Date: September 30, 2005

To: T10 Committee (SCSI)

From: George Penokie (IBM/Tivoli)

Subject: SBC-3, SPC-4: Application ownership of protection information Reference Tag

1 Overview

Some of the current applications using proprietary end-to-end protection method would like to convert to using the protection defined in the SBC and SPC standards. However, the methods used require a larger application tag field than is currently defined. They also imbed information that performs a similar function to the reference tag field. As a result they would like to have the option to expand the application tag field to include the reference tag field.

The following proposal requests the RTO_EN bit be expanded to a 3 bit field to allow different usages of the reference tag field (e.g., setting the RTO_EN field to 010b would have the effect of preventing the device server from modifying the reference tag). A bit is also added to Extended INQUIRY Data VPD page to inform the application client if this option is supported.

Changes to SPC-4

1.0.1 Standard INQUIRY data

The standard INQUIRY data (see table 1) shall contain at least 36 bytes.

Table 1 — Standard INQUIRY data format

Bit / Byte	7	6	5	4	3	2	1	0
0	PERIPHERAL QUALIFIER			PERIPHERAL DEVICE TYPE				
1	RMB	Reserved						
2	VERSION							
3	Obsolete	Obsolete	NORMACA	HISUP	RESPONSE DATA FORMAT			
4	ADDITIONAL LENGTH (n-4)							
5	SCCS	ACC	TPGS		3PC	Reserved		PROTECT
6	BQUE	ENCSERV	VS	MULTIP	MCHNGR	Obsolete	Obsolete	ADDR16[a]
7	Obsolete	Obsolete	WBUS16[a]	SYNC[a]	LINKED	Obsolete	CMDQUE	VS
8	(MSB)	T10 VENDOR IDENTIFICATION						
15								(LSB)
16	(MSB)	PRODUCT IDENTIFICATION						
31								(LSB)
32	(MSB)	PRODUCT REVISION LEVEL						
35								(LSB)
36	Vendor specific							
55								
56	Reserved				CLOCKING[a]		QAS[a]	IUS[a]
57	Reserved							
58	(MSB)	VERSION DESCRIPTOR 1						
59								(LSB)
	⋮							
72	(MSB)	VERSION DESCRIPTOR 8						
73								(LSB)
74	Reserved							
95								
	Vendor specific parameters							
96	Vendor specific							
n								

[a] The meanings of these fields are specific to SPI-5 (see 6.4.3). For SCSI transport protocols other than the SCSI Parallel Interface, these fields are reserved.

....

A PROTECT bit set to zero indicates that the logical unit does not support protection information (i.e., type 0 protection) (see 7.6.4 and SBC-~~2~~3). A PROTECT bit set to one indicates that the logical unit supports ~~protection information~~ type 1 protection, type 2 protection, or type 3 protection (see SBC-3). The RTO field (see 1.0.2) indicates which type of protection the logical unit supports.

....

1.0.2 Extended INQUIRY Data VPD page

The Extended INQUIRY Data VPD page (see table 2) provides the application client with a means to obtain information about the logical unit.

Table 2 — Extended INQUIRY Data VPD page

Bit / Byte	7	6	5	4	3	2	1	0
0	PERIPHERAL QUALIFIER			PERIPHERAL DEVICE TYPE				
1	PAGE CODE (86h)							
2	Reserved							
3	PAGE LENGTH (3Ch)							
4	Reserved		RTO			GRD_CHK	APP_CHK	REF_CHK
5	Reserved			GROUP_SUP	PRIOR_SUP	HEADSUP	ORDSUP	SIMPSUP
6	Reserved						NV_SUP	V_SUP
7	Reserved							
63								

The PERIPHERAL QUALIFIER field and the PERIPHERAL DEVICE TYPE field are as defined in 6.4.2.

The PAGE LENGTH field specifies the length of the following VPD page data and shall be set to 60. The relationship between the PAGE LENGTH field and the CDB ALLOCATION LENGTH field is defined in 4.3.4.6.

~~A reference tag ownership (RTO) bit set to zero indicates that the logical unit does not support application client ownership of the LOGICAL BLOCK REFERENCE TAG field in the protection information (see SBC-2), if any. A RTO bit set to one indicates that the logical unit supports application client ownership of the LOGICAL BLOCK REFERENCE TAG field.~~

A reference tag ownership (RTO) field (see table 3) indicates the type of protection the logical unit supports.

Table 3 — RTO field

Code	Definition
000b	The logical unit supports type 1 protection (see SBC-3).
001b	The logical unit supports type 2 protection (see SBC-3).
010b	Reserved
011b	The logical unit supports type 3 protection (see SBC-3).
100b - 111b	Reserved

Changes to SBC-3

1.1 Protection information model

1.1.1 Protection information overview

The protection information model provides for protection of user data while it is being transferred between a sender and a receiver. Protection information is generated at the application layer and may be checked by any object associated with the I_T_L nexus. Once received, protection information is retained (e.g., written to medium, stored in non-volatile memory, or recalculated on read back) by the device server until overwritten. Power loss, hard reset, logical unit reset, and I_T nexus loss shall have no effect on the retention of protection information.

Support for protection information shall be indicated in the PROTECT bit in the standard INQUIRY data (see SPC-3).

~~For commands that are using protection information, the data-in buffer and/or data-out buffer shall consist of logical blocks with both user data and protection information. For commands that are not using protection information, the data-in buffer and/or data-out buffer shall consist of logical blocks with only user data.~~

If the logical unit is formatted with protection information and the EMDP bit is set to one in the Disconnect-Reconnect mode page (see SPC-3), then checking of the logical block reference tag within the service delivery subsystem without accounting for modified data pointers and data alignments may cause false errors when logical blocks are transmitted out of order.

1.1.2 Protection types

1.1.2.1 Protection types overview

The content of protection information is dependent on the type of protection to which a logical unit has been formatted.

The type of protection supported by the logical unit shall be indicated in the RTO field in the Extended INQUIRY Data VPD page (see SPC-4). The current protection type shall be indicated in the RTO_EN field in the READ CAPACITY(16) command (see 1.6).

An application client may format the logical unit to a specific type of protection using the RTO_REQ bit and PROTECTION FIELD USAGE field in the FORMAT command (see 1.2).

The media access commands that a device server is allowed to accept when the logical unit has been formatted for protection information depends on the type of protection in effect. When used in relation to types of protection, the term “media access commands” is defined as the following commands:

a) READ (10);
b) READ (12);
c) READ (16);
d) READ (32);
e) VERIFY (10);
f) VERIFY (12);
g) VERIFY (16);
h) VERIFY (32);
i) WRITE (10);
j) WRITE (12);
k) WRITE (16);
l) WRITE (32);
m) WRITE AND VERIFY (10);
n) WRITE AND VERIFY (12);
o) WRITE AND VERIFY (16);
p) WRITE AND VERIFY (32);
q) WRITE SAME (10);
r) WRITE SAME (16);

s) XDWRITE (10); and
t) XDWRITEREAD (10).

The device server may allow the READ (6) command (see 1.3) and the WRITE (6) command (see 1.9) regardless of the type of protection to which the logical unit has been formatted.

1.1.2.2 Type 0 protection

Type 0 protection defines no protection over that which is defined within the transport protocol.

A logical unit that has been formatted with protection information disabled (see 1.2) or a logical unit that does not support protection information (i.e., the PROTECT bit set to zero in the Standard INQUIRY data (see SPC-4)) has type 0 protection.

If type 0 protection is enabled and the RDPROTECT field, WRPROTECT field, or VRPROTECT field is set to a non-zero value, then media commands are invalid and may be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.

