fast forwarded or rewound to the block. As a result, the SEEK command often is more useful for a tape than for a disk. The only way an application client may determine if a direct-access block device is a tape is by using the medium type code returned by the MODE SENSE command.

5.1.14.3 Memory media

Memory media includes logical units that are traditionally used for primary storage within computer systems, such as solid state static or dynamic random access memories (for example, SRAM, DRAM or Flash).

These logical units may be non-mechanical and therefore the entire physical medium may be accessed in virtually the same access time. The data may be accessed as a bit or byte and this also speeds access time. Memory block devices may store less data than disks or tapes and are usually volatile (except Flash) when not protected by battery backup.

5.1.15 Model for XOR commands

5.1.15.0 General

In storage arrays, a storage array controller organizes a group of storage devices into objects. The type of object used by this model is the redundancy group. Some areas within the address space of the storage array are used for check data. The check data is generated by performing a cumulative exclusive-or (XOR) operation with the data from other areas within the address space of the storage array known as protected data. The XOR operation may be performed by the storage array controller or by the storage device.

Performing the XOR operation in the storage device may result in a reduced number of data transfers across the interconnect. For example, when the XOR operation is done within the storage array controller four data transfer operations are needed for a typical update write sequence, as follows:

- a read transfer from the device containing protected data;
- a write transfer to the device containing protected data;
- a read transfer from the device containing check data;
- a write transfer to the device containing check data.

The storage array controller also does two internal XOR operations in this sequence.

In contrast, during storage array controller supervised XOR operations (see 5.1.15.1) only three data transfer operations are needed:

- a write transfer to the device containing protected data;
- a read transfer from the device containing protected data;
- a write transfer to the device containing check data.

During third party XOR operations (see 5.1.15.2) only two data transfer operations are needed:

- a write transfer from the storage array controller to the device containing protected data, and
- a write transfer from the device containing protected data to the device containing check data.

Performing the XOR operation in the device eliminates the need for the storage array controller to perform any XOR operations. A storage array controller supervises three basic operations that require XOR functionality. These are the update write, regenerate and rebuild operations. A command sequence for each of these operations is defined for the following operating modes. The command sequences use the device server to perform the XOR functions needed for the major operations.

5.1.15.1 Storage array controller supervised XOR operations

5.1.15.1.0 General

Three XOR commands are needed to implement storage array controller supervised XOR operations: XDWRITE, XPWRITE, and XDREAD. The storage array controller also uses READ and WRITE commands for certain operations. The XOR functionality may be used when all of the devices are in the same domain, when all devices are in separate domains, or any combination thereof, as long as the domains are accessible by the storage array controller.

5.1.15.1.1 Update write operation

The update write operation writes user data to a device containing protected user data and updates the parity information on the device containing check data. The sequence is:

a) an XDWRITE command is sent to the device containing protected user data. This transfers the user write data to that device. The device reads the old user data, performs an XOR operation using the old user data and the received user data, retains the intermediate XOR result and writes the received user data to the medium;

b) an XDREAD command is sent to the device containing protected user data. This command transfers the intermediate XOR data from the XOR device to the storage array controller;

c) an XPWRITE command is sent to the device containing check data. This transfers the intermediate XOR data (received in the previous XDREAD command) to the device containing check data. The device reads the old XOR data, performs an XOR operation using the old XOR data and the intermediate XOR data, and writes the new XOR result to the medium.

5.1.15.1.2 Regenerate operation

The regenerate operation is used to recreate a data block that has an error. This is done by reading the associated data block from each of the other devices within the redundancy group and performing an XOR operation with each of these data blocks. The last XOR result is the data that should have been present on the unreadable device. The number of steps is dependent on the number of devices in the redundancy group, but the sequence is as follows:

a) a READ command is sent to the first device. This transfers the data from the device to the storage array controller;

b) an XDWRITE command with the DISABLE WRITE bit set is sent to the next device. This transfers the data from the previous read operation to the device. The device reads its data, performs an XOR operation on the received data and its data, and retains the intermediate XOR result;

c) an XDREAD command is sent to the same device as in step 2. This transfers the intermediate XOR data from the device to the storage array controller;

d) steps 2 and 3 are repeated until all devices (except the failed device) in the redundancy group have been accessed. The intermediate XOR data returned by the last XDREAD command is the regenerated user data for the failed device.

5.1.15.1.3 Rebuild operation

The rebuild operation is similar to the regenerate operation, except that the last XOR result is written to the replacement device. This function is used when a failed device is replaced and the storage array controller is writing the rebuilt data to the replacement device. The sequence is as follows:

a) a READ command is sent to the first device. This transfers the data from the device to the storage array controller;

b) an XDWRITE command with the DISABLE WRITE bit equal one is sent to the next device. This transfers the data from the previous read operation to the device. The device reads its data, performs an XOR operation using the received data and its data, and retains the intermediate XOR result;

c) an XDREAD command is sent to the same device as in step 2. This transfers the intermediate XOR data from the device to the storage array controller;

d) steps 2 and 3 are repeated until all devices (except the replacement device) in the redundancy group have been accessed. The intermediate XOR data returned by the last XDREAD command is the regenerated user data for the replacement device;

e) a WRITE command is sent to the replacement device. This transfers the regenerated user data from step 4 to the replacement device. The replacement device writes the regenerated user data to the medium.

5.1.15.2 Third party XOR operations

5.1.15.2.0 General

Five XOR commands are needed to implement the third party XOR operations: XDWRITE EXTENDED, XPWRITE, XDREAD, REGENERATE and REBUILD. The storage array controller also uses READ and WRITE commands for certain operations. Third party XOR operations are restricted to systems where all devices involved in the operations are located in the same SCSI domain since direct interaction between those devices is required.

5.1.15.2.1 Update write operation

The update write operation is used to write user data to a device containing protected data and updates the parity information on a different device containing check data.

a) an XDWRITE EXTENDED command is sent to the device containing protected data. This transfers the new write data to that device. The device reads its old user data, performs an XOR operation using the old user data and the received user data, temporarily stores the XOR result and writes the received user data to the medium;

b) the device containing protected data becomes a temporary initiator and sends an XPWRITE command to the device containing check data. This transfers the resulting XOR data from the device containing protected data to the device containing check data. The device containing check data reads its check data, performs an XOR operation using the check data and the received XOR data and writes the resulting XOR result to the medium;

c) after the device containing protected data receives status for its XPWRITE command, it returns ending status for the XDWRITE EXTENDED command to the storage array controller. This indicates that the operations on both the device containing protected data and the device containing check data have completed.

5.1.15.2.2 Regenerate operation

The regenerate operation is used to recreate a data block that is not readable from a data device. This is done by reading the associated data block from each of the other devices within the redundancy group and performing an XOR operation with each of these data blocks. The last XOR result is the regenerated data that had the error. The number of steps is dependent on the number of devices in the redundancy group, but the sequence is as follows (since XOR operands are commutable the XOR order is irrelevant and the order of steps 2 and 3 is interchangeable):

a) a REGENERATE command is sent to a valid device in the redundancy group (a valid device is any device in the group other than the failed device). This transfers the regenerate parameter list from the storage array controller to the device;

b) the device reads the requested data from its own medium. The device retains the requested data for a subsequent XOR operation;

c) the device becomes a temporary initiator and sends a READ command to another device included in the regenerate parameter list. That target device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the read data from the previous step and the read data received in this step. The resulting XOR data is retained for the next step;

d) step 3 is repeated until all devices listed in the regenerate parameter list have been accessed. The last XOR data result is retained by the temporary initiator. The temporary initiator returns completion status for the REGENERATE command to the storage array controller when this regenerated user data is available;

e) an XDREAD command is sent from the storage array controller to the device that had been a temporary initiator in the above steps. This transfers the regenerated user data from the last XOR data result from the device to the storage array controller.

5.1.15.2.3 Rebuild operation

The rebuild operation is similar to the regenerate operation, except that the last XOR result is written to the replacement device. This is used when a failed device is replaced and rebuilt data is written to the replacement device. The sequence is as follows:

a) a REBUILD command is sent to the replacement device in the redundancy group (the device that replaces a failed device). This transfers the rebuild parameter list from the storage array controller to the device;

b) the device becomes a temporary initiator and sends a READ command to a device included in the rebuild parameter list. That target device transfers the requested data to the temporary initiator. The temporary initiator retains this data for a subsequent XOR operation;

c) the temporary initiator sends a READ command to another device included in the rebuild parameter list. That device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the read data from the previous step and the read data received in this step. The resulting XOR data is retained for the next step;

d) step 3 is repeated until all devices listed in the rebuild parameter list have been accessed. The last XOR data result is written to the replacement device's medium, then the device returns completion status for the REBUILD command to the storage array controller.

5.1.15.3 Hybrid subsystem XOR operations

5.1.15.3.0 General

In a hybrid subsystem the redundancy group is divided between two or more domains (see 5.1.15.1) and at least one of those domains contains two or more of the devices in the redundancy group. Such a system could do its XOR operations as described in 5.1.15.1 (Storage array controller supervised XOR operations), but it may choose to use third party XOR commands for parts of the XOR operation where all the involved devices are in the same domain. This subclause describes use of the third party XOR operations on a hybrid system with two domains. For illustration the redundancy group has six devices, with three devices in each domain.

5.1.15.3.1 Update write operation

When the update write operation involves two devices that are in different domains, the storage array controller uses the technique described in storage array controller supervised XOR operations. When the update write operation involves two devices that are in the same domain the storage array controller may use either the storage array controller supervised operation or the third party XOR operation.

5.1.15.3.2 Regenerate operation

The regenerate operation, for the illustrated case, always involves five XOR devices (all but the failed device) where three devices are in one domain (referred to as domain A) and two devices are in the other domain (referred to as domain B). The sequence is as follows (since XOR operands are commutable the XOR order is irrelevant and the order of steps 2 and 3 is interchangeable. Likewise, the order of steps 7 and 8 is interchangeable):

a) a REGENERATE command is sent to a device in domain A. This transfers the regenerate parameter list (containing the other two valid devices and data extents) from the storage array controller to the device;

b) the device reads the requested data from its own medium. The device retains the requested data for a future XOR operation;

c) the device becomes a temporary initiator and sends a READ command to another device included in the regenerate parameter list. That device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the read data from the previous step and the read data received in this step. The resulting XOR data is retained for the next step;

d) step 3 is repeated until all devices listed in the regenerate parameter list have been accessed. The last XOR data result is retained by the temporary initiator. The temporary initiator returns completion status for the REGENERATE command to the storage array controller when this partially regenerated user data is available;

e) an XDREAD command is sent from the storage array controller to the temporary initiator device. This transfers the partially regenerated user data from the last XOR data result from the device to the storage array controller;

f) a REGENERATE command with the intermediate data bit set is sent to a device in domain B. This transfers the regenerate parameter list (containing the other valid device and data extent) from the storage array controller to the device. The partially regenerated user data received in step 5 is sent as the intermediate data;

g) the device reads the requested data from its own medium. The device performs an XOR operation between the intermediate data and its own data. The resulting XOR data is retained for the next step;

h) the device becomes a temporary initiator and sends a READ command to the other device included in the regenerate parameter list. That target device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the XOR data from step 7 and the read data received in this step. The last XOR data result is retained by the temporary initiator. The temporary initiator returns completion status for the REGENERATE command to the storage array controller when this regenerated user data is available;

i) an XDREAD command is sent from the storage array controller to the device that had been a temporary initiator device in the above steps. This transfers the regenerated user data from the last XOR data result from the device to the storage array controller.

5.1.15.3.3 Rebuild operation

The rebuild operation for this illustration involves five valid devices and the replacement device where three valid devices are in one domain (referred to as domain A) and two valid devices and the replacement device are in the other domain (referred to as domain B). The sequence is as follows (since XOR operands are commutable the XOR order is irrelevant, and the order of steps 2 and 3 is interchangeable):

a) a REGENERATE command is sent to a device in domain A. This transfers the regenerate parameter list (containing the other two valid devices and data extents) from the storage array controller to the device;

b) the device reads the requested data from its own medium. The device retains this data for a future XOR operation;

c) the device becomes a temporary initiator and sends a READ command to another device included in the regenerate parameter list. That device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the read data from the previous step and the read data received in this step. The resulting XOR data is retained for the next step;

d) step 3 is repeated until all devices listed in the regenerate parameter list have been accessed. The last XOR data result is retained by the temporary initiator. The temporary initiator returns completion status for the REGENERATE command to the storage array controller when the data is available;

e) an XDREAD command is sent from the storage array controller to the temporary initiator device. This transfers the partially regenerated data from the device to the storage array controller;

f) a REBUILD command with the intermediate data bit set is sent to the replacement device in domain B. This transfers the rebuild parameter list (containing the two valid devices and data extents) from the storage array controller to the device. The partially rebuilt data received in step 5 is sent as the intermediate data;

g) the device becomes a temporary initiator and sends a READ command to a device included in the rebuild parameter list. That target device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the intermediate data and the read data received in this step. The resulting XOR data is retained for the next step;

h) the temporary initiator sends a READ command to the other device included in the rebuild parameter list. That device transfers the requested data to the temporary initiator. The temporary initiator performs an XOR operation between the read data from the previous step and the read data received in this step;

i) the last XOR data result is written to the replacement device's medium, then the device returns completion status for the REBUILD command to the storage array controller.

5.1.15.4 Additional array subsystem considerations

5.1.15.4.0 General

This clause lists considerations that apply to any array subsystem, but describes how use of the XOR commands may affect handling of those situations.

5.1.15.4.1 Buffer full status handling

When the storage array controller sends an XDWRITE or REGENERATE command to a device, the device has an obligation to retain the resulting XOR data until the storage array controller issues a matching XDREAD command to retrieve the data. This locks up part or all (depending on the size of the device's buffer and the size of the XOR data block) of the device's buffer space. When all of the device's buffer is allocated for XOR data, it may not be able to accept new media access commands other than valid XDREAD commands and it may not be able to begin execution of commands that are already in the task set.

When the device is not able to accept a new command because there is not enough space in the buffer, the device shall terminate that command with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the BUFFER FULL additional sense code.

When a storage array controller receives this status, it may issue any matching XDREAD commands needed to satisfy any previous XDWRITE or REGENERATE commands. This results in buffer space being freed for other commands. If it is a multi-initiator system and the storage array controller has no XDREAD commands to send, the storage array controller may assume the buffer space has been allocated to another initiator. The storage array controller may retry the command in the same manner that a command ending with TASK SET FULL status would be retried including not retrying the command too frequently.

The storage array controller may use command linking to avoid a buffer full condition. For example, a storage array controller supervised update write operation would consist of an XDWRITE command linked to an XDREAD command.

5.1.15.4.2 Access to an inconsistent stripe

A stripe is a set of corresponding strips of consecutively addressed storage from two or more block devices. A strip is an equal division of the storage capacity in a set of consecutively addressed LBAs on a single block device. When the storage array controller issues an update write to a device, the data in the device has been updated when successful status is returned for the command. Until the device containing check data has been updated, however, the associated stripe in the redundancy group is not consistent (for example, performing an XOR operation on the protected data does not produce the check data). The storage array controller shall keep track of this window of inconsistency and make sure that a regenerate or rebuild operation for any data extent within the stripe is not attempted until after the device containing check data has been updated (making the stripe consistent again). For multi-initiator systems, tracking the updates may be more complex because each storage array controller needs to ensure that a second storage array controller is not writing to a stripe that the first storage array controller is regenerating or rebuilding. The coordination between storage array controllers is system specific and is beyond the scope of this standard. The following list identifies cases where a storage array controller needs to prevent data corruption due to a temporarily inconsistent stripe:

a) when an XDWRITE command has been issued and completed, the device containing protected data has been updated but the device containing check data has not. The stripe is inconsistent until the XPWRITE command to the device containing check data returns completion status;

b) when an XDWRITE EXTENDED command has been issued, the device containing protected data and the device containing check data are updated at different times during the course of the command. The stripe should be treated as inconsistent between the time the storage array controller issues the XDWRITE EXTENDED command and the completion status for the command is received;

c) any time a regenerate or rebuild operation is in progress for a given stripe, update writes to that stripe should be avoided.

5.1.15.4.3 Error handling considerations

5.1.15.4.3.0 General

If any of the XOR commands end with CHECK CONDITION status and an unrecovered error is indicated, an inconsistent stripe may result. It is the storage array controller's responsibility to identify the failing device and the extent of the failure, then limit access to the inconsistent stripe. In the case of third party XOR operations the failing device may be a device containing protected data or a device containing check data. The storage array controller may identify the failing device from the resulting sense data or, it may access the devices directly to determine the condition of the affected devices. The recovery procedures that the storage array controller implements are not addressed by this standard.

5.1.15.4.3.1 Errors during third party XOR operations

5.1.15.4.3.1.0 General

Third party operations involve the processing of several commands exchanged among three or more devices. For the purposes of this clause, a command that causes the recipient of that command to generate one or more other commands to another device (or devices) is referred to as a primary command and the recipient of a primary command is referred to as a primary target. All commands generated by a primary target (based on the receipt of a primary command) are referred to as secondary commands and are sent to a secondary target or secondary targets. The definitions of primary command, primary target, secondary command, and secondary target are temporary, and for this clause only, and they should not be associated with the more general "SCSI Primary Command" or "SCSI Target" usage.

The primary target of an XDWRITE EXTENDED primary command generates an XPWRITE secondary command; the primary target of a REBUILD primary command generates one or more READ secondary commands. The primary command shall not be completed until the primary target is prepared to report the completion status or implied completion status of the secondary commands. Two classes of exception conditions may occur during these commands. One class consists of those resulting directly from the primary command. The other class consists of those resulting from a secondary command. Either or both of these classes of exception may occur during a third party operation.

5.1.15.4.3.1.1 Primary errors – Errors resulting directly from the primary command

The first class of errors consists of exception conditions that are detected by the device that received the primary command (primary target) and are not due to the failure of a resulting secondary command. These conditions include, but are not limited to, invalid parameters in the primary command. Inability of the primary target to continue operating, and parity errors while transferring the primary command, data, or status byte. In the event of such an exception condition, the primary target shall:

a) terminate the primary command with CHECK CONDITION status;

b) build sense data according to the exception condition.

5.1.15.4.3.1.2 Secondary errors – Errors resulting from the secondary command

The second class of errors consists of exception conditions resulting from the failure of a secondary command. The sense data for such errors shall be passed to the initiator of the primary command in the additional sense bytes field of the sense data.

If the primary target detects the exception (i.e., by some means other than receiving CHECK CONDITION status from the secondary target), it shall:

a) terminate the primary command with CHECK CONDITION status;

b) set the sense key to ABORTED COMMAND if there are no primary errors to report. Otherwise, the sense key shall be set according to the primary error;

c) set the first byte of the command specific information field of the sense data to the starting byte number, relative to the first byte of sense data, of an area that contains the primary target's sense data for the secondary error. A zero value in this byte indicates no secondary error has been detected by the primary target. The secondary sense data shall be built in the standard sense data format as defined for the REQUEST SENSE command;

d) in the case of a REBUILD or REGENERATE primary command, set the third byte of the command specific information field of the sense data to an index value indicating the target identifier of the failing secondary target. This value shall be an index into the source descriptor entries of the parameter data of the primary command, and shall point to the entry containing the target identifier of the failing device; 0 points to the first entry, 1 points to the second entry, etc. This byte shall be ignored if the primary command is not a REBUILD or REGENERATE.

If the secondary target detects the exception, the primary target receives CHECK CONDITION status from the secondary target. The primary target shall recover the sense data associated with the exception condition, clear any exception conditions associated with the CHECK CONDITION status and shall:

a) terminate the primary command with CHECK CONDITION status;

b) set the sense key to ABORTED COMMAND if there are no primary errors to report. Otherwise, the sense key shall be set according to the primary error;

c) set the second byte of the command specific information field of the sense data to the starting byte number, relative to the first byte of sense data, of an area that contains (unchanged) the secondary target's status byte followed by its sense data. A zero value in this byte indicates no secondary error has been reported by the secondary target;

d) in the case of a REBUILD or REGENERATE (primary) command, set the third byte of the command specific information field of the sense data to an index value indicating the target identifier of the failing secondary target. This value shall be an index into the source descriptor entries of the parameter data of the primary command and shall point to the entry containing the target identifier of the failing device. 0 points to the first entry, 1 points to the second entry, etc. This byte is invalid and shall be ignored if the primary command is not a REBUILD or REGENERATE.

