SCSI TOOLBOX, LLC Disk Drive Testing 101

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Introduction

Disk drives are complex devices, marvels of mechanical engineering and real-time computing magic.

For example, the heads of a rotating magnetic disk physically fly over the moving platters, flying at a height of as little as 3 nanometers at a speed over 128 mph! No wonder bumps and drops can do so much damage – just like flying an extremely fragile airplane into metal-hard ground at 128 mph! Not only can the airplane (drive head) be damaged, but the ground (platter surface) can be dug-up, furloughed, damaged. The magnetic coating on the platter is like a thin layer of top soil – scraping it away scrapes away data.

Bottom line – be gentle with your disk drives. You may be under pressure to get a large number of drives tested by the end of the day – but take your time. Move them gently and slowly. *Never* move a drive while it is spinning. Never drop a drive or bump it into anything. And keep the drive cooled while testing – *never* power up a disk drive without some kind of fan to move air around the drive to draw away the heat it generates.

All disk drives have a built-in computer to control all the physical operations of the drive as well as dealing with data encoding/decoding, queuing, transferring data in and out – a marvel of real-time computing!

Disk drives can work perfectly, or they cannot work at all, or they can "sort of" work, work marginally or poorly. The goal of basic disk drive testing is to:

- 1. determine if the drive is working at all or not
- 2. determine if the drive itself can tell us if it has had a problem in the past
- 3. determine if the drive can reliably store and retrieve data
- 4. determine if drive settings are appropriate for the intended use of the drive and,
- 5. determine the performance characteristics of the drive.

Is the drive working or not?

Determining if the drive is alive or not is simply a matter of connecting it to a test system and checking that the drive spins up, is "online", and can report its capacity. Using the STB Suite Original mode look at the device window or click the Scan System button to scan all of the storage controllers in your test system. Do you see the drive? Does it report a valid capacity? Does the drive information (manufacturer name, drive part number, firmware version) look reasonable?

If the drive does not show up at all on the test machine you must check all cabling and power for the drive test fixture. See if there are indicator LEDs on the drive that show any activity. Listen to see if you can hear that the drive is spinning, or gently feel if you can sense vibration from the drive.

If the drive does not report a reasonable capacity, for example if it reports it has zero blocks or a negative number of blocks than the drive may need a low-level format before continuing testing.

If the drive information is jumbled or wrong – for instance if the drive is a "SEAGATE" drive but the STB Suite is reporting it as "SEAGGGG" you may have a dead drive or you may have a cabling/termination problem. Try moving the drive to a different slot or connector or bus to see if the problem goes away.

Here is what you should see:

👮 SCSI Toolbox32, version 8. 3. 4 (build) 1	10208, Def Drv=10), OS = Windows 7	
File Adapter Options Disk Tape Jukebox Help	ATA/SATA	ese	tsi Bus Ana
Scan Bus Scan System	Note	e that drive info is good and capacity is	
Target 515: SEAGATE ST373455SS Capacity = 71687 MB	Version S51	reasonable	Safe Ju
Target 516: SEAGATE ST373455SS Capacity = 71687 MB	Version S513	Type None	
Target 517: SEAGATE ST373455SS Capacity = 71687 MB	Version S512	Clear F	File View
Target 518: SEAGATE ST373455SS Capacity = 71687 MB	Version S513	Log Performa	ance Data
Target 519: Not Available		Send "A" to COM1	I: on Error J
Target 520: Not Available			
Target 521: Not Available			
Target 522: Not Available	_		
	<u> </u>		
Target selected = 515		Read Capacity	

Can the drive tell us it has had problems?

Disk drives will store historical data which can be retrieved and analyzed. SCSI/FC/SAS drives store this type of information in LOG PAGES. ATA/SATA drives store this information in SATA SMART data.