1.1.2.3 Type 1 protection

Type 1 protection:

a) defines the content of the LOGICAL BLOCK GUARD field;
b) does not define the content of the LOGICAL BLOCK APPLICATION TAG field; and
c) defines the content the LOGICAL BLOCK REFERENCE TAG field.

If type 1 protection is enabled, then the following media commands are invalid and shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE:

a) READ (32);
b) VERIFY (32); and
c) WRITE (32).

For valid media access commands in which the RDPROTECT field, WRPROTECT field, or VRPROTECT field is set to:

a) zero, the data-in buffer and/or data-out buffer associated with those commands shall consist of logical blocks with only user data; or
b) a non-zero value, the data-in buffer and/or data-out buffer shall consist of logical blocks with both user data and protection information.

1.1.2.4 Type 2 protection

Type 2 protection:

a) defines the content of the LOGICAL BLOCK GUARD field;
b) does not define the content of the LOGICAL BLOCK APPLICATION TAG field; and
c) defines, except for the first logical block, the content of the LOGICAL BLOCK REFERENCE TAG field.

If type 2 protection is enabled and the RDPROTECT field, WRPROTECT field, or VRPROTECT field is set to a non-zero value, then the following media commands are invalid and shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE:

a) READ (10);
b) READ (12);
c) READ (16);
d) VERIFY (10);
e) VERIFY (12);
f) VERIFY (16);
g) WRITE (10);
h) WRITE (12);

i) WRITE (16);
j) WRITE AND VERIFY (10);
k) WRITE AND VERIFY (12);
l) WRITE AND VERIFY (16);
m) WRITE AND VERIFY (32);
n) WRITE SAME (10);
o) WRITE SAME (16);
p) XDWRITE (10); and
q) XDWRITEREAD (10).

For valid media access commands in which the RDPROTECT field, WRPROTECT field, or VRPROTECT field is set to:

a) zero, the data-in buffer and/or data-out buffer associated with those commands shall consist of logical blocks with only user data; or
b) a non-zero value, the data-in buffer and/or data-out buffer shall consist of logical blocks with both user data and protection information.

1.1.2.5 Type 3 protection

Type 3 protection:

a) defines the content of the LOGICAL BLOCK GUARD field within the logical blocks of the data-in buffer and/or data-out buffer;
b) does not define the content of the LOGICAL BLOCK APPLICATION TAG field; and
c) does not define the content of the LOGICAL BLOCK REFERENCE TAG field.

If type 3 protection is enabled, then the following media commands are invalid and shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE:

a) READ (32);
b) VERIFY (32); and
c) WRITE (32).

For valid media access commands in which the RDPROTECT field, WRPROTECT field, or VRPROTECT field is set to:

a) zero, the data-in buffer and/or data-out buffer associated with those commands shall consist of logical blocks with only user data; or
b) a non-zero value, the data-in buffer and/or data-out buffer shall consist of logical blocks with both user data and protection information.

1.1.3 Protection information format

Table 4 defines the placement of protection information in a logical block.

Table 4 — User data and protection information format

Byte\Bit	7	6	5	4	3	2	1	0
0	USER DATA							
n - 1								
n	(MSB)	LOGICAL BLOCK GUARD						
n + 1								(LSB)
n + 2	(MSB)	LOGICAL BLOCK APPLICATION TAG						
n + 3								(LSB)
n + 4	(MSB)	LOGICAL BLOCK REFERENCE TAG						
n + 7								(LSB)

The USER DATA field shall contain user data. The contents of the USER DATA field shall be used to generate and check the CRC contained in the LOGICAL BLOCK GUARD field.

The LOGICAL BLOCK GUARD field contains the CRC (see 4.16.3) of the contents of the USER DATA field.

The LOGICAL BLOCK APPLICATION TAG field is set by the application client. A LOGICAL BLOCK APPLICATION TAG field set to FFFFh disables checking of all protection information for the logical block when reading from the medium. Otherwise, the contents of the logical block application tag are not defined by this standard. The LOGICAL BLOCK APPLICATION TAG field may be modified by a device server if the ATO bit is set to zero in the Control mode page (see SPC-3). The contents of the LOGICAL BLOCK APPLICATION TAG field shall not be used to generate or check the CRC contained in the LOGICAL BLOCK GUARD field.

~~The LOGICAL BLOCK REFERENCE TAG field is an incrementing value associated with the logical block. The LOGICAL BLOCK REFERENCE TAG field of the first logical block in the data-in buffer and/or data-out buffer depends on the command being processed:~~

~~a) for a command that does not include an EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field (e.g., READ (16)) the LOGICAL BLOCK REFERENCE TAG field of the first logical block in the data-in buffer and/or data-out buffer shall contain the least significant four bytes of the LBA contained in the LOGICAL BLOCK ADDRESS field of the command; and~~

~~b) for a command that does include an EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field (e.g., READ (32)) the LOGICAL BLOCK REFERENCE TAG field of the first logical block shall contain the value in the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field of the command. These commands are only processed if the medium was formatted with application client ownership of the logical block reference tag (i.e., with the RTO_REQ bit set to one in the FORMAT UNIT command (see 5.2)).~~

~~Each subsequent logical block in the data-in buffer and/or data-out buffer shall contain a logical block reference tag field with the logical block reference tag of the previous logical block plus one.~~

The LOGICAL BLOCK REFERENCE TAG field of the first logical block in the data-in buffer and/or data-out buffer shall contain the value specified in table 5.

Table 5 — Contents of the LOGICAL BLOCK REFERENCE TAG field of the first logical block in the data-in buffer and/or data-out buffer

Protection Type	Content of the LOGICAL BLOCK REFERENCE TAG field of the first logical block in the data-in buffer and/or data-out buffer
Type 1 protection (see 1.1.2.3)	The least significant four bytes of the LBA contained in the LOGICAL BLOCK ADDRESS field of the command.
Type 2 protection (see 1.1.2.4)	The value in the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field of the READ (32) command, VERIFY (32) command or WRITE (32) command.
Type 3 protection (see 1.1.2.5)	Not defined in this standard.

The LOGICAL BLOCK REFERENCE TAG field subsequent logical blocks in the data-in buffer and/or data-out buffer shall be set as specified in table 6.

Table 6 — Setting the LOGICAL BLOCK REFERENCE TAG field of the subsequent logical blocks in the data-in buffer and/or data-out buffer

Protection Type	The content of the LOGICAL BLOCK REFERENCE TAG field of each subsequent logical block in the data-in buffer and/or data-out buffer
Type 1 protection (see 1.1.2.3) and Type 3 protection (see 1.1.2.5)	The logical block reference tag of the previous logical block plus one.
Type 2 protection (see 1.1.2.4)	Not defined in this standard.

The contents of the LOGICAL BLOCK REFERENCE TAG field shall not be used to generate or check the CRC contained in the LOGICAL BLOCK GUARD field.

1.2 FORMAT UNIT command

1.2.1 FORMAT UNIT command overview

...

A format protection information (FMTPINFO) bit (see table 9) specifies if the device server enables or disables the use of protection information. ~~set to zero specifies that the device server shall disable the use of protection information (see 4.16) and format the medium to the block length specified in the mode parameter block descriptor of the mode parameter header (see SPC-3). A FMTPINFO bit set to one specifies that the device server shall enable the use of protection information (see 4.16) and format the medium to the block length specified in the mode parameter block descriptor of the mode parameter header plus eight (e.g., if the block length is 512, then the formatted block length is 520).~~ Following a successful format, the RTO_EN ~~bit~~ field in the READ CAPACITY (16) parameter data (see 1.6.2) indicates whether protection information (see 4.16) is enabled.

