



**SPC BENCHMARK 2™  
FULL DISCLOSURE REPORT**

**FUJITSU LIMITED  
FUJITSU STORAGE SYSTEMS  
ETERNUS DX200 S3 STORAGE ARRAY**

**SPC-2™ V1.5**

**Submitted for Review: February 26, 2015  
Submission Identifier: B00071**

## **First Edition – February 2015**

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# AUDIT CERTIFICATION



C.A. (Sandy) Wilson  
Fujitsu Limited  
1250 East Arques Ave.  
P.O. Box 3470  
Sunnyvale, CA 94088 3470

February 26, 2015

The SPC Benchmark 2™ Reported Data listed below for the **Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array** was produced in compliance with the SPC Benchmark 2™ V1.5 Remote Audit requirements.

SPC Benchmark 2™ V1.5 Reported Data	
Tested Storage Product (TSP) Name: Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array	
Metric	Reported Result
SPC-2 MBPS™	6,266.50
SPC-2 Price-Performance	\$15.42/SPC-2 MBPS™
ASU Capacity	23,551.453 GB
Data Protection Level	Protected 2 (RAID-5)
Total Price (including three-year maintenance)	\$96,644.50
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

The following SPC Benchmark 2™ Remote Audit requirements were reviewed and found compliant with V1.5 of the SPC Benchmark 2™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by documentation supplied by Fujitsu Limited:
  - ✓ Physical Storage Capacity and related requirements.
  - ✓ Configured Storage Capacity and related requirements.
  - ✓ Addressable Storage Capacity and related requirements.
  - ✓ Capacity of each Logical Volume and related requirements.
  - ✓ Capacity of the Application Storage Unit (ASU) and related requirements.
- The total Application Storage Unit (ASU) Capacity was filled with random data prior to the execution of the SPC-2 Tests

Storage Performance Council  
643 Bair Island Road, Suite 103  
Redwood City, CA 94062  
[AuditService@StoragePerformance.org](mailto:AuditService@StoragePerformance.org)  
650.556.9384



## AUDIT CERTIFICATION (CONT.)

Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array  
SPC-2 Audit Certification

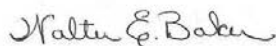
Page 2

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Documentation supplied by Fujitsu Limited to verify the components matched the above diagram.
- Listings and commands used to create and configure the Benchmark Configuration/Tested Storage Configuration.
- Documentation that no customer tunable parameter or option was changed from its default value.
- The following Host System items were verified by documentation supplied by Fujitsu Limited:
  - ✓ Required Host System configuration information.
  - ✓ The TSC boundary within the Host System.
- The following SPC-2 Workload Generator information was verified by documentation supplied by Fujitsu Limited:
  - ✓ The presence and version number of the Workload Generator on each Host System.
  - ✓ Commands and parameters used to configure the SPC-2 Workload Generator.
- The Test Results Files and resultant Summary Results Files received from Fujitsu Limited for each of the following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 6 and 7 of the SPC-2 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Large File Processing Test
  - ✓ Large Database Query Test
  - ✓ Video on Demand Delivery Test
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 9 of the SPC-2 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 10 of the SPC-2 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

**Audit Notes:**

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker  
SPC Auditor

Storage Performance Council  
643 Bair Island Road, Suite 103  
Redwood City, CA 94062  
[AuditService@StoragePerformance.org](mailto:AuditService@StoragePerformance.org)  
650.556.9384

## LETTER OF GOOD FAITH



---

Kanagawa-ken, Kawasaki-shi, Nakahara-ku, Kamikodanaka, 4-1-1, JAPAN 211-8588  
Phone: 044-754-3240

November 28, 2014  
From: Shigeo Konno, Fujitsu Limited

To: Walter E. Baker, SPC Auditor  
Gradient Systems, Inc.  
643 Bair Island Road, Suite 103  
Redwood City, CA 94063-2755. U.S.A.

Contact Information: Carrel A. (Sandy) Wilson  
Fujitsu America, Inc.  
1250 East Arques Ave. PO Box 3470  
Sunnyvale, CA 94088, U.S.A.

