April 18, 1998

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Logo
for

John Lohmeyer
Chairperson, X3T10
Symbios Logic Inc.
1635 Aeroplaza Drive
Colorado Springs, Colorado 80916

Subject: Proposal for Enclosure Services Interface implementation

Dear Mr. Chairperson:

A broad class of SCSI device enclosures now provide significant internal
intelligence to monitor the state of the power supplies, fans, and external
switches as well as to set the state of reconfiguration circuits and indicators. In
the Small Form Factor committee definitions for single connector attachment
SCSI and Fibre Channel drives, these enclosure services can be accessed across
the SCA connector using SCSI commands. In other implementations, the
enclosure may actually provide a special target that performs these services. The
SCSI committee has requested that I contribute the text that would define these
capabilities in the SPC document. In addition, the SAF-TE specification has
been proposed as a mechanism for performing similar functions. After
consultation with the SAF-TE principals, Intel, Conner Peripherals, Adaptec,
and Mylex, revision 2 of X3T10/95-324 combines, extends, and refines the
definitions of both the SCSI ESI and the SAF-TE specifications in a single
document.

This document includes those changes decided upon at a meeting held in
Milpitas, CA on February 16, 1996.

Change bars denote the modifications made between revision 2.1 and 3.

Sincerely,

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Enclosure Services proposal

1 Description of Enclosure Services Interface and proposal:

1.1 Overview

Using SCSI-3 technologies, disk drives and other SCSI devices may reside in subsystem enclosures some distance from the host initiators. To maintain a single communication interface with the host computer, it is important that any status information in the subsystem enclosure be available through the same SCSI interface that provides communications with the SCSI devices inside the enclosure. In addition, indicators, locks, and displays on the subsystem must be managed by the host through the SCSI interface. Some enclosures may make this information available through special ports to the standard SCSI devices. An example of such a port is the Enclosure Service Interface defined for FC-AL SCA-2 devices by the Small Form Factor document SFF-8067. More sophisticated enclosures may actually create a special logical unit with its own or a shared target id that provides only enclosure services. The SAF-TE proposal by Intel and Conner Peripherals defined a series of bits that are appropriate for most enclosure services functions. This document uses those definitions and clarifies and expands them for more general cases.

1.2 Enclosure Services capabilities

Enclosure services can be implemented as a component of a standard SCSI device or as a separate LUN. The enclosure services commands are optional for any SCSI device. The enclosure services model and the accompanying commands are defined in SPC or a follow-on document to SPC. The commands used to transmit enclosure service information to or from the device are SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS. New diagnostic pages are defined to contain the transmitted and received information. A page code field is provided in RECEIVE DIAGNOSTIC RESULTS to explicitly request the desired enclosure status.

A set of functionality is made available to SCSI devices from the enclosure. This functionality may include an enclosure unique short status or a full set of enclosure information provided from a sophisticated enclosure management processor.

The enclosure services device model defines a very simple device that implements certain SCSI-3 primary commands and that transmits and receives enclosure services information.

2 Proposed Modifications to SPC

Table numbers and section numbers, where applicable, are referenced using SPC X3T10/995D revision 8.

2.1 Additions to INQUIRY command

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Those devices using the enclosure services device type model use a peripheral device type code of 0Dh. The following entries must be added or modified in Table 21, Peripheral device type. Only those rows that are added or modified are included in the following table.

Table 21 - Peripheral device type

Code	Doc.	Description
0Dh	here	Enclosure services device
0Eh - 1Eh		Reserved

Those devices providing enclosure services, but not using the enclosure services device model will use the following bit and bit definition in the INQUIRY command to indicate their support for those commands.

Byte 3, bit 4 of Table 19 - Standard INQUIRY data format (section 7.5.1) is changed from reserved to ES. The following text is added in section 7.5.1 in the proper order to describe the ES bit.

The ES (Enclosure Services) bit of one indicates that the device supports the enclosure services pages of the SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS page. An ES bit of zero indicates that the device does not support the enclosure services pages. The bit is ignored by the application client for enclosure services type devices, since they support the enclosure services pages by definition.

2.2 Definition of SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS

Section 7.23 of SPC defines the SEND DIAGNOSTIC command. No change is required.

Section 7.16 of SPC defines the RECEIVE DIAGNOSTIC RESULTS command. The first paragraph and the parameter descriptions are modified to allow a particular page to be requested and to allow the command to be executed without a preceding SEND DIAGNOSTIC command as follows. Note that this text also corrects a discrepancy in the present definition of the command, where the definition of the returned page is not specified clearly for the case where no SEND DIAGNOSTIC precedes the RECEIVE DIAGNOSTIC RESULTS command.

7.16   RECEIVE DIAGNOSTIC RESULTS command.

The RECEIVE DIAGNOSTIC RESULTS command (see table 41) requests that analysis data be sent to the application client after completion of a SEND DIAGNOSTIC command (see 7.23).

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The command optionally specifies which diagnostic page is to be returned by setting the page code to a value other than zero.

Table 41: RECEIVE DIAGNOSTIC RESULTS command

Bits Bytes	7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	reserved							
2	page code							
3	(MSB)							
4	Allocation Length							(LSB)
5	Control							

If the target supports the page code option and a page value of zero is specified by the RECEIVE DIAGNOSTIC RESULTS command, the page code field and parameters sent in the previous SEND DIAGNOSTIC command specifies the format of the returned data. If no previous SEND DIAGNOSTIC command was provided from the same application client, the Supported Diagnostic Pages (page code 0) is returned as defined in 8.1.1. If the page code is set to a value other than zero in the RECEIVE DIAGNOSTIC RESULTS command, the command shall return the specified page if it supports the page code option. If the specified page code is not supported or if the page code option is not implemented by the device server, the target shall return CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

If the allocation length is greater than the length of the fields to be returned, only the data specified by the page formats is returned. Device servers shall not adjust the content of the returned data to reflect truncation if the allocation length is less than the length specified by the page formats.

[paragraphs including: "A reservation conflict shall occur....page format definitions." remain unchanged.

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Section 8.1 Table 66 is modified to define a generic page code for Enclosure Services as shown below. The mandatory or optional nature of each page is defined in the text for each page, consistent with the other subclauses of clause 8.

Table 66 - Diagnostic page codes

Page Code	SEND DIAGNOSTIC	RECEIVE DIAGNOSTIC RESULTS	Subclause
00h	N/A	Supported diagnostics	8.1.1
01h	N/A	ES Configuration	8.1.2
02h	ES Enclosure Control	ES Enclosure Status	8.1.4, 3
03h	N/A	ES Help Text	8.1.5
04h	ES String Out	ES String In	8.1.6, 7
05h	ES Threshold Out	ES Threshold In	8.1.8
06h	ES Array Control	ES Array Status	8.1.9
07h	N/A	Element Descriptor	8.1.10
08h-3Fh	Reserved (applies to all device type pages)	Reserved (applies to all device type pages)	
40h-7Fh	See specific device type for definition	See specific device type for definition	
80h-FFh	Vendor-specific pages	Vendor-specific pages	

The next to the last paragraph of subclause 8.1 is modified to indicate how truncation operates.

The page length field specifies the length in bytes of the diagnostic parameters that follow this field. For a SEND DIAGNOSTIC command, if the application client sends an allocation length that is not equal to the page length value + 4 bytes, the device server shall terminate the command with the CHECK CONDITION status. The actual number of bytes transferred across the SCSI connection shall be the allocation length or 4, whichever is shorter. The sense key shall be set to ILLEGAL REQUEST with the additional sense code set to INVALID FIELD IN PARAMETER LIST. The information in the page shall not be used by the target device if such a truncation occurs.

For a RECEIVE DIAGNOSTIC RESULTS command, it is not an error for the allocation length to specify a value shorter than the total length of the diagnostic page. The page length field shall always specify the correct length of a complete diagnostic page.

The last paragraph of subclause 8.1.1 is modified to indicate that, if enclosure services pages are supported by a SCSI device, then the pages are indicated as supported regardless of the temporary or permanent ability of the enclosure to provide the necessary information to the device.

The supported page list filed shall contain a list of all diagnostic page codes implemented by the target in ascending order beginning with page code 00h. If the device is capable of accessing a diagnostic function or enclosure function that may temporarily or permanently be unavailable to the device, the page code associated with that information shall be included in the list. Check conditions are only posted by the target when a diagnostic command is executed and fails, not when the list of supported pages is generated.

