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Enterprise Performance 10K HDD

v9 SAS Product Manual

512E*/4KN	512N
Standard Models	**Standard Models**
ST2400MM0129 ST1800MM0129 ST1200MM0129 ST600MM0099	ST1200MM0009 ST600MM0009
Self-Encrypting Drive (SED) Models	**Self-Encrypting Drive (SED) Models**
ST2400MM0139 ST1800MM0139 ST1200MM0139 ST600MM0109	ST1200MM0039 ST600MM0039
SED FIPS140-2 Models Review Pending	**SED FIPS140-2 Models Review Pending**
ST2400MM0149 ST1800MM0149 ST1200MM0149	ST1200MM0069
Instant Secure Erase (ISE) Models	**Instant Secure Erase (ISE) Models**
ST2400MM0159 ST1800MM0159 ST1200MM0159 ST600MM0119	ST1200MM0099 ST600MM0069

* Default configuration is 512E for 512E / 4KN drives.
See **Section 4.2.2** to Fast Format to 4KN in seconds

Not all drives may be available in all countries.

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July 2017

Document Revision History

Revision	Date	Pages affected and Description of changes
Rev. A	06/14/2017	Initial release.
Rev. B	06/23/2017	8, 12-13 & 18: Added (available on 512E / 4Kn only) or "only" 9: Revised tested standards; Added Section 2.1.1 Regulatory model 9: Corrected tested UL/cUL standards statement 10: Updated Section 2.1.3 Electromagnetic compliance subsections 13, 15 & 30: Corrected RPM to 10.5K 15: Updated Section 4.2.1 Format command execution time (minutes) 19: Changed exponents to superscript 34-35: Corrected Section 6.5 figure references & added legends to IOPs charts 38: Removed Section 4.6.8 Electromagnetic susceptibility
Rev. C	06/26/2017	10: Updated EMC for EU to reflect 2014/30/EU dated 20 April 2016
Rev. D	07/25/2017	fc, 8 & 54: Added ISE models

Publication number: 100818015, Rev. D July 2017

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1.0 Scope

This manual describes Seagate® Enterprise Performance 10K HDD (Serial Attached SCSI) with Advanced Caching disk drives (available on 512E/4Kn only).

Seagate Enterprise Performance 10K HDD drives support the SAS Protocol specifications to the extent described in this manual. The *SAS Interface Manual* (part number 100293071) describes the general SAS characteristics of this and other Seagate SAS drives. The Self-Encrypting Drive Reference Manual, part number 100515636, describes the interface, general operation, and security features available on Self-Encrypting Drive models.

Product data communicated in this manual is specific only to the model numbers listed in this manual. The data listed in this manual may not be predictive of future generation specifications or requirements. If integrators are designing a system which will use one of the models listed or future generation products and need further assistance, please contact the Field Applications Engineer (FAE) or our global support services group as shown on page 7.

Unless otherwise stated, the information in this manual applies to standard and Self-Encrypting Drive models.

Standard Models	Self-Encrypting Drive (SED) Models	FIPS 140-2 Level 2 Models Review Pending	Instant Secure Erase ISE Models
512 Emulation / 4K Native			
ST2400MM0129	ST2400MM0139	ST2400MM0149	ST2400MM0159
ST1800MM0129	ST1800MM0139	ST1800MM0149	ST1800MM0159
ST1200MM0129	ST1200MM0139	ST1200MM0149	ST1200MM0159
ST600MM0099	ST600MM0109		ST600MM0119
512 Native			
ST1200MM0009	ST1200MM0039	ST1200MM0069	ST1200MM0099
ST600MM0009	ST600MM0039		ST600MM0069

Note Previous generations of Seagate Self-Encrypting Drive models were called Full Disk Encryption (FDE) models before a differentiation between drive-based encryption and other forms of encryption was necessary.

Note The Self-Encrypting Drive models indicated on the cover of this product manual have provisions for "Security of Data at Rest" based on the standards defined by the Trusted Computing Group (see www.trustedcomputinggroup.org).

For more information on FIPS 140-2 Level 2 certification see Section 7.0 on page 40.

For product certification status visit - http://csrc.nist.gov/groups/STM/cmvp/documents/140-1/1401vend.htm.

2.0 Applicable standards and reference documentation

The drives documented in this manual have been developed as system peripherals to the highest standards of design and construction. The drives depend on host equipment to provide adequate power and environment for optimum performance and compliance with applicable industry and governmental regulations. Special attention must be given in the areas of safety, power distribution, shielding, audible noise control, and temperature regulation. In particular, the drives must be securely mounted to guarantee the specified performance characteristics. Mounting by bottom holes must meet the requirements of Section 10.3.

2.1 Standards

The Seagate Enterprise Performance 10K HDD family complies with Seagate standards as noted in the appropriate sections of this manual and the Seagate *SAS Interface Manual*, part number 100293071.

The drives are recognized in accordance with UL/cUL 60950-1 and UL/cUL 62368-1 as testing witnessed by UL, and EN 60950-1 and EN 62368-1 as testing witnessed by TUV.

The security features of Self-Encrypting Drive models are based on the "TCG Storage Architecture Core Specification" and the "TCG Storage Workgroup Security Subsystem Class: Enterprise_A" specification with additional vendor-unique features as noted in this product manual.

2.1.1 Regulatory Models

The following regulatory model number represent all features and configurations within the series:

Regulatory Model Numbers: STT003

2.1.2 Electromagnetic compatibility

The drive, as delivered, is designed for system integration and installation into a suitable enclosure prior to use. The drive is supplied as a subassembly and is not subject to Subpart B of Part 15 of the FCC Rules and Regulations.