The reference tag own request (RTO_REQ) bit (see table 9) specifies whether the application client or the device server has ownership of the LOGICAL BLOCK REFERENCE TAG field in protection information (see 4.16.2). ~~If the FMTPINFO bit is set to one, and the RTO_REQ bit is set to one, the device server shall enable application client ownership of the LOGICAL BLOCK REFERENCE TAG field. If the FMTPINFO bit set to one and the RTO_REQ bit is set to zero, the device server shall disable application client ownership (i.e., enable device server ownership) of the LOGICAL BLOCK REFERENCE TAG field. If the FMTPINFO bit is set to zero and the RTO_REQ bit is set to one the device server shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.~~ Following a successful format, the RTO_EN field in the READ CAPACITY (16) parameter data (see 1.6.2) indicates the type of protection currently in effect on the logical unit.

When protection information is written during a FORMAT UNIT command (i.e., the FMTPINFO bit is set to one) protection information shall be written to a default value of FFFFFFFF_FFFFFFFFh.

....

1.2.1.1 Parameter list header

The parameter list headers (see table 7 and table 8) provide several optional format control parameters. Device servers that implement these headers provide the application client additional control over the use of the four defect sources, and the format 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 with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The short parameter list header (see table 7) is used if the LONGLIST bit is set to zero in the FORMAT UNIT CDB.

Table 7 — Short parameter list header

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved					PROTECTION FIELDS USAGE		
1	FOV	DPRY	DCRT	STPF	IP	Obsolete	IMMED	Vendor specific
2	(MSB)	DEFECT LIST LENGTH						
3								(LSB)

The long parameter list header (see table 8) is used if the LONGLIST bit is set to one in the FORMAT UNIT CDB.

Table 8 — Long parameter list header

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved					PROTECTION FIELDS USAGE		
1	FOV	DPRY	DCRT	STPF	IP	Obsolete	IMMED	Vendor specific
2	Reserved							
3	Reserved							
4	(MSB)	DEFECT LIST LENGTH						
7								(LSB)

The PROTECTION FIELD USAGE field in combination with the FMTPINFO bit and the RTO_REQ bit (see table 9) specifies the requested protection type (see 1.1.2).

Table 9 — FMTPINFO bit, RTO_REQ bit, and PROTECTION FIELD USAGE field

Device server indication		Application client speficifation			Description
RTO [a]	PROTECT [b]	FMTPINFO	RTO_REQ	PROTECTION FIELD USAGE	
xxxb	0	0	0	000b	The logical unit shall be formatted to type 0 protection [c] (see 1.1.2.2) resulting in the RTO_ENABLE field [d] being set to 000b.
xxxb	0	0	0	>000b	Illegal [e]
xxxb	0	0	1	xxxb	Illegal [f]
xxxb	0	1	x	xxxb	Illegal [f]
xxxb	1	0	0	000b	The logical unit shall be formatted to type 0 protection [c] (see 1.1.2.2) resulting in the RTO_ENABLE field [d] being set to 000b.
xxxb	1	0	0	>000b	Illegal [e]
xxxb	1	0	1	xxxb	Illegal [f]
000b 001b 011b	1	1	0	000b	The logical unit shall be formatted to type 1 protection [g] (see 1.1.2.3) resulting in the RTO_ENABLE field [d] being set to 000b.
000b 001b 011b	1	1	0	>000b	Illegal [e]
000b	1	1	1	xxxb	Illegal [f]
001b	1	1	1	000b	The logical unit shall be formatted to type 2 protection [g] (see 1.1.2.4) resulting in the RTO_ENABLE field [d] being set to 001b.
001b	1	1	1	001b	Illegal [e]
001b	1	1	1	010b - 111b	Reserved
011b	1	1	1	001b	The logical unit shall be formatted to type 3 protection. [g] (see 1.1.2.5) resulting in the RTO_ENABLE field [d] being set to 010b.
011b	1	1	1	010b - 111b	Reserved
100b	1	1	x	xxxb	Reserved

[a] See the Extended INQUIRY Data VPD page (see SPC-3) for the definition of the RTO field.
[b] See the standard INQUIRY data (see SPC-3) for the definition of the PROTECT bit.
[c] The device server shall format the medium to the block length specified in the mode parameter block descriptor of the mode parameter header (see SPC-3).
[d] See the READ CAPACITY command (see 1.6.1) for the definition of the RTO_ENABLE field.
[e] The device server shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.
[f] The device server shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.
[g] The device server shall format the medium to the block length specified in the mode parameter block descriptor of the mode parameter header plus eight (e.g., if the block length is 512, then the formatted block length is 520). Following a successful format, the PROT_EN bit in the READ CAPACITY (16) parameter data (see 1.6.2) indicates whether protection information (see 4.16) is enabled.

A format options valid (FOV) bit set to zero specifies that the device server shall use its default settings for the DPRY, DCRT, STPF, and IP bits. If the FOV bit is set to zero, the application client shall set these bits to zero. If the FOV bit is set to zero and any of the other bits listed in this paragraph are not set to zero, the device server

shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

1.3 READ (6) command

...

The device server shall check the protection information read from the medium before returning status for the command as described in table 10.

Table 10 — Protection information checking for READ (6)

Logical unit formatted with protection information	Shall device server transmit protection information?	Field in protection information [f]	Extended INQUIRY Data VPD page bit value [d]	If check fails [b] [c], additional sense code
Yes	No	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
			GRD_CHK = 0	No check performed
		LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [a]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
			APP_CHK = 0	No check performed
		LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [g]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
			REF_CHK = 0	No check performed
No		No protection information available to check		

[a] The device server checks the logical block application tag only if it has knowledge of the contents of the LOGICAL BLOCK APPLICATION TAG field. The method for acquiring this knowledge is not defined by this standard.

[b] If an error is reported, the sense key shall be set to ABORTED COMMAND.

[c] If multiple errors occur, the selection of which error to report is not defined by this standard.

[d] See the Extended INQUIRY Data VPD page (see SPC-3) for the definitions of the GRD_CHK bit, APP_CHK bit, and REF_CHK bit.

[e] ~~If the device server detects a LOGICAL BLOCK APPLICATION TAG field set to FFFFh, it shall not check any protection information in the associated logical block.~~

[f] If the device server detects a:

a) LOGICAL BLOCK APPLICATION TAG field set to FFFFh and type 1 protection (see 1.1.2.3) or type 2 protection (see 1.1.2.4) is enabled ; or

b) LOGICAL BLOCK APPLICATION TAG field set to FFFFh, LOGICAL BLOCK REFERENCE TAG field set to FFFF FFFFh, and type 3 protection (see 1.1.2.5) is enabled,

then the device server shall not check any protection information in the associated logical block.

[g] ~~If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6)~~ If type 1 protection is enabled, the device server checks the logical block reference tag by comparing it to the lower 4 bytes of the LBA associated with the logical block. ~~If the RTO_EN bit is set to one~~ If type 2 protection or type 3 protection is enabled, the device server checks the logical block reference tag only if it has knowledge of the contents of the LOGICAL BLOCK REFERENCE TAG field. The method for acquiring this knowledge is not defined by this standard.

1.4 READ (10) command

...

The device server shall check the protection information read from the medium before returning status for the command based on the RDPROTECT field as described in table 11.