Additional subclauses, 8.1.2 - 8.1.8, are added to define the contents of the Enclosure Services pages.

8.1.2 Enclosure services configuration page

The enclosure services configuration page returns a list of components in an enclosure. This page shall be implemented if the device supports enclosure services. The component list shall include all components for which component status or controls are defined and may list any other components in the enclosure. The configuration page provides global enclosure information and parameters. The configuration page optionally provides descriptive text which can be used by drivers to identify components in more detail. The configuration page may be read by the RECEIVE DIAGNOSTIC RESULTS command. The transmission of a page with page code 01 using a SEND DIAGNOSTIC command is an error, causing the presentation of CHECK

CONDITION and an ASC/ASCQ of INVALID FIELD IN PARAMETER LIST (26/00). Table aa describes the enclosure services configuration page.

Table aa - Enclosure services configuration page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (01h)							
1	Reserved							
2	(MSB)							
3	Page Length (n-3)							(LSB)
4-7	(MSB) Generation Code							(LSB)
8	Global descriptor length (m, allowable values 36 -252, 4-byte granularity)							
9	Reserved							
10	Number of unit types supported (T, allowable values 0-255)							
11	Reserved							
12 - 19	Enclosure Logical Identifier (World Wide Name or other identifier) (optional)							
20 - 27	Enclosure vendor identification (As defined for INQUIRY command) (optional)							
28-43	Product identification (as defined for INQUIRY command) (optional)							
44-47	Product revision level (as defined for INQUIRY command) (optional)							
48 - (11+m)	Vendor Unique global descriptor information (optional)							
(11+m) to (11+m+4T)	Type descriptor header 4 bytes for each type of element in enclosure							
(12+m+4T) thru n	Type descriptor text specified text string for each element in enclosure optional for each element							

The generation code is a four byte value that is incremented by 1 by the enclosure services device every time the configuration page is changed. The value is not changed by status changes for elements already described by the configuration page. Enclosures that cannot change in configuration use a fixed value equal to 0 for the generation code. A Unit Attention condition shall be established when a configuration change occurs for any command except READ DIAGNOSTIC RESULTS with a page code of configuration page or a REQUEST SENSE command.

The global descriptor length specifies the number of bytes that follow the 4-byte global descriptor header. The value shall be a multiple of 4, having allowed values between 0 and 252.

The number of unit types supported field defines the number of 4-byte type descriptor fields that will follow the global descriptor.

The placement of a value in the enclosure logical identifier field is optional. The first 8 bytes of the global descriptor shall always contain either the logical identifier of the enclosure or a value of 0. The enclosure logical identifier shall use the world wide name format defined by X3.230-1995.

The placement of a value in the enclosure vendor identification field is optional. The field shall always contain either the enclosure vendor identification as specified for the INQUIRY command data field or a value of 0.

the placement of a value in the product identification field is optional. The field shall always contain either the product identification field as specified for the INQUIRY command data field or a value of 0.

The placement of a value in the product revision field is optional. The field shall always contain either the product identification field as specified for the INQUIRY command data field or a value of 0.

The vendor unique global descriptor information is optional. It may contain vendor unique identification of the enclosure profile, vendor unique identification of the enclosure's software and hardware level, and vendor unique text strings describing the enclosure's characteristics.

The type descriptor header is a 4-byte header that indicates the type of element being described, the number of such elements, and the length of an ASCII text descriptor of the element type. The elements of an enclosure will be listed in the same order in the configuration page, the type descriptor text of the configuration page, the status page, and the control page. All those elements defining SCSI devices shall be specified before elements of other types. The format of the type descriptor header is shown in table ab.

The type descriptor text is an optional ASCII text string from 0 to 255 bytes for each type descriptor header. The text string, if it has a length greater than zero, may contain any descriptive information about the element type that might be useful to a driver that is displaying the configuration of the enclosure. Examples include the manufacturer's part number for a replacement element, a brief description of the element and its properties, or instructions about configuration limitations and redundancy requirements of the elements of that type.

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Table ab - Configuration page type descriptor header format

Bits / Bytes	7	6	5	4	3	2	1	0
0	Type of element							
1	Number of elements (number of that type possible in enclosure)							
2	Ext	Reserved						
3	Type descriptor text length							

The type of element field in each type descriptor indicates the type of element being described in that particular header. Standard element types and reserved element type values are shown in Table ac. More than one type descriptor header may exist for a particular type of element. As an example, there may be two power supplies that provide +12 volts, and five power supplies that provide +5 volts. In this case, separate headers may be used for each of the power supply types, since they may have separate text descriptions.

The Ext bit indicates that the group of elements defined by this element descriptor are physically outside the particular enclosure being addressed, but are under the control of the enclosure. The elements are otherwise identical to any other set of elements of a corresponding type, although different capabilities may be available in the control and sense pages.

Table ac - Element type codes

Type Code	Type of element
00h	unspecified
01h	enclosure device (page 02)
01h	array device (page 06)
02h	Power supply
03h	Cooling Element
04h	Temperature Sensors
05h	Door Lock
06h	Audible Alarm
07h	ESI controller electronics
08h	SCC controller electronics
09h	Nonvolatile cache
0Ah	Reserved
0Bh	Uninterruptible Power Supply
0Ch	Display
0Dh	Key pad entry device
0Eh	Reserved
0Fh	SCSI port/transceiver
10h	Language
11h	Communication port
12h	Voltage Sensor
13h	Current Sensor
14h	SCSI Target Port
15h	SCSi Initiator Port
16-7Fh	Reserved
80h-FFh	Vendor-specific codes

The number of elements field indicates the number of elements of that type that can be installed in the enclosure.

The type descriptor text length field specifies the length of the type descriptor text for the particular element. Vendor unique element types shall have a descriptor length field that is nonzero and shall have a type descriptor text adequate to identify the element to a driver program.

Some very simple devices are not capable of reporting any enclosure service page except the short status page, defined in section 8.1.3. Such devices shall always provide the short status page, regardless of which enclosure services page was requested.

8.1.3 Enclosure services enclosure status page

The enclosure services enclosure status page returns a generic information entry for each type of element included in the enclosure services configuration page. Below each generic information entry, there is a type specific status entry for each of the elements of that type that have been allowed for by the element count value of the configuration page. For SCSI devices, the information element returned shall be the device enclosure status element.

The status page has the standard enclosure services diagnostic page header. This page shall be implemented if the device supports enclosure services. The status page is read by the RECEIVE DIAGNOSTIC RESULTS command. The transmission of a page with page code 2 is

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defined as the transmission of an enclosure services enclosure control page. Table bb describes the enclosure services enclosure status page.

Table bb - Normal enclosure services enclosure status page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (02h)							
1	Short (=0)				Info	Non-Crit	Crit	Unre-cov
2	(MSB)							
3	Page Length (= n-3)							(LSB)
4-7	(MSB) Generation Code							(LSB)
8 -11	Global status for first element type							
12 - 15	Element status for first element of first element type							

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4 bytes	Element status for last element of first element type
4 bytes	Global status for second element type
4 bytes	Element status for first element of second element type

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n-3 to n	Element status for last element of last element type

The elements for each element type are arranged in a fixed order. The relationship between the element number and the location of the element is vendor unique. The relationship may be described by the descriptor fields of the configuration page, by the descriptors in the element descriptor page, or by external references.

Some very simple devices are not capable of reporting any enclosure service page except the short status page, defined in table bc. Such devices shall always provide the short status page, regardless of which enclosure services page was requested. It shall not be an error to respond with a short status page when another enclosure services page has been requested by a RECEIVE DIAGNOSTIC RESULTS command.

Table bc - Enclosure services short enclosure status page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (02h)							
1	Short (= 1)	VU	VU	VU	VU	VU	VU	VU
2	(MSB)							
3	Page Length (= 0)							(LSB)

> Note: The short status page is provided when a device that is capable of supporting full enclosure services determines that the enclosure attached to it is only capable of providing a single 7-bit data field. Such a device is defined by the Small Form Factor specification SFF-8045, describing a single connector SCSI FCP FC-AL disk drive with a simple enclosure sensing mechanism.