The design characteristics of the drive serve to minimize radiation when installed in an enclosure that provides reasonable shielding. The drive is capable of meeting the Class B limits of the FCC Rules and Regulations when properly packaged; however, it is the user's responsibility to assure that the drive meets the appropriate EMI requirements in their system. Shielded I/O cables may be required if the enclosure does not provide adequate shielding. If the I/O cables are external to the enclosure, shielded cables should be used, with the shields grounded to the enclosure and to the host controller.

2.1.2.1 Electromagnetic susceptibility

As a component assembly, the drive is not required to meet any susceptibility performance requirements. It is the responsibility of those integrating the drive within their systems to perform those tests required and design their system to ensure that equipment operating in the same system as the drive or external to the system does not adversely affect the performance of the drive. See Section 6.4, DC power consumption.

2.1.3 Electromagnetic compliance

Seagate uses an independent laboratory to confirm compliance with the directives/standards for CE Marking and RCM Marking. The drive was tested in a representative system for typical applications and comply with the Electromagnetic Interference/ Electromagnetic Susceptibility (EMI/EMS) for Class B products. The selected system represents the most popular characteristics for test platforms.

Although the test system with this Seagate model complies with the directives/standards, we cannot guarantee that all systems will comply. The computer manufacturer or system integrator shall confirm EMC compliance and provide the appropriate marking for their product.

Electromagnetic compliance for the European Union

If this model has the CE Marking it complies with the European Union requirements of the Electromagnetic Compatibility Directive 2014/30/EU as put into place on 20 April 2016.

Australian RCM

If this model has the RCM Marking it complies with the Australia/New Zealand Standard AS/NZ CISPR32 and meets the Electromagnetic Compatibility (EMC) Framework requirements of the Australian Communications and Media Authority (ACMA).

Canada ICES-003

If this model has the ICES-003 marking it complies with requirements of ICES tested per ANSI C63.4-2014.

Korean KCC

If these drives have the Korean Communications Commission (KCC) logo, they comply with KN32 and KN35.

Morocco

If this model has the Morocco marking, it complies with the Morocco Order of the Minister of Industry, Trade, Investment and Digital Economy No. 2574-14 of 29 Ramadan 1436 (16 July 2015) on electromagnetic compatibility of equipment.

Taiwanese BSMI

If this model has the Taiwanese certification mark then it complies with Chinese National Standard, CNS13438.

2.1.4 European Union Restriction of Hazardous Substances (RoHS)

The European Union Restriction of Hazardous Substances (RoHS) Directive restricts the presence of chemical substances, including Lead (Pb), in electronic products effective July 2006.

A number of parts and materials in Seagate products are procured from external suppliers. We rely on the representations of our suppliers regarding the presence of RoHS substances in these parts and materials. Our supplier contracts require compliance with our chemical substance restrictions, and our suppliers document their compliance with our requirements by providing material content declarations for all parts and materials for the disk drives documented in this publication. Current supplier declarations include disclosure of the inclusion of any RoHS-regulated substance in such parts or materials.

Seagate also has internal systems in place to ensure ongoing compliance with the RoHS Directive and all laws and regulations which restrict chemical content in electronic products. These systems include standard operating procedures that ensure that restricted substances are not utilized in our manufacturing operations, laboratory analytical validation testing, and an internal auditing process to ensure that all standard operating procedures are complied with.

2.1.5 China Requirements — China RoHS 2

China RoHS 2 refers to the Ministry of Industry and Information Technology Order No. 32, effective July 1, 2016, titled Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products. To comply with China RoHS 2, we determined this product's Environmental Protection Use Period (EPUP) to be 20 years in accordance with the *Marking for the Restricted Use of Hazardous Substances in Electronic and Electrical Products,* SJT 11364-2014.

中国电器电子产品有害物质限制使用管理办法

(Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products _ China RoHS)

产品中有害物质的名称及含量

(Name and Content of the Hazardous Substances in Product)

Table 1 Hazardous Substances

部件名称 Part Name	有害物质 Hazardous Substances					
	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (CF^{+6})	多溴联苯 Polybrominated biphenyls (PBB)	多溴二苯醚 Polybrominated diphenyl ethers (PBDE)
印刷电路板组装 PCBA	X	O	O	O	O	O
机壳 Chassis	X	O	O	O	O	O

本表格依据 SJ/T 11364 的规定编制。

This table is prepared in accordance with the provisions of SJ/T 11364-2014

O： 表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。

O: Indicates that the hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement of GB/T26572.

X： 表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。

X: Indicates that the hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement of GB/T26572.

Reference documents

SCSI Commands Reference Manual — Seagate part number: 100293068

SAS Interface Manual — Seagate part number: 100293071

ANSI SAS Documents

SFF-8223	2.5" Drive Form Factor with Serial Connector
SFF-8460	HSS Backplane Design Guidelines
SFF-8470	Multi Lane Copper Connector
SFF-8482	SAS Plug Connector
ANSI INCITS.xxx	Serial Attached SCSI (SAS-3) Standard (T10//BSR INCITS 519 rev. 06)
ISO/IEC 14776-xxx	SCSI Architecture Model-3 (SAM-4) Standard (T10/1683-D)
ISO/IEC 14776-xxx	SCSI Primary Commands-3 (SPC-3) Standard (T10/1416-D)
ISO/IEC 14776-xxx	SCSI Block Commands-3 (SBC-2) Standard (T10/1417-D)

ANSI Small Computer System Interface (SCSI) Documents

X3.270-1996	(SCSI-3) Architecture Model

Trusted Computing Group (TCG) Documents (apply to Self-Encrypting Drive models only)

TCG Storage Architecture Core Specification, Rev. 1.0

TCG Storage Security Subsystem Class Enterprise Specification, Rev. 1.0

Self-Encrypting Drives Reference Manual — Seagate part number: 100515636

In case of conflict between this document and any referenced document, this document takes precedence.

