



HGST Ultrastar C15K600 TCG Enterprise HDDs
FIPS 140-2 Cryptographic Module
Security Policy

Protection of Data at Rest

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Cryptographic Module Overview

HGST Ultrastar C15K600 TCG Enterprise HDDs, hereafter referred to as “Ultrastar C15K600” or “the Cryptographic Module” are multi-chip embedded modules that comply with FIPS 140-2 Level 2 security. They also comply with the *Trusted Computing Group (TCG) SSC: Enterprise Specification*. The drive enclosure is the cryptographic boundary (see Figure 1).

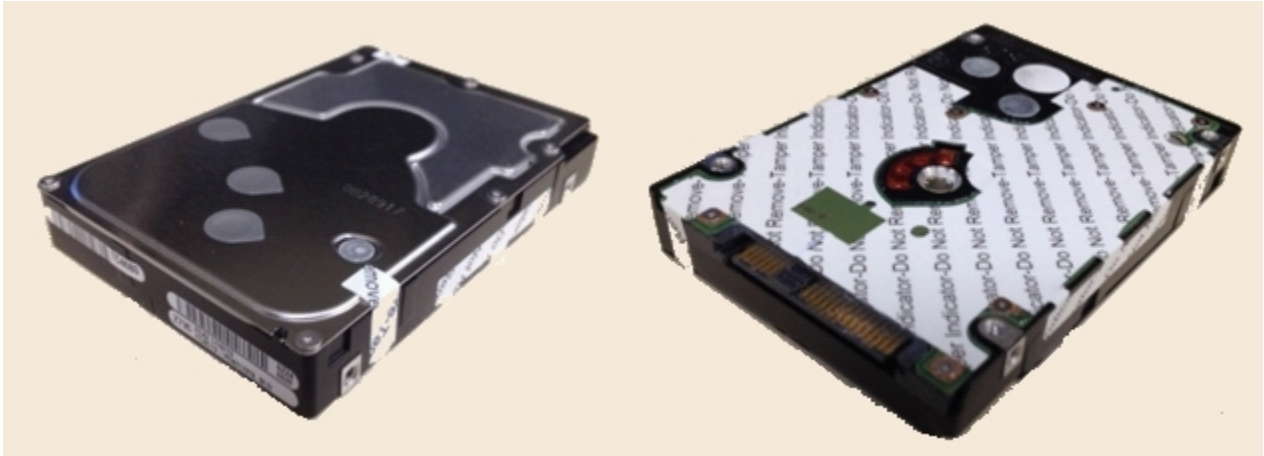


Figure 1: Cryptographic Boundary

1.1 Models

The Ultrastar C15K600 is available in several models that vary by storage capacity and block size. Table 1 enumerates the models and characteristics and includes the hardware and firmware versions.

Model Number [Hardware Version]	Firmware Version	Capacity (GB)	Block Size (bytes)	Description
HUC156060CS4205 [1]	R3A0	600	4K Native, 512 emulation	SAS 12 Gb/s, 15000 RPM
HUC156045CS4205 [1]	R3A0	450	4K Native, 512 emulation	SAS 12 Gb/s, 15000 RPM
HUC156030CS4205 [1]	R3A0	300	4K Native, 512 emulation	SAS 12 Gb/s, 15000 RPM
HUC156060CSS205 [1]	R3A0	600	512 Native	SAS 12 Gb/s, 15000 RPM
HUC156045CSS205 [1]	R3A0	450	512 Native	SAS 12 Gb/s, 15000 RPM
HUC156030CSS205 [1]	R3A0	300	512 Native	SAS 12 Gb/s, 15000 RPM

Table 1 - Ultrastar C15K600 Product Models

1.2 Security Level

The Cryptographic Module meets all requirements applicable to FIPS 140-2 *Level 2* Security.

FIPS 140-2 Security Requirements Section	FIPS 140-2 Security Level Achieved
Cryptographic Module Specification	3
Module Ports and Interfaces	2
Roles, Services and Authentication	3
Finite State Model	2
Physical Security	2
Operational Environment	N/A
Cryptographic Key Management	2
EMI/EMC	2
Self-Tests	2
Design Assurance	2
Mitigation of Other Attacks	N/A

Table 2 - Module Security Level Specification

2 Modes of Operation

2.1 FIPS Approved Mode of Operation

The Cryptographic Module has a single FIPS Approved mode of operation that is entered after successful completion of the Initialize Cryptographic Module service. Once configured to run in FIPS Approved mode, the Cryptographic Module will always run in FIPS-Approved mode as long as all of the self-tests complete successfully. A FIPS mode indicator is available from the Get FIPS Mode service.