For a given primary command, if errors are generated by more than one secondary command, the sense data shall contain error information for the secondary error first obtained by the primary target.

Since, for secondary errors, the sense key is set to ABORTED COMMAND only if there are no primary errors to report (see item b) above), the first and second bytes of the command specific information field should be checked, even when the sense key is a value other than ABORTED COMMAND, to determine if any secondary errors have occurred.

NOTE 1 All three of the above error types might occur during the same third party operation. If this happens, there are three unique pieces of error information contained in the sense data: one for the primary error (starting at byte 0), and two for the secondary errors (in the additional sense bytes).

5.1.15.4.4 XOR data retention requirements

The target shall retain XOR data while awaiting retrieval by an XDREAD command until performing one of the following events: a matching XDREAD command, TARGET RESET, power cycle, CLEAR TASK SET, ABORT TASK if the task matches the pending XDREAD, ABORT TASK SET.

5.2 Model for optical memory block devices

5.2.0 General

An optical memory block device is a logical unit that can potentially support a variety of optical media, (for example, read-only, write-once, erasable or reversible). In several respects, an optical memory block device is similar to a direct-access block device. However, optical memory block devices may offer features that are not available with other logical units, including large capacity removable media.

These logical units often require the functions that are not found in direct-access block devices such as logical block update, pre-erasure before writing, or scanning for blank medium and twelve-byte command descriptor blocks. This standard includes specific device types for write-once and CD-ROM block devices that also use optical media, but are not capable of supporting several types of optical media. A logical unit that uses write-once media can be an optical memory block device. Logical units that use read-only media can be optical memory block devices. However, logical units using CD-ROM media have certain unique characteristics and should not be implemented as optical memory block devices.

A model of optical memory block devices is complicated by the nature of one of its potential advantages, that it can support media that has different characteristics. There are three types of optical media in general use, read-only, write-once and reversible. Read-only media are used for publishing applications requiring dissemination of large amounts of data since the data may be replicated on a disk at low cost. Write-once media are used in applications that have large backup or archiving requirements. It is also used in applications that need large amounts of on-line reference information. Reversible media is used in applications that need large amounts of temporary storage (for example, a graphics workstation) and can take advantage of removable media. In some applications, reversible media devices are used instead of direct-access block devices.

Reversible media usually need to be reversed (erased, blanked) before new data can be written. In such cases an erase operation is required before data can be written. Some optical memory block devices perform this erase operation implicit with each write operation that impacts the data throughput. Some block devices can perform the erase separately. The ERASE command may be used to erase areas of the medium with a corresponding increase in data throughput on subsequent write operations. Products using optical media should not be implemented as direct-access block devices, due to the overhead penalty on performance from the emulation and the lack of support in direct-access block devices to take advantage of the features specifically available with optical memory block devices.

The type of medium supported by the block device and the type of medium currently loaded may be determined by examining the MODE SENSE data. One unique feature of optical memory block devices is support of media with mixed types (for example, media with read-only and write-once areas). The INQUIRY command informs the application client that the logical unit is an optical memory block device. The application client should then determine the medium type from the MODE SENSE data. The application client needs to be cognizant of the medium type since the logical unit's characteristics may change when the media are changed.

Write-once media can have valid data written to a logical block once. This is an important feature where audit trails and permanent archives are needed. Optical memory block devices supporting write-once media may have the ability to update a logical block, preserving the previous generation of data. These logical units may provide a means to recover the previous data through use of commands that allow read access to the different generations of data that are stored at the same logical block address.

An important requirement in dealing with optical media is determining if logical blocks contain written data and or if they are blank. A blank logical block is one that is properly initialized so that data subsequently written to it can be recovered. The logical blocks may have a flag associated with each that indicates whether they have been written or not.

Strategies used to manage write once and erasable media may depend on being able to determine the boundary between written and blank areas of the medium. The MEDIUM SCAN command is useful in finding blank areas for subsequent write operations.

5.2.1 Defect management

Defect management may be performed on logical blocks by updating in a manner similar to that used by direct-access block devices with the REASSIGN BLOCKS command. The advantage of using the updating (that is not supported by direct-access block devices) is access to the previous data.

The update operation assigns an alternate physical block to the logical block while simultaneously writing the data to the block. Commands are provided to allow the recovery of previous generations of updated blocks.

Defect management on optical-memory block devices may be vendor-specific. However, there are standards for some types of optical-memory media that specify defect management techniques. These standards may supersede the requirements pertaining to error and defect reporting in this standard.

5.2.2 Error reporting

If any of the following conditions occur during the execution of a command (see Table 2), the device server shall return CHECK CONDITION status and the appropriate sense key shall be set with the appropriate additional sense code for the condition. The following list illustrates some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 2 – Sample error conditions

Condition	Sense key
Invalid logical block address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Logical unit reset or medium change since last command from this application client	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR
Unrecovered read error	MEDIUM ERROR or HARDWARE ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to write on write protected medium	DATA PROTECT
Attempt to read a blank or previously unwritten block	BLANK CHECK
Attempt to write a previously written block and blank checking is enabled	BLANK CHECK
Attempt to write on read-only medium	DATA PROTECT

In the case of an invalid logical block address, the sense data information field shall be set to the logical block address of the first invalid address.

In the case of an attempt to read a blank or previously unwritten block, the sense data information field shall be set to the logical block address of the first blank block encountered. The data read up to that block shall be transferred.

In the case of an attempt to write a previously written block when blank checking is enabled, the sense information field shall be set to the logical block address of the first non-blank block encountered.

5.3 Model for write-once block devices

5.3.0 General

The model for the write-once block device is a variation on the optical memory model. Most of the aspects of a write-once block device are similar to optical memory block devices. The differences are summarized in this subclause.

5.3.1 Logical blocks

Data may be written to a logical block only once. A subsequent write to a logical block already written may or may not be corrupted, depending on the implementation. Write-once physical media is non-volatile.

SCSI write-once block devices are intended to be archival in nature. Data at a logical block address is not expected to change once it is written. The update commands are not recommended for this device type. Logical units that require the update function should use the optical memory device type.

Block devices may be able to determine the state of a logical block prior to access. These block devices can determine whether a block is blank or written. This is useful in detecting previously written blocks and preventing a destructive overwrite. This is also useful in finding blank areas for later writing. The MEDIUM SCAN command may be used to find blank and written areas prior to WRITE and READ commands.

5.3.2 Initialization

The FORMAT UNIT command is not used by write-once block devices. Write-once media is shipped pre-formatted by the manufacturer and is ready for use when mounted.

5.3.3 Physical medium defects

The raw defect rate may be higher for optical medium than for magnetic medium. Data may or may not be recovered through the use of sophisticated error correction algorithms. The level of error correction used for data recovery may be selectable. However, write-once block devices may have a minimum level that is always used and is not changeable through the error recovery mode parameter. Control of the error correction algorithms and level of correction is vendor-specific.

Defect management on write-once block devices may be vendor-specific. However, there are standards for some types of write-once media that specify defect management techniques. These standards, may supersede the implementation requirements pertaining to error and defect reporting in this standard.

5.3.4 Error reporting

If any of the following conditions occur during the execution of a command (see Table 3) the device server shall return CHECK CONDITION status and the appropriate sense key shall be set with the additional sense code for the condition. The following list illustrates some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 3 – Sample error conditions

Condition	Sense key
Invalid logical block address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Logical unit reset or medium change since last command from this application client	UNIT ATTENTION
Self-diagnostic failed	HARDWARE ERROR
Unrecovered read error	MEDIUM ERROR or HARDWARE ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to write on write protected medium	DATA PROTECT
Attempt to read a blank or previously unwritten block	BLANK CHECK
Attempt to write a previously written block and blank checking is enabled	BLANK CHECK

In the case of an invalid logical block address, the sense data information field shall be set to the logical block address of the first invalid address.

In the case of an attempt to read a blank or previously unwritten block, the sense data information field shall be set to the logical block address of the first blank block encountered. The data read up to that block shall be transferred.

In the case of an attempt to write a previously written block and blank checking is enabled, the sense information field shall be set to the logical block address of the first non-blank block encountered.

6 Commands for block devices

6.1 Commands for direct-access block devices overview

6.1.1 Commands for direct-access block devices

The commands for direct-access block devices shall be as shown in Table 4.

Table 4 – Commands for direct-access block devices

Command name	Operation code	Type	Subclause
CHANGE DEFINITION	40h	O	*ISO/IEC 14776-311, SPC*
COMPARE	39h	O	*ISO/IEC 14776-311, SPC*
COPY	18h	O	*ISO/IEC 14776-311, SPC*
COPY AND VERIFY	3Ah	O	*ISO/IEC 14776-311, SPC*
FORMAT UNIT	04h	M	6.1.2
INQUIRY	12h	M	*ISO/IEC 14776-311, SPC*
LOCK-UNLOCK CACHE	36h	O	6.1.3
LOG SELECT	4Ch	O	*ISO/IEC 14776-311, SPC*
LOG SENSE	4Dh	O	*ISO/IEC 14776-311, SPC*
MODE SELECT(6)	15h	O	*ISO/IEC 14776-311, SPC*
MODE SELECT(10)	55h	O	*ISO/IEC 14776-311, SPC*
MODE SENSE(6)	1Ah	O	*ISO/IEC 14776-311, SPC*
MODE SENSE(10)	5Ah	O	*ISO/IEC 14776-311, SPC*
MOVE MEDIUM	A7h	O	SMC
Obsolete	01h	OB	3.3.4
Obsolete	31h	OB	3.3.4
Obsolete	30h	OB	3.3.4
Obsolete	32h	OB	3.3.4
Obsolete	0Bh	OB	3.3.4
PERSISTENT RESERVE IN	5Eh	O[1]	*ISO/IEC 14776-311, SPC*
PERSISTENT RESERVE OUT	5Fh	O[1]	*ISO/IEC 14776-311, SPC*
PRE-FETCH	34h	O	6.1.4
PREVENT-ALLOW MEDIUM REMOVAL	1Eh	O	*ISO/IEC 14776-311, SPC*
READ(6)	08h	M	6.1.5
READ(10)	28h	M	6.1.6
READ(12)	A8h	O	6.2.4
READ BUFFER	3Ch	O	*ISO/IEC 14776-311, SPC*
READ CAPACITY	25h	M	6.1.7
READ DEFECT DATA(10)	37h	O	6.1.8
READ DEFECT DATA(12)	B7h	O	6.2.5
READ ELEMENT STATUS	B4h	O	SMC
READ LONG	3Eh	O	6.1.9
REASSIGN BLOCKS	07h	O	6.1.10
REBUILD	81h	O	6.1.11
RECEIVE DIAGNOSTIC RESULTS	1Ch	O	*ISO/IEC 14776-311, SPC*

Table 4 *(continued)*

Command name	Operation code	Type	Subclause
REGENERATE	82h	O	6.1.12
RELEASE(6)	17h	O[2]	*ISO/IEC 14776-311, SPC*
RELEASE(10)	57h	M	*ISO/IEC 14776-311, SPC*
REPORT LUNS	A0h	O	*ISO/IEC 14776-311, SPC*
REQUEST SENSE	03h	M	*ISO/IEC 14776-311, SPC*
RESERVE(6)	16h	O[2]	*ISO/IEC 14776-311, SPC*
RESERVE(10)	56h	M	*ISO/IEC 14776-311, SPC*
SEEK(10)	2Bh	O	6.1.13
SEND DIAGNOSTIC	1Dh	M	*ISO/IEC 14776-311, SPC*
SET LIMITS(10)	33h	O	6.1.14
SET LIMITS(12)	B3h	O	6.2.8
START STOP UNIT	1Bh	O	6.1.15
SYNCHRONIZE CACHE	35h	O	6.1.16
TEST UNIT READY	00h	M	*ISO/IEC 14776-311, SPC*
VERIFY	2Fh	O	6.1.17
WRITE(6)	0Ah	O	6.1.18
WRITE(10)	2Ah	O	6.1.19
WRITE(12)	AAh	O	6.2.13
WRITE AND VERIFY	2Eh	O	6.1.20
WRITE BUFFER	3Bh	O	*ISO/IEC 14776-311, SPC*
WRITE LONG	3Fh	O	6.1.21
WRITE SAME	41h	O	6.1.22
XDREAD	52h	O	6.1.23
XDWRITE	50h	O	6.1.24
XDWRITE EXTENDED	80h	O	6.1.25
XPWRITE	51h	O	6.1.26

Key

M = Command implementation is mandatory

O = Command implementation is optional

OB = Obsolete

SPC = SCSI-3 Primary Commands

SMC = SCSI-3 Medium Changer Command Set

NOTE 1 Optional PERSISTENT RESERVE Commands, if implemented, shall both be implemented as a group.

NOTE 2 Optional RELEASE(6) and RESERVE(6) Commands, if implemented, shall both be implemented as a group.

NOTE 3 The following operation codes are vendor-specific: 02h, 05h, 06h, 09h, 0Ch, 0Dh, 0Eh, 0Fh, 10h, 13h, 14h, 19h, 20h, 21h, 22h, 23h, 24h, 26h, 27h, 29h, 2Ch, 2Dh and C0h through FFh. All remaining operation codes for direct-access block devices are reserved for future standardization.

6.1.2 FORMAT UNIT command

6.1.2.0 General

The FORMAT UNIT command (see Table 5) formats the medium into application client addressable logical blocks according to the application options defined by the client. In addition, the medium may be certified and control structures may be created for the management of the medium and defects. The degree to which the medium is altered by this command is vendor-specific.

Table 5 – FORMAT UNIT command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (04h)							
1	Reserved			FMTDATA	CMPLST	DEFECT LIST FORMAT		
2	VENDOR-SPECIFIC							
3	(MSB)							
4	INTERLEAVE							(LSB)
5	CONTROL							

The simplest mandatory form of the FORMAT UNIT command (with no format data) accomplishes medium formatting with little application client control over defect management. The device server implementation determines the degree of defect management that is to be performed. Two additional mandatory forms of this command increase the application client's control over defect management. Several optional forms of this command further increase the application client's control over defect management, by allowing the application client to specify

- defect list(s) to be used,
- defect locations (in several formats),
- that logical unit certification be enabled, and
- exception handling in the event that defect lists are not accessible.

If the logical unit is reserved, a reservation conflict shall occur when a FORMAT UNIT command is interpreted from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation, or any extent reservation, from any application client, is active for the specified logical unit.

During the format operation, the device server shall respond to commands as follows:

a) in response to all commands except REQUEST SENSE and INQUIRY, the device server shall return CHECK CONDITION status unless a reservation conflict exists, in that case RESERVATION CONFLICT status shall be returned;

b) in response to the INQUIRY command, the device server shall respond as commanded;

c) in response to the REQUEST SENSE command, unless an error has occurred, the device server shall return a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY FORMAT IN PROGRESS, with the sense key specific bytes set for progress indication (as described in *ISO/IEC 14776-311, SCSI-3 Primary Commands*). Refer to *ISO/IEC 14776-311, SCSI-3 Primary Commands* for a description of deferred error handling that may occur during the format operation.

NOTE 1 The MODE SELECT parameters (if any) should be set prior to issuing the FORMAT UNIT command.

During the execution of the FORMAT UNIT command, the device server may perform a medium defect management algorithm (that may be controlled by the application client, using

optional forms of this command). Four sources of defect location information (hereafter called defects) are defined as follows:

a) primary defect list (PLIST). This is the list of defects, that may be supplied by the original manufacturer of the device or medium, that are considered permanent defects. The PLIST is located outside of the application client-accessible logical block space. The PLIST is accessible by the device server (to reference while formatting), but it is not accessible by the application client except through the READ DEFECT DATA command. Once created, the original PLIST shall not be subject to change;

b) logical unit certification list (CLIST). This list includes defects detected by the device server during an optional certification process executed during the FORMAT UNIT command. This list shall be added to the GLIST;

c) data defect list (DLIST). This list of defect descriptors may be supplied to the device server by the application client in the data-out buffer transfer of the FORMAT UNIT command. This list shall be added to the GLIST. The DEFECT LIST LENGTH in the defect list header may be zero, in that case, there is no DLIST;

d) grown defect list (GLIST). The GLIST includes all defects sent by the application client or detected by the device server. The GLIST does not include the PLIST. If the CMPLST bit is zero, the GLIST shall include DLISTs provided to the device server during the previous and the current FORMAT UNIT commands. The GLIST shall also include:

   1) defects detected by the format operation during medium certification;

   2) defects previously identified with a REASSIGN BLOCKS command;

   3) defects previously detected by the device server and automatically reallocated.

A format data (FMTDATA) bit of zero indicates that data-out buffer shall not be transferred. The source of defect information is not specified.

A FMTDATA bit of one indicates that the FORMAT UNIT parameter list (see Table 6) shall be in the data-out buffer transfer. The data-out buffer transfer consists of a defect list header (see Table 7), followed by an initialization pattern descriptor, followed by zero or more defect descriptors. Each defect descriptor identifies a location on the medium that the device server shall map out of the user-accessible area.

Table 6 – FORMAT UNIT parameter list

Bit / Byte	7	6	5	4	3	2	1	0
	DEFECT LIST HEADER							
	INITIALIZATION PATTERN DESCRIPTOR (if any)							
	DEFECT DESCRIPTOR(s) (if any)							
0	DEFECT DESCRIPTOR 0							
n	(See specific table for length.)							
	:							
0	DEFECT DESCRIPTOR x							
n	(See specific table for length.)							

The defect list header (see Table 7) provides several optional format control bits. Device servers that implement these bits provide the application client additional control over the use of the four defect sources and the formatting operation. If the application client attempts to select any function not implemented by the device server, the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST.

Table 7 – DEFECT LIST HEADER

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	FOV	DPRY	DCRT	STPF	IP	DSP	IMMED	VS
2	(MSB)							
3	DEFECT LIST LENGTH							(LSB)

A complete list (CMPLST) bit of zero indicates that the defect list sent by the application client is an addition to the existing list of defects. As a result, a new GLIST is constructed that contains the existing GLIST, the DLIST (if it is sent by the application client), and the CLIST (if certification is enabled). The device server may add any defects it detects during the format operation to this DLIST.

A CMPLST bit of one indicates that the defect list sent by the application client is a complete list of defects. Any existing defect list except the PLIST shall be ignored by the device server. As a result, a new GLIST is constructed that contains the DLIST (if it is sent by the application client), and the CLIST (if certification is enabled). The device server may add any defects it detects during the format operation to this DLIST.

Table 8 defines the defect descriptor requirements for the FORMAT UNIT command.

Table 8 – FORMAT UNIT defect descriptor format and requirements

FMTDATA	CMPLST	Defect list format	Defect list length	Type	Comments
0	0	000b	N/A	M	Vendor-specific defect information
BLOCK FORMAT					
1	0	000b	Zero	M	See notes (1) and (3)
1	1	000b	Zero	M	See notes (1) and (4)
1	0	000b	>0	O	See notes (2) and (3)
1	1	000b	>0	O	See notes (2) and (4)
BYTES FROM INDEX FORMAT					
1	0	100b	Zero	O	See notes (1) and (3)
1	1	100b	Zero	O	See notes (1) and (4)
1	0	100b	>0	O	See notes (2) and (3)
1	1	100b	>0	O	See notes (2) and (4)
PHYSICAL SECTOR FORMAT					
1	0	101b	Zero	000b	See notes (1) and (3)
1	1	101b	Zero	000b	See notes (1) and (4)
1	0	101b	>0	000b	See notes (2) and (3)
1	1	101b	>0	000b	See notes (2) and (4)
VENDOR-SPECIFIC FORMAT					
1	0	110b			
1	1	110b			
All remaining codes are reserved.					
Key M = Command implementation is mandatory. O = Command implementation is optional.					
NOTE 1 No DLIST is transferred to the device server during the data-out buffer transfer. NOTE 2 A DLIST is transferred to the device server during the data-out buffer transfer. Add the DLIST defects to the new GLIST. NOTE 3 Use the existing GLIST as a defect source. Add existing GLIST defects to the new GLIST. NOTE 4 Discard the existing GLIST. Do not add existing GLIST defects to the new GLIST. NOTE 5 All the options described in this table cause a new GLIST to be created during execution of the FORMAT UNIT command as described in the text.					

The DEFECT LIST FORMAT field specifies the defect descriptor to be used if the FMTDATA bit is one (see Table 8).

