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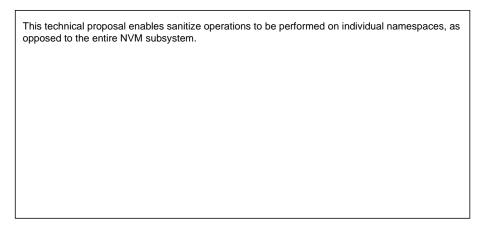
NVM Express® Technical Proposal (TP)

Technical Proposal ID	TP4153 Sanitize Per Namespace			
Revision Date	2025.04.07			
	NVM Express Base Specification 2.1			
Build on Specification(s)	NVM Express NVM Command Set Specification 1.1			
	NVM Express Zoned Namespace Command Set Specification 1.2			
	NVM Express Subsystem Local Memory Command Set Specification 1.0a			
	NVM Express Computational Programs Command Set Specification 1.0a			
	NVM Express Management Interface Specification 2.0			
References	ECN124			

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Technical Proposal Overview



Revision History

Revision Date	Change Description
2023.11.30	Initial draft
2024.03.01	Another pre-TWG version
2024.03.20	Synchronized with TP4152 Post-Sanitize Media Verification 2024.03.20 Preratification – first version posted to Causeway workspace
	Reviewed/scoped all allocate and deallocate statements to the sanitization target.
	Synchronized text with 2.0d base and appropriate revisions of other specs
2024.04.03	Updated all references to match the .NEXT specifications from 2024.03.20
	Changes all text for sanitization that targets to sanitization with a sanitization target of – removes the two different uses of target for sanitization.
	Incorporated comments from Paul Suhler and Mike Allison
	Added Dword1 AEN Specific text to AER Command Completion
2024.04.17	Backed out generic "sanitization target" from Sanitize Command and Sanitize Namespace command text and used subsystem and namespace respectively
	Clarified NSID field in Get Log Page command for Sanitize Status log
2024.04.18	Revised intro to Admin command restrictions table with requirements for command processing and table describes the results for those commands.
2024.04.16	Backed out all generic sanitization target references for sections that were specific to namespaces or the NVM Subsystem.
	Restructured commands to factor out common material
2024.05.24	Incorporated review comments from Matt Goepfert, Paul Suhler, Dan Hubbard
	Incorporated table view of sanitize scope for namespaces and subsystem from Paul Suhler
2024.05.29	Removed all uses of "target of a sanitize operation" and reworked to use defined term "sanitization target"
	Moved reporting NSID in AEN requirement to 8.30.TBD, general AEN reporting rules, and removed it from each AEN report statement.
	Added restrictions on Get Features for Namespace scoped features
	Pulled in additional MI text that needs updated for Sanitize Namespace
2024.05.30	Reviewed/commented suggestion on removing Sanitize Namespace specific error codes.
	Scoped media verification to only reads in a sanitization target that is in the media verification state.
	New text for ZNS command set for Sanitize Namespace.
2024.06.12	Careful review/edit of state machine for requirements on "all controllers" for cases where the action does not affect sanitize operations on a namespace.
	Incorporated comments from Dan Hubbard and Paul Suhler.
2024.06.26	Cleaned up change tracking

	Revised Sanitize command processing restrictions to exclude failure states and point to existing text for those.
2024.08.23	Added Sanitize/Sanitize Namespace command processing restrictions to each sanitize state under 8.1.24.3.x Aligned sections 5, 5.TBD.x, 8.1.24.3.x, and 8.1.24.4 to NVMe 2.1
2024.08.30	 Mark old/completed comments as resolved Completed NVMe 2.1 alignment
2024.09.06	Added definitions for sanitize subsystem operation and sanitize namespace operation
2024.09.19	 Renamed new definitions to subsystem sanitize operation and namespace sanitize operation and corrected the text for both Corrected "set to 0h" to "cleared to 0h" globally Removed sanitization command definition
2024.09.20	Added Sanitize Namespace Status List log page Included in Log Page Support Requirements table and Management Endpoint Log Page Support table Removed MSSA field from Sanitize Status log page
2024.09.24	Made changes to Sanitize Namespace Status List log page:
2024.09.25	Added changes to SLM Command Set Specification.
2024.09.26	Includes comments and minor edits from 9/26 TWG call
2024.10.02	 Added overwrite sanitize action support for Sanitize Namespace Added LSP bit to Sanitize Namespace Status List log page to allow host to choose either the in progress namespace sanitize operation list or the completed namespace sanitize operation list Added statement in model clause to make it clear that running namespace sanitize operations on every namespace in the NVM subsystem != a subsystem sanitize operation Added new field to subsystem scope Sanitize Status log page that indicates the maximum number of namespace sanitize operations that can be in progress concurrently Added an accompanying command specific error status code for Sanitize Namespace when the number of in progress namespace sanitize operations has been exceeded
2024.10.03	Namespace sanitize operations purge all data in the volatile cache used by the sanitized namespace Corrected location of MNSOIP in Sanitize Status log page to be Dword aligned
2024.10.09	 Removed overwrite sanitize action for Sanitize Namespace Added clarification that MNSOIP field cleared to 0h = not reported Changed "saved features" to "current features and saved features" in Figure TBD-4 Removed "saved values that are not features" from Figure TBD-4 Added changes to Computational Programs Command Set Specification

Added requirement to section 3.1.2.6 that if Sanitize Namespace is supported then NSIDs shall be unique within the NVM subsystem and removed ban of private namespaces since NSIDs will be unique Cleaned up wording for error condition of MNSOIP being exceeded in Sanitize Namespace command section Added text to applicable state machine sections to make it clear that successfully completed subsystem sanitize operations cause GDE=1 and SANS=Idle in the Sanitize Status log page for each namespace in the NVM subsystem Added Namespace Data Erased (NDE) bit to Sanitize Status log page Reworked text in the following sections due to NDE/GDE split:
Reworked text in the following sections due to NDE/GDE split: 8.1.24.2 Sanitize Operation Types and Support 5.1.12.1.TBD Sanitize Namespace Status List log page 2024.10.17 8.1.24.3.2 Restricted Processing State 8.1.24.3.4 Unrestricted Processing State 8.1.24.3.7 Post-Verification Deallocation State 6. GDE bit shall be cleared to '0' for namespaces
log page Made some minor Phase 3 edits found by Mike Allison
Removed requirement that Sanitize Namespace Status List log page be retained across power cycles GDE bit is set to '1' for successful subsystem sanitize operation ever in namespace-scoped log page as this bit still reports global state
Filled in changes description sections
Changed features row text to "current values and saved values of features" in Figure TBD-4 Added reference to IEEE Std 2883 for usage of "purge" in Figure TBD-4 Accepted all tracked changes and cleared out resolved comments
Added changes to Sanitize Status log page from ECN124 Changed every occurrence of "subsystem sanitize operation" definition to "NVM subsystem sanitize operation" Changed NVM subsystem sanitize operation to NVM Subsystem sanitize operation in MI into the TP and added specificity as needed Collapsed separate namespace sanitize operation Admin command processing restrictions section into section 6.4 in MI and added the Sanitize Namespace command into the restrictions table Added Sanitize Namespace Failure Mode AE into MI Added text specifying that the Sanitize in Progress Response Message Status value (2Ah in Byte 4) shall not be used in MI implementations later than 2.0. Sanitize in Progress shall be indicated in CQEDW0 (1Dh) at the NVMe Base layer – not at the MI
layer

	0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	Cleaned up text in section 5.TBD.2 Deleted "attached/unattached" row in Figure TBD-1 Cleaned up text in MI AE footnote
2024.12.11	Added new section 3.2.5.TBD that contains explanatory text that domain division events may or may not prevent successful completion of sanitize operations Removed "able to be attached" language Made NVM subsystem vs. namespace scope requirements ordering in model clause state machine sections consistent
2024.12.12	Reordered paragraphs in section 3.2.5.TBD per TWG feedback Added clarification to controller attribute lead in text in section 8.1.24.2 per TWG feedback Removed duplicative text about log page scope in Sanitize Status log page section Repositioned namespace-scoped log page requirement text and changed "value other than 0h or FFFFFFFFh" to "value of an allocated NSID" in Sanitize Status log page section Corrected Sanitize Namespace command section number to 5.1.TBD Added reference to MNSOIP field in Maximum Namespace Sanitize Operations In Progress Exceeded status definition Added text to Namespace Metadata feature to describe what happens to the feature values after a successful sanitize operation
2024.12.18	Revised new section in Domains and Partitions for more clear ties into existing text. Proposed several comments move to bug report as changes to existing text, not new capability in this TP
2024.12.19	Cleaned for phase 3 exit review Removed purple text that was highlighting recently revised text for Sanitize Verification and turned to black as that is all in release bundle 2.1 Removed orange text tracking changes from ECNs prior to 2.1 and turned to black as that is all in release bundle 2.1 Removed some text that had been pulled in for discussion of possible changes but where it was decided to not change any text Fixed a missing check for namespace sanitize in Sanitize Status log and Media Verification Cancelled reporting Removed closed discussion items Fixed an incorrect restatement of restrictions on starting sanitize operations when a division exists in 8.1.24.
2025.01.08	Fixed capitalization to Sanitize In Progress for added text globally Moved Sanitize In Progress (2Ah) deprecation text from Figure 29 to section 6.4 in the MI spec Changed Sanitize In Progress (2Ah) deprecation text to a bulleted list and modified the text as needed
2025.01.09	Made changes to the moved text in section 6.4 based upon feedback from Austin Bolen
2025.02.06	Changed font color from purple to black for bullet points that got missed prior to member review Incorporated changes from Curtis' latest review:

	Clarified in the Restricted Failure State section that only the Sanitize command can be used for recovery from a failed NVM subsystem sanitize operation, whereas either the Sanitize command or Sanitize Namespace command can be used for recovery from a failed namespace sanitize operation Removed section 5 from the ZNS portion of this TP as no changes were made in that section Removed the entire KV portion of this TP as no changes were made to the KV spec
2025.02.10	Incorporated changes and comments from Samsung's latest review
2025.02.14	Incorporated changes from 2/13 TWG meeting: Turned list of capabilities that require unique NSIDs for private namespace into a bulleted list in section 3.2.1.6 Renamed "Maximum Namespace Sanitize Operations In Progress Exceeded" command specific status code to "Request Exceeds Maximum Namespace Sanitize Operations In Progress" Removed two "should to shall" conversions in section 5.TBD.1 that require a specific status code to be sent when aborting a command Removed any mention of the SEL field for Migration Send/Receive Admin command processing restrictions during namespace sanitize operations — always abort these commands if a namespace sanitization target is attached Remove GDE bit interaction text from NDE bit as the requirement already exists in the state machine
2025.02.19	Added ZNS spec sanitize changes from ECN???
2025.02.20	Changes from ECN??? (Bug 472) will be handled in this TP SLM spec: Moved sanitize operations text out of the command sections and put them into a Sanitize Operations section and added references to the Base spec in those command sections Computational Programs spec: Made the same change as done to the SLM spec Clean version ready for integration with all changes accepted and comments removed
2025.03.06	Integrated
2025.04.06	Editorial Updates
2025.04.07	Matching changes made in Base specification review.

Description for Changes Document for NVM Express Base Specification 2.1

New Features/Feature Enhancements/Required Changes:

- Sanitize Namespace (optional)
 - o Description of changes:
 - Added definitions for NVM subsystem sanitize operation and namespace sanitize operation
 - Expanded sanitization target definition to include namespaces
 - Defined Sanitize Namespace command (includes the crypto erase operation type)
 - Defined Sanitize Namespace Status List log page
 - Defined Sanitize Namespace Failed and Sanitize Namespace In Progress generic command status values
 - Defined Request Exceeds Maximum Namespace Sanitize Operations In Progress command specific status value
 - The Event Specific Parameter field in CQE Dword1 is set to the NSID of the sanitized namespace for the Sanitize Operation Completed and Sanitize Operation Entered Media Verification State AENs
 - Added NSID field to Sanitize Start and Sanitize Completion Persistent Event Log events
 - Added Namespace Data Erased bit and Sanitization Target NSID field to namespace scoped Sanitize Status log page
 - Added Maximum Namespace Sanitization Operations In Progress field to NVM subsystem scoped Sanitize Status log page
 - Added Namespace Verification Support bit to I/O Command Set Independent Identify Controller data structure
 - New requirement / incompatible change in section 3.2.1.6:
 - If the Sanitize Namespace command is supported, then NSIDs for private namespaces have to be unique within the NVM subsystem
 - o References
 - ECN124
 - TP4153 Sanitize Per Namespace

Description for Changes Document for NVM Express NVM Command Set Specification 1.1

New Features/Feature Enhancements/Required Changes:

- Sanitize Namespace (optional)
 - Description of changes:
 - Added some text in the Media Verification subsection of the Sanitize Operations section to make it clear that the controller needs to validate that each LBA specified

in a read command needs to be in that sanitization target that is in the Media Verification state in order to account for namespace sanitization targets

- o New requirement / incompatible change
 - None
- References
 - TP4153 Sanitize Per Namespace
 - No in-flight documents are referenced

Description for Changes Document for NVM Express Zoned Namespace Command Set Specification 1.3

New Features/Feature Enhancements/Required Changes:

- Sanitize Namespace (optional)
 - o Description of changes:
 - Added Sanitize Namespace command section that references the base spec
 - Added references to the base spec in the Sanitize command section
 - Moved sanitize operations text into the Sanitize Operations section
 - New requirement / incompatible change
 - None
 - References
 - ECN124
 - TP4153 Sanitize Per Namespace

Description for Changes Document for NVM Express Subsystem Local Memory Command Set Specification 1.1

New Features/Feature Enhancements/Required Changes:

- Sanitize Namespace (optional)
 - Description of changes:
 - Added Sanitize Namespace command section that references the base spec
 - Added references to the base spec in the Sanitize command section
 - Moved sanitize operations text into a new Sanitize Operations section
 - o New requirement / incompatible change
 - None
 - References
 - TP4153 Sanitize Per Namespace
 - No in-flight documents are referenced

Description for Changes Document for NVM Express Computational Programs Command Set Specification 1.1

New Features/Feature Enhancements/Required Changes:

- Sanitize Namespace (optional)
 - o Description of changes:
 - Added a Sanitize Namespace command section that references the base spec
 - Added references to the base spec in the Sanitize command section
 - Moved sanitize operations text into a new Sanitize Operations section
 - o New requirement / incompatible change
 - None
 - o References
 - TP4153 Sanitize Per Namespace
 - No in-flight documents are referenced

Description for Changes Document for NVM Express Management Interface Specification 2.0

New Features/Feature Enhancements/Required Changes:

- Sanitize Namespace (optional)
 - o Description of changes:
 - Added Sanitize Namespace command to List of NVMe Admin Commands Supported Using the Out-of-Band Mechanism table
 - Added Sanitize Namespace Status List log page to Management Endpoint Log Page Support table
 - Added namespace sanitize operations to the Sanitize Operation and Format NVM Command section
 - Added Sanitize Namespace Failure Mode NSHDS bit and accompanying Sanitize Namespace Failure Mode
 - Added a footnote to the scope column of the Asynchronous Events table to clarify which identifier is used for each scope type
 - New requirement / incompatible change
 - None
 - References
 - ECN124
 - TP4153 Sanitize Per Namespace

Markup Conventions:

Black: Unchanged (however, hot links are removed)

Red Strikethrough: Deleted Blue: New

Blue Highlighted: TBD values, anchors, and links to be inserted in new text.

<Green Bracketed>: Notes to editor or reviewer

Brown: Text moved from another location

Brown Strikethrough: Text that has been moved to another location

Description of Specification Changes for NVM Express Base Specification 2.1

1 Introduction

...

1.5 Definitions

. . .

1.5.87 sanitize operation

Process by which all user data in the NVM subsystem sanitization target is altered as described in section 8.1.24 such that recovery of the previous user data from any cache or the non-volatile storage media is infeasible for a given level of effort (refer to IEEE 2883™-2022).

1.5. DEF1 NVM subsystem sanitize operation

A sanitize operation with a sanitization target of the NVM subsystem.

1.5. DEF2 namespace sanitize operation

A sanitize operation with a sanitization target of a namespace.

1.5.88 sanitization target

The target scope of a sanitize operation (i.e., an NVM subsystem, or a namespace).

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3 NVM Express Architecture

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3.1 NVM Controller Architecture

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3.1.3 Controller Types

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3.1.3.4 Command Support Requirements

Figure 28 defines commands that are mandatory, optional, and prohibited for an I/O controller, Administrative controller, and Discovery controller. I/O Command Set specific command support requirements are described within individual I/O Command Set specifications. Since an Administrative controller does not support I/O queues, I/O Command Set specific commands that are not Admin commands are not supported by an Administrative controller.

A host may utilize the Commands Supported and Effects log page to determine optional commands that are supported by a controller.

Figure 28: Admin Command Support Requirements

Command	Combined Opcode	Controller Support Requirements ¹			Reference	
Command	Value	I/O	Administrative	Discovery	Kelelelice	
Security Receive	82h	0	0	Р	5.1.23	
Sanitize	84h	o^3	O ³	Р	5.1.22	
Sanitize Namespace	8Ch	0	0	Р	5.1.TBD	

- O/M/P definition: O = Optional, M = Mandatory, P = Prohibited
- Prohibited if the Keep Alive Timer feature is not supported (refer to section 3.9). Prohibited for an Exported NVM Subsystem (refer to section 8.3.3).
- Mandatory if any of the features in Figure 32 are implemented.

3.1.3.5 Log Page Support Requirements

Figure 31 defines log pages that are mandatory, optional, and prohibited for an I/O controller, Administrative controller, and Discovery controller. I/O Command Set specific log page support requirements are described within individual I/O Command Set specifications.

Figure 31: Log Page Support Requirements

Log Page Name	Log Page	Controller Support Requirements ¹			Reference
og : ugo ::uo	Identifier	1/0	Administrative	Discovery	11010101100
Supported Log Pages	00h	м ³	M ³	М	5.1.12.1.1
Sanitize Status	81h	0	08	Р	5.1.12.1.33
Sanitize Namespace Status List	7Fh	0	0	P	5.1.12.1.TBD

- 1. O/M/P definition: O = Optional, M = Mandatory, P = Prohibited
- Mandatory for controllers that support Fixed Capacity Management (refer to section 8.1.4.2).
- Optional for NVM Express revision 1.4 and earlier.
- If this log page is not described for a specific physical interface (refer to the applicable NVM Express transport specification), then this log page is prohibited for that transport.
- Mandatory for controllers that support the Flexible Data Placement capability (refer to section 8.1.10). Refer to the FDPS bit in Figure 312.
- Optional for controllers that do not support Reachability Reporting (refer to section 8.1.19).
- Optional if the NVMe-MI Send command and the NVMe-MI Receive command are not supported (refer to Figure
- Prohibited for an Exported NVM subsystem (refer to section 8.3.3).

3.2 NVM Subsystem Entities

3.2.1 Namespaces

3.2.1.6 NSID and Namespace Usage

If Namespace Management (refer to section 8.1.15), ANA Reporting (refer to section 8.1.1), or NVM Sets (refer to section 3.2.2) capabilities are supported, then NSIDs shall be unique within the NVM subsystem (e.g., NSID of 3 shall refer to the same physical namespace regardless of the accessing controller) if:

- a) Namespace Management (refer to section 8.1.15), ANA Reporting (refer to section 8.1.1), or NVM Sets (refer to section 3.2.2) capabilities are supported; or
- b) the Sanitize Namespace command is supported.

If the Namespace Management capability, the ANA Reporting capability, and the Sanitize Namespace command are not supported, then NSIDs:

- a) for shared namespaces shall be unique within the NVM subsystem; and
- b) for private namespaces are not required to be unique within the NVM subsystem.

The Identify command (refer to section 5.1.13) may be used to determine the active NSIDs for a controller and the allocated NSIDs in the NVM subsystem.

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3.2.5 Domains and Divisions

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3.2.5. TBD Domains and Sanitize Operations

If an NVM subsystem supports multiple domains and supports performing a sanitize operation (refer to section 8.1.24), then performing a sanitize operation is affected by division events and the existence of divisions.

If a division exists and the controller is not able to successfully perform a sanitize operation as specified in section 8.1.24 (e.g., if the division prevents access to some objects in the scope of the sanitize operation, refer to Figure TBD-4) then the controller is not able to start a sanitize operation and the command requesting the sanitize operation is aborted as specified in section 8.1.24.TBD.

