Seagate® IronWolf Pro™ SATA

Product Manual

512E Standard Models

ST24000NT002

ST20000NT001

ST16000NT001

ST12000NT001

206815300, Rev B
July 2025

Revision History

Version and Date	Description of Changes
Rev A, December 2023	Initial release of the document.
Rev B, July 2025	Revised model numbers.

Contents

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1. Introduction

This manual describes the functional, mechanical, and interface specifications for the Seagate® IronWolf Pro™ SATA drive model.

Table 1 - 512E Models

512E Models Standard
ST24000NT002
ST20000NT001
ST16000NT001
ST12000NT001

These drives provide the following key features:

- 7200 RPM spindle speed
- Fluid dynamic bearing motor
- 512MB data buffer
- Tri-stage actuator
- 512MB cache buffer
- Full-track multiple-sector transfer without local processor intervention
- High instantaneous (burst) data-transfer rates (up to 600MB per second)
- Native Command Queuing with command ordering to increase performance in demanding applications
- PowerChoice™ for selectable power savings
- Perpendicular recording technology provides the drives with increased areal density
- SeaTools™ diagnostic software performs a drive self-test that eliminates unnecessary drive returns
- State-of-the-art cache and on-the-fly error-correction algorithms.
- Support for SMART drive monitoring and reporting
- Supports latching SATA cables and connectors
- T13 Fast Format conversion (see Section 2.2.1 *LBA mode*)
- Top cover attached motor for excellent vibration tolerance
- Worldwide Name (WWN) capability uniquely identifies the drive

NOTE Seagate recommends validating the configuration with the selected HBA/RAID controller manufacturer to ensure use of full capacity is supported

2. Drive specifications

Unless otherwise noted, all specifications are measured under ambient conditions and nominal power. For convenience, the phrases *the drive* and *this drive* are used throughout this manual to indicate the Seagate IronWolf Pro SATA drive model.

2.1 Specification summary tables

The specifications listed in the following tables are for quick reference. For details on specification measurement or definition, see the appropriate section of this manual.

Table 2 - Drive specifications summary

Drive specification	ST24000NT002	ST20000NT001	ST16000NT001	ST12000NT001
Formatted (512 bytes/sector) *	24TB	20TB	16TB	12TB
Guaranteed sectors	(see Section 2.2 *Formatted capacity*)			
Heads	20	18	15 or 14	10
Disk	10	9	8 or 7	5
Bytes per logical sector	512			
Bytes per physical sector	4096			
Recording density, KBPI (Kb/in max)	2552			
Track density, KTPI (ktracks/in avg)	537			
Areal density, (Gb/in^2 avg)	1260			
Spindle speed (RPM)	7200			
Internal data transfer rate (Mb/s max)	2951			
Max sustained transfer rate OD (MB/s)	272			
Sustained transfer rate OD (MB/s)	259			
I/O data-transfer rate (MB/s max)	600			
ATA data-transfer modes supported	PIO modes 0–4 Multiword DMA modes 0–2 Ultra DMA modes 0–6			
Cache buffer	512MB			
Weight (max)	685g (1.51 lb)		670g (1.48 lb)	655g (1.44 lb)
Average latency	4.16ms			
Power-on to ready (sec) (typ/max)	25/30			
Standby to ready (sec) (typ/max)	25/30			
Startup current (typical) 12V (peak)	2.0A			
Voltage tolerance (including noise)	5V ± 5% 12V ± 10%			
Operating temperature	5°C to 65°C (Drive Reported Temperature)			
Non-Operating temperature	–40°C to 70°C (Ambient Temperature, see Section 2.6.1 *Temperature* and Section 2.13 *Product warranty*)			
Temperature gradient (°C per hour max)	20°C (operating) 20°C (non-operating)			

Table 2 - Drive specifications summary *(continued)*

Drive specification	ST24000NT002	ST20000NT001	ST16000NT001	ST12000NT001
Relative humidity **	5% to 95% (operating) 5% to 95% (non-operating)			
Relative humidity gradient	20% per hour max			
Altitude, operating	–304.8m to 3,048m (–1000 ft to 10,000 ft)			
Altitude, nonoperating (below mean sea level, max)	–304.8m to 12,192m (–1000 ft to 40,000 ft)			
Operational Shock (2 ms)	40 *g*			
Non-Operational Shock (2 ms)	200 *g*			
Linear Random Operating Vibration	5–500 Hz: 0.70 Grms			
Random Rotary Operating Vibration	20–1500Hz: 12.5 rads/s^2			
Linear Random Non-Operating Vibration	2–500 Hz: 2.27 Grms			
Drive acoustics, sound power (bels)				
Idle	2.8 (typical) 3.0 (max) During periods of drive idle, some offline activity may occur according to the SMART specification, which may increase acoustic and power to operational levels.			
Performance seek	3.2 (typical) 3.4 (max)			
Nonrecoverable read errors	1 sector per 10^{15} bits read			
Annualized Failure Rate (AFR) **	0.35% based on 8760 POH			
Maximum Rated Workload **	Maximum rate of <550TB/year Workloads exceeding the annualized rate may degrade the drive MTBF and impact product reliability. The Annualized Workload Rate is in units of TB per year, or TB per 8760 power on hours. Workload Rate = TB transferred * (8760 / recorded power on hours).			
Warranty	For warranty assistance, visit https://www.seagate.com/warranty. Enter the drive serial number and country of purchase. The system will display the warranty information for the drive.			
Load-unload cycles	600,000			
Supports Hotplug operation per Serial ATA Revision 3.3 specification	Yes			

* One GB equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting.

** See Section 2.9 *Reliability* for rated MTBF device operating condition requirements.

2.2 Formatted capacity

Table 3 - Formatted capacity

ST models	Formatted capacity *	Guaranteed sectors	Bytes per logical sector
ST24000NT002	24TB	46,875,541,504	512 (Default)
ST20000NT001	20TB	39,063,650,304	
ST16000NT001	16TB	31,251,759,104	
ST12000NT001	12TB	23,437,770,752	

* One GB equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting.

NOTE LBA Counts for drive capacities greater than 8TB are calculated based upon SFF-8447 standard publication.

2.2.1 LBA mode

When addressing these drives in LBA mode, all blocks (sectors) are consecutively numbered from 0 to n–1, where n is the number of guaranteed sectors as defined above.

See Section 4.3.1 *Identify Device command* (words 60-61 and 100-103) for additional information about 48-bit addressing support of drives with capacities over 137GB.

2.3 Recording and interface technology

Table 4 - Recording and interface technology

Interface	Serial ATA (SATA)
Recording method	Perpendicular
Recording density, KBPI (Kb/in max)	2552
Track density, KTPI (ktracks/in avg)	537
Areal density (Gb/in^2 avg)	1260
Spindle speed (RPM) (± 0.2%)	7200
Internal data transfer rate (Mb/s max)	2951
Sustained data transfer rate (MB/s max)	
24/20/16/12TB	285
I/O data-transfer rate (MB/s max)	600 (Ultra DMA mode 5)

2.4 Start/stop times

Power-on to Ready time is based on typical operating conditions, default full current spin-up profile, and clean shutdown prior to measurement. To ensure a clean shutdown, a Flush Cache, Standby, or Standby Immediate command must be completed before removal of interface power.

Table 5 - Start/stop times

Interface	Time
Power-on to Ready (sec) (typ/max)	25/30
Standby to Ready (sec) (typ/max)	25/30
Ready to Spindle Stop (sec) (max)	20

NOTE An unexpected power loss event and/or spin up at cold or hot temperature extremes may cause the drive to exceed the typical time to ready by 5 seconds. Extended time to ready is dependent on cache state and environmental conditions prior to the unexpected power loss and during the subsequent power on.

2.5 Power specifications

The drive receives DC power (+5V or +12V) through a native SATA power connector. Figure 3, *Attaching SATA cabling*, on page 21.

2.5.1 Power consumption

Power requirements for the drives are listed in Table 6, *DC power requirements (24/20/16/12TB models)*. Typical power measurements are based on an average of drives tested, under nominal conditions, using 5.0V and 12.0V input voltage at 35°C ambient temperature.