2.2 Approved Algorithms

The Cryptographic Module supports the following FIPS Approved algorithms.

FIPS Approved Algorithm	CAVP Certificate
SP800-90A DRBG	302
Hardware AES ECB-128,256, XTS-128, 256	2067
AES ECB-256	2365
RSA 2048 PSS Verify	1220
SHA-256	2037
HMAC-SHA-256	1468
SP800-132 KDF	Vendor Affirmed

Table 3 - FIPS Approved Algorithms

The Cryptographic Module supports the following non-Approved but Allowed algorithm:

- Hardware NDRNG for seeding the Approved SP800-90A DRBG
- AES (Cert. #2365, key wrapping; key establishment methodology provides 256 bits of encryption strength)
-

3 Ports and Interfaces

Table 3 below identifies its ports and interfaces of the Cryptographic Module. A maintenance access interface is not provided.

FIPS 140-2 Interface	Cryptographic Module Ports
Power	Power connector [SAS]
Control Input	SAS connector [SAS]
Status Output	SAS connector [SAS]
Data Input	SAS connector [SAS]
Data Output	SAS connector [SAS]

Table 4 - Ultrastar C15K600 Pins and FIPS 140-2 Ports and Interfaces

4 Identification and Authentication Policy

The Cryptographic Module enforces the following FIPS140-2 operator roles.

4.1 Cryptographic Officer

4.1.1 Secure ID (SID) Authority

This TCG authority initializes the Cryptographic Module. TCG SSC: Enterprise Section 11.3.1 defines this role.

4.1.2 EraseMaster Authority

This TCG authority zeroizes the Cryptographic Module. TCG SSC: Enterprise Section 11.4.1 defines this role. It may also disable User roles and erase LBA bands (user data regions).

4.2 User

User roles correspond to Bandmaster Authorities; they are defined in TCG SSC: Enterprise Section 11.4.1. They are authorized to lock/unlock and configure LBA bands (user data regions) and to issue read/write commands to the SED. The TCG EraseMaster authority can disable Users.

4.3 Unauthenticated

Services are provided that do not require authentication. With one exception, these do not disclose, modify, or substitute Critical Security Parameters, use an Approved security function, or otherwise affect the security of the Cryptographic Module. The excepted service is the Generate Random service, which provides output from an instance of the SP800-90A DRBG.

4.4 Maker

Out of scope services are provided for the vendor to configure and perform failure analysis within the vendor's facilities. Maker authentication data shall not leave the vendor's facilities. Maker is disabled when the Cryptographic Officer invokes the Initialize Cryptographic Module service.

The following table maps TCG authorities to FIPS140-2 roles.

TCG Authority	Description	Authentication Type	Authentication Data
SID Authority	A Cryptographic Officer role which initializes the Cryptographic Module and authorizes Firmware download.	Identity-based	Well Known CO Identity (TCG <i>SID Authority</i>) and PIN (TCG <i>SID Authority PIN</i>)
EraseMaster	A Cryptographic Officer role which zeroizes Media Encryption keys and disables Users.	Identity-based	Well Known CO Identity (TCG <i>EraseMaster Authority</i>) and PIN (TCG <i>EraseMaster PIN</i>)

TCG Authority	Description	Authentication Type	Authentication Data
BandMasterN (N = 0 to 5)	A User role which controls read/write access to LBA Bands.	Identity-based	Well Known User Identity (TCG <i>BandMaster Authority</i>) and PIN (TCG <i>BandMaster PIN</i>)
Anybody	A role that does not require authentication.	Unauthenticated	N/A
Maker	A TCG Authority which is not available upon completion of the Initialize Cryptographic Module service	Identity-based	Well Known User Identity (TCG Maker Authority) and PIN (HGST Maker PIN)

Table 5 - Roles and Required Identification and Authentication

The Cryptographic Module enforces role separation by requiring a Well Known role identifier and an authentication credential (Personal Identification Number or PIN).