If a division event occurs during a sanitize operation, then that division event:

- may prevent successful completion of that sanitize operation as specified in section 8.1.24 (e.g., the division prevents access to some objects in the scope of the sanitize operation, refer to Figure TBD-4, and those objects have not already been sanitized by that sanitize operation); or
- may not affect the sanitize operation (i.e., if the sanitize operation is able to be processed successfully as described in section 8.1.24).

If a division exists that impacts global state within the NVM subsystem (refer to section 3.2.5.1), then a controller may or may not be able to return valid information in a Sanitize Status log page (refer to section 5.1.12.1.33) or a Sanitize Namespace Status List log page (refer to section 5.1.12.1.TBD).

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3.2.5.3 Domain Identifier Use (Informative)

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3.5 Controller Initialization

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3.5.3 Controller Ready Modes During Initialization

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Figure 84: Admin Commands Permitted to Return a Status Code of Admin Command
Media Not Ready

Admin Command Additional Restrictions				

Format NVM				
Sanitize				
Sanitize Namespace				
Security Receive ¹				

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3.11 Firmware Update Process

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If the firmware image is not able to be successfully loaded, then the controller shall revert to the firmware image present in the most recently activated firmware slot or the baseline read-only firmware image, if available, and indicate the failure as an asynchronous event with a Firmware Image Load Error. If the controller changes (e.g., reverts) the firmware image while a sanitize operation is in progress, then that sanitize operation fails (refer to section 8.1.24.3).

If a host overwrites (i.e., updates) the firmware image in the active firmware slot, then the previously active firmware image may no longer be available. As a result, any action (e.g., power cycling the controller) that requires the use of that firmware slot may instead use the firmware image that is currently in that firmware slot. If the firmware image that is currently in that firmware slot would be activated by such an action replacing the currently active firmware, then:

- this is a pending firmware activation with reset; and
- a controller aborts subsequent Sanitize commands or Sanitize Namespace commands with a status code indicating the appropriate reset required to activate the pending activation as defined in section 5.1.22.

4 Data Structures

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4.2 Completion Queue Entry

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4.2.3 Status Field Definition

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4.2.3.1 Generic Command Status Definition

Completion queue entries with a Status Code Type (SCT) of Generic Command Status indicate a status value associated with the command that is generic across many different types of commands.

Figure 102: Status Code - Generic Command Status Values

Value	Description	I/O Command Set(s) ¹
1Ch	Sanitize Failed: The most recent NVM subsystem sanitize operation failed and no recovery action has been successfully completed	

Value	Description	I/O Command Set(s) ¹
1Dh	Sanitize In Progress: The requested function (e.g., command) is prohibited while an NVM subsystem sanitize operation is in progress. Refer to section 8.1.24.3.	
2Bh	Sanitize Namespace Failed: The most recent namespace sanitize operation failed and no recovery action has been successfully completed.	
2Ch	Sanitize Namespace In Progress: The requested function (e.g., command) is prohibited while a namespace sanitize operation is in progress. Refer to section 8.1.24.4.	
2D B h to 7Fh	Reserved	
	•••	

4.2.3.2 Command Specific Status Definition

Completion queue entries with a Status Code Type (SCT) of Command Specific Errors indicate an error that is specific to a particular command opcode. Status codes of 00h to 7Fh are for Admin command errors. Status codes of 80h to BFh are specific to the selected I/O command sets.

Figure 103: Status Code - Command Specific Status Values

Value	Description	Commands Affected
0Ah	Invalid Format	Format NVM, Namespace Management
0Bh	Firmware Activation Requires Conventional Reset	Firmware Commit, Sanitize, Sanitize Namespace
0Ch	Invalid Queue Deletion	Delete I/O Completion Queue

0Fh	Feature Not Namespace Specific	Set Features
10h	Firmware Activation Requires NVM Subsystem Reset	Firmware Commit, Sanitize, Sanitize Namespace
11h	Firmware Activation Requires Controller Level Reset	Firmware Commit, Sanitize, Sanitize Namespace
12h	Firmware Activation Requires Maximum Time Violation	Firmware Commit

22h	Invalid Resource Identifier	Virtualization Management
23h	Sanitize Prohibited While Persistent Memory Region is Enabled	
24h	ANA Group Identifier Invalid	Namespace Management
3Ch	Request Exceeds Maximum Namespace Sanitize Operations In Progress	Sanitize Namespace
Notes:		
1. The Dire	ectives Specific range defines Directives specific status val	lues. Refer to section 8.1.8.

5 Admin Command Set

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Figure 141 defines all Admin commands. Refer to Figure 28 for mandatory, optional, and prohibited commands for the various controller types.

Figure 141: Opcodes for Admin Commands

Opcode by Field			Namaanaaa		
(07:02) (01:00)		Combined Namespace Identifier		8	
Function	Data			Command	Reference 8
	Transfer ³	•	Used ²		
1000 01b	00b	84h	No	Sanitize	5 <u>.1.22</u>
1000 11b	00b	8Ch	Yes ⁴	Sanitize Namespace	TBD
1000 01b	01b	85h	Yes	Load Program	CP

Notes:

- Opcodes not listed are reserved.
- 2. A subset of commands use the Namespace Identifier (NSID) field. If the Namespace Identifier field is used, then the value FFFFFFFh is supported in this field unless otherwise indicated in footnotes in this figure that a specific command does not support that value or supports that value only under specific conditions. When this field is not used, the field is cleared to 0h as described in Figure 92.
- 00b = no data transfer; 01b = host to controller; 10b = controller to host; 11b = bidirectional. Refer to the Data Transfer Direction field in Figure 91.
- 4. This command does not support the use of the Namespace Identifier (NSID) field set to FFFFFFFh.
- Support for the Namespace Identifier field set to FFFFFFFh depends on the Directive Operation (refer to section 8.1.8).
- 6. Use of the Namespace Identifier field depends on the CNS value in the Identify Command as described in Figure 310.
- 7. The use of the Namespace Identifier is Security Protocol specific.
- Section 5.1 contains commands common to all transport models, section 5.2 contains commands specific to the Memory-based transport model, and section 5.3 contains commands specific to the Message-based transport model. NVM = NVM Command Set specific, ZNS = Zoned Namespace Command Set.
- All Fabrics commands use the opcode 7Fh with the data transfer direction specified as shown in Figure 540. Refer to section 6 for details.
- Support for this command is prohibited in NVM subsystems that use a Memory-Based Transport Model (e.g., the PCle transport) for any controller.
- 11. Use of the Namespace Identifier field is specified further in section 5.1.12 and Figure 202.

5.TBD Admin Command Processing Restrictions

5.TBD.1 NVM Subsystem Sanitize Operation and Format NVM Admin Command Processing Restrictions

Figure 142 lists the Admin commands that are allowed while an NVM subsystem sanitize operation is in progress and the Admin commands that should be allowed during the processing of a Format NVM command

If a Format NVM command is in progress, then an Admin command not listed in Figure 142 that is submitted for any namespace affected by that Format NVM command may be aborted. If aborted for that reason, then a status code of Format iIn Progress should be returned.

If there are Admin commands not listed in Figure 142 being processed for a namespace, then a Format NVM command which is submitted that affects that namespace may be aborted. If aborted for that reason, then a status code of Command Sequence Error should be returned.

Figure 142: NVM Subsystem Sanitize Operations and Format NVM Command – Admin Commands Allowed

Admin Command	Additional Restrictions for a Format NVM Command	Additional Restrictions for a Sanitize Operation
Abort		
Asynchronous Event Request		
Create I/O Completion Queue		

Figure 142: NVM Subsystem Sanitize Operations and Format NVM Command – Admin Commands Allowed

Admin Command	Additional Restrictions for a NVM Command	Format	Additional Restrictions for a Sanitize Operation	
Create I/O Submission Queue				
Device Self-test	evice Self–test Only Controller DST should be allowed		Prohibited	
Delete I/O Completion Queue				
Delete I/O Submission Queue				
Get Features				
	sanitize operations are listed belo	ow.	M command and NVM subsystem Iditional Restrictions for both	
			Format NVM command and sanitize operations	
	Error Information	Re	eturn 0h in the LBA field.	
Get Log Page	SMART / Health Information			
Get Log i age	Changed Attached Namespace	List		
	Reservation Notification			
	Asymmetric Namespace Acces	S		
	Sanitize Status			
	Vendor specific F		Prohibited for Sanitize	
	Persistent Event Log	Pro	ohibited for Sanitize	
	Boot Partition			
Identify			_	
Keep Alive				
NVMe-MI Receive	Allowed unless explicitly prohibit	ted in the N\	/M Express Management Interface	
NVMe-MI Send	Specification.			
			Prohibited during NVM subsystem	
			sanitize operations if the SANACT	
Sanitize			field is set to a value other than 101b	
			(i.e., Exit Media Verification State).	
			Sanitize operations are described in	
O-t Ft	Name and a Maite Doct ation On		section 8.1.24.	
Set Features	Namespace Write Protection Cor The Fabrics commands allowed			
	The Fabrics commands allowed			
	Fabrics command	nand Additional Restrictions for a Format NVN Command and a Sanitize Operation		
	Property Set			
On so do 7Fh	Connect			
Opcode 7Fh	Disconnect			
	Property Get			
	Authentication Send			
	Authentication Receive			
	Vendor Specific	retrieve us		
Vendor Specific	Commands are allowed that do n	ot affect or re	etrieve user data.	

5.TBD.2 Namespace Sanitize Operation Admin Command Processing Restrictions

Figure TBD-1 lists Admin commands that have processing restrictions while a namespace sanitize operation is in progress.

If an Admin command is being processed that either:

- affects (e.g., changes or deletes) a namespace that is the sanitization target of an in progress namespace sanitize operation (e.g., a command that affects all namespaces or a command with an NSID set to the NSID of a namespace which is being sanitized); or
- causes the user data to be accessed (e.g., read) for a namespace that is the sanitization target of an in progress namespace sanitize operation,

then that command shall be aborted with a status code of Sanitize Namespace In Progress.

Some Admin commands only affect attached namespaces while other Admin commands are capable of affecting namespaces that are not attached. Figure TBD-1 describes Admin command processing restrictions for all controllers while any namespace is a sanitization target of an in progress namespace sanitize operation. Figure TBD-1b describes Admin command processing restrictions for controllers with an attached namespace that is a sanitization target of an in progress namespace sanitize operation. Admin commands not shown in Figure TBD-1 or Figure TBD-1b (e.g., Vendor Specific commands) are aborted with a status code of Sanitize Namespace In Progress if the implementation of that Admin command affects a namespace which is a sanitization target of an in progress namespace sanitize operation.

Figure TBD-1: Namespace Sanitize Operations – Admin Command Restrictions, All Controllers

Combined Opcode	Command	Additional Admin Command Restrictions While a Namespace is a Sanitization Target
0Dh	Namespace Management	Abort the command with a status code of Sanitize Namespace In Progress if the SEL field is set to 2h (i.e., Delete) and: the NSID specified in the command is the NSID of a namespace with a namespace sanitize operation in progress on that namespace; or the NSID field is set to FFFFFFFh.
10h	Firmware Commit	Abort the command with a status code of Sanitize Namespace
11h	Firmware Image Download	In Progress.
15h	Namespace Attachment	Abort the command with a status code of Sanitize Namespace
19h	Directive Send	In Progress if the NSID specified in the command is set to
1Ah	Directive Receive	FFFFFFFh or is set to the NSID of a namespace with a namespace sanitize operation in progress on that namespace.
20h	Capacity Management	Abort the command with a status code of Sanitize Namespace In Progress if the operation specified requests an action that includes the deletion of a namespace with a namespace sanitize operation in progress on that namespace.
28h	Clear Exported NVM Resource Configuration	Abort the command with a status code of Sanitize Namespace In Progress if any exported namespace has a sanitize operation in progress on that namespace.
2Dh	Manage Exported NVM Subsystem	Abort the command with a status code of Sanitize Namespace In Progress if the management operation specified requests the deletion of a namespace with a namespace sanitize operation in progress on that namespace.
41h	Migration Send	Abort the command with a status code of Sanitize Namespace In Progress if the CNTLID field specifies the identifier of a controller that has an attached namespace that is the sanitization target of an in progress namespace sanitize operation.
42h	Migration Receive	Abort the command with a status code of Sanitize Namespace In Progress if the CNTLID field specifies the identifier of a controller that has an attached namespace that is the sanitization target of an in progress namespace sanitize operation.

Combined Opcode	Command	Additional Admin Command Restrictions While a Namespace is a Sanitization Target
84h	Sanitize	Refer to section 8.1.24.3 (i.e., the Sanitize Operation State Machine) for restrictions on processing a Sanitize command.
C0h to FFh	Vendor Specific	Abort the command with a status code of Sanitize Namespace In Progress if the command affects a namespace that is a sanitization target or that accesses (e.g., reads) user data from a namespace that is a sanitization target.

Figure TBD-1b: Namespace Sanitize Operations – Admin Command Restrictions if Sanitizing Attached Namespace

Combined Opcode	Command	Additional Restrictions for Sanitize Namespace command
02h	Get Log Page	Abort the command with a status code of Sanitize Namespace In Progress if the NSID specified in the command is the NSID of a namespace with a namespace sanitize operation in progress on that namespace and the log page specified is not the Sanitize Status log page.
09h	Set Features	Abort the command with a status code of Sanitize Namespace In Progress if the NSID specified in the command is the NSID of a namespace with a
0Ah	Get Features	namespace sanitize operation in progress on that namespace (i.e., for a feature with a scope of Namespace (refer to Figure 385) and specifiying the NSID of a namespace being sanitized).
14h	Device Self-test	Abort the command with a status code of Sanitize Namespace In Progress if the NSID specified in the command is set to FFFFFFFh or is set to the NSID of a namespace with a namespace sanitize operation in progress on that namespace.
24h	Lockdown	Abort the command with a status code of Sanitize Namespace In Progress.
80h	Format NVM	Abort the command with a status code of Sanitize Namespace In Progress if the NSID specified in the command is set to FFFFFFFh or is set to the NSID of a namespace with a namespace sanitize operation in progress on that namespace.
86h	Get LBA Status	Abort the command with a status code of Sanitize Namespace In Progress if the NSID specified in the command is set to the NSID of a namespace with a namespace sanitize operation in progress on that namespace.
8Ch	Sanitize Namespace	Refer to section 8.1.24.3 (i.e., the Sanitize Operation State Machine) for restrictions on processing a Sanitize Namespace command.

5.1 Common Admin Commands

5.1.2 Asynchronous Event Request command

Asynchronous events are used to notify a host of status, error, and health information as these events occur. To enable asynchronous events to be reported by the controller, a host needs to submit one or more Asynchronous Event Request commands to the controller. The controller specifies an event to the host by completing an Asynchronous Event Request command. A host should expect that the controller may not execute the command immediately; the command should be completed when there is an event to be reported.

...

5.1.2.1 Command Completion

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Figure 152: Asynchronous Event Information – I/O Command Specific Status

Value	Description
00h	Reservation Log Page Available: Indicates that one or more Reservation Notification log pages (refer to section 5.1.12.1.32) have been added to the Reservation Notification log. To clear this event, the host reads the Reservation log page with the Retain Asynchronous Event bit cleared to '0'.

Figure 152: Asynchronous Event Information - I/O Command Specific Status

scription nitize Operation Completed: Indicates that a sanitize operation has completed (including any sociated additional media modification, refer to the No-Deallocate Modifies Media After Sanitize	
sociated additional media modification, refer to the No-Deallocate Modifies Media After Sanitize	
d in Figure 312) without unexpected deallocation of all media in the sanitization target that is posted for user data (refer to section 5.1.25.1.15) and status is available in the Sanitize Status log ge (refer to section 5.1.12.1.33). To clear this event, the host reads the Sanitize Status log page in the Retain Asynchronous Event bit cleared to '0'.	
e Event Specific Parameter field in Completion Queue Entry Dword 1 shall be cleared to 0h if the nitization target was the NVM subsystem. The Event Specific Parameter field shall be set to the BID of the sanitization target if the sanitization target was a namespace.	
Sanitize Operation Completed With Unexpected Deallocation: Indicates that a sanitize operation for which No-Deallocate After Sanitize (refer to Figure 372) was requested has completed with the unexpected deallocation of all media in the sanitization target that is allocated for user data (refer to section 5.1.25.1.15) and status is available in the Sanitize Status log page (refer to section 5.1.12.1.33). To clear this event, the host reads the Sanitize Status log page with the Retain Asynchronous Event bit cleared to '0'.	
Sanitize Operation Entered Media Verification State: Indicates that sanitize processing was successful, the sanitize operation entered the Media Verification state (refer to section 8.1.24), and status is available in the Sanitize Status log page (refer to section 5.1.12.1.33). The Event Specific Parameter field in Completion Queue Entry Dword 1 shall be cleared to 0h if the sanitization target was the NVM subsystem. The Event Specific Parameter field shall be set to the NSID of the sanitization target if the sanitization target was a namespace.	
served	

5.1.12 Get Log Page command

Figure 202 defines the log pages that are able to be retrieved with the Get Log Page command and the scope of the information that is returned in those log pages. Section 5.1.12.1 describes log pages that are common to all transport models. Section 5.1.12.2 describes log pages that are specific to the Memorybased transport model. Section 5.1.12.3 describes log pages that are specific to the Message-based transport model.

Figure 202: Get Log Page - Log Page Identifiers

Log Page Identifier	csi ⁸	Scope Log Page Name		Reference Section	
7Fh	N	Controller	Sanitize Namespace Status List	5.1.12.1.TBD	
80h	N	Controller	Reservation Notification	5.1.12.1.32	
81h	N	NVM subsystem ¹ / Namespace ² Sanitize Status		5.1.12.1.33	
82h to BEh	I/O Command Set Specific				

Notes:

- For namespace identifiers of 0h or FFFFFFFh.
 For namespace identifiers other than 0h or FFFFFFFh.

5.1.12.1 Common Log Specific Information

5.1.12.1.14 Persistent Event (Log Page Identifier 0Dh)

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5.1.12.1.14.2 Persistent Event Log Events

. . .

5.1.12.1.14.2.9 Sanitize Start Event (Event Type 09h)

A Sanitize Start event shall be recorded in the Persistent Event Log at the start of a sanitize operation (i.e., the sanitization target transitions to the Restricted Processing state or the Unrestricted Processing state, as described in section 8.1.24.3).

The Sanitize Start event shall set the Persistent Event Log Event Format Header:

- Event Type field to 09h; and
- Event Type Revision field to 02h 01h.

Figure 243: Sanitize Start Event Data Format (Event Type 09h)

Bytes	Description
03:00	Sanitize Capabilities (SANICAP): Contains the contents of the SANICAP field from the Identify
03.00	Controller data structure.
07:04	Sanitize CDW10 (SCDW10): Contains the value from command Dword 10 of the Sanitize
07:04	command that started the sanitize operation (refer to Figure 372).
11:08	Sanitize CDW11 (SCDW11): Contains the value from command Dword 11 of the Sanitize
11.00	command that started the sanitize operation (refer to Figure 373).
	Namespace Identifier (NSID): If the sanitization target is:
15:12	 a namespace, then this field contains the value from the NSID of the sanitization target;
	or
	 the NVM subsystem, then this field shall be set to FFFFFFFh.

5.1.12.1.14.2.10 Sanitize Completion Event (Event Type 0Ah)

A Sanitize Completion event shall be recorded in the Persistent Event Log at the completion of a sanitize operation (i.e., the sanitization target transitions to the Idle state, the Restricted Failure state, or the Unrestricted Failure state, as described in section 8.1.24.3).

The Sanitize Completion event shall set the Persistent Event Log Event Format Header:

- Event Type field to 0Ah; and
- Event Type Revision field to 02h 01h.

Figure 244: Sanitize Completion Event Data Format (Event Type 0Ah)

Bytes	Description			
01:00	Sanitize Progress (SPROG): Contains the sanitize progress for the sanitize operation with the sanitization target indicated in the NSID field at the time of this event using the format specified for the SPROG field in the Sanitize Status log page (refer to section 5.1.12.1.33).			
03:02	Sanitize Status (SSTAT): Contains the sanitize status of the sanitize operation with the sanitization target indicated in the NSID field for the time of this event using the format specified for the SSTAT field in the Sanitize Status log page. (e.g., the Global Data Erase bit indicates the status at the time of this event).			
05:04	Completion Information (CINFO): Contains a vendor specific value that may provide more information about the completion of the sanitize operation with the sanitization target indicated in the NSID field (e.g., if the sanitize operation did not complete successfully, then this field may contain a vendor specific code that indicates a vendor specific reason).			
07:06	Reserved			
11:08	Namespace Identifier (NSID): If the sanitization target is: a namespace, then this field contains the value from the NSID of the sanitization target; or			
	 the NVM subsystem, then this field shall be set to FFFFFFFh. 			