Table 11 — RDPROTECT **field** (part 1 of 4)

Code	Logical unit formatted with protection information	Shall device server transmit protection information?	Field in protection information [i]	Extended INQUIRY Data VPD page bit value [g]	If check fails [d] [f], additional sense code
000b ~~j~~	Yes	No	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
				GRD_CHK = 0	No check performed
			LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
				APP_CHK = 0	No check performed
			LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [k]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
				REF_CHK = 0	No check performed
	No		No protection information available to check		
001b 101b [b] ~~j~~	Yes	Yes [e]	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
				GRD_CHK = 0	No check performed
			LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
				APP_CHK = 0	No check performed
			LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [k]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
				REF_CHK = 0	No check performed
	No [a]	No protection information available to transmit to the data-in buffer or for checking			

Table 11 — RDPROTECT **field** (part 2 of 4)

Code	Logical unit formatted with protection information	Shall device server transmit protection information?	Field in protection information [i]	Extended INQUIRY Data VPD page bit value [g]	If check fails [d] [f], additional sense code
010b [b] [j]	Yes	Yes [e]	LOGICAL BLOCK GUARD	No check performed	
			LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
				APP_CHK = 0	No check performed
			LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [k]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
				REF_CHK = 0	No check performed
	No [a]	No protection information available to transmit to the data-in buffer or for checking			
011b [b] [j]	Yes	Yes [e]	LOGICAL BLOCK GUARD	No check performed	
			LOGICAL BLOCK APPLICATION TAG	No check performed	
			LOGICAL BLOCK REFERENCE TAG	No check performed	
	No [a]	No protection information available to transmit to the data-in buffer or for checking			

Table 11 — RDPROTECT **field** (part 3 of 4)

Code	Logical unit formatted with protection information	Shall device server transmit protection information?	Field in protection information [i]	Extended INQUIRY Data VPD page bit value [g]	If check fails [d] [f], additional sense code
100b [b] [j]	Yes	Yes [e]	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
				GRD_CHK = 0	No check performed
			LOGICAL BLOCK APPLICATION TAG	No check performed	
			LOGICAL BLOCK REFERENCE TAG	No check performed	
	No [a]	No protection information available to transmit to the data-in buffer or for checking			
110b - 111b	Reserved				

Table 11 — RDPROTECT **field** (part 4 of 4)

Code	Logical unit formatted with protection information	Shall device server transmit protection information?	Field in protection information [i]	Extended INQUIRY Data VPD page bit value [g]	If check fails [d] [f], additional sense code

[a] A read operation to a logical unit that supports protection information (see 4.16) and has not been formatted with protection information shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[b] If the logical unit does not support protection information the requested command should be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[c] The device server shall check the logical block application tag if it has knowledge of the contents of the LOGICAL BLOCK APPLICATION TAG field. If the READ (32) command (see 1.5) is used and the ATO bit is set to one in the Control mode page (see SPC-3), this knowledge is acquired from the EXPECTED LOGICAL BLOCK APPLICATION TAG field and the LOGICAL BLOCK APPLICATION TAG MASK field in the CDB. Otherwise, this knowledge may be acquired by a method not defined by this standard.

[d] If an error is reported, the sense key shall be set to ABORTED COMMAND.

[e] Transmit protection information to the data-in buffer.

[f] If multiple errors occur, the selection of which error to report is not defined by this standard.

[g] See the Extended INQUIRY Data VPD page (see SPC-3) for the definitions of the GRD_CHK bit, the APP_CHK bit, and the REF_CHK bit.

[h] ~~If the application client or device server detects a LOGICAL BLOCK APPLICATION TAG field set to FFFFh, the checking of all protection information in the associated logical block shall be disabled.~~

[i] If the application client or device server detects a:

a) LOGICAL BLOCK APPLICATION TAG field set to FFFFh and type 1 protection (see 1.1.2.3) or type 2 protection (see 1.1.2.4) is enabled ; or

b) LOGICAL BLOCK APPLICATION TAG field set to FFFFh, LOGICAL BLOCK REFERENCE TAG field set to FFFF FFFFh, and type 3 protection (see 1.1.2.5) is enabled,

then the device server shall not check any protection information in the associated logical block.

[j] ~~If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6), the device server may process the command. If the RTO_EN bit is set to one, READ (10) commands, READ (12) commands, and READ (16) commands with the RDPROTECT field set to 000b may be processed by the device server. If the RTO_EN bit is set to one, the device server shall terminate READ (10) commands, READ (12) commands, and READ (16) commands with the RDPROTECT field not set to 000b with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.~~

[k] ~~If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6)~~ If type 1 protection is enabled, the device server checks the logical block reference tag by comparing it to the lower 4 bytes of the LBA associated with the logical block.

[l] ~~If the RTO_EN bit is set to one the device server checks the logical block reference tag based on the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in the CDB (see 4.16.2).~~ If type 2 protection or type 3 protection is enabled, the device server checks the logical block reference tag if it has knowledge of the contents of the LOGICAL BLOCK REFERENCE TAG field. If type 2 protection is enabled, then this knowledge may be acquired through the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in a READ (32) command (see 1.5). If type 3 protection is enabled, then the method for acquiring this knowledge is not defined by this standard.

1.5 READ (32) command

The READ (32) command (see table 12) requests that the device server read the specified logical block(s) and transfer them to the data-in buffer. Each logical block read includes user data and, if the medium is formatted with protection information enabled, protection information. Each logical block transferred includes user data and may include protection information, based on the RDPROTECT field and the medium format.

The READ (32) command shall only be processed if type 2 protection is enabled (see 1.1.2.4).

~~If the RTO_EN bit field is set to zero in the READ CAPACITY (16) parameter data (see 1.6.2), the device server shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. If the RTO_EN bit field is not set to zero one, the device server may process the command (see 1.1.3).~~

Table 12 — READ (32) command

Byte\Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (7Fh)							
1	CONTROL							
2	Reserved							
5								
6	Reserved			GROUP NUMBER				
7	ADDITIONAL CDB LENGTH (18h)							
8	(MSB)							
9	SERVICE ACTION (0009h)							(LSB)
10	RDPROTECT			DPO	FUA	Reserved	FUA_NV	Reserved
11	Reserved							
12	(MSB)							
19	LOGICAL BLOCK ADDRESS							(LSB)
20	(MSB)							
23	EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG							(LSB)
24	(MSB)							
25	EXPECTED LOGICAL BLOCK APPLICATION TAG							(LSB)
26	(MSB)							
27	LOGICAL BLOCK APPLICATION TAG MASK							(LSB)
28	(MSB)							
31	TRANSFER LENGTH							(LSB)

See the READ (10) command (see 1.4) for the definitions of the GROUP NUMBER field, the RDPROTECT field, the DPO bit, the FUA bit, the FUA_NV bit, the LOGICAL BLOCK ADDRESS field, and the TRANSFER LENGTH field.

When checking of the LOGICAL BLOCK REFERENCE TAG field is enabled (see table 11 in 1.4) the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field contains the value of the LOGICAL BLOCK REFERENCE TAG field expected in the protection information of the first logical block accessed by the command instead of a value based on the LBA (see 4.16.2).

If the ATO bit is set to one in the Control mode page (see SPC-3) and checking of the LOGICAL BLOCK APPLICATION TAG field is enabled (see table 11 in 1.4), the LOGICAL BLOCK APPLICATION TAG MASK field contains a value that is a bit mask for enabling the checking of the LOGICAL BLOCK APPLICATION TAG field in the protection information for each logical block accessed by the command. A LOGICAL BLOCK APPLICATION TAG MASK field bit set to one enables the checking of the corresponding bit of the EXPECTED LOGICAL BLOCK APPLICATION TAG field with the corresponding bit of the LOGICAL BLOCK APPLICATION TAG field in the protection information.

The LOGICAL BLOCK APPLICATION TAG MASK field and the EXPECTED LOGICAL BLOCK APPLICATION TAG field shall be ignored if:

a) the ATO bit is set to zero; or

b) the ATO bit is set to one in the Control mode page (see SPC-3) and checking of the LOGICAL BLOCK APPLICATION TAG field is disabled (see table 11 in 1.4).

1.6 READ CAPACITY (16) command

1.6.1 READ CAPACITY (16) command overview

The READ CAPACITY (16) command (see table 13) requests that the device server transfer parameter data describing the capacity and medium format of the direct-access block device to the data-in buffer. This command is mandatory if the logical unit supports protection information (see 4.16) and optional otherwise. This command is implemented as a service action of the SERVICE ACTION IN operation code (see A.2). This command may be processed as if it has a HEAD OF QUEUE task attribute (see 4.11).