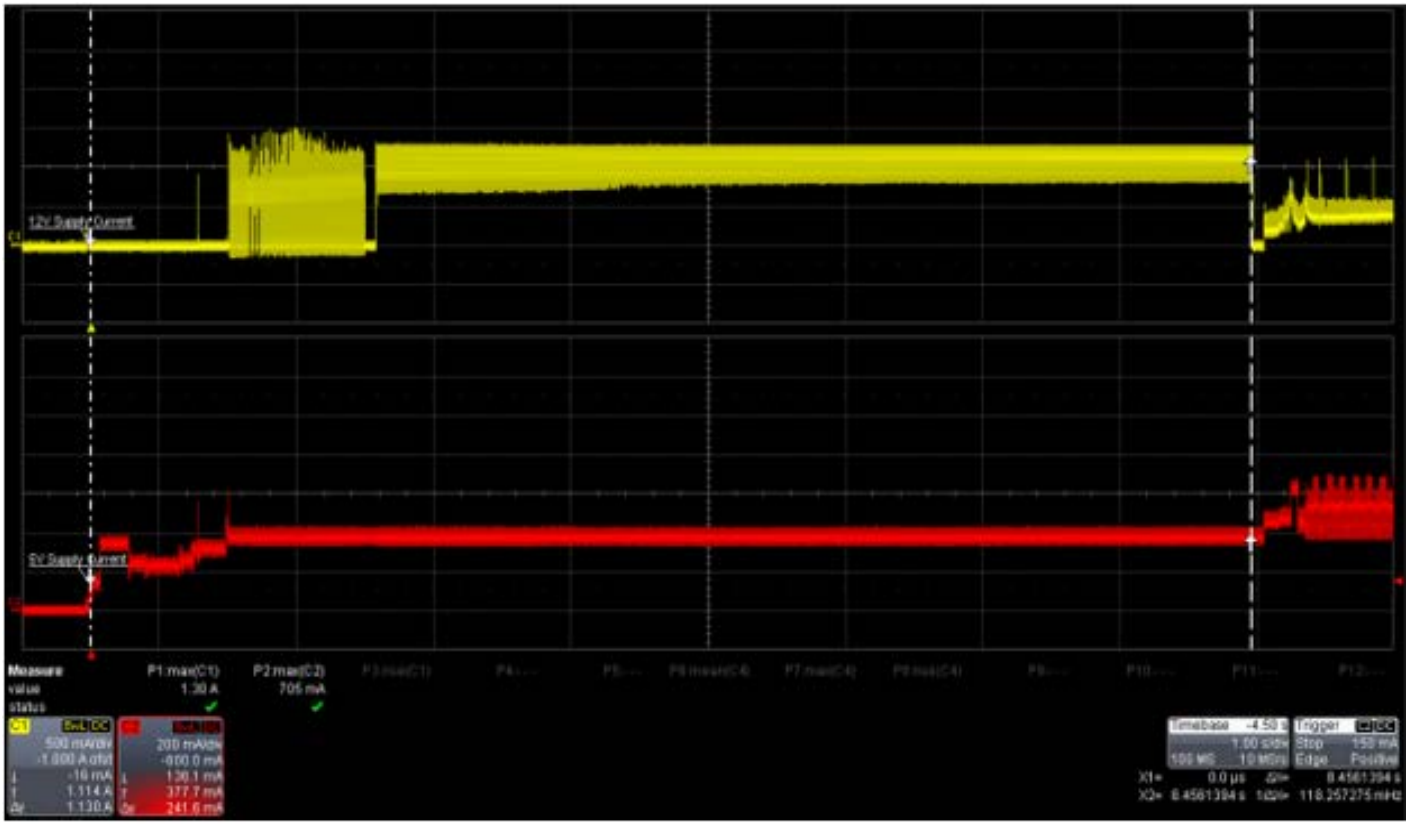
Table 6 - DC power requirements (24/20/16/12TB models)

Workload Mode		6.0Gb mode		
Voltage		+5V	+12V	Watts
Regulation		± 5%	± 10%	Total
Avg Idle Current *		0.328	0.378	6.19
Advanced Idle Current *				
	Idle_A	0.337	0.375	6.20
	Idle_B	0.260	0.227	4.03
	Idle_C	0.256	0.143	3.00
	Standby	0.206	0.01	1.16
Maximum Start Current				
	DC (peak DC)	0.868	1.69	
	AC (Peak DC)	1.06	1.96	
	Delayed motor start (max) DC	0.585	0.812	
Operating current (random read 4K16Q):				
	Typical DC	0.395	0.582	8.98
	Maximum DC	0.401	0.587	9.07
	Maximum DC (peak)	1.012	2.03	
Operating current (random write 4K16Q)				
	Typical DC	0.409	0.556	8.75
	Maximum DC	0.414	0.561	8.83
	Maximum DC (peak)	1.023	1.812	
Operating current (sequential read 64K16Q)				
	Typical DC	0.78	0.364	8.3
	Maximum DC	0.792	0.367	8.4
	Maximum DC (peak)	1.042	2.021	
Operating current (sequential write 64K16Q)				
	Typical DC	0.848	0.359	8.58
	Maximum DC	0.858	0.362	8.67
	Maximum DC (peak)	1.062	1.622	

NOTE During periods of drive idle, some offline activity may occur according to the SMART specification, which may increase acoustic and power to operational levels.

2.5.1.1 Typical current profiles

Figure 1. DC power requirements (24TB models)



2.5.2 Conducted noise

Noise is specified as a periodic and random distribution of frequencies covering a band from DC to 10 MHz. Maximum allowed noise values given below are peak-to-peak measurements and apply at the drive power connector.

+5v	=	250 mV pp from 100 Hz to 20 MHz
+12v	=	800 mV pp from 100 Hz to 8 KHz 450 mV pp from 8 KHz to 20 KHz 250 mV pp from 20 KHz to 5 MHz

2.5.3 Voltage tolerance

Voltage tolerance (including noise):

+5v	=	± 5%
+12v	=	± 10%

2.5.4 Extended Power Conditions - PowerChoice™

Utilizing the load/unload architecture a programmable power management interface is provided to tailor systems for reduced power consumption and performance requirements.

The table below lists the supported power conditions available in PowerChoice. Power conditions are ordered from highest power consumption (and shortest recovery time) to lowest power consumption (and longest recovery time) as follows: Idle_a power >= Idle_b power >= Idle_c power >= Standby_z power. Note in the table that lower power states result in greater energy savings. For example, Idle_b results in greater power savings than the Idle_a power condition. Standby results in the greatest power savings.

Table 7 - Extended power conditions - PowerChoice

Power Condition Name	Power Condition ID	Description
Idle_a	81H	Reduced electronics.
Idle_b	82H	Heads unloaded. Disks spinning at full RPM.
Idle_c	83H	Heads unloaded. Disks spinning at reduced RPM.
Standby_z	00H	Heads unloaded. Motor stopped (disks not spinning).

Each power condition has a set of current, saved and default settings. Default settings are not modifiable. Default and saved settings persist across power-on resets. The current settings do not persist across power-on resets. At the time of manufacture, the default, saved and current settings are in the Power Conditions log match.

PowerChoice is invoked using one of two methods:

- Automatic power transitions which are triggered by expiration of individual power condition timers. These timer values may be customized and enabled using the Extended Power Conditions (EPC) feature set using the standardized Set Features command interface.
- Immediate host commanded power transitions may be initiated using an EPC Set Features "Go to Power Condition" subcommand to enter any supported power condition. Legacy power commands Standby Immediate and Idle Immediate also provide a method to directly transition the drive into supported power conditions.

PowerChoice exits power saving states under the following conditions:

- Any command which requires the drive to enter the PM0: Active state (media access)
- Power-on reset

PowerChoice provides the following reporting methods for tracking purposes:

Check Power Mode Command

- Reports the current power state of the drive

Identify Device Command

- EPC Feature set supported flag
- EPC Feature enabled flag is set if at least one Idle power condition timer is enabled

Power Condition Log reports the following for each power condition:

- Nominal recovery time from the power condition to active
- If the power condition is Supported, Changeable, and Savable
- Default enabled state and timer value
- Saved enabled state and timer value
- Current enabled state and timer value

SMART Read Data Reports

- Attribute 192 - Emergency Retract Count
- Attribute 193 - Load/Unload Cycle Count

PowerChoice manufacturer default power condition timer values

Default power condition timer values have been established to assure product reliability and data integrity. A minimum timer value threshold of two minutes ensures the appropriate amount of background drive maintenance activities occur. Attempting to set a timer value less than the specified minimum timer value threshold will result in an aborted EPC "Set Power Condition Timer" subcommand.

Table 8 - PowerChoice default timer values

Power Condition Name	Default Timer Values
Idle_a	100 ms
Idle_b	2 min
Idle_c	10 min
Standby_z	15 min

Setting power condition timer values less than the manufacturer specified defaults or issuing the EPC "Go to Power Condition" subcommand at a rate exceeding the default timers may limit this products reliability and data integrity.

PowerChoice supported extended power condition feature subcommands

Table 9 - PowerChoice supported extended condition feature subcommands

EPC Subcommand	Description
00H	Restore Power Condition Settings
01H	Go to Power Condition
02H	Set Power Condition Timer
03H	Set Power Condition State
04H	Enable EPC Feature Set
05H	Disable EPC Feature Set

PowerChoice supported extended power condition identifiers

Table 10 - PowerChoice supported extended power condition identifiers

Power Condition Identifiers	Power Condition Name
00H	Standby_z
01 - 80H	Reserved
81H	Idle_a
82H	Idle_b
83H	Idle_c
84 - FEH	Reserved
FFH	All EPC Power Conditions

2.6 Environmental limits

Temperature and humidity values experienced by the drive must be such that condensation does not occur on any drive part. Altitude and atmospheric pressure specifications are referenced to a standard day at 58.7°F (14.8°C).

NOTE To maintain optimal performance, drives should be run at nominal drive temperatures and humidity. See Section 2.9 *Reliability* for rated MTBF device operating condition requirements.

2.6.1 Temperature

Table 11 - Temperature ranges (operating/non-operating)

Operating	41°F to 149°F (5°C to 65°C) temperature range with a maximum temperature gradient of 36°F (20°C) per hour as reported by the drive. The maximum allowable drive reported temperature is 140°F (60°C). Airflow may be required to achieve consistent nominal drive temperature values (see Section 3.3 *Drive mounting*). To confirm that the required cooling is provided for the electronics and HDA, place the drive in its final mechanical configuration, and perform random write/read operations. After the temperatures stabilize, monitor the current drive temperature using the SMART temperature attribute 194 or Device Statistics log 04h page 5.
Non-operating	–40°F to 158°F (–40°C to 70°C) package ambient with a maximum gradient of 36°F (20°C) per hour. This specification assumes that the drive is packaged in the shipping container designed by Seagate for use with drive.