..

5.1.12.1.33 Sanitize Status (Log Page Identifier 81h)

The Sanitize Status log page is used to report sanitize operation time estimates and information about the most recent sanitize operation (refer to section 8.1.24) for the specified sanitization target.

The Get Log Page command returns a data buffer containing a log page formatted as defined in Figure 291. This log page shall be retained across power cycles and resets. This log page shall contain valid data whenever CSTS.RDY is set to '1'. If the controller is not able to report valid data (e.g., due to a division event that prevents reporting sanitize status information), then the Get Log Page command shall be aborted with a status code of Controller Pathing Error. If a Get Log Page command is aborted with a status code of Controller Pathing Error, then submitting a subsequent Get Log Page command to a controller with a different domain identifier and requesting the same Sanitize Status log page may be successful. If the controller is able to report valid data, then this log page shall contain valid data whenever CSTS.RDY is set to '1'.

If the Sanitize Capabilities (SANICAP) field in the Identify Controller data structure is not cleared to 0h (i.e., the Sanitize command is supported), then this log page shall be supported. If the Sanitize Capabilities field in the Identify Controller data structure is cleared to 0h, then this log page is reserved.

If the Sanitize Namespace command is supported, then this log page shall support setting the NSID field to the value of an allocated NSID.

The NSID field in the Get Log Page command specifies the sanitization target for the requested Sanitize Status log page (i.e., whether the scope of the Sanitize Status log page is the NVM subsystem or a namespace). If the NSID field is set to:

- Oh or is set to FFFFFFFh, then the Sanitize Status log page for the NVM subsystem is requested;
- an allocated NSID, then the Sanitize Status log page for the namespace indicated by the NSID is requested.

If the NSID specified in the NSID field specifies an unallocated NSID, then the command shall be aborted with a status code of Invalid Namespace or Format.

If the NSID field specifies a namespace as the sanitization target and an NVM subsystem sanitize operation is in progress, then the command shall be aborted with a status code of Sanitize In Progress.

If the NSID field specifies a namespace as the sanitization target and the NVM subsystem is in the Restricted Failure state or the Unrestricted Failure state, then the command shall be aborted with a status code of Sanitize Failed.

Figure 291: Sanitize Status Log Page

Bytes	Description
	Sanitize Progress (SPROG): This field indicates the fraction complete of the:
01:00	 sanitize processing state (i.e., the Restricted Processing state or the Unrestricted Processing state) for the sanitization target; or Post-Verification Deallocation state for the sanitization target, if the Post-Verification Deallocation state is entered as part of the sanitize operation.
01:00	The value is the numerator of the fraction complete that has 65,536 (10000h) as its denominator. This value shall be set to FFFFh if the Sanitize Operation Status (SOS) field is set to a value other than 010b (i.e., Sanitizing) or if the sanitization target is in the Media Verification state. Refer to section 8.1.24.3 for the effects of state changes that change the value of this field.

Bits	Definition
15: 10 11	
10	Namespace Data Erased (NDE): If the Sanitize Namespace command is supported, the sanitization target specified by this Get Log Page command is a namespace, and no user data has been written to the specified namespace: a) since the namespace was created; or b) since the most recent successful sanitize operation with a sanitization target that included the namespace specified by this Get Log Page command (i.e., an NVM subsystem sanitize operation or a namespace sanitize operation with a sanitization target of the specified namespace), then this bit shall be set to '1'.
	Otherwise, this bit shall be cleared to '0'.
	Media Verification Canceled (MVCNCLD): This bit indicates whether the Media Verification state is canceled.
	If the most recent sanitize operation was started by a Sanitize command with the EMVS bit set to '1' and during the Restricted Processing state, the Unrestricted Processing state, or the Media Verification state:
09	a) a change in the composition of the NVM subsystem prevents media verification; or b) a Controller Level Reset of: a. any controller in the NVM subsystem occurs if the sanitization target specified by this Get Log Page command is the NVM subsystem; or b. any controller in the NVM subsystem that is attached to the namespace if the sanitization target specified by this Get Log Page command is a namespace, that is caused by:
	 a transport-specific reset type (refer to the applicable NVMe Transport specification); or
	an NVM Subsystem Reset,
	then this bit is set to '1'. Otherwise, this bit is cleared to '0'.
	Refer to the Sanitize Operation State Machine defined in section 8.1.24.3 for conditions that affect the setting of this bit.
08	Global Data Erased (GDE): If no user data has been written to the NVM subsystem and no Persistent Memory Region in the NVM subsystem has been enabled: a) since being manufactured and the NVM subsystem has never been sanitized; or b) since the most recent successful NVM subsystem sanitize operation,
	•
07:03	then this bit shall be set to '1'. Otherwise, this bit shall be cleared to '0'. Overwrite Passes Completed (OPC): This field shall indicate the number of completed passes if the most recent sanitize operation was an Overwrite. This field shall be cleared to 0h if the most recent sanitize operation was not an Overwrite. If the sanitization target specified by this Get Log Page command is a
	namespace, then this field shall be cleared to 0h.
02:00	Sanitize Operation Status (SOS): This field indicates the status of the most recent sanitize operation for the sanitization target specified by this Get Log Page command as shown below. Sanitize states are described in section 8.1.24.3.

Value	State
000Ь	Sanitize Never Started: If the NSID specifies the NVM subsystem and an NVM subsystem sanitize operation has never been started in the NVM subsystem, then this value shall be reported. Otherwise, this value shall not be reported. If the NSID specifies a namespace and a sanitize operation that includes the specified namespace has never been started in that namespace since that namespace was created, then this value shall be reported.
	Sanitized: If: a) the most recent sanitize operation that included the specified
001b	sanitization target completed successfully; and b) the Sanitize Operation State Machine is in the Idle state,
	then this value shall be reported. Otherwise, this value shall not be reported. Sanitizing: If a sanitize operation that includes the sanitization target specified by
010b	this Get Log Page command is currently in progress (i.e., in the Restricted Processing state, the Unrestricted Processing state, the Media Verification state, or the Post-Verification Deallocation state), then this value shall be reported. Otherwise, this value shall not be reported.
	Sanitize Failed: If the most recent sanitize operation that included the sanitization target specified by this Get Log Page command failed, then this value shall be reported. Otherwise, this value shall not be reported.
011b	This value shall be reported when the Sanitize Operation State Machine is in the Restricted Failure state or the Unrestricted Failure state.
	This value is able to be reported when the Sanitize Operation State Machine is in the Idle state. Sanitized Unexpected Deallocate: If:
100Ь	a) the most recent sanitize operation for which No-Deallocate After Sanitize (refer to section 5.1.22) was requested has completed successfully with deallocation of all media in the NVM subsystem that is allocated for user data (refer to section 5.1.25.1.15); and b) the Sanitize Operation State Machine is in the Idle state,
	then this value shall be reported. Otherwise, this value shall not be reported.

Bytes	Description
-	101b to 111b Reserved
07:04	Sanitize Command Dword 10 Information (SCDW10): This field shall indicate the value of the Command Dword 10 field of the Sanitize command that started the sanitize operation whose status is reported in the SSTAT field. Refer to Figure 372.
	Estimated Time For Overwrite (ETO): This field indicates the estimated time for an overwrite. This field shall be set to the estimated number of seconds required to complete sanitize processing (i.e., the time difference between entering and exiting the Restricted Processing state or the Unrestricted Processing state) of an Overwrite sanitize operation with 16 passes in the background (refer to section 5.1.22) when the No-Deallocate Modifies Media After Sanitize field (refer to Figure 312) is set to a value other than 10b.
11:08	A value of 0h indicates that the sanitize processing is expected to be completed in the background when the Sanitize command that started that operation is completed. A value of FFFFFFFFh indicates that no time period is reported.
	This field shall be set to FFFFFFFh if the sanitization target specified by this Get Log Page command is a namespace.
15:12	Estimated Time For Block Erase (ETBE): This field indicates the estimated time for a block erase. This field shall be set to the estimated number of seconds required to complete sanitize processing (i.e., the time difference between entering and exiting the Restricted Processing state or the Unrestricted Processing state) of a Block Erase sanitize operation in the background (refer to section 5.1.22) when the No-Deallocate Modifies Media After Sanitize field (refer to Figure 312) is set to a value other than 10b.
.02	A value of 0h indicates that the sanitize processing is expected to be completed in the background when the Sanitize command that started that operation is completed. A value of FFFFFFFh indicates that no time period is reported.
	This field shall be set to FFFFFFFh if the sanitization target specified by this Get Log Page command is a namespace.
19:16	Estimated Time For Crypto Erase (ETCE): This field indicates the estimated time for a crypto erase. This field shall be set to the estimated number of seconds required to complete sanitize processing (i.e., the time difference between entering and exiting the Restricted Processing state or the Unrestricted Processing state) of a Crypto Erase sanitize operation for the specified sanitization target in the background (refer to section 5.1.22) when the No-Deallocate Modifies Media After Sanitize field (refer to Figure 312), if any, is set to a value other than 10b.
	A value of 0h indicates that the sanitize processing is expected to be completed in the background when the Sanitize command that started that operation is completed. A value of FFFFFFFFh indicates that no time period is reported.
	Estimated Time For Overwrite With No-Deallocate Media Modification (ETODMM): This field indicates the estimated time for a No-Deallocate Media overwrite. This field shall be set to the estimated number of seconds required to complete sanitize processing (i.e., the time difference between entering and exiting the Restricted Processing state or the Unrestricted Processing state) of an Overwrite sanitize operation, including associated additional media modification, in the background (refer to section 5.1.22) when:
23:20	a) the No-Deallocate After Sanitize bit was set to '1' in the Sanitize command that requested the Overwrite sanitize operation; and b) the No-Deallocate Modifies Media After Sanitize field (refer to Figure 312) is set to 10b. A value of 0h indicates that the sanitize processing is expected to be completed in the
	background when the Sanitize command that started that operation is completed. A value of FFFFFFFh indicates that no time period is reported.
	This field shall be set to FFFFFFFh if the sanitization target specified by this Get Log Page command is a namespace.

Bytes	Description
	Estimated Time For Block Erase With No-Deallocate Media Modification (ETBENMM): This field indicates the estimated time for a No-Deallocate Media block erase. This field shall be set to the estimated number of seconds required to complete sanitize processing (i.e., the time difference between entering and exiting the Restricted Processing state or the Unrestricted Processing state) of a Block Erase sanitize operation, including associated additional media modification, in the background (refer to section 5.1.22) when:
27:24	a) the No-Deallocate After Sanitize bit was set to '1' in the Sanitize command that requested the Block Erase sanitize operation; and b) the No-Deallocate Modifies Media After Sanitize field (refer to Figure 312) is set to 10b. A value of 0h indicates that the sanitize processing is expected to be completed in the background when the Sanitize command that started that operation is completed. A value of FFFFFFFFh indicates that no time period is reported.
	This field shall be set to FFFFFFFh if the sanitization target specified by this Get Log Page command is a namespace.
	Estimated Time For Crypto Erase With No-Deallocate Media Modification (ETCENMM): This field indicates the estimated time for a No-Deallocate Media crypto erase. This field shall be set to the estimated number of seconds required to complete sanitize processing (i.e., the time difference between entering and exiting the Restricted Processing state or the Unrestricted Processing state) of a Crypto Erase sanitize operation for the specified sanitization target, including associated additional media modification, in the background (refer to section 5.1.22) when:
31:28	 a) the No-Deallocate After Sanitize bit was set to '1' in the Sanitize command that requested the Crypto Erase sanitize operation; and b) the No-Deallocate Modifies Media After Sanitize field (refer to Figure 312) is set to 10b.
	A value of 0h indicates that the sanitize processing is expected to be completed in the background when the Sanitize command that started that operation is completed. A value of FFFFFFFh indicates that no time period is reported.
	This field shall be set to FFFFFFFh if the sanitization target specified by this Get Log Page command is a namespace.
35:32	Estimated Time For Post-Verification Deallocation State (ETPVDS): This field indicates the estimated time for post-verification deallocation. This field shall be set to the estimated number of seconds required to deallocate all media in the specified sanitization target that is allocated for user data after exiting the Media Verification state (i.e., the time difference between entering and exiting the Post-Verification Deallocation state), if that state is entered as part of the sanitize operation. A value of FFFFFFFh indicates that no time period is reported.

Sanitize State Information (SSI): This field indicates additional information about the state of sanitization. Bits	Bytes	Description					
of sanitization. Bits Description	Dytes	Sanitize State II	formation (SSI		on about the state		
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5.1.12.1.TBD Sanitize Namespace Status List (Log Page Identifier 7Fh)

The Sanitize Namespace Status List log page is used to report a list of zero or more NSIDs that are each associated with a Sanitize Status log page (refer to section 5.1.12.1.33) that:

- has a Sanitize State other than Idle (i.e., namespace sanitize operations that are in progress); or
- has a Sanitize State of Idle and the Namespace Data Erased bit is set to '1' (i.e., namespace sanitize operations that have successfully completed).

The Log Specific Parameter (LSP) field in Command Dword 10 (refer to Figure 197) for this log page is defined in Figure TBD-LSP. The LSP field is used to select the NSID List type the host is requesting (i.e., is used to select either the list of in progress namespace sanitize operations or the list of successfully completed namespace sanitize operations).

Figure TBD-LSP: Sanitize Namespace Status List Log Specific Parameter Field

Bits	Description					
14:09	Reserved					
		t Type (NLT): This field specifies which NSID List type the controller returns after processing og Page command.				
	Value	Definition				
08	0b	In Progress: The NSID List returned by the controller in the Sanitize Namespace Status List log page shall only contain NSIDs that are associated with a Sanitize Status log page that has a Sanitize State other than Idle.				
	1b	Successfully Completed: The NSID List returned by the controller in the Sanitize Namespace Status List log page shall only contain NSIDs that are associated with a Sanitize Status log page that has a Sanitize State of Idle and that has the Namespace Data Erased bit set to '1'.				

The Get Log Page command returns a data buffer containing a log page formatted as defined in Figure TBD-SNSL. The NSID List, defined in Figure TBD-SNSL, is an ordered list of ascending NSIDs. If the controller is not able to report valid data (e.g., due to a division event that prevents accessing some of the sanitize status information), then the Get Log Page command shall be aborted with a status code of Controller Pathing Error. If a Get Log Page command is aborted with a status code of Controller Pathing a subsequent Get Log Page command to a controller with a different domain identifier and requesting the same Sanitize Namespace Status List log page may be successful. If the controller is able to report valid data, then this log page shall contain valid data whenever CSTS.RDY is set to '1'.

If the Sanitize Namespace command is supported by the controller, then this log page shall be supported by the controller.

Figure TBD-SNSL: Sanitize Namespace Status List Log Page

Bytes	Description			
Header				
07:00	Generation Counter (GENCTR): This field contains a value that is incremented each time the information in this log page changes (i.e., each time an NSID is added or removed from this log page) since the last time the host read this log page. If the value of this field is FFFFFFFFFFFFFFFF, then the field shall be cleared to 0h when incremented (i.e., rolls over to 0h).			
15:08	Number of NSIDs (NUMNSID): This field indicates the number of NSIDs contained in this log page.			
	NSID List			
19:16	NSID 0: This field contains the first NSID of a namespace that is associated with a Sanitize Status log page (refer to section 5.1.12.1.33), if any.			
23:20	NSID 1: This field contains the second NSID of a namespace that is associated with a Sanitize Status log page (refer to section 5.1.12.1.33), if any.			
(NUMNSID*4)+15:((NUMNSID- 1)*4)+16	NSID NUMNSID-1: This field contains the last NSID of a namespace that is associated with a Sanitize Status log page (refer to section 5.1.12.1.33), if any.			

5.1.13 Identify command

...

5.1.13.2 Common Identify Data Structures

5.1.13.2.1 Identify Controller Data Structure (CNS 01h)

The Identify Controller data structure (refer to Figure 312) is returned to the host for the controller processing the command.

				entity Controller I	Data Structure, I/O Command Set Independent
Bytes	1/0 ¹	Admin ¹	Disc ¹	Description	
				If the Sanitize com	es (SANICAP): This field indicates attributes for sanitize operations mand is supported, then this field shall be non-zero. If the Sanitiz oported, then this field shall be cleared to 0h. Refer to section 8.1.24
				Bits	Description
				31:30	No-Deallocate Modifies Media After Sanitize (NODMMAS): This field indicates if media is additionally
				29	No-Deallocate Inhibited (NDI): If this bit is set to '1' and the No-Deallocate Response Mode bit (refer to Figure 408)
				28:04 28:05	Reserved
331:328 O	0	0	R	04	Namespace Verification Support (NVERS): If this bit is set to '1', then the controller supports the Media Verification state and the Post-Verification Deallocation state for a sanitization target of a namespace. If this bit is cleared to '0', then the controller does not support the Media Verification state and does not support the Post-Verification Deallocation state for a sanitization target of a namespace.
					If the BES bit is cleared to '0' and the CES bit is cleared to '0', then this bit shall be cleared to '0'.
				02	Overwrite Support (OWS): If this bit is set to '1', then the controller
				01	Block Erase Support (BES): If this bit is set to '1', then the controller
				00	Crypto Erase Support (CES): If this bit is set to '1', then the controller

5.1.22 Sanitize command

The Sanitize command is used to start an NVM subsystem sanitize operation (refer to section 1.5.DEF1) that targets the NVM subsystem or to recover from a previously failed NVM subsystem sanitize operation that targeted the NVM subsystem. The NVM subsystem sanitize operation types that may be supported are Block Erase, Crypto Erase, and Overwrite.

An NVM subsystem sanitize operation consists of:

• sanitize processing, (refer to section 8.1.24), which may include:

- o deallocation of all media in the NVM subsystem that is allocated for user data; and
- additional media modification;
- optional verification of media in the NVM subsystem that is allocated for user data; and
- post-verification deallocation of all media in the NVM subsystem that is allocated for user data following media verification, if any, as described in section 8.1.24.

Refer to section **8.1.24.TBD** for command processing requirements that are common to the Sanitize command and the Sanitize Namespace command.

All sanitize operations are performed in the background (i.e., completion of the Sanitize command that starts a sanitize operation does not indicate completion of that sanitize operation). Refer to section 8.1.24 for details on the sanitize operation.

If the NVM subsystem supports multiple domains and the Sanitize command is not able to start a sanitize operation as a result of the NVM subsystem being divided (refer to section 3.2.5), then the controller shall abort the Sanitize command with a status code of Asymmetric Access Inaccessible or Asymmetric Access Persistent Loss.

The Sanitize command shall not be supported by Exported NVM Subsystems (refer to section 8.1.24.5).

The Sanitize Capabilities (SANICAP) field in the Identify Controller data structure (refer to Figure 312) indicates:

- a) the NVM subsystem sanitize operation types supported for the Sanitize command;
- whether setting the No-Deallocate After Sanitize (NDAS) bit (refer to Figure 372) causes media to be modified as part of sanitize processing;
- whether the controller inhibits the functionality of the No-Deallocation After Sanitize bit in the Sanitize command; and
- d) whether the controller supports the Media Verification state and the Post-Verification Deallocation state (refer to the Verification Support (VERS) bit in the SANICAP field in Figure 312).

If a Sanitize command specifies an unsupported value in the SANACT field (refer to Figure 372), then the controller shall abort the command with a status code of Invalid Field in Command.

If the Verification Support (VERS) bit is cleared to '0' and a Sanitize command specifies the Enter Media Verification State (EMVS) bit set to '1' (refer to Figure 372), then the controller shall abort the command with a status code of Invalid Field in Command.

If the Verification Support (VERS) bit is set to '1' and a Sanitize command is processed that specifies:

- a) the Enter Media Verification State (EMVS) bit set to '1', the SANACT field set to a value of 010b (i.e., Block Erase) or a value of 100b (i.e., Crypto Erase), and the No-Deallocate After Sanitize (NDAS) bit cleared to '0', then successful sanitize processing is followed by entry to the Media Verification state;
- b) the Enter Media Verification State (EMVS) bit set to '1' and:
 - a) the SANACT field set to 011b (i.e., Overwrite); or
 - b) the No-Deallocate After Sanitize (NDAS) bit set to '1';

then the controller shall abort the command with a status code of Invalid Field in Command;

- c) the SANACT field set to 101b (i.e., Exit Media Verification State) and the sanitization target is in the Media Verification state, then:
 - the controller does not start a new NVM subsystem sanitize operation; and
 - the sanitization target transitions from the Media Verification state to the Post-Verification Deallocation state, in which all media allocated for user data in the NVM subsystem is deallocated:

or

d) the SANACT field set to 101b (i.e., Exit Media Verification State) and the sanitization target is not in the Media Verification state, then the controller shall abort the command with a status code of Invalid Field in Command.