The INTERLEAVE field specifies the interleave that is used when performing the format operation. This allows the logical blocks to be related in a way that may facilitate matching the transfer rate between the application client and the peripheral. An interleave of zero specifies that the device server use its default interleave. An interleave of one specifies that consecutive logical blocks be placed in contiguous ascending order. All other values are vendor-specific.

A format options valid (FOV) bit of zero indicates that the device server shall use its default settings for the DPRY, DCRT, STPF, IP and DSP bits (see below). If FOV is zero, the application client shall set these bits to zero. If FOV is zero and any of the other bits in this paragraph are not zero, the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST.

A FOV bit of one indicates that the device server shall examine the setting of the DPRY, DCRT, STPF, IP and DSP bits. When the FOV bit is one, the DPRY, DCRT, STPF, IP and DSP bits are defined as follows.

A disable primary (DPRY) bit of zero indicates that the device server shall not use portions of the medium identified as defective in the primary defect PLIST for application client addressable logical blocks. If the device server is not able to locate the PLIST, or is not able to determine whether a PLIST exists, it shall perform the action specified by the STPF bit. A DPRY bit of one indicates that the device server shall not use the PLIST to identify defective areas of the medium. The PLIST is not deleted.

A disable certification (DCRT) bit of zero indicates that the device server shall perform a vendor-specific medium certification operation to generate a CLIST. A DCRT bit of one indicates that the device server shall not perform any vendor-specific medium certification process or format verification operation while executing the FORMAT UNIT command.

The stop format (STPF) bit controls the behavior of the device server when one of the following events occurs:

a) the device server has been requested to use the primary defect list (DPRY is zero), or the grown defect list (CMPLST is zero) and the device server is not able to locate the list nor determine whether the list exists;

b) the device server has been requested to use the primary defect list (DPRY is zero) or the grown defect list (CMPLST is zero), and the device server encounters an error while accessing the defect list.

A STPF bit of zero indicates that, if one or both of the above conditions occurs, the device server shall continue to execute the FORMAT UNIT command. The device server shall return CHECK CONDITION status at the completion of the FORMAT UNIT command and the sense key shall be set to RECOVERED ERROR with the additional sense code set to either DEFECT LIST NOT FOUND if the first condition occurred, or DEFECT LIST ERROR if the second condition occurred.

A STPF bit of one indicates that, if one or both of the above conditions occurs, the device server shall terminate the FORMAT UNIT command with CHECK CONDITION status and the sense key shall be set to MEDIUM ERROR with the additional sense code set to either DEFECT LIST NOT FOUND if the first condition occurred, or DEFECT LIST ERROR if the second condition occurred.

NOTE 2 The use of the FMTDATA bit, the CMPLST bit, and the defect header allow the application client to control the source of the defect lists used by the FORMAT UNIT command. Setting the DEFECT LIST LENGTH to zero allows the application client to control the use of PLIST and CLIST without having to specify a DLIST.

An initialization pattern (IP) bit of zero indicates that an initialization pattern descriptor is not included and that the device server shall use its default initialization pattern. An IP bit of one indicates that an initialization pattern descriptor (see 6.1.2.2) is included in the FORMAT UNIT parameter list immediately following the defect list header.

A disable saving parameters (DSP) bit of zero specifies that the device server shall save all the MODE SELECT savable parameters for all application clients to non-volatile memory during the format operation. A DSP bit of one specifies that the device server shall not save the MODE SELECT savable parameters to non-volatile memory during the format operation. Pages that are not reported as savable are not affected by the DSP bit.

An immediate (IMMED) bit of zero indicates that status shall be returned after the format operation has completed. An IMMED bit value of one indicates that the device server shall return status as soon as the command descriptor block has been validated and the entire defect list has been transferred.

The bit designated VS is vendor-specific.

The DEFECT LIST LENGTH field in the defect list header specifies the total length in bytes of the defect descriptors that follow and does not include the initialization pattern descriptor or initialization pattern, if any. The length of the defect descriptors varies with the format of the defect list. The three formats for the defect descriptor(s) field in the defect lists are shown in 6.1.2.1.

6.1.2.1 Defect list formats

This subclause describes the defect list formats used in the FORMAT UNIT, READ DEFECT DATA and translate page of the SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS commands.

NOTE 3 The selected reporting format accounts for variables that impact the information in the returned data. For example, the specific location of a defect, while constant in angular and radial location on the block device, may change in reported location if a format operation with different geometry parameters is performed. It is the responsibility of the application client to use a defect list format appropriate for the intended operation with the current or future geometry parameters. If the device server is able to detect that the selected defect list format would provide inconsistent results, the device server may return CHECK CONDITION status.

Each block format defect descriptor (see Table 9) specifies a four-byte defective block address that contains the defect. Use of the Block format is vendor-specific.

Table 9 – DEFECT DESCRIPTOR – Block format

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
3	DEFECTIVE BLOCK ADDRESS							(LSB)

The DEFECT LIST LENGTH is equal to four times the number of defect descriptors.

The defect descriptors should be in ascending order. More than one physical or logical block may be affected by each defect descriptor. A device server may return CHECK CONDITION if the defect descriptors are not in ascending order.

Each byte from index defect descriptor (see Table 10) specifies the location of a defect that is no more than eight bytes long.

Table 10 – DEFECT DESCRIPTOR – Bytes from index format

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
2	CYLINDER NUMBER OF DEFECT							(LSB)
3	HEAD NUMBER OF DEFECT							
4	(MSB)							
7	DEFECT BYTES FROM INDEX							(LSB)

The DEFECT LIST LENGTH is equal to eight times the number of defect descriptors.

Each descriptor comprises the cylinder number of the defect, the head number of the defect and the defect bytes from index to the defect. The defect descriptors shall be in ascending order. The cylinder number of the defect is the most significant part of the address and the defect bytes from index is the least significant part of the address. More than one logical block may be affected by each defect. If the defect bytes from index has a value of FFFFFFFFh, this indicates that the entire track shall be considered defective.

Each physical sector defect descriptor (see Table 11) specifies the location of a defect that is the length of a sector.

Table 11 – DEFECT DESCRIPTOR – Physical sector format

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
2	CYLINDER NUMBER OF DEFECT							(LSB)
3	HEAD NUMBER OF DEFECT							
4	(MSB)							
7	DEFECT SECTOR NUMBER							(LSB)

The DEFECT LIST LENGTH is equal to eight times the number of defect descriptors.

Each descriptor comprises a cylinder number of the defect, the head number of the defect, and the defect's sector number. The defect descriptors shall be in ascending order. The cylinder number of the defect is the most significant part of the address and the defect's sector number is the least significant part of the address. More than one logical block may be affected by each defect descriptor. A defect's sector number of FFFFFFFFh indicates that the entire track shall be considered defective.

6.1.2.2 Initialization pattern option

The initialization pattern option specifies that the logical blocks contain the specified initialization pattern. The initialization pattern descriptor (see Table 12) is sent to the device server as part of the FORMAT UNIT parameter list.

Table 12 – Initialization pattern descriptor

Bit Byte	7	6	5	4	3	2	1	0
0	IP MODIFIER		SI	Reserved				
1	PATTERN TYPE							
2	(MSB)							
3	INITIALIZATION PATTERN LENGTH							(LSB)
4								
n	INITIALIZATION PATTERN							

The IP MODIFIER field specifies the type and location of a header that modifies the initialization pattern (see Table 13).

Table 13 – Initialization pattern modifier

IP Modifier	Description
00b	No header. The device server shall not modify the initialization pattern.
01b	The device server shall overwrite the initialization pattern to write the logical block address in the first four bytes of the logical block. The LOGICAL BLOCK ADDRESS shall be written with the most significant byte first.
10b	The device server shall overwrite the initialization pattern to write the logical block address in the first four bytes of each physical block contained within the logical block.
	The lowest numbered logical block or part thereof that occurs within the physical block is used. The LOGICAL BLOCK ADDRESS shall be written with the most significant byte first.
11b	Reserved.

The INITIALIZATION PATTERN TYPE field (see Table 14) indicates the type of pattern the device server shall use to initialize each logical block within the application client accessible portion of the medium. All bytes within a logical block shall be written with the initialization pattern. The initialization pattern is modified by the IP MODIFIER field as described in Table 13.

A security initialize (SI) bit of one indicates that the device server shall attempt to write the initialization pattern to all areas of the media including those that may have been reassigned. An SI bit of one shall take precedence over any other FORMAT UNIT field. The initialization pattern shall be written using a security erasure write technique. Application clients may choose to use this command multiple times to fully erase the previous data. Such security erasure write technique procedures are outside the scope of this standard. The exact requirements placed on the security erasure write technique are vendor-specific. The intent of the security erasure write is to render any previous user data unrecoverable by any analog or digital technique.

An SI bit of zero indicates that the device server shall initialize the application client accessible area of the media. The device server is not required to initialize other areas of the media. However, the device server shall format the medium as defined in the FORMAT UNIT command.

When the SI bit is one, the device server need not rewrite (format) header and other information not previously accessible to the application client. If any area of the medium that previously was accessible to the application client cannot be written, the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to MEDIUM ERROR with the appropriate additional sense code for the condition.

Table 14 – Initialization pattern type

Initialization pattern type	Description
00h	Use default pattern (see NOTE 1).
01h	Repeat the initialization pattern as required to fill the logical block. (note 2)
02h - 7Fh	Reserved
80h - FFh	Vendor-specific

NOTE 1 If the initialization pattern length is not zero the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST.

NOTE 2 If the initialization pattern length is zero the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The INITIALIZATION PATTERN LENGTH field indicates the number of bytes contained in the initialization pattern. If the length exceeds the current logical block size the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST. The pattern is modified by the IP MODIFIER field.

6.1.3 LOCK UNLOCK CACHE command

The LOCK UNLOCK CACHE command (see Table 15) requests that the device server disallow or allow logical blocks within the specified range to be removed from the cache memory by the device server's cache replacement algorithm. Locked logical blocks may be written to the medium when modified, but a copy of the modified logical block shall remain in the cache memory.

Table 15 – LOCK UNLOCK CACHE command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (36h)							
1	Reserved						LOCK	RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6				Reserved				
7	(MSB)							
8				NUMBER OF BLOCKS				(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a LOCK UNLOCK CACHE command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The LOCK UNLOCK CACHE command shall be evaluated for extent reservation conflicts as if it were performing normal write and read operations. LOCK UNLOCK CACHE commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the LOCK UNLOCK CACHE operation is prohibited by an extent reservation.

A LOCK bit of zero indicates that all logical blocks in the specified range that are currently locked into the cache memory shall be unlocked, but may not be removed. A LOCK bit of one indicates that any logical block in the specified range that is currently present in the cache memory shall be locked into cache memory. Only logical blocks that are already present in the cache memory are actually locked.

A relative address (RELADR) bit of zero indicates that the LOGICAL BLOCK ADDRESS field specifies the first logical block of the range of logical blocks for this command.

A RELADR bit of one indicates that the LOGICAL BLOCK ADDRESS field is a two's complement displacement. This negative or positive displacement shall be added to the logical block address last accessed on the block device to form the LOGICAL BLOCK ADDRESS for this command. This feature is only available with linked commands. This feature also requires that a previous command in the linked group has accessed a block of data on the block device.

The NUMBER OF BLOCKS field specifies the total number of contiguous logical blocks within the range. A NUMBER OF BLOCKS field of zero indicates that all remaining logical blocks on the block device shall be within the range.

Multiple locks may be in effect from more than one application client. Locks from different application clients may overlap. An unlock of an overlapped area does not release the lock of another initiator.

6.1.4 PRE-FETCH command

The PRE-FETCH command (see Table 16) requests that the device server transfer the specified logical blocks to the cache memory. No data shall be transferred to the application client.

Table 16 – PRE-FETCH command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (34h)							
1	Reserved						IMMED	RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Reserved							
7	(MSB)							
8				TRANSFER LENGTH				(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a PRE-FETCH command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The PRE-FETCH command shall be evaluated for extent reservation conflicts as if it were performing normal read operations. PRE-FETCH commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the PRE-FETCH operation is prohibited by an extent reservation.

An immediate (IMMED) bit of zero indicates that status shall be returned after the operation is complete. An IMMED bit of one indicates that status shall be returned as soon as the command descriptor block has been validated.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH field specifies the number of contiguous logical blocks of data that shall be transferred to the block device's cache memory. A TRANSFER LENGTH of zero indicates that the contiguous logical blocks up to and including the last logical block of the block device shall be transferred to the block device's cache memory. Any other value indicates the number of logical blocks that shall be transferred. The device server may elect to not transfer logical blocks that already are contained in the cache memory.

If the IMMED bit is zero and the specified logical blocks were successfully transferred to the cache memory, the device server shall return CONDITION MET status. If the LINK BIT (see *ISO/IEC 14776-311, SCSI-3 Primary Commands*) is one, the device server shall return INTERMEDIATE-CONDITION MET status.

If IMMED is one, and the unlocked cache memory has sufficient capacity to accept all of the specified logical blocks, the device server shall return CONDITION MET status. If the LINK bit is one, and the unlocked cache memory has sufficient capacity to accept all of the specified logical blocks, the device server shall return INTERMEDIATE-CONDITION MET status.

If IMMED is one, and the unlocked cache memory does not have sufficient capacity to accept all of the specified logical blocks, the device server shall return GOOD status. The device server shall transfer to cache memory as many logical blocks that fit. If the LINK bit is one, the device server shall return INTERMEDIATE status.

6.1.5 READ(6) command

The READ(6) command (see Table 17) requests that the device server transfer data to the application client. The most recent data value written, or to be written if cached, in the addressed logical block shall be returned.

Table 17 – READ(6) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (08h)							
1	Reserved			(MSB)				
2	LOGICAL BLOCK ADDRESS							
3								(LSB)
4	TRANSFER LENGTH							
5	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ(6) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The READ(6) command shall be evaluated for extent reservation conflicts. READ(6) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the READ(6) operation is prohibited by an extent reservation.

The cache control bits (see 6.1.6) are not provided for this command. Block devices with cache memory may have values for the cache control bits that affect the READ(6) command. However, no default value is defined by this standard. If explicit control is required, the READ(10) command should be used.

The LOGICAL BLOCK ADDRESS field specifies the logical block where the read operation shall begin.

The TRANSFER LENGTH field specifies the number of contiguous logical blocks of data to be transferred. A TRANSFER LENGTH of zero indirectly indicates that 256 logical blocks shall be transferred. Any other value directly indicates the number of logical blocks that shall be transferred.

NOTE 4 Although the READ(6) command is limited to directly addressing logical blocks up to a capacity of 2 Gigabytes, for logical block sizes of 512 bytes, this command has been maintained as mandatory since some system initialization routines require that the READ(6) command be used. Application clients should migrate from the READ(6) command to the READ(10) command which may address 2 Terabytes with logical block sizes of 512 bytes.

6.1.6 READ(10) command

The READ(10) command (see Table 18) requests that the device server transfer data to the application client. The most recent data value written in the addressed logical block shall be returned.

Table 18 – READ(10) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (28h)							
1	Reserved			DPO	FUA	Reserved		RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Reserved							
7	(MSB)							
8				TRANSFER LENGTH				(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The READ(10) command shall be evaluated for extent reservation conflicts. READ(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the READ(10) operation is prohibited by an extent reservation.

A disable page out (DPO) bit of zero indicates the priority shall be determined by the RETENTION PRIORITY fields in the caching page. A DPO bit of one indicates that the device server shall assign the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. A DPO bit of one overrides any retention priority specified in the caching page (see 7.1.3.1). All other aspects of the algorithm implementing the cache memory replacement strategy are not defined by this standard.

NOTE 5 The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks. If the DPO bit is one, the host is indicating that the logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory. If the DPO bit is zero, the host is indicating that the logical blocks accessed by this command are likely to be accessed again in the near future.

A force unit access (FUA) bit of zero indicates that the device server may satisfy the command by accessing the cache memory. For read operations, any logical blocks that are contained in the cache memory may be transferred to the application client directly from the cache memory. For write operations, logical blocks may be transferred directly to the cache memory. GOOD status may be returned to the application client prior to writing the logical blocks to the medium. Any error that occurs after the GOOD status is returned is a deferred error. Information regarding the error is not reported until a subsequent command.

A (FUA) bit of one indicates that the device server shall access the media in performing the command prior to returning GOOD status. Read commands shall access the specified logical blocks from the media (i.e., the data is not directly retrieved from the cache). If the cache contains a more recent version of a logical block than the media, the logical block shall first be written to the media. Write commands shall not return GOOD status until the logical blocks have actually been written on the media (i.e., the data is not write cached). Read commands that cause data to be written to the media from cache and that encounter an error shall cause a deferred error to be reported. See *ISO/IEC 14776-311, SCSI-3 Primary Commands*.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH field specifies the number of contiguous logical blocks of data that shall be transferred. A TRANSFER LENGTH of zero indicates that no logical blocks shall be transferred. This condition shall not be considered an error. Any other value indicates the number of logical blocks that shall be transferred.

6.1.7 READ CAPACITY command

The READ CAPACITY command (see Table 19) provides a means for the application client to request information regarding the capacity of the block device.

Table 19 – READ CAPACITY command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (25h)							
1	Reserved							RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							PMI
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ CAPACITY command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. READ CAPACITY commands with a reservation conflict shall be terminated with RESERVATION CONFLICT status. The READ CAPACITY command shall not be evaluated for extent reservation conflicts (for example, extent reservations do not conflict with the READ CAPACITY command).

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The LOGICAL BLOCK ADDRESS shall be zero if the PMI bit is zero. If the PMI bit is zero and the LOGICAL BLOCK ADDRESS is not zero, the device server shall return a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to ILLEGAL FIELD IN CDB.

A partial medium indicator (PMI) bit of zero indicates that the RETURNED LOGICAL BLOCK ADDRESS and the BLOCK LENGTH IN BYTES are those of the last logical block on the block device.

A PMI bit of one indicates that the RETURNED LOGICAL BLOCK ADDRESS and BLOCK LENGTH IN BYTES are those of the last logical block address before a substantial delay in data transfer may be encountered. This returned LOGICAL BLOCK ADDRESS shall be greater than or equal to the logical block address specified by the RELADR and LOGICAL BLOCK ADDRESS fields in the command descriptor block.

NOTE 6 This function assists storage management software. It determines whether there is sufficient space on the current track, cylinder, etc., to contain a frequently accessed data structure, such as a file directory or file index, without incurring an access delay.

The READ CAPACITY data (see Table 20) shall be sent during the data-in buffer transfer of the command.

Table 20 – READ CAPACITY data

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
3	RETURNED LOGICAL BLOCK ADDRESS							(LSB
4	(MSB)							
7	BLOCK LENGTH IN BYTES							(LSB)

6.1.8 READ DEFECT DATA(10) command

The READ DEFECT DATA(10) command (see Table 21) requests that the device server transfer the medium defect data to the application client.

Table 21 – READ DEFECT DATA(10) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (37h)							
1	Reserved							
2	Reserved			PLIST	GLIST	DEFECT LIST FORMAT		
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)							
8	ALLOCATION LENGTH							(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ DEFECT DATA(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. READ DEFECT DATA(10) commands with a reservation conflict shall be terminated with RESERVATION CONFLICT status. The READ DEFECT DATA(10) command shall not be evaluated for extent reservation conflicts (for example, extent reservations do not conflict with the READ DEFECT DATA(10) command).

If the device server is unable to access the medium defect data, it shall terminate the command with CHECK CONDITION status and the sense key shall be set to either MEDIUM ERROR, if a medium error occurred, or NO SENSE, if the list does not exist; with the additional sense code set to DEFECT LIST NOT FOUND.

NOTE 7 Some device servers may not be able to return medium defect data until after a FORMAT UNIT command has been completed successfully.

A primary defect list (PLIST) bit of zero requests that the device server not return the primary list of defects. A PLIST bit of one requests that the device server return the primary list of defects.

A grown defect list (GLIST) bit of zero requests that the device server not return the grown defect list. A GLIST bit of one requests that the device server return the grown defect list.

A PLIST bit of zero and a GLIST bit of zero requests that the device server return only the defect list header.

A PLIST bit of one and a GLIST bit of one requests that the device server return the primary and the grown defect lists. The order the lists are returned in is vendor-specific. Whether the lists are merged or not is vendor-specific.

The DEFECT LIST FORMAT field is used by the application client to indicate the preferred format for the defect list. This field is intended for those device servers capable of returning more than one format, as defined in the FORMAT UNIT command (see 6.1.2.1, defect list format). A device server unable to return the requested format shall return the defect list in its default format (see the DEFECT LIST FORMAT field in the defect list header below).