3.0 General description

Seagate® Enterprise Performance 10K HDD drives provide high performance, high capacity data storage for a variety of systems including engineering workstations, network servers, mainframes, and supercomputers. The Serial Attached SCSI interface is designed to meet next-generation computing demands for performance, scalability, flexibility and high-density storage requirements.

The Advanced Caching functionality (available on 512E/4Kn only) provides improved performance over standard HDDs in real-world workloads. This improvement is due to the addition of a solid state component that caches "hot" data for reads as well as protects write data via non-volatile cache (NVC).

Seagate Enterprise Performance 10K HDD drives are random access storage devices designed to support the Serial Attached SCSI Protocol as described in the ANSI specifications, this document, and the *SAS Interface Manual* (part number 100293071) which describes the general interface characteristics of this drive. Seagate Enterprise Performance 10K HDD drives are classified as intelligent peripherals and provide level 2 conformance (highest level) with the ANSI SCSI-1 standard. The SAS connectors, cables and electrical interface are compatible with Serial ATA (SATA), giving future users the choice of populating their systems with either SAS or SATA hard disk drives. This allows integrators to continue to leverage existing investment in SCSI while gaining a 12Gb/s serial data transfer rate.

Note	Never disassemble the HDA and do not attempt to service items in the sealed enclosure (heads, media, actuator, etc.) as this requires special facilities. The drive does not contain user-replaceable parts. Opening the HDA for any reason voids the warranty.

Seagate Enterprise Performance 10K HDD drives use a dedicated load/unload zone at the outermost radius of the media to eliminate the possibility of destroying or degrading data by landing in the data zone. The heads automatically go to the ramp load/unload when power is removed from the drive and during the deeper sleep modes.

An automatic shipping lock prevents potential damage to the heads and discs that results from movement during shipping and handling. The shipping lock disengages and the head load process begins when power is applied to the drive.

The drives also use a high-performance actuator assembly with a low-inertia, balanced, patented, straight arm design that provides excellent performance with minimal power dissipation in any orientation.

3.1 Standard features

Enterprise Performance 10K HDD drives have the following standard features:

- 128 - deep task set (queue)
- 256MB / 128MB data buffer (see Section 4.5)
- 3.0 / 6.0 / 12.0 Gb Serial Attached SCSI (SAS) interface
- 8MB NVC-backed write cache 512E/4Kn only
- Dedicated head load/unload zone and automatic shipping lock
- Drive Self Test (DST)
- Dynamic spindle brake
- ECC maximum burst correction length of 520 bits for 512 byte blocks and 3000 bits for 4K byte blocks.
- Embedded servo design
- Firmware downloadable using the SAS interface
- Flawed logical block reallocation at format time
- Idle Read After Write (IRAW)
- Industry standard SFF 2.5-inch dimensions
- Integrated dual port SAS controller supporting the SCSI protocol
- Jumperless configuration
- Multi-Sensor Magnetic Recording (implements dual readers)
- No preventive maintenance or adjustments required
- Power Balance supported (see Section 6.2 on page 26)
- Power Choice
- Programmable auto write and read reallocation
- Programmable logical block reallocation scheme
- RAID Rebuild ™
- Reallocation of defects on command (Post Format)
- SAS Power Disable
- Self diagnostics performed when power is applied to the drive

- Support for SAS expanders and fanout adapters
- Supports up to 32 initiators
- T10 Fast Format supported (see Section 4.2.2)
- TurboBoost 16GB read cache 512E/4Kn only
- User-selectable logical block sizes for 4096 native models (4096, 4160 or 4224 bytes per logical block)
- User-selectable logical block sizes for 512 emulation and native models (512, 520 or 528 bytes per logical block)
- Vertical, horizontal, or top down mounting
- Zone bit recording (ZBR)

Seagate Enterprise Performance 10K HDD Self-Encrypting Drive models have the following additional features:
- 32 independent data bands
- Authenticated firmware download
- Automatic data encryption/decryption
- Controlled access
- Cryptographic erase of user data for a drive that will be repurposed or scrapped
- Drive locking
- Random number generator

3.2 Media description

The media used on the drive has an glass substrate coated with a thin film magnetic material, overcoated with a proprietary protective layer for improved durability and environmental protection.

3.3 Performance
- 10.5K RPM spindle. Average latency = 2.9ms
- 1200MB/s maximum instantaneous data transfers.
- Adaptive seek velocity; improved seek performance
- Background processing of queue
- Firmware-controlled multisegmented cache designed to dynamically adjust segments for enhanced system performance
- Supports start and stop commands (spindle stops spinning)

Note	There is no significant performance difference between Self-Encrypting Drive and standard (non-Self-Encrypting Drive) models.

3.4 Formatted capacities

Standard OEM models are formatted to 512 bytes per block for 512 emulation and native drives and 4096 bytes per block for 4096 native drives. The block size is selectable at format time. Supported block sizes are 512, 520 and 528 for 512 emulation and native drives and 4096, 4160 and 4224 for 4096 native drives. Users having the necessary equipment may modify the data block size before issuing a format command and obtain different formatted capacities than those listed.

To provide a stable target capacity environment and at the same time provide users with flexibility if they choose, Seagate recommends product planning in one of two modes:

Seagate designs specify capacity points at certain block sizes that Seagate guarantees current and future products will meet. We recommend customers use this capacity in their project planning, as it ensures a stable operating point with backward and forward compatibility from generation to generation. The current guaranteed operating points for this product are shown below.