Subject: SPC-2 Letter of Good Faith for the ETERNUS DX200S3

Fujitsu Limited is the SPC-2 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-2 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.5 of the SPC-2 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark necessary to reproduce the reported results even if the items are not explicitly required to be disclosed by the SPC-2 benchmark specification.

Signed:

Date:

A handwritten signature in black ink that reads "Shigeo Konno". The signature is written over a horizontal line.

Shigeo Konno  
Vice President, Storage Systems Division

A handwritten date in black ink that reads "Nov. 28, 2014". The date is written over a horizontal line.

Date of Signature

## EXECUTIVE SUMMARY

### Test Sponsor and Contact Information

Test Sponsor and Contact Information	
<b>Test Sponsor Primary Contact</b>	Fujitsu Limited – <a href="http://www.fujitsu.com/services/computing/storage/">http://www.fujitsu.com/services/computing/storage/</a> Fujitsu America, Inc. C.A. (Sandy) Wilson <a href="mailto:swilson@us.fujitsu.com">swilson@us.fujitsu.com</a> 1250 East Arques Ave PO Box 3470 Sunnyvale, CA 94088-3470 Phone: (916) 434-8593
<b>Test Sponsor Alternate Contact</b>	Fujitsu Limited – <a href="http://www.fujitsu.com/services/computing/storage/">http://www.fujitsu.com/services/computing/storage/</a> Fujitsu America, Inc. Kun Katsumata <a href="mailto:kkatsumata@us.fujitsu.com">kkatsumata@us.fujitsu.com</a> 1250 East Arques Ave PO Box 3470 Sunnyvale, CA 94088-3470 Phone: (408) 746-6415
<b>Test Sponsor Alternate Contact</b>	Fujitsu Limited <a href="http://www.fujitsu.com/services/computing/storage/">http://www.fujitsu.com/services/computing/storage/</a> Shigeo Konno <a href="mailto:konno.shigeo@jp.fujitsu.com">konno.shigeo@jp.fujitsu.com</a> 1-1 Kamikodanaka 4-chome, Nakahara-ku, Kawasaki-shi, Kanagawa-ken 211-8588, Japan Phone: (044) 754-3632 FAX: (044) 754-3719
<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">http://www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@StoragePerformance.org">AuditService@StoragePerformance.org</a> 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

### Revision Information and Key Dates

Revision Information and Key Dates	
<b>SPC-2 Specification revision number</b>	V1.5
<b>SPC-2 Workload Generator revision number</b>	V1.2
<b>Date Results were first used publicly</b>	February 26, 2015
<b>Date FDR was submitted to the SPC</b>	February 26, 2015
<b>Date the TSC will be available for shipment to customers</b>	currently available
<b>Date the TSC completed audit certification</b>	February 25, 2015

### Tested Storage Product (TSP) Description

The scalable and unified Fujitsu Storage ETERNUS DX200 S3 delivers enterprise-class functionality to small and medium-sized companies and subsidiaries with an excellent price/performance ratio. It is the perfect solution when consolidating data for server virtualization, e-mail, databases and business applications as well as centralized file services. Simple, intuitive system management, highly flexible network connectivity and the option of field upgrades to higher system classes significantly reduce operational and migration costs. The ETERNUS DX family architecture lets customers benefit from software options, such as thin provisioning, automatic storage tiering and quality of service management even as early as the entry-level class. This all contributes to better business support.

## SPC-2 Reported Data

SPC-2 Reported Data consists of three groups of information:

- The following SPC-2 Primary Metrics, which characterize the overall benchmark result:
  - SPC-2 MBPS™
  - SPC-2 Price Performance™
  - Application Storage Unit (ASU) Capacity
- Supplemental data to the SPC-2 Primary Metrics.
  - Total Price
  - Data Protection Level
  - Currency Used
  - Target Country
- Reported Data for each SPC Test: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand Delivery (VOD) Test.

**SPC-2 MBPS™** represents the aggregate data rate, in megabytes per second, of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand (VOD).

**SPC-2 Price-Performance™** is the ratio of **Total Price** to **SPC-2 MBPS™**.

**ASU (Application Storage Unit) Capacity** represents the total storage capacity available to be read and written in the course of executing the SPC-2 benchmark.