Authentication Mechanism	Mechanism Strength
TCG Credential (PIN)	<p>TCG Credentials are 256 bits, which provides 2^{256} possible values. The probability that a random attempt succeeds is 1 chance in 2^{256} (approximately 8.64×10^{-78}) which is significantly less than 1/1,000,000 (1×10^{-6}).</p> <p>Multiple, successive authentication attempts can only occur sequentially (one at a time) and only when the failed authentication <i>Tries</i> count value does not exceed the associated <i>TriesLimit</i> value. Any authentication attempt consumes at least approximately 750 microseconds. Hence, at most, approximately 80,000 authentication attempts are possible in one minute. Thus, the probability that a false acceptance occurs a one minute interval is approximately 6.91×10^{-73} which is significantly less than 1 chance in 100,000 (1×10^{-5}).</p>

Table 6 - Authentication Mechanism Strengths

5 Access Control Policy

5.1 Roles and Services

Service	Description	Role(s)
Initialize Cryptographic Module	Cryptographic Officer provisions the Cryptographic Module from organizational policies	CO (TCG SID)
Authenticate	Input a TCG Credential for authentication	CO, Users, Maker (TCG SID, EraseMaster, BandMasters)
Lock/Unlock Firmware Download Control	Deny/Permit access to Firmware Download service	CO (TCG SID)
Firmware Download	Load and verify by RSA2048 an entire firmware image. If the new self-tests complete successfully, the SED executes the new code. The Firmware Download Control shall be unlocked before Firmware can be downloaded.	CO (TCG SID)
Disable Zeroize	Disable TCG Revert method	CO (TCG SID)
Set	Write data structures; access control enforcement occurs per data structure field	CO, Users, Maker (TCG SID, EraseMaster, BandMasters)
Set TCG Credential	Inputs authentication data and replaces stored hashed PIN data.	CO, Users (TCG SID, EraseMaster), (BandMasters)
Set LBA Band	Set the starting location, size, and attributes of a set of contiguous Logical Blocks	Users (BandMasters)
Lock/Unlock LBA Band	Deny/Permit access to a LBA Band	Users (BandMasters)
Write Data	Transform plaintext user data to ciphertext and write in a LBA band	Users (BandMasters)

Service	Description	Role(s)
Read Data	Read ciphertext from a LBA band and output user plaintext data	Users (BandMasters)
Set Data Store	Write a stream of bytes to unstructured storage	Users (BandMasters)
Erase LBA Band	Band cryptographic-erasure by changing LBA band encryption keys to new values. When the EraseMaster erases a LBA band, the TCG Credential is set to the default value.	CO (EraseMaster)
Set Vendor Data	A Non-Approved service that is unavailable after the Initialize Cryptographic Module service completes	Maker

Table 7 - Authenticated CM Services

5.2 Unauthenticated Services

The Cryptographic Module provides these unauthenticated services:

Service	Description
Reset Module	Power on Reset
Self-Test	The Cryptographic Module performs self-tests when it powers up
Status Output	TCG (IF-RECV) protocol
Get FIPS Mode	TCG 'Level 0 Discovery' method outputs the FIPS mode of the Cryptographic Module.
Start Session	Start TCG session
End Session	End a TCG session by clearing all session state
Generate Random	TCG Random method generates a random number from the SP800-90A DRBG
Get	Reads data structure; access control enforcement occurs per data structure field
Get Data Store	Read a stream of bytes from unstructured storage
Zeroize	TCG Revert method to return the Cryptographic Module to its original manufactured state; authentication data (PSID) is printed on the external label
SCSI	[SCSI Core] and [SCSI Block] commands to function as a standardized storage device

Table 8 - Unauthenticated Services

5.3 Definition of Critical Security Parameters (CSPs)

The Cryptographic Module contains the following CSPs:

Key Name	Type	Description
PIN - TCG Credential (8 total)	256-bit authentication data	Authenticates the Cryptographic Officer and User roles
MEK - Media Encryption Key (6 total - 1 per LBA band)	XTS-AES-256 (512 bits)	Encrypts and decrypts LBA Bands
KEK – Key Encrypting Key (6 total)	KDF (256 bits)	Keys derived from BandMaster PINs which wrap the MEKs
NDRNG	Entropy output	Entropy source for DRBG
DRBG	Internal CTR_DRBG state	All properties and state associated with the SP800-90A Deterministic Random Bit Generator

Table 9 - CSPs and Private Keys

5.4 Definition of Public Security Parameters

The Cryptographic Module contains the following public key:

Key Name	Type	Description
RSAFW	RSA 2048 public key	Verify firmware download

Table 10 - Sensitive Security Parameters

5.5 SP800-132 Key Derivation Function Affirmations

The Cryptographic Module deploys a [SP800-132] Key Derivation Function (KDF).