Table 13 — READ CAPACITY (16) command

Byte\Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (9Eh)							
1	Reserved			SERVICE ACTION (10h)				
2	(MSB)							
...				LOGICAL BLOCK ADDRESS				
9								(LSB)
10	(MSB)							
...				ALLOCATION LENGTH				
13								(LSB)
14	Reserved							PMI
15	CONTROL							

See the READ CAPACITY (10) command (see 5.10) for definitions of the LOGICAL BLOCK ADDRESS field and the PMI bit.

The ALLOCATION LENGTH field specifies the maximum number of bytes that the application client has allocated for returned parameter data. An allocation length of zero indicates that no data shall be transferred. This condition shall not be considered as an error. The device server shall terminate transfers to the data-in buffer when the number of bytes specified by the ALLOCATION LENGTH field have been transferred or when all available data has been transferred, whichever is less. The contents of the parameter data shall not be altered to reflect the truncation, if any, that results from an insufficient allocation length.

1.6.2 READ CAPACITY (16) parameter data

The READ CAPACITY (16) parameter data is defined in table 14. Any time the READ CAPACITY (16) parameter data changes, the device server should establish a unit attention condition as described in 4.6.

Table 14 — READ CAPACITY (16) parameter data

Byte\Bit	7	6	5	4	3	2	1	0
0	(MSB)							
...				RETURNED LOGICAL BLOCK ADDRESS				
7								(LSB)
8	(MSB)							
...				BLOCK LENGTH IN BYTES				
11								(LSB)
12	Reserved				RTO_EN			PROT_EN
13								
...				Reserved				
31								

The RETURNED LOGICAL BLOCK ADDRESS field and BLOCK LENGTH IN BYTES field of the READ CAPACITY (16) parameter data are the same as the in the READ CAPACITY (10) parameter data (see 5.10). The maximum value that shall be returned in the RETURNED LOGICAL BLOCK ADDRESS field is FFFFFFFF_FFFFFFFEh.

~~A reference tag own enable (RTO_EN) bit set to one indicates that application client ownership of the LOGICAL BLOCK REFERENCE TAG field in protection information is enabled (i.e., the medium was formatted with protection information (see 4.16) enabled and the RTO_REQ bit was set to one). An RTO_EN bit set to zero indicates that application client ownership of the LOGICAL BLOCK REFERENCE TAG field in protection information is disabled.~~

The reference tag owner (RTO_EN) field and the PROT_EN bit (see table 15) indicate the logical unit's current type of protection.

Table 15 — RTO_EN field and PROT_EN bit

PROT_EN	RTO_EN	Description
0	xxxb	The logical unit is formatted to type 0 protection (see 1.1.2.2).
1	000b	The logical unit is formatted to type 1 protection (see 1.1.2.3).
1	001b	The logical unit is formatted to type 2 protection (see 1.1.2.4).
1	010b	The logical unit is formatted to type 3 protection (see 1.1.2.5).
1	011b - 111b	Reserved

~~A PROT_EN bit set to one indicates that the medium was formatted with protection information (see 4.16) enabled. A PROT_EN bit set to zero indicates that the medium was not formatted with protection information enabled.~~

1.7 VERIFY (10) command

...

If the BYTCHK bit is set to zero, the device server shall check the protection information read from the medium based on the VRPROTECT field as described in table 16.

Table 16 — VRPROTECT **field with** BYTCHK **set to zero - checking protection information read from the medium** (part 1 of 4)

Code	Logical unit formatted with protection information	Field in protection information [h]	Extended INQUIRY Data VPD page bit value [f]	If check fails [d] [e], additional sense code
000b	Yes	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
			GRD_CHK = 0	No check performed
		LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
			APP_CHK = 0	No check performed
		LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [i]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
			REF_CHK = 0	No check performed
	No	No protection information on the medium to check. Only user data is checked.		
001b 101b [b]	Yes	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
			GRD_CHK = 0	No check performed
		LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
			APP_CHK = 0	No check performed
		LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [i]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
			REF_CHK = 0	No check performed
	No	Error condition [a]		
010b [b]	Yes	LOGICAL BLOCK GUARD	No check performed	
		LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
			APP_CHK = 0	No check performed
		LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [i]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
			REF_CHK = 0	No check performed
	No	Error condition [a]		

Table 16 — VRPROTECT **field with** BYTCHK **set to zero - checking protection information read from the medium** (part 2 of 4)

Code	Logical unit formatted with protection information	Field in protection information [h]	Extended INQUIRY Data VPD page bit value [f]	If check fails [d] [e], additional sense code
011b [b]	Yes	LOGICAL BLOCK GUARD	No check performed	
		LOGICAL BLOCK APPLICATION TAG	No check performed	
		LOGICAL BLOCK REFERENCE TAG	No check performed	
	No	Error condition [a]		

Table 16 — VRPROTECT **field with** BYTCHK **set to zero - checking protection information read from the medium** (part 3 of 4)

Code	Logical unit formatted with protection information	Field in protection information [h]	Extended INQUIRY Data VPD page bit value [f]	If check fails [d] [e], additional sense code
100b [b]	Yes	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
			GRD_CHK = 0	No check performed
		LOGICAL BLOCK APPLICATION TAG	No check performed	
		LOGICAL BLOCK REFERENCE TAG	No check performed	
	No	Error condition [a]		
110b - 111b	Reserved			

Table 16 — VRPROTECT **field with** BYTCHK **set to zero - checking protection information read from the medium** (part 4 of 4)

Code	Logical unit formatted with protection information	Field in protection information [h]	Extended INQUIRY Data VPD page bit value [f]	If check fails [d] [e], additional sense code

[a] A verify operation to a logical unit that supports protection information (see 4.16) and has not been formatted with protection information shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[b] If the logical unit does not support protection information the requested command should be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[c] The device server shall check the logical block application tag if it has knowledge of the contents of the LOGICAL BLOCK APPLICATION TAG field. If the VERIFY (32) command (see 1.8) is used and the ATO bit is set to one in the Control mode page (see SPC-3), this knowledge is acquired from the EXPECTED LOGICAL BLOCK APPLICATION TAG field and the LOGICAL BLOCK APPLICATION TAG MASK field in the CDB. Otherwise, this knowledge may be obtained by a method not defined by this standard.

[d] If an error is reported, the sense key shall be set to ABORTED COMMAND.

[e] If multiple errors occur, the selection of which error to report is not defined by this standard.

[f] See the Extended INQUIRY Data VPD page (see SPC-3) for the definitions of the GRD_CHK bit, the APP_CHK bit, and the REF_CHK bits.

~~[g] If the application client or device server detects a LOGICAL BLOCK APPLICATION TAG field set to FFFFh, the checking of all protection information shall be disabled for the associated logical block.~~

[h] If the application client or device server detects a:

a) LOGICAL BLOCK APPLICATION TAG field set to FFFFh and type 1 protection (see 1.1.2.3) or type 2 protection (see 1.1.2.4) is enabled ; or

b) LOGICAL BLOCK APPLICATION TAG field set to FFFFh, LOGICAL BLOCK REFERENCE TAG field set to FFFF FFFFh, and type 3 protection (see 1.1.2.5) is enabled,

then the device server shall not check any protection information in the associated logical block.