If the requested defect list format and the returned defect list format are not the same, the device server shall transfer the defect data and then terminate the command with CHECK CONDITION status and the sense key shall be set to RECOVERED ERROR with the additional sense code set to DEFECT LIST NOT FOUND.

The READ DEFECT DATA(10) defect list (see Table 22) contains a four-byte header, followed by zero or more defect descriptors.

Table 22 – READ DEFECT DATA(10) defect list

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved			PLIST	GLIST	DEFECT LIST FORMAT		
2	(MSB)							
3	DEFECT LIST LENGTH							(LSB)
	DEFECT DESCRIPTOR(S) (if any)							
0	DEFECT DESCRIPTOR 0							
n	(See specific table for length.)							
	:							
0	DEFECT DESCRIPTOR *x*							
n	(See specific table for length.)							

A PLIST bit of zero indicates that the data returned does not contain the primary defect list. A PLIST bit of one indicates that the data returned contains the primary defect list.

A GLIST bit of zero indicates that the data returned does not contain the grown defect list. A GLIST bit of one indicates that the data returned contains the grown defect list.

The DEFECT LIST FORMAT field indicates the format of the defect descriptors returned by the device server. This field is defined in the FORMAT UNIT command (see 6.1.2.1).

NOTE 8 The use of the block format is not recommended. There is no standard model that defines the meaning of the logical block address of a defect. In the usual case, a defect that has been reassigned no longer has a logical block address.

Defect descriptors returned in the block format are vendor-specific. Defect descriptors returned in the physical sector format may or may not include defects in areas not accessible to the application client. Defect descriptors returned in bytes-from-index format shall comprise a complete list of the defects. A complete list of the defects may include defects in areas not within the capacity returned in the READ CAPACITY command.

The DEFECT LIST LENGTH field specifies the length in bytes of the defect descriptors that follow. The DEFECT LIST LENGTH is equal to four or eight times the number of the defect descriptors, depending on the format of the returned descriptors (see 6.1.2.1).

If the ALLOCATION LENGTH is insufficient to transfer all of the defect descriptors, the DEFECT LIST LENGTH shall not be adjusted to reflect the truncation and the device server shall not create a CHECK CONDITION status. The application client is responsible for comparing the DEFECT LIST LENGTH and the ALLOCATION LENGTH to determine that a partial list was received.

NOTE 9 The application client may determine the length of the defect list by sending the READ DEFECT DATA(10) command with an ALLOCATION LENGTH of four. The device server returns the defect list header that contains the length of the defect list.

The defect descriptors may or may not be sent in ascending order. The application client may determine the exact number of the defects by dividing the DEFECT LIST LENGTH by the length of a single defect descriptor for the returned format.

6.1.9 READ LONG command

The READ LONG command (see Table 23) requests that the device server transfer data to the application client. The data passed during the READ LONG command is vendor-specific, but shall include the data bytes and the ECC bytes recorded on the medium. The most recent data written, or to be written, in the addressed logical block shall be returned. READ LONG is independent of the read-write error recovery page but does allow retries.

Table 23 – READ LONG command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Eh)							
1	Reserved						CORRCT	RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Reserved							
7	(MSB)							
8				BYTE TRANSFER LENGTH				(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ LONG command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The READ LONG command shall be evaluated for extent reservation conflicts. READ LONG commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the READ LONG operation is prohibited by an extent reservation.

Any other bytes that can be corrected by ECC should be included (for example, data synchronization mark within the area covered by ECC). It is not required for the ECC bytes to be at the end of the data bytes. However, they should be in the same order as they are on the media.

A correct (CORRCT) bit of zero requests that a logical block be read without any correction made by the device server. A CORRCT bit of 0 should result with GOOD status unless data is not transferred for some reason other than that the data is non-correctable. In this case, the appropriate status and/or sense data shall be set. A CORRCT bit of one requests that the data be corrected by ECC before being transferred to the application client.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The BYTE TRANSFER LENGTH field species the number of bytes of data that should be transferred. If a non-zero BYTE TRANSFER LENGTH does not match the available data length, the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB. The valid and ILI bits (see *ISO/IEC 14776-311, SCSI-3 Primary Commands*) shall be set to one and the INFORMATION field shall be set to the difference (residue) of the requested length minus the actual length in bytes. Negative values shall be indicated by two's complement notation.

A BYTE TRANSFER LENGTH of zero indicates that no bytes shall be transferred and shall not be considered an error.

6.1.10 REASSIGN BLOCKS command

The REASSIGN BLOCKS command (see Table 24) requests the device server to reassign the defective logical blocks to another area on the medium set aside for this purpose. The device server should also record the location of the defective logical blocks to the grown defect list if such a list is supported. More than one physical or logical block may be relocated by each defect descriptor sent by the application client. This command does not alter the contents of the PLIST (see 6.1.2, FORMAT UNIT command).

Table 24 – REASSIGN BLOCKS command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (07h)							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a REASSIGN BLOCKS command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The REASSIGN BLOCKS command shall be evaluated for extent reservation conflicts. Any overlap in logical block addresses between the REASSIGN BLOCKS command and an extent reservation of any type shall be an extent reservation conflict. A REASSIGN BLOCKS command with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the REASSIGN BLOCKS operation is prohibited by an extent reservation.

The application client transfers a defect list that contains the logical block addresses to be reassigned. The device server shall reassign the physical medium used for each LOGICAL BLOCK ADDRESS in the list. The data contained in the logical blocks specified in the defect list may be altered, but the data in all other logical blocks on the medium shall be preserved.

NOTE 10 The effect of specifying a logical block to be reassigned that previously has been reassigned is to reassign the block again. Although not likely, over the life of the medium, a logical block may be assigned to multiple physical addresses until no more spare locations remain on the medium.

The REASSIGN BLOCKS defect list (see Table 25) contains a four-byte header followed by one or more defect descriptors. The length of each defect descriptor is four bytes.

Table 25 – REASSIGN BLOCKS defect list

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	(MSB)							
3	DEFECT LIST LENGTH							(LSB)
	DEFECT DESCRIPTOR(S)							
0	(MSB)							
3	DEFECT LOGICAL BLOCK ADDRESS							(LSB)
	:							
n-3	(MSB)							
n	DEFECT LOGICAL BLOCK ADDRESS							(LSB)

The DEFECT LIST LENGTH field specifies the total length in bytes of the defect descriptors that follow. The DEFECT LIST LENGTH is equal to four times the number of defect descriptors and does not include the defect list header length.

The defect descriptor specifies a four-byte defect logical block address that contains the defect. The defect descriptors shall be in ascending order.

If the block device has insufficient capacity to reassign all of the logical blocks specified in the defect descriptors, the command shall terminate with CHECK CONDITION status and the sense key shall be set to HARDWARE ERROR with the additional sense code set to NO DEFECT SPARE LOCATION AVAILABLE.

If the block device is unable to successfully complete a REASSIGN BLOCKS command, the command shall terminate with CHECK CONDITION status with the appropriate sense information. The logical block address of the first defect descriptor not reassigned shall be returned in the COMMAND-SPECIFIC INFORMATION field of the sense data. If information about the first defect descriptor not reassigned is not available, or if all the defects have been reassigned, this field shall be set to FFFFFFFFh.

If the REASSIGN BLOCKS command failed due to an unexpected unrecoverable read error that would cause the loss of data in a block not specified in the defect list, the logical block address of the unrecoverable block shall be returned in the INFORMATION field of the sense data and the valid bit shall be set to one.

NOTE 11 If the REASSIGN BLOCKS command returns CHECK CONDITION status and the sense data COMMAND-SPECIFIC INFORMATION field contains a valid logical block address, the application client should remove all defect descriptors from the defect list prior to the one returned in the COMMAND-SPECIFIC INFORMATION field. If the sense key is MEDIUM ERROR and the valid bit is one (the INFORMATION field contains the valid block address) the application client should insert that new defective logical block address into the defect list and reissue the REASSIGN BLOCKS command with the new defect list. Otherwise, the application client should perform any corrective action indicated by the sense data and then reissue the REASSIGN BLOCKS command with the new defect list.

6.1.11 REBUILD command

The REBUILD command (see Table 26) requests that the target write to the medium the XOR data generated from the specified source devices. The target, acting as a temporary initiator, issues READ commands to retrieve the specified data.

Table 26 – REBUILD command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (81h)							
1	Reserved			DPO	FUA	INTDATA	PORT CONTROL	
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	(MSB)							
7	REBUILD LENGTH							
8								
9								(LSB)
10	(MSB)							
11	PARAMETER LIST LENGTH							
12								
13								(LSB)
14	Reserved							
15	CONTROL							

For a definition of the DPO and FUA bits, see 6.1.6.

If the intermediate data (INTDATA) bit is zero, then intermediate data is not sent with the rebuild parameter list (see Table 28). If the bit is one, the rebuild parameter list includes intermediate data. The length of the intermediate data may be calculated by multiplying the REBUILD LENGTH by the block size. This data shall be treated as an additional source, and an XOR operation shall be performed with it and the data from the specified sources.

The PORT CONTROL field is defined in Table 27. If the PORT CONTROL field has a value of 01b and the target is not a multiple port device the command shall be terminated with a CHECK CONDITION status and the sense data shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB.

Table 27 – PORT CONTROL field

Value	Description
00b	The target transfers the data using the same port that received the command.
01b	The target transfers the data using a different port than the one that received the command.
10b	The target transfers the data using one port of the target's choice.
11b	The target transfers the data using one or more ports of the target's choice.

NOTE 12 The target that receives the REBUILD command is not one of the source devices. If only one source is specified, then an XOR operation does not occur. This case may occur in disk mirroring applications.

If the command terminates with CHECK CONDITION status the sense data shall contain the logical block address of the failed block with the lowest logical block address. All logical blocks affected by the command and having a logical block address lower than the one of the reported failing block shall have been rebuilt and written to the medium.

The LOGICAL BLOCK ADDRESS field specifies the starting logical block address where the target shall write the XOR result data on its own medium. The REBUILD LENGTH field specifies the number of blocks to be written to the medium. It also specifies the number of blocks that are read from each source.

The PARAMETER LIST LENGTH field specifies the length in bytes of the parameter list that shall be transferred from the initiator to the target. The REBUILD parameter data is described in Table 28.

Table 28 – REBUILD and REGENERATE parameter data

Byte \ Bit	7	6	5	4	3	2	1	0
0	NUMBER OF SOURCE DESCRIPTORS (X)							
1	Reserved							
2	(MSB)							
3	SOURCE DESCRIPTOR/PAD LENGTH							(LSB)
	SOURCE DESCRIPTOR(s) (if any)							
4 19	SOURCE DESCRIPTOR (first)							
	.							
	.							
	.							
16*x* + 12 16*x* + 3	SOURCE DESCRIPTOR (last)							
16*x* + 4	PAD, if any (LENGTH *y*)							
16*x*+*y*+3								
16*x*+*y*+4	(MSB)							
	INTERMEDIATE DATA, if any (LENGTH *z*)							
16*x*+*y*+*z*+3								(LSB)

The number of SOURCE DESCRIPTOR field indicates the number of SOURCE DESCRIPTORs in the parameter data.

The SOURCE DESCRIPTOR/PAD LENGTH specifies the sum of the lengths in bytes of all of the source descriptors and the PAD.

The SOURCE DESCRIPTORs identify the source device target identifiers and starting logical block addresses on the devices for the regenerate or rebuild operation. See Table 29 for the SOURCE DESCRIPTOR format.

Table 29 – SOURCE DESCRIPTOR format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
	SOURCE DEVICE ADDRESS							
7								(LSB)
8	(MSB)							
	Reserved							
11								(LSB)
12	(MSB)							
	SOURCE STARTING LOGICAL BLOCK ADDRESS							
15								(LSB)

The SOURCE DEVICE ADDRESS field specifies an *ISO/IEC 14776-411:1999. SCSI-3 Architecture Model* compliant target identifier of a device that is a data source.

The SOURCE STARTING LOGICAL BLOCK ADDRESS field indicates the starting logical block address to use when reading data from the source specified in the SOURCE DEVICE ADDRESS field.

The PAD field accommodates initiators that require the INTERMEDIATE DATA to be aligned on a particular memory boundary. The PAD field shall be ignored.

The INTERMEDIATE DATA field contains data that shall be used in the XOR operation with the data from the specified source devices. The length of the data is equal to the rebuild/regenerate length multiplied by the block size.

6.1.12 REGENERATE command

The REGENERATE command (see Table 30) requests that the target write to the buffer the XOR data generated from its own medium and the specified source devices. The target, acting as a temporary initiator, issues READ commands to retrieve the specified data.

Table 30 – REGENERATE command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (82h)							
1	Reserved			DPO	FUA	INTDATA	PORT CONTROL	
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	(MSB)							
7	REGENERATE LENGTH							
8								
9								(LSB)
10	(MSB)							
11	PARAMETER LIST LENGTH							
12								
13								(LSB)
14	Reserved							
15	CONTROL							

The resulting XOR data is retained in the target's buffer until it is retrieved by an XDREAD command with a starting LOGICAL BLOCK ADDRESS and TRANSFER LENGTH that match, or is a subset of, the LOGICAL BLOCK ADDRESS and REGENERATE LENGTH of this command.

See 6.1.6 for a definition of the DPO & FUA bits and 6.1.11 for a definition of the INTDATA and PORT CONTROL fields.

The LOGICAL BLOCK ADDRESS field specifies the starting logical block address for the target to read data from its own medium. This data is a source for the regenerate operation.

The REGENERATE LENGTH field indicates the length in logical blocks of the resulting XOR data. It also specifies the length in logical blocks that is transferred from each of the specified sources.

The parameter data for the REGENERATE command is defined in Table 28. The parameter data describes the other devices that are sources for the regenerate operation. The target receiving the REGENERATE command is implicitly a source and is not included in the parameter data.

6.1.13 SEEK(10) command

The SEEK(10) (see Table 31) command requests that the block device seek to the specified logical block address. This command is included for device types based on the MMC standard. This command allows the host to provide advanced notification that particular data may be requested in a subsequent command.

If the logical unit is reserved, a reservation conflict shall occur when a SEEK command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The SEEK command shall be evaluated for extent reservation conflicts as if it were a read operation. SEEK commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the SEEK operation is prohibited by an extent reservation.

Table 31 – SEEK(10) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Bh)							
1	Reserved							
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	CONTROL							

6.1.14 SET LIMITS(10) command

The SET LIMITS command (see Table 32) defines the range where subsequent linked commands may operate. A second SET LIMITS command shall not be linked to a chain of commands if a SET LIMITS command has already been issued in the chain. If a second SET LIMITS command within a linked list of commands is detected, the command shall be rejected with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition.

Table 32 – SET LIMITS(10) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (33h)							
1	Reserved						RDINH	WRINH
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	(MSB)			NUMBER OF BLOCKS				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a SET LIMITS command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The SET LIMITS command shall be evaluated for extent reservation conflicts. An overlap with an extent reservation of any type shall be detected as a reservation conflict. SET LIMITS commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the SET LIMITS operation is prohibited by an extent reservation.

A read inhibit (RDINH) bit of zero indicates that read operations within the range are not inhibited.

A RDINH bit of one indicates that read operations within the range shall be inhibited.

A write inhibit (WRINH) bit of zero indicates that write operations within the range are not inhibited. A write inhibit (WRINH) bit of one indicates that write operations within the range shall be inhibited.

The LOGICAL BLOCK ADDRESS field specifies the starting address for the range.

The NUMBER OF BLOCKS field specifies the number of logical blocks within the range. A number of blocks of zero indicates that the range shall extend to the last logical block on the block device.

Any attempt to access outside of the restricted range or any attempt to perform an inhibited operation within the restricted range shall cause the function to not be performed. The command shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition.

6.1.15 START STOP UNIT command

The START STOP UNIT command (see Table 34) requests that the device server enable or disable the block device for media access operations and controls certain power conditions.

Table 33 – START STOP UNIT command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (1Bh)							
1	Reserved							IMMED
2	Reserved							
3	Reserved							
4	POWER CONDITIONS				Reserved		LOEJ	START
5	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a START STOP UNIT command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The START STOP UNIT command shall be evaluated for extent reservation conflicts. Any extent reservation of any type shall be detected as a reservation conflict. START STOP UNIT commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if an extent reservation is active for the logical unit.

An immediate (IMMED) bit of zero indicates that status shall be returned after the operation is completed. An IMMED bit of one indicates that status shall be returned as soon as the command descriptor block has been validated.

The POWER CONDITIONS field requests the block device to be placed in the power condition defined in Table 34. If this field has a value other than 0h then the START and the LOEJ bits shall be ignored.

Table 34 – POWER CONDITIONS

Code	Description
0h	No change in power conditions or in the device that is controlling power conditions.
1h	Place device into the Active condition
2h	Place device into Idle condition
3h	Place device into Standby condition
4h	Reserved
5h	Place device into Sleep condition
6h	Reserved
7h	Transfer control of power conditions to block device
8h - 9h	Reserved
Ah	Force Idle Condition Timer to zero
Bh	Force Standby Condition Timer to zero
Ch - Fh	Reserved

There shall be no indication from the block device that it has entered the requested power condition. An application client may determine if a power condition is active by issuing a request sense command to the logical unit (see 5.1.4).

If the START STOP UNIT command is issued with the POWER CONDITIONS field set to 1h, 2h or 3h the block device shall

a) change power conditions only on receipt of another START STOP UNIT command or a RESET task management function or RESET SERVICE DELIVERY SUBSYSTEM,

b) suspend any Power Condition timers (see 7.1.3.6) that are active on receipt of the START STOP UNIT command until another START STOP UNIT command is received that returns control of the power condition to the block device or a RESET task management function or RESET SERVICE DELIVERY SUBSYSTEM occurs,

c) terminate any command received that requires more power than allowed by the START STOP UNIT command's most recent power condition setting with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to LOW POWER CONDITION ACTIVE.

If the START STOP UNIT command is issued with the POWER CONDITION field set to 5h the server shall

a) suspend any Power Condition timers that are active on receipt of the START STOP UNIT command until a WAKEUP task management function is received by the device server,

b) not respond to a task requests until a WAKEUP task management function is received by the device server.

On receipt of a WAKEUP task management function any previously active power condition timers shall be restored to those values indicated by the saved power condition mode page parameters. Before returning a function complete response the target shall place itself into a condition capable of receiving commands and task management functions and shall create a unit attention condition for all initiators. The sense key shall be set to UNIT ATTENTION and the additional sense code set to LOW POWER CONDITION ACTIVE.

If the START STOP UNIT command is issued with the POWER CONDITIONS field set Ah or Bh the block device shall

a) force the selected timer(s) to zero. Forcing the timer(s) to zero shall place the block device into the same power condition that would have occurred if the timer(s) would have timed out. After the timer(s) are set to zero control of the power conditions is returned to the block device,

b) terminate any START STOP UNIT command that selects a timer that is not supported by the block device or a timer that has been disabled with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB.

It is not an error to request that the block device be placed into a power condition that already exists.

In the Sleep condition the device server shall only respond to a WAKEUP task management function. When a target has multiple logical units attached it shall enter the Sleep condition only after all the logical units have been placed into a Sleep condition.

A load eject (LOEJ) bit of zero requests that no action be taken regarding loading or ejecting the medium. A LOEJ bit of one requests that the medium shall be unloaded if the START bit is zero. A LOEJ bit of one requests that the medium is to be loaded if the START bit is one.

A START bit of zero requests that the block device be stopped (media shall not be accessed by the application client). A START bit of one requests that the block device be made ready for use.

Block devices that contain cache memory shall implicitly perform a SYNCHRONIZE CACHE command for the entire medium prior to executing the STOP UNIT command.

6.1.16 SYNCHRONIZE CACHE command

The SYNCHRONIZE CACHE command (see Table 37) ensures that logical blocks in the cache memory, within the specified range, have their most recent data value recorded on the physical medium. If a more recent data value for a logical block within the specified range exists in the cache memory than on the physical medium, then the logical block from the cache memory shall be written to the physical medium. Logical blocks may not be removed from the cache memory as a result of the synchronize cache operation. The SYNCHRONIZE CACHE function is also required implicitly by other SCSI functions as defined in other clauses of this standard.