**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 17.

**Data Protection Level of Protected 2** using **RAID-5**, which provides data protection by distributing check data corresponding to user data across multiple disks in the form of bit-by-bit parity.

***Protected 2:** The single point of failure of any **component** in the configuration will not result in permanent loss of access to or integrity of the SPC-2 Data Repository.*

**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-2 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

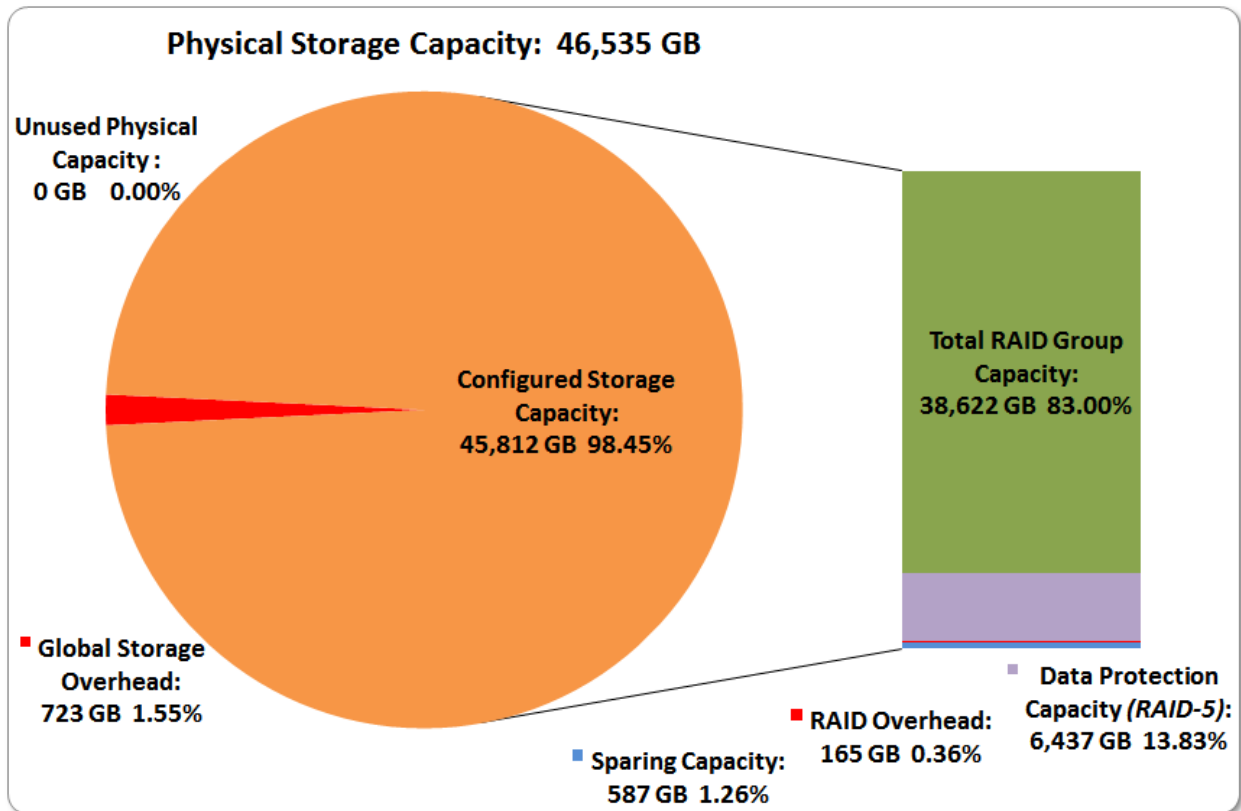
## SPC-2 Reported Data (continued)