2.6.2 Humidity

The values below assume that no condensation on the drive occurs. Maximum wet bulb temperature is 84.2°F (29°C).

Table 12 - Relative humidity (operating/non-operating)

Operating	5% to 95% non-condensing relative humidity with a maximum gradient of 20% per hour.
Non-operating	5% to 95% non-condensing relative humidity with a maximum gradient of 20% per hour.

2.6.3 Effective Altitude

Table 13 - Effective altitude (sea level)

Operating	–304.8m to 3048m (–1000 ft to 10,000 ft)
Non-operating	–304.8m to 12,192m (–1000 ft to 40,000 ft)

2.6.4 Shock and Vibration

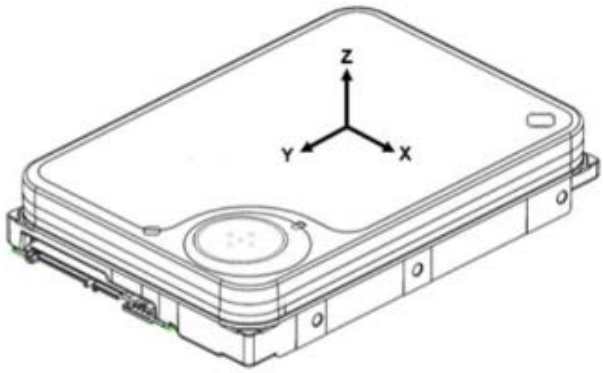
Shock and vibration measurements specified in this document are made directly on the drive itself and applied in the X, Y, and Z axis at the drive mounting point locations.

2.6.4.1 Shock

Table 14 - Shock

Operating	The drive will operate without error while subjected to intermittent shock pulses not exceeding 40 *g* typical at a 2ms duration limited by Z-axis, shown in Figure 2, *Drive orientation*.
Non-operating	The drive will operate without non-recoverable errors after being subjected to shock pulses not exceeding 200 *g* at a duration of 2ms.

Figure 2 Drive orientation



2.6.4.2 Vibration

Linear random operating vibration

The drive will operate without non-recoverable errors while being subjected to the random power spectral density noise specified below.

Table 15 - Linear random operating vibration

PSD OF 5-500 Hz random noise at 0.70 Grms					
Frequency (Hz)	5	20	200	250	500
G^2/Hz	0.00025	0.00210	0.00210	0.00020	0.00020

Random rotary operating vibration

The drive will exhibit greater than 90% throughput for sequential and random write operations while subjected to the shaped random power spectral density noise specified below.

Table 16 - Random rotary operating vibration

PSD OF 20-1500 Hz at 12.5 rad/sec^2				
Frequency (Hz)	20	200	800	1500
(rad/sec^2)^2/Hz	5.53E-02	5.53E-02	3.49E-01	6.14E-04

Linear random non-operating vibration

The drive will not incur physical damage or have non-recoverable errors after being subjected to the power spectral density noise specified below.

Table 17 - Linear random non-operating vibration

PSD Profile 2-500 Hz at 2.27 Grms				
Frequency (Hz)	2	4	100	500
G^2/Hz	0.001	0.030	0.030	0.001

2.7 Acoustics

Drive acoustics are measured as overall A-weighted acoustic sound power levels (no pure tones). All measurements are consistent with ISO document 7779. Sound power measurements are taken under essentially free-field conditions over a reflecting plane. For all tests, the drive is oriented with the cover facing upward.

NOTE For seek mode tests, the drive is placed in seek mode only. The number of seeks per second is defined by the following equation:

(Number of seeks per second = 0.4 / (average latency + average access time))

Table 18 - Fluid Dynamic Bearing (FDB) motor acoustics

	Idle*	Performance seek
All models	2.8 bels (typ) 3.0 bels (max)	3.2 bels (typ) 3.4 bels (max)

* During periods of drive idle, some offline activity may occur according to the SMART specification, which may increase acoustic and power to operational levels.

2.7.1 Test for Prominent Discrete Tones (PDTs)

Seagate follows the ECMA-74 standards for measurement and identification of PDTs. An exception to this process is the use of the absolute threshold of hearing. Seagate uses this threshold curve (originated in ISO 389-7) to discern tone audibility and to compensate for the inaudible components of sound prior to computation of tone ratios according to Annex D of the ECMA-74 standards.

2.8 Electromagnetic immunity

When properly installed in a representative host system, the drive operates without errors or degradation in performance when subjected to the radio frequency (RF) environments defined in the following table:

Table 19 - Radio frequency environments

Test	Description	Performance level	Reference standard
Electrostatic discharge	Contact, HCP, VCP: ± 4 kV; Air: ± 8 kV	B	EN 61000-4-2: 95
Radiated RF immunity	80 to 1000 MHz, 3 V/m, 80% AM with 1 kHz sine 900 MHz, 3 V/m, 50% pulse modulation @ 200 Hz	A	EN 61000-4-3: 96 ENV 50204: 95
Electrical fast transient	± 1 kV on AC mains, ± 0.5 kV on external I/O	B	EN 61000-4-4: 95
Surge immunity	± 1 kV differential, ± 2 kV common, AC mains	B	EN 61000-4-5: 95
Conducted RF immunity	150 kHz to 80 MHz, 3 Vrms, 80% AM with 1 kHz sine	A	EN 61000-4-6: 97
Voltage dips, interrupts	0% open, 5 seconds 0% short, 5 seconds 40%, 0.10 seconds 70%, 0.01 seconds	C C C B	EN 61000-4-11: 94

2.9 Reliability

2.9.1 Annualized Failure Rate (AFR) and Mean Time Between Failures (MTBF)

The production disk drive will achieve an annualized failure-rate of 0.35% (MTBF of 2,500,000 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 >= 10°C and <= 30°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.

Non-recoverable read errors	1 per 10^{15} bits read, max
Load unload cycles	600,000 cycles

Maximum Rated Workload	Maximum rate of <550TB/year Workloads exceeding the annualized rate may degrade the drive MTBF and impact product reliability. The Annualized Workload Rate is in units of TB per year, or TB per 8760 power on hours. Workload Rate = TB transferred * (8760 / recorded power on hours).
Warranty	For warranty assistance, visit https://www.seagate.com/warranty. Enter the drive serial number and country of purchase. The system will display the warranty information for the drive.
Preventive maintenance	None required

2.10 HDD and SSD Regulatory Compliance and Safety

For the latest regulatory and compliance information, go to www.seagate.com/support. Scroll down the page and select the Compliance, Safety and Disposal Guide link.

2.10.1 Regulatory Models

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

Regulatory Model Numbers: STL027

2.11 Corrosive environment

Electronic drive components pass accelerated corrosion testing equivalent to 10 years exposure to light industrial environments containing sulfurous gases, chlorine, and nitric oxide, classes G and H per ASTM B845. However, this accelerated testing cannot duplicate every potential application environment.

Users should use caution exposing any electronic components to uncontrolled chemical pollutants and corrosive chemicals as electronic drive component reliability can be affected by the installation environment. The silver, copper, nickel, and gold films used in hard disk drives are especially sensitive to the presence of sulfide, chloride, and nitrate contaminants. Sulfur is found to be the most damaging. Materials used in cabinet fabrication, such as vulcanized rubber that can outgas corrosive compounds, should be minimized or eliminated. The useful life of any electronic equipment may be extended by replacing materials near circuitry with sulfide-free alternatives.

Seagate recommends that data centers be kept clean by monitoring and controlling the dust and gaseous contamination. Gaseous contamination should be within ANSI/ISA S71.04-2013 G2 classification levels (as measured on copper and silver coupons), and dust contamination to ISO 14644-1 Class 8 standards, and MTBF rated conditions as defined in the Annualized Failure Rate (AFR) and Mean Time Between Failure (MTBF) section.

2.12 Reference documents

Supported Standards

Serial ATA Revision 3.3 specification

ANSI Documents

ISO/IEC 17760-105 ATA Command Set - 5 (ACS-5)

Specification for Acoustic Test Requirement and Procedures

Seagate part number: 30553-001

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

2.13 Product warranty

Beginning on the date of shipment to the customer and continuing for the period specified in the purchase contract, Seagate warrants that each product (including components and subassemblies) that fails to function properly under normal use due to defect in materials or workmanship or due to nonconformance to the applicable specifications will be repaired or replaced, at Seagate's option and at no charge to the customer, if returned by customer at customer's expense to Seagate's designated facility in accordance with Seagate's warranty procedure. Seagate will pay for transporting the repair or replacement item to the customer. For more detailed warranty information, refer to the standard terms and conditions of purchase for Seagate products on the purchase documentation.

For warranty assistance, visit https://www.seagate.com/warranty. Enter the drive serial number and country of purchase. The system will display the warranty information for the drive.

2.13.1 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 the authorized Seagate distributor to purchase additional boxes. Seagate recommends shipping by an air-ride carrier experienced in handling computer equipment.

2.13.2 Storage

Maximum storage periods are 180 days within original unopened Seagate shipping package or 60 days unpackaged within the defined non-operating limits (refer to environmental section in this manual). Storage can be extended to one year packaged or unpackaged under optimal environmental conditions (25°C, <40% relative humidity non-condensing, and non-corrosive environment). During any storage period the drive non-operational temperature, humidity, wet bulb, atmospheric conditions, shock, vibration, magnetic, and electrical field specifications should be followed.

2.13.3 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.