Capacity (Blocks)

Sector Size	2400GB		1800GB		1200GB		600GB	
	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex
512	4,688,430,768	11773C6B0	3,516,328,368	D196E9B0h	2,344,225,968	8BBA0CB0h	1,172,123,568	45DD2FB0h
520	4,589,230,784	1118A1AC0	3,441,923,088	CD279410h	2,294,615,392	88C50D60h	1,147,307,696	446286B0h
528	4,462,998,224	10A03F2D0	3,347,248,672	C782F620h	2,231,499,112	8501F968h	1,115,749,560	4280FCB8h
4096	586,053,846	22EE78D6	439,541,046	1A32DD36h	293,028,246	11774196h	146,515,446	8BBA5F6h
4160	574,615,392	223FEF60	430,961,544	19AFF388h	287,307,696	111FF7B0h	143,653,848	88FFBD8h
4224	563,068,183	218FBD18	422,301,144	192BCDD8h	281,534,096	10C7DE90h	140,767,048	863EF48h

3.5 Programmable drive capacity

Using the Mode Select command, the drive can change its capacity to something less than maximum. See the Mode Select (6) parameter list table in the *SAS Interface Manual*, part number 100293071. A value of zero in the Number of Blocks field indicates that the drive will not change the capacity it is currently formatted to have. A number other than zero and less than the maximum number of LBAs in the Number of Blocks field changes the total drive capacity to the value in the Number of Blocks field. A value greater than the maximum number of LBAs is rounded down to the maximum capacity.

3.6 Factory-installed options

The following items may be ordered which are incorporated at the manufacturing facility during production or packaged before shipping. Some of the options available are (not an exhaustive list of possible options):

- Other capacities can be ordered depending on sparing scheme and sector size requested.
- Single-unit shipping pack. The drive is normally shipped in bulk packaging to provide maximum protection against transit damage. Units shipped individually require additional protection as provided by the single unit shipping pack. Users planning single unit distribution should specify this option.
- The *Safety and Regulatory Agency Specifications*, part number 75789512, is usually included with each standard OEM drive shipped, but extra copies may be ordered.

4.0 Performance characteristics

This section provides detailed information concerning performance-related characteristics and features of Seagate Enterprise Performance 10K HDD drives.

4.1 Internal drive characteristics

	2400GB	1800GB	1200GB	600GB	Models
Sector size	4KN or 512E	4KN or 512E	4KN or 512E / 512N	4KN or 512E / 512N	
Drive capacity	2.4TB	1.8TB	1.2TB	0.6TB	GB (formatted, rounded off value)
Read/write data heads	8	6	4	2	
Bytes per track	1261	1261	1261 / 1168	1261 / 1168	Kbytes (avg, rounded off values)
Bytes per surface	300,016	300,016	300,016	300,016	MB (unformatted, rounded off value)
Tracks per surface (total)	249	249	249	249	Ktracks (user accessible, rounded off values)
Tracks per inch	342	342	342 / 369	342 / 369	KTPI (avg, rounded off values)
Peak bits per inch	2460	2460	2460	2460	Kb/in
Areal density	841	841	841 / 908	841 / 908	Gb/in2
Disk rotation speed	10.5K	10.5K	10.5K	10.5K	rpm
Avg rotational latency	2.9	2.9	2.9	2.9	ms

4.2 Performance characteristics

4.2.1 Format command execution time (minutes)

	2400GB models	1800GB models	1200GB models	600GB models
Maximum (with verify)	420	320	220	120
Maximum (without verify)	210	160	110	60

Execution time measured from receipt of the last byte of the Command Descriptor Block (CDB) to the request for a Status Byte Transfer to the Initiator (excluding connect/disconnect).

When changing sector sizes, the format times shown above may need to be increased by 30 minutes.

4.2.2 Fast Format

Drive sector size transition

- Single code to support sector sizes from 512E to 4KN
- T10 fast format conversion between 4KNand 512E configurations in the field.
  - Possible only if sector sizes are exact multiples of 8 & vice versa
- The selected sector size will take effect only after fast format or full format
- Drive default is 512E from the factory.
- 512E / 4KN features set after Fast Format

T10 Fast Format

- Implements the fast format based on T10 Spec.
- To request Fast Format, the FFMT bits (Byte 4, Bits 1:0) should be set to 01b.
- A setting of 10b or 11b will return a check condition with 05/24 sense code (pointing to FFMT MSB in CDB).

Mode Select - Parameter list header

- Set Write buffer: // Set Block Descriptor Length = 0x08, Number of LBA's = 0xFFFFFFFF
- 00 00 00 00 00 00 00 08 FF FF FF FF 00 00 **02 00** // Set block size to 0512 (0x0200)
- **10 00** // Set block size to 4096 (0x1000)
- Then Send Mode Select Command
- cdb: 55 01 00 00 00 00 00 00 10 00 // (SP bit = 1, Parameter list = 0x10)

Format Unit - Parameter list header

- Set Write buffer: // Set IMMED = 1
- 00 02 00 00
- Then Send Format Unit Command
- cdb: 04 14 00 00 01 00 // (FMTDAT = 1, DEFECT LIST FORMAT = 010b, FFMT = 01b)

4.2.3 General performance characteristics

Sustained transfer rate for 4096 native and 512 emulation models	124 to 254 MiB/s ** 130 to 266 MB/s
Sustained transfer rate for 512 native models	124 to 238 MiB/s ** 130 to 250 MB/s
SAS Interface maximum instantaneous transfer rate	1200 MB/s* per port (dual port = 2400 MB/s*)
Logical block sizes 512 emulation and native - 512 (default), 520 or 528 4096 native - 4096 (default), 4160 or 4224	
Read/write consecutive sectors on a track	Yes
Flaw reallocation performance impact (for flaws reallocated at format time using the spare sectors per sparing zone reallocation scheme.)	Negligible
Average rotational latency	2.9ms

*Assumes no errors and no relocated logical blocks. Rate measured from the start of the first logical block transfer to or from the host.
** MiB/s x 1.048 = MB/s

4.3 Start/stop time

The drive accepts the commands listed in the *SAS Interface Manual* less than 3 seconds after DC power has been applied.