SCSI/SAS/FC Log Pages

A quick way to see an overview of some of the more important Log Pages is to double-click on the drive in the device selection window to bring up the Device Information display. Select the *Error Data* tab and you will see historical data describing how much data has been read and written and the number of and type of errors that have happened during reads and writes –

Host Adapter:	4	Target:	515	LUN: 0	
Inquiry Information	Charles Error Da				
Vendor: SEAGATE	Statistics Error Da	a EVPD Dat	a Mode h	"ages	
			Write Error	Counters	
Product: ST373455SS	Total KB Written	1810597266		Errors Recovered w/o Dela	9 0
Revision: S513	Errors Recovered	w/ retries 0		Errors Recovered w/ ECC	0
s/n: 3LQ1271W	Total Times Reco	very Invoked	0	1	
Device Type: 0 - Direct Access	Total Unrecovere	d Errors 0		Total Errors Recovered	0
Dence Type: 0 Dilett Addess		F	Read Error	Counters	
Removable: No	Total KB Read 8			Errors Recovered w/o Dela	763558
Multi-Ported Dual Ported	Errors Recovered	w/ retries 0		Errors Recovered w/ ECC	1
	Total Times Reco	very Invoked	763559		
Data Width: 8 bit			1999 - 19		
Taq Queing: Supported	Total Unrecovere	d Errors 0		Total Errors Recovered	1 763559
SCSI Level 5	Clear Values	l'			Print
SCSI Level D		1			
SAS/w/wN 500000004945CAC					

As a general rule – uncorrected errors are always a bad thing to have. Uncorrected errors usually will cause the LBA in question to be marked as bad.

For SCSI/SAS/FC drives this will mean an increase in the drives G defect list. On the Device Information display click the Statistics tab and note the number of G List defects –

Statistics Error Data EVPD Data Mode Pages		
Read Transfer Rates - Avg = 0.00 High = 0.00 KB/S		
Number of Blocks Read - 0		
Write Transfer Rates - Avg = 0.00 High = 0.00 KB/S		
Number of Blocks Written - 0		
Average Seek Time - 0.00 Ms		
Number of P defects - 1656 Number of G defects - 0		
Number of Hard Errors - 0 Number of Soft Errors - 0		

As another general rule – good disk drives don't have any grown defects.

For a detailed "raw" data view of every log page a drive has you can right-click on the drive in the device selection window, then from the Quick Command list choose *View Log Pages* –

View Log Pages	×		
Available Pages	Log Page Data - Page 02		
Page 02 • Write Error Counter Page Page 03 • Read Error Counter Page Page 05 • Verify Error Counter Page Page 06 • Non-medium Error Counter Page Page 0D • Temperature Page Page 0F • Application Client Page Page 10 • Self-Test Results Page Page 15 Page 18 Page 2F Page 37 • Cache Statistics Page Page 3F	Errors corrected with possible delays 00 00 00 00 Total rewrites 00 00 00 00 Total Errors Corrected (soft errors) - 00 00 00 00 Total Times Correction Algorithm Processed - 00 00 00 00 Total Bytes Processed - 00 00 00 EA DF 35 26 00 Total Errors Uncorrected (hard errors) - 00 00 00 00		
Use Description File C:\Program Files (x86)\STB\SCSI toolbox32 Browse			
C Current Threshold C Current Cumulative C Default Threshold C Default Cumulative			
OK Clear Log Pages	Save to File Save all Pages to File Cancel		

Be sure to use the Browse button to select a log page definition file – the file "default.dat" is usually fine for any disk drive. The available Log Pages are shown on the left of the display, double-clicking on a Log Page will display that pages parameters on the right.

Note that you can save all of this information to a file. A good thing to do as you test drives is to build a database of the drives you've tested.

ATA/SATA SMART Information

This same type of historical error data is found in the SMART data for ATA and SATA drives. To view and save this info go to the STB Suite main menu ATA/SATA->Commands->View SMART Data choice. Select the drive of interest from the lists to the right and the SMART data will be displayed on the left.

Note: to learn about how to interpret SATA SMART data look at

http://en.wikipedia.org/wiki/S.M.A.R.T.