2.13.4 Immersion Cooling Environments

Seagate hard disk drive (HDD) is designed to operate within specified environmental conditions to ensure optimal performance and reliability. While the product has been rigorously tested and validated under various scenarios, it is essential to note that immersion cooling environments are not currently supported for the Seagate IronWolf Pro SATA series.

3. Configuring and mounting the drive

This section contains the specifications and instructions for configuring and mounting the drive.

3.1 Handling and static-discharge precautions

After unpacking, and before installation, the drive may be exposed to potential handling and electrostatic discharge (ESD) hazards. Observe the following standard handling and static-discharge precautions:

Caution	• Before handling the drive, put on a grounded wrist strap. Wear a grounded wrist strap throughout the entire installation procedure. • Handle the drive by its edges or frame only. • The drive is extremely fragile—handle it with care. Do not press down on the top cover. • Always rest the drive on a padded, antistatic surface until mounting it in the computer. • Do not touch the connector pins or the printed circuit board. • Do not remove the factory-installed labels from the drive or cover them with additional labels. Removal voids the warranty. Some factory-installed labels contain information needed to service the drive. Other labels are used to seal out dirt and contamination.

3.2 Serial ATA cables and connectors

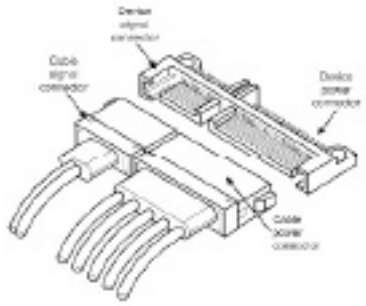
The Serial ATA interface cable consists of four conductors in two differential pairs, plus three ground connections. The cable size may be 30 to 26 AWG with a maximum length of one meter (39.37 in).

See Table 21, *Serial ATA connector pin definitions* for connector pin definitions. Either end of the SATA signal cable can be attached to the drive or host.

For direct backplane connection, the drive connectors are inserted directly into the host receptacle. The drive and the host receptacle incorporate features that enable the direct connection to be hot pluggable and blind mateable.

For installations which require cables, users can connect the drive as illustrated in Figure 3, *Attaching SATA cabling*.

Figure 3 Attaching SATA cabling



Each cable is keyed to ensure correct orientation. Seagate IronWolf Pro SATA drives support latching SATA connectors.

3.3 Drive mounting

Users can mount the drive in any orientation using four screws in the side-mounting holes or four screws in the bottom-mounting holes. See Figure 4, *Mounting configuration dimensions*, on page 22 for drive mounting dimensions. Follow these important mounting precautions when mounting the drive:

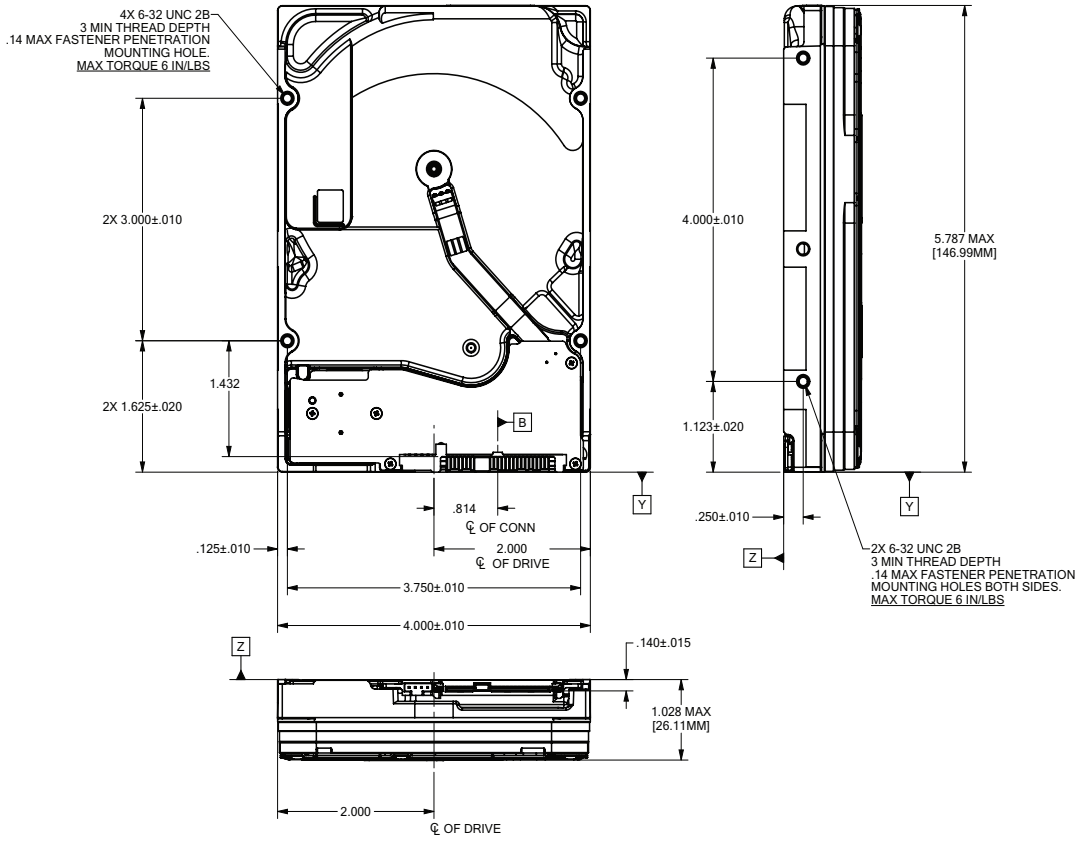
- Allow a minimum clearance of 0.030 in (0.76mm) around the entire perimeter of the drive for cooling.
- Use only 6-32 UNC mounting screws.
- The screws should be inserted no more than 0.140 in (3.56mm) into the bottom or side mounting holes.
- Do not overtighten the mounting screws (maximum torque: 6 in-lb).

3.3.1 Mechanical specifications

Refer to Figure 4, *Mounting configuration dimensions* for detailed mounting configuration dimensions.

NOTE These dimensions conform to the Small Form Factor Standard documented in SFF-8301 and SFF-8323, found at www.snia.org/technology-communities/sff/specifications.

Figure 4 Mounting configuration dimensions



NOTE The image is for mechanical dimension reference only and may not represent the actual drive.

Table 20 - Weight

Capacity	Weight (lb/g)
24TB	1.51/685
20TB	
16TB	1.48/670
12TB	1.44/655

4. Serial ATA (SATA) interface

These drives use the industry-standard Serial ATA interface that supports FIS data transfers. It supports ATA programmed input/output (PIO) modes 0–4; multiword DMA modes 0–2, and Ultra DMA modes 0–6.

For detailed information about the Serial ATA interface, refer to the "Serial ATA: High Speed Serialized AT Attachment" specification.

4.1 Hot-Plug compatibility

Seagate IronWolf Pro SATA drives incorporate connectors which enable users to hot plug these drives in accordance with the Serial ATA Revision 3.3 specification. This specification can be downloaded from www.serialata.org.

Caution	The drive motor must come to a complete stop (Ready to Spindle Stop time indicated in Section 2.4 *Start/stop times*) prior to changing the plane of operation. This time is required to ensure data integrity.

4.2 Serial ATA device plug connector pin definitions

Table 21, *Serial ATA connector pin definitions* summarizes the signals on the Serial ATA interface and power connectors.

Table 21 - Serial ATA connector pin definitions

Segment	Pin	Function	Definition
Signal	S1	Ground	2nd mate
	S2	A+	Differential signal pair A from Phy
	S3	A-	
	S4	Ground	2nd mate
	S5	B-	Differential signal pair B from Phy
	S6	B+	
	S7	Ground	2nd mate
Key and spacing separate signal and power segments			

Table 21 - Serial ATA connector pin definitions *(continued)*

Segment	Pin	Function	Definition
Power	P1	V33	Not Used (P1 and P2 tied internally)
	P2	V33	Not Used (P1 and P2 tied internally)
	P3	PWRDIS	Enter/Exit Power Disable (option)
	P4	Ground	1st mate
	P5	Ground	2nd mate
	P6	Ground	2nd mate
	P7	V5	5V power, pre-charge, 2nd mate
	P8	V5	5V power
	P9	V5	5V power
	P10	Ground	2nd mate
	P11	Ground or LED signal	If grounded, drive does not use deferred spin
	P12	Ground	1st mate
	P13	V12	12V power, pre-charge, 2nd mate
	P14	V12	12V power
	P15	V12	12V power

Notes:

1. All pins are in a single row, with a 1.27mm (0.050”) pitch.
2. The comments on the mating sequence apply to the case of backplane blindmate connector only. In this case, the mating sequences are:
   - the ground pins P4 and P12.
   - the pre-charge power pins and the other ground pins.
   - the signal pins and the rest of the power pins.
3. There are three power pins for each voltage. One pin from each voltage is used for pre-charge when installed in a blind-mate backplane configuration.
4. All used voltage pins (V_x) must be terminated.

4.3 Supported ATA commands

The following table lists Serial ATA standard commands that the drive supports. For a detailed description of the ATA commands, refer to the Serial ATA: High Speed Serialized AT Attachment specification. See Section 4.3.5 *SMART commands* for details and subcommands used in the SMART implementation.