If the drive receives a NOTIFY (ENABLE SPINUP) primitive through either port and has not received a START STOP UNIT command with the START bit equal to 0, the drive becomes ready for normal operations within 20 seconds (excluding the error recovery procedure).

If the drive receives a START STOP UNIT command with the START bit equal to 0 before receiving a NOTIFY (ENABLE SPINUP) primitive, the drive waits for a START STOP UNIT command with the START bit equal to 1. After receiving a START STOP UNIT command with the START bit equal to 1, the drive waits for a NOTIFY (ENABLE SPINUP) primitive. After receiving a NOTIFY (ENABLE SPINUP) primitive through either port, the drive becomes ready for normal operations within 20 seconds (excluding the error recovery procedure).

If the drive receives a START STOP UNIT command with the START bit and IMMED bit equal to 1 and does not receive a NOTIFY (ENABLE SPINUP) primitive within 5 seconds, the drive fails the START STOP UNIT command.

The START STOP UNIT command may be used to command the drive to stop the spindle. Stop time is 20 seconds (maximum) from removal of DC power. SCSI stop time is 20 seconds. There is no power control switch on the drive. However, power can be cycled on the drive by utilizing SAS Power Disable feature defined by T10 (i.e. drive Pin 3 high).

4.4 Prefetch/multi-segmented cache control

The drive provides a prefetch (read look-ahead) and multi-segmented cache control algorithms that in many cases can enhance system performance. Cache refers to the drive buffer storage space when it is used in cache operations. To select this feature, the host sends the Mode Select command with the proper values in the applicable bytes in page 08h. Prefetch and cache operations are independent features from the standpoint that each is enabled and disabled independently using the Mode Select command; however, in actual operation, the prefetch feature overlaps cache operation somewhat as described in sections 4.5.1 and 4.5.2.

All default cache and prefetch mode parameter values (Mode Page 08h) for standard OEM versions of this drive family are given in Section 11.3.2.

4.5 Cache operation

Note. Refer to the *SAS Interface Manual* for more detail concerning the cache bits.

The buffer is divided into logical segments from which data is read and to which data is written.

The drive keeps track of the logical block addresses of the data stored in each segment of the buffer. If the cache is enabled (see RCD bit in the *SAS Interface Manual*), data requested by the host with a read command is retrieved from the buffer, if possible, before any disk access is initiated. If cache operation is not enabled, the buffer is still used, but only as circular buffer segments during disk medium read operations (disregarding Prefetch operation for the moment). That is, the drive does not check in the buffer segments for the requested read data, but goes directly to the medium to retrieve it. The retrieved data merely passes through some buffer segment on the way to the host. All data transfers to the host are in accordance with buffer-full ratio rules. See the explanation provided with the information about Mode Page 02h (disconnect/reconnect control) in the *SAS Interface Manual.*

The following is a simplified description of the prefetch/cache operation:

Case A—read command is received and all of the requested logical blocks are already in the cache:

1. Drive transfers the requested logical blocks to the initiator.

Case B—A Read command requests data, and at least one requested logical block is not in any segment of the cache:

1. The drive fetches the requested logical blocks from the disk and transfers them into a segment, and then from there to the host in accordance with the Mode Select Disconnect/Reconnect parameters, page 02h.
2. If the prefetch feature is enabled, refer to section 4.5.2 for operation from this point.

Each cache segment is actually a self-contained circular buffer whose length is an integer number of logical blocks. The drive dynamically creates and removes segments based on the workload. The wrap-around capability of the individual segments greatly enhances the cache's overall performance.

Note	The size of each segment is not reported by Mode Sense command page 08h, bytes 14 and 15. The value 0XFFFF is always reported regardless of the actual size of the segment. Sending a size specification using the Mode Select command (bytes 14 and 15) does not set up a new segment size. If the STRICT bit in Mode page 00h (byte 2, bit 1) is set to one, the drive responds as it does for any attempt to change an unchangeable parameter.

4.5.1 Caching write data

Note	Write caching in this section is the traditional SCSI write caching (WCE=1) where writes are not protected on power loss. Advanced Caching (512E/4Kn only) provides NVC-protected write caching when WCE=0 over a portion of the DRAM.

Note	Refer to the SAS Interface Manual for more detail concerning the cache bits.

Write caching is a write operation by the drive that makes use of a drive buffer storage area where the data to be written to the medium is stored while the drive performs the Write command.

If read caching is enabled (RCD=0), then data written to the medium is retained in the cache to be made available for future read cache hits. The same buffer space and segmentation is used as set up for read functions. The buffer segmentation scheme is set up or changed independently, having nothing to do with the state of RCD. When a write command is issued, if RCD=0, the cache is first checked to see if any logical blocks that are to be written are already stored in the cache from a previous read or write command. If there are, the respective cache segments are cleared. The new data is cached for subsequent Read commands.

If the number of write data logical blocks exceed the size of the segment being written into, when the end of the segment is reached, the data is written into the beginning of the same cache segment, overwriting the data that was written there at the beginning of the operation; however, the drive does not overwrite data that has not yet been written to the medium.