If any Persistent Memory Region is enabled in an NVM subsystem, then the controller shall abort any Sanitize command with a status code of Sanitize Prohibited While Persistent Memory Region is Enabled.

If any namespace is write protected in an NVM subsystem (refer to section 8.1.16), then the controller aborts any Sanitize command with a status code of Namespace is Write Protected.

If any namespace is in the Restricted Failure state and the AUSE bit is set to '1' or the SANACT field is set to 001b (i.e., Exit Failure Mode), then the controller shall abort the Sanitize command with a status code of Sanitize Failed.

If a firmware activation with reset is pending, then the controller shall abort any Sanitize command (refer to section 5.1.8.1 and section 3.11).

If the Firmware Commit command that established the pending firmware activation with reset condition returned a status code of:

- a) Firmware Activation Requires Controller Level Reset;
- b) Firmware Activation Requires Conventional Reset; or
- c) Firmware Activation Requires NVM Subsystem Reset,

then the controller shall abort the Sanitize command with that same status code.

If the Firmware Commit command that established the pending firmware activation with reset condition completed successfully or returned a status code other than:

- a) Firmware Activation Requires Controller Level Reset;
- b) Firmware Activation Requires Conventional Reset; or
- c) Firmware Activation Requires NVM Subsystem Reset,

then the controller shall abort the Sanitize command with a status code of Firmware Activation Requires Controller Level Reset.

Activation of new firmware is prohibited during a sanitize operation (refer to section 8.1.24.4).

If one or more controllers in the NVM subsystem is suspended (refer to section 5.1.17.1.1), then the controller shall abort the command with a status code of Controller Suspended.

Support for Sanitize commands in a Controller Memory Buffer (i.e., submitted to an Admin Submission Queue in a Controller Memory Buffer or specifying an Admin Completion Queue in a Controller Memory Buffer) is implementation specific. If an implementation does not support Sanitize commands in a Controller Memory Buffer and a controller's Admin Submission Queue or Admin Completion Queue is in the Controller Memory Buffer, then the controller shall abort all Sanitize commands with a status code of Command Not Supported for Queue in CMB.

All sanitize operations (i.e., Block Erase, Crypto Erase, and Overwrite) are performed in the background (i.e., Sanitize command completion does not indicate sanitize operation completion). If a sanitize operation starts as a result of a Sanitize command, then the controller shall complete that Sanitize command with a status code of Successful Completion. If the controller completes a Sanitize command with any status code other than Successful Completion, then the controller:

- · shall not start the sanitize operation for that command;
- · shall not modify the Sanitize Status log page; and
- · shall not alter any user data.

The Sanitize command uses Command Dword 10 and Command Dword 11. All other command specific fields are reserved.

Figure 372: Sanitize - Command Dword 10

Bits	Description			
31:11	Reserved			
	Enter Media Verification State (EMVS): If this bit is set to '1', then the Media Verification state shall be entered if sanitize processing completes successfully (i.e., the Global Data Erased (GDE) bit is set to '1' (refer to Figure 291)).			
10	If this bit is cleared to	'0', then this bit shall have no effect.		
	any value other than	oes not specify starting an NVM subsystem sanitize operation (i.e., is set to 010b, 011b, or 100b), then this bit shall be ignored by the controller.		
	(refer to Figure 312) is	Sanitize (NDAS): If this bit is set to '1' and the No-Deallocate Inhibited bit is cleared to '0', then the controller shall not deallocate any media in the NVM llocated for user data as a result of successfully completing the NVM peration. If this bit is:		
09	a) cleared to '0 b) set to '1' and	'; or I the No-Deallocate Inhibited bit is set to '1',		
		ould deallocate all media in the NVM subsystem that is allocated for user coessfully completing the NVM subsystem sanitize operation.		
		oes not specify starting an NVM subsystem sanitize operation (i.e., is set to 010b, 011b, or 100b), then this bit shall be ignored by the controller.		
08	Overwrite Invert Pattern Between Passes (OIPBP): If this bit is set to '1', then the Overwrite Pattern shall be inverted between passes. If this bit is cleared to '0', then the overwrite pattern shall not be inverted between passes. If the Sanitize Action field is set to a value other than 011b (i.e., Overwrite), then this field shall be ignored by the controller.			
07:04	Overwrite Pass Count (OWPASS): This field specifies the number of overwrite passes (i.e., how many times the media is to be overwritten) using the data from the Overwrite Pattern field of this command. A value of 0h specifies 16 overwrite passes. If the Sanitize Action field is set to a value other than 011b (i.e., Overwrite), then this bit shall be ignored by the controller.			
03	Allow Unrestricted Sanitize Exit (AUSE): If this bit is set to '1', then the sanitize processing is performed in unrestricted completion mode (i.e., in the Unrestricted Processing state; refer to section 8.1.24.3.4). If this bit is cleared to '0', then the sanitize processing is performed in restricted completion mode (i.e., in the Restricted Processing state; refer to section 8.1.24.3.2). If the SANACT field does not specify starting an NVM subsystem sanitize operation (i.e., is set to			
	any value other than 010b, 011b, or 100b), then this bit shall be ignored by the controller. Sanitize Action (SANACT): This field specifies the sanitize action to perform.			
	`	, ,		
	Value	Description		
	000b	Reserved		
02:00	001b	Exit Failure Mode		
02.00	010b	Start a Block Erase NVM subsystem sanitize operation		
	011b	Start an Overwrite NVM subsystem sanitize operation		
	100b 101b	Start a Crypto Erase NVM subsystem sanitize operation Exit Media Verification State		
	110b to 111b	Reserved		
	1100 (0 1110	VESCIAER		

Figure 373: Sanitize - Command Dword 11

Bits	Description
21:00	Overwrite Pattern (OVRPAT): This field specifies a 32-bit pattern that is used for the Overwrite NVM subsystem sanitize operation. Refer to section 8.1.24.
31:00	If the Sanitize Action field is set to a value other than 011b (i.e., Overwrite), then this field shall be ignored by the controller.

5.1.22.1 Command Completion

When the command is complete, the controller shall post a completion queue entry to the Admin Completion Queue indicating the status for the command. All NVM subsystem sanitize operations are performed in the background (i.e., completion of the Sanitize command that started that NVM subsystem sanitize operation does not indicate completion of the NVM subsystem sanitize operation. If an NVM subsystem sanitize operation starts (refer to section 8.1.24.3), then the Sanitize Status log page shall be updated before posting the completion queue entry for the command that started that NVM subsystem sanitize operation.

Sanitize command specific status values (i.e., SCT field set to 1h) are shown in Figure 374.

Figure 374: Sanitize – Command Specific Status Values ion

Value	Description
0Bh	Firmware Activation Requires Conventional Reset: The NVM subsystem sanitize operation could not be started because a firmware activation is pending and a Conventional Reset (refer to the NVM Express NVMe over PCIe Transport Specification) is required.
10h	Firmware Activation Requires NVM Subsystem Reset: The NVM subsystem sanitize operation could not be started because a firmware activation is pending and an NVM Subsystem Reset is required.
11h	Firmware Activation Requires Controller Level Reset : The NVM subsystem sanitize operation could not be started because a firmware activation is pending and a Controller Level Reset is required.
23h	Sanitize Prohibited While Persistent Memory Region is Enabled: An NVM subsystem sanitize operation is prohibited while the Persistent Memory Region is enabled.
39h	Controller Suspended: One or more controllers in the NVM subsystem have been suspended by a Migration Send command.

5.1. TBD Sanitize Namespace command

The Sanitize Namespace command is used to start a namespace sanitize operation (refer to section 1.5.DEF2) or to recover from a previously failed namespace sanitize operation. The only namespace sanitize operation type is Crypto Erase.

A namespace sanitize operation consists of:

- sanitize processing, (refer to section 8.1.24), which may include deallocation of all media that is allocated for user data in that namespace;
- optional verification of media in the namespace that is allocated for user data; and
- post-verification deallocation of all media in the namespace that is allocated for user data following media verification, if any, as described in section 8.1.24.

Refer to section **8.1.24.TBD** for command processing requirements that are common to the Sanitize command and the Sanitize Namespace command.

The Sanitize Capabilities (SANICAP) field in the Identify Controller data structure (refer to Figure 312) indicates:

- a) the namespace sanitize operation types supported for the Sanitize Namespace command; and
- whether the controller supports the Media Verification state and the Post-Verification Deallocation state (refer to the Namespace Verification Support (NVERS) bit in the SANICAP field in Figure 312).

The Maximum Namespace Sanitize Operations In Progress (MNSOIP) field in the Sanitize Status log page (refer to Figure 291) is used to indicate the maximum number of namespace sanitize operations that are allowed to be in progress concurrently in the NVM subsystem. If the controller processes a Sanitize Namespace command that requests the controller to exceed the limit indicated in the MNSOIP field, then the controller shall abort the command with a status code of Request Exceeds Maximum Namespace Sanitize Operations In Progress.

If the NSID field:

- is cleared to 0h;
- is set to FFFFFFFh;
- specifies an inactive NSID; or
- · specifies a namespace that is in the process of being deleted,

then the controller shall abort the command with a status code of Invalid Namespace or Format.

If the NVM subsystem is in the Restricted Failure State or is in the Unrestricted Failure state, then the controller shall abort the command with a status code of Sanitize Failed.

If the Namespace Verification Support (NVERS) bit is set to '1' and a Sanitize Namespace command specifies:

- a) the Enter Media Verification State (EMVS) bit set to '1', and the SANACT field set to a value of 100b (i.e., Crypto Erase), then successful sanitize processing is followed by entry to the Media Verification state;
- b) the SANACT field set to 101b (i.e., Exit Media Verification State) and the namespace is in the Media Verification state, then:
 - the controller does not start a new namespace sanitize operation; and
 - the namespace transitions from the Media Verification state to the Post-Verification Deallocation state, in which all media that is allocated for user data in the namespace is deallocated;

or

c) the SANACT field set to 101b (i.e., Exit Media Verification State) and the namespace is not in the Media Verification state, then the controller shall abort the command with a status code of Invalid Field in Command.

If the namespace is write protected (refer to section 8.1.16), then the controller shall abort the Sanitize Namespace command with a status code of Namespace is Write Protected.

The Sanitize Namespace command uses Command Dword 10. All other command specific fields are reserved

Figure TBD-2: Sanitize Namespace – Command Dword 10

Bits	Description
31:11	Reserved
10	Enter Media Verification State (EMVS): If this bit is set to '1', then the Media Verification state shall be entered after sanitize processing completes successfully (i.e., the Namespace Data Erased bit is set to '1' in the Sanitize Status log page for the specified namespace; refer to Figure 291). If this bit is cleared to '0', then this bit shall have no effect. If the SANACT field does not specify starting a namespace sanitize operation (i.e., is set to any value other than 100b), then this bit shall be ignored by the controller.
09:04	Reserved
03	Allow Unrestricted Sanitize Exit (AUSE): If this bit is set to '1', then the sanitize processing is performed in unrestricted completion mode (i.e., in the Unrestricted Processing state, refer to section 8.1.24.3.4). If this bit is cleared to '0', then the sanitize processing is performed in restricted completion mode (i.e., in the Restricted Processing state, refer to section 8.1.24.3.2). If the SANACT field does not specify starting a namespace sanitize operation (i.e., is set to any value other than 100b), then this bit shall be ignored by the controller.

Figure TBD-2: Sanitize Namespace – Command Dword 10

Bits	Description				
	Sanitize Action (SANACT): This field specifies the sanitize action to perform.				
	Value	Description			
	000b	Reserved			
02:00	001b	Exit Failure Mode			
	010b to 011b	Reserved			
	100b	Start a Crypto Erase namespace sanitize operation			
	101b	Exit Media Verification State			
	110b to 111b	Reserved			

5.1. TBD.1 Command Completion

When the command is complete, the controller shall post a completion queue entry to the Admin Completion Queue indicating the status for the command. All namespace sanitize operations are performed in the background (i.e., completion of the Sanitize Namespace command that started that namespace sanitize operation does not indicate completion of the namespace sanitize operation). If a namespace sanitize operation starts (refer to section 8.1.24.3), then the Sanitize Status log page for the sanitization target shall be updated before posting the completion queue entry for the command that started that namespace sanitize operation.

Sanitize Namespace command specific status values (i.e., SCT field set to 1h) are shown in Figure TBD-

Figure TBD-3: Sanitize Namespace – Command Specific Status Values

Value	Description
0Bh	Firmware Activation Requires Conventional Reset: The namespace sanitize operation could not be started because a firmware activation is pending and a Conventional Reset is required.
10h	Firmware Activation Requires NVM Subsystem Reset: The namespace sanitize operation could not be started because a firmware activation is pending and an NVM Subsystem Reset is required.
11h	Firmware Activation Requires Controller Level Reset: The namespace sanitize operation could not be started because a firmware activation is pending and a Controller Level Reset is required.
12h	Request Exceeds Maximum Namespace Sanitize Operations In Progress: The namespace sanitize operation could not be started because the maximum number of namespace sanitize operations that are allowed to be in progress concurrently in the NVM subsystem has been exceeded (refer to the Maximum Namespace Sanitize Operations In Progress (MNSOIP) field in Figure 291).

5.1.25 Set Features command

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5.1.25.1 Common Feature Specific Information

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5.1.25.1.22 Namespace Admin Label (Feature Identifier 1Fh)

The Namespace Admin Label feature provides the ability to set and get the Namespace Admin Label for a namespace. This Feature shall be saveable and therefore shall not be supported if the Save and Select Feature Support (SSFS) bit is cleared to '0' in the Optional NVM Command Support (ONCS) field of the Identify Controller data structure (refer to Figure 312). The attributes in Figure 423 are transferred in the data buffer.

...

The default value of this Feature is all nulls (i.e., all bytes cleared to 0h). Sanitize operations (refer to section 8.1.24) affect the values of this Feature; any successful sanitize operation shall modify this Feature by resetting both the saved value and the current value to the default value (refer to Figure TBD-4).

...

5.1.25.1.26 Host Metadata (Feature Identifier 7Dh), (Feature Identifier 7Eh), (Feature Identifier 7Fh)

...

5.1.25.1.26.3 Namespace Metadata (Feature Identifier 7Fh)

This Feature is used to store metadata about a namespace associated with a controller for later retrieval. This Feature is namespace specific and controller specific. The Add Entry Multiple action is prohibited for this Feature.

...

If a Get Features command with the SEL field set to 011b (i.e., Supported Capabilities) with the Namespace Metadata Feature value is submitted, then the NS Specific bit in Dword 0 of the corresponding completion queue entry shall be set to '1'.

Sanitize operations may affect the values of this Feature as specified in Figure TBD-4.

... _

8 Extended Capabilities

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8.1.24 Sanitize Operations

A sanitize operation alters all user data in the sanitization target such that recovery of any previous user data from any cache, the non-volatile storage media, or any Controller Memory Buffer is not possible. The scope of a sanitize operation is different for an NVM subsystem sanitize operation (refer to section 1.5.DEF1) and for a namespace sanitize operation (refer to section 1.5.DEF2) as shown in Figure TBD-4. Performing a namespace sanitize operation on every namespace that exists in the NVM subsystem does not have the same effect upon certain portions of data in the NVM subsystem as performing an NVM subsystem sanitize operation (e.g., namespace sanitize operations have no effect on the Controller Memory Buffer). If a namespace sanitize operation has been performed on every namespace that exists in the NVM subsystem and no user data has been written to any of those namespaces since each namespace sanitize operation completed successfully, then the Global Data Erased bit (refer to Figure 291) in the Sanitize Status log page for the sanitization target of the NVM subsystem shall not be set '1' as a result of successfully completing those namespace sanitize operations.

Figure TBD-4: Sanitization Operation Scope Based on Sanitize Operation

NVM Subsystem Data	Sanitize Operation		
	NVM Subsystem Sanitize Operation	Namespace Sanitize Operation	
Media allocated for user data	Purge (refer to IEEE Std 2883) all user data in the NVM subsystem from all media allocated for user data	Purge all data in the namespace from all media allocated for use by the sanitization target	
Media that is deallocated	Purge all data	Purge all data from all media that had been allocated for use by the sanitization target	
Volatile caches that contain user data	Purge all data	Purge all data in the volatile cache used by the sanitization target	

NVM Subsystem Data	Sanitize Operation		
•	NVM Subsystem Sanitize Operation	Namespace Sanitize Operation	
Non-Volatile caches that contain user data ¹	Purge all data	Purge all data that had been written in the sanitization target	
Media not able to be written (e.g., write protected)	All media not able to be written shall be made not retrievable	All media that was allocated for use by the sanitization target and not able to be written shall be made not retrievable.	
NVM subsystem information that is not writeable (e.g., serial number)	No effect	No effect	
Firmware	No effect	No effect	
Current values and saved values of features	Feature specific, may be modified to prevent derivation of user data (refer to section 8.1.24.2)	Purge Namespace Metadata feature and Namespace Admin Label feature values, all others may be modified to prevent derivation of user data that was written to the sanitization target (refer to section 8.1.24.2)	
Log pages	May be modified to prevent derivation of user data (refer to section 8.1.24.2)	May be modified to prevent derivation of user data (refer to section 8.1.24.2)	
Security credentials (e.g., in-band authentication credentials)	No effect	No effect	
Boot partition	No effect	No effect	
CMB	Implementation specific	No effect	
HMB	No effect	No effect	
PMR	Required to be disabled before an NVM subsystem sanitize operation is allowed to start	No effect	

For an NVM subsystem sanitize operation, it-It is implementation specific whether Submission Queues and Completion Queues within a Controller Memory Buffer are altered by a sanitize operation; all other data stored in all Controller Memory Buffers is altered by a that NVM subsystem sanitize operation. If a portion of the user data, that was required to be altered, was not altered and the NVM subsystem sanitize operation completed successfully, then the NVM subsystem shall ensure permanent inaccessibility of that portion of the media in the NVM subsystem that is allocated for user data for any future use within the NVM subsystem (e.g., retrieval from NVM media, caches, or any Controller Memory Buffer) and permanent inaccessibility of that portion of the media in the NVM subsystem that is allocated for user data via any interface to the NVM subsystem, including management interfaces as defined by the NVM Express Management Interface Specification.

If the composition of the NVM subsystem (refer to section 3.2.5) changes (e.g., a new domain is added, or a division event occurs) and that change prevents the successful completion of a sanitize operation, then the sanitize operation shall fail. If the composition of the NVM subsystem changes and that change does not prevent the successful completion of a sanitize operation, then that NVM subsystem composition change does not cause the sanitize operation to fail.

If the composition of the NVM subsystem changes (e.g., a new domain is added, or a division event occurs) and that change prevents verification of media in the sanitization target that is allocated for user data, then the Media Verification state is canceled and the MVCNCLD bit is set to '1'.

Sanitize operations do not affect the Replay Protected Memory Block, boot partitions, or other media and caches that do not contain user data. A sanitize operation also may alter log pages and features as necessary (e.g., to prevent derivation of user data from log page information or feature information). A sanitize operation is only able to be started if the NVM subsystem is not divided does not have a division (refer to section 3.2.5) that prevents successfully processing a sanitize operation (refer to section 8.1.24.TBD). A sanitize operation in the Restricted Processing state, the Unrestricted Processing state, the Media Verification state, or the Post-Verification Deallocation state is not able to be aborted and continues

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Commented [MA1]: Required to

Commented [MA2]: Is allowed ro

after a Controller Level Reset, including across power cycles. Refer to Annex A for further information about sanitize operations.

8.1.24.TBD Common Requirements For Commands Requesting Sanitize Operations

Requirements and behaviors that are common for commands requesting sanitize operations (i.e., Sanitize commands (refer to section 5.1.22) and Sanitize Namespace commands (refer to section 5.1.TBD)) are described in this section.

The Sanitize command (refer to section 5.1.22) and the Sanitize Namespace command (refer to section 5.1.TBD) are is-used to start a sanitize operation, to recover from a previously failed sanitize operation, or to exit the Media Verification state.