Table 22 - Supported ATA commands

Command name		Command code (in hex)
Accessible Max Address Configuration		
	Get Native Max Address Ext	78H / 0000H
	Set Accessible Max Address Ext	78H / 0001H
	Freeze Accessible Max Address Ext	78H / 0002H
Check Power Mode		E5H
Configure Stream		51H

Table 22 - Supported ATA commands

Command name	Command code (in hex)
Download Microcode	92H
Execute Device Diagnostics	90H
Flush Cache	E7H
Flush Cache Extended	EAH
Get Physical Element Status	12H
Identify Device	ECH
Idle	E3H
Idle Immediate	E1H
Read Buffer	E4H
Read DMA	C8H
Read DMA Extended	25H
Read FPDMA Queued	60H
Read Log DMA Ext	47H
Read Log Ext	2FH
Read Multiple	C4H
Read Multiple Extended	29H
Read Sectors	20H
Read Sectors Extended	24H
Read Stream DMA Ext	2AH
Read Verify Sectors	40H
Read Verify Sectors Extended	42H
Receive FPDMA Queued	65H
Request Sense Data Ext	0BH
Remove Element And Truncate	7CH
Restore Elements And Rebuild	7DH
Sanitize Device - Crypto Scramble	B4H / 0011H (SED and ISE drives only)
Sanitize Device - Overwrite Ext	B4H / 0014H
Sanitize Device - Freeze Lock Ext	B4H / 0020H
Sanitize Device - Status Ext	B4H / 0000H
Security Disable Password	F6H
Security Erase Prepare	F3H
Security Erase Unit	F4H
Security Freeze	F5H
Security Set Password	F1H
Security Unlock	F2H
Seek	70H
Send FPDMA Queued	64H
Set Date & Time Ext	77H
Set Features	EFH
Set Multiple Mode	C6H

Table 22 - Supported ATA commands

Command name	Command code (in hex)
Set Sector Configuration Ext	B2H
Sleep	E6H
SMART Disable Operations	B0H / D9H
SMART Enable/Disable Autosave	B0H / D2H
SMART Enable Operations	B0H / D8H
SMART Execute Offline	B0H / D4H
SMART Read Attribute Thresholds	B0H / D1H
SMART Read Data	B0H / D0H
SMART Read Log Sector	B0H / D5H
SMART Return Status	B0H / DAH
SMART Save Attribute Values	B0H / D3H
SMART Write Log Sector	B0H / D6H
Standby	E2H
Standby Immediate	E0H
Trusted Send	5EH (SED drives only)
Trusted Send DMA	5FH (SED drives only)
Trusted Receive	5CH (SED drives only)
Trusted Receive DMA	5DH (SED drives only)
Write Buffer	E8H
Write DMA	CAH
Write DMA Extended	35H
Write DMA FUA Extended	3DH
Write FPDMA Queued	61H
Write Log DMA Ext	57H
Write Log Extended	3FH
Write Multiple	C5H
Write Multiple Extended	39H
Write Multiple FUA Extended	CEH
Write Sectors	30H
Write Sectors Extended	34H
Write Stream DMA Ext	3AH
Write Uncorrectable Extended	45H

4.3.1 Identify Device command

The Identify Device command (command code ECH) transfers information about the drive to the host following power up. The data is organized as a single 512-byte block of data, whose contents are shown in Table 2, *Drive specifications summary*. All reserved bits or words should be set to zero. Parameters listed with an "x" are drive-specific or vary with the state of the drive. See Section 2. *Drive specifications* for default parameter settings.

The following commands contain drive-specific features that may not be included in the Serial ATA specification.

Table 23 - Identify Device command

Word	Description	Value
0	Configuration information: • Bit 15: 0 = ATA; 1 = ATAPI • Bit 7: removable media • Bit 6: removable controller • Bit 0: reserved	0C5AH
1	Obsolete	16,383
2	ATA-reserved	C837H
3	Obsolete	16
4	Retired	0000H
5	Retired	0000H
6	Obsolete	003FH
7–9	Retired	0000H
10–19	Serial number: (20 ASCII characters, 0000H = none)	ASCII
20-21	Retired	0000H
22	Obsolete	0000H
23–26	Firmware revision (8 ASCII character string, padded with blanks to end of string)	x.xx
27–46	Drive model number: (40 ASCII characters, padded with blanks to end of string)	ST24000NT002 ST20000NT001 ST16000NT001 ST12000NT001
47	(Bits 7–0) Maximum sectors per interrupt on Read multiple and Write multiple (16)	8010H (512e) / 8002H (4KN)
48	Trusted computing feature set supported bit 0 (SED only)	4000H
49	Standard Standby timer, IORDY supported and may be disabled	2F00H
50	Capabilities	4000H
51-52	Obsolete	xxxxH
53	Misc	0007H
54–58	Obsolete	xxxxH
59	(Bit 15: 0) Block Erase Ext Not Supported - N (Bit 14: 1) Overwrite Ext Supported - Y (Bit 13: X) Crypto Scramble Ext Supported (SED Only) - N (Bit 12: 1) Sanitize feature set supported - Y (Bit 11: 1) Commands allowed during sanitize op as specified in ACS-3 - Y (Bit 10: 1) Sanitize Antifreeze Lock Ext command supported - Y	5D10H (512E) / 5D02H (4KN)
60–61	Total number of user-addressable LBA sectors available (see Section 2.2 *Formatted capacity* for related information) *Note: The maximum value allowed in this field is: 0FFFFFFFh (268,435,455 sectors, 137GB). Drives with capacities over 137GB will have 0FFFFFFFh in this field and the actual number of user-addressable LBAs specified in words 100-103. This is required for drives that support the 48-bit addressing feature.	0FFFFFFFh*
62	Obsolete	0000H
63	Multiword DMA active and modes supported (see note following this table)	xx07H
64	Advanced PIO modes supported (modes 3 and 4 supported)	0003H

Table 23 - Identify Device command

Word	Description	Value
65	Minimum multiword DMA transfer cycle time per word (120 ns)	0078H
66	Recommended multiword DMA transfer cycle time per word (120 ns)	0078H
67	Minimum PIO cycle time without IORDY flow control (240 ns)	0078H
68	Minimum PIO cycle time with IORDY flow control (120 ns)	0078H
69	Additional supported	0008H
70–74	ATA-reserved	0000H
75	Queue depth	001FH
76	Serial ATA capabilities	8D0EH
77	(Bit 6:1) Send/Receive FPDMA Queued Commands Supported	0046H
78	Serial ATA features supported	xxCCH
79	Serial ATA features enabled	0040H
80	Major version number	1FE0H (ACS-5)
81	Minor version number	FFFFH
82	Command sets supported	306BH
83	Command sets supported	7561H
84	Command sets support extension (see note following this table)	6173H
85	Command sets enabled	3069H
86	Command sets enabled	B441H
87	Command sets enable extension	6173H
88	Ultra DMA support and current mode (see note following this table)	007FH
89	Security erase time	xxxxH
90	Enhanced security erase time	xxxxH
92	Master password revision code	FFFEH
93	Hardware reset value	xxxxH
95–99	ATA-reserved	0000H
100–103	Total number of user-addressable LBA sectors available. These words are required for drives that support the 48-bit addressing feature. Maximum value: 0000FFFFFFFFFFFFh.	(see Section 2.2 *Formatted capacity*)
104	Streaming Transfer Time	0000H
106	Physical/Logical sector size	6003H (512E) / 5000H (4KN)
107	ATA-reserved	0000H
108–111	The mandatory value of the world wide name (WWN) for the drive. NOTE: This field is valid if word 84, bit 8 is set to 1 indicating 64-bit WWN support.	Each drive will have a unique value.
112–118	ATA-reserved	0000H
119	Commands and feature sets supported	43DEH
120	Commands and feature sets supported or enabled	409CH
121-127	ATA-reserved	0000H
128	Security status	0021H
129–159	Seagate-reserved	xxxxH
160–167	ATA-reserved, CF Assoc	0000H
168	Device Nominal Form Factor	3.5“

Table 23 - Identify Device command

Word	Description	Value
169–205	ATA-reserved	0000H
206	SCT Command Transport command set. If bit 0 is set to one, then the device supports SCT Command Transport. Bits 7:2 indicate individual SCT feature support.	xxBDH
207-208	ATA-reserved	0000H
209	Alignment of Logical Blocks in Physical Block	4000
210-211	Write-Read-Verify Mode 3 Count	0000
212-213	Write-Read-Verify Mode 2 Count	0000
214-216	Obsolete	
217	Nominal media rotation rate	7200
218-219	ATA-reserved	0000H
222	Transport Major Version	11FFH (SATA 3.3)
223	Transport Minor Version	0000H
224-229	ATA-reserved	0000H
230-233	Extended Number of User Accessible Sectors	(see Section 2.2 *Formatted capacity*)
234-254	ATA-reserved	0000H
255	Integrity word	xxA5H

NOTE See the bit descriptions below for words 63, 84, and 88 of the Identify Drive data.

Table 24 - Bit descriptions for words 63, 84, and 88 of the Identify Drive data

Description (if bit is set to 1)	
Bit	Word 63
0	Multiword DMA mode 0 is supported.
1	Multiword DMA mode 1 is supported.
2	Multiword DMA mode 2 is supported.
8	Multiword DMA mode 0 is currently active.
9	Multiword DMA mode 1 is currently active.
10	Multiword DMA mode 2 is currently active.
Bit	Word 84
0	SMART error logging is supported.
1	SMART self-test is supported.
2	Media serial number is not supported.
3	Media Card Pass Through Command feature set is not supported.
4	Streaming feature set is supported.
5	GPL feature set is supported.
6	WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands are supported.
7	WRITE DMA QUEUED FUA EXT command is not supported.
8	64-bit World Wide Name is supported.
9-10	Obsolete.
11-12	Reserved for TLC.