- The KEKs (SP800-132 Master Keys) are derived from the User PINs (SP800-132 Password) with SP800-132 Option 1a.
- The length of the operator PIN is 256 bits and the stored security strength is 128 bits.
- The upper bound for the probability of guessing the User PIN is 2^{-128} .
- The difficulty of guessing the User PIN is equivalent to a brute force attack.
- The KEKs (SP800-132 Master Keys) are only used to wrap the Media Encryption Keys (MEKs).

5.6 Definition of CSP Modes of Access

Table 11 defines the relationship between access to Critical Security Parameters (CSPs) and the different Cryptographic Module services. The modes of access shown in the table are defined as:

- **G = Generate:** The Cryptographic Module generates a CSP from the SP800-90A DRBG, derives a CSP with the Key Derivation Function or hashes authentication data with SHA-256.
- **R = Read:** The Cryptographic Module reads a CSP. The read access is performed before the Cryptographic Module uses the CSP.
- **W = Write:** The Cryptographic Module writes a CSP. The write access is performed after the Cryptographic Module generates a CSP.
- **Z = Zeroize:** The Cryptographic Module zeroizes a CSP.

Service	CSPs and Keys	Type of CSP Access
Initialize Cryptographic Module	CO PIN and User PIN and DRBG and KEK and MEK	R,W R,W R G G,W
Authenticate	CO PIN or User PIN	R R
Lock/Unlock Firmware Download Control	CO PIN	R
Firmware Download	CO PIN and RSAFW	R R
Disable Zeroize	CO PIN	R
Set	CO PIN or User PIN or Maker PIN	R R R
Set TCG Credential	CO PIN or User PIN	W W
Set LBA Band	User PIN	R
Lock/Unlock LBA Band	User PIN and KEK and MEK	R G R
Write Data	User PIN and MEK	R R

Service	CSPs and Keys	Type of CSP Access
Read Data	User PIN and MEK	R R
Set Data Store	User PIN	R
Erase LBA Band	CO PIN and KEK and MEK	R G Z,G,W
Self-Test	NDRNG and DRBG	R W
Reset Module	None	
Status Output	None	
Get FIPS mode	None	
Start Session	None	
End Session	None	
Generate Random	DRBG	R
Get Data Store	None	
Set Vendor Data	None	
Zeroize	PSID and CO PIN and User PIN and DRBG and KEK and MEK	R W W G G Z,G,W
SCSI	None	

Table 11 - CSP Access Rights within Roles & Services

6 Operational Environment

The Cryptographic Module operating environment is non-modifiable. While the Cryptographic Module is operational, the environment cannot be modified; the code working set cannot be added, deleted or modified. Firmware can be upgraded (replaced in entirety) with an authenticated download service. If the download operation is successfully authorized and verified, then the Cryptographic Module will begin operating with the new code working set. New firmware versions within the scope of this validation must be validated through the FIPS 140-2 CMVP. Any other firmware loaded into this Module is out of the scope of this validation and requires a separate FIPS 140-2 validation.

7 Security Rules

Ultrastar C15K600 enforces applicable *FIPS 140-2 Level 2 security* requirements. This section documents the security rules that the Cryptographic Module enforces.

7.1 Invariant Rules

1. The Cryptographic Module supports two distinct types of operator roles: Cryptographic Officer and User.
2. Cryptographic Module power cycles clear all existing authentications.
3. When the Cryptographic Module has successfully completed self-tests and has been initialized, it is in FIPS mode, and the FIPS mode indicator is set to 1.
4. When the Cryptographic Module is unable to authenticate TCG Credentials, operators do not have access to any cryptographic service other than the unauthenticated Generate Random service.
5. The Cryptographic Module performs the following tests
 - A. Power up Self-Tests
 - 1) Firmware Integrity 16-bit CRC
 - 2) Hardware AES Encrypt/Decrypt KAT (Known Answer Test)
 - 3) Firmware AES Encrypt/Decrypt KAT
 - 4) RSA Verify KAT
 - 5) SHA-256 KAT
 - 6) DRBG KAT
 - 7) HMAC-SHA-256 KAT
 - B. Conditional Tests
 - 1) Continuous Random Number Generator test is performed on the DRBG and the hardware NDRNG entropy source.
 - 2) Firmware Download Check
6. An operator can command the Cryptographic Module to perform the power-up self-test by power cycling the device.
7. Power-up self-tests do not require operator action.
8. Data output is inhibited during key generation, self-tests, zeroization, and error states.
9. Status information does not contain CSPs or sensitive data that if misused, could compromise the Cryptographic Module.
10. There are no restrictions on which plaintext keys or CSPs the zeroization service deletes.
11. The Cryptographic Module does not support a maintenance interface or maintenance role.
12. The Cryptographic Module does not support manual key entry.