The top of the display will show all SMART attributes and will indicate pending problems

ATA S.M.A.R.T. Information

Click on a device in the Devices list to view its SMART information

SMART Information
Attribute 1 (** Raw Read Error Rate) - Flags = OF, Current Value = 120, Threshold = 50, 1
Attribute 5 (** Reallocated Sector Count) - Flags = 33, Current Value = 96, Threshold = :
Attribute 9 (Power-On Hours Count) - Flags = 32, Current Value = 100, Threshold = 0, Wor:
Attribute 12 (Device Power-Cycle Count) - Flags = 32, Current Value = 100, Threshold = 0
Attribute 174 () - Flags = 30, Current Value = 0, Threshold = 0, Worst = 0 Raw = (1A 00
Attribute 177 () - Flags = 00, Current Value = 0, Threshold = 90, Worst = 0 Raw = (00 00
<pre>!!! ERROR !!! attribute value 0 is less than threshold 90</pre>
Attribute 184 () - Flags = 32, Current Value = 100, Threshold = 0, Worst = 100 Raw = (00
Attribute 187 () - Flags = 32, Current Value = 100, Threshold = 0, Worst = 100 Raw = (00-
Attribute 188 () - Flags = 32, Current Value = 100, Threshold = 0, Worst = 100 Raw = (00
Attribute 190 (Airflow Temperature) - Flags = 22, Current Value = 67, Threshold = 0, Wor:
Attribute 194 (Device Temperature) - Flags = 22, Current Value = 33, Threshold = 0, Wors
Attribute 195 (Hardware ECC Recovered) - Flags = 1C, Current Value = 120, Threshold = 3,
Attribute 196 (** Reallocation Event Count) - Flags = 33, Current Value = 100, Threshold
Attribute 198 (** Off-Line Scan Uncorrectable Sector Count) - Flags = 10, Current Value
Attribute 199 (Ultra DMA CRC Error Count) - Flags = 3E, Current Value = 200, Threshold =
Attribute 230 (GMR Head Amplitude) - Flags = 13, Current Value = 100, Threshold = 10, Wo:
Attribute 231 (Temperature) - Flags = 13, Current Value = 95, Threshold = 0, Worst = 951
Attribute 233 () - Flags = 00, Current Value = 0, Threshold = 0, Worst = 0 Raw = (00 00 🔽

And at the bottom of the display you will see attributes which may indicate the actual number of errors or counts such as Power-On Hours, etc –

SMART Information		

Attributes with raw data that may have meaning:		
Attribute 9 (Power-On Hours Count) Raw Data (hex) = (26 O2 OO OO 58 5F), (dec) = 550		
Attribute 12 (Device Power-Cycle Count) Raw Data (hex) = (1D 00 00 00 00 00), (dec) = 2:		
Attribute 174 () Raw Data (hex) = (1A 00 00 00 00 00), (dec) = 26		
Attribute 184 () Raw Data (hex) = (00 00 00 00 00 00), (dec) = 0		
Attribute 187 () Raw Data (hex) = (00 00 00 00 00 00), (dec) = 0		
Attribute 188 () Raw Data (hex) = (00 00 00 00 00 00), (dec) = 0		
Attribute 190 (Airflow Temperature) Raw Data (hex) = (21 00 1F 21 00 00), (dec) = 55567		
Attribute 194 (Device Temperature) Raw Data (hex) = (21 00 22 00 00 00), (dec) = 222825		
Attribute 196 (** Reallocation Event Count) Raw Data (hex) = (00 00 00 00 00 00), (dec)		
Attribute 198 (** Off-Line Scan Uncorrectable Sector Count) Raw Data (hex) = (00 00 00 (
Attribute 199 (Ultra DMA CRC Error Count) Raw Data (hex) = (00 00 00 00 00 00), (dec) =		
Attribute 231 (Temperature) Raw Data (hex) = (01 00 00 00 00 00), (dec) = 1		
Attribute 233 () Raw Data (hex) = (00 00 00 00 00 00), (dec) = 0		
Attribute 235 () Raw Data (hex) = (00 00 00 00 00 00), (dec) = 0		
Attribute 241 () Raw Data (hex) = (80 00 00 00 00 00), (dec) = 128		
Attribute 242 () Raw Data (hex) = (00 01 00 00 00 00), (dec) = 256		

Can the drive reliably write and read data?