If write caching is enabled (WCE=1), then the drive may return Good status on a write command after the data has been transferred into the cache, but before the data has been written to the medium. If an error occurs while writing the data to the medium, and Good status has already been returned, a deferred error will be generated.

The Synchronize Cache command may be used to force the drive to write all cached write data to the medium. Upon completion of a Synchronize Cache command, all data received from previous write commands will have been written to the medium. Section 11.3.2 shows the mode default settings for the drive.

4.5.2 Prefetch operation

If the Prefetch feature is enabled, data in contiguous logical blocks on the disk immediately beyond that which was requested by a Read command are retrieved and stored in the buffer for immediate transfer from the buffer to the host on subsequent Read commands that request those logical blocks (this is true even if cache operation is disabled). Though the prefetch operation uses the buffer as a cache, finding the requested data in the buffer is a prefetch hit, not a cache operation hit.

To enable Prefetch, use Mode Select page 08h, byte 12, bit 5 (Disable Read Ahead - DRA bit). DRA bit = 0 enables prefetch.

The drive does not use the Max Prefetch field (bytes 8 and 9) or the Prefetch Ceiling field (bytes 10 and 11).

When prefetch (read look-ahead) is enabled (enabled by DRA = 0), the drive enables prefetch of contiguous blocks from the disk when it senses that a prefetch hit will likely occur. The drive disables prefetch when it decides that a prefetch hit is not likely to occur.

4.5.3 Advanced Caching (512E/4Kn only) operations

Read data that has been promoted into the Advanced read cache does not persist through a power cycle. Read data is retrieved from the rotating media after a power cycle.

When WCE=0, Advanced provides NVC-protected write caching over the portion of the DRAM used to coalesce writes. Write data only goes into NVC when there is an unexpected power loss to the drive. The NVC has 90-day data retention. When WCE=1, a Advanced Caching drive will operate on writes like a standard drive–writes in cache are not protected by NVC and may be lost with power loss.

5.0 Reliability specifications

The following reliability specifications assume correct host and drive operational interface, including all interface timings, power supply voltages, environmental requirements and drive mounting constraints.

Seek error rate:	Less than 10 errors in 10^8 seeks
Read Error Rates[1]	
Recovered Data	Less than 10 error in 10^{12} bits transferred (OEM default settings)
Unrecovered Data	Less than 1 sector in 10^{16} bits transferred
Miscorrected Data	Less than 1 sector in 10^{21} bits transferred
Interface error rate:	Less than 1 error in 10^{12} bits transferred
Mean Time Between Failure (MTBF):	2,000,000 hours
Annualized Failure Rate (AFR):	0.44%
Preventive maintenance:	None required

1. Error rate specified with automatic retries and data correction with ECC enabled and all flaws reallocated.

5.1 Error rates

The error rates stated in this manual assume the following:

- The drive is operated in accordance with this manual using DC power as defined in paragraph 6.4, "DC power consumption."
- Errors caused by host system failures are excluded from error rate computations.
- Assume random data.
- Default OEM error recovery settings are applied. This includes AWRE, ARRE, full read retries, full write retries and full retry time.

5.1.1 Recoverable Errors

Recoverable errors are those detected and corrected by the drive, and do not require user intervention.

Recoverable Data errors will use Error Correction when needed.

Recovered Data error rate is determined using read bits transferred for recoverable errors occurring during a read, and using write bits transferred for recoverable errors occurring during a write.

5.1.2 Unrecoverable Errors

An unrecoverable data error is defined as a failure of the drive to recover data from the media. These errors occur due to head/media or write problems. Unrecoverable data errors are only detected during read operations, but not caused by the read. If an unrecoverable data error is detected, a MEDIUM ERROR (03h) in the Sense Key will be reported. Multiple unrecoverable data errors resulting from the same cause are treated as 1 error.

5.1.3 Seek errors

A seek error is defined as a failure of the drive to position the heads to the addressed track. After detecting an initial seek error, the drive automatically performs an error recovery process. If the error recovery process fails, a seek positioning error (Error code = 15h or 02h) will be reported with a Hardware error (04h) in the Sense Key. Recoverable seek errors are specified at Less than 10 errors in 108 seeks. Unrecoverable seek errors (Sense Key = 04h) are classified as drive failures.

5.1.4 Interface errors

An interface error is defined as a failure of the receiver on a port to recover the data as transmitted by the device port connected to the receiver. The error may be detected as a running disparity error, illegal code, loss of word sync, or CRC error.

5.2 Reliability and service

The reliability of Seagate Enterprise Performance 10K HDD disk drives can be enhanced by ensuring that the drive receives adequate cooling. Section 6.0 provides temperature measurements and other information that may be used to enhance the service life of the drive. Section 10.2 provides recommended air-flow information.

5.2.1 Annualized Failure Rate (AFR) and Mean Time Between Failure (MTBF)

The production disk drive shall achieve an annualized failure-rate of 0.44% (MTBF of 2,000,000 hours) over a 5 year service life when used in Enterprise Storage field conditions as limited by the following:

- 8760 power-on hours per year.
- HDA temperature as reported by the drive <= 50°C
- Ambient wet bulb temp <= 26°C
- Typical workload
- The AFR (MTBF) is a population statistic not relevant to individual units.
- ANSI/ISA S71.04-2013 G2 classification levels and dust contamination to ISO 14644-1 Class 8 standards (as measured at the device)

The MTBF specification for the drive assumes the operating environment is designed to maintain nominal drive temperature and humidity. Occasional excursions in operating conditions between the rated MTBF conditions and the maximum drive operating conditions may occur without significant impact to the rated MTBF. However continual or sustained operation beyond the rated MTBF conditions will degrade the drive MTBF and reduce product reliability.