13. The Cryptographic Module does not have any external input/output devices used for entry/output of data.
14. The Cryptographic Module does not output plaintext CSPs.
15. The Cryptographic Module does not output intermediate key values.
16. The Cryptographic Module does not support concurrent operators.
17. The End Session service deletes the current operator authentication. The Cryptographic Module requires operators to re-authenticate upon execution of the End Session service.

7.2 Initialization Rules

The Cryptographic Officer shall follow the instructions in the Delivery & Operation (Cryptographic Officer) Manual for acceptance and end of life procedures. Acceptance instructions include:

- Establish authentication data for the TCG Authorities
- Establish the LBA Bands, including Media Encryption Keys
- Disable Maker Authority
- Lock the Firmware Download service control

7.3 Zeroization Rules

Zeroization is performed by the Cryptographic Officer with the TCG Revert Method. Revert includes zeroization of all Critical Security Parameters:

- Operator authentication data
- Media Encryption Keys
- NDRNG state
- DRBG state

9 Mitigation of Other Attacks Policy

The Cryptographic Module is not designed to mitigate any attacks beyond FIPS 140-2 Security Level 2 requirements.

10 Definitions

Allowed: NIST approved, i.e., recommended in a NIST Special Publication, or acceptable, i.e., no known security risk as opposed to deprecated, restricted and legacy-use. [SP800-131A] for terms

Anybody: A formal TCG term for a role that is not authenticated. [TCG Core]

Approved: [FIPS140] approved or recommended in a NIST Special Publication.

Approved mode of operation: A mode of the cryptographic module that employs only Approved security functions. [FIPS140]

Authenticate: Prove the identity of an Operator or the integrity of an object.

Authorize: Grant an authenticated Operator access to a service or an object.

Confidentiality: A cryptographic property that sensitive information is not disclosed to unauthorized parties.

Credential: A formal TCG term for data that is used to authenticate an Operator. [TCG Core]

Critical Security Parameter (CSP): Security-related information (e.g., secret and private cryptographic keys, and authentication data such as credentials and PINs) whose disclosure or modification can compromise the security of a cryptographic module. [FIPS140]

Cryptographic Boundary: An explicitly defined continuous perimeter that establishes the physical bounds of a cryptographic module and contains all the hardware, software, and/or firmware components of a cryptographic module. [FIPS140]

Cryptographic key (Key): An input parameter to an Approved cryptographic algorithm

Cryptographic Module: The set of hardware, software, and/or firmware that an implement Approved security functions and is contained within the cryptographic boundary. [FIPS140]

Cryptographic Officer: An Operator performing cryptographic initialization and management functions. [FIPS140]

Ciphertext: Encrypted data transformed by an Approved security function.

Data at Rest: User data residing on the storage device media where the storage device is powered off.

Discovery: A TCG method that provides the properties of the TCG device. [TCG Enterprise]

Integrity: A cryptographic property that sensitive data has not been modified or deleted in an unauthorized and undetected manner.

Interface: A logical entry or exit point of a cryptographic module that provides access to the cryptographic module for logical information flows. [FIPS140]

Key Derivation Function (KDF): An Approved cryptographic algorithm by which one or more keys are derived from a shared secret and other information.

Key Encrypting Key (KEK): A cryptographic key that is used to encrypt or decrypt other keys.

Key management: The activities involving the handling of cryptographic keys and other related security parameters (e.g., authentication data) during the entire life cycle of the Cryptographic Module.

Key Wrap: An Approved cryptographic algorithm that uses a KEK to provide Confidentiality and Integrity.

LBA Band: A formal [TCG Core] term that defines a contiguous logical block range (sequential LBAs) to store encrypted User Data; bands do not overlap and each has its own unique encryption key and other settable properties.

Method: A TCG command or message. [TCG Core]

Manufactured SID (MSID): A unique, default value that vendors assign to each SED during manufacturing; it is typically printed on an external label and is readable with the TCG protocol; it is the initial and default value for all TCG credentials. [TCG Core]

Operator: A consumer, either human or automation, of cryptographic services that is external to the Cryptographic Module. [FIPS140]

Personal Identification Number (PIN): A formal TCG term designating a string of octets that is used to authenticate an identity. [TCG Core]

Plaintext: Data that is not encrypted.