Obviously a disk drive must be able to reliably store and retrieve data. The best way to test these two functions is to run a test which first writes a known data pattern to every block on the drive. Then every block on the drive is read and using data compare each block of data is checked to insure that it is exactly the same as what was written.

Obviously writing and reading the entire drive will take some amount of time. Can you reliably determine if the drives write/read functionality is OK by checking less than the entire drive? Technically, probably not – what if there is a problem with a block which you didn't test? Statistically – maybe yes. The choice is up to you – balancing the accuracy of your results with the time it takes to complete a test.

The good news in this regard is the STB Suite Disk Manufacturing Module (DMM) is extremely efficient and fast – it can test many drives at once. DMM will tell you exactly how long a given test is going to take to complete so as you test more drives you will soon learn how many drives per hour or day you will be able to test to your company's specification.

Another choice to be made concerning write/read testing is the *access method*. The most basic access method is *sequential* – the test starts at LBA 0 and progresses sequentially through to the last block. Another access method is *Random*. As the name implies, random access moves through the drives blocks in a random manner. An advantage of random access is that it will generate more vibration in the drives under test, which will stress the drive harder. A new STB Suite access method is *CPAM*. CPAM is a

method which creates random access and also guarantees that every block on the drive will be accessed once and only once.

Getting started with DMM is covered in earlier articles and in videos on our web site at : <u>http://www.scsitoolbox.com/Training/</u>

The STB Original mode also has a number of canned tests, more appropriate for testing a single drive at a time. Select a drive then click the top menu Disk-Tests choice pulldown to see a list of available tests – for example, the Quick QC test checks write/read functionality at the beginning, middle, and end of the drive. The Quick Drive Profile Test will show a good overview of the drive -

uick Drive Profile				
Vendor = SEAGATE Product = ST373455SS F/W = S513				
Read Transfer Rate Average = 86587.47 High = 153515.45 KB/S Number of Blocks Read = 970				
Write Transfer Rate Average = 183552.84 High = 191111.97 KB/S Number of Blocks Written = 970				
Read Blocks 2 = 70.88 8 = 993.59 64 = 67124.85 128 = 148680.06 256 = 149139.97 512 = 153515.45 KB/S				
write Blocks $2 = \begin{bmatrix} 342.26 \\ 8 = \end{bmatrix} \begin{bmatrix} 16201.22 \\ 64 = \end{bmatrix} \begin{bmatrix} 125186.85 \\ 128 = \end{bmatrix} \begin{bmatrix} 163836.77 \\ 256 = \end{bmatrix} \begin{bmatrix} 183525.69 \\ 512 = \end{bmatrix} \begin{bmatrix} 191111.97 \\ KB/S \end{bmatrix} $				
Average Seek = 4.774893 Ms Write Cache = 0N Read Cache = 0N Number of Segments = 32				
Number of Primary Defects = 1656 Number of Grown Defects = 0 Hard Errors = 0				
Status: Finished				
Enable Destructive Tests				
Exit Profile Drive File Output Cancel				

Is the drive set up appropriately?

SCSI/SAS/FC drive behavior can be specified by Mode Page settings. To see the most common or important Mode Page settings go back to STB Original mode, double-click on your drive, and choose the *Mode Page tab* –

Statistics Error Data EVPD Data Mode Pages		
Read/Write Error Recovery AWRE 1 ARRE 1 TB 0 RC 0 ERR 0 PER 0 DTE 0 DCR 0 Read Retry Count 11 Write Retry Count 5 Correction Span 255		
Caching		
IC 0 ABPF 0 CAP 0 DISC 1 SIZE 0 WCE 1 MF 0 RCD 0		
Cache Segments 32 Disable Read Ahead 0		
Information Exceptions Control PERF 0 EWASC 0 DEXCPT 0 TEST 0 LOGERR 1		
Change/Edit Mode Pages Print		

Settings such as enabling or disabling read ahead and write caching are shown, to change any settings click the *Change/Edit Mode Pages* button.