The short bit is 1 if the enclosure services short status page is being returned. The short status page may be returned in response to a RECEIVE DIAGNOSTIC RESULTS page with any enclosure services page code. The short bit is 0 if the normal enclosure services enclosure status page is being returned.

The summary bits are returned in normal status pages and are mandatory. The bits can be recovered with a very short allocation length and can be examined by an enclosure polling procedure to determine if any special or unusual conditions requiring more exhaustive sensing procedures are required. The bits are set independently and can be presented in any combination.

The information bit (Info bit) shall be set to 1 if one or more conditions have been detected in the enclosure since the last time a enclosure services enclosure status page has been presented to the application client that should be provided for the information of the application client, but that do not reflect any error or abnormal condition. Such conditions include temperature and battery status that do not reflect a failure or reduction of availability. The information bit shall be provided once as an indication to the application client that interesting information is available and not provided again until some new condition requires it to be set.

The noncritical condition (Non-Crit) shall be set to 1 to indicate that an element is not operating correctly or is operating outside its specification, but that the failure of the element will not affect continued normal operation of the enclosure and all SCSI devices in the enclosure. The degree of operational redundancy may be reduced by a noncritical condition. The noncritical condition bit shall continue to be presented until all noncritical conditions have been corrected.

The critical condition (Crit) bit shall be set to 1 to indicate that an element is not operating correctly or is operating outside its specification and that the failure of the element has affected or will soon affect the continued normal operation of the enclosure. Other elements of the enclosure may continue to operate normally. The critical condition bit shall continue to be presented until all critical conditions have been corrected.

The unrecoverable condition (Unrecov) bit shall be set to 1 to indicate that an element is not operating correctly and that the failure of the element has disabled some functions of the enclosure. The enclosure may be incapable of recovering or redundantly bypassing the failure and will normally require repairs to correct the condition. The unrecoverable condition bit shall continue to be presented until all repairs necessary to correct unrecoverable conditions are completed.

If the optional short status bit is set to 1, the page format is fixed. The 7 bits of byte 1 contain vendor unique enclosure condition indicator bits.

The generation code is a four byte value that is incremented by 1 by the enclosure services device every time the configuration page is changed. The value is not changed by status changes for elements already described by the configuration page.

The global status entry for each element type has the same format as the corresponding element status entry. There is exactly one global status entry for each type descriptor in the configuration page. The global status optionally indicates a summary of the status for all of the elements of that type collectively. The global status also may be used to indicate the status of those elements whose individual status is not available, but that do have a measurable global status. An example might be an enclosure with 3 temperature sensors that cannot record the individual temperatures from those sensors. The global status entry might report the average of the 3 sensors.

One or more element status entries are provided immediately after the global status entry for that element type. There are n element status entries for each type descriptor in the configuration page, where n shall be identical to the number of elements field in the type descriptor entry. Each element status entry optionally indicates the status for the particular element. Each standard element type has a fixed format for its status.

The global status and element status formats and the corresponding element control formats for each element type are described in section 8.1.8

8.1.4 Enclosure services enclosure control page

The enclosure services enclosure control page transmits a global control entry for each type of element included in the enclosure services configuration page. Below each global control entry, there is an element control entry for each of the elements of that type that have been allowed for by the element count value of the configuration page. The control page has the standard

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enclosure services diagnostic page header. For SCSI devices, the device enclosure control elements shall be offered in this page.

The page shall be implemented if the device supports enclosure services. The control page is transmitted by the SEND DIAGNOSTIC command. The request of a page using RECEIVE DIAGNOSTIC RESULTS, page code 2 is defined as the request for an enclosure services enclosure status page. Table cc describes the enclosure services enclosure control page.

Table cc - Enclosure services enclosure control page

Bytes \ Bits	7	6	5	4	3	2	1	0
0	Page Code (02h)							
1					Info	Non-Crit	Crit	Unrecov
2	(MSB)							
3	Page Length (= n-3)							(LSB)
4-7	Reserved							
8-11	Global control for first element type							
12-15	Element control for first element of first element type							

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4 bytes	Element control for last element of first element type
4 bytes	Global control for second element type
4 bytes	Element control for first element of second element type

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n-3 to n	Element control for last element of last element type

The Info, Non-Crit, Crit, and Unrecov bits may be optionally set by the application client using the control page. This allows an application client to set a state which may be observed by another process or another application client. It also allows an application client to turn on enclosure indicators associated with such status. The bits may be overridden or ignored by the enclosure.

The global control entry for each element type has the same format as the corresponding element control entry. There is exactly one global control entry for each type descriptor in the configuration page. The global control entry provides collective control for all elements described in the element control entries. Control values may be applied to either the global control entry or the element control entry.

Following the global control entry, there shall be n element control entries for each type descriptor in the configuration page, where n shall be identical to the number of elements field

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in the type descriptor entry. Each element control entry optionally contains control information for the specified element. Each standard element type has a standard fixed format for its control entry. In most cases, the status entries and control entries are very similar and contain complementary functions.

The global status and element status formats and the corresponding element control formats for each element type are described in section 8.1.8

8.1.5 Enclosure services help text page

The enclosure services help text page transmits an ASCII string of data from the enclosure that describes the present state of the enclosure and provides text indicating what corrective actions, if any, are desirable to bring the enclosure to its fully operational state. The help text page has the standard enclosure services diagnostic page header. The help text page is intended to allow the writing of enclosure independent SCSI drivers that can return enclosure specific text describing the state of the enclosure and explaining enclosure dependent corrective actions that may be required. The page is optional.

The enclosure services help text page shall be read by the RECEIVE DIAGNOSTIC RESULTS command. The transmission of a page with page code 03 using a SEND DIAGNOSTIC command is an error, causing the presentation of CHECK CONDITION and ASC/ASCQ of INVALID FIELD IN PARAMETER LIST (26/00).

Some very simple devices are not capable of reporting any enclosure service page except the short status page, defined in section 8.1.3. Such devices shall always provide the short status page, regardless of which enclosure services page was requested.

Table dd describes the enclosure services help text page.

Table dd - Enclosure services help text page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (03h)							
1	Reserved							
2	(MSB)							
3	Page Length (= n-3)							(LSB)
4 - n	Enclosure services ASCII help text string							

8.1.6 Enclosure services string in page

The enclosure services string in page transmits an enclosure dependent binary string from the enclosure to the application client. The string may contain bits describing keyboard states, switch states, or the content of other information provided through or by the enclosure to the application client. The format is not specified by this standard. The format of the string may be determined by an application client using manufacturer name and model from the INQUIRY command and any applicable descriptive text in the RECEIVE DIAGNOSTIC RESULTS enclosure services configuration page. Table ee describes the enclosure services string in page received using the RECEIVE DIAGNOSTIC RESULTS command.

Some very simple devices are not capable of reporting any enclosure service page except the short status page, defined in section 8.1.3. Such devices shall always provide the short status page, regardless of which enclosure services page was requested.

Table ee - Enclosure services string in page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (04h)							
1	Reserved							
2	(MSB)							
3			Page Length (= n-3)					(LSB)
4-n	Binary string provided by enclosure to application client							

8.1.7 Enclosure services string out page

The enclosure services string out page transmits an enclosure dependent binary string from the application client to the enclosure. The string may contain bits describing indicator states, text or graphic display information, or control information outside the context of the enclosure elements defined in the enclosure services configuration page. The format is not specified by this standard. The format of the string may be established by an application client using manufacturer name and model from the INQUIRY command and any applicable descriptive text in the RECEIVE DIAGNOSTIC RESULTS enclosure services configuration page. Table ff

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describes the enclosure services string out page transmitted using the SEND DIAGNOSTIC command.

Table ff - Enclosure services string out page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (04h)							
1	Reserved							
2	(MSB)							
3	Page Length (= n-3)							(LSB)
4-n	Binary string provided by application client to enclosure							

8.1.8 Enclosure Services Threshold In and Threshold Out pages

The enclosure services threshold in page returns a generic threshold entry for each relevant type of element included in the enclosure. Below each generic threshold entry, there is a standard threshold entry for each of the elements of that type that have been allowed for by the element count value of the configuration page. The individual entry overrides the generic entry where the elements are implemented with individually settable thresholds. Each threshold entry has the standard format specified in table ma.