Table 24 - Bit descriptions for words 63, 84, and 88 of the Identify Drive data *(continued)*

Description (if bit is set to 1)	
13	IDLE IMMEDIATE command with IUNLOAD feature is supported.
14	Shall be set to 1.
15	Shall be cleared to 0.
Bit	Word 88
0	Ultra DMA mode 0 is supported.
1	Ultra DMA mode 1 is supported.
2	Ultra DMA mode 2 is supported.
3	Ultra DMA mode 3 is supported.
4	Ultra DMA mode 4 is supported.
5	Ultra DMA mode 5 is supported.
6	Ultra DMA mode 6 is supported.
8	Ultra DMA mode 0 is currently active.
9	Ultra DMA mode 1 is currently active.
10	Ultra DMA mode 2 is currently active.
11	Ultra DMA mode 3 is currently active.
12	Ultra DMA mode 4 is currently active.
13	Ultra DMA mode 5 is currently active.
14	Ultra DMA mode 6 is currently active.

4.3.2 Identify Device Data log

The Identify Device Data log (log 30H) transfers information about the drive. The data is organized as a set of 512-byte blocks of data, whose contents are shown in Table 25, *Identify Device Data log*. All reserved bits or words should be set to zero. Parameters listed with an "x" are drive-specific or vary with the state of the drive.

The following may contain drive-specific features that may are included in the Serial ATA specification:

Table 25 - Identify Device Data log

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
00	List of supported pages			
	0..7	63:24	Reserved	
		23:16	Page number	00
		15:0	Revision number	0001
	8		Number of entries in the following list	09
	9		Page number of the 1st supported ID data log page	00
	10		Page number of the 2nd supported ID data log page	01
	11		Page number of the next supported ID data log page	02
	12		Page number of the next supported ID data log page	03
	13		Page number of the next supported ID data log page	04
	14		Page number of the next supported ID data log page	05

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	15		Page number of the next supported ID data log page	06
	16		Page number of the next supported ID data log page	00
	17		Page number of the last supported ID data log page	08
	18..511		Reserved	
01	Copy of IDENTIFY DEVICE data			
	0..511		Copy of IDENTIFY DEVICE command data	
02	Capacity			
	0..7	Capacity page information header (QWord)		
		63	Shall be set to 1	1
		62:24	Reserved	
		23:16	Page number	02
		15:0	Revision number	0001
	8..15	Device Capacity (QWord)		
		63	Shall be set to 1	1
		62:48	Reserved	0
		47:0	Accessible capacity	(see Section 2.2 *Formatted capacity*)
	16..23	Physical/Logical Sector Size (QWord)		
		63	Contents of the QWord are valid	1
		62	LOGICAL TO PHYSICAL SECTOR RELATIONSHIP SUPPORTED bit	1 (512E) / 0 (4KN)
		61	LOGICAL SECTOR SIZE SUPPORTED bit	1 (4KN) / 0 (512E)
		60:22	Reserved	0
		19:16	Logical to physical sector relationship	0 (4KN) / 3 (512E)
		15:0	Logical sector offset	4000H
	24..31	Logical Sector Size (QWord)		
		63	Contents of the QWord are valid	1
		62:32	Reserved	0
		31:0	Logical Sector Size	4096b (4KN)
	32..39	Nominal Buffer Size (QWord)		
		63	Contents of the QWord are valid	1
		62:0	Buffer size	512
	40..511		Reserved	0
03	Supported Capabilities			

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	0..7	Supported Capabilities page information header (QWord)		
		63	Shall be set to one	1
		62:24	Reserved	
		23:16	Page number	03
	8..15	Supported Capabilities (QWord)		
		63	Shall be set to one	1
		62:55	Reserved	0
		54	ADVANCED BACKGROUND OPERATION SUPPORTED bit	0
		53	PERSISTENT SENSE DATA REPORTING bit	0
		52	SFF-8447 REPORTING bit	1
		51	DEFINITIVE ENDING PATTERN SUPPORTED bit	1
		50	DATA SET MANAGEMENT XL SUPPORTED bit	0
		49	SET SECTOR CONFIGURATION SUPPORTED bit	1
		48	ZERO EXT SUPPORTED bit	0
		47	SUCCESSFUL NCQ COMMAND SENSE DATA SUPPORTED bit	1
		46	DLC SUPPORTED bit	0
		45	REQUEST SENSE DEVICE FAULT SUPPORTED bit	1
		44	DSN SUPPORTED bit	1
		43	LOW POWER STANDBY SUPPORTED bit	0
		42	SET EPC POWER SOURCE SUPPORTED bit	0
		41	AMAX ADDR SUPPORTED bit	1
		40	Reserved for CFA	0
		39	DRAT SUPPORTED bit	0
		38	LPS MISALIGNMENT REPORTING SUPPORTED bit	0
		37	Reserved	0
		36	READ BUFFER DMA SUPPORTED bit	0
		35	WRITE BUFFER DMA SUPPORTED bit	0
		34	Reserved	0
		33	DOWNLOAD MICROCODE DMA SUPPORTED bit	0
		32	28-BIT SUPPORTED bit	0

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
		31	RZAT SUPPORTED bit	0
		30	Reserved	0
		29	NOP SUPPORTED bit	0
		28	READ BUFFER SUPPORTED bit	1
		27	WRITE BUFFER SUPPORTED bit	1
		26	Reserved	0
		25	READ LOOK-AHEAD SUPPORTED bit	1
		24	VOLATILE WRITE CACHE SUPPORTED bit	1
		23	SMART bit	1
		22	FLUSH CACHE EXT SUPPORTED bit	1
		21	Reserved	0
		20	48-BIT SUPPORTED bit	1
		19	Reserved	0
		18	SPIN-UP SUPPORTED bit	1
		17	PUIS SUPPORTED bit	1
		16	APM SUPPORTED bit	1
		15	Reserved for CFA	0
		14	DOWNLOAD MICROCODE SUPPORTED bit	1
		13	UNLOAD SUPPORTED bit	1
		12	WRITE FUA EXT SUPPORTED bit	1
		11	GPL SUPPORTED bit	1
		10	STREAMING SUPPORTED bit	1
		9	Reserved	0
		8	SMART SELF-TEST SUPPORTED bit	1
		7	SMART ERROR LOGGING SUPPORTED bit	1
		6	EPC SUPPORTED bit	1
		5	SENSE DATA SUPPORTED bit	1
		4	FREE-FALL SUPPORTED bit	0
		3	DM MODE 3 SUPPORTED bit	1
		2	GPL DMA SUPPORTED bit	1
		1	WRITE UNCORRECTABLE SUPPORTED bit	1
		0	WRV SUPPORTED bit	1

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	16..23	DOWNLOAD MICROCODE Capabilities (QWord)		
		63	Contents of the QWord are valid	1
		62:36	Reserved	0
		35	DM CLEARS NONACTIVATED DEFERRED DATA bit	0
		34	DM OFFSETS DEFERRED SUPPORTED bit	1
		33	DM IMMEDIATE SUPPORTED bit	1
		32	DM OFFSETS IMMEDIATE SUPPORTED bit	1
		31:16	DM MAXIMUM TRANSFER SIZE field	0000H
		15:0	DM MINIMUM TRANSFER SIZE field	0000H
	24..31	Nominal Media Rotation Rate (QWord)		
		63	Shall be set to one	1
		62:16	Reserved	0
		15:0	NOMINAL MEDIA ROTATION RATE field	7200
	32..39	Form Factor (QWord)		
		63	Contents of the QWord are valid	1
		62:4	Reserved	0
		3:0	NOMINAL FORM FACTOR field	3.5″
	40..47	Write-Read-Verify Sector Count Mode 3 (QWord)		
		63	Contents of the QWord are valid	1
		62:32	Reserved	0
		31:0	WRV MODE 3 COUNT field	0
	48..55	Write-Read-Verify Sector Count Mode 2 (QWord)		
		63	Contents of the QWord are valid	1
		62:32	Reserved	0
		31:0	WRV MODE 2 COUNT field	0
	56..71	World wide name (DQWord)		
		127	Shall be set to one	1
		126:64	Reserved	0
		63:0	WORLD WIDE NAME field	unique
	72..79	DATA SET MANAGEMENT (QWord)		
		63	Shall be set to one	1
		62:32	Reserved	0
		31:16	MAX PAGES PER DSM COMMAND field	0
		15:8	LOGICAL BLOCK MARKUPS SUPPORTED field	0
		7:1	Reserved	0
		0	TRIM SUPPORTED bit	0

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	80..95	Utilization Per Unit Time (DQWord)		
		127	Shall be set to one	1
		126:120	Reserved	0
		119:112	UTILIZATION TYPE field	Combined Writes and Reads
		111:104	UTILIZATION UNITS field	TB
		103:96	UTILIZATION INTERVAL field	Per Year
		95:34	Reserved	0
		63:32	UTILIZATION B field	
		31:0	UTILIZATION A field	550
	96..103	Utilization Usage Rate Support (QWord)		
		63	Contents of the QWord are valid	0
		62:24	Reserved	0
		23	SETTING RATE BASIS SUPPORTED bit	0
		22:9	Reserved	0
		8	SINCE POWER ON RATE BASIS SUPPORTED bit	0
		7:5	Reserved	0
		4	POWER ON HOURS RATE BASIS SUPPORTED bit	0
		3:1	Reserved	0
		0	DATE/TIME RATE BASIS SUPPORTED bit	0
	104..111	Zoned Capabilities (QWord)		
		63	Contents of the QWord are valid	0
		62:2	Reserved	0
		1:0	Zoned	0
	112..119	Supported ZAC Capabilities (QWord)		
		63	Contents of the QWord are valid	0
		62:5	Reserved	0
		4	NON-DATA RESET WRITE POINTERS EXT SUPPORTED bit	0
		3	NON-DATA FINISH ZONE EXT SUPPORTED bit	0
		2	NON-DATA CLOSE ZONE EXT SUPPORTED bit	0
		1	NON-DATA OPEN ZONE EXT SUPPORTED bit	0
		0	REPORT ZONES EXT SUPPORTED bit	0