All sanitize operations (i.e., Block Erase, Crypto Erase, and Overwrite) are performed in the background (i.e., completion of the Sanitize command that starts a sanitize operation does not indicate completion of that sanitize operation). The completion of a sanitize operation, which may include an and the optional transition into the Media Verification state, is are indicated in the Sanitize Status log page, and with:

- the Sanitize Operation Completed asynchronous event with the Event Specific Parameter field:
 - o cleared to 0h if the sanitization target is the NVM subsystem; or
 - o set to the NSID of the sanitization target if the sanitization target is a namespace;
- the Sanitize Operation Completed With Unexpected Deallocation asynchronous event with the NSID field cleared to 0h₁; or
- the Sanitize Operation Entered Media Verification State asynchronous event with the Event Specific Parameter field:
 - o cleared to 0h if the sanitization target is the NVM subsystem; or
 - o set to the NSID of the sanitization target if the sanitization target is a namespace.

If the Sanitize command that started a sanitize operation was submitted to a controller's Admin Submission Queue, then the asynchronous event shall be reported only by that controller. If the Sanitize command that started a sanitize operation was submitted to a Management Endpoint (refer to the NVM Express Management Interface Specification), then the asynchronous event shall not be reported by any controller in the NVM subsystem.

All sanitize operations (i.e., Block Erase, Crypto Erase, and Overwrite) are performed in the background (i.e., Sanitize command completion does not indicate sanitize operation completion). If a sanitize operation starts as a result of a Sanitize command, then the controller shall complete that Sanitize the command that requested the sanitize operation with a status code of Successful Completion. If the controller completes a Sanitize command that requested a sanitize operation with any status code other than Successful Completion, then the controller:

- shall not start the sanitize operation for that command;
- shall not modify the Sanitize Status log page for the sanitization target; and
- shall not alter any user data.

If the NVM subsystem supports multiple domains and a the Sanitize command requesting a sanitize operation is not able to start a sanitize operation as a result of the NVM subsystem being divided (refer to section 3.2.5), then the controller shall abort the Sanitize command with a status code of Asymmetric Access Inaccessible or Asymmetric Access Persistent Loss.

If a Sanitize command requesting a sanitize operation specifies an unsupported value in the SANACT field (refer to Figure 372 and Figure TBD-2), then the controller shall abort the command with a status code of Invalid Field in Command.

If a firmware activation with reset is pending (refer to section 5.1.8.1 and section 3.11), then the controller shall abort any Sanitize command requesting a sanitize operation as specified in section 5.1.8.1 and section 3.11. (refer to section 5.1.8.1 and section 3.11).

If the Firmware Commit command that established the pending firmware activation with reset condition returned a status code of:

- a) Firmware Activation Requires Controller Level Reset;
- b) Firmware Activation Requires Conventional Reset; or
- c) Firmware Activation Requires NVM Subsystem Reset,

then the controller shall abort the Sanitize command that requested the sanitize operation with that same status code.

If the Firmware Commit command that established the pending firmware activation with reset condition completed successfully or returned a status code other than:

- a) Firmware Activation Requires Controller Level Reset;
- b) Firmware Activation Requires Conventional Reset; or
- c) Firmware Activation Requires NVM Subsystem Reset,

then the controller shall abort the Sanitize command that requested the sanitize operation with a status code of Firmware Activation Requires Controller Level Reset.

Activation of new firmware is prohibited during a sanitize operation (refer to section 8.1.24.4).

After validating the Sanitize command parameters, the controller starts the sanitize operation in the background, updates the Sanitize Status log page for the sanitization target and then completes the Sanitize command that requested the sanitize operation with Successful Completion status.

If a Sanitize command is completed with any status code other than Successful Completion, then the controller shall not start the sanitize operation and shall not update the Sanitize Status log page. The controller shall ignore Critical Warning(s) in the SMART / Health Information log page (e.g., read only mode) and shall attempt to complete the sanitize operation requested. Refer to section 5 for further information about restrictions on Admin commands during the processing of a Sanitize command requesting a sanitize operation.

8.1.24.1 Elements of Sanitize Operations

A sanitize operation consists of:

- sanitize processing, which may include:
 - deallocation of all media in the sanitization target that is allocated for user data, if permitted;
 and
 - o additional media modification;
- optional verification of media in the sanitization target that is allocated for user data; and
- post-verification deallocation of all media in the sanitization target that is allocated for user data following media verification, if any.

Sanitize processing is performed in either restricted completion mode (i.e., in the Restricted Processing state) or in unrestricted completion mode (i.e., in the Unrestricted Processing state), as specified by the Allow Unrestricted Sanitize Exit (AUSE) bit in the Sanitize command (refer to Figure 372) or in the Sanitize Namespace command (refer to Figure TBD-2).

Additional media modification may be performed as part of sanitize processing (i.e., in the Restricted Processing state or the Unrestricted Processing state) to prevent commands that access media after completion of sanitize processing from encountering data integrity errors caused by that sanitize processing.

For a sanitization target of NVM subsystem, additional Additional media modification shall be performed if the NODMMAS field is set to 10b (refer to Figure 312) and the Sanitize command that started the sanitize operation specifies:

- the Enter Media Verification State (EMVS) bit cleared to '0'; and
- the No-Deallocate After Sanitize (NDAS) bit set to '1'.

Verification of media in the sanitization target that is allocated for user data is able to be performed by the host if the Sanitize Operation State Machine is in the Media Verification state. A Block Erase sanitize operation or Crypto Erase sanitize operation may invalidate error correction codes on the media, causing

subsequent reads to fail because of media errors. In the Media Verification state, reads are successful regardless of such invalid error correction codes which enables the host to perform an audit (refer to section 1.5.11) to verify that the media was sanitized. Refer to the applicable I/O Command Set specification for details. Media verification is performed if the Sanitize command that starts the sanitize operation specified specifies the EMVS bit set to '1' and sanitize processing completed sempletes successfully.

If a sanitize operation includes deallocation of all media in the sanitization target that is allocated for user data, then that deallocation shall be performed in exactly one of the following states:

- Restricted Processing state;
- · Unrestricted Processing state; or
- Post-Verification Deallocation state.

If the Sanitize command (refer to Figure 372 and Figure TBD-2) that starts a sanitize operation specified specifies:

- the Enter Media Verification State (EMVS) bit cleared to '0';
- the AUSE bit cleared to '0'; and
- the No-Deallocate After Sanitize (NDAS) bit, if anyis:
 - o cleared to '0'; or
 - set to '1' and the controller encounters a condition that results in unexpected deallocation
 of all media in the sanitization target that is allocated for user data (refer to section
 5.1.25.1.15),

then deallocation of all media in the sanitization target that is allocated for user data shall be performed in the Restricted Processing state. If that deallocation fails, then sanitize processing fails.

If the Media Verification state is canceled (i.e., the MVCNCLD bit is set to '1') during the Restricted Processing state, then deallocation of all media in the sanitization target that is allocated for user data shall be performed in the Restricted Processing state.

If the Sanitize command that started the sanitize operation specifies:

- the Enter Media Verification State (EMVS) bit cleared to '0';
- the AUSE bit set to '1'; and
- the No-Deallocate After Sanitize (NDAS) bit, if anyis:
 - o cleared to '0'; or
 - set to '1' and the controller encounters a condition that results in unexpected deallocation
 of all media in the sanitization target that is allocated for user data (refer to section
 5.37.1.19),

then deallocation of all media in the sanitization target that is allocated for user data shall be performed in the Unrestricted Processing state. If that deallocation fails, then sanitize processing fails.

If the Media Verification state is canceled (i.e., the MVCNCLD bit is set to '1') during the Unrestricted Processing state, then deallocation of all media in the sanitization target that is allocated for user data shall be performed in the Unrestricted Processing state.

In the Post-Verification Deallocation state the controller deallocates all user data.

In the Post-Verification Deallocation state, if the controller:

- successfully completes deallocating all media in the sanitization target that is allocated for user data, then the sanitization target enters the Idle state; or
- fails to deallocate all media in the sanitization target that is allocated for user data, then the
 sanitization target enters the Restricted Failure state or the Unrestricted Failure state, as described
 in section 8.1.24.3.7.

A Controller Level Reset may cause the sanitize operation not to include the Media Verification state and the Post-Verification Deallocation state, as described in section 8.1.24.3.

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8.1.24.2 Sanitize Operation Types and Support

The scope of a sanitize operation is all locations in the NVM subsystem that are able to contain user data, including caches, Persistent Memory Regions, and unallocated or deallocated areas of the media.

If the composition of the NVM subsystem (refer to section 3.2.5) changes (e.g., a new domain is added, or a division event occurs) and that change prevents the successful completion of a sanitize operation, then the sanitize operation shall fail.

If the composition of the NVM subsystem changes (e.g., a new domain is added, or a division event occurs) and that change prevents verification of media allocated for user data, then the Media Verification state is canceled and the MVCNCLD bit is set to '1'.

Sanitize operations do not affect the Replay Protected Memory Block, boot partitions, or other media and caches that do not contain user data. A sanitize operation also may alter log pages and features as necessary (e.g., to prevent derivation of user data from log page information or feature information). A sanitize operation is only able to be started if the NVM subsystem is not divided (refer to section 3.2.5). A sanitize operation in the Restricted Processing state, the Unrestricted Processing state, the Media Verification state, or the Post-Verification Deallocation state is not able to be aborted and continues after a Controller Level Reset, including across power cycles. Refer to Annex A for further information about sanitize operations.

The Sanitize command (refer to section 5.1.22) is used to start a sanitize operation, to recover from a previously failed sanitize operation, or to exit the Media Verification state. All sanitize operations are performed in the background (i.e., completion of the Sanitize command that starts a sanitize operation does not indicate completion of that sanitize operation). The completion of a sanitize operation and the optional transition into the Media Verification state are indicated in the Sanitize Status log page, and with:

- · the Sanitize Operation Completed asynchronous event,
- the Sanitize Operation Completed With Unexpected Deallocation asynchronous event, or
- the Sanitize Operation Entered Media Verification State asynchronous event.

If the Sanitize command that started a sanitize operation was submitted to a controller's Admin Submission Queue, then the asynchronous event shall be reported only by that controller. If the Sanitize command that started a sanitize operation was submitted to a Management Endpoint (refer to the NVM Express Management Interface Specification), then the asynchronous event shall not be reported by any controller in the NVM subsystem.

The Sanitize Capabilities (SANICAP) field of the Identify Controller data structure (refer to Figure 312) indicates the sanitize operation types supported and controller attributes specific to sanitize operations.

The sanitize operation types are:

- the Block Erase sanitize operation, which alters user data with a low-level block erase method that
 is specific to the media for all locations on the media within the sanitization target in which user
 data may be stored;
- the Crypto Erase sanitize operation, which alters user data by changing the media encryption keys
 for all locations on the media within the sanitization target in which user data may be stored; and
- the Overwrite sanitize operation, which alters user data by writing a fixed data pattern or related
 patterns one or more times to all locations on the media within the sanitization target in which user
 data may be stored. Figure 647 defines the data pattern or patterns that are written.

Controller attributes that affect the processing of specific to sanitize operations include:

- the No-Deallocate Modifies Media After Sanitize (NODMMAS) field, which indicates whether
 media is modified by the controller as part of sanitize processing for an NVM subsystem sanitize
 operation and that had been requested with the No-Deallocate After Sanitize (NDAS) bit set to '1'
 in the Sanitize command that started the NVM subsystem sanitize operation;
- the No-Deallocate Inhibited (NDI) bit, which indicates if the controller supports the No-Deallocate After Sanitize bit in the Sanitize command; and

- the Verification Support (VERS) bit, which indicates if the controller supports the Media Verification state and the Post-Verification Deallocation state for sanitization NVM subsystem sanitize operations that perform block erase or crypto erase-; and
- the Namespace Verification Support (NVERS) bit, which indicates if the controller supports the Media Verification state and the Post-Verification Deallocation state for namespace sanitize operations.

If the NODMMAS field indicates a value of 10b in the Identify Controller data structure (refer to Figure 312), and a Sanitize command that starts an NVM subsystem sanitize operation specifies the No-Deallocate After Sanitize (NDAS) bit set to '1', then sanitize processing includes additional media modification. Refer to Annex A.3 for further information about sanitize operations and interactions with integrity circuits.

The Overwrite sanitize operation is media specific and may not be appropriate for all media types. For example, if the media is NAND, multiple pass overwrite operations may have an adverse effect on media endurance.

If the NVM subsystem supports the Key Per I/O capability (refer to section 8.1.11), then a sanitize operation shall alter all user data such that recovery of any previous user data using the KEYTAG values specified when that previous user data was written (i.e., original KEYTAG values) is infeasible for a given level of effort (refer to ISO/IEC 27040).

Fig	jure 647: Sanitiz	ze Operations – Overwrite Mechai	nism
erwrite	Overwrite Base Number	User Data except PI Metadata	Protecti

	OIPBP ¹	Overwrite Pass Count 1	Overwrite Pass Number	User Data except PI Metadata	Protection Information ²
	'0'	All	All	Overwrite Pattern ¹	Each byte set to FFh
	'1' Even		First	Inversion of Overwrite Pattern ¹	Each byte cleared to 00h
		Subsequent	Inversion of Overwrite Pattern ¹ from XORed with '1')	previous pass (i.e., each bit	
	'1' Odd	First	Overwrite Pattern ¹	Each byte set to FFh	
		Odd	Subsequent	Inversion of Overwrite Pattern ¹ from XORed with '1')	previous pass (i.e., each bit

Notes:

To start a sanitize operation, the host:

- submits a Sanitize command specifying the SANACT field set to:
 - 010b (i.e., start a Block Erase type NVM subsystem sanitize operation);
 - 011b (i.e., start an Overwrite type NVM subsystem sanitize operation); or
 - 100b (i.e., start a Crypto Erase type NVM subsystem sanitize operation)-;

or

submits a Sanitize Namespace command specifying the SANACT field set to 100b (i.e., start a Crypto Erase type namespace sanitize operation).

The Sanitize command specifies other parameters, including:

- the Allow Unrestricted Sanitize Exit (AUSE) bit;
- the No-Deallocate After Sanitize (NDAS) bit; and
- the Enter Media Verification State (EMVS) bit.

Parameters are specified in Command Dword 10 and Command Dword 11 of the corresponding Sanitize command that started the Overwrite operation. The Overwrite Invert Pattern Between Passes (OIPBP) field is defined in Command Dword 10. The Overwrite Pass Count field is defined in Command Dword 10. The Overwrite Pattern field is defined in Command Dword 11. Refer to section 5.1.22. If Protection Information is present within the metadata.

After validating the Sanitize command parameters, the controller starts the sanitize operation in the background, updates the Sanitize Status log page and then completes the Sanitize command with Successful Completion status.

If a Sanitize command is completed with any status code other than Successful Completion, then the controller shall not start the sanitize operation and shall not update the Sanitize Status log page for the sanitization target. The controller shall ignore Critical Warning(s) in the SMART / Health Information log page (e.g., read only mode) and shall attempt to complete the sanitize operation requested. Refer to section 5 for further information about restrictions on Admin commands during the processing of a Sanitize command.

Following a successful sanitize operation, the values of user data (including protection information (PI), if any, and non-PI metadata, if any) that result from an audit (refer to section 1.5.11) of the sanitization target are defined in the I/O command set specifications.

The Sanitize Status log page (refer to section 5.1.12.1.33) indicates estimated times for sanitize operations and a consistent snapshot of information about the most recently started sanitize operation for the sanitization target specified in the Get Log Page command, including whether a sanitize operation is in progress, the sanitize operation parameters and the status of the most recent sanitize operation. The controller shall report that a sanitize operation is in progress if:

- · sanitize processing is in progress (including additional media modification, if required);
- the sanitization target is in the Media Verification state; or
- the sanitization target is in the Post-Verification Deallocation state.

If an NVM subsystem sanitize operation is not in progress, then the Global Data Erased (GDE) bit in the log page indicates whether the sanitization target NVM subsystem may contain any user data (i.e., whether the sanitization target NVM subsystem has been written to since the most recent successful NVM subsystem sanitize operation).

If a namespace sanitize operation is not in progress on the namespace associated with a Sanitize Status log page, then the Namespace Data Erased (NDE) bit in that log page indicates whether the namespace may contain any user data (i.e., whether the namespace has been written to since the most recent successful namespace sanitize operation).

The Sanitize Status log page shall be:

- initialized before any controller in the NVM subsystem is ready as described in sections 3.5.3 and 3.5.4; and
- updated when a namespace is created (i.e., the Sanitize Status log page for that namespace is created); and
- updated when any state transition occurs (refer to section 8.1.24.3).

The Sanitize Status log page is updated periodically during a sanitize operation to make progress information available to hosts.

During a sanitize operation, the host may periodically examine the Sanitize Status log page to check for progress, however, the host should limit this polling (e.g., to at most once every several minutes) to avoid interfering with the progress of the sanitize operation itself.

The Sanitize Progress (SPROG) field in the Sanitize Status log page indicates progress during states that may take long times to complete (i.e., the Restricted Processing state, the Unrestricted Processing state, and the Post-Verification Deallocation state). The SPROG field is cleared to 0h upon entry to any of those states, and while in any of those states is updated as described in Figure 291. The SPROG field shall not be modified under any conditions not explicitly permitted by this specification.

A sanitize operation completes when the sanitization target enters any of the following states (refer to section 8.1.24.3):

• the Idle state;

- the Restricted Failure state: or
- the Unrestricted Failure state.

Upon completion of a sanitize operation or upon entry to the Media Verification state, the host should read the Sanitize Status log page, specifying the NSID indicating the sanitization target (i.e., cleared to 0h or set to FFFFFFFFh for the NVM subsystem or set to the NSID of the namespace), and with the Retain Asynchronous Event bit cleared to '0' (which clears the asynchronous event, if one was generated).

If a sanitize operation fails (i.e., the sanitization target enters the Restricted Failure state or the Unrestricted Failure state), all controllers in the NVM subsystem shall abort any command not allowed during a sanitize operation with a status code of Sanitize Failed (refer to section 8.1.24.3) until a subsequent sanitize operation is started or successful recovery from the failed sanitize operation occurs. A subsequent successful sanitize operation or the Exit Failure Mode action may be used to recover from a failed sanitize operation. Refer to section 5.1.22 for recovery details.

If a command that requests sanitize operations (i.e., the Sanitize command or the Sanitize Namespace command) is supported, then all controllers in the NVM subsystem shall:

- · support the Sanitize Status log page;
- support the Sanitize Operation Completed asynchronous event;
- support the Sanitize Operation Completed With Unexpected Deallocation asynchronous event, if the Sanitize Config feature is supported;
- support the Exit Failure Mode action for that commanda Sanitize command;
- support at least one of the following sanitize operation types: Block Erase, Overwrite, or Crypto Frase:
- support the same set of sanitize operation types for that command;
- indicate the supported sanitize operation types in the Sanitize Capabilities field in the Identify Controller data structure; and
- if the Verification Support (VERS) bit is set to '1' or the Namespace Verification Support (NVERS) bit is set to '1' in the Identify Controller data structure (refer to Figure 312), support:
 - o the FAILS field in the Sanitize Status log page (refer to section 5.1.12.1.33);
 - $\circ \quad \text{ the SANS field in the Sanitize Status log page;} \\$
 - o the Media Verification state;
 - o the Post-Verification Deallocation state; and
 - o the Sanitize Operation Entered Media Verification State asynchronous event.

The Sanitize Config Feature Identifier (refer to section 5.1.25.1.15) contains the No-Deallocate Response Mode (NODRM) bit that specifies the response of the controller to a Sanitize command specifying the No-Deallocate After Sanitize (NDAS) bit (refer to Figure 372) set to '1' if the No-Deallocate Inhibited bit is set to '1' in the Sanitize Capabilities field of the Identify Controller data structure (refer to Figure 312). In the No-Deallocate Error Response Mode, the controller aborts such Sanitize commands with a status code of Invalid Field in Command. In the No-Deallocate Warning Response Mode, the controller processes such Sanitize commands, and if a resulting NVM subsystem sanitize operation is completed successfully, then the SOS field is set to 100b (i.e., Sanitized Unexpected Deallocate) in the Sanitize Status log page (refer to Figure 291).