Table ma - standard format for threshold entry

Bits Bytes	7	6	5	4	3	2	1	0
0	High Critical Threshold							
1	High Warning Threshold							
2	Low Warning Threshold							
3	Low Critical Threshold							

The threshold in page is requested by the RECEIVE DIAGNOSTIC RESULTS command. Those elements for which no threshold is defined shall return an entry with all values equal to zero. The threshold may be undefined either because the element has no value which can be compared against a threshold or because the element is implemented in such a manner that the threshold is not adjustable or accessible.

The threshold out page is transmitted by the SEND DIAGNOSTIC command. Those elements which have no value to be compared with a threshold shall ignore the contents of the threshold entry. Those elements which have a value which can be compared with a threshold may accept

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the specified thresholds, round the specified thresholds to a more appropriate value, or may ignore the contents of any or all of the threshold entries. A threshold entry with all four thresholds having a value of zero shall be ignored for that element. This allows individual entries to be modified without the requirement of setting all other entries at the same time.

Each 8-bit threshold value shall have the same meaning as the corresponding 8-bit status value. As an example, temperature sensor elements measure temperature in degrees Celsius + 20. The threshold value is also established and presented in degrees Celsius + 20. All values are considered positive, and must be either inverted or biased to a positive value if negative values are possible. The values shall be selected such that:

High Critical > High Warning > normal value range > Low Warning > Low Critical

If the values do not meet this requirement, and if the values are not ignored by the enclosure services device, the enclosure services device shall generate a CHECK CONDITION with an ASC/ASCQ indicating INVALID FIELD IN PARAMETER LIST.

When the value of a sensed parameter rises equal to the high critical threshold or falls below the low critical threshold, indications of a critical failure are presented in the enclosure services enclosure status page. For those commands that use CHECK CONDITION to indicate enclosure failures, sense information of Enclosure Failure shall be presented.

When the value of a sensed parameter rises equal to the high warning threshold or falls below the low warning threshold, indictions of a noncritical failure are presented in the enclosure services enclosure status page. For those commands that use CHECK CONDITION to indicate enclosure failures, sense information of Enclosure Degraded Warning shall be presented.

The format of the threshold in and threshold out pages is shown in table mb. Implementation of this page is optional.

Table mb - Format of Threshold In and Threshold Out pages

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (05h)							
1								
2	(MSB)							
3	Page Length (= n-3)							(LSB)
4-7	Reserved							
4-7	Global threshold entry for first element type							
8-15	Element threshold entry for first element of first element type							

●●●

4 bytes	Element trellised entry for last element of first element type
4 bytes	Global threshold entry for second element type
4 bytes	Element trellised entry for first element of second element type

●●●

n-3 to n	Element trellised entry for last element of last element type

8.1.9 Enclosure services array status and array control pages

The optional enclosure services array status and array control pages return and transmit the device array element. This information is specialized for managing the state of indicators and flags associated with each device's membership and status within a RAID array. Some relevant information is duplicated in both the device enclosure elements and the device array elements. In those cases, the actual state of the device or device bay shall be expressed by the logical 'OR' of the two conditions.

Only the elements associated with devices are included in the array status and array control pages. The device elements are in the same order as the device elements in the enclosure status and enclosure control pages.

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The array status page is read by the RECEIVE DIAGNOSTIC RESULTS command. The transmission of a page with page code 6 is defined as the transmission of an enclosure services array control page. Table qb describes the enclosure services status page.

Table qb - Enclosure services array status page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (06h)							
1					Info	Non-Crit	Crit	Unre-cov
2	(MSB)							
3		Page Length (= n-3)						(LSB)
4-7	(MSB)							
		Generation Code						(LSB)
8 -11	Global status for device array element type							
12 - 15	Element status for first device array element type							

●●●

| n-3 to n | Element status for last device array element type | | | | | | | |

The array control page is transmitted by the SEND DIAGNOSTIC command. The request of a page using RECEIVE DIAGNOSTIC RESULTS, page code 5 is defined as the request for an

n

enclosure services array status page. Table qc describes the enclosure services array control page.

Table cc - Enclosure services array control page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (06h)							
1					Info	Non-Crit	Crit	Unrecov
2	(MSB)							
3				Page Length (= n-3)				(LSB)
4-7	Reserved							
8-11	Global control for device array type							
12-15	Element control for first device array element							

●●●

4 bytes	Element control for last device array element							

8.1.10 Enclosure services element descriptor page

The enclosure services element descriptor page returns a list of variable length fields, one for each element in the enclosure services enclosure status page. The variable length fields contain a vendor unique string that may include such useful information as the vendor's element part number, the revision level, and other descriptive information. Each element has a four-byte header with the format shown in table qd.

Table bd - General format of global and element descriptor header

Bits Bytes	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	(LSB)							
3				Descriptor field length				(MSB)

The descriptor length may be zero, in which case, the descriptor field is not placed between consecutive headers.

n

The format is always in ASCII and is not modified by the language element. Table qb describes the enclosure services element descriptor page.

Table qb - Normal enclosure services element descriptor page

Bits Bytes	7	6	5	4	3	2	1	0
0	Page Code (07h)							
1								
2	(MSB)							
3	Page Length (= n-3)							(LSB)
4-7	(MSB) Generation Code							(LSB)
8 -11	Global descriptor header for first element type							
?	Global descriptor field for first element type							
(4)	Element descriptor header for first element of first element type							
?	Element descriptor field for first element of first element type							

•••

(4)	Element descriptor header for last element of first element type							
?	Element descriptor field for last element of first element type							
4 bytes	Global descriptor header for second element type							
4 bytes	Global descriptor field for second element type							
(4)	Element descriptor header for first element of second element type							
?	Element descriptor field for first element of first second type							

•••

(4)	Element descriptor header for last element of last element type							
?-n	Element descriptor field for last element of last element type							

8.1.11 Global and element status and control formats

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The element status format for all elements is provided in table bd.

Table bd - General format of global and element status entries

Bytes ⟍ Bits	7	6	5	4	3	2	1	0
0	Resrvd	PredFail			Status Code			
1	Element status 1							
2	Element status 2							
3	Element status 3							

The optional PredFail (Predicted Failure) bit of 1 indicates that the element of the enclosure has the capability of predicting failure and that a failure has been predicted. The bit has the optional capability of being set to 1 by the PredFail bit of the element control entries. The PredFail bit set to 0 shall indicate that the predicted failure state is not set or that the predicted failure function is not implemented.

The status codes and the definition of the status codes are shown in table be.

Table be - Element status codes

Type Code	Name	Condition	Mandatory Optional
00h	Unsupported	element status detection is not implemented for this element	Optional
01h	OK	element is installed and no error conditions are known by the enclosure.	Mandatory
02h	Critical	critical element failure is detected	Optional
03h	Noncritical	noncritical element failure is detected	Optional
04h	Unrecoverable	unrecoverable element failure is detected	Optional
05h	Not installed	element is detected to be not installed in enclosure	Mandatory
06h	Unknown	element sensor has failed or element status is not available	Optional
07h	Not Available	element installed, no known errors, but the element has not been turned on or set into operation.	Optional

n

The element control format for all elements is provided in table bf.

Table bf - General format of global and element control entries

Bits Bytes	7	6	5	4	3	2	1	0
0	Select	PredFail	Disable	Reserved				
1	Element control 1							
2	Element control 2							
3	Element control 3							

The select bit is set to one if the control function defined by this element control entry is to be performed. The select bit is set to zero if this element control entry is to be ignored by the enclosure. The select bit allows individual element control entries from the entire list of control entries to be selected for execution.

The optional PredFail (Predicted Failure) bit shall be set to 1 to indicate that the application client wants to set the predicted failure state for the element. The PredFail bit shall be set to 0 to indicate that the application client wants to turn off the predicted failure state for the element. The element is not required to implement the bit or the predicted failure state.

The optional Disable bit shall be set to 1 to indicate that the application client wants to disable this sensor. The Disable bit will only be recognized on sensor type elements, including the temperature sensors, the voltage sensors, and the current sensors. This enables sensors that are giving erroneous results to be shut off.

Unless otherwise specified, all status and control bits are optional. The enclosure is not required to present any optional status bit. The enclosure is not required to act on any optional control bit and may ignore any control bit if required to maintain a proper operating environment in the enclosure.