Table 35 – SYNCHRONIZE CACHE command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (35h)							
1	Reserved						IMMED	RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Reserved							
7	(MSB)			NUMBER OF BLOCKS				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a SYNCHRONIZE CACHE command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The SYNCHRONIZE CACHE command shall be evaluated for extent reservation conflicts as if it were a write operation. SYNCHRONIZE CACHE commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the SYNCHRONIZE CACHE operation is prohibited by an extent reservation.

An immediate (IMMED) bit of zero indicates that the status shall not be returned until the operation has been completed. An IMMED bit of one indicates that the device server shall return status as soon as the command descriptor block has been validated. If the IMMED bit is one and the device server does not support the IMMED bit, the command shall terminate with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The NUMBER OF BLOCKS field specifies the total number of contiguous logical blocks within the range. A number of blocks of zero indicates that all remaining logical blocks on the block device shall be within the range.

A logical block within the specified range that is not in cache memory is not considered an error.

6.1.17 VERIFY command

The VERIFY command (see Table 36) requests that the device server verify the data written on the medium.

Table 36 – VERIFY command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Fh)							
1	Reserved			DPO	Reserved	Reserved	BYTCHK	RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Reserved							
7	(MSB)							
8				VERIFICATION LENGTH				(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a VERIFY command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The VERIFY command shall be evaluated for extent reservation conflicts as if it were a read operation. VERIFY commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the VERIFY operation is prohibited by an extent reservation.

If the MODE SELECT command is implemented, and the verify error recovery parameters page is also implemented, then the current settings in that page specifies the verification error criteria. If the verify error recovery parameters page is not implemented, then the verification criteria is vendor-specific.

If the byte check (BYTCHK) bit is zero, a medium verification shall be performed with no data comparison. If the BYTCHK bit is one, a byte-by-byte comparison of data written on the medium and the data transferred from the application client shall be performed. If the comparison is unsuccessful for any reason, the device server shall return CHECK CONDITION status and the sense key shall be set to MISCOMPARE with the appropriate additional sense code for the condition.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The VERIFICATION LENGTH field specifies the number of contiguous logical blocks of data that shall be verified. A TRANSFER LENGTH of zero indicates that no logical blocks shall be verified. This condition shall not be considered as an error. Any other value indicates the number of logical blocks that shall be verified.

See 6.1.6 for a description of the cache control bit (DPO).

6.1.18 WRITE(6) command

The WRITE(6) command (see Table 37) requests that the device server write the data transferred by the application client to the medium.

Table 37 – WRITE(6) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (0Ah)							
1	Reserved			(MSB)				
2	LOGICAL BLOCK ADDRESS							
3								(LSB)
4	TRANSFER LENGTH							
5	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE(6) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE(6) command shall be evaluated for extent reservation conflicts. WRITE(6) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE(6) operation is prohibited by an extent reservation.

The cache control bits are not provided for this command. Block devices with cache memory may have values for the cache control bits that may affect the WRITE(6) command, however, no default value is defined by this standard. If explicit control is required, the WRITE(10) command should be used.

The LOGICAL BLOCK ADDRESS field specifies the logical block where the write operation shall begin.

The TRANSFER LENGTH field specifies the number of contiguous logical blocks of data to be transferred. A TRANSFER LENGTH of zero indirectly indicates that 256 logical blocks shall be transferred. Any other value directly indicates the number of logical blocks that shall be transferred.

6.1.19 WRITE(10) command

The WRITE(10) command (see Table 38) requests that the device server write the data transferred by the application client to the medium.

Table 38 – WRITE(10) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Ah)							
1	Reserved			DPO	FUA	Reserved	Reserved	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	(MSB)			TRANSFER LENGTH				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE(10) command shall be evaluated for extent reservation conflicts. WRITE(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE(10) operation is prohibited by an extent reservation.

See 6.1.6 for a definition of the cache control bits (DPO and FUA).

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH field specifies the number of contiguous logical blocks of data that shall be transferred. A TRANSFER LENGTH of zero indicates that no logical blocks shall be transferred. This condition shall not be considered an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

6.1.20 WRITE AND VERIFY command

The WRITE AND VERIFY command (see Table 39) requests that the device server write the data transferred from the application client to the medium and then verify that the data is correctly written. The data is only transferred once from the application client to the device server.

Table 39 – WRITE AND VERIFY command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Eh)							
1	Reserved			DPO	Reserved	Reserved	BYTCHK	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	(MSB)			TRANSFER LENGTH				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE AND VERIFY command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE AND VERIFY command shall be evaluated for extent reservation conflicts. WRITE AND VERIFY commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE AND VERIFY operation is prohibited by an extent reservation.

If the MODE SELECT command is implemented, and the verify error recovery page is also implemented (see 7.1.3.9), then the current settings in that page along with the AWRE bit from the read-write error recovery page specify the verification error criteria. If these pages are not implemented, then the verification criteria is vendor-specific.

A byte check (BYTCHK) bit of zero requests a medium verification to be performed with no data comparison. A BYTCHK bit of one requests a byte-by-byte comparison of data written on the medium and the data transferred from the application client. If the comparison is unsuccessful for any reason, the device server shall return CHECK CONDITION status with the sense key set to MISCOMPARE with the appropriate additional sense code for the condition.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

See WRITE(10) command (6.1.19) for a definition of the TRANSFER LENGTH field.

See 6.1.6 for a description of the cache control bit (DPO).

NOTE 13 The WRITE AND VERIFY command specifically states that the data are not to be transferred twice (i.e., once for the write pass, and once for the verify pass) when performing a byte compare. If there is a need for two transfers to occur (for example, to ensure the integrity of the path to the media), then the application client should issue a WRITE command with a LINK bit of one followed by a VERIFY command with a BYTCMP bit of one, transferring the same data on each command.

6.1.21 WRITE LONG command

The WRITE LONG command (see Table 40) requests that the device server write the data transferred by the application client to the medium. The data passed during the WRITE LONG command is implementation specific, but shall include the data bytes and the ECC bytes.

Table 40 – WRITE LONG command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Fh)							
1	Reserved							RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	TRANSFER LENGTH							(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE LONG command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE LONG command shall be evaluated for extent reservation conflicts. WRITE LONG commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE LONG operation is prohibited by an extent reservation.

NOTE 14 Any other bytes that can be corrected by ECC should be included (for example, a data synchronization mark within the area covered by ECC). The READ LONG command may be issued before issuing a WRITE LONG command. The WRITE LONG data should be the same length and in the same order as the data returned by the READ LONG command.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The BYTE TRANSFER LENGTH field should specify the number of bytes of data that the device server would return for the READ LONG command. If a non-zero BYTE TRANSFER LENGTH does not exactly match the data length the device server would return for the READ LONG command, then the device server shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB. The ILI and VALID bits shall be set to one and the INFORMATION field shall be set to the difference (residue) of the requested length minus the actual length in bytes. Negative values shall be indicated by two's complement notation. A TRANSFER LENGTH of zero indicates that no bytes shall be transferred and shall not be considered an error.

6.1.22 WRITE SAME command

The WRITE SAME command (see Table 41) requests that the device server write the single block of data transferred by the application client to the medium multiple times to consecutive multiple logical blocks.

Table 41 – WRITE SAME command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (41h)							
1	Reserved					PBDATA	LBDATA	RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	(MSB)	NUMBER OF BLOCKS						
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE SAME command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE SAME command shall be evaluated for extent reservation conflicts. WRITE SAME commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE SAME operation is prohibited by an extent reservation.

NOTE 15 This command may be useful if large areas of the medium need to be written, prepared for certification, or otherwise initialized without the application client having to transfer all the data.

A logical block data (LBDATA) bit of zero and a physical block data (PBDATA) bit of zero indicates that the single block of data transferred by the application client shall be used without modification. A LBDATA bit of one requests that the device server replace the first four bytes of the data to be written to the current logical block with the logical block address of the block currently being written.

A PBDATA bit of one requests that the device server replace the first eight bytes of the data to be written to the current physical sector with the physical address of the sector currently being written using the physical sector format (see 6.1.2.1).

If PBDATA and LBDATA are one the command shall be terminated with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the appropriate additional sense code for the condition.

See 6.1.3 for a definition of the RELADR bit and the LOGICAL BLOCK ADDRESS field.

The NUMBER OF BLOCKS field specifies the number of contiguous logical blocks to be written. A NUMBER OF BLOCKS field of zero requests that all the remaining logical blocks on the medium be written.

6.1.23 XDREAD command

The XDREAD command (see Table 42) requests that the target transfer to the initiator the XOR data generated by an XDWRITE or REGENERATE command.

Table 42 – XDREAD command

Bit / Byte	7	6	5	4	3	2	1	0
0								
1	Reserved							
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	(MSB)			TRANSFER LENGTH				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when an XDREAD command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The XDREAD command shall be evaluated for extent reservation conflicts. XDREAD commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the XDREAD operation is prohibited by an extent reservation.

The XOR data transferred is identified by the LOGICAL BLOCK ADDRESS and TRANSFER LENGTH. The LOGICAL BLOCK ADDRESS and TRANSFER LENGTH shall be the same as, or a subset of, those specified in a prior XDWRITE or REGENERATE command. If a match is not found the command is terminated with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB.

6.1.24 XDWRITE command

The XDWRITE command (see Table 43) requests that the target XOR the data transferred with the data on the medium. The resulting XOR data is stored by the target until it is retrieved by an XDREAD command.

Table 43 – XDWRITE command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (50h)							
1	Reserved	Reserved	Reserved	DPO	FUA	DISABLE WRITE	Reserved	
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	(MSB)			TRANSFER LENGTH				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when an XDWRITE command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The XDWRITE command shall be evaluated for extent reservation conflicts. XDWRITE commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the XDWRITE operation is prohibited by an extent reservation.

See 6.1.6 for a definition of the cache control bits (DPO and FUA).

A DISABLE WRITE bit of zero indicates that the data transferred from the initiator shall be written to the medium after the XOR operation is complete. A DISABLE WRITE bit of one indicates that the data shall not be written to the medium.

The LOGICAL BLOCK ADDRESS specifies the starting logical block address of the data on which an XOR operation shall be performed with the data from the medium.

The TRANSFER LENGTH field specifies the number of logical blocks that shall be transferred to the XDWRITE target and the number of logical blocks on which an XOR operation shall be performed with the data from the medium.

The resulting XOR data is retrieved by an XDREAD command with starting LOGICAL BLOCK ADDRESS and TRANSFER LENGTH fields that match, or is a subset of, the starting LOGICAL BLOCK ADDRESS and TRANSFER LENGTH of this command.

6.1.25 XDWRITE EXTENDED command

The XDWRITE EXTENDED command (see Table 44) requests that the target XOR the data transferred with the data on the medium. The resulting XOR data may subsequently be sent to a secondary device using an XPWRITE command.

Table 44 – XDWRITE EXTENDED command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (80h)							
1	TABLE ADDRESS	Reserved	Reserved	DPO	FUA	DISABLE WRITE	PORT CONTROL	
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	(MSB)							
7				SECONDARY LOGICAL BLOCK ADDRESS				
8								
9								(LSB)
10	(MSB)							
11				TRANSFER LENGTH				
12								
13								(LSB)
14	SECONDARY ADDRESS							
15	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when an XDWRITE EXTENDED command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The XDWRITE EXTENDED command shall be evaluated for extent reservation conflicts. XDWRITE EXTENDED commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the XDWRITE EXTENDED operation is prohibited by an extent reservation.

A TABLE ADDRESS bit of zero indicates that the SECONDARY ADDRESS field contains the target identifier of the target that will receive the XOR data transfer. The implied LUN of the secondary target shall be zero. If the transport protocol requires more than one byte for the target identifier and the TABLE ADDRESS bit is zero, the SECONDARY ADDRESS field specifies the least significant byte of the secondary target identifier. The upper bytes of the secondary target identifier shall be equal to the upper bytes of the target identifier of the XDWRITE EXTENDED target.

A TABLE ADDRESS bit of one indicates that the SECONDARY ADDRESS field contains a pointer to a look up table of *ISO/IEC 14776-411:1999, SCSI-3 Architecture Model* compliant target identifiers. The look up table is reserved for future definition.

See 6.1.6 for a definition of the DPO and FUA bits.

A DISABLE WRITE bit of zero indicates that the data transferred from the initiator shall be written to the medium after the XOR operation is complete. A DISABLE WRITE bit of one indicates that the data shall not be written to the medium.

See 6.1.11 for a definition of the PORT CONTROL field. If the PORT CONTROL field has a value of 01b and the target is not a multiple port device the command shall be terminated with a CHECK CONDITION status and the sense data shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB.

The TRANSFER LENGTH field specifies the number of logical blocks that shall be transferred to the XDWRITE EXTENDED target and to the XPWRITE target.

The XOR data transfer to the secondary target is performed using an XPWRITE command. The XPWRITE command shall be sent to the device specified in the SECONDARY ADDRESS field. The SECONDARY LOGICAL BLOCK ADDRESS field value shall be placed in the LOGICAL BLOCK ADDRESS field of the XPWRITE command. The TRANSFER LENGTH field value shall be placed in the TRANSFER LENGTH field of the XPWRITE command. The completion status of the XDWRITE EXTENDED command shall not be returned to the initiator until the completion status of the XPWRITE command has been received.

NOTE 16 The XOR data transfer to the secondary target may be broken into multiple XPWRITE commands. If this is done, the XDWRITE EXTENDED target calculates the logical block addresses and transfer lengths for the individual XPWRITE commands. Also, the completion status of the XDWRITE EXTENDED command is not returned to the initiator until the completion status of all XPWRITE commands have been received.

If the prior XPWRITE command terminates with a CHECK CONDITION status and the sense key is not set to RECOVERED ERROR the XDWRITE EXTENDED command shall return CHECK CONDITION status.

6.1.26 XPWRITE command

The XPWRITE command (see Table 45) requests that the target XOR the data transferred with the data on the medium and then write the XOR data to the medium.

Table 45 – XPWRITE command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (51h)							
1	Reserved			DPO	FUA	Reserved		
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	TRANSFER LENGTH							
8								
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when an XPWRITE command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The XPWRITE command shall be evaluated for extent reservation conflicts. XPWRITE commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the XPWRITE operation is prohibited by an extent reservation.

See 6.1.6 for a definition of the DPO and FUA bits.

The LOGICAL BLOCK ADDRESS field specifies the starting logical block address where the target shall read data from its medium. It also specifies the starting logical block address where the XOR result data shall be written to the medium.

The TRANSFER LENGTH field specifies the number of blocks that shall be read from the medium. It also specifies the number of blocks that shall be written to the medium.

6.2 Commands for optical memory block devices

6.2.0 General

The commands for optical memory block devices shall be as shown in Table 46.

Table 46 – Commands for optical memory block devices

Command name	Operation code	Type	Subclause
CHANGE DEFINITION	40h	O	*ISO/IEC 14776-311, SPC*
COMPARE	39h	O	*ISO/IEC 14776-311, SPC*
COPY	18h	O	*ISO/IEC 14776-311, SPC*
COPY AND VERIFY	3Ah	O	*ISO/IEC 14776-311, SPC*
ERASE(10)	2Ch	O	6.2.1
ERASE(12)	ACh	O	6.2.2
FORMAT UNIT	04h	O	6.1.2
INQUIRY	12h	M	*ISO/IEC 14776-311, SPC*
LOCK-UNLOCK CACHE	36h	O	6.1.3
LOG SELECT	4Ch	O	*ISO/IEC 14776-311, SPC*
LOG SENSE	4Dh	O	*ISO/IEC 14776-311, SPC*
MEDIUM SCAN	38h	O	6.2.3
MODE SELECT(6)	15h	O	*ISO/IEC 14776-311, SPC*
MODE SELECT(10)	55h	O	*ISO/IEC 14776-311, SPC*
MODE SENSE(6)	1Ah	O	*ISO/IEC 14776-311, SPC*
MODE SENSE(10)	5Ah	O	*ISO/IEC 14776-311, SPC*
MOVE MEDIUM	A5h	O	SMC
Obsolete	01h	OB	3.3.4
Obsolete	31h	OB	3.3.4
Obsolete	B1h	OB	3.3.4
Obsolete	30h	OB	3.3.4
Obsolete	B0h	OB	3.3.4
Obsolete	32h	OB	3.3.4
Obsolete	B2h	OB	3.3.4
Obsolete	0Bh	OB	3.3.4
PERSISTENT RESERVE IN	5Eh	O[1]	*ISO/IEC 14776-311, SPC*
PERSISTENT RESERVE OUT	5Fh	O[1]	*ISO/IEC 14776-311, SPC*
PRE-FETCH	34h	O	6.1.4
PREVENT-ALLOW MEDIUM REMOVAL	1Eh	O	*ISO/IEC 14776-311, SPC*
READ(6)	08h	O	6.1.5
READ(10)	28h	M	6.1.6
READ(12)	A8h	O	6.2.4
READ BUFFER	3Ch	O	*ISO/IEC 14776-311, SPC*
READ CAPACITY	25h	M	6.1.7
READ DEFECT DATA(10)	37h	O	6.1.8
READ DEFECT DATA(12)	B7h	O	6.2.5
READ ELEMENT STATUS	B8h	O	SMC
READ GENERATION	29h	O	6.2.6
READ LONG	3Eh	O	6.1.9
READ UPDATED BLOCK	2Dh	O	6.2.7
REASSIGN BLOCKS	07h	O	6.1.10
RECEIVE DIAGNOSTIC RESULTS	1Ch	O	*ISO/IEC 14776-311, SPC*
RELEASE(6)	17h	O[2]	*ISO/IEC 14776-311, SPC*

Table 46 *(continued)*

Command name	Operation code	Type	Subclause
RELEASE(10)	57h	M	*ISO/IEC 14776-311, SPC*
REQUEST SENSE	03h	M	*ISO/IEC 14776-311, SPC*
RESERVE(6)	16h	O[2]	*ISO/IEC 14776-311, SPC*
RESERVE(10)	56h	M	*ISO/IEC 14776-311, SPC*
SEEK(10)	2Bh	O	6.1.13
SEND DIAGNOSTIC	1Dh	M	*ISO/IEC 14776-311, SPC*
SET LIMITS(10)	33h	O	6.1.14
SET LIMITS(12)	B3h	O	6.2.8
START STOP UNIT	1Bh	O	6.1.15
SYNCHRONIZE CACHE	35h	O	6.1.16
TEST UNIT READY	00h	M	*ISO/IEC 14776-311, SPC*
UPDATE BLOCK	3Dh	O	6.2.9
VERIFY(10)	2Fh	O	6.2.10
VERIFY(12)	AFh	O	6.2.11
WRITE(6)	0Ah	O	6.1.18
WRITE(10)	2Ah	M	6.1.19
WRITE(12)	AAh	O	6.2.13
WRITE AND VERIFY(10)	2Eh	O	6.2.14
WRITE AND VERIFY(12)	AEh	O	6.2.15
WRITE BUFFER	3Bh	O	*ISO/IEC 14776-311, SPC*
WRITE LONG	3Fh	O	6.1.21
Key: M = Command implementation is mandatory. O = Command implementation is optional. OB = Obsolete SPC = SCSI-3 Primary Commands SMC = SCSI-3 Medium Changer Command Set			
NOTE 1 Optional PERSISTENT RESERVE Commands, if implemented, shall both be implemented as a group.			

The following codes are vendor-specific: 20h, 21h, 22h, 23h, and C0h through FFh. All remaining codes for optical memory block devices are reserved for future standardization.

6.2.1 ERASE(10) command

The ERASE(10) command (see Table 47) requests that the device server erase the specified number of blocks starting at the specified logical block address on the medium. As used here, erased means either the medium shall be erased, or a pattern shall be written on the medium that appears to the device server as no data present. The blocks erased shall be considered blank for purposes of blank checking (see 5.2). The previous data recorded on the medium, if any, shall not be recoverable.

Table 47 – ERASE(10) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Ch)							
1	Reserved					ERA	Reserved	RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	(MSB)	TRANSFER LENGTH						
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when an ERASE(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The ERASE(10) command shall be evaluated for extent reservation conflicts as if it were a write operation. ERASE(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the ERASE(10) operation is prohibited by an extent reservation.

An erase all (ERA) bit of one indicates that all remaining blocks on the medium shall be erased. If the ERA bit is one and if the number of blocks is not zero, the device server shall return CHECK CONDITION, and the sense key shall be set to ILLEGAL REQUEST, with an additional sense code of INVALID FIELD IN CDB.