8.1.24.2.1 Sanitize NVM Subsystem Failure Handling

If an NVM subsystem sanitize operation fails (i.e., the sanitization target enters the Restricted Failure state or the Unrestricted Failure state), all controllers in the NVM subsystem shall abort any command not allowed during an NVM subsystem sanitize operation with a status code of Sanitize Failed (refer to section 8.1.24.3) until a subsequent NVM subsystem sanitize operation is started or successful recovery from the failed NVM subsystem sanitize operation occurs. A subsequent successful NVM subsystem sanitize operation or the Exit Failure Mode action may be used to recover from a failed NVM subsystem sanitize operation. Refer to section 5.1.22 for recovery details.

8.1.24.2.2 Sanitize Namespace Failure Handling

If a namespace sanitize operation fails (i.e., the sanitization target enters the Restricted Failure state or the Unrestricted Failure state):

- all controllers shall process Admin commands as specified for Sanitize Namespace Admin command processing restrictions in section 5.TBD.2 except that commands are aborted with a status code of Sanitize Namespace Failed; and
- all controllers shall abort all I/O commands specifying the NSID of a sanitization target that is in the Restricted Failure state or the Unrestricted Failure state with a status code of Sanitize Namespace Failed.

8.1.24.3 Sanitize Operation State Machine

The Sanitize Operation State Machine (refer to Figure 648) defines the state of sanitization of a sanitization target. There is one instance of the state machine for each supported sanitization target (i.e., one for the NVM subsystem if an NVM subsystem sanitize operation is supported, and one for each allocated namespace if a namespace sanitize operation is supported). The label on each transition begins with a letter and may include a number. The letter indicates the condition causing that transition, as described in the section for each state. The number differentiates between different transitions that have the same transition condition.

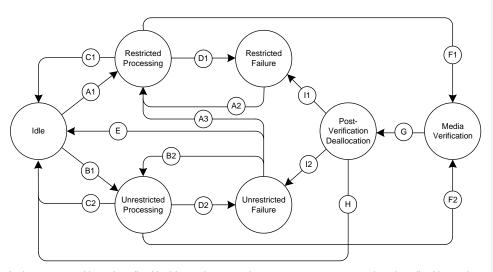


Figure 648: Sanitize Operation State Machine

In the state transitions described in this section, asynchronous events are reported as described in section 8.1.24.2 8.1.24.TBD. In the Completion Queue Entry Dword 0 (refer to Figure 147) for the Asynchronous Event Request command:

- for Dword 0 (refer to Figure 147):
 - a) the Log Page Identifier field shall be set to 81h (i.e., Sanitize Status log page);
 - b) the Asynchronous Event Information field (refer to section 5.1.2.1) shall be set to:
 - 01h (i.e., Sanitize Operation Completed);
 - 02h (i.e., Sanitize Operation Completed With Unexpected Deallocation); or
 - 03h (i.e., Sanitize Operation Entered Media Verification State;

and

- c) the Asynchronous Event Type field shall be set to 110b (i.e., I/O Command specific status)-; and
- for Dword 1, as specified in section 8.1.24.TBD, the Event Specific Parameter (i.e., Completion Queue Entry Dword 1, refer to Figure 148) is set to the NSID for the sanitization target. For a sanitization target of the NVM subsystem, the NSID value reported is cleared to 0h.

In each state transition described in this section, the controller shall set the Sanitize State (SANS) field in the Sanitize Status log page for the sanitization target to the value corresponding to the state being entered.

8.1.24.3.1 Idle State

In this state, no sanitize operation is in process. This state applies in the following cases:

- a) no sanitize operation has ever been performed:
 - o on the NVM subsystem since the NVM subsystem was manufactured; or
 - o on the namespace since the namespace was created;
- b) the most recent sanitize operation on the NVM subsystem sanitization target was successful; and
- c) the most recent sanitize operation failed in the unrestricted completion mode (i.e., the Sanitize command specified the AUSE bit set to '1') and then the Sanitize Operation State Machine transitioned from the Unrestricted Failure state to the Idle state when any controller in the NVM subsystem performed an Exit Failure Mode action on the sanitization target associated with this state machine.

In this state, the Sanitize command and the Sanitize Namespace command are processed without restrictions. In this state, any controller in the NVM subsystem processing a Sanitize command specifying the Sanitize Action field set to 001b (i.e., Exit Failure Mode) and specifying the sanitization target associated with this state machine shall not be considered an error.

In this state, all controllers in the NVM subsystem are permitted to resume any power management that was suspended by any prior sanitize operation.

Figure 649: Idle State Transition Conditions

State Transition			
Starting	Ending	Label 1	Transition Condition
Idle	Restricted Processing	A1	The controller starts a sanitize operation on the sanitization target associated with this state machine in restricted completion mode (i.e., the Sanitize command specified the AUSE bit cleared to '0').
luie	Unrestricted Processing	B1	The controller starts a sanitize operation on the sanitization target associated with this state machine in unrestricted completion mode (i.e., the Sanitize command specified the AUSE bit set to '1').
Notes:	to Figure 648.		

Transition Idle:Restricted Processing:

The controller shall, in the Sanitize Status log page for the sanitization target, clear the:

- a) Sanitize Progress (SPROG) field to 0h; and
- b) Media Verification Canceled (MVCNCLD) bit to '0'.

Transition Idle:Unrestricted Processing:

The controller shall, in the Sanitize Status log page for the sanitization target, clear the:

- a) Sanitize Progress (SPROG) field to 0h; and
- b) Media Verification Canceled (MVCNCLD) bit to '0'.

8.1.24.3.2 Restricted Processing State

In this state, if the sanitize operation fails, then the sanitization target transitions to the Restricted Failure state.

In this state:

- a) the controller shall set the Sanitize Progress (SPROG) field, in the Sanitize Status log page for the sanitization target, as described in Figure 291;
- b) the controller shall perform additional media modification, if required, as described in section 8.1.24.1:
- the controller should deallocate all media in the sanitization target that is allocated for user data, if permitted, as described in section 8.1.24.1;
- d) if a change in the composition of the NVM subsystem occurs then the MVCNCLD bit, in the Sanitize Status log page for the sanitization target, shall be set to '1';
- e) if a Controller Level Reset of any controller in the NVM subsystem occurs that is caused by:
 - a transport-specific reset type (refer to the applicable NVMe Transport specification); or
 - an NVM Subsystem Reset,

then the MVCNCLD bit, in the Sanitize Status log page for the sanitization target, shall be set to '1'-and

- f) all controllers and Management Endpoints in the NVM subsystem shall process commands as described in section 8.1.24.4.:
- g) if the sanitization target is the NVM subsystem, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command: and
 - · Sanitize Namespace command,

with a status code of Sanitize In Progress; and

- h) if the sanitization target is a namespace, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command; and
 - Sanitize Namespace command for the sanitization target associated with this state machine.

with a status code of Sanitize Namespace In Progress.

Figure 650: Restricted Processing State Transition Conditions

State Transition			
Starting	Ending	Label ¹	Transition Condition
Restricted Processing	ldle	C1	Sanitize processing completes successfully and the EMVS bit was: cleared to '0' in the Sanitize command that started the sanitize operation; or set to '1' in the Sanitize command that started the sanitize operation, the MVCNCLD bit is set to '1' in the Sanitize Status log page for the sanitization target, and deallocation of all media in the sanitization target that is allocated for user data completes successfully.
	Restricted Failure	D1	Sanitize processing fails.
	Media Verification	F1	The EMVS bit was set to '1' in the Sanitize command that started the sanitize operation, the sanitize processing completes successfully, and the MVCNCLD bit is cleared to '0' in the Sanitize Status log page for the sanitization target.
Notes:	040		
 Refer to Fig 	gure 648.		

Transition Restricted Processing:Idle:

The controller shall:

- a) if the sanitization target is the NVM subsystem:
 - o if the Sanitize Namespace command is not supported:
 - i. set the Global Data Erased (GDE) bit to '1' in the Sanitize Status log page for the NVM subsystem; and

ii. set the Sanitize State (SANS) field to 0h (i.e., Idle state) in the Sanitize Status log page for the NVM subsystem;

or

- o if the Sanitize Namespace command is supported:
 - i. set the Global Data Erased (GDE) bit to '1' in every Sanitize Status log page;
 - ii. set the Namespace Data Erased (NDE) bit to '1' in the Sanitize Status log page for each namespace that exists in the NVM subsystem; and
 - iii. set the SANS field to 0h (i.e., Idle state) in the Sanitize Status log page for the NVM subsystem and each namespace that exists in the NVM subsystem;
- b) if the sanitization target is a namespace:
 - set the Namespace Data Erased (NDE) bit to '1' in the Sanitize Status log page for that namespace; and
 - set the SANS field to 0h (i.e., Idle state) in the Sanitize Status log page for that namespace;

and

 report the Sanitize Operation Completed asynchronous event or the Sanitize Operation Completed With Unexpected Deallocation asynchronous event, as described in section 8.1.24.2 8.1.24.TBD.

Transition Restricted Processing:Restricted Failure:

The controller shall:

- set the FAILS field, in the Sanitize Status log page for the sanitization target, to 1h (i.e., Restricted Processing state; and
- report the Sanitize Operation Completed asynchronous event or the Sanitize Operation Completed With Unexpected Deallocation asynchronous, as described in section 8.1.24.2 8.1.24.TBD.

Transition Restricted Processing: Media Verification:

The controller shall:

 a) report the Sanitize Operation Entered Media Verification State asynchronous event as described in section 8.1.24.7BD.

8.1.24.3.3 Restricted Failure State

This state is entered if sanitize processing was performed in the Restricted Processing state and:

- a) sanitize processing failed; or
- b) a failure occurred during deallocation of media in the sanitization target that is allocated for user data in the Post-Verification Deallocation state.

In this state:

- a) all controllers and Management Endpoints in the NVM subsystem shall process commands as described in section 8.1.24.4;
- failure recovery requires the host to issue a subsequent Sanitize command or, for a namespace in this state, a Sanitize Namespace command specifying the AUSE bit cleared to '0' (i.e., restricted completion mode);
- c) if the sanitize target is the NVM subsystem, then all controllers in the NVM subsystem shall abort a Sanitize command, or a Sanitize Namespace command for the sanitization target associated with this state machine, that specifying specifies:
 - the SANACT field set to 001b (i.e., Exit Failure Mode), with a status code of Sanitize Failed;
 - the SANACT field set to 101b (i.e., Exit Media Verification State), with a status code of Invalid Field in Command; or
 - the AUSE bit set to '1' (i.e., unrestricted completion mode), with a status code of Sanitize Failed:

and

d) if the sanitize target is a namespace, then all controllers in the NVM subsystem shall abort a Sanitize command, or a Sanitize Namespace command for the sanitization target associated with this state machine, that specifies:

- the SANACT field set to 001b (i.e., Exit Failure Mode), with a status code of Sanitize Namespace Failed;
- the SANACT field set to 101b (i.e., Exit Media Verification State), with a status code of Invalid Field in Command; or
- the AUSE bit set to '1' (i.e., unrestricted completion mode), with a status code of Sanitize Namespace Failed;

and

e) the Persistent Memory Region shall behave as described in section 8.1.24.4.

Figure 651: Restricted Failure State Transition Conditions

State Transition			
Starting	Ending	Label 1	Transition Condition
Restricted Failure	Restricted Processing	A2	The controller starts a sanitize operation on the sanitization target associated with this state machine in restricted completion mode (i.e., the Sanitize command specified the AUSE bit cleared to '0').
Notes: 1. Refer to Fig			

Transition Restricted Failure:Restricted Processing:

The controller shall start a sanitize operation in the Restricted Processing state. The controller shall, in the Sanitize Status log page for the sanitization target, clear the:

- a) clear the Sanitize Progress (SPROG) field to 0h; and
- b) clear the Media Verification Canceled (MVCNCLD) bit to '0'.

8.1.24.3.4 Unrestricted Processing State

In this state, if the sanitize operation fails, then the sanitization target transitions to the Unrestricted Failure state, from which it is able to transition to the Idle state without successful sanitization.

In this state:

- a) the controller shall set the Sanitize Progress (SPROG) field, in the Sanitize Status log page for the sanitization target, as described in Figure 291;
- the controller shall perform additional media modification, if required, as described in section 8.1.24.1;
- the controller should deallocate all media in the sanitization target that is allocated for user data, if permitted, as described in section 8.1.24.1;
- d) if a change in the composition of the NVM subsystem occurs then the MVCNCLD bit shall be set to '1' in the Sanitize Status log page for the sanitization target;
- e) if the sanitization target is the NVM subsystem and a Controller Level Reset of any controller in the NVM subsystem occurs that is caused by:
 - a transport-specified reset type (refer to the applicable NVMe Transport specification); or
 - an NVM Subsystem Reset,

then the MVCNCLD bit shall be set to '1'; and

- f) if the sanitization target is a namespace and a Controller Level Reset on any controller that is attached to the sanitization target occurs that is caused by:
 - a transport-specified reset type (refer to the applicable NVMe Transport specification); or
 - an NVM Subsystem Reset,

then the MVCNCLD bit shall be set to '1';

- g) all controllers and Management Endpoints in the NVM subsystem shall process commands as described in section 8.1.24.4-;
- if the sanitization target is the NVM subsystem, then all controllers in the NVM subsystem shall abort a:
 - · Sanitize command; and
 - Sanitize Namespace command,

with a status code of Sanitize In Progress; and

- i) if the sanitization target is a namespace, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command; and
 - Sanitize Namespace command for the sanitization target associated with this state machine,

with a status code of Sanitize Namespace In Progress.

Figure 652: Unrestricted Processing State Transition Conditions

State Transition				
Starting	Ending	Label ¹	Transition Condition	
Unrestricted Processing			The sanitize processing completes successfully and the EMVS bit was:	
	Idle	C2	a) cleared to '0' in the Sanitize command that started the sanitize operation; or b) set to '1' in the Sanitize command that started the sanitize operation, the MVCNCLD bit is set to '1', and deallocation of all media in the sanitization target that is allocated for user data completes successfully.	
	Unrestricted Failure	D2	The sanitize processing fails.	
	Media Verification	F2	The EMVS bit was set to '1' in the Sanitize command that started the sanitize operation, the sanitize processing completes successfully, and the MVCNCLD bit is cleared to '0' in the Sanitize Status log page for the sanitization target.	
Notes:	Figure 648.			

Transition Unrestricted Processing:Idle:

The controller shall:

- a) if the sanitization target is the NVM subsystem:
 - o if the Sanitize Namespace command is not supported:
 - i. set the Global Data Erased (GDE) bit to '1' in the Sanitize Status log page for the NVM subsystem; and
 - set the Sanitize State (SANS) field to 0h (i.e., Idle state) in the Sanitize Status log page for the NVM subsystem;

or

- if the Sanitize Namespace command is supported:
 - i. set the Global Data Erased (GDE) bit to '1' in every Sanitize Status log page;
 - ii. set the Namespace Data Erased (NDE) bit to '1' in the Sanitize Status log page for each namespace that exists in the NVM subsystem; and
 - set the SANS field to 0h (i.e., Idle state) in the Sanitize Status log page for the NVM subsystem and each namespace that exists in the NVM subsystem;
- b) if the sanitization target is a namespace:
 - set the Namespace Data Erased (NDE) bit to '1' in the Sanitize Status log page for that namespace; and
 - o set the SANS field to 0h (i.e., Idle state) in the Sanitize Status log page for that namespace;

and

 report the Sanitize Operation Completed asynchronous event or the Sanitize Operation Completed With Unexpected Deallocation asynchronous event, as described in section 8.1.24.2 8.1.24.TBD.

Transition Unrestricted Processing:Unrestricted Failure:

The controller shall:

 a) set the FAILS field to 3h in the Sanitize Status log page for the sanitization target (i.e., Unrestricted Processing state); and

 report the Sanitize Operation Completed asynchronous event or the Sanitize Operation Completed With Unexpected Deallocation asynchronous event, as described in section 8.1.24.2 8.1.24.TBD.

Transition Unrestricted Processing: Media Verification:

The controller shall:

 a) report the Sanitize Operation Entered Media Verification State asynchronous event as described in section 8.1.24.2 8.1.24.TBD.

8.1.24.3.5 Unrestricted Failure State

This state is entered if sanitize processing was performed in the Unrestricted Processing state and:

- a) sanitize processing failed; or
- a failure occurred during deallocation of media in the sanitization target that is allocated for user data in the Post-Verification Deallocation state.

In this state:

- a) all controllers and Management Endpoints in the NVM subsystem shall process commands as described in section 8.1.24.4;
- all controllers in the NVM subsystem shall abort a Sanitize command or Sanitize Namespace command specifying the SANACT field set to 101b (i.e., Exit Media Verification State) with a status code of Invalid Field in Command;
- if the sanitization target is the NVM subsystem, then all controllers in the NVM subsystem shall abort a Sanitize command, and a Sanitize Namespace command for the sanitization target associated with this state machine, that specifying specifies the SANACT field set to a value that is not set to 101b (i.e., Exit Media Verification State) and that is set to a value other than:
 - 001b (i.e., Exit Failure Mode);
 - 010b (i.e., Start a Block Erase sanitize operation);
 - 011b (i.e., Start an Overwrite sanitize operation); or
 - 100b (i.e., Start a Crypto Erase sanitize operation)-

with a status code of Sanitize Failed; and

- d) if the sanitization target is a namespace, then all controllers in the NVM subsystem shall abort a Sanitize command, and a Sanitize Namespace command for the sanitization target associated with this state machine, that specifies the SANACT field set to a value that is not set to 101b (i.e., Exit Media Verification State) and that is set to a value other than:
 - 001b (i.e., Exit Failure Mode); or
 - 100b (i.e., Start a Crypto Erase sanitize operation),

with a status code of Sanitize Namespace Failed; and

e) the Persistent Memory Region shall behave as described in section 8.1.24.4.

Figure 653: Unrestricted Failure State Transition Conditions

State Transition				
Starting	Ending	Label 1	Transition Condition	
Hannatai ata d	Restricted Processing	А3	The controller starts a sanitize operation in restricted completion mode (i.e., the Sanitize command specified the AUSE bit cleared to '0').	
Unrestricted Failure	Unrestricted Processing	B2	The controller starts a sanitize operation in unrestricted completion mode (i.e., the Sanitize command specified the AUSE bit set to '1').	
	Idle	E	Any controller in the NVM subsystem performs an Exit Failure Mode action.	
Notes: 1. Refer to F	igure 648.			

Transition Unrestricted Failure:Restricted Processing:

The controller shall start a sanitize operation in the Restricted Processing state. The controller shall, in the Sanitize Status log page for the sanitization target, clear the:

- a) clear the Sanitize Progress (SPROG) field to 0h; and
- b) clear the Media Verification Canceled (MVCNCLD) bit to '0'.

Transition Unrestricted Failure:Unrestricted Processing:

The controller shall start a sanitize operation in the Unrestricted Processing state. The controller shall, in the Sanitize Status log page for the sanitization target, clear the:

- a) clear the Sanitize Progress (SPROG) field to 0h; and
- b) clear the Media Verification Canceled (MVCNCLD) bit to '0'.

Transition Unrestricted Failure:Idle:

If any controller in the NVM subsystem performs an Exit Failure Mode action for the sanitization target associated with this state machine, then the controller shall recover from the sanitization failure by transitioning the Sanitize Operation State Machine to the Idle state and shall complete the Sanitize command that specified the Exit Failure Mode action with a status code of Successful Completion.

8.1.24.3.6 Media Verification State

In this state, the sanitize processing completed successfully, and all media allocated for user data in the sanitization target is readable by the host for purposes of verifying sanitization.

In this state:

- a) if the sanitization target is the NVM subsystem (i.e., the sanitization target associated with this state
 machine is the NVM subsystem), then the Sanitize Operation State Machine shall transition to the
 Post-Verification Deallocation state if any controller in the NVM subsystem performs an Exit Media
 Verification State action with a sanitization target of the NVM subsystem;
- b) if the sanitization target is a namespace (i.e., the sanitization target associated with this state machine is a namespace), then the Sanitize Operation State Machine shall transition to the Post-Verification Deallocation state if any controller in the NVM subsystem performs an Exit Media Verification State action with that namespace specified as the sanitization target;
- if the sanitization target is the NVM subsystem, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command specifying the SANACT field not set to 101b (i.e., Exit Media Verification State); and
 - Sanitize Namespace command specifying the SANACT field not set to 101b (i.e., Exit Media Verification State):

with a status code of Invalid Field in Command; and

- d) if the sanitization target is a namespace, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command with the SANACT field not set to 101b (i.e., Exit Media Verification State);
 and
 - Sanitize Namespace command for the sanitization target associated with this state machine and with the SANACT field not set to 101b (i.e., Exit Media Verification State);

with a status code of Invalid Field in Command; and

 e) all controllers and Management Endpoints in the NVM subsystem shall process commands as described in section 8.1.24.4, with exceptions as described in the appropriate I/O command set specification (e.g., the Read command in the NVM Command Set is processed as described in the Media Verification section of the NVM Command Set Specification).