5.2.2 Preventive maintenance

No routine scheduled preventive maintenance is required.

5.2.3 Hot plugging the drive

When a disk is powered on by switching the power or hot plugged, the drive runs a self test before attempting to communicate on its' interfaces. When the self test completes successfully, the drive initiates a Link Reset starting with OOB. An attached device should respond to the link reset. If the link reset attempt fails, or any time the drive looses sync, the drive initiated link reset. The drive will initiate link reset once per second but alternates between port A and B. Therefore each port will attempt a link reset once per 2 seconds assuming both ports are out of sync.

If the self-test fails, the drive does not respond to link reset on the failing port.

Note	It is the responsibility of the systems integrator to assure that no temperature, energy, voltage hazard, shorting of PCBA to ground, or ESD potential hazard is presented during the hot connect/disconnect operation. Discharge the static electricity from the drive carrier prior to inserting it into the system.

Caution	The drive motor must come to a complete stop prior to changing the plane of operation. This time is required to insure data integrity.

5.2.4 S.M.A.R.T.

S.M.A.R.T. is an acronym for Self-Monitoring Analysis and Reporting Technology. This technology is intended to recognize conditions that indicate imminent drive failure and is designed to provide sufficient warning of a failure to allow an application to back up the data before an actual failure occurs.

Note	The drive's firmware monitors specific attributes for degradation over time but can't predict instantaneous drive failures.

Each monitored attribute has been selected to monitor a specific set of failure conditions in the operating performance of the drive and the thresholds are optimized to minimize "false" and "failed" predictions.

Controlling S.M.A.R.T.

The operating mode of S.M.A.R.T. is controlled by the DEXCPT and PERF bits on the Informational Exceptions Control mode page (1Ch). Use the DEXCPT bit to enable or disable the S.M.A.R.T. feature. Setting the DEXCPT bit disables all S.M.A.R.T. functions. When enabled, S.M.A.R.T. collects on-line data as the drive performs normal read and write operations. When the PERF bit is set, the drive is considered to be in "On-line Mode Only" and will not perform off-line functions.

Applications can measure off-line attributes and force the drive to save the data by using the Rezero Unit command. Forcing S.M.A.R.T. resets the timer so that the next scheduled interrupt is in one hour.

Applications can interrogate the drive through the host to determine the time remaining before the next scheduled measurement and data logging process occurs. To accomplish this, issue a Log Sense command to log page 0x3E. This allows applications to control when S.M.A.R.T. interruptions occur. Forcing S.M.A.R.T. with the RTZ command resets the timer.

Performance impact

S.M.A.R.T. attribute data is saved to the disk so that the events that caused a predictive failure can be recreated. The drive measures and saves parameters once every hour subject to an idle period on the drive interfaces. The process of measuring off-line attribute data and saving data to the disk is interruptable. The maximum on-line only processing delay is summarized below

Maximum processing delay

	Fully-enabled delay DEXCPT = 0
S.M.A.R.T. delay times	75 ms

Reporting control

Reporting is controlled by the MRIE bits in the Informational Exceptions Control mode page (1Ch). Subject to the reporting method. For example, if the MRIE is set to one, the firmware will issue to the host an 01-5D00 sense code. The FRU field contains the type of predictive failure that occurred. The error code is preserved through bus resets and power cycles.

Determining rate

S.M.A.R.T. monitors the rate at which errors occur and signals a predictive failure if the rate of degraded errors increases to an unacceptable level. To determine rate, error events are logged and compared to the number of total operations for a given attribute. The interval defines the number of operations over which to measure the rate. The counter that keeps track of the current number of operations is referred to as the Interval Counter.

S.M.A.R.T. measures error rates. All errors for each monitored attribute are recorded. A counter keeps track of the number of errors for the current interval. This counter is referred to as the Failure Counter.

Error rate is the number of errors per operation. The algorithm that S.M.A.R.T. uses to record rates of error is to set thresholds for the number of errors and their interval. If the number of errors exceeds the threshold before the interval expires, the error rate is considered to be unacceptable. If the number of errors does not exceed the threshold before the interval expires, the error rate is considered to be acceptable. In either case, the interval and failure counters are reset and the process starts over.

Predictive failures

S.M.A.R.T. signals predictive failures when the drive is performing unacceptably for a period of time. The firmware keeps a running count of the number of times the error rate for each attribute is unacceptable. To accomplish this, a counter is incremented each time the error rate is unacceptable and decremented (not to exceed zero) whenever the error rate is acceptable. If the counter continually increments such that it reaches the predictive threshold, a predictive failure is signaled. This counter is referred to as the Failure History Counter. There is a separate Failure History Counter for each attribute.

5.2.5 Thermal monitor

Seagate Enterprise Performance 10K HDD drives implement a temperature warning system which:

1. Signals the host if the temperature exceeds a value which would threaten the drive.
2. Saves a S.M.A.R.T. data frame on the drive which exceeds the threatening temperature value.

A temperature sensor monitors the drive temperature and issues a warning over the interface when the temperature exceeds a set threshold. The temperature is measured at power-up and then at ten-minute intervals after power-up.

The thermal monitor system generates a warning code of 01-0B01 when the temperature exceeds the specified limit in compliance with the SCSI standard.

This feature is controlled by the Enable Warning (EWasc) bit, and the reporting mechanism is controlled by the Method of Reporting Informational Exceptions field (MRIE) on the Informational Exceptions Control (IEC) mode page (1Ch).

5.2.6 Drive Self Test (DST)

Drive Self Test (DST) is a technology designed to recognize drive fault conditions that qualify the drive as a failed unit. DST validates the functionality of the drive at a system level.