See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH specifies the number of contiguous logical blocks that shall be erased when the ERA bit is zero. If the ERA bit is zero a TRANSFER LENGTH of zero indicates that no blocks shall be erased. This condition shall not be considered an error and no data shall be erased. Any other value indicates the number of logical blocks that shall be erased.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict exists and no data shall be erased.

NOTE 17 This command allows the user to separate the erase and write operations. This may increase system performance in certain applications.

6.2.2 ERASE(12) command

The ERASE(12) command (see Table 48) requests that the device server erase the specified number of blocks starting at the specified logical block address on the medium.

Table 48 – ERASE(12) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (ACh)							
1	Reserved					ERA	Reserved	RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	(MSB)							
7	TRANSFER LENGTH							
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a ERASE(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The ERASE(12) command shall be evaluated for extent reservation conflicts as if it were a write operation. ERASE(12) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the ERASE(12) operation is prohibited by an extent reservation.

See 6.2.1 for a description of the fields in this command.

6.2.3 MEDIUM SCAN command

The MEDIUM SCAN command (see Table 58) requests that the device server scan the medium for a contiguous set of written or blank logical blocks.

Table 49 – MEDIUM SCAN command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (38h)							
1	Reserved			WBS	ASA	RSD	PRA	RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	PARAMETER LIST LENGTH							
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a MEDIUM SCAN command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The MEDIUM SCAN command shall be evaluated for extent reservation conflicts as if it were a read operation. MEDIUM SCAN commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the MEDIUM SCAN operation is prohibited by an extent reservation.

A written block search (WBS) bit of zero indicates that the scan is for blank blocks. A WBS bit of one indicates that the scan is for written blocks.

An advanced scan algorithm (ASA) bit of zero indicates that the scan area is scanned in sequential order (as selected by the RSD bit). An ASA bit of one indicates to the device server that the written and blank areas within the scan area form contiguous extents (as opposed to scattered blocks). This indication is advisory to the device server.

NOTE 18 The purpose of the ASA bit is to allow the device server to use a more advanced algorithm (such as a binary search) to locate the requested blocks.

A reverse scan direction (RSD) bit of zero indicates the scan shall begin with the first logical block of the scan area. A RSD bit of one indicates the scan shall begin with the last logical block of the scan area.

A partial results acceptable (PRA) bit of zero indicates that the scan shall not be considered satisfied until a contiguous set of blocks is found within the scan area that is at least equal in size to the number of blocks requested, and meets the other criteria specified in the command descriptor block. A PRA bit of one indicates that the scan may be satisfied by a contiguous set of blocks within the scan area that is less than the number of blocks requested, and meets the other criteria specified in the command descriptor block.

See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

The PARAMETER LIST LENGTH specifies the length in bytes of the parameter list that shall be transferred during the data-out buffer transfer. A PARAMETER LIST LENGTH of zero indicates that the NUMBER OF BLOCKS REQUESTED field has a value of one, and the NUMBER OF BLOCKS TO SCAN field has a value of zero. This condition shall not be considered an error. The contents of the parameter list are specified in Table 50.

Table 50 – MEDIUM SCAN parameter list

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1								
2		NUMBER OF BLOCKS REQUESTED						
3								(LSB)
4	(MSB)							
5								
6		NUMBER OF BLOCKS TO SCAN						
7								(LSB)

A LINK BIT of zero indicates a non-linked command; if the scan is satisfied, the command shall be terminated with a CONDITION MET status. A REQUEST SENSE command may then be issued to determine the starting logical block address of the area that meets the request. If the scan is not satisfied and no error occurs, the command shall be terminated with GOOD status.

A LINK BIT of one indicates that a command is linked to the MEDIUM SCAN command; if the search is satisfied, CONDITION MET status is returned and the next command is executed. If the RELADR bit in the next command is one, the LOGICAL BLOCK ADDRESS of the next command is used as a displacement from the logical block address where the search was satisfied. If a linked scan is not satisfied, the command is terminated with a CHECK CONDITION status. A REQUEST SENSE command may then be issued.

A REQUEST SENSE command following a satisfied MEDIUM SCAN command shall

a) return a sense key of EQUAL if the scan was satisfied by a contiguous set of blocks equal in size to the number of blocks requested. If the PRA bit is one and the scan was satisfied by a contiguous set of blocks less than the number of blocks requested, then a sense key of NO SENSE shall be returned,
b) return the valid bit set to one,
c) return the logical block address of the first logical block of the contiguous set of blocks that satisfied the scan criteria in the information bytes,
d) return the number of contiguous logical blocks meeting the scan criteria in the command specific information bytes.

A REQUEST SENSE command following an unsatisfied MEDIUM SCAN command shall

e) return a sense key of NO SENSE if no errors occurred during the command execution,
f) return the VALID bit set to zero.

The NUMBER OF BLOCKS REQUESTED field specifies the number of blocks that meet the specified requirements. The NUMBER OF BLOCKS REQUESTED field, if zero, indicates that the scan shall not take place. This shall not be considered an error condition.

The NUMBER OF BLOCKS TO SCAN field specifies the length in blocks of the area to be scanned on the medium. The NUMBER OF BLOCKS TO SCAN field, if zero, indicates that the scan shall continue for all remaining blocks on the medium or until the scan is satisfied. See 5.2.2 for a description of error reporting.

6.2.4 READ(12) command

The READ(12) command (see Table 51) requests that the device server transfer data to the application client from the medium. See 6.1.6 for a complete description of the fields in this command.

Table 51 – READ(12) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (A8h)							
1	Reserved			DPO	FUA	Reserved		RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	(MSB)							
7				TRANSFER LENGTH				
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The READ(12) command shall be evaluated for extent reservation conflicts. READ(12) commands with a reservation conflict shall be terminated with CHECK CONDITION and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the READ(12) operation is prohibited by an extent reservation.

6.2.5 READ DEFECT DATA(12) command

The READ DEFECT DATA(12) command (see Table 52) requests that the device server transfer the medium defect data to the application client. See 6.1.8 for a description of the fields in this command.

Table 52 – READ DEFECT DATA(12) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (B7h)							
1	Reserved			PLIST	GLIST	DEFECT LIST FORMAT		
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	(MSB)							
7				ALLOCATION LENGTH				
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ DEFECT DATA(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. READ DEFECT DATA(12) commands with a reservation conflict shall be terminated with RESERVATION CONFLICT status. The READ DEFECT DATA(12) command shall not be evaluated for extent reservation conflicts (for example, extent reservations do not conflict with the READ DEFECT DATA(12) command).

The READ DEFECT DATA(12) list header (see Table 53) contains an eight byte header, followed by zero or more defect descriptors.

Table 53 – READ DEFECT DATA(12) list header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved			PLIST	GLIST	DEFECT LIST FORMAT		
2	Reserved							
3	Reserved							
4	(MSB)							
5				DEFECT LIST LENGTH				
6								
7								(LSB)
DEFECT DESCRIPTORS								
0								
n								

See the description of the READ DEFECT DATA defect list (see 6.1.2.1) for a description of the fields in this header.

6.2.6 READ GENERATION command

The READ GENERATION command (see Table 54) requests that the device server transfer to the application client the maximum generation address for the logical block specified.

Table 54 – READ GENERATION command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (29h)							
1	Reserved							RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	ALLOCATION LENGTH							
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ GENERATION command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The READ GENERATION command shall be evaluated for extent reservation conflicts. READ GENERATION commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the READ GENERATION operation is prohibited by an extent reservation.

See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

The READ GENERATION data is defined in Table 55.

Table 55 – Maximum generation data block

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	MAXIMUM GENERATION ADDRESS							(LSB)
2	Reserved							
3	Reserved							

The MAXIMUM GENERATION ADDRESS field defines the maximum generation address available for the LOGICAL BLOCK ADDRESS specified.

6.2.7 READ UPDATED BLOCK(10) command

The READ UPDATED BLOCK(10) command (see Table 56) requests that the device server transfer data to the application client from the specified generation and logical block.

Table 56 – READ UPDATED BLOCK(10) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Dh)							
1	Reserved			DPO	FUA	Reserved		RELADR
2	(MSB)							
3								
4				LOGICAL BLOCK ADDRESS				
5								(LSB)
6	Latest	(MSB)						
7		GENERATION ADDRESS						(LSB)
8	Reserved							
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a READ UPDATED BLOCK(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The READ UPDATED BLOCK(10) command shall be evaluated for extent reservation conflicts. READ UPDATED BLOCK(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the READ UPDATED BLOCK(10) operation is prohibited by an extent reservation.

See 6.1.6 for a description of the cache control bits (DPO and FUA).

See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

One block of data is transferred during the data-in buffer transfer.

The LATEST bit determines the meaning of the GENERATION ADDRESS field. A LATEST bit of zero indicates that the GENERATION ADDRESS is specified relative to the first generation of the block; GENERATION ADDRESS zero specifies the first generation. Increasing generation addresses specify later generations.

A LATEST bit of one indicates that the GENERATION ADDRESS is specified relative to the latest generation of the block; GENERATION ADDRESS zero specifies the most recent generation. Increasing generation addresses specify earlier generations.

If the requested generation does not exist, the command shall be terminated with CHECK CONDITION status and the sense key shall be set to BLANK CHECK with the additional sense code set to GENERATION DOES NOT EXIST.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict exists and no data shall be transferred.

6.2.8 SET LIMITS(12) command

The SET LIMITS(12) command (see Table 57) defines the range where subsequent linked commands may operate. See 6.1.14 for a description of the fields in this command.

Table 57 – SET LIMITS(12) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (B3h)							
1	Reserved						RDLNH	WRINH
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	(MSB)							
7				NUMBER OF BLOCKS				
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a SET LIMITS(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The SET LIMITS(12) command shall be evaluated for extent reservation conflicts. An overlap with an extent reservation of any type shall be detected as a reservation conflict. SET LIMITS(12) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the SET LIMITS(12) operation is prohibited by an extent reservation.

6.2.9 UPDATE BLOCK command

The UPDATE BLOCK command (see Table 58) requests that the device server logically replace data on the medium with the data sent during the data-out buffer transfer.

Table 58 – UPDATE BLOCK command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Dh)							
1	Reserved							RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when an UPDATE BLOCK command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The UPDATE BLOCK command shall be evaluated for extent reservation conflicts as if it were a write operation. UPDATE BLOCK commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the UPDATE BLOCK operation is prohibited by an extent reservation.

See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

One block of data is transferred during the data-out buffer transfer.

NOTE 19 See 7.1.4.3 for a description of the behavior of the UPDATE BLOCK command relative to the enable blank check (EBC) bit.

This standard does not define the result of a WRITE command issued to a block previously updated by an UPDATE BLOCK command when blank checking is disabled. It is recommended that the device server inhibit this behavior.

A logical block may be updated until the alternate block area is exhausted. The alternate blocks used for the update operation shall not be reported in the READ CAPACITY data. If the alternate block area is exhausted, the command shall be terminated with CHECK CONDITION, the sense key shall be set to MEDIUM ERROR and the additional sense code set to NO DEFECT SPARE LOCATION AVAILABLE.

If the report updated block read (RUBR) bit specifies posting of recovered errors for a read operation of a logical block that has had a successful update operation performed, and a recovered error occurs, the command shall terminate with a CHECK CONDITION status and the sense key shall be set to RECOVERED ERROR with the additional sense code set to UPDATED BLOCK READ. See 7.1.4.4 for a description of the RUBR bit.

6.2.10 VERIFY(10) command

The VERIFY command (see Table 59) requests that the device server verify the data on the medium.

Table 59 – VERIFY command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Fh)							
1	Reserved			DPO	Reserved	BLKVFY	BYTCHK	RELADR
2	(MSB)							
3	LOGICAL BLOCK ADDRESS							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	VERIFICATION LENGTH							(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a VERIFY(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The VERIFY(10) command shall be evaluated for extent reservation conflicts as if it were a read operation. VERIFY(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the VERIFY(10) operation is prohibited by an extent reservation.

If the MODE SELECT command is implemented, and the verify error recovery parameters page is also implemented, then the current settings in that page define the verification criteria. If the verify error recovery parameters page is not implemented, then the verification criteria is vendor-specific.

A byte check (BYTCHK) bit of zero causes a medium verification to be performed with no data comparison. A BYTCHK bit of one causes a byte-by-byte compare of the data written on the medium and the data transferred from the application client. The data shall be transferred as it would be for a WRITE command. If the compare is unsuccessful, for any reason, the device server shall return CHECK CONDITION status and the sense key shall be set to MISCOMPARE with the appropriate additional sense code for the condition.

A blank verify (BLKVFY) bit of zero indicates that it is not requested to verify that the blocks are blank. A blank verify (BLKVFY) bit of one causes a verification that the blocks are blank.

If the BYTCHK is one and the BLKVFY bit is one the device server shall return CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN CDB.

See 6.1.6 for a description of the cache control bit (DPO). See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

The VERIFICATION LENGTH specifies the number of contiguous logical blocks of data or blanks that shall be verified. A VERIFICATION LENGTH of zero indicates that no logical blocks shall be verified. This condition shall not be considered as an error. Any other value indicates the number of logical blocks that shall be verified.

6.2.11 VERIFY(12) command

The VERIFY(12) command (see Table 60) requests that the device server verify the data on the medium. See 6.2.10 for a description of the fields in this command.

Table 60 – VERIFY(12) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (AFh)							
1	Reserved			DPO	Reserved	BLKVFY	BYTCHK	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	(MSB)							
7				VERIFICATION LENGTH				
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a VERIFY(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The VERIFY(12) command shall be evaluated for extent reservation conflicts as if it were a read operation. VERIFY(12) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the VERIFY(12) operation is prohibited by an extent reservation.

6.2.12 WRITE(10) command

Table 61 – WRITE(10) command

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Ah)							
1	Reserved			DPO	FUA	EBP	Reserved	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	(MSB)			TRANSFER LENGTH				
8								(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE(10) command is received from an initiator other than the one holding a logical unit reservation (see Table 61). The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE(10) command shall be evaluated for extent reservation conflicts. WRITE(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE(10) operation is prohibited by an extent reservation.

An erase by-pass (EBP) bit of zero indicates that the block device shall default to the normal write operation. An EBP bit of one indicates that the device server is allowed to by-pass the erase operation prior to writing the data. When accessing write-once media and for direct-access block devices, the EBP bit shall be considered reserved.

See 6.1.6 for a description of the cache control bits (DPO and FUA). See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH specifies the number of contiguous logical blocks of data that shall be transferred. A TRANSFER LENGTH of zero indicates that no data shall be transferred. This condition shall not be considered an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict exists and no data shall be written.

6.2.13 WRITE(12) command

The WRITE(12) command (see Table 62) requests that the device server write the data transferred from the application client to the medium. See 6.1.19 for a description of the fields in this command.

Table 62 – WRITE(12) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (AAh)							
1	Reserved			DPO	FUA	EBP	Reserved	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	(MSB)							
7				TRANSFER LENGTH				
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE(12) command shall be evaluated for extent reservation conflicts. WRITE(12) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE(12) operation is prohibited by an extent reservation.

6.2.14 WRITE AND VERIFY(10) command

The WRITE AND VERIFY(10) command (see Table 63) requests that the device server write the data transferred from the application client to the medium and then verify that the data is correctly written.

Table 63 – WRITE AND VERIFY(10) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (2Eh)							
1	Reserved			DPO	Reserved	EBP	BYTCHK	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8				TRANSFER LENGTH				(LSB)
9	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE AND VERIFY(10) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE AND VERIFY(10) command shall be evaluated for extent reservation conflicts. WRITE AND VERIFY(10) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE AND VERIFY(10) operation is prohibited by an extent reservation.

If the MODE SELECT command is implemented, and the verify error recovery parameters page is also implemented, then the current settings in that page define the verification criteria. If the verify error recovery parameters page is not implemented, then the verification criteria is vendor-specific.

A byte check (BYTCHK) bit of zero causes a medium verification to be performed with no data comparison. A BYTCHK bit of one causes a byte-by-byte comparison of the data written on the medium and the data transferred from the application client. The data shall be transferred as it would be for a WRITE command. If the compare is unsuccessful for any reason, the device server shall return CHECK CONDITION status and the sense key shall be set to MISCOMPARE with the appropriate additional sense code for the condition.

An erase by-pass (EBP) bit of zero indicates that the block device shall default to the normal write operation. An EBP bit of one indicates that the device server is allowed to by-pass the erase operation prior to writing the data. When accessing write-once media, the EBP bit shall be considered reserved.

See 6.1.6 for a description of the cache control bit (DPO). See 6.1.3 for a description of the RELADR bit and LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH specifies the number of contiguous logical blocks of data that shall be transferred. A TRANSFER LENGTH of zero indicates that no logical blocks shall be transferred. This condition shall not be considered as an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

6.2.15 WRITE AND VERIFY(12) command

The WRITE AND VERIFY(12) command (see Table 64) requests that the device server write the data transferred from the application client to the medium and then verify that the data is correctly written. See 6.2.14 for a description of the bits in this command.

Table 64 – WRITE AND VERIFY(12) command

Bit Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (AEh)							
1	Reserved			DPO	Reserved	EBP	BYTCHK	RELADR
2	(MSB)							
3				LOGICAL BLOCK ADDRESS				
4								
5								(LSB)
6	(MSB)							
7				TRANSFER LENGTH				
8								
9								(LSB)
10	Reserved							
11	CONTROL							

If the logical unit is reserved, a reservation conflict shall occur when a WRITE AND VERIFY(12) command is received from an initiator other than the one holding a logical unit reservation. The command shall be rejected with RESERVATION CONFLICT status if the reservation conflict is due to a logical unit reservation. The WRITE AND VERIFY(12) command shall be evaluated for extent reservation conflicts. WRITE AND VERIFY(12) commands with a reservation conflict shall be terminated with CHECK CONDITION status and the sense key shall be set to DATA PROTECT with the appropriate additional sense code for the condition if any part of the WRITE AND VERIFY(12) operation is prohibited by an extent reservation.

6.3 Commands for write-once block devices

The commands for write-once block devices shall be as shown in Table 65.

Table 65 – Commands for write-once block devices

Command name	Operation code	Type	Subclause
CHANGE DEFINITION	40h	O	*ISO/IEC 14776-311, SPC*
COMPARE	39h	O	*ISO/IEC 14776-311, SPC*
COPY	18h	O	*ISO/IEC 14776-311, SPC*
COPY AND VERIFY	3Ah	O	*ISO/IEC 14776-311, SPC*
INQUIRY	12h	M	*ISO/IEC 14776-311, SPC*
LOCK-UNLOCK CACHE	36h	O	6.1.3
LOG SELECT	4Ch	O	*ISO/IEC 14776-311, SPC*
LOG SENSE	4Dh	O	*ISO/IEC 14776-311, SPC*
MEDIUM SCAN	38h	O	6.2.3
MODE SELECT(6)	15h	O	*ISO/IEC 14776-311, SPC*
MODE SELECT(10)	55h	O	*ISO/IEC 14776-311, SPC*
MODE SENSE(6)	1Ah	O	*ISO/IEC 14776-311, SPC*
MODE SENSE(10)	5Ah	O	*ISO/IEC 14776-311, SPC*
MOVE MEDIUM	A5h	O	SMC
Obsolete	01h	OB	3.3.4
Obsolete	31h	OB	3.3.4
Obsolete	B1h	OB	3.3.4
Obsolete	30h	OB	3.3.4
Obsolete	B0h	OB	3.3.4
Obsolete	32h	OB	3.3.4
Obsolete	B2h	OB	3.3.4
Obsolete	0Bh	OB	3.3.4
PERSISTENT RESERVE IN	5Eh	O[1]	*ISO/IEC 14776-311, SPC*
PERSISTENT RESERVE OUT	5Fh	O[1]	*ISO/IEC 14776-311, SPC*
PRE-FETCH	34h	O	6.1.4
PREVENT-ALLOW MEDIUM REMOVAL	1Eh	O	*ISO/IEC 14776-311, SPC*
READ(6)	08h	O	6.1.5
READ(10)	28h	M	6.1.6
READ(12)	A8h	O	6.2.4
READ BUFFER	3Ch	O	*ISO/IEC 14776-311, SPC*
READ CAPACITY	25h	M	6.1.7
READ ELEMENT STATUS	B8h	O	SMC
READ LONG	3Eh	O	6.1.9
REASSIGN BLOCKS	07h	O	6.1.10
RECEIVE DIAGNOSTIC RESULTS	1Ch	O	*ISO/IEC 14776-311, SPC*
RELEASE(6)	17h	O[2]	*ISO/IEC 14776-311, SPC*
RELEASE(10)	57h	M	*ISO/IEC 14776-311, SPC*
REQUEST SENSE	03h	M	*ISO/IEC 14776-311, SPC*
RESERVE(6)	16h	O[2]	*ISO/IEC 14776-311, SPC*
RESERVE(10)	56h	M	*ISO/IEC 14776-311, SPC*
SEEK(10)	2Bh	O	6.1.13
SEND DIAGNOSTIC	1Dh	M	*ISO/IEC 14776-311, SPC*
SET LIMITS	33h	O	6.1.14

Table 65 *(continued)*

Command name	Operation code	Type	Subclause
CHANGE DEFINITION	40h	O	*ISO/IEC 14776-311, SPC*
SET LIMITS (12)	B3h	O	6.2.8
START STOP UNIT	1Bh	O	6.1.15
SYNCHRONIZE CACHE	35h	O	6.1.16
TEST UNIT READY	00h	M	*ISO/IEC 14776-311, SPC*
VERIFY (10)	2Fh	O	6.2.10
VERIFY (12)	AFh	O	6.2.11
WRITE(6)	0Ah	O	6.1.18
WRITE(10)	2Ah	M	6.2.10
WRITE(12)	AAh	O	6.2.13
WRITE AND VERIFY (10)	2Eh	O	6.2.14
WRITE AND VERIFY (12)	AEh	O	6.2.15
WRITE BUFFER	3Bh	O	*ISO/IEC 14776-311, SPC*
WRITE LONG	3Fh	O	6.1.21
Key: M = Command implementation is mandatory. O = Command implementation is optional. OB = Obsolete		SPC = SCSI-3 Primary Commands SMC = SCSI-3 Medium Changer Command Set	
NOTE 1 Optional PERSISTENT RESERVE commands, if implemented, shall both be implemented as a group. NOTE 2 Optional RELEASE(6) and RESERVE(6) commands, if implemented, shall both be implemented as a group.			