Figure 654: Media Verification State Transition Conditions

State Transition				
Starting	Ending	Label 1	Transition Condition	
Media Verification	Post- Verification Deallocation	G	a) Any controller in the NVM subsystem performs an Exit Media Verification State action for the sanitization target associated with this state machine; b) an NVM Subsystem Reset occurs in any domain in the NVM subsystem; c) a Controller Level Reset caused by a transport-specific rese type (refer to the applicable NVMe Transport specification) occurs on any controller: 1. in the NVM subsystem when the sanitization target for this state machine is the NVM subsystem; or 2. attached to that namespace when the sanitization targe for this state machine is a namespace; or d) a change in the composition of the NVM subsystem prevents media verification.	

Transition Media Verification:Post-Verification Deallocation:

The controller shall:

- a) in the Sanitize Status log page for the sanitization target:
 - o clear the Sanitize Progress (SPROG) field to 0h;
 - set the Media Verification Canceled (MVCNCLD) bit to '1', if any controller in the NVM subsystem processes a Controller Level Reset caused by:
 - an NVM Subsystem Reset; or
 - a transport-specific reset type (refer to the applicable NVMe Transport specification), if any;

and

 set the Media Verification Canceled (MVCNCLD) bit to '1' in the Sanitize Status log page for the sanitization target, if a change in the composition of the NVM subsystem prevents media verification;

and

b) Complete the Sanitize command or the Sanitize Namespace command with a status code of Successful Completion, if any controller in the NVM subsystem performs an Exit Media Verification State action for the sanitization target associated with this state machine.

8.1.24.3.7 Post-Verification Deallocation State

In this state:

- a) the controller shall deallocate all media allocated for user data in the sanitization target:
- b) the Sanitize Progress (SPROG) field in the Sanitize Status log page for the sanitization target shall be set as described in Figure 291; and
- all controllers and Management Endpoints in the NVM subsystem shall process commands as described in section 8.1.24.4-;
- d) if the sanitization target is the NVM subsystem, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command; and
 - Sanitize Namespace command,

with a status code of Sanitize In Progress; and

- e) if the sanitization target is a namespace, then all controllers in the NVM subsystem shall abort a:
 - Sanitize command; and

Sanitize Namespace command for the sanitization target associated with this state machine, with a status code of Sanitize Namespace In Progress.

Figure 655: Post-Verification Deallocation state Transition Conditions

Starting Ending Label 1 Transition Condition Idle H The controller completes deallocation of all media in the saturaget that is allocated for user data. The sanitize operation was started by a Sanitize command AUSE bit cleared to '0' (i.e., restricted completion mode), a	
target that is allocated for user data. The sanitize operation was started by a Sanitize command. ALISE hit cleared to '0' (i.e. restricted completion mode).	
Postricted ALISE bit cleared to '0' (i.e. restricted completion mode) a	anitization
Post-Verification Deallocation	and a failure
Unrestricted Failure The sanitize operation was started by a Sanitize command AUSE bit set to '1' (i.e., unrestricted completion mode), an occurs during deallocation of all media in the sanitization to allocated for user data.	nd a failure

Transition Post-Verification Deallocation:Idle:

The controller shall:

- a) if the sanitization target is the NVM subsystem:
 - o if the Sanitize Namespace command is not supported:
 - i. set the Global Data Erased (GDE) bit to '1' in the Sanitize Status log page for the NVM subsystem; and
 - ii. set the Sanitize State (SANS) field to 0h (i.e., Idle state) in the Sanitize Status log page for the NVM subsystem;

- if the Sanitize Namespace command is supported:
 - i. set the Global Data Erased (GDE) bit to '1' in every Sanitize Status log page;
 - ii. set the Namespace Data Erased (NDE) bit to '1' in the Sanitize Status log page for each namespace that exists in the NVM subsystem; and
 - iii. set the SANS field to 0h (i.e., Idle state) in the Sanitize Status log page for the NVM subsystem and each namespace that exists in the NVM subsystem;
- b) if the sanitization target is a namespace:
 - set the Namespace Data Erased (NDE) bit to '1' in the Sanitize Status log page for that
- set the SANS field to 0h (i.e., Idle state) in the Sanitize Status log page for that namespace; and c) report the Sanitize Operation Completed asynchronous event as described in section 8.1.24.2

Transition Post-Verification Deallocation:Restricted Failure:

The controller shall:

- a) report the Sanitize Operation Completed asynchronous event as described in section 8.1.24.2 8.1.24.TBD; and
- set the FAILS field in the Sanitize Status log page for the sanitization target to 6h (i.e., Post-Verification Deallocation state).

Transition Post-Verification Deallocation:Unrestricted Failure:

The controller shall:

- a) report the Sanitize Operation Completed asynchronous event as described in section 8.1.24.28
- set the FAILS field in the Sanitize Status log page for the sanitization target to 6h (i.e., Post-Verification Deallocation state).

8.1.24.4 Sanitize Operation Restrictions

In the following states:

- · Restricted Processing;
- Restricted Failure:
- · Unrestricted Processing;
- Unrestricted Failure;
- Media Verification; and
- Post-Verification Deallocation,

all enabled controllers in the NVM subsystem have restrictions in the set of actions that they are allowed to perform. are restricted to performing only a limited set of actions.

When a sanitize operation starts on any controller (i.e., a transition into the Restricted Processing state occurs or a transition into the Unrestricted Processing state occurs), all controllers in the NVM subsystem shall:

- update the Sanitize Status log page for the sanitization target (refer to section 5.1.12.1.33);
- suspend autonomous power state management activities as described in section 8.1.17.2;
- for NVM subsystem sanitize operations:
 - o clear all of the following outstanding asynchronous events:
 - Sanitize Operation Completed asynchronous event, if any;
 - Sanitize Operation Completed With Unexpected Deallocation asynchronous event, if any; and
 - Sanitize Operation Entered Media Verification State asynchronous event, if any;
 - abort any command (submitted or in progress) not allowed during an NVM subsystem sanitize operation (refer to Figure 142) with a status code of Sanitize In Progress, unless otherwise specified (e.g., a media verification Read command);
 - abort any in progress device self-test operations in progress;
 - suspend autonomous power state management activities as described in section 8.1.17.2;
 and
 - $\circ \quad \text{release stream identifiers for any open streams}.$

and

- for namespace sanitize operations:
 - abort any I/O command (submitted or in progress) specifying the NSID of the namespace, unless otherwise specified (e.g., a media verification Read command);
 - process any Admin command as specified in section 5.TBD.2
 - abort any in progress device self-test operations specifying the NSID of the namespace or specifying the NSID set to FFFFFFFh; and
 - release stream identifiers allocated for exclusive use by the namespace for any open streams.

If a sanitize operation is in any of the following states (i.e., is in progress):

- Restricted Processing;
- Unrestricted Processing;
- Media Verification; and
- Post-Verification Deallocation,

then for each controller in the NVM subsystem;

- processing of a Flush command is specified in section 7.2;
- activation of new firmware is prohibited;
- and if the sanitization target is the NVM subsystem:
 - all I/O Commands other than a Flush command shall be aborted with a status code of Sanitize In Progress, unless otherwise specified;
 - processing of a Flush command is specified in section 7.2;
 - any command or command option that is not explicitly permitted in Figure 142 shall be aborted with a status code of Sanitize In Progress if processed by the controller; and
 - the Persistent Memory Region shall be prevented from being enabled (i.e., setting PMRCTL.EN to '1' does not result in PMRSTS.NRDY being cleared to '0'); and
 - activation of new firmware is prohibited.;

and

- if the sanitization target is a namespace, then for each controller in the NVM subsystem:
 - if the sanitize operation is in the Media Verification state, then the Sanitize Namespace command is permitted with access restrictions (refer to section 8.1.24.3);
 - all I/O commands specifying the NSID of the namespace, other than a Flush command, shall be aborted with a status code of Sanitize Namespace In Progress, unless otherwise specified; and
 - all Admin commands shall be processed by the controller as specified in section 5.TBD.2.

While the sanitization target is in the Restricted Failure state or the Unrestricted Failure state, then for each controller in the NVM subsystem:

- the Sanitize command is permitted with action restrictions (refer to section 5.1.22);
- if the sanitization target is the NVM subsystem, then:
 - any command or command option that is not explicitly permitted in Figure 142 shall be aborted with a status code of Sanitize In Progress if processed by the controller;
 - all I/O Commands other than a Flush command (refer to section 7.2) shall be aborted with a status code of Sanitize Failed;
 - o the Sanitize command is permitted with action restrictions (refer to section 5.1.22); and
 - the Persistent Memory Region shall be prevented from being enabled (i.e., setting PMRCTL.EN to '1' does not result in PMRSTS.NRDY being cleared to '0');

and

- if the sanitization target is a namespace, then:
 - o the Sanitize command is permitted with access restrictions (refer to section 8.1.24.3);
 - the Sanitize Namespace command is permitted with access restrictions (refer to section 8 1 24 3).
 - all Admin commands other than a Sanitize command or a Sanitize Namespace command shall be processed by the controller as specified in section 5.TBD.2; and
 - all I/O commands that specify the NSID of the namespace, other than a Flush command (refer to section 7.2), shall be aborted with a status code of Sanitize Namespace Failed;

When a sanitize operation starts on any controller in an NVM subsystem (i.e., a transition into the Restricted Processing state occurs or a transition into the Unrestricted Processing state occurs), all Management Endpoints in the NVM subsystem shall perform the sanitize operation as described in the NVM Express Management Interface Specification.

8.1.24.5 Sanitize Operation Effects on Exported NVM Subsystems

Performing a sanitize operation on an Underlying NVM Subsystem (refer to section 8.3.3) sanitizes user data in all Underlying Namespaces contained in that NVM subsystem, including any Underlying Namespace that is associated with an Exported Namespace in any Exported NVM Subsystem (refer to section 5.3.7).

Performing a sanitize operation on an Exported Namespace (refer to section 8.3.3) sanitizes all user data in the Underlying Namespace (refer to section 8.3.3).

If an Exported NVM Subsystem contains an Exported Namespace that is associated with an Underlying Namespace in an Underlying NVM Subsystem for which one of the following conditions exists:

- a sanitize operation is in progress; or
- the most recent sanitize operation has failed and successful recovery from the failed sanitize
 operation has not occurred,

then, while that condition exists, that Exported NVM Subsystem shall enforce the I/O command sanitize operation restrictions described in section 8.1.24.4 on I/O commands that specify that Exported Namespace and may enforce additional sanitize operation restrictions described in that section.

If an Exported Namespace is associated with an Underlying Namespace in an Underlying NVM Subsystem for which one of the following conditions exists:

- · a sanitize operation is in progress; or
- the most recent sanitize operation has failed and successful recovery from the failed sanitize operation has not occurred,

then, while that condition exists, the Exported NVM Subsystem containing that Exported Namespace shall enforce the I/O command sanitize operation restrictions described in section 8.1.24.4 on I/O commands that specify that Exported Namespace and may enforce additional sanitize operation restrictions described in that section.

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Annex A. Sanitize Operation Considerations (Informative)

A.1 Overview

The Sanitize command starts a sanitize operation that makes all user data previously written to the sanitization target inaccessible (i.e., all user data has been purged, as defined in IEEE Std 2883-2022). It is very difficult to prove that the sanitize operation successfully purged all user data. This annex provides some context and considerations for understanding the result of the operation and the practical limitations for auditing the result of the sanitize operation.

A.2 Hidden Storage (Overprovisioning)

Sanitize operations purge all physical storage in the sanitization target that is able to hold user data. Many NVMe SSDs contain more physical storage than is addressable through the interface (e.g., overprovisioning). That physical storage is used for vendor specific purposes which may include providing increasing endurance, improving performance, and providing extra capacity to allow retiring bad or wornout storage without affecting capacity. This excess capacity as well as any retired storage are not accessible through the interface. Vendor specific innovative use of this extra capacity supports advantages to the end user, but the lack of observability makes it difficult to ensure that all storage within the sanitization target was correctly purged. Only the accessible storage is able to be audited for the results of a sanitization operation.

A.3 Integrity checks and No-Deallocate After Sanitize

Another issue is availability of the data returned through the interface. Some of the sanitize operations (e.g., Block Erase) affect the physical devices in such a way that directly reading the accessible storage may trigger internal integrity checks resulting in error responses instead of returning the contents of the storage. Other sanitize operations (e.g., Crypto Erase) may scramble the vendor specific internal format of the data, also resulting in error responses instead of returning the contents of the storage.

To compensate for these issues, a controller may perform additional internal write operations to media that is able to be allocated for user data (i.e., additional media modification, refer to section 8.1.24.1) so that all

media in the sanitization target that is allocated for user data is readable without error. However, this has the side effect of potentially significant additional wear on the media as well as the side effect of obscuring the results of the initial sanitize operation (i.e., the writes destroy the ability to forensically audit the result of the initial sanitize operation). Given this side effect, process audits of sanitize behavior only provide effective results when the No-Deallocate After Sanitize bit is set the same way (e.g., set to '1') for both process audits and the individual forensic device audits.

The Sanitize command introduced in NVM Express Base Specification Revision 1.3 included a mechanism to specify that sanitized media in the NVM subsystem that is allocated for user data not be deallocated, thereby allowing observations of the results of the sanitization operation. However, some architectures and products (e.g., integrity checking circuitry) interact with this capability in such a way as to defeat the sanitize result observability purpose. New features were added to NVM Express Base Specification Revision 1.4 that include extended information about the sanitization capabilities of devices, a new asynchronous event, and configuration of the response to No-Deallocate After Sanitize requests. These features are intended to both support new systems that understand the new capabilities, as well as to help manage legacy systems that do not understand the new capabilities without losing the ability to sanitize as requested.

These issues in returning the contents of accessible storage do not apply if the sanitization target is in the Media Verification state (refer to section 8.1.24.3.6). In that state, failure of internal integrity checks do not cause error responses to Read commands (refer to the Media Verification section of the NVM Command Set Specification). Because the Sanitize command that caused entry to the Media Verification state specified the Enter Media Verification State (EMVS) bit set to '1', the controller does not perform the additional media modification described in this section.

A.4 Bad Media and Vendor Specific NAND Use

Another audit capability that is not supported by NVM Express is checking that any media that could not be sanitized (e.g., bad physical blocks) has been removed from the pool of storage that is able to be used as addressable storage.

An approach that is performed under some circumstances is removing the physical storage components from the NVM Express device after a sanitize operation and reading the contents in laboratory conditions. However, this approach also has multiple difficulties. When physical storage components are removed from an-a NVM Express device, much context is lost. This includes:

- a) any encoding for zero's/one's balance;
- b) identification of which components contain device firmware or other non-data information; and
- c) which media has been retired and cannot be sanitized.

Description of Specification Changes for the NVM Express NVM Command Set Specification 1.1

5 Extended Capabilities

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5.10 Sanitize Operations

Sanitize operates as defined in the NVM Express Base Specification. NVM Command Set specific definitions and extensions are defined in this section.

Following a successful sanitize operation, the values of user data, protection information, and non-PI metadata that result from an audit (refer to the NVM Express Base Specification) of the sanitization target are specified in Figure 179. If the controller deallocates logical blocks after successful completion of a sanitize operation, then values read from deallocated logical blocks are described in section 3.3.3.2.1. The host may specify that sanitized logical blocks not be deallocated by setting the No-Deallocate After Sanitize bit to '1' in the Sanitize command.

Figure 179: Sanitize Operation Types - User Data Values

Sanitize Operation Type	User Data
Block Erase	Vendor specific value
Crypto Erase	Indeterminate value
Overwrite	Refer to Sanitize Operations – Overwrite Mechanism in the NVM Express Base Specification

5.10.1 Media Verification

While the sanitization target is in the Media Verification state (refer to the Sanitize Operation State Machine Section in the NVM Express Base Specification), the controller processes Read commands as described in this section and shall not abort those commands with a status code of Sanitize In Progress or Sanitize Namespace In Progress.

lf:

- the controller processes a Read command that does not specify any Protection Information (PI) checking (i.e., the PRCHK field is cleared to 000b; refer to Figure 11); and
- each LBA specified by that Read command is in a sanitization target that is in the Media Verification state (i.e., is in the NVM subsystem for a sanitization target of the NVM subsystem or is in the namespace for a sanitization target of a namespace); and
- for each LBA specified by that command for which media is allocated, the controller is able to read data from the media.

then:

- for each LBA specified by that command for which media is allocated, the controller:
 - shall ignore data integrity errors, if any (e.g., shall not abort that command with a status code of Unrecovered Read Error if the controller is able to read that media);
 - shall return data that is read from that media; and
 - may return different data for successive reads (i.e., without any writes between those reads) of the same LBA (e.g., to obscure media reliability);
- for each LBA specified by that command for which media is not allocated, the controller shall return
 data or abort that command with a status code of Deallocated or Unwritten Logical Block as
 described in section 3.3.3.2.1; and
- the controller shall complete that command with a status code of Successful Media Verification Read if the command has not been aborted with a different status code (e.g., Deallocated or Unwritten Logical Block).

If the controller processes a Read command that does not specify any PI checking and is unable to read the data from the media for any LBA specified by that command for which media is allocated, then the controller shall abort the command with a status code of Unrecovered Read Error. If the controller processes a Read command specifying PI checking (i.e., the PRCHK field is set to a non-zero value), then the controller shall abort that command with a status code of Invalid Field in Command. Technical input submitted to the NVM Express® Workgroup is subject to the terms of the NVM Express® Participant's agreement. Copyright © 2008 to 2025 NVM Express, Inc.

Description of Specification Changes for the NVM Express Zoned Namespace Command Set Specification 1.3

4 Admin Commands for the Zoned Namespace Command Set

4.1 Admin Command behavior for the Zoned Namespace Command Set

4.1.7 Sanitize command

The Sanitize command operates as defined in the NVM Express Base Specification, with additional requirements for controllers implementing the Zoned Namespace Command Set defined in this section.

The Sanitize Status (SSTAT) (refer to Sanitize Status (Log Page Identifier 81h) section in the NVM Express Base Specification) and resultant zone state as a result of a successful sanitize operation of a zoned namespace that supports the Zoned Namespace Command Set are defined in Figure 55.

All fields of the Sanitize command are as defined in the NVM Express Base Specification.

The resulting zone state and event to report as a result of a successful sanitize operation is dependent on the setting of the:

- a) No Deallocate After Sanitize bit in the Sanitize command that requested the sanitize operation;
- b) No-Deallocate Modifies Media After Sanitize field;
- c) No-Deallocate Inhibited bit;
- d) No-Deallocate Response Mode bit; and
- e) Sanitize Action field.

Figure 55: Sanitize Behavior for the Zoned Namespace Command Set

No	No-Deallocate	No-	No-Deallocate	Results	of a successful sa	nitize operation
Deallocate	Modifies Media	Deallocate	Response	Zone	Logical Block	
After	After Sanitize	Inhibited	Mode	1	2	Sanitize Status 4
Sanitize	(NODMMAS)	(NDI)	(NODRM)	State T	Content ~	
0b	n/a ³	n/a ³	n/a ³	ZSE:Empty	Refer to section 2.1.1.2.1.2	001b

Notes:

- 1. ZSO:Offline state is a valid zone state as a result of a successful sanitize operation.
- This field describes the read value from a deallocated logical block. Refer to the Deallocated or Unwritten Logical Blocks section in the NVM Command Set Specification.
- 3. This value is not relevant in the setup conditions defined in that row.
- 4. Value reported in the Sanitize Operation Status (SOS) field of the Sanitize Status (SSTAT) field in the Sanitize Status log page (Log Identifier 81h) (refer to the NVM Express Base Specification).
- 5. Sanitize command is aborted with a status code of Invalid Field in Command.
- 6. Block Erase and Crypto Erase are not defined in this specification; Overwrite shall be the overwrite pattern specified in the Sanitize command that requested the sanitize operation.

4.1. TBD Sanitize Namespace command

The Sanitize Namespace command operates as defined in the NVM Express Base Specification, with additional requirements for controllers implementing the Zoned Namespace Command Set defined in this section.

All fields of the Sanitize Namespace command are as defined in the NVM Express Base Specification.

...

5 Extended Capabilities

...