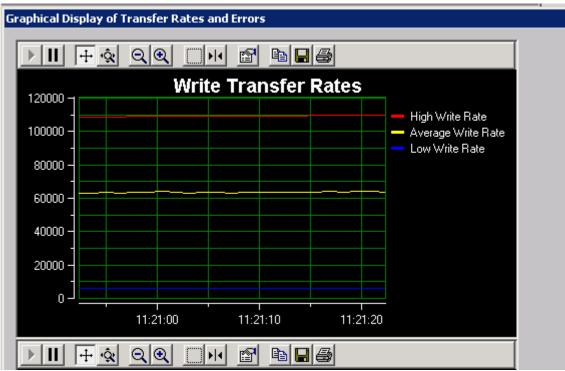
Choose Mode Select Page	
 00 - Unit Attention Page 00 - IBM Vendor Unique Page 01 - Error Recovery 02 - Disconnect/Reconnect 04 - Ridged Disc Drive Parameters 07 - Verify Error Recovery 08 - Caching 	 0x0A - Control Mode 0x10 - XOR Control 0x14 - Enclosure Service Management 0x19 - Fibre Channel Interface Control 0x19 - SAS SSP Page 0x1A - Power Condition Page 0x1C - IE Control 0x1C - SubPage 1 BCM 0x25 - Digital Special Function
Edit Page Return	 Hex Edit Display all available pages

Note: in general you will want Write Caching (WCE) to be **ON**. This will greatly increase the write speed of the drive.

There are many settings available via Mode Pages. DMM has a feature whereby you can set up a golden drive with all mode pages set the way you or your customer defines – and then during DMM testing each drive under test will automatically have all of its Mode Pages set to match your golden drive.

What is the performance profile of your drive?

For a quick look at the performance of an individual drive you can select it in STB Original mode, then run a test and watch the real-time performance with Drive Watch – here is a view of the write © Copyright 2011 SCSI Toolbox, LLC Sales: 720.249.2641 General: 303.972.2072 performance of a drive:



DMM will reveal real-time performance metrics as well as logging them to log files. Here is a similar example to the above – a sequential write test :

Pre-Test Actions Post-Test Actions Test	Test Setup Status Test Thresholds			
Drives HA 4, Target 515, Lun 0, SEAGATE, ST373455SS				
Test Status: Test In Progres Number of Blocks Transferred:				
Number of Bytes Transferred: This Drive's Transfer Rate:				
Time Running: Estimated Time Remaining:				
Total System Transfer Rate:				
Total System Burst Rate: Sense Data:				
Miscompare Info: N/A				

Note that DMM tells you how long the current test step will take to complete – experiment with this and you will quickly get a feel for estimating how long any given test is going to take to complete.

And the DMM log file for this drive shows:

>> SCSI Toolbox32, Version 8. 3. 4 (build) 110208, running on \\S2008×64-SSD
>> Default Driver: 10, Operating System: Windows 7<<</pre> << Fest Date: 03/02/2011 11:23:07 Fest Pass: 1 Device: 4:515:0 SEAGATE ST37345555 Serial: 3LQ1271W Results: 03/02/2011 11:23:07 TEST 1 of 1: write Test; Sequential; for 1 Minutes Fixed-Length Transfers of 128 (0x0080) Blocks Start Block: 0 Data Pattern: Decrementing Queue Depth = 1 FUA = OFF 03/02/2011 11:24:07 Test Completed Successfully Transfer Rate: 124.32 MB/sec I/O Per Second: 1989.07 IO/sec Number of Blocks Transferred: 15276032 Fastest Command Completion Time: 0.340 ms Slowest Command Completion Time: 18.760 ms Average Command Completion Time: 0.491 ms Standard Deviation of Command Completion Times: 0.227 ms 03/02/2011 11:24:07 PASSED _____

Summary

Basic testing to confirm overall drive health is easily done with the STB Suite. Use Original mode to examine single drives at a time in detail/depth, and use DMM to test many drives at a time.

STB Original Mode Advantages:

-extreme depth of detail available to examine each and every drive setting

-versatile set of tests to get a quick snapshot view of drive health

STB Suite DMM Advantages:

-multi-threaded high speed multi drive testing

-can test multiple HBA's/controllers simultaneously

-extremely detailed logs generated for each drive under test

-easy to define any type of test sequence – test sequences can be saved and reloaded