Code 00h, Unspecified element type

The element status bits are reserved for the status entry for the unspecified element type.
The element control bits are reserved for the control entry for the unspecified element type.

Code 01h, device enclosure element type

The element is defined for the device enclosure status page (page code 02). This element contains information pertaining to the enclosure of the device. Those codes common to the

n

device array status page, used with page code 06, shall be set to 1 for both status elements if they are present in either status element.

Table bg - Element status bytes for device enclosure element

Bytes \ Bits	7	6	5	4	3	2	1	0
1	Hard address setting for device							
2		Do not remove		Swap	Ready to Insert	Remove	Identify	
3		Sense Fault	Fault Reqstd	Drive Off	Enable Byp A	Enable Byp B	Byp A Enabled	Byp B Enabled

The element is defined for the device enclosure control page (page code 02). This element contains control information related to the enclosure of the device. Those codes common to the device array control page, used with page code 06, shall have effect if they are set by either the enclosure control page or the array control page.

Table bh - Element control bytes for device enclosure element

Bytes \ Bits	7	6	5	4	3	2	1	0
2		Do not remove		Rst Swap	Rqst Insert	Rqst remove	Rqst Identify	
3			Rqst Fault	Drive Off	Enable Byp A	Enable Byp B		

Byte 1

    Hard address setting for device
    Set to value of SCSI target address defined for designated element.

    For global device enclosure elements, this is an arbitrary identifier for the group of devices and may be related to a path identifier for the group of devices.

Byte 2, Bit 1

    Identify (status)
    1 = enclosure identify indicator has been set
    Request Identify (control)
    1 = request that the identify indicator be set.

Byte 2, Bit 2

    Remove (status)
    1 = device is prepared for removal and removal indicators, if any, are set
    Request remove (control)
    1 = request that device be prepared for removal.

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Byte 2, Bit 3
    Insert (status)
    1 = device bay is prepared for device to be inserted and insertion indicators, if any, are set
    Request Insert (control)
    1 = request that device bay be prepared for insertion.

Byte 2, Bit 6
    Do not remove (status)
    1 = indicates that device should not be removed, and protective indicators, if any, are set
    Do not remove (control)
    1 = set to request that device not be removed

Byte 3, bit 0/1
    Bypass B/A Enabled (status)
    1 = indicates that device bypass is enabled by device

Byte 3, bit 2/3
    Enable Bypass B/A (status)
    1 = indicates that device bypass is enabled by enclosure
    Enable Bypass B/A (control)
    1 = request that device bypass be enabled by enclosure

Byte 3, bit 4
    Drive off (status)
    1 = indicates that device is powered off
    Drive off (control)
    1 = requests that device be powered off

Byte 3, bit 5
    Fault Requested (status)
    1 = indicates that fault indicators are set by enclosure
    Request Fault (control)
    1 = requests that fault indicators be set

Byte 3, bit 6
    Fault Sensed (status)
    1 = indicates that fault indicators are set by device

Code 01h, device array element type

The element is defined for the device array status page (page code 06). This element contains information defining the state of the device relative to any array activities. Those codes common

to the device enclosure status page, used with page code 02, shall be set to 1 for both status elements if they are present in either status element.

Table bg - Element status bytes for device array element

Bytes \ Bits	7	6	5	4	3	2	1	0
1	OK	Rsrvd Drive	Hot Spare	Cons Chk	In Crit Array	In Failed Array	Rebuild/ Remap	R/R Aborted
2		Do not remove		Swap		Remove	Identify	
3					Enable Byp A	Enable Byp B	Byp A Enabled	Byp B Enabled

The element is defined for the device array control page (page code 06). This element contains control information related to the device's use in an array. Those codes common to the device enclosure control page, used with page code 02, shall have effect if they are set by either the enclosure control page or the array control page.

Table bh - Element control bytes for device array element

Bytes \ Bits	7	6	5	4	3	2	1	0
1	Set OK	Set Rsrvd Drive	Set Hot Spare	Set Cons Check	Set In Crit Array	Set In Failed Array	Set Rebuild/ Remap	Set R/R Aborted
2		Do not remove		Rst Swap		Rqst remove	Rqst Identify	
3					Enable Byp A	Enable Byp B		

Byte 1, Bit 0

Rebuild/Remap Aborted (status)

1 = indicates that enclosure has set the rebuild/remap aborted indicators

Set Rebuild/Remap Aborted (control)

1 = requests that the rebuild/remap aborted indicators be set

Byte 1, bit 1

Rebuild/Remap (status)

1 = indicates that the enclosure has set the rebuild/remap indicators

Set Rebuild/Remap (control)

1 = requests that the rebuild/remap indicators be set

Byte 1, bit 2

In Failed Array (status)

1 = indicates that the enclosure has set the failed array indicators

Set in failed array (control)

1 = requests that the in failed array indicators be set

n

Byte 1, bit 3
    In Critical Array (status)
    1 = indicates that the enclosure has set the in critical array indicators
    Set In Critical Array (control)
    1 = requests that the in critical array indicators be set

Byte 1, bit 4
    Consistency Check in Progress (status)
    1 = indicates that the enclosure has set the consistency check in progress indicators
    Set Consistency Check in Progress (control)
    1 = requests that the consistency check in progress indicators be set

Byte 1, bit 5
    Hot Spare (status)
    1 = indicates that the enclosure has set the hot spare indicators
    Set Hot Spare (control)
    1 = requests that the hot spare indicators be set

Byte 1, bit 6
    Reserved Drive (status)
    1 = indicates that the enclosure has set the reserved drive indicators
    Set Reserved Drive (control)
    1 = requests that the reserved drive indicators be set

Byte 1, bit 7
    OK (status)
    1 = indicates that the enclosure has set the OK indicators
    Set OK (control)
    1 = requests that the OK indicators be set

Code 02h, Power Supply element type

Table bi - Element status bytes for power supply

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2					DC over-voltage	DC under-voltage	DC over-current	
3		Fail	Rqsted On		Overtmp Fail	Temp warning	AC Fail	DC Fail

Table bj - Element control bytes for power supply

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3		Set Fail Indicator	Rqst On					

Byte 2, Bit 1
> DC Overcurrent (status)
> 1 = DC current limitation was exceeded

Byte 2, Bit 2
> DC Undervoltage (status)
> 1 = DC voltage was below limits

Byte 2, Bit 3
> DC Overvoltage (status)
> 1 = DC voltage was above limits

Byte 3, Bit 0
> DC Fail (Status)
> 1 = Indicates power supply cannot provide specified DC power.

Byte 3, Bit 1
> AC Fail (Status)
> 1 = Indicates power supply is not receiving specified AC power.

Byte 3, Bit 2
> Temp warning (Status)
> 1 = Indicates temperature is higher than normal operating temperature, but has not yet reached a temperature that requires the power supply to shut down.

Byte 3, Bit 3
> Overtemp fail (Status)
> 1 = Indicates temperature is higher than a safe operating temperature and the power supply is or soon will be shutdown.

Byte 3, Bit 5
> Requested on (Status)
> 1 = Indicates that the power supply has been requested to be in the operating state.
> Request on (Control)
> 1 = Instructs the power supply to turn on or remain on.
> 0 = Instructs the power supply to turn off or remain off.

Byte 3, Bit 6
> Fail (Status)
> 1 = Indicates that failure indicator is on or has been set on.
> Set Fail Indicator (Control)
> 1 = Instructs the enclosure to turn the power supply failure indicator on.

n

0 = Instructs the enclosure to turn the power supply failure indicator off unless turned on by internal circuitry.

Code 03h, Cooling element type

Table bk - Element status bytes for cooling element

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3		Fail	Rqsted On			Actual Speed Code		

Table bl - Element control bytes for cooling element

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3		Set Fail Indicator	Rqst On			Requested Speed Code		

Byte 3, Bit 2 through 0
  Actual Speed Code (Status)
    Code indicates actual speed of fan or cooling device

Requested Speed Code (Control)
Code indicates requested speed of fan or cooling device

Table bla - Speed Code

Speed Code	Description
000b	Fan stopped (Actual Speed Code only)
001b	Fan at lowest speed
010	Fan at second lowest speed
011	Fan at speed 3
100	Fan at speed 4
101	Fan at speed 5
110b	Fan at intermediate speed
111b	Fan at highest speed

Byte 3, Bit 5
Requested on (Status)
1 = Indicates that the cooling element has been requested to be in the operating state.
Request on (Control)
1 = Instructs the cooling element to turn on or remain on.
0 = Instructs the cooling element to turn off or remain off.