5.8 Sanitize Operations

The Sanitize Status (SSTAT) field in the Sanitize Status log page (refer to Sanitize Status (Log Page Identifier 81h) section in the NVM Express Base Specification) and resultant zone state for all zones in a zoned namespace as a result of a successful sanitize operation of a zoned namespace that supports the Zoned Namespace Command Set:

- for an NVM subsystem sanitize operation (refer to the NVM Express Base Specification) are defined in Figure ZNS.TBD; and
- for a namespace sanitize operation (refer to the NVM Express Base Specification) are defined in Figure ZNS.TBD+1.

The resulting zone state of all zones and event status to report as a result of a successful NVM subsystem sanitize operation is dependent on the setting of the:

- a) No Deallocate After Sanitize bit in the Sanitize command that requested the sanitize operation;
- b) No-Deallocate Modifies Media After Sanitize field in the Identify Controller data structure;
- No-Deallocate Inhibited bit in the Identify Controller data structure;
- No-Deallocate Response Mode bit in the Sanitize Config feature (refer to the NVM Express Base Specification); and
- Sanitize Action field in the Sanitize command that requested the NVM subsystem sanitize operation.

Figure ZNS.TBD: Sanitize NVM Subsystem Behavior for the Zoned Namespace Command Set

No Deallocate	No-Deallocate Modifies Media	No- Deallocate	No-Deallocate Response	Results of a	successful NVM soperation	subsystem sanitize
After Sanitize	After Sanitize (NODMMAS)	Inhibited (NDI)	Mode (NODRM)	Zone State ¹	Logical Block Content ²	Sanitize Status ⁴
0b	n/a ³	n/a ³	n/a ³	ZSE:Empty	Refer to section 2.1.1.2.1.2	001b

Notes:

- ZSO:Offline state is a valid zone state as a result of a successful sanitize operation.
- This field describes the read value from a deallocated logical block. Refer to the Deallocated or Unwritten Logical Blocks section in the NVM Command Set Specification.
- 3. This value is not relevant in the setup conditions defined in that row.
- Value reported in the Sanitize Operation Status (SOS) field of the Sanitize Status (SSTAT) field in the Sanitize Status log page (Log Identifier 81h) (refer to the NVM Express Base Specification).
- Sanitize command is aborted with a status code of Invalid Field in Command.
- Block Erase and Crypto Erase are not defined in this specification; Overwrite shall be the overwrite pattern specified in the Sanitize command that requested the NVM subsystem sanitize operation.

The resulting zone state as a result of a successful namespace sanitize operation is defined in Figure 7NS TRD+1

Figure ZNS,TBD+1: Sanitize Namespace Behavior for the Zoned Namespace Command Set

Results of a successful namespace sanitize operation				
Zone State ¹	Logical Block Content 2	Sanitize Status ³		
ZSE:Empty	Refer to section 2.1.1.2.1.2	001b		

Results of a successful namespace sanitize operation					
Zone State ¹	Logical Block Content 2	Sanitize Status ³			
Notoe:					

- ZSO:Offline state is a valid zone state as a result of a successful namespace sanitize operation.

 This field describes the read value from a deallocated logical block.
- Refer to the Deallocated or Unwritten Logical Blocks section in the NVM Command Set Specification.
- Value reported in the Sanitize Operation Status (SOS) field of the Sanitize Status (SSTAT) field in the Sanitize Status log page (Log Page Identifier 81h) (refer to the NVM Express Base Specification).

If the NVM subsystem is in the Media Verification state (refer to the Sanitize Operations section of the NVM Express Base Specification), then the logical block content is described in the Media Verification section of the NVM Express NVM Command Set Specification.

Description of NVM Express Subsystem Local Memory Command Set Specification 1.1 Changes

4 Admin Commands for the Subsystem Local Memory Command Set

4.1 Admin Command behavior for the SLM Command Set

...

4.1.9 Sanitize command

Sanitize clears all bytes of memory namespaces to 0h. For memory namespaces, there is no difference in sanitize operation based on sanitize type (i.e., Block Erase, Crypto Erase, and Overwrite). The Sanitize command operates as defined in the NVM Express Base Specification.

All fields of the Sanitize command are as defined in the NVM Express Base Specification.

4.1. TBD Sanitize Namespace command

The Sanitize Namespace command operates as defined in the NVM Express Base Specification.

All fields of the Sanitize Namespace command are as defined in the NVM Express Base Specification.

...

5 Extended Capabilities

This command set does not add any Extended Capabilities beyond what are defined in the NVM Express Base Specification.

5.TBD Sanitize Operations

The NVM subsystem sanitize operation (refer to NVM Express Base Specification) Sanitize clears all bytes of memory namespaces to 0h. For memory namespaces, there is no difference in an NVM subsystem sanitize operation based on sanitize type (i.e., Block Erase, Crypto Erase, and Overwrite).

The namespace sanitize operation (refer to NVM Express Base Specification) clears all bytes of memory namespaces to 0h.

Description of NVM Express Computational Programs Command Set Specification 1.1 Changes

4 Admin Commands for the Computational Programs Command Set

4.1 Admin Command behavior for the Computational Programs Command Set

. . .

4.1.8 Sanitize command

Sanitize deletes downloaded programs and removes associated PIND entries. It also removes any program-related remnants or parameters that may be in the internal compute environment of the namespace. Sanitize does not affect Memory Range Sets that have been created by the host. Sanitize does not remove program activation settings for device-defined programs. During a sanitize operation, all Admin commands and I/O commands defined by this I/O Command Set shall be aborted as defined in the NVM Express Base Specification. Block Erase, Crypto Erase, and Overwrite sanitize operation types have the same effect on compute namespaces. The Sanitize command operates as defined in the NVM Express Base Specification.

All fields of the Sanitize command are as defined in the NVM Express Base Specification.

4.1. TBD Sanitize Namespace command

The Sanitize Namespace command operates as defined in the NVM Express Base Specification.

All fields of the Sanitize Namespace command are as defined in the NVM Express Base Specification.

...

5 Extended Capabilities

This I/O Command Set does not add any Extended Capabilities beyond what is defined in the NVM Express Base Specification.

5. TBD Sanitize Operations

The NVM subsystem sanitize operation (refer to NVM Express Base Specification) Sanitize deletes downloaded programs and removes associated PIND entries. It also removes any program-related remnants or parameters that may be in the internal compute environments of all compute namespaces in the NVM subsystem environment of the namespace. The NVM subsystem sanitize operation Sanitize does not affect Memory Range Sets that have been created by the host. The NVM subsystem sanitize operation Sanitize operation settings for device-defined programs. During an NVM subsystem sanitize operation, all Admin commands and I/O commands defined by this I/O Command Set shall be aborted as defined in the NVM Express Base Specification. Block Erase, Crypto Erase, and Overwrite sanitize operation types have the same effect on compute namespaces.

The namespace sanitize operation (refer to NVM Express Base Specification) deletes downloaded programs and removes associated PIND entries for the specified compute namespace. It also removes any program-related remnants or parameters that may be in the internal compute environment of the specified compute namespace. The namespace sanitize operation does not affect Memory Range Sets that have been created by the host. The namespace sanitize operation does not remove program activation settings for device-defined programs in the specified compute namespace. During a namespace sanitize operation, all Admin commands and I/O commands defined by this I/O Command Set shall be aborted as defined in the NVM Express Base Specification.

Description of NVM Express Management Interface Specification 2.0 Changes

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4 Message Servicing Model

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4.1 NVMe-MI Messages

. . .

4.1.2 Response Messages

- - -

Figure 29: Response Message Status Values

Value							
	Status Values that do not indicate an error (i.e., Success Response).						
	Status Values that indicate an error (i.e., Error Response).						
	···						
21h	PCle Inaccessible: The PCle functionality is not available at this time.	4.1.2.1					
22h	Management Endpoint Buffer Cleared Due to Sanitize: An attempt was made to read data as defined in section 4.2.3 in the Management Endpoint Buffer that was zeroed due to an NVM Subsystem sanitize operation.	4.1.2.1					
23h	23h Enclosure Services Failure: The Enclosure Services Process has failed in an unknown manner.						
29h	Enclosure Degraded: A noncritical failure has been detected by the Enclosure Services Process.	4.1.2.1					
2Ah	2Ah Sanitize In Progress: The requested command is prohibited while an NVM Subsystem sanitize operation is in progress. Refer to section 6.4.						
2Bh to DFh							
	Status Values that may or may not indicate an error.						
E0h to FFh	Vendor Specific	Vendor Specific					

4.2 Out-of-Band Request Message Servicing Model

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4.2.3 Management Endpoint Buffer

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The Management Endpoint Buffer is considered a cache in the context of NVM Subsystem sanitize operations (refer to the NVM Express Base Specification) performed in an NVM Subsystem. The MCTP Management Endpoint Buffer may contain Response Data associated with a previously processed command that is not allowed during an NVM Subsystem sanitize operation. When an NVM Subsystem sanitize operation is initiated, the contents of the Management Endpoint Buffer shall be cleared to 0h. An attempt to access this zeroed data by a Management Endpoint Buffer Read command or any Command Message that uses the Management Endpoint Buffer, then the Management Endpoint responds with a Response Message Status of Management Endpoint Buffer Cleared Due to Sanitize. This Response

Message Status is commonly associated with a Management Endpoint Buffer Read command but may be associated with any command that uses the Management Endpoint Buffer as Request Data.

4.4 Out-of-Band AEM Servicing Model

4.4.5 AE Identifier Information

Figure 63: Asynchronous Events

Identifier	Scope ¹	AE	AE Occurrence Trigger when the AE is Enabled
0Bh	Port	PCIe Link Active	The link active state changes. This is the same link active state that is reported by the Port 0 PCIe Link Active bit in the NVM Subsystem Health data structure and the Port 1 PCIe Link Active bit in the NVM Subsystem Health data structure. The AE Occurrence Port Type bit for this AE shall be set '1' to indicate that the AE Occurrence Port ID field contains the
			NVMe-MI port associated with the event.
0Ch	NVM Subsystem	Sanitize Failure Mode	The sanitize NVM Subsystem failure state changes. This is the same sanitize NVM Subsystem failure state that is reported by the Sanitize Failure Mode bit in the NVM Subsystem Health data structure.
0Dh	h Namespace Nam Failu		The sanitize namespace failure state changes. This is the same sanitize namespace failure state that is reported by the Sanitize Namespace Failure Mode bit in the NVM Subsystem Health data structure.
ODhOEh to BFh	Reserved		
C0h to FFh	Vendor specific		

4.4.6 AE Occurrence Specific Information

Figure 65: AE Occurrence Specific Info Data Structure

Asynchronous Event ID	Description

The AE Occurrence Scope field of the AE Occurrence data structure indicates the scope of the AE (refer to Figure 62). The AE Occurrence Scope ID Info field of the AE Occurrence data structure contains the identifier of the entity associated with the AE in a format that matches the scope indicated in the AE Occurrence Scope field (refer to Figure 64).

Figure 65: AE Occurrence Specific Info Data Structure

Asynchronous Event ID	Descrip	tion				
		nk Active Info (PLAI): This field defines the contents of the AE Occurrence Specific Info the PCIe Link Active AE.				
	Bits	Description				
0Bh	Reserved					
(PCIe Link Active Value (PLAV): If the Port Scope ID Info field indicates associated with PCIe Port 0, then this bit shall indicate the value of the PC PCIe Link Active bit in the NVM Subsystem Health data structure.						
If the Port Scope ID Info field indicates the AE is associated with PCIe Por this bit shall indicate the value of the PCIe Port 1 PCIe Link Active bit in t Subsystem Health data structure.						
0Ch		Failure Mode Info (SFMI): This field defines the contents of the AE Occurrence Specific for the Sanitize Failure Mode AE.				
(Sanitize	Bits	Description				
Failure Mode)	7:1	Reserved				
O Sanitize Failure Mode Value (SFMV): This bit shall indicate the value of the San Failure Mode bit in the NVM Subsystem Health data structure.						
		Initize Namespace Failure Mode Info (SNFMI): This field defines the contents of the AE occurrence Specific Info field for the Sanitize Namespace Failure Mode AE.				
0Dh (Sanitize Bits Description						
Namespace Failure Mode) 7:1 Reserved 7:1 Reserved						
r allule Mode)	Sanitize Namespace Failure Mode Value (SNFMV): This bit shall indicate the value of the Sanitize Namespace Failure Mode bit in the NVM Subsystem Health data structure.					
ODhOEh to BFh	Reserve	d				
C0h to FFh	There shall be no AE Occurrence Specific Info defined for these AEs.					

5 Management Interface Command Set

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5.4 Management Endpoint Buffer Read

. . .

When an attempt is made to read Management Endpoint Buffer contents that were zeroed due to an NVM Subsystem sanitize operation (refer to the NVM Express Base Specification), then the Management Endpoint shall respond with a Response Message Status of Management Endpoint Buffer Cleared Due to Sanitize.

...

5.6 NVM Subsystem Health Status Poll

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Figure 108: NVM Subsystem Health Data Structure (NSHDS)

Bytes	Descrip	tion						
,	NVM Subsystem Status (NSS): This field indicates the status of the NVM Subsystem.							
	Bits	Description						
	7	AEM Transmission Failure (ATF): If there is an AEM transmission failure on any Management Endpoint in the NVM Subsystem, then this bit shall be set to '1'. An AEM transmission failure on a given Management Endpoint occurs when: a) the AEM Retry Delay field is not cleared to 0h and the amount of time specified by the AEM Retry Delay has elapsed since the end of transmission of the final attempt (refer to section 4.4.3) to transmit the AEM without processing an AEM Ack; b) the AEM Retry Delay field is cleared to 0h and 5 s has elapsed since the end of transmission of the first attempt to transmit the AEM without processing an AEM Ack, an AE Sync, or a Management Endpoint Reset; or c) the physical transport external to the NVM Subsystem is unavailable when the Management Endpoint attempts the final transmission of an AEM (e.g., an AEM on a PCIe VDM Management Endpoint is unable to be transmitted due to the PCIe link being down).						
		This bit shall be cleared to '0' if: a) an AE Sync occurs; or b) a Management Endpoint Reset occurs.						
	6	Sanitize Failure Mode (SFM): If the NVM Subsystem is in the Sanitize failure mode, then this bit shall be set to '1'. If the NVM Subsystem is not in the Sanitize failure mode, then this bit shall be cleared to '0'. The NVM Subsystem is in the Sanitize failure mode when while the most recent NVM Subsystem sanitize operation failed and no recovery action has been completed successfully (refer to the NVM Express Base Specification).						
0	5	Drive Functional (DF): If the NVM Subsystem is functional, then this bit shall be set to '1'. If there is an unrecoverable failure detected in the NVM Subsystem, then this bit shall be cleared to '0'.						
	4	Reset Not Required (RNR): If the NVM Subsystem does not require an NVM Subsystem Reset to resume normal operation, then this bit shall be set to '1'. If the NVM Subsystem does require an NVM Subsystem Reset to resume normal operation, then this bit shall be cleared to '0'.						
	3	Port 0 PCle Link Active (P0LA): If the PCle link on the port with the lowest Port Identifier is active (i.e., the Data Link Control and Management State Machine is in the DL_Active state as defined by the PCl Express Base Specification), then this bit shall be set to '1'. If the PCle link on the port with the lowest Port Identifier is not active (i.e., the Data Link Control and Management State Machine is not in the DL_Active state as defined by the PCl Express Base Specification), then this bit shall be cleared to '0'.						
	2	Port 1 PCIe Link Active (P1LA): If the PCIe link on the port with the second lowest Port Identifier is active (i.e., the Data Link Control and Management State Machine is in the DL_Active state as defined by the PCI Express Base Specification), then this bit shall be set to '1'. If the PCIe link on the port with the second lowest Port Identifier is not active (i.e., the Data Link Control and Management State Machine is not in the DL_Active state as defined by the PCI Express Base Specification) or there is no port 1, then this bit shall be cleared to '0'.						
	1	Sanitize Namespace Failure Mode (SNFM): If any namespace in the NVM Subsystem is in the Sanitize Namespace failure mode, then this bit shall be set to '1'. If no namespaces in the NVM Subsystem are in the Sanitize Namespace failure mode, then this bit shall be cleared to '0'. A namespace is in the Sanitize Namespace failure mode while the most recent namespace sanitize operation failed and no recovery action has been completed successfully (refer to the NVM Express Base Specification).						
	1: 0	Reserved						

6 NVM Express Admin Command Set

The NVM Express Admin Command Set allows NVMe Admin Commands to be issued to any Controller in the NVM Subsystem using the out-of-band mechanism. Figure 134 shows NVMe Admin Commands that are mandatory, optional, and prohibited for an NVMe Storage Device and an NVMe Enclosure using the out-of-band mechanism. All NVMe Admin Commands are prohibited using the in-band tunneling mechanism. The commands are defined in the NVM Express Base Specification and the I/O Command Set specifications. If an NVMe Admin Command is issued in a Request Message that is a prohibited command in Figure 134, the Management Endpoint shall return an Invalid Command Opcode Error Response. The NVM Express Admin Command Set is supported in the out-of-band mechanism and is prohibited in the in-band tunneling mechanism.

Figure 134: List of NVMe Admin Commands Supported using the Out-of-Band Mechanism

Command	Opcode	NVMe Storage Device O/M/P 1	NVMe Enclosure O/M/P ¹	Reference Specification
Sanitize	84h	0	0	NVM Express Base Specification
Sanitize Namespace	8Ch	0	0	NVM Express Base Specification
_	·		·	•

. . .

6.3 Get Log Page

Figure 141 defines the log pages that are mandatory, optional, and prohibited for 2-Wire and PCle VDM Management Endpoint on NVMe Storage Devices and NVMe Enclosures. The set of optional log pages supported on each Management Endpoint is allowed to differ (refer to NVM Express Base Specification).

Figure 141: Management Endpoint - Log Page Support

	_	Support Requirements ¹	
Log Page Name ³	Log Identifier	NVMe Storage Device	NVMe Enclosure
Supported Log Pages	00h	M ²	M ²
Sanitize Namespace Status List	7Fh	0	0
Sanitize Status	81h	0	0

Notes:

- 1. O = Optional, M = Mandatory, P = Prohibited.
- 2. Optional for versions 1.1 and earlier of this specification.
- 3. Refer to the NVM Express Base Specification unless another footnote specifies otherwise.

6.4 Sanitize Operation and Format NVM Command

Figure 142 specifies the Command Messages allowed during a sanitize operation (including an NVM Subsystem sanitize operation and a namespace sanitize operation) and the Command Messages that should be allowed during the processing of a Format NVM command. Refer to the NVM Express Base Specification for the definition of a sanitize operation.

Figure 142: Command Messages Allowed During a Sanitize Operation and During the Processing of a Format NVM Command

Command Set	Command Message	Allowed	
Management Interface Command Set	Configuration Get	Yes	
	Configuration Set		
	Controller Health Status Poll		
	Management Endpoint Buffer Read		
	Management Endpoint Buffer Write		
	NVM Subsystem Health Status Poll		
	Read NVMe-MI Data Structure		
	Reset		
	SES Receive		
	SES Send		
	Shutdown		
	VPD Read		
	VPD Write		
NVMe Admin Command Set ¹	Capacity Management	Same restrictions as defined by the NVM Express Base Specification	
	Device Self-test		
	Firmware Activate/Commit		
	Firmware Image Download		
	Format NVM		
	Get Features		
	Get Log Page		
	Identify		
	Namespace Attachment		
	Namespace Management		
	Sanitize		
	Sanitize Namespace		
	Security Receive/Send		
	Security Send		
	Set Features		
	Vendor Specific		
PCIe Command Set	Virtualization Management		
	PCIe Configuration Read		
	PCIe Configuration Write PCIe I/O Read	Yes	
	PCIe Memory Read PCIe Memory Write		
Notes:	Pole Welliory Write	l	

Notes:

<Note to editor: In the below paragraph, change: "...compliant to a revision of this specification later than 2.0..." to: "compliant to revision 2.1 or later of this specification..." in the integration copy of the spec.>

If an NVM Subsystem sanitize operation is in progress and a Management Endpoint implementation compliant to a revision of this specification later than 2.0 processes an Admin command that is prohibited while an NVM Subsystem sanitize operation is in progress, then that Management Endpoint shall return a Success Response with a status code of Sanitize In Progress as defined by the NVM Express Base Specification in the Status field in Completion Queue Entry Dword 3 of the Response Message.

<Note to editor: End of changes to MI Spec.>

NVMe Admin Commands that are prohibited via the out-of-band mechanism (refer to Figure 134) are not listed since those commands are always prohibited including during a sanitize