[i] ~~If the rto_en bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6) (i.e., the command is a VERIFY (10) command, a VERIFY (12) command, or a VERIFY (16) command),~~ If type 1 protection is enabled, the device server ~~shall check~~ checks the logical block reference tag by comparing it to the lower 4 bytes of the LBA associated with the logical block. ~~If the RTO_EN bit is set to one (i.e., the command is a VERIFY (32) command), the device server shall check the logical block reference tag based on the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in the CDB (see 4.16.2).~~ If type 2 protection or type 3 protection is enabled, the device server checks the logical block reference tag if it has knowledge of the contents of the LOGICAL BLOCK REFERENCE TAG field. If type 2 protection is enabled, then this knowledge may be acquired through the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in a VERIFY (32) command (see 1.8). If type 3 protection is enabled, then the method for acquiring this knowledge is not defined by this standard.

If the BYTCHK bit is set to one, the device server shall check the protection information read from the medium based on the VRPROTECT field as described in table 17.

Table 17 — VRPROTECT field with BYTCHK set to one - checking protection information read from the medium (part 1 of 2)

Code	Logical unit formatted with protection information	Field in protection information [h]	Extended INQUIRY Data VPD page bit value [f]	If check fails [d] [e], additional sense code
000b	Yes	LOGICAL BLOCK GUARD	GRD_CHK = 1	LOGICAL BLOCK GUARD CHECK FAILED
			GRD_CHK = 0	No check performed
		LOGICAL BLOCK APPLICATION TAG	APP_CHK = 1 [c] [g]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
			APP_CHK = 0	No check performed
		LOGICAL BLOCK REFERENCE TAG	REF_CHK = 1 [i]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
			REF_CHK = 0	No check performed
	No	No protection information on the medium available to check		
001b 010b 011b 100b 101b [b]	Yes	LOGICAL BLOCK GUARD	No check performed	
		LOGICAL BLOCK APPLICATION TAG	No check performed	
		LOGICAL BLOCK REFERENCE TAG	No check performed	
	No	Error condition [a]		

Table 17 — VRPROTECT field with BYTCHK set to one - checking protection information read from the medium (part 2 of 2)

Code	Logical unit formatted with protection information	Field in protection information [h]	Extended INQUIRY Data VPD page bit value [f]	If check fails [d] [e], additional sense code
110b - 111b	Reserved			

[a] A verify operation to a logical unit that supports protection information (see 4.16) and has not been formatted with protection information shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[b] If the logical unit does not support protection information the requested command should be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[c] The device server shall check the logical block application tag if it has knowledge of the contents of the LOGICAL BLOCK APPLICATION TAG field. If the VERIFY (32) command (see 1.8) is used and the ATO bit is set to one in the Control mode page (see SPC-3), this knowledge is acquired from the EXPECTED LOGICAL BLOCK APPLICATION TAG field and the LOGICAL BLOCK APPLICATION TAG MASK field in the CDB. Otherwise, this knowledge may be obtained by a method not defined by this standard.

[d] If an error is reported, the sense key shall be set to ABORTED COMMAND.

[e] If multiple errors occur, the selection of which error to report is not defined by this standard.

[f] See the Extended INQUIRY Data VPD page (see SPC-3) for the definitions of the GRD_CHK bit, the APP_CHK bit, and the REF_CHK bit.

[g] ~~If the application client or device server detects a LOGICAL BLOCK APPLICATION TAG field set to FFFFh, the checking of all protection information shall be disabled for the associated logical block.~~

[h] If the application client or device server detects a:

a) LOGICAL BLOCK APPLICATION TAG field set to FFFFh and type 1 protection (see 1.1.2.3) or type 2 protection (see 1.1.2.4) is enabled ; or

b) LOGICAL BLOCK APPLICATION TAG field set to FFFFh, LOGICAL BLOCK REFERENCE TAG field set to FFFF FFFFh, and type 3 protection (see 1.1.2.5) is enabled,

then the device server shall not check any protection information in the associated logical block.

[i] ~~If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6) (i.e., the command is a VERIFY (10) command, a VERIFY (12) command, or a VERIFY (16) command),~~ If type 1 protection is enabled, the device server ~~shall check~~ checks the logical block reference tag by comparing it to the lower 4 bytes of the LBA associated with the logical block. ~~If the RTO_EN bit is set to one (i.e., the command is a VERIFY (32) command), the device server shall check the logical block reference tag based on the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in the CDB (see 4.16.2).~~ If type 2 protection or type 3 protection is enabled, the device server checks the logical block reference tag if it has knowledge of the contents of the LOGICAL BLOCK REFERENCE TAG field. If type 2 protection is enabled, then this knowledge may be acquired through the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in a VERIFY (32) command (see 1.8). If type 3 protection is enabled, then the method for acquiring this knowledge is not defined by this standard.

If the BYTCHK bit is set to one, the device server shall check the protection information transferred from the data-out buffer based on the VRPROTECT field as described in table 18.

Table 18 — VRPROTECT **field with** BYTCHK **set to one - checking protection information from the data-out buffer** (part 1 of 2)

Code	Logical unit formatted with protection information	Field in protection information	Device server check	If check fails [d] [e], additional sense code
000b	Yes	No protection information received from application client to check		
	No	No protection information received from application client to check		
001b [b]	Yes	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG	May [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK REFERENCE TAG	Shall [f]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No	Error condition [a]		
010b [b]	Yes	LOGICAL BLOCK GUARD	Shall not	No check performed
		LOGICAL BLOCK APPLICATION TAG	May [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK REFERENCE TAG	May [f]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No	Error condition [a]		
011b [b]	Yes	LOGICAL BLOCK GUARD	Shall not	No check performed
		LOGICAL BLOCK APPLICATION TAG	Shall not	No check performed
		LOGICAL BLOCK REFERENCE TAG	Shall not	No check performed
	No	Error condition [a]		
100b [b]	Yes	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG	Shall not	No check performed
		LOGICAL BLOCK REFERENCE TAG	Shall not	No check performed
	No	Error condition [a]		

Table 18 — VRPROTECT **field with** BYTCHK **set to one - checking protection information from the data-out buffer** (part 2 of 2)

Code	Logical unit formatted with protection information	Field in protection information	Device server check	If check fails [d] [e], additional sense code
101b [b]	Yes	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG	May [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK REFERENCE TAG	May [f]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No	Error condition [a]		
110b - 111b	Reserved			

[a] A verify operation to a logical unit that supports protection information (see 4.16) and has not been formatted with protection information shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[b] If the logical unit does not support protection information the requested command should be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[c] The device server may check the logical block application tag if the ATO bit is set to one in the Control mode page (see SPC-3) and if it has knowledge of the contents of the LOGICAL BLOCK APPLICATION TAG field. If the VERIFY (32) command (see 1.8) is used, this knowledge is obtained from the EXPECTED LOGICAL BLOCK APPLICATION TAG field and the LOGICAL BLOCK APPLICATION TAG MASK field in the CDB. Otherwise, this knowledge is obtained by a method not defined by this standard.

[d] If an error is reported, the sense key shall be set to ABORTED COMMAND.

[e] If multiple errors occur, the selection of which error to report is not defined by this standard.

[f] ~~If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6.2)(i.e., the command is a VERIFY (10) command, a VERIFY (12) command, or a VERIFY (16) command),~~ If type 1 protection is enabled, the device server ~~shall check~~ checks the logical block reference tag by comparing it to the lower 4 bytes of the LBA associated with the logical block. ~~If the RTO_EN bit is set to one (i.e., the command is a VERIFY (32) command), the device server shall check checks the logical block reference tag based on the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in the CDB (see 4.16.2).~~ If type 2 protection or type 3 protection is enabled, the device server checks the logical block reference tag if it has knowledge of the contents of the LOGICAL BLOCK REFERENCE TAG field. If type 2 protection is enabled, then this knowledge may be acquired through the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in a VERIFY (32) command (see 1.8). If type 3 protection is enabled, then the method for acquiring this knowledge is not defined by this standard.