Byte 3, Bit 6
Fail (Status)
1 = Indicates that cooling element failure indicator is on or has been set on.
Set Fail Indicator (Control)
1 = Instructs the enclosure to turn the cooling element failure indicator on.
0 = Instructs the enclosure to turn the cooling element failure indicator off unless turned on by
internal circuitry.

Code 04h, Temperature sensor element type

Table bm - Element status bytes for temperature sensors

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2	Temperature (degrees Celsius + 20)							
3					OT, Failure	OT, warning	UT, Failure	UT, warning

Table bn - Element control bytes for temperature sensors

Bytes \ Bits	7	6	5	4	3	2	1	0
1-3	Reserved							

Byte 2, bits 0-7
> Temperature (Status)
> value = temperature at sensor in degrees Celsius + 20. Range is
> from -20 to +245 degrees Celsius

Byte 3, bit 0
> Under Temperature (UT) Warning (Status)
> 1 = temperature at sensor is lower than normal operating temperature range but will not
> damage the enclosure.

Byte 3, bit 1
> Under Temperature (UT) Failure (Status)
> 1 = temperature at sensor is lower than a safe operating temperature and enclosure damage
> may occur.

Byte 3, bit 2
> Over Temperature (OT) Warning (Status)
> 1 = temperature at sensor is higher than normal operating temperature but will not damage the
> enclosure.

Byte 3, bit 3
> Over Temperature (OT) Failure (Status)
> 1 = temperature at sensor is higher than a safe operating temperature and enclosure damage
> may occur.

Code 05h, Door lock element type

Table bo - Element status bytes for door lock

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								Unlocked

n

Table bp - Element control bytes for door lock

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								Unlock

Byte 3, Bit 0
      Unlocked (Status)
      1 = Indicates door lock is unlocked
      Unlock (Control)
      1 = Instructs door latch to unlock or remain unlocked.
      0 = Instructs door latch to lock or remain locked.

Code 06h, Audible Alarm element type

Table bq - Element status bytes for audible alarm

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3	Rqst Mute	Muted		Remind	Info	Non-Crit	Crit	Unrecov

Table br - Element control bytes for audible alarm

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3		Muted		Remind	Info	Non-Crit	Crit	Unrecov

Byte 3, Bit 0 - 3, tone urgency indicator/control
      Each bit establishes a tone of increasing urgency (bit 4, least urgent).
      If more than one bit is set to 1, the most urgent of the selected tones is activated.

      The quality of each tone and the use of separate tones is enclosure dependent. The bits and
      tones may be set either through the control byte or by the enclosure.

      If a new error condition occurs while the audible alarm is set in the Remind or Muted state, the
      state will be reset and the normal alarm conditions will occur for that error, but not the previous

error.

Unrecov
1 = Indicates/sets audible alarm with tone suitable for unrecoverable failure.
Crit
1 = Indicates/sets audible alarm with tone suitable for critical failure.
Non-Crit
1 = Indicates/sets audible alarm with tone suitable for noncritical failure.
Info
1 = Indicates/sets audible alarm with tone suitable for informational warning.
All bits = 0 indicates audible alarm is quiet.

Byte 3, Bit 4
Remind
1 = Indicates/sets audible alarm to tone suitable for reminding user that other tones have been previously active.
0 = Indicates/sets audible alarm to transmit tone requested by tone urgency indicators/controls.

Byte 3, Bit 7
Rqst Mute
1 = Indicates panel control has been manipulated to request that the audible alarm be muted.
0 = Indicates panel control has not been activated.

Byte 3, Bit 6
Muted
1 = Indicates/sets audible alarm to muted state. The remind state may optionally be used instead of the muted state under software control.
0 = Indicates/sets audible alarm to un-muted state.

Code 07h, ESI controller electronics element type

Table bs - Element status bytes for ESI controller electronics

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Table bt - Element control bytes for ESI controller electronics

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

n

Bits to be defined
Code 08h, SCC controller electronics element type

Table bu - Element status bytes for SCC controller electronics

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Table bv - Element control bytes for SCC controller electronics

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Bits to be defined

Code 09h, Nonvolatile cache element type

Table bw - Element status bytes for nonvolatile cache

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Table bx - Element control bytes for nonvolatile cache

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Bits to be defined

n

Code 0Bh, Uninterruptible power supply element type

Table by - Element status bytes for uninterruptible power supply

Bits Bytes	7	6	5	4	3	2	1	0
1	Battery Status (minutes of charge at present power usage rate)							
2	AC lo	AC hi	AC qual	AC fail	DC fail	UPS fail	Warn	Intf Fail
3							Batt fail	BPF

Table bz - Element control bytes for uninterruptible power supply

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								

Byte 1

Battery status is indicated in minutes of capability from 1 to 254 minutes. An indication of 255 minutes indicates that the battery will last longer than 254 minutes. An indication of 0 minutes indicates that the battery is not operating or not available.

Byte 2, bit 0

Intf Fail (Status)

1 = The enclosure services interface to the UPS has failed.

Byte 2, bit 1

Warn (Status)

1 = The UPS has provided a warning signal that indicates that output power will soon fail.

Byte 2, bit 2

UPS Fail (Status)

1 = The UPS is detected to have an operational failure.

Byte 2, bit 3

DC Fail (Status)

1 = DC line voltage has failed.

Byte 2, bit 4

AC fail (Status)

1 = AC line voltage has failed.

Byte 2, bit 5

AC qual(Status)

1 = AC line voltage quality is outside specified values.

Byte 2, bit 6
> AC hi(Status)
> 1 = AC line voltage is higher than specified value.

Byte 2, bit 7
> AC lo(Status)
> 1 = AC line voltage is lower than specified value.

Byte 3, bit 0
> BPF (Battery Predicted Failure) (Status)
> 1 = UPS battery is detected to be close to a failure condition.

Byte 3, bit 1
> Batt fail (Status)
> 1 = UPS battery has failed.

Code 0Ch, Display element type

Table baa - Element status bytes for display element

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Table bab - Element control bytes for display element

Bytes \ Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Bits to be defined

Code 0Dh, Key pad entry device element type

Table bac - Element status bytes for key pad entry

Bytes＼Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Table bad - Element control bytes for key pad entry

Bytes＼Bits	7	6	5	4	3	2	1	0
1								
2								
3								

Bits to be defined

Code 0Fh, SCSI port/transceiver element type

Table bag - Element status bytes for SCSI port/transceiver

Bytes＼Bits	7	6	5	4	3	2	1	0
1								
2								
3				Disabled			LOL	Lsr Fail

Table bah - Element control bytes for SCSI port/transceiver

Bytes＼Bits	7	6	5	4	3	2	1	0
1								
2								
3				Disable				

n

Byte 3, Bit 0
    Laser Failure(Status)
    1 = Indicates transmit laser has failed and has been turned off

Byte 3, Bit 1
    Loss of Light (Status)
    1 = Indicates receiver is not detecting input, either due to a receiver failure or a line failure.

Byte 3, Bit 4
    Disabled (Status)
    1 = Indicates transceiver is disabled
    Disable (Control)
    1 = Instructs transceiver to disable or remain disabled.
    0 = Instructs transceiver to enable or remain enabled.

Code 10h, Language element type

Table bag - Element status bytes for Language

Bits Bytes	7	6	5	4	3	2	1	0
1								
2	Language code							
3								

Bytes 2 and 3
    Indicate the language and character encoding of all text scripts. Code structure to be selected.
    A code of all zero indicates that the default of technical English using ASCII character encoding
    is being used.

Table bah - Element control bytes for Language

Bits Bytes	7	6	5	4	3	2	1	0
1								
2	Language code							
3								

Bytes 2 and 3
    Request the language and character encoding of all text scripts. Code structure to be selected.

n

Code 11h, Communication port element type

Table bag - Element status bytes for Communication port

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								Disabled

Table bah - Element control bytes for Communication Port

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								Disable

Byte 3, Bit 0
> Disabled (Status)
> 1 = Indicates communication port is disabled
> Disable (Control)
> 1 = Instructs communication port to disable or remain disabled.
> 0 = Instructs communication port to enable or remain enabled.