The following command codes are vendor-specific: 02h, 05h, 06h, 09h, 0Ch, 0Dh, 0Eh, 0Fh, 10h, 11h, 13h, 14h, 19h, 20h, 21h, 22h, 23h, 24h, 26h, 27h, 29h, and C0h through FFh. All remaining command codes for write once block devices are reserved for future standardization.

7 Parameters for block devices

7.1 Parameters for direct-access block devices

7.1.1 Diagnostic parameters

7.1.1.1 Diagnostic parameters overview

This subclause defines the descriptors and pages for diagnostic parameters used with direct-access block devices. The diagnostic page codes for direct-access block devices are defined in Table 66.

Table 66 – Diagnostic page codes

Page code	Description	Subclause
00h	Supported diagnostic pages	*ISO/IEC 14776-311, SPC*
40h	Translate address page – SEND DIAGNOSTIC	7.1.1.1
40h	Translate address page – RECEIVE DIAGNOSTIC	7.1.1.2
41h	Device status page – SEND DIAGNOSTIC	7.1.1.3
41h	Device status page – RECEIVE DIAGNOSTIC	7.1.1.4
01h - 3Fh	Reserved (for pages that apply to all device types)	*ISO/IEC 14776-311, SPC*
42h - 7Fh	Reserved (for this standard)	
80h - FFh	Vendor-specific pages	

7.1.1.2 Translate address page – SEND DIAGNOSTIC

The translate address page allows the application client to translate a logical block address, physical sector address or physical bytes from index address into any one of the other formats. The address to be translated is passed to the device server with the SEND DIAGNOSTIC command. The results are returned to the application client by the RECEIVE DIAGNOSTIC RESULTS command. The format of the translate address page SEND DIAGNOSTIC is shown in Table 67. The translated address is returned in the translate address page RECEIVE DIAGNOSTIC RESULTS (see Table 68).

Table 67 – Translate address page – SEND DIAGNOSTIC

Bit Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (40h)							
1	Reserved							
2	(MSB)							
3	PAGE LENGTH (000Ah)							(LSB)
4	Reserved					SUPPLIED FORMAT		
5	Reserved					TRANSLATE FORMAT		
6	ADDRESS TO TRANSLATE							
13								

The SUPPLIED FORMAT field specifies the format of ADDRESS TO TRANSLATE field. Valid values for this field are defined in the FORMAT UNIT command (see 6.1.2). If the device server does not support the requested format, it shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The TRANSLATE FORMAT field specifies the format the application client requests for the result of the address translation. Valid values for this field are defined in the FORMAT UNIT command (see 6.1.2). If the device server does not support the requested format it shall terminate the command with CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The ADDRESS TO TRANSLATE field contains a single address the application client is requesting the device server to translate. The format of this field depends on the value in the SUPPLIED FORMAT field. The formats are described in 6.1.2.1. If the logical block format is specified the block address shall be in the first four bytes of the field with the remaining bytes set to zero.

7.1.1.3 Translate address page – RECEIVE DIAGNOSTIC

The translate address page allows the application client to translate a logical block address, physical sector address or physical bytes from index address into any one of the other formats. The address to be translated is passed to the device server with the SEND DIAGNOSTIC command and the results are returned to the application client by the RECEIVE DIAGNOSTIC RESULTS command. The translated address is returned in the translate address page RECEIVE DIAGNOSTIC (see Table 68).

Table 68 – Translate address page – RECEIVE DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (40h)							
1	Reserved							
2	(MSB)							
3	PAGE LENGTH							(LSB)
4	Reserved					SUPPLIED FORMAT		
5	RAREA	ALTSEC	ALTTRK	Reserved		TRANSLATED FORMAT		
6	(MSB)							
	TRANSLATED ADDRESS 1							
13								(LSB)
	.							
n								
n + 7	TRANSLATED ADDRESS *x* (if required)							

The translate address page contains a four-byte page header that specifies the page code and length followed by two bytes that describe the translated address followed by zero or more translated address(es).

The PAGE LENGTH field contains the number of parameter bytes that follow.

The SUPPLIED FORMAT field contains the value from the SEND DIAGNOSTIC command SUPPLIED FORMAT field (see 7.1.1.2).

A reserved area (RAREA) bit of zero indicates that no part of the translated address falls within a reserved area of the medium. A RAREA bit of one indicates that all or part of the translated address falls within a reserved area of the medium (for example, speed tolerance gap, alternate sector, vendor reserved area, etc.). If the entire translated address falls within a reserved area, the device server may not return a translated address.

An alternate sector (ALTSEC) bit of zero indicates that no part of the translated address is located in an alternate sector of the medium or that the device server is unable to determine this information. An ALTSEC bit of one indicates that the translated address is physically located in an alternate sector of the medium. If the device server is unable to determine if all or part of the translated address is located in an alternate sector, it shall set this bit to zero.

An alternate track (ALTTRK) bit of zero indicates that no part of the translated address is located on an alternate track of the medium. An ALTTRK bit of one indicates that part or all of the translated address is located on an alternate track of the medium or the device server is unable to determine if all or part of the translated address is located on an alternate track.

The TRANSLATED FORMAT field contains the value from the SEND DIAGNOSTIC command TRANSLATE FORMAT field (see 7.1.1.2).

The TRANSLATED ADDRESS field contains the address(es) the device server translated from the address supplied by the application client in the SEND DIAGNOSTIC command. This field shall be in the format specified in the TRANSLATE FORMAT field. The different formats are described in 6.1.2.1. If the logical block format is specified, the block address shall be in the first four bytes of the field and the remaining bytes shall be set to zero.

If the returned data is in the logical block or physical sector format and the address to be translated covers more than one address after it has been translated (for example, accounting for speed tolerance or multiple physical sectors within a single logical block or multiple logical blocks within a single physical sector) the device server shall return all possible addresses that are contained in the area specified by the address to be translated.

If the returned data is in bytes from index format, the device server shall return a pair of translated values for each of the possible addresses that are contained in the area specified by the ADDRESS TO TRANSLATE field. Of the pair of translated values returned, the first indicates the starting location and the second the ending location of the area.

7.1.1.4 Device status page – SEND DIAGNOSTIC

The device status page allows the application client to query the device regarding operational status of the device. The format of the device status page SEND DIAGNOSTIC, is shown in Table 69. The device status information is returned in the device status page RECEIVE DIAGNOSTIC.

Table 69 – Device status page – SEND DIAGNOSTIC

Bit Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (41h)							
1	Reserved							
2	(MSB)							
3	PAGE LENGTH (0008h)							(LSB)
4								
7	Reserved							
8								
11	Reserved							

7.1.1.5 Device status page – RECEIVE DIAGNOSTIC

The device status page allows the application client to query the device regarding operational status of the device. The format of the device status page RECEIVE DIAGNOSTIC is shown in Table 70.

Table 70 – Device status page – RECEIVE DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (41h)							
1	Reserved							
2	(MSB)							
3	PAGE LENGTH (*n*-3)							(LSB)
4								
5	Reserved							
6	Reserved				SYNCHRONIZATION		RPL	
7	Reserved					SSIS	SSIE	SSSL
8								
47	Reserved							
	Vendor-specific							
48								
n	Reserved							

The SYNCHRONIZATION field is used to report whether or not the spindle has synchronized with the reference signal or to report that the synchronization is in progress. The definitions of values in this field are shown in Table 71.

Table 71 – SYNCHRONIZATION field

Status	Description
00b	Synchronization status reporting is not supported or the status is not determined.
01b	Spindle is synchronized with the reference signal.
10b	Spindle is not able to synchronize with the reference signal or no reference signal is present.
11b	Spindle is in process of synchronizing with the reference signal.

If the logical unit has not been selected as a master, master control or slave, or if the reporting of synchronous status is not supported, the synchronous status shall be set to 00b.

If no reference signal is being received but the logical unit is currently a master, slave or master control, the SYNCHRONIZATION field is set to 10b.

Once the reference signal is received, the logical unit shall begin its internal synchronization, attempting to match the device's spindle speed to the reference signal. During this time, the SYNCHRONIZATION field shall be set to 11b. The amount of time required to achieve synchronization is not defined by this standard.

If the logical unit is unable to synchronize to the reference signal, the logical unit shall set the SYNCHRONIZATION field to 10b. The sense key shall be set to UNIT ATTENTION, the additional sense code shall be set to RPL STATUS CHANGE.

Once the logical unit successfully synchronizes with the reference signal, if the synchronization signal is lost due to a loss of the reference signal or a malfunction, unit attention conditions shall be generated for all application clients and the SYNCHRONIZATION field shall be set to 10b. The sense key shall be set to UNIT ATTENTION. If the logical unit has successfully achieved synchronization and then loses synchronization while executing a task and no other error occurs, then the device server shall return CHECK CONDITION status and the sense key shall be set to RECOVERED ERROR if the logical unit is able to complete the task, or HARDWARE ERROR if the logical unit is unable to complete the task, with the appropriate additional sense code set to RPL STATUS CHANGE. The rotational position locking (RPL) field shall be returned as the current value found in the rigid disk geometry page (see Table 93).

An synchronous spindle invalid signal (SSIS) bit of zero indicates, no signal is present or a valid synchronization signal is being received. A ssis bit of one indicates that the synchronous spindle signal received by the device was invalid or not recognized by the device as a valid synchronization signal. An example of this event is the receipt of synchronous signals from multiple masters.

A synchronous spindle internal error (SSIE) bit of zero indicates no internal electronic failure has been detected by the device. A SSIE bit of one indicates that the synchronization spindle electronics has detected an internal failure and the spindle is not synchronized with the synchronization signal.

A synchronization spindle signal loss (SSSL) bit of zero indicates that a spindle synchronization signal is being received. A SSSL bit of one indicates that the device detects receiving no synchronization signal.

The above three synchronization status error reporting fields, SSIS, SSIE and SSSL, are used to indicate error conditions of a device set to master or slave spindle synchronization mode using the rigid disk geometry MODE SELECT page RPL field. A device not set as master or slave shall report zero in these fields.

7.1.2 Log parameters

7.1.2.0 General

This subclause defines the descriptors and pages for log parameters used with direct-access block devices. See *ISO/IEC 14776-311, SPC* for a detailed description of logging operations. The log page codes for direct-access block devices are defined in Table 72.

Table 72 – Log page codes

Page code	Description	Subclause
01h	Buffer overrun/under-run page	*ISO/IEC 14776-311, SPC*
03h	Error counter page (read) page	*ISO/IEC 14776-311, SPC*
04h	Error counter page (read reverse) page	*ISO/IEC 14776-311, SPC*
05h	Error counter page (verify) page	*ISO/IEC 14776-311, SPC*
02h	Error counter page (write) page	*ISO/IEC 14776-311, SPC*
07h	Last *n* error events page	*ISO/IEC 14776-311, SPC*
06h	Non-medium error page	*ISO/IEC 14776-311, SPC*
00h	Supported log pages	*ISO/IEC 14776-311, SPC*
08h	Format status page	7.1.2.1
09h - 2Fh	Reserved	
3Fh	Reserved	
30h - 3Eh	Vendor-specific pages	

7.1.2.1 Format status page

This page (PAGE CODE 08h) captures the state of the block device since the most recent successful FORMAT UNIT command was completed. Additionally, this page provides Defect Management information for the device server. Table 73 defines the parameter codes for the format status log page.

Table 73 – Format status log page

Parameter code	Description
0000h	Format DATA OUT
0001h	Grown defects during certification
0002h	Total blocks reallocated during format
0003h	Total new blocks reallocated
0004h	Power on minutes since format
0005h - 7FFFh	Reserved
8000h - FFFFh	Vendor-specific parameters

Event counts are returned as a result of the LOG SENSE command. LOG SELECT shall not pre-set (a value other than zero) for any of the event counts listed in Table 73. Attempts to change these event counts by issuing a LOG SELECT with these fields set to non-zero values is not considered an error and shall have no effect on the saved values.

All of the log parameters described above shall be reported as the value –1 (FFh in all bytes of the log parameter) if the most recent FORMAT UNIT command failed. Individual log parameters described above shall be reported as the value –1 if no such information is available.

The FORMAT DATA OUT field contains the entire data-out buffer transfer of the most recently successful FORMAT UNIT operation completed. This includes the DEFECT LIST HEADER (4 bytes), the INITIALIZATION PATTERN DESCRIPTOR(s) if any (variable number of bytes), and the DEFECT DESCRIPTOR(s) if any (variable number of bytes). Refer to 6.1.2.1 for details about these fields.

The GROWN DEFECTS DURING CERTIFICATION field is a count of the number of defects detected as a result of performing Certification during execution of a FORMAT UNIT command. This count reflects only those defects detected and replaced that were not already part of the PLIST or GLIST. If a Certification pass was not performed this field shall be returned with a zero value.

The TOTAL BLOCKS REALLOCATED DURING FORMAT field is a count of the total number of blocks that have been reallocated since the completion of the last successful FORMAT UNIT command.

The POWER ON MINUTES SINCE FORMAT field represents the unsigned number of usage minutes (power applied regardless of power state) that have elapsed since the most recently successful FORMAT UNIT command.

Upon receiving the FORMAT UNIT command, the device server should set all fields within the format status log page to reflect no such information being available. Only upon successful completion of the FORMAT UNIT command should the device server update the affected fields.

The target save disable (TSD) bit is always returned as 0 to indicate that the device server shall provide an implicit saving frequency.

NOTE 20 Removable media device servers may save log page information with the media in a vendor-specific manner and location.

7.1.3 Mode parameters

7.1.3.0 General

This subclause defines the descriptors and pages for mode parameters used with direct-access device types.

The mode parameter list, including the mode parameter header and mode block descriptor are described in *ISO/IEC 14776-311, SPC*.

The MEDIUM-TYPE CODE field is contained in the mode parameter header (*ISO/IEC 14776-311, SPC*). Table 74 defines this field for direct-access block devices.

Table 74 – Direct-access medium-type codes

Code value	Medium type			
00h	Default medium type (currently mounted medium type)			
01h	Flexible disk, single-sided; unspecified medium			
02h	Flexible disk, double-sided; unspecified medium			
	Flexible disks			
	Diameter mm (in)	Bit density Bits/radian	Track density /mm (/in)	Number of sides
05h	200 (8,0)	6 631	1,9 (48)	1
06h	200 (8.0)	6 631	1,9 (48)	2
09h	200 (8,0)	13 262	1,9 (48)	1
0Ah	200 (8,0)	13 262	1,9 (48)	2
0Dh	130 (5,25)	3 979	1,9 (48)	1
12h	130 (5,25)	7 958	1,9 (48)	2
16h	130 (5,25)	7 958	3,8 (96)	2
1Ah	130 (5,25)	13 262	3,8 (96)	2
1Eh	90 (3,5)	7 958	5,3 (135)	2
	Direct-access magnetic tapes			
	Width mm (in)	Density Tracks	Ft/mm (ft/in)	
40h	6,3 (0,25)	12	394 (10 000)	
44h	6,3 (0,25)	24	394 (10 000)	
Code values 80h – FFh are vendor-specific. All remaining code values are reserved.				

The DEVICE SPECIFIC PARAMETER field (see Table 75) is contained in the mode parameter header (see *ISO/IEC 14776-311, SPC*).

Table 75 – Device specific parameter

Bit	7	6	5	4	3	2	1	0
	WP	Reserved		DPOFUA	Reserved			

When used with the MODE SELECT command the write protect (WP) bit is not defined.

When used with the MODE SENSE command a WP bit of zero indicates that the medium is write enabled. A WP bit of one indicates that the medium is write protected.

When used with the MODE SELECT command, the DPOFUA bit is not used and the field is reserved.

When used with the MODE SENSE command, a DPOFUA bit of zero indicates that the device server does not support the DPO and FUA bits. When used with the MODE SENSE command, a DPOFUA bit of one indicates that the device server supports the DPO and FUA bits (see 6.1.6).

The DENSITY CODE field is contained in the mode parameter block descriptor (see *ISO/IEC 14776-311, SPC*). This field is reserved for direct-access block devices.

The mode page codes for direct-access block devices are shown in Table 76.

Table 76 – Mode page codes

Page code	Description	Subclause
08h	Caching page	7.1.3.1
02h	Disconnect-reconnect page	*ISO/IEC 14776-311, SPC*
05h	Flexible disk page	7.1.3.2
03h	Format device page	7.1.3.3
10h	XOR control mode page	7.1.3.10
1Ch	Informational exceptions control page	*ISO/IEC 14776-311, SPC*
0Bh	Medium types supported page	7.1.3.4
0Ch	Notch and partition page	7.1.3.5
09h	Peripheral device page	*ISO/IEC 14776-311, SPC*
0Dh	Power condition page	7.1.3.6
1Ah	Power condition page	*ISO/IEC 14776-311, SPC*
01h	Read-write error recovery page	7.1.3.7
04h	Rigid disk geometry page	7.1.3.8
07h	Verify error recovery page	7.1.3.9
06h	Reserved	
0Eh - 0Fh	Reserved	
11h - 1Bh	Reserved	
1Dh - 1Fh	Reserved	
00h	Vendor-specific (does not require page format)	
20h - 3Eh	Vendor-specific (page format required)	
3Fh	Return all pages (valid only for the MODE SENSE command)	

In some cases the mode pages do not apply to the entire logical unit (see the notch page 7.1.3.5).

7.1.3.1 Caching page

The caching parameters page (see Table 77) defines the parameters that affect the use of the cache.

Table 77 – Caching page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	PAGE CODE (08h)					
1	PAGE LENGTH (12h)							
2	IC	ABPF	CAP	DISC	SIZE	WCE	MF	RCD
3	DEMAND READ RETENTION PRIORITY				WRITE RETENTION PRIORITY			
4	(MSB)							
5	DISABLE PRE-FETCH TRANSFER LENGTH							(LSB)
6	(MSB)							
7	MINIMUM PRE-FETCH							(LSB)
8	(MSB)							
9	MAXIMUM PRE-FETCH							(LSB)
10	(MSB)							
11	MAXIMUM PRE-FETCH CEILING							(LSB)
12	FSW	LBCSS	DRA	VS	VS	Reserved		
13	NUMBER OF CACHE SEGMENTS							
14	(MSB)							
15	CACHE SEGMENT SIZE							(LSB)
16	Reserved							
17	(MSB)							
18	NON CACHE SEGMENT SIZE							
19								(LSB)

The parameters savable (PS) bit is only used with the MODE SENSE command. This bit is reserved with the MODE SELECT command. A PS bit of one indicates that the device server is capable of saving the page in a non-volatile vendor-specific location. If the PS is one in MODE SENSE data then the page shall be savable by issuing a MODE SELECT command with the SP bit of one.