There are two test coverage options implemented in DST:

1. Extended test
2. Short test

The most thorough option is the extended test that performs various tests on the drive and scans every logical block address (LBA) of the drive. The short test is time-restricted and limited in length—it does not scan the entire media surface, but does some fundamental tests and scans portions of the media.

If DST encounters an error during either of these tests, it reports a fault condition. If the drive fails the test, remove it from service and return it to Seagate for service.

5.2.6.1 DST failure definition

The drive will present a "diagnostic failed" condition through the self-tests results value of the diagnostic log page if a functional failure is encountered during DST. The channel and servo parameters are not modified to test the drive more stringently, and the number of retries are not reduced. All retries and recovery processes are enabled during the test. If data is recoverable, no failure condition will be reported regardless of the number of retries required to recover the data.

The following conditions are considered DST failure conditions:

- Seek error after retries are exhausted
- Track-follow error after retries are exhausted
- Read error after retries are exhausted
- Write error after retries are exhausted

Recovered errors will not be reported as diagnostic failures.

5.2.6.2 Implementation

This section provides all of the information necessary to implement the DST function on this drive.

5.2.6.2.1 State of the drive prior to testing

The drive must be in a ready state before issuing the Send Diagnostic command. There are multiple reasons why a drive may not be ready, some of which are valid conditions, and not errors. For example, a drive may be in process of doing a format, or another DST. It is the responsibility of the host application to determine the "not ready" cause.

While not technically part of DST, a Not Ready condition also qualifies the drive to be returned to Seagate as a failed drive.

A Drive Not Ready condition is reported by the drive under the following conditions:

- Motor will not spin
- Motor will not lock to speed
- Servo will not lock on track
- Drive cannot read configuration tables from the disk

In these conditions, the drive responds to a Test Unit Ready command with an 02/04/00 or 02/04/03 code.

5.2.6.2.2 Invoking DST

To invoke DST, submit the Send Diagnostic command with the appropriate Function Code (001b for the short test or 010b for the extended test) in bytes 1, bits 5, 6, and 7.

5.2.6.2.3 Short and extended tests

DST has two testing options:

1. short
2. extended

These testing options are described in the following two subsections.

Each test consists of three segments: an electrical test segment, a servo test segment, and a read/verify scan segment.

Short test (Function Code: 001b)

The purpose of the short test is to provide a time-limited test that tests as much of the drive as possible within 120 seconds. The short test does not scan the entire media surface, but does some fundamental tests and scans portions of the media. A complete read/verify scan is not performed and only factual failures will report a fault condition. This option provides a quick confidence test of the drive.

Extended test (Function Code: 010b)

The objective of the extended test option is to empirically test critical drive components. For example, the seek tests and on-track operations test the positioning mechanism. The read operation tests the read head element and the media surface. The write element is tested through read/write/read operations. The integrity of the media is checked through a read/verify scan of the media. Motor functionality is tested by default as a part of these tests.

The anticipated length of the Extended test is reported through the Control Mode page.

5.2.6.2.4 Log page entries

When the drive begins DST, it creates a new entry in the Self-test Results Log page. The new entry is created by inserting a new self-test parameter block at the beginning of the self-test results log parameter section of the log page. Existing data will be moved to make room for the new parameter block. The drive reports 20 parameter blocks in the log page. If there are more than 20 parameter blocks, the least recent parameter block will be deleted. The new parameter block will be initialized as follows:

1. The Function Code field is set to the same value as sent in the DST command
2. The Self-Test Results Value field is set to Fh
3. The drive will store the log page to non-volatile memory

After a self-test is complete or has been aborted, the drive updates the Self-Test Results Value field in its Self-Test Results Log page in non-volatile memory. The host may use Log Sense to read the results from up to the last 20 self-tests performed by the drive. The self-test results value is a 4-bit field that reports the results of the test. If the field is set to zero, the drive passed with no errors detected by the DST. If the field is not set to zero, the test failed for the reason reported in the field.

The drive will report the failure condition and LBA (if applicable) in the Self-test Results Log parameter. The Sense key, ASC, ASCQ, and FRU are used to report the failure condition.

5.2.6.2.5 Abort

There are multiple ways to abort a diagnostic. Two examples are: using a SCSI Bus Reset or a Bus Device message to abort the diagnostic

To abort a DST executing in background mode, use the abort code in the DST Function Code field. This will cause a 01 (self-test aborted by the application client) code to appear in the self-test results values log. All other abort mechanisms will be reported as a 02 (self-test routine was interrupted by a reset condition).

5.2.7 Product warranty

See "Seagate® Technology Support Services" on page 7. for warranty contact information.

Shipping

When transporting or shipping a drive, use only a Seagate-approved container. Keep the original box. Seagate approved containers are easily identified by the Seagate Approved Package label. Shipping a drive in a non-approved container voids the drive warranty.

Seagate repair centers may refuse receipt of components improperly packaged or obviously damaged in transit. Contact an authorized Seagate distributor to purchase additional boxes. Seagate recommends shipping by an air-ride carrier experienced in handling computer equipment.

Storage

The maximum recommended storage period for the drive in a non-operational environment is 90 days. Drives should be stored in the original unopened Seagate shipping packaging when ever possible. Once the drive is removed from the Seagate original packaging the recommended maximum period between drive operation cycles is 30 days. During any storage period the drive non-operational temperature, humidity, wet bulb, atmospheric conditions, shock, vibration, magnetic and electrical field specifications should be followed.

Product repair and return information

Seagate customer service centers are the only facilities authorized to service Seagate drives. Seagate does not sanction any third-party repair facilities. Any unauthorized repair or tampering with the factory seal voids the warranty.