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	120..127	Advanced Background Operations Capabilities (QWord)		
		63	Contents of the QWord are valid	0
		62	ABO FOREGROUND MODE SUPPORTED bit	0
		61	ABO IR MODE SUPPORTED bit	0
		60:48	Reserved	0
		47:16	ABO MINIMUM FRACTION field	0
		15:0	ABO MINIMUM SUPPORTED TIMELIMIT field	0
	128..135	Advanced Background Operations Recommendations (QWord)		
		63	Contents of the QWord are valid	0
		62:32	Reserved	0
		31:16	DEVICE MAINTENANCE POLLING TIME field	0
		15:0	ABO RECOMMENDED ABO START INTERVAL field	0
	136..143	Queue Depth (QWord)		
		63	Contents of the QWord are valid	0
		62:5	Reserved	0
		4:0	QUEUE DEPTH field	32
	144..151	Supported SCT Capabilities (QWord)		
		63	Contents of the QWord are valid	1
		62:27	Reserved	0
		26	SCT WRITE SAME FUNCTION 103 SUPPORTED bit	1
		25	SCT WRITE SAME FUNCTION 102 SUPPORTED bit	1
		24	SCT WRITE SAME FUNCTION 101 SUPPORTED bit	1
		23:19	Reserved	0
		18	SCT WRITE SAME FUNCTION 3 SUPPORTED bit	1
		17	SCT WRITE SAME FUNCTION 2 SUPPORTED bit	1
		16	SCT WRITE SAME FUNCTION 1 SUPPORTED bit	1
		15:6	Reserved	0
		5	SCT DATA TABLES SUPPORTED bit	1
		4	SCT FEATURE CONTROL SUPPORTED bit	1
		3	SCT ERROR RECOVERY CONTROL SUPPORTED bit	1
		2	SCT WRITE SAME SUPPORTED bit	1
		1	Reserved	0
		0	SCT SUPPORTED bit	1

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	152..159	Depopulation Capabilities (QWord)		
		63	Contents of the QWord are valid	1
		62:3	Reserved	0
		2	RESTORE ELEMENTS AND REBUILD SUPPORTED bit	1
		1	GET PHYSICAL ELEMENT STATUS SUPPORTED bit	1
		0	REMOVE ELEMENT AND TRUNCATE SUPPORTED bit	1
	160..167	35	Depopulation Execution Time (QWord)	
			Bit Description: 63 Contents of the QWord are valid	1
			62:0 DEPOPULATION TIME field	Unique per drive
	168..503	Reserved		
	504..511	Vendor Specific Supported Capabilities (QWord)		
		63	Contents of the QWord are valid	1
		62:0	Vendor specific	
04	Current Settings			
	0..7	Current Settings page information header (QWord)		
		63	Shall be set to one	1
		62:24	Reserved	0
		23:16	Page number	04

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	8..15	Current Settings (QWord)		
		63	Shall be set to one	1
		62:19	Reserved	0
		18	SUCCESSFUL NCQ COMMAND SENSE DATA ENABLED bit	1
		17	DLC ENABLED bit	0
		16	DSN ENABLED bit	0
		15	EPC ENABLED bit	1
		14	Reserved	0
		13	VOLATILE WRITE CACHE ENABLED bit	1
		12	Reserved	0
		11	REVERTING TO DEFAULTS ENABLED bit	0
		10	SENSE DATA ENABLED bit	0
		9	Reserved	0
		8	NON-VOLATILE WRITE CACHE bit	1
		7	READ LOOK-AHEAD ENABLED bit	1
		6	SMART ENABLED bit	1
		5	Reserved	0
		4	Reserved	0
		3	PUIS ENABLED bit	0
		2	APM ENABLED bit	0
		1	FREE-FALL ENABLED bit	0
		0	WRV ENABLED bit	0
	16..23	Feature Settings (QWord)		
		63	Contents of the QWord are valid	1
		62:18	Reserved	0
		17:16	POWER SOURCE field	0
		15:8	APM LEVEL field	0
		7:0	WRV MODE field	0
	24..31	DMA Host Interface Sector Times (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	DMA SECTOR TIME field	0
	32..39	PIO Host Interface Sector Times (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	PIO SECTOR TIME field	0

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	40..47	Streaming Minimum Request Size (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	STREAM MIN REQUEST SIZE field	1000H
	48..55	Streaming Access Latency (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	STREAM ACCESS LATENCY field	0
	56..63	Streaming Performance Granularity (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	STREAM GRANULARITY field	2710H
	64..71	Free-fall Control Sensitivity (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	FREE-FALL SENSITIVITY field	0
	72..79	Device Maintenance Schedule (QWord)		
		63	Contents of the QWord are valid	0
		62:58	Reserved	0
		57:48	MINIMUM INACTIVE TIME IN MILLISECONDS field	0
		47:32	TIME SCHEDULED FOR DEVICE MAINTENANCE field	0
		31:16	TIME TO PERFORMANCE DEGRADATION field	0
		15:0	MINIMUM INACTIVE TIME field	0
	80..87	Advanced Background Operations Settings (QWord)		
		63	Contents of the QWord are valid	0
		62:8	Reserved	0
		7:0	ABO STATUS field	0
	88..511	Reserved		
05	Strings			
	0..7	Supported Capabilities page information header (QWord)		
		63	Shall be set to one	1
		62:24	Reserved	
		23:16	PAGE NUMBER field	05
	8..27	Serial number (ATA String)		XXXXXXXXH
	28..31	Reserved		

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	32..39	FIRMWARE REVISION field (ATA String)		XXXXH
	40..47	Reserved		
	48..87	MODEL NUMBER field (ATA String)		ST24000NT002 ST20000NT001 ST16000NT001 ST12000NT001
	88..95	Reserved		
	96..103	ADDITIONAL PRODUCT IDENTIFIER field (ATA String)		0
	104..511	Reserved		
06	Security			
	0..7	Security page information header (QWord)		
		63	Shall be set to 1	1
		62:24	Reserved	
		23:16	PAGE NUMBER field	06
	8..15	Master Password Identifier (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15:0	MASTER PASSWORD IDENTIFIER field	FFFEH
	16..23	Security Status (QWord)		
		63	Contents of the QWord are valid	1
		62:7	Reserved	0
		6	SECURITY SUPPORTED bit	1
		5	MASTER PASSWORD CAPABILITY bit	0
		4	ENHANCED SECURITY ERASE SUPPORTED bit	1
		3	SECURITY COUNT EXPIRED bit	0
		2	SECURITY FROZEN bit	0
		1	SECURITY LOCKED bit	0
		0	SECURITY ENABLED bit	0
	24..31	Time required for an Enhanced Erase mode SECURITY ERASE UNIT command (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15	ENHANCED SECURITY ERASE TIME FORMAT bit	1
		14:0	ENHANCED SECURITY ERASE TIME field	(Unique per drive)

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	32..39	Time required for an Normal Erase mode SECURITY ERASE UNIT command (QWord)		
		63	Contents of the QWord are valid	1
		62:16	Reserved	0
		15	NORMAL SECURITY ERASE TIME FORMAT bit	1
		14:0	NORMAL SECURITY ERASE TIME field	(Unique per drive)
	40..47	Trusted Computing Feature Set (QWord)		
		63	Contents of the QWord are valid	1
		62:1	Reserved	0
		0	TRUSTED COMPUTING SUPPORTED bit	0 (1, SED drives only)
	48..55	Security Capabilities (QWord)		
		63	Contents of the QWord are valid	1
		62:7	Reserved	0
		6	COMMANDS ALLOWED BY SANITIZE bit	1
		5	SANITIZE ANTIFREEZE LOCK SUPPORTED bit	1
		4	BLOCK ERASE SUPPORTED bit	0
		3	OVERWRITE SUPPORTED bit	1
		2	CRYPTO SCRAMBLE SUPPORTED bit	1
		1	SANITIZE SUPPORTED bit	1
		0	ENCRYPT ALL SUPPORTED bit	1
	56..511	Reserved		
07	Parallel ATA			
	000..511		(Not supported for SATA drives)	all zeros
08	Serial ATA			
	0..7	Serial ATA page information header (QWord)		
		63	Shall be set to 1	0
		62:24	Reserved	
		23:16	Page number	08

