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T E C H N O L O G Y P A P E R
F O R M S E A G A T E

Enhanced Drive Self-Test—Winning the War Against Unnecessary Drive Returns

Executive Summary

Building on the work done by Compaq to develop drive self-test (DST), Seagate® has further improved these diagnostic routines built into every standards-based personal storage drive.

DST is a set of drive tests built into the firmware of every industry hard drive. These tests are invoked by a DST-aware diagnostic software application that resides on the host computer (one example of this software is SeaTools drive diagnostic software from Seagate).

DST comprises two tests: the short test and the extended test. The short test takes approximately two minutes and, until now, was able to detect whether the drive had failed in 60 to 70 percent of the cases. If a drive was operational after the short test, the extended test was needed to verify whether the drive had failed. Although the extended test has an accuracy rate of ± 95 percent, the test requires approximately one minute for each gigabyte measured. Today's rapidly increasing areal densities create downtime issues that could impact the decision to run a diagnostic routine on the drive.

Enhanced DST (NDST) improves the short test to the point that its accuracy now equals that of the extended test, forecasted to deliver 95 percent accuracy. Returned drives can now be reliably and accurately tested in less than two minutes as part of an RMA reduction process. This will have the added benefit of enabling the customer to discover, within two minutes, whether the drive or another system factor is causing problems—keeping a good drive in the system and minimizing the disruption caused by unnecessarily replacing the drive.

For customers of any drive manufacturer implementing NDST, this may result in a reduction in labor costs needed to process RMAs, reduction in overhead inventory required to unnecessarily replace operable hard drives, and less downtime and disruption for the end-user.

NDST is available on Seagate's Barracuda® ATA II hard drives and will be standard on all new Seagate Personal Storage drive families.



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DST—Industry-Standard Diagnostics on Every Drive

The PC industry and its suppliers have noted that a large percentage of drives returned are designated as no problem found (NPF). End users experiencing system problems can, at times, interpret any issue as a hard drive failure. Service centers then replace the hard drive, frequently the most expensive component of the system, without examining other possible system issues such as operating system or file system corruption, software incompatibilities or other system components. This is disruptive to the user, causing loss of productivity and the possibility of lost data if the drive's contents were not backed up by the end-user.

The genesis for DST was to solve the problem of retiring good drives from service because of diagnostics that were either inadequate or not readily available. Before DST was included in the firmware of each drive, a host software diagnostic application was required to fully test the hard drive. This software was not always readily available and relied on standard read and write commands to diagnose the drive. With Compaq Computer Corporation's invention of DST, drive diagnostics were moved into the firmware on the drive (DST subsequently became an industry standard and was adopted by all major PC OEMs). This provided several advantages:

- **Improved diagnostics capability.** Each drive manufacturer knows how to optimally test its drive. Additionally, there are diagnostic tests that only the drive firmware can execute and are not available to host-only hard drive diagnostic software. Continuous diagnostic improvement can be made by the drive supplier on each new drive to tailor the best diagnostics for the new drive design.
- **Simple and standard host software required.** Creating legacy host-based hard drive diagnostics applications required sophisticated knowledge of hard drive technology. Diagnostics were also impractical to include in the BIOS due to the amount of code space required. However, under the standard ATA-5 DST command set, drive diagnostics applications (such as SeaTools) issue a single command instructing the drive to execute the short or extended diagnostic. This simplicity allows the diagnostic command to be issued from a standard PC BIOS without the need for Windows to boot or the requirement for diagnostic software to boot from a floppy.

The ATA-5 specification describes two levels of diagnostic tests that the host can instruct the drive to execute: the short test and the extended test. The extended test accurately distinguishes good and bad devices but does not execute quickly enough for frequent use. The extended test takes approximately one minute for every gigabyte of disc space. The short test takes less than 120 seconds and reports almost no false positives (that is, good devices reported as bad). Unfortunately, the short test tends to indicate an unacceptable number—up to 40 percent—of false negatives (that is, bad devices reported as good). Diagnostics coverage is described by a simple truth table.