The initiator control (IC) enable bit, when one, requests that the device server use the number of CACHE SEGMENTS or CACHE SEGMENT SIZE fields, dependent upon the Size bit, to control the caching algorithm rather than the device server's own adaptive algorithm.

The abort pre-fetch (ABPF) bit, when one, with the DRA bit equal to zero, requests that the device server abort the pre-fetch upon receipt of a new command. The ABPF bit of one takes precedence over the Minimum Pre-fetch bytes. When the ABPF bit is zero, with the DRA bit equal to zero, the termination of any active pre-fetch is dependent upon caching page bytes 4 through 11 and is operation and/or vendor-specific.

The caching analysis permitted (CAP) bit, when one, requests that the device server perform caching analysis during subsequent operations. When zero, CAP requests that caching analysis be disabled to reduce overhead time or to prevent nonpertinent operations from impacting tuning values.

The discontinuity (DISC) bit, when one, requests that the device server continue the pre-fetch across time discontinuities, such as across cylinders (or tracks in an embedded servo device), up to the limits of the buffer or segment space available for the pre-fetch. When zero, the DISC requests that pre-fetches be truncated (or wrapped) at time discontinuities.

The size enable (SIZE) bit, when one, indicates that the CACHE SEGMENT SIZE is to be used to control caching segmentation. When SIZE equals zero, the application client requests that the NUMBER OF CACHE SEGMENTS is to be used to control caching segmentation. Simultaneous use of both the number of segments and the segment size is vendor-specific.

A write cache enable (WCE) bit of zero specifies that the device server shall return GOOD status for a WRITE command after successfully writing all of the data to the medium. A WCE bit of one specifies that the device server may return GOOD status for a WRITE command after successfully receiving the data and prior to having successfully written it to the medium.

A multiplication factor (MF) bit of zero specifies that the device server shall interpret the MINIMUM and MAXIMUM PRE-FETCH fields in terms of the number of logical blocks for each of the respective types of pre-fetch. An MF bit of one specifies that the device server shall interpret the MINIMUM and MAXIMUM PRE-FETCH fields to be specified in terms of a scalar number that, when multiplied by the number of logical blocks to be transferred for the current command, yields the number of logical blocks for each of the respective types of pre-fetch.

A read cache disable (RCD) bit of zero specifies that the device server may return data requested by a READ command by accessing either the cache or media. An RCD bit of one specifies that the device server shall transfer all of the data requested by a READ command from the medium (i.e., data shall not be transferred from the cache).

The DEMAND READ RETENTION PRIORITY field (see Table 78) advises the device server the retention priority to assign for data read into the cache that has also been transferred from the logical unit to the application client.

Table 78 – Demand read retention priority and write retention priority

Value	Description
0h	Indicates the device server should not distinguish between retaining the indicated data and data placed into the cache memory by other means (for example, pre-fetch).
1h	Demand read retention priority: Data put into the cache via a READ command should be replaced sooner (has lower priority) than data placed into the cache by other means (for example, pre-fetch).
	Write retention priority: Data put into the cache during a WRITE or WRITE AND VERIFY command should be replaced sooner (has lower priority) than data placed into the cache by other means (for example, pre-fetch).
Fh	Demand read retention priority: Data put into the cache via a READ command should not be replaced if there is other data in the cache that was placed into the cache by other means (for example, pre-fetch) and it may be replaced (i.e., it is not locked).
	Write retention priority: Data put into the cache during a WRITE or WRITE AND VERIFY command should not be replaced if there is other data in the cache that was placed into the cache by other means (for example, pre-fetch) and it may be replaced (i.e., it is not locked).
2h - Eh	Reserved

The WRITE RETENTION PRIORITY field advises the device server *the retention priority* to assign for data written into the cache that has also been transferred from the cache memory to the medium.

An anticipatory pre-fetch occurs when data is placed in the cache that has not been requested. This may happen in conjunction with the reading of data that has been requested. All the following parameters give an indication to the device server how it should manage the cache based on the

last READ command. An anticipatory pre-fetch may occur based on other information. All the remaining caching parameters are only recommendations to the device server and should not cause a CHECK CONDITION to occur if the device server is not able to satisfy the request.

The DISABLE PRE-FETCH TRANSFER LENGTH field specifies the selective disabling of anticipatory pre-fetch on long transfer lengths. The value in this field is compared to the number of blocks requested by the current READ command. If the number of blocks is greater than the disable pre-fetch transfer length, then an anticipatory pre-fetch is not done for the command. Otherwise the device server should attempt an anticipatory pre-fetch. If the pre-fetch disable transfer length is zero, then all anticipatory pre-fetching is disabled for any request for data, including those for zero logical blocks.

The MINIMUM PRE-FETCH field indicates either a number of blocks or a scalar multiplier of the TRANSFER LENGTH, depending upon the setting of the MF bit. In either case, the resulting number of blocks is the number to pre-fetch regardless of the delays it might cause in executing subsequent commands.

The pre-fetching operation begins at the logical block immediately after the last logical block of the previous READ command. Pre-fetching shall always halt before exceeding the end of the media. Errors that occur during the pre-fetching operation shall not be reported to the application client unless the device server is unable to, as a result of the error, execute subsequent commands correctly. In this case, the error may be reported either immediately as an error for the current READ command, or as a deferred error, at the discretion of the device server and according to the rules for reporting deferred errors.

If the pre-fetch has read more than the amount of data indicated by the MINIMUM PRE-FETCH then pre-fetching should be terminated whenever another command is ready to execute. This consideration is ignored when the MINIMUM PRE-FETCH is equal to the MAXIMUM PRE-FETCH.

The MAXIMUM PRE-FETCH field indicates either a number of blocks or a scalar multiplier of the TRANSFER LENGTH, depending upon the setting of the MF bit. In either case, the resulting number of blocks is the number to pre-fetch if the pre-fetch does not delay executing subsequent commands.

The MAXIMUM PRE-FETCH field contains the maximum amount of data to pre-fetch into the cache as a result of one READ command. It is used in conjunction with the DISABLE PRE-FETCH TRANSFER LENGTH and MAXIMUM PRE-FETCH CEILING parameters to trade off pre-fetching new data with displacing old data already stored in the cache.

The MAXIMUM PRE-FETCH CEILING field specifies an upper limit on the number of logical blocks computed as the maximum pre-fetch. If this number of blocks is greater than the MAXIMUM PRE-FETCH, then the number of logical blocks to pre-fetch shall be truncated to the value stored in the MAXIMUM PRE-FETCH CEILING field.

NOTE 21 If the MF bit is one the MAXIMUM PRE-FETCH CEILING field is useful in limiting the amount of data to be pre-fetched.

The force sequential write (FSW) bit when one, indicates that multiple block writes are to be transferred over the SCSI bus and written to the media in an ascending, sequential, logical block order. When the FSW bit equals zero, the device server is allowed to reorder the sequence of writing addressed logical blocks in order to achieve a faster command completion.

The logical block cache segment size (LBCSS) bit, when one, indicates that the CACHE SEGMENT SIZE field units shall be interpreted as logical blocks. When the LBCSS bit equals zero the CACHE SEGMENT SIZE field units shall be interpreted as bytes. The LBCSS shall not impact the units of other fields.

The disable read-ahead (DRA) bit, when one, requests that the device server not read into the buffer any logical blocks beyond the addressed logical block(s). When the DRA bit equals zero, the device server may continue to read logical blocks into the buffer beyond the addressed logical block(s).

The vendor-specific (VS) bits may optionally be used for vendor-specific purposes.

The NUMBER OF CACHE SEGMENTS advises the device server how many segments the host requests that the cache be divided into.

The CACHE SEGMENT SIZE field indicates the requested segment size in bytes. This standard defines that the CACHE SEGMENT SIZE field is valid only when the SIZE bit is one.

If the NON CACHE BUFFER SIZE field is greater than zero, this field advises the device server how many bytes the application client requests that the device server allocate for a buffer function when all other cache segments are occupied by data to be retained. If the number is at least one, caching functions in the other segments need not be impacted by cache misses to perform the SCSI buffer function. The impact of the NON CACHE BUFFER SIZE equals 0 or the sum of this field plus the CACHE SEGMENT SIZE greater than the buffer size is vendor-specific.

7.1.3.2 Flexible disk page

The flexible disk page (see Table 79) contains parameters for control and reporting of flexible disk device parameters.

Table 79 – Flexible disk page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	PAGE CODE (05h)					
1	PAGE LENGTH in bytes (1Eh)							
2	(MSB)							
3	TRANSFER RATE							(LSB)
4	NUMBER OF HEADS							
5	SECTORS PER TRACK							
6	(MSB)							
7	DATA BYTES PER SECTOR							(LSB)
8	(MSB)							
9	NUMBER OF CYLINDERS							(LSB)
10	(MSB)							
11	STARTING CYLINDER-WRITE PRECOMPENSATION							(LSB)
12	(MSB)							
13	STARTING CYLINDER-REDUCED WRITE CURRENT							(LSB)
14	(MSB)							
15	DEVICE STEP RATE							(LSB)
16	DEVICE STEP PULSE WIDTH							
17	(MSB)							
18	HEAD SETTLE DELAY							(LSB)
19	MOTOR ON DELAY							
20	MOTOR OFF DELAY							
21	TRDY	SSN	MO	Reserved				
22	Reserved					SPC		
23	WRITE COMPENSATION							
24	HEAD LOAD DELAY							
25	HEAD UNLOAD DELAY							
26	PIN 34					PIN 2		
27	PIN 4					PIN 1		
28	(MSB)							
29	MEDIUM ROTATION RATE							(LSB)
30	Reserved							
31	Reserved							

The parameters savable (PS) bit is only used with the MODE SENSE command. This bit is reserved with the MODE SELECT command. A PS bit of one indicates that the device server is capable of saving the page in a non-volatile vendor-specific location.

NOTE 22 Table 79 defines parameters of flexible disk devices, but may be used for other logical units, if applicable.

The transfer rate indicates the data rate of the peripheral block device. See Table 80 for examples of common transfer rates.

Table 80 – Examples of transfer rates

Value	Transfer rate
00FAh	250 kbit/s transfer rate
012Ch	300 kbit/s transfer rate
01F4h	500 kbit/s transfer rate
03E8h	1 Mbit/s transfer rate
07D0h	2 Mbit/s transfer rate
1388h	5 Mbit/s transfer rate

The NUMBER OF HEADS field specifies the number of heads used for reading and writing data on the medium. Heads used exclusively for servo-information are excluded.

The SECTORS PER TRACK field specifies the number of sectors per revolution per head.

The DATA BYTES PER SECTOR field specifies the number of bytes of data per sector that an application client can read or write.

The NUMBER OF CYLINDERS field specifies the number of cylinders used for data storage.

The STARTING CYLINDER FOR WRITE PRECOMPENSATION field specifies the cylinder where write precompensation is to begin. Cylinders are numbered starting with zero. If the starting cylinder for write precompensation is equal to the value in the NUMBER OF CYLINDERS field, write precompensation shall be disabled by the device server.

The STARTING CYLINDER FOR REDUCED WRITE CURRENT field specifies cylinder where write current is reduced. Cylinders are numbered starting with zero. If the starting cylinder for reduced write current is equal to the value in the NUMBER OF CYLINDERS field, reduced write current shall be disabled by the device server.

The DEVICE STEP RATE field specifies the step rate in units of 100 µs. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*. A value of zero requests the device server to set its default value.

The DEVICE STEP PULSE WIDTH field specifies the width of the step pulse in microseconds. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*. A value of zero requests the device server to set its default value.

The HEAD SETTLE DELAY field specifies the head settle time in units of 100 µs. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*. A value of zero requests the device server to set its default value.

If a true ready signal is not available, the MOTOR ON DELAY field specifies in tenths of a second the time that the device server shall wait before attempting to access the medium after the motor on signal is asserted. If a true ready signal is available, the MOTOR ON DELAY field specifies in tenths of a second the time that the device server shall wait for device ready status before aborting an attempt to access the medium. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*.

The MOTOR OFF DELAY field specifies in tenths of a second the time that the device server shall wait before releasing the motor on signal after an idle condition exists. A value of FFh indicates that the motor on signal shall not be released. The START STOP UNIT command is not affected by this parameter. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*.

A true ready (TRDY) bit of one specifies that a signal is provided that indicates the medium is ready to be accessed.

A start sector number (SSN) bit of zero specifies that sectors are numbered starting with zero. A SSN bit of one specifies that sectors are numbered starting with one.

An motor on (MO) bit of zero indicates that pin 16 (motor on) shall be asserted. A MO bit of one specifies that pin 16 (motor on) shall remain released. This bit shall be set to one when using high capacity (192 tracks per inch) devices and their pre-formatted diskettes.

The step pulse per cylinder (SPPC) field is used to specify the number of additional step pulses required per cylinder. Non-zero values allow a device to read a diskette formatted on a device with a lower number of tracks per inch. For example, a value of one allows a 96 track-per-inch device to access tracks on a diskette that was formatted for 48 tracks per inch.

The WRITE COMPENSATION field is used to specify the amount of write compensation to be used starting at the cylinder specified in the STARTING CYLINDER FOR WRITE PRECOMPENSATION field. The correlation of any values used in this field to actual write precompensation time values is vendor-specific. If a zero is specified in this field, the device server shall use its default write precompensation value. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*.

The HEAD LOAD DELAY field specifies the head loading time in milliseconds. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*. A value of zero requests the device server to set its default value.

The HEAD UNLOAD DELAY field specifies the head unloading time in milliseconds. This value may be rounded as defined in *ISO/IEC 14776-311, SPC*. A value of zero requests the device server to set its default value.

The PIN 34 field defines the usage of pin 34 of the flexible disk device interface. The use of this pin varies among flexible disk vendors and flexible disk devices. The settings allow the application client to select how pin 34 shall be used by the flexible disk interface. See Table 81.

Table 81 – PIN 34 field

Bit 7 6 5 4	Description of pin 34 use
P 0 0 0	Open
P 0 0 1	Ready
P 0 1 0	Disk changed
NOTE 1 P is a polarity bit, where 0 is active low and 1 is active high. NOTE 2 All undefined values are reserved.	

The PIN 2 field definition is vendor specific.

The PIN 4 field defines the usage of pin 4 of the flexible disk device interface. The use of this pin varies among flexible disk device vendors and flexible disk devices. The settings allow the application client to specify how pin 4 shall be used by the flexible disk interface. See Table 82.

Table 82 – PIN 4 field

Bit 7 6 5 4	Description of pin 4 use
P 0 0 0	Open
P 0 0 1	In use
P 0 1 0	Eject
P 1 0 0	Head load
NOTE 1 P is a polarity bit, where 0 is active low and 1 is active high. NOTE 2 All undefined values are reserved.	

The PIN 1 field defines the usage of pin 1 of the flexible disk device interface. This use of this pin varies among flexible disk vendors and flexible disk devices. The settings allow the application client to specify how pin 1 shall be used by the flexible disk interface. See Table 83.

Table 83 – PIN 1 field

Bit 7 6 5 4	Description of pin 34 use
P 0 0 0	Open
P 0 0 1	Disk change reset
NOTE 1 P is a polarity bit, where 0 is active low and 1 is active high. NOTE 2 All undefined values are reserved.	

The MEDIUM ROTATION RATE field specifies the speed where the medium rotates. The unit of measure is rotations per minute (for example, 2 400 rpm). This field shall not be changed by a MODE SELECT command.

7.1.3.3 Format device page

The format device page (see Table 84) contains parameters that specify the medium format.

Table 84 – Format device page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	PAGE CODE (03h)					
1	PAGE LENGTH (16h)							
2	(MSB)	TRACKS PER ZONE						
3								(LSB)
4	(MSB)	ALTERNATE SECTORS PER ZONE						
5								(LSB)
6	(MSB)	ALTERNATE TRACKS PER ZONE						
7								(LSB)
8	(MSB)	ALTERNATE TRACKS PER LOGICAL UNIT						
9								(LSB)
10	(MSB)	SECTORS PER TRACK						
11								(LSB)
12	(MSB)	DATA BYTES PER PHYSICAL SECTOR						
13								(LSB)
14	(MSB)	INTERLEAVE						
15								(LSB)
16	(MSB)	TRACK SKEW FACTOR						
17								(LSB)
18	(MSB)	CYLINDER SKEW FACTOR						
19								(LSB)
20	SSEC	HSEC	RMB	SURF	Reserved			
21								
23	Reserved							

The parameters savable (PS) bit is only used with the MODE SENSE command. This bit is reserved with the MODE SELECT command. A PS bit of one indicates that the device server is capable of saving the page in a non-volatile vendor-specific location.

NOTE 23 If the application client changes any of the current physical parameters defined below, the device server may not be able to access the media until a subsequent FORMAT UNIT command has been successfully completed.

If the defect handling format parameters (TRACKS PER ZONE, ALTERNATE SECTORS PER ZONE, ALTERNATE TRACKS PER ZONE and ALTERNATE TRACKS PER LOGICAL UNIT) requested by the application client are not supported by the device server the device server may round these fields to acceptable values as described in *ISO/IEC 14776-311, SPC*.

The TRACKS PER ZONE field specifies the number of tracks per zone to use in dividing the capacity of the block device for the purpose of allocating alternate sectors. A value of zero means that one zone is defined for the entire block device. The last zone on the block device might not contain the same number of tracks as the previous zone(s).

The ALTERNATE SECTORS PER ZONE field specifies the number of sectors per zone the device server shall reserve for defect handling. The device server shall de-allocate these sectors from the application client addressable blocks during the FORMAT UNIT command. If the notch page is implemented and the ND bit of the notch page is one and the ACTIVE NOTCH field of the notch page is zero, then a value of zero indicates that no alternate sectors shall be reserved. Otherwise, a value of zero indicates that the number of alternate sectors is vendor specific.

The ALTERNATE TRACKS PER ZONE field specifies the number of tracks per zone the device server shall reserve for defect handling. The device server shall de-allocate these tracks from the application client addressable blocks during the FORMAT UNIT command. If the notch page is implemented and the ND bit of the notch page is one and the ACTIVE NOTCH field of the notch page is zero, then a value of zero indicates that no alternate tracks shall be reserved. Otherwise, a value of zero indicates that the number of alternate tracks is vendor specific.

The ALTERNATE TRACKS PER LOGICAL UNIT field specifies the number of tracks per logical unit the device server shall reserve for defect handling. The device server shall de-allocate these tracks from the application client addressable blocks during the FORMAT UNIT command. If the notch page is implemented and the ND bit of the notch page is one and the ACTIVE NOTCH field of the notch page is zero, then a value of zero indicates that no alternate tracks shall be reserved. Otherwise, a value of zero indicates that the number of alternate tracks is vendor-specific.

The SECTORS PER TRACK field specifies the number of physical sectors included within each track. This number includes any alternate sectors the device server may allocate. A value of zero in this field during MODE SELECT indicates that the device server shall define the number of sectors per track. For block devices with a variable number of sectors per track, the value in MODE SELECT shall be zero and the value reported in MODE SENSE for the number of sectors per track is vendor specific.

The DATA BYTES PER PHYSICAL SECTOR field specifies the number of data bytes per physical sector that the device server shall use. This value may be different from the logical block size reported in the MODE SELECT data. The device server shall return CHECK CONDITION status if it determines that the combination of this field and the SECTORS PER TRACK field exceed the capability of the medium. A value of zero indicates that the data bytes per physical sector is defined by the device server.

For MODE SENSE the INTERLEAVE field returns the same parameter that was used in the last completed format unit operation. The device server shall report this field as defined in the corresponding MODE SENSE command. For MODE SELECT this field shall be ignored. The INTERLEAVE field shall be marked non-changeable and application clients shall send the value returned in MODE SENSE.

The TRACK SKEW FACTOR field specifies the number of physical sectors between the last logical block of one track and the first logical block on the next sequential track of the same cylinder.

The CYLINDER SKEW FACTOR field specifies the number of physical sectors between the last logical block of one cylinder and the first logical block on the next sequential cylinder.

The SSEC bit of one indicates that the device server shall use soft sector formatting.

The HSEC bit of one indicates that the device server shall use hard sector formatting. The HSEC bit and the SSEC bit are mutually exclusive in MODE SELECT commands.

The combinations of sector formatting supported that are reported in response to a request for default values are defined in Table 85.