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	8..15	SATA Capabilities		
		63	Shall be set to one	1
		62:32	Reserved	0
		31	POWER DISABLE FEATURE ALWAYS ENABLED bit	0
		30	POWER DISABLE FEATURE SUPPORTED bit	0
		29	REBUILD ASSIST SUPPORTED bit	0
		28	DIPM SSP PRESERVATION SUPPORTED bit	0
		27	HYBRID INFORMATION SUPPORTED bit	0
		26	DEVSLEEP TO REDUCEDPWRSTATE CAPABILITY SUPPORTED bit	0
		25	DEVICE SLEEP SUPPORTED bit	0
		24	NCQ AUTOSENSE SUPPORTED bit	1
		23	SOFTWARE SETTINGS PRESERVATION SUPPORTED bit	1
		22	HARDWARE FEATURE CONTROL SUPPORTED bit	0
		21	IN-ORDER DATA DELIVERY SUPPORTED bit	0
		20	DEVICE INITIATED POWER MANAGEMENT SUPPORTED bit	1
		19	DMA SETUP AUTO-ACTIVATION SUPPORTED bit	1
		18	NONZERO BUFFER OFFSETS SUPPORTED bit	0
		17	SEND AND RECEIVE QUEUED COMMANDS SUPPORTED bit	1
		16	NCQ QUEUE MANAGEMENT COMMAND SUPPORTED bit	0
		15	NCQ STREAMING SUPPORTED bit	0
		14	READ LOG DMA EXT AS EQUIVALENT TO READ LOG EXT SUPPORTED bit	1
		13	DEVICE AUTOMATIC PARTIAL TO SLUMBER TRANSITIONS SUPPORTED bit	0
		12	HOST AUTOMATIC PARTIAL TO SLUMBER TRANSITIONS SUPPORTED bit	0
		11	NCQ PRIORITY INFORMATION SUPPORTED bit	0
		10	UNLOAD WHILE NCQ COMMANDS ARE OUTSTANDING SUPPORTED bit	1
		9	SATA PHY EVENT COUNTERS LOG SUPPORTED bit	1
		8	RECEIPT OF HOST INITIATED POWER MANAGEMENT REQUESTS SUPPORTED bit	0
		7	NCQ FEATURE SET SUPPORTED bit	1
		6:3	Reserved	0
		2	SATA GEN3 SIGNALING SPEED SUPPORTED bit	1
		1	SATA GEN2 SIGNALING SPEED SUPPORTED bit	1
		0	SATA GEN1 SIGNALING SPEED SUPPORTED bit	1

Table 25 - Identify Device Data log *(continued)*

Page (hex)	QWord Offset (dec)	Bits	Description	Value (hex)
	16..23	Current SATA Settings (QWord)		
		63	Shall be set to one	1
		62:14	Reserved	0
		13	HYBRID ENABLED bit	0
		12	REBUILD ASSIST ENABLED bit	0
		11	POWER DISABLE FEATURE ENABLED bit	0
		10	DEVICE SLEEP ENABLED bit	0
		9	AUTOMATIC PARTIAL TO SLUMBER TRANSITIONS ENABLED bit	0
		8	SOFTWARE SETTINGS PRESERVATION ENABLED bit	1
		7	HARDWARE FEATURE CONTROL IS ENABLED bit	0
		6	IN-ORDER DATA DELIVERY ENABLED bit	0
		5	DEVICE INITIATED POWER MANAGEMENT ENABLED bit	0
		4	DMA SETUP AUTO-ACTIVATION ENABLED bit	0
		3	NONZERO BUFFER OFFSETS ENABLED bit	0
		2:0	CURRENT NEGOTIATED SERIAL ATA SIGNAL SPEED field	(6.0, 3.0, 1.5) Gb/s
	24..39	Reserved		
	40..41	CURRENT HARDWARE FEATURE CONTROL IDENTIFIER field (Word)		
	42..43	SUPPORTED HARDWARE FEATURE CONTROL IDENTIFIER field (Word)		
	44..47	Reserved		
	48..55	Device Sleep Timing Variables (QWord)		
		63	DEVSLP TIMING VARIABLES SUPPORTED bit	0
		62:16	Reserved	0
		15:8	DEVSLEEP EXIT TIMEOUT field (DETO)	0
		7:5	Reserved	0
		4:0	MINIMUM DEVSLP ASSERTION TIME field (MDAT)	0
	56..511	Reserved		

4.3.3 Device Statistics log

The Device Statistics log (log 04H) transfers information about the drive. The data is organized as a set of 512-byte blocks of data, whose contents are shown in Table 26, *Device Statistics Log*. All reserved bits or words should be set to zero. Parameters listed with an "x" are drive-specific or vary with the state of the drive.

The following may contain drive-specific features that are included in the SATA specifications.

Table 26 - Device Statistics Log

Page (hex)	Statistic	Supported
00	List of supported log pages	Yes
01	General Statistics	
	Lifetime Power-on Resets	Yes
	Power-on Hours	Yes
	Logical Sectors Written	Yes
	Number of Write Commands	Yes
	Logical Sectors Read	Yes
	Number of Read Commands	Yes
	Pending Error Count	Yes
	Workload Utilization	No
	Utilization Usage Rate	No
	Resource Availability	No
	Random Write Resources Used	No
02	Free Fall Statistics	
	Number of Free-Fall Events Detected	No
	Overlimit Shock Events	No
03	Rotating Media Statistics	
	Spindle Motor Power-on Hours	Yes
	Head Flying Hours	Yes
	Head Loaded Events	Yes
	Number of Reallocated Logical Sectors	Yes
	Read Recovery Attempts	Yes
	Number of Mechanical Start Failures	Yes
	Number of Reallocation Candidate Logical Sectors	Yes
	Number of High Priority Unload Events	Yes
04	General Errors Statistics	
	Number of Reported Uncorrectable Errors	Yes
	Number of Resets Between Command Acceptance and Command Completion	Yes
	Physical Element Status Changed	Yes

Table 26 - Device Statistics Log *(continued)*

Page (hex)	Statistic	Supported
05	Temperature Statistics	
	Current Temperature	Yes
	Average Short Term Temperature	Yes
	Average Long Term Temperature	Yes
	Highest Temperature	Yes
	Lowest Temperature	Yes
	Highest Average Short Term Temperature	Yes
	Lowest Average Short Term Temperature	Yes
	Highest Average Long Term Temperature	Yes
	Lowest Average Long Term Temperature	Yes
	Time in Over-Temperature	Yes
	Specified Maximum Operating Temperature	Yes
	Time in Under-Temperature	Yes
	Specified Minumum Operating Temperature	Yes
06	Transport Statistics	
	Number of Hardware Resets	Yes
	Number of ASR Events	Yes
	Number of Interface CRC Errors	Yes
07	Solid State Device Statistics	
	Percentage Used Endurance Indicator	No
08	Zoned Device Statistics	
	Maximum Open Zones	No
	Maximum Explicitly Open Zones	No
	Maximum Implicitly Open Zones	No
	Minimum Empty Zones	No
	Maximum Non Sequential Zones	No
	Zones Emptied	No
	Suboptimal Write Commands	No
	Commands Exceeding Optimal Limit	No
	Failed Explicit Opens	No
	Read Rule Violations	No
	Write Rule Violations	No
	Maximum Implicitly Open Sequential Or Before Required Zones	No
09..FE	Reserved	
FF	Vendor Specific Statistics	

4.3.4 Set Features command

This command controls the implementation of various features that the drive supports. When the drive receives this command, it sets BSY, checks the contents of the Features register, clears BSY and generates an interrupt. If the value in the register does not represent a feature that the drive supports, the command is aborted. Power-on default has the read look-ahead and write caching features enabled. The acceptable values for the Features register are defined as follows:

Table 27 - Set Features command values

Value	Command	
02H	Enable write cache (default)	
03H	Set transfer mode (based on value in Sector Count register). Sector Count register values:	
	Value	Mode
	00H	Set PIO mode to default (PIO mode 2)
	01H	Set PIO mode to default and disable IORDY (PIO mode 2)
	08H	PIO mode 0
	09H	PIO mode 1
	0AH	PIO mode 2
	0BH	PIO mode 3
	0CH	PIO mode 4 (default)
	20H	Multiword DMA mode 0
	21H	Multiword DMA mode 1
	22H	Multiword DMA mode 2
	40H	Ultra DMA mode 0
	41H	Ultra DMA mode 1
	42H	Ultra DMA mode 2
	43H	Ultra DMA mode 3
	44H	Ultra DMA mode 4
	45H	Ultra DMA mode 5
	46H	Ultra DMA mode 6
10H	Enable use of SATA features	
55H	Disable read look-ahead (read cache) feature	
82H	Disable write cache	
90H	Disable use of SATA features	
AAH	Enable read look-ahead (read cache) feature (default)	
F1H	Report full capacity available	

NOTE At power-on, or after a hardware or software reset, the default values of the features are as indicated above.

4.3.5 SMART commands

SMART provides near-term failure prediction for disk drives. When SMART is enabled, the drive monitors predetermined drive attributes that are susceptible to degradation over time. If self-monitoring determines that a failure is likely, SMART makes a status report available to the host. Not all failures are predictable. SMART predictability is limited to the attributes the drive can monitor. For more information on SMART commands and implementation, see the Draft ATA-5 Standard.

SeaTools diagnostic software activates a built-in drive self-test (DST SMART command for D4H) that eliminates unnecessary drive returns. The diagnostic software ships with all new drives and is also available at www.seagate.com/support/downloads/seatools.

This drive is shipped with SMART features disabled. Users must have a recent BIOS or software package that supports SMART to enable this feature. The table below shows the SMART command codes that the drive uses.

Table 28 - SMART commands

Code in features register	SMART command
D0H	SMART Read Data
D2H	SMART Enable/Disable Attribute Autosave
D3H	SMART Save Attribute Values
D4H	SMART Execute Off-line Immediate (runs DST)
D5H	SMART Read Log Sector
D6H	SMART Write Log Sector
D8H	SMART Enable Operations
D9H	SMART Disable Operations
DAH	SMART Return Status

NOTE If an appropriate code is not written to the Features Register, the command is aborted and 0x04 (abort) is written to the Error register.

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