Code 12h, Voltage Sensor element type

Table cag - Element status bytes for voltage sensor

Bits Bytes	7	6	5	4	3	2	1	0
1							Over	Under
2 thru 3	sign	(MSB)						
		Voltage Value (millivolts, 2's complement notation) (LSB)						

Byte 1, Bit 0
> Under voltage sensed
> 1 = Under voltage warning or critical threshold violated

Byte 1, Bit 1
> Over voltage sensed
> 1 = Over voltage warning or critical threshold violated

Bytes 2 and 3
> Indicate the 2's complement value of voltage being detected at the sensor, measured in units of 1 millivolt.

Table bah - Element control bytes for voltage sensor

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								

Code 13h, Current Sensor element type

Table cag - Element status bytes for current sensor

Bits Bytes	7	6	5	4	3	2	1	0
1							Over	
2 thru 3	sign	(MSB)				Current Value (milliamps, 2's complement notation)		(LSB)

Byte 1, Bit 1
> Over current sensed
> 1 = Over current warning or critical threshhold violated

Bytes 2 and 3
> Indicate the 2's complement value of current being detected at the sensor, measured in units of 1 milliamp.

Table bah - Element control bytes for current sensor

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								

Code 14h, SCSI Target Port element type

Table bag - Element status bytes for SCSI Target Port

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								Enabled

Table bah - Element control bytes for SCSi Target Port

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								Enable

Byte 3, bit 0
        Enabled (status)
        1 = SCSI target port is enabled
        Enable (control)
        1 = SCSI target port shall be enabled

Code 15h, SCSI Initiator Port element type

Table bag - Element status bytes for SCSI Initiator Port

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								Enabled

Table bah - Element control bytes for SCSi Initiator Port

Bits Bytes	7	6	5	4	3	2	1	0
1								
2								
3								Enable

Byte 3, bit 0
      Enabled (status)
      1 = SCSI initiator port is enabled
      Enable (control)
      1 = SCSI initiator port shall be enabled

2.3 Definition of enclosure services device model

A new section is added to SPC or to the appropriate document to describe the enclosure services device model. The model uses a new device type code defined in the INQUIRY command. The model is added as section 11 of SPC revision 8. The description of parameters for devices obeying the model is added as section 12 of SPC revision 8.

11   Model and commands for enclosure services devices

11.1   Models for access to enclosure services devices

Two architectures may be used to transfer enclosure services information to and from an enclosure services device.

An application client may address the enclosure services as a logical unit having the peripheral device type of enclosure services device. The commands for this model are described in clause 11.2. The model uses the SEND DIAGNOSTIC command and the enclosure services outbound pages to set various indicators and states in the enclosure, allowing the enclosure to provide the most appropriate environment for the other SCSI logical units contained within it. Similarly, the application client may request information from the enclosure services logical unit using the RECEIVE DIAGNOSTIC RESULTS command and the enclosure services inbound pages to examine various status and warning information available from the enclosure. The pages and page formats are defined in section 8.1.

An application client may also be able to address the enclosure services using some other peripheral device type as a transport for enclosure services information to and from the application client. Such peripheral devices have a port that communicates with the enclosure services circuitry. The actual enclosure services device is not visible as a SCSI device, but merely transmits the standard enclosure services bit patterns to and from the addressed SCSI device for transport. Those devices shall use the same SEND DIAGNOSTIC and RECEIVE

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DIAGNOSTIC RESULTS commands that would be used by an enclosure services device, but otherwise support the device model specified by their peripheral device type value. Support for the enclosure services pages is determined by using the RECEIVE DIAGNOSTIC RESULTS supported diagnostics page. The existence of an enclosure services port to the device is determined by requesting the configuration page.

11.2 Commands for enclosure services devices

The commands for enclosure services devices shall be as shown in table nn. All remaining operation codes are reserved for future standardization.

Table nn - Commands for enclosure services devices

Command name	Operation Code	Type	Subclause
INQUIRY	12h	M	7.5
MODE SELECT (6)	15h	O	7.8
MODE SELECT (10)	55h	O	7.9
MODE SENSE (6)	1Ah	O	7.10
MODE SENSE (10)	5Ah	O	7.11
PERSISTENT RESERVE IN	5Eh	O	TBD
PERSISTENT RESERVE OUT	5Fh	O	TBD
RECEIVE DIAGNOSTIC RESULTS	1Ch	M	7.16
RELEASE(6)	17h	O	7.17
RELEASE(10)	57h	O	7.18
REQUEST SENSE	03h	M	7.20
RESERVE(6)	16h	O	7.21
RESERVE(10)	56h	O	7.22
SEND DIAGNOSTIC	1Dh	M	7.23
TEST UNIT READY	00h	M	7.24
WRITE BUFFER	3Bh	0	7.25

Key: M = Command implementation is mandatory
O = Command implementation is optional.

12   Parameters for enclosure services devices

12.1   Diagnostic Parameters

This subclause specifies the descriptors and pages for diagnostic parameters that shall be used with enclosure services devices. The formats for these pages are contained in clause 8.1.

The diagnostic page codes for enclosure services devices are defined in table mm.

Table mm - Diagnostic page codes

Page Code	SEND DIAGNOSTIC	Mandatory/ Optional	RECEIVE DIAGNOSTIC RESULTS	Mandatory/ Optional
00h	N/A		Supported diagnostics	Mandatory
01h	N/A		Enclosure Services Config	Mandatory
02h	Enclosure Services Control	Mandatory	Enclosure Services Status	Mandatory
03h	N/A		Enclosure Services Help Text	Optional
04h	Enclosure Services String Out	Optional	Enclosure Services String In	Optional

2.4 Additional ASC/ASCQ for enclosure services function integrated into devices.

Seven new ASC/ASCQ values should be defined for conditions associated with enclosure services or with the delivery of enclosure services information.

Enclosure Failure: This ASC/ASCQ is provided to indicate when a critical or an unrecoverable enclosure failure has been detected by the enclosure. This is provided using the Sense Key of HARDWARE ERROR. Further information may be available using the REQUEST DIAGNOSTIC RESULTS command and requesting the enclosure services in page. This condition can only be presented by an enclosure services type device for a command other than SEND DIAGNOSTIC or RECEIVE DIAGNOSTIC RESULTS.

Enclosure Degraded Warning: This ASC/ASCQ is provided to indicate that an informational condition or a noncritical failure has been detected by the enclosure. This is provided using the Sense Key of RECOVERED ERROR and may be managed by the Informational Exceptions Control mode page. Further information may be available using the RECEIVE DIAGNOSTIC RESULTS command and requesting the enclosure services in page. This condition can only be presented by an enclosure services type device for a command other than SEND DIAGNOSTIC or RECEIVE DIAGNOSTIC RESULTS.

Unspecified Enclosure Services Failure: This ASC/ASCQ is provided to indicate that the enclosure services device has failed in an unknown manner. This condition can be presented by any device that provides enclosure services access.

Unsupported Enclosure Function: This ASC/ASCQ indicates that the device has been asked to invoke an enclosure services function that does not exist. This condition can be presented by any device that provides enclosure services access.

Enclosure Services Unavailable: This ASC/ASCQ indicates that the device has been asked to invoke an enclosure services function that is temporarily busy or unavailable. This condition can be presented by any device that provides enclosure services access.

Enclosure Transfer Failure: This ASC/ASCQ indicates that the device communication with the enclosure services function has failed. This condition can be presented by any device that provides enclosure services access.

Enclosure Transfer Refused: This ASC/ASCQ indicates that the device or the enclosure services function indicated either an error or an invalid format in their communication. This condition can be presented by any device that provides enclosure services access.

Table TBD - Summary of new ASC/ASCQs required

ASC/ASCQ	SEND DIAGNOSTIC
TBD1/0	Enclosure failure
TBD2/0	Enclosure degraded warning
TBD3/0	Unspecified Enclosure Services Failure
TBD3/1	Unsupported Enclosure Function
TBD3/2	Enclosure Services Unavailable
TBD3/3	Enclosure Transfer Failure
TBD3/4	Enclosure Transfer Refused

2.5 Additional MODE SENSE/MODE SELECT pages for enclosure services.

The mode select pages defined for all devices should include the necessary definitions for support of devices that support enclosure services. This will be added as a new section to section 8.3, probably placed alphabetically between sections 8.3.2 and 8.3.3. In addition, Table 83 will need to have an additional entry to include the new optional page. The entry is obvious, and so will not be expanded here. The text of the new section will be as follows:

8.3.n Enclosure services management page.