If the BYTCHK bit is set to one, the device server shall perform a byte-by-byte comparison of protection information transferred from the data-out buffer with protection information read from the medium based on the VRPROTECT field as described in table 19.

Table 19 — VRPROTECT **field with** BYTCHK **set to one - byte-by-byte comparison requirements** (part 1 of 2)

Code	Logical unit formatted with protection information	Field	Byte-by-byte Comparison	If compare fails [c] [d], additional sense code
000b	Yes	No protection information received from application client to compare. Only user data is compared within each logical block.		
	No	No protection information or the medium or received from application client to compare. Only user data is compared within each logical block.		
001b 011b 100b [b]	Yes	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG (ATO = 1) [e]	Shall	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG (ATO = 0) [f]	Shall not	No compare performed
		LOGICAL BLOCK REFERENCE TAG	Shall	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No	Error condition [a]		

Table 19 — VRPROTECT field with BYTCHK set to one - byte-by-byte comparison requirements (part 2 of 2)

Code	Logical unit formatted with protection information	Field	Byte-by-byte Comparison	If compare fails [c] [d], additional sense code
010b [b]	Yes	LOGICAL BLOCK GUARD	Shall not	No compare performed
		LOGICAL BLOCK APPLICATION TAG (ATO = 1) [e]	Shall	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG (ATO = 0) [f]	Shall not	No compare performed
		LOGICAL BLOCK REFERENCE TAG	Shall	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No	Error condition [a]		
101b [b]	Yes	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG (ATO = 1) [e]	Shall	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG (ATO = 0) [f]	Shall not	No compare performed
		LOGICAL BLOCK REFERENCE TAG	Shall not	No compare performed
	No	Error condition [a]		
110b - 111b	Reserved			

[a] A verify operation to a logical unit that supports protection information (see 4.16) and has not been formatted with protection information shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.
[b] If the logical unit does not support protection information the requested command should be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.
[c] If an error is reported, the sense key shall be set to MISCOMPARE.
[d] If multiple errors occur, the selection of which error to report is not defined by this standard.
[e] If the ATO bit is set to one in the Control mode page (see SPC-3), the logical block application tag shall not be modified by a device server.
[f] If the ATO bit is set to zero in the Control mode page (see SPC-3), the logical block application tag may be modified by a device server.

1.8 VERIFY (32) command

The VERIFY (32) command (see table 20) requests that the device server verify the specified logical block(s) on the medium. Each logical block includes user data and may include protection information, based on the VRPROTECT field and the medium format.

The VERIFY (32) command shall only be processed if type 2 protection is enabled (see 1.1.2.4).

~~If the RTO_EN bit field is set to zero in the READ CAPACITY (16) parameter data (see 1.6.2), the device server shall terminate this command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. If the RTO_EN bit field is not set to zero one, the device server may process the command (see 1.1.3).~~

Table 20 — VERIFY (32) command

Byte\Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (7Fh)							
1	CONTROL							
2	Reserved							
5								
6	Reserved			GROUP NUMBER				
7	ADDITIONAL CDB LENGTH (18h)							
8	(MSB)							
9	SERVICE ACTION (000Ah)							(LSB)
10	VRPROTECT			DPO	Reserved		BYTCHK	Reserved
11	Reserved							
12	(MSB)							
19	LOGICAL BLOCK ADDRESS							(LSB)
20	(MSB)							
23	EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG							(LSB)
24	(MSB)							
25	EXPECTED LOGICAL BLOCK APPLICATION TAG							(LSB)
26	(MSB)							
27	LOGICAL BLOCK APPLICATION TAG MASK							(LSB)
28	(MSB)							
31	VERIFICATION LENGTH							(LSB)

See the VERIFY (10) command (see 1.7) for the definitions of the GROUP NUMBER field, VRPROTECT field, DPO bit, BYTCHK bit, LOGICAL BLOCK ADDRESS field, and VERIFICATION LENGTH field.

When checking of the LOGICAL BLOCK REFERENCE TAG field is enabled (see table 16, table 17, table 18, and table 19 in 1.7) the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field contains the value of the LOGICAL BLOCK REFERENCE TAG field expected in the protection information of the first logical block accessed by the command instead of a value based on the LBA (see 4.16.2).

If the ATO bit is set to one in the Control mode page (see SPC-3) and checking of the LOGICAL BLOCK APPLICATION TAG field is enabled (see table 16, table 17, table 18, and table 19 in 1.7), the LOGICAL BLOCK APPLICATION TAG MASK field contains a value that is a bit mask for enabling the checking of the LOGICAL BLOCK APPLICATION TAG field in the protection information for each logical block accessed by the command. A LOGICAL BLOCK APPLICATION TAG MASK bit set to one enables the checking of the corresponding bit of the EXPECTED LOGICAL BLOCK APPLICATION TAG field with the corresponding bit of the LOGICAL BLOCK APPLICATION TAG field in the protection information.

The LOGICAL BLOCK APPLICATION TAG MASK field and the EXPECTED LOGICAL BLOCK APPLICATION TAG field shall be ignored if:

a) the ATO bit is set to zero; or

b) the ATO bit is set to one in the Control mode page (see SPC-3) and checking of the LOGICAL BLOCK APPLICATION TAG field is disabled (see table 16, table 17, table 18, and table 19 in 1.7).

1.9 WRITE (6) command

The WRITE (6) command (see table 21) requests that the device server transfer the specified logical block(s) from the data-out buffer and write them. Each logical block transferred includes user data but does not include protection information. Each logical block written includes user data and, if the medium is formatted with protection information enabled, protection information.

Table 21 — WRITE (6) command

Byte\Bit	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							

The cache control bits are not provided for this command. Direct-access block devices with cache 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.

See the PRE-FETCH (10) command (see 5.3) for the definition of the LOGICAL BLOCK ADDRESS field.

The TRANSFER LENGTH field specifies the number of contiguous logical blocks of data that shall be transferred from the data-out buffer and written, starting with the logical block specified by the LOGICAL BLOCK ADDRESS field. A TRANSFER LENGTH field set to zero specifies that 256 logical blocks shall be written. Any other value specifies the number of logical blocks that shall be written. If the logical block address plus the transfer length exceeds the capacity of the medium, the device server shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to LOGICAL BLOCK ADDRESS OUT OF RANGE. The TRANSFER LENGTH field is constrained by the MAXIMUM TRANSFER LENGTH field in the Block Limits VPD page (see 6.4.2).

NOTE 1 - For the WRITE (10) command, WRITE (12) command, WRITE (16) command, and WRITE (32) command, a TRANSFER LENGTH field set to zero specifies that no logical blocks are transferred.

If a WRITE (6) command is received after protection information is enabled the device server shall set the protection information (see 4.16) as follows as it writes each logical block to the medium:

a) the LOGICAL BLOCK GUARD field set to a properly generated CRC (see 4.16.3);
b) the LOGICAL BLOCK REFERENCE TAG field set to:
   A) the least significant four bytes of the LBA, if the RTO_EN ~~bit~~ field is set to 000b in the READ CAPACITY (16) parameter data (see 1.6.2); or
   B) FFFFFFFFh, if the RTO_EN ~~bit~~ field is not set to 000b ~~one~~;

   and

c) the LOGICAL BLOCK APPLICATION TAG field set to:
   A) FFFFh, if the ATO bit is set to one in the Control mode page (see SPC-3); or
   B) any value, if the ATO bit is set to zero in the Control mode page (see SPC-3).

1.10 WRITE (10) command

...

The device server shall check the protection information transferred from the data-out buffer based on the WRPROTECT field as described in table 22.