Port: A physical entry or exit point of a cryptographic module that provides access to the Cryptographic Module for physical signals. [FIPS140]

Public Security Parameters (PSP): Public information whose modification can compromise the security of the cryptographic module (e.g., a public key of a keypair).

Read Data: An external request to transfer User Data from the SED. [SCSI Block]

Reserved Area: Private data on the Storage Medium that is not accessible outside the Cryptographic Boundary.

Session: A formal TCG term that envelops the lifetime of an Operator's authentication. [TCG Core]

Security Identifier (SID): A TCG authority used by the Cryptographic Officer. [TCG Core]

Self-Encrypting Drive (SED): A storage device that provides data storage services.

Storage Medium: The non-volatile, persistent storage location of a SED; it is partitioned into two disjoint sets, a User Data area and a Reserved Area.

User: An Operator that consumes cryptographic services. [FIPS140]

User Data: Data that is transferred from/to a SED using the Read Data and Write Data commands. [SCSI Block]

Well Known: A published constant.

Write Data: An external request to transfer User Data to a SED. [SCSI Block]

Zeroize: Invalidate a Critical Security Parameter. [FIPS140]

11 Acronyms

CO	Cryptographic Office [FIPS140]
CSP	Critical Security Parameter [FIPS140]
DRBG	Deterministic Random Bit Generator
DRAM	Dynamic Random Access Memory
HDD	Hard Disk Drive
EMI	Electromagnetic Interference
FIPS	Federal Information Processing Standard
KAT	Known Answer Test
LBA	Logical Block Address
MEK	Media Encryption Key
MSID	TCG Manufactured SID - a public, drive-unique value that is created during manufacturing and is used as default PIN credential values
NDRNG	Non-deterministic Random Number Generator that is the source of entropy for the DRBG
NIST	National Institute of Standards and Technology
PIN	Personal Identification Number
PSID	Physical SID – a drive-unique value that is printed on the Cryptographic Module’s label and is used as authentication data and proof of physical presence for the Zeroize service
PSP	Public Security Parameter
SAS	Serial Attached SCSI
SCSI	Small Computer System Interface
SED	Self encrypting Drive
SID	TCG Security Identifier, the authority representing the Cryptographic Module owner
TCG	Trusted Computing Group
XTS	A mode of AES

12 References

12.1 NIST Specifications

- [AES] Advanced Encryption Standard, FIPS PUB 197, NIST, 2001, November
- [DSS] Digital Signature Standard, FIPS PUB 186-3, NIST, 2006, March
- [FIPS140] Security Requirements for Cryptographic Modules, FIPS PUB 140-2, NIST, 2002 December
- [HMAC] The Keyed-Hash Message Authentication Code, FIPS PUB 198-1, 2007 June
- [SHA] Secure Hash Standard (SHS), FIPS PUB 180-3, NIST, 2007 June
- [SP800-38E] Recommendation for Block Cipher Modes of Operation: The XTS-AES Mode for Confidentiality on Storage Devices, SP800-38E, NIST, 2010 January
- [SP800-38F] Recommendation for Block Cipher Modes of Operation: Methods for Key Wrapping, NIST, 2012 December
- [SP800-57] Recommendation for Key Management – Part I General (Revision 3), NIST, 2012 July
- [SP800-90A] Recommendation for Random Number Generation Using Deterministic Random Bit Generators, NIST, 2012 Jan
- [SP800-131A] Transitions: Recommendation for Transitioning the Use of Cryptographic Algorithms and Key Lengths, NIST, 2011 Jan
- [SP800-132] Recommendation for Password-Based Key Derivation, NIST, 2010 December

12.2 Trusted Computing Group Specifications

- [TCG Core] *TCG Storage Architecture Core Specification*, Version 1.0 Revision 0.9 (May 24, 2007)
- [TCG Enterprise] *TCG Storage Security Subsystem Class: Enterprise Specification*, Version 1.00 Final Revision 1.00 (January 27, 2009)
- [TCG App Note] *TCG Storage Application Note: Encrypting Storage Devices Compliant with SSC: Enterprise*, Version 1.00 Revision 1.00 Final
- [TCG Opal] *TCG Storage Security Subsystem Class: Opal Specification*, Version 2.00 Final Revision 1.00 (February 24, 2012)

12.3 International Committee on Information Technology Standards T10 Technical Committee Standards

- [SCSI Core] SCSI Primary Commands-4 Rev 15 (SPC-4)

- [SCSI Block] SCSI Block Commands Rev15 (SBC-3)
- [SAS] Serial Attached SCSI-2 Rev 13 (SAS-2)