The enclosure services management page (see table qq) provides controls over those SCSI features involving communication with the enclosure for a SCSI device.

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Table qq" Enclosure services management page

Bits Bytes	7	6	5	4	3	2	1	0
0	PS	Rsrvd	Page Code (TBDh)					
1	Page length							
2	Reserved							
3	Reserved							
4	Reserved							
5							TD	EnblTD
6	(MSB)	Maximum disconnected time						
7								(LSB)

The optional TD (Timed Disconnect) bit shall be set to 1 by the device server in the MODE SENSE command if the timed disconnect function is implemented by the device server. The bit shall be set to 0 if the timed disconnect function is not supported by the device server. The bit shall be ignored by the device server in the MODE SELECT command.

The EnblTD (Enable Timed Disconnect) bit shall be supported by the device server if it supports the timed disconnect function. The application client uses the EnblTD to enable or disable the use of the timed disconnect function by the device server. If the EnblTD is set to 1, the device server shall enable the timed disconnect function. If the EnblTD is set to 0, the device server shall disable the timed disconnect function. In a MODE SENSE command, the EnblTD shall be set to 1 if the timed disconnect function is enabled and to 0 if the function is not enabled.

The maximum disconnected time indicates the maximum time that a device server may choose to remain disconnected after the transmission of a REQUEST DIAGNOSTIC RESULTS CDB to the device server. The value is specified in units of 100 milliseconds.

When a REQUEST DIAGNOSTIC RESULTS command is transmitted to a device that supports enclosure services and the EnblTD bit has been set to 1 to enable timed disconnect, the device may disconnect and wait up to the time specified by the maximum disconnected time field before returning the appropriate parameter page. The device will normally perform this delay operation only for status pages. If a noncritical, critical, or unrecoverable event is present or occurs during the disconnected period, the device shall report the event by returning the proper status page as soon as possible. The intent of the timed disconnect function is to allow an application client to execute status polling commands relatively infrequently, while still learning quickly of any important occurrences in the enclosure.

2.6 Bibliography and references

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A bibliography with an entry for the Small Form Factor Committee specification SFF-8045 (SCA-2 disk drive for Fibre Channel Loop Attachment) shall be created.
The references need to include: Fibre Channel Physical and Signaling Interface (FC-PH), ANS X3.230-1995.

3 Administrative Information

3.1 Issues and questions

1)   MIB

It has been suggested that a MIB/MIF be created for the enclosure services model. This is presently outside the scope of the project.

3.2 Control of document

March 9, 1996, Revisions from 2.1 to 3.0

1)   Slot ID

Slot ID is added to SCSI device bay/slot element. See table from 8.1.8.

2)   Global field of configuration page expanded

The global field was expanded to include:
        Global ID (8)
        Vendor ID (8)
        Product ID (16)
        Revision ID (4)

The fields are required to be present, but the inclusion of appropriate values in the fields is optional to the device. See table in section 8.1.2 and subsequent bit definitions.

3)   INQUIRY enclosure services supported bit

A bit is placed in the INQUIRY command's data field to indicate that a device that does not follow the enclosure services device model actually supports the enclosure services commands. See section 2.1.

4)   Threshold page

A threshold page is designed to allow the optional specification of values for temperature, voltage, current, and airflow. Each threshold element contains four one-byte values specifying a high critical, low critical, high warning, and low warning value. The threshold page may be set or sensed, although the enclosure device could ignore invalid values, modifying them to values it feels are more appropriate. The page is defined in 8.1.8.

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5)   Fast polling

A fast polling mechanism is provided that uses a timed disconnect. A MODE SENSE/SELECT page enables the optional timed disconnect and sets the maximum disconnect time value (2 bytes with 100 ms resolution). The target can then optionally wait up to the maximum disconnect time value for the RECEIVE DIAGNOSTIC RESULTS command before it is required to complete the command. If a polling event returns before the maximum disconnect time value is approached, the event can be reported immediately using the pending command. The polling event would be any status transition that would change the value of the summary bits in the status page or any noncritical, critical, or unrecoverable condition. This function is defined in section 2.5, 8.3.n.

6)   Improve notification of configuration changes

An enclosure services device shall provide UNIT ATTENTION to a command if a new configuration has been established in the device. The definition of a new configuration is a change that modifies the configuration page (i.e., a second string of disk drive slots is added to the system). Status changes (i.e., the installation of a new disk drive in an existing slot) is managed by the information provided in the status page. See 8.1.2

An enclosure services device shall specify a generation code in the configuration page and status page. The generation field is incremented every time a change in the configuration page takes place. The generation field is not incremented by changes in the status page. The generation field simplifies management by layered or independent processes. This is described in sections 8.1.2 and 8.1.3.

7)   Allow set of summary status field

The summary status field will be made settable in the control page. See section 8.1.3

8)   Audible Alarm element

The speaker element is renamed as the audible alarm element. The element is provided with controls and indicators that distinguish different tones and intensities for the four classes of indication. In addition, a reminder tone is distinguished. Muting and a mute signal are provided. See section 8.1.11

9)   Fan speed

Seven fan speeds are provided instead of 3.

10)   Predicted Failure Indicator

A standard predicted failure indicator is provided for all relevant elements in the control field. See section 8.1.11.

11)   Language element

A language element is defined. While the recommendation has been made that the Unicode structure be used, it is not clear which standard is most appropriate. A default of technical English with ASCII character encoding is defined. See section 8.1.11.

10)   Communication Port element

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A communication port element is defined. The port may be enabled or disabled. Additional status is managed inside the port. See section 8.1.11.

11)   Element number reference

The text is clarified to indicate that element order is fixed and is related to the location of the element in a vendor unique manner. See section 8.1.3.

12)   EFW removed

EFW is removed. No one has any use for it, especially given all the other capabilities that can be implemented so much more naturally in the enclosure services command set. This changes sections 1.2, 8.1.3, section 2.5 (8.3.n)

13) Disk slot status completely reformatted.

The disk slot status is redefined into two separate pages, one designed to provide enclosure information, the other designed to provide array relationships. The bits of the elements are defined accordingly. Affected sections include:

8.1, 8.1.3, 8.1.4, 8.1.9, and 8.1.11.

I have arbitrarily required that disk slots be defined first in the configuration page, and therefore in all the other pages that order enclosure elements. (See 8.1.2)

14) Additional power supply indicators

Power supply indicators are provided for over and under voltage and for over current. (See 8.1.11)

15) New elements

The following new element definitions are provided in section 8.1.11.
Language element
Voltage Sensor Element
Current Sensor Element
SCSI Target Port Element
SCSI Initiator Port Element
Communications Port Element

16) Sensor disable

A sensor disable bit was added to the general control field.

17) External bit

An external bit is added to the configuration page type descriptor to qualify a group of elements as being mounted external to the enclosure being addressed, but still being under direct control of that enclosure processor.

18) Renamed fan element

The fan element is renamed the cooling element.

19) New element status code

A new element status code of "not available" is created, indicating that while an element is installed, and while it does not have any known failures, its operation has not been invoked.

20) New temperature state

An undertemperature warning and failure indication are provided.

21) UPS Batter element

The UPS battery element is combined with the UPS element. The following UPS status bits are identified, although further work is expected on these details.

> AC line in lo
>
> AC line in hi
>
> AC line in quality failure
>
> AC line in fail
>
> DC in fail
>
> UPS fail
>
> Loss of power warning
>
> UPS interface failure
>
> Battery fail
>
> Battery predicted failure
>
> Charging status of battery (minutes of charge, 0-255)

22) Port Transceivers

A loss of light and laser failure indication were added to this element.

23) ASC/ASCQ clarification

Some clarifying text has been added to the ASC/ASCQ descriptions, but I believe that some of the failures should be removed.

24) Element descriptor page

An element descriptor page is defined to provide revision numbers and part numbers for FRUs. The page uses a variable length descriptor field for each defined element. The field is an ASCII field and contains vendor unique information.