Table 22 — WRPROTECT field (part 1 of 3)

Code	Logical unit formatted with protection information	Field in protection information	Device server check	If check fails [d] [i], additional sense code
000b	Yes [f] [g] [h]	No protection information received from application client to check		
	No	No protection information received from application client to check		
001b [b] [j]	Yes [e]	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG	May [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK REFERENCE TAG	Shall [k]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No [a]	No protection information available to check		
010b [b] [j]	Yes [e]	LOGICAL BLOCK GUARD	Shall not	No check performed
		LOGICAL BLOCK APPLICATION TAG	May [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK REFERENCE TAG	May [k]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No [a]	No protection information available to check		
011b [b] [j]	Yes [e]	LOGICAL BLOCK GUARD	Shall not	No check performed
		LOGICAL BLOCK APPLICATION TAG	Shall not	No check performed
		LOGICAL BLOCK REFERENCE TAG	Shall not	No check performed
	No [a]	No protection information available to check		
100b [b] [j]	Yes [e]	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG	Shall not	No check performed
		LOGICAL BLOCK REFERENCE TAG	Shall not	No check performed
	No [a]	No protection information available to check		

Table 22 — WRPROTECT **field** (part 2 of 3)

Code	Logical unit formatted with protection information	Field in protection information	Device server check	If check fails [d] [i], additional sense code
101b [b] [j]	Yes [e]	LOGICAL BLOCK GUARD	Shall	LOGICAL BLOCK GUARD CHECK FAILED
		LOGICAL BLOCK APPLICATION TAG	May [c]	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
		LOGICAL BLOCK REFERENCE TAG	May [k]	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
	No [a]	No protection information available to check		

Table 22 — WRPROTECT **field** (part 3 of 3)

Code	Logical unit formatted with protection information	Field in protection information	Device server check	If check fails [d] [i], additional sense code
110b - 111b	Reserved			

[a] A write operation to a logical unit that supports protection information (see 4.16) and has not been formatted with protection information shall be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[b] If the logical unit does not support protection information the requested command should be terminated with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

[c] The device server may check the logical block application tag if the ATO bit is set to one in the Control mode page (see SPC-3) and if it has knowledge of the contents of the LOGICAL BLOCK APPLICATION TAG field. If the WRITE (32) command (see 1.11) is used, this knowledge is obtained from the EXPECTED LOGICAL BLOCK APPLICATION TAG field and the LOGICAL BLOCK APPLICATION TAG MASK field in the CDB. Otherwise, this knowledge is obtained by a method not defined by this standard.

[d] If an error is reported, the sense key shall be set to ABORTED COMMAND.

[e] Device server shall preserve the contents of protection information (e.g., write to medium, store in non-volatile memory).

[f] The device server shall write a properly generated CRC (see 4.16.3.2) into each LOGICAL BLOCK GUARD field.

[g] If the RTO_EN ~~bit~~ field is set to 000b in the READ CAPACITY (16) parameter data (see 1.6.2), the device server shall write the least significant four bytes of each LBA into the LOGICAL BLOCK REFERENCE TAG field of each of the written logical blocks. If the RTO_EN ~~bit~~ field is not set to 000b ~~one~~, the device server shall write a value of FFFFFFFFh into the LOGICAL BLOCK REFERENCE TAG field of each of the written logical blocks.

[h] If the ATO bit is set to one in the Control mode page (see SPC-3), the device server shall write FFFFh into each LOGICAL BLOCK APPLICATION TAG field. If the ATO bit is set to zero, the device server may write any value into each LOGICAL BLOCK APPLICATION TAG field.

[i] If multiple errors occur, the selection of which error to report is not defined by this standard.

~~[j] If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6), the device server may process the command. If the RTO_EN bit is set to one, WRITE (10) commands, WRITE (12) commands, and WRITE (16) commands with the WRPROTECT field set to 000b may be processed by the device server. If the RTO_EN bit is set to one, the device server shall terminate WRITE (10) commands, WRITE (12) commands, and WRITE (16) commands with the WRPROTECT field not set to 000b with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.~~

[k] ~~If the RTO_EN bit is set to zero in the READ CAPACITY (16) parameter data (see 1.6.1),~~ If type 1 protection is enabled, the device server checks the logical block reference tag by comparing it to the lower 4 bytes of the LBA associated with the logical block. ~~If the RTO_EN bit is set to one (i.e., the command is a WRITE (32) command), the device server checks the logical block reference tag based on the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in the CDB (see 4.16.2)~~. If type 2 protection or type 3 protection is enabled, the device server checks the logical block reference tag if it has knowledge of the contents of the LOGICAL BLOCK REFERENCE TAG field. If type 2 protection is enabled, then this knowledge may be acquired through the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field in a WRITE (32) command (see 1.11). If type 3 protection is enabled, then the method for acquiring this knowledge is not defined by this standard.

1.11 WRITE (32) command

The WRITE (32) command (see table 23) requests that the device server transfer the specified logical block(s) from the data-out buffer and write them. Each logical block transferred includes user data and may

include protection information, based on the WRPROTECT field and the medium format. Each logical block written includes user data and, if the medium is formatted with protection information enabled, protection information.

The WRITE (32) command shall only be processed if type 2 protection is enabled (see 1.1.2.4).

~~If the RTO_EN bit field is set to zero in the READ CAPACITY (16) parameter data (see 1.6.2), the device server shall terminate the WRITE (32) command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. If the RTO_EN bit field is not set to zero one, the device server may process the command (see 1.1.3).~~

Table 23 — WRITE (32) command

Byte\Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (7Fh)							
1	CONTROL							
2	Reserved							
5								
6	Reserved			GROUP NUMBER				
7	ADDITIONAL CDB LENGTH (18h)							
8	(MSB)							
9	SERVICE ACTION (000Bh)							(LSB)
10	WRPROTECT			DPO	FUA	Reserved	FUA_NV	Reserved
11	Reserved							
12	(MSB)							
19	LOGICAL BLOCK ADDRESS							(LSB)
20	(MSB)							
23	EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG							(LSB)
24	(MSB)							
25	EXPECTED LOGICAL BLOCK APPLICATION TAG							(LSB)
26	(MSB)							
27	LOGICAL BLOCK APPLICATION TAG MASK							(LSB)
28	(MSB)							
31	TRANSFER LENGTH							(LSB)

See the WRITE (10) command (see 1.10) for the definitions of the GROUP NUMBER field, the WRPROTECT field, the DPO bit, the FUA bit, the FUA_NV bit, the LOGICAL BLOCK ADDRESS field, and the TRANSFER LENGTH field.

When checking of the LOGICAL BLOCK REFERENCE TAG field is enabled (see table 22 in 1.10) the EXPECTED INITIAL LOGICAL BLOCK REFERENCE TAG field contains the value of the LOGICAL BLOCK REFERENCE TAG field expected in the protection information of the first logical block accessed by the command instead of a value based on the LBA (see 4.16.2).

If the ATO bit is set to one in the Control mode page (see SPC-3) and checking of the LOGICAL BLOCK APPLICATION TAG field is enabled (see table 22 in 1.10), the LOGICAL BLOCK APPLICATION TAG MASK field contains a value that is a bit mask for enabling the checking of the LOGICAL BLOCK APPLICATION TAG field in the protection information for each logical block accessed by the command. A LOGICAL BLOCK APPLICATION TAG MASK bit set to one enables the checking of the corresponding bit of the EXPECTED LOGICAL BLOCK APPLICATION TAG field with the corresponding bit of the LOGICAL BLOCK APPLICATION TAG field in the protection information.

The LOGICAL BLOCK APPLICATION TAG MASK field and the EXPECTED LOGICAL BLOCK APPLICATION TAG field shall be ignored if:

a) the ATO bit is set to zero; or
b) the ATO bit is set to one in the Control mode page (see SPC-3) and checking of the LOGICAL BLOCK APPLICATION TAG field is disabled (see table 22 in 1.10).