Diagnostic Truth Table		
	Passed Diagnostic	Failed Diagnostic
Good Drive	Negative	False Positive
Bad Drive	False Negative	Positive

NDST—Accurate Diagnostics in Two Minutes

The advent of Enhanced DST (NDST) breaks the mold of traditional diagnostics that only execute tests when instructed by host software. NDST-capable drives continuously log errors that are discovered during operating system read and write commands. This information is then stored in an ATA error log, located on sectors of the drive that are inaccessible to the end-user.

In addition to logging errors in the ATA error log, NDST drives log a variety of additional noteworthy events in a new Critical Event Log.

Example: If sectors required an extraordinary number of error-recovery steps to read the data, this information would be stored in the Critical Event Log.

NDST drives will re-read sectors that were previously written to ensure the data is recoverable. Under rare circumstances, data may not be recoverable because of events such as spliced writes caused by a microscopic particle temporarily coming between the head and the media. In this case, NDST drives execute Seagate Write Authentication Tests (SWAT), a new background test that verifies that data is recorded correctly. SWAT failures are recorded in the Critical Event Log.

Other information recorded with each event in the Critical Event Log includes:

- Time stamp
- Error type
- Logical block address
- HDD temperature at the time of the event

This diagnostic activity occurs in the background, transparently to the user, and does not affect drive performance.

These logs contain a complete snapshot of recent error events. When the DST short test is initiated by the host, the drive firmware can use these historical logs that record error events while the drive is executing host reads and writes. In the past, the test relied on run-time diagnostics of the drive only.

In a sense, an NDST-capable hard drive is continuously running diagnostics by leveraging the normal reads and writes occurring during the hard drive operations by the host.

When a diagnostic software application commands the NDST-capable drive to run short DST, the drive runs a short list of diagnostics ensuring the basic functionality of the drive and then inspects the historical logs for previously detected failures. This breakthrough in diagnostic capability greatly reduces the number of false negatives reported by the previous DST short test report.

Under NDST, the short test is expected to have the effectiveness of the extended test, detecting a failed drive approximately 95 percent of the time in two minutes.



Comparison of DST Short Test Operations			
Test	Function	DST	NDST
Repeatable run-out test	Ensures that servo is working within acceptable design parameters	✓	✓
Limited write test	Ensures that all drive heads can write and read data	✓	✓
Limited read scan	Reads a limited amount of data at the outer diameter of the disc where typical operating system and executable files are located. Also reads the inner diameter of the disc, where damage can occur if a disc drive is mishandled.	✓	✓
Scan Critical Event Log	Drive firmware collects unusual events in this log using the new Seagate Write Authentication Test.		✓
Scan ATA Error Log	Drive firmware continuously records failed read or write commands issued by the host into the ATA Error Log.		✓
Forecasted accuracy rate	Measurement of false positives reported by the host system's diagnostic application	60%–70%	95%

Definitions

Drive diagnostics

Individual tests that are either included within drive firmware (DST) or within host software.

ATA Error Log

An industry-standard (ATA-5) protocol that describes how the drive should record a historical log of failed drive commands.

DST (drive self-test)

An industry standard (ATA-5) protocol that defines the commands for the host to instruct the drive to execute either a short or extended drive test aimed at failure diagnostics. This means that a drive initiates a testing process and reports a pass/fail result.

Enhanced DST (NDST)

DST augmented by the ability to quickly read the new Critical Event Log during the short test. This gives the short test, usually completed in two minutes or less, the same accuracy as the previous extended test, forecasted at 95 percent.

Critical Event Log

This log records a variety of error-recovery events in nonuser sectors that are later used by Short DST to improve diagnostics of the drive.

Seagate Write Authentication Test

This new test reads the previously written sectors and verifies that the data is recoverable.