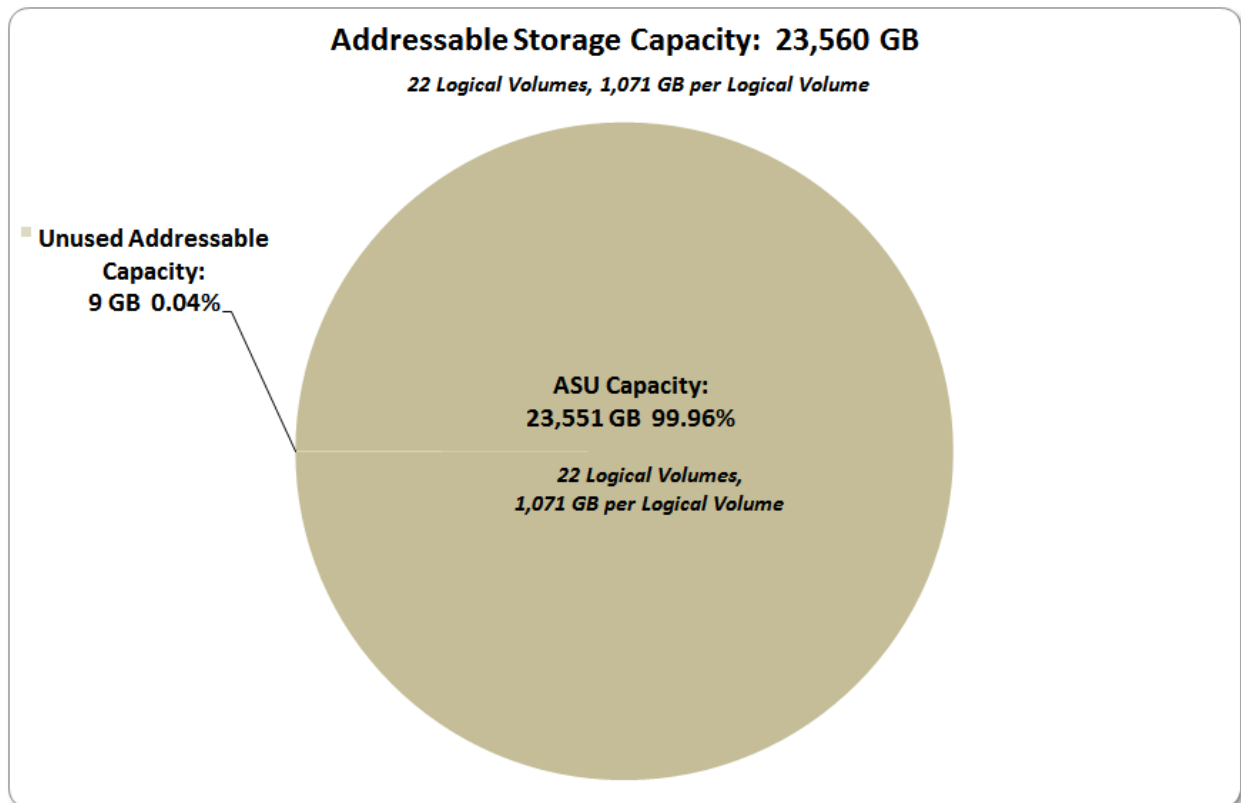
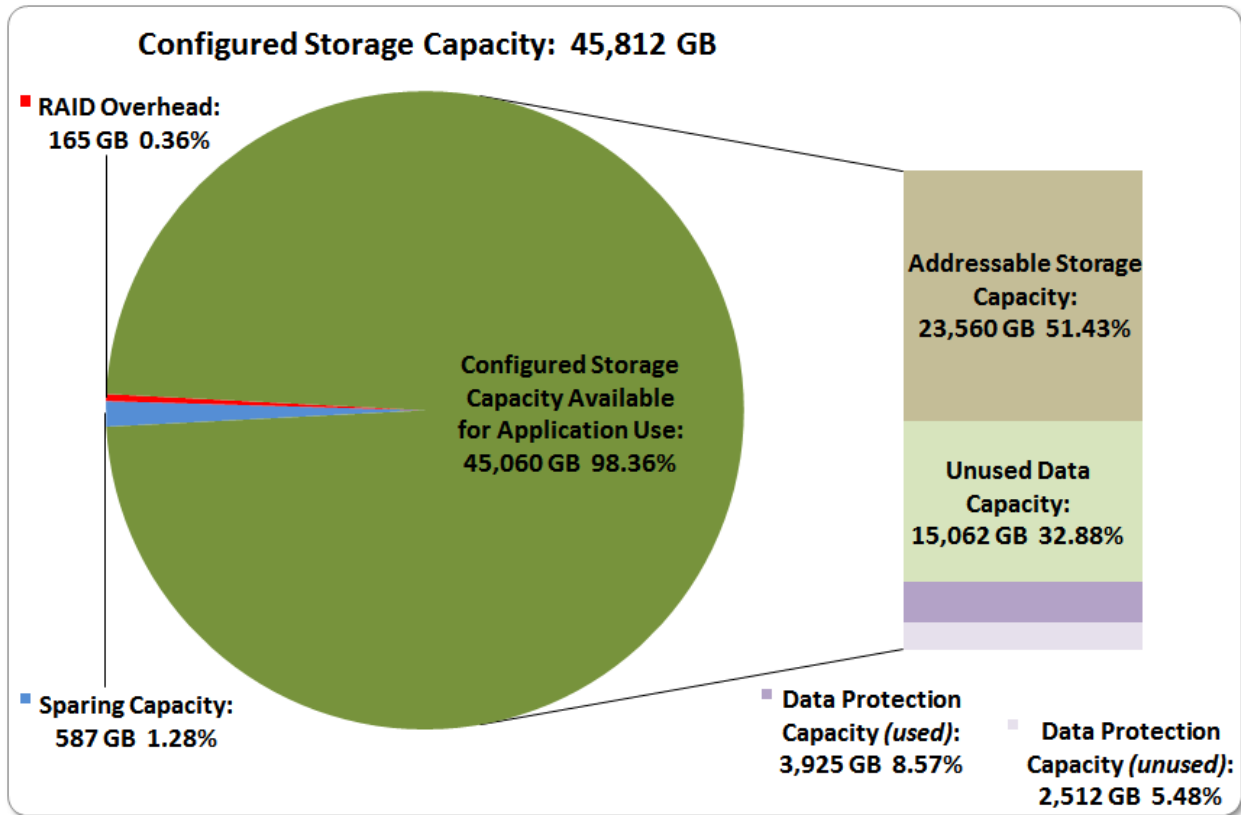
SPC-2 Reported Data				
Fujitsu Storage Systems ETERNUS DX200 S3				
SPC-2 MBPS™	SPC-2 Price-Performance	ASU Capacity (GB)	Total Price	Data Protection Level
6,266.50	\$15.42	23,551.453	\$96,644.30	Protected 2 (RAID-5)
<i>The above SPC-2 MBPS™ value represents the aggregate data rate of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video On Demand (VOD)</i>				
<b>Currency Used:</b>		<b>"Target Country":</b>		
U.S. dollars		USA		
SPC-2 Large File Processing (LFP) Reported Data				
	Data Rate (MB/second)	Number of Streams	Data Rate per Stream	Price-Performance
LFP Composite	5,435.82			\$17.78
Write Only:				
1024 KiB Transfer	4,152.50	32	129.77	
256 KiB Transfer	4,209.63	128	32.89	
Read-Write:				
1024 KiB Transfer	5,261.03	64	82.20	
256 KiB Transfer	5,114.87	144	35.52	
Read Only:				
1024 KiB Transfer	6,951.44	32	217.23	
256 KiB Transfer	6,925.44	128	54.10	
<i>The above SPC-2 Data Rate value for LFP Composite represents the aggregate performance of all three LFP Test Phases: (Write Only, Read-Write, and Read Only).</i>				
SPC-2 Large Database Query (LDQ) Reported Data				
	Data Rate (MB/second)	Number of Streams	Data Rate per Stream	Price-Performance
LDQ Composite	6,757.68			\$14.30
1024 KiB Transfer Size				
4 I/Os Outstanding	6,831.12	32	213.47	
1 I/O Outstanding	6,798.97	32	212.47	
64 KiB Transfer Size				
4 I/Os Outstanding	6,698.83	128	52.33	
1 I/O Outstanding	6,701.79	128	52.36	
<i>The above SPC-2 Data Rate value for LDQ Composite represents the aggregate performance of the two LDQ Test Phases: (1024 KiB and 64 KiB Transfer Sizes).</i>				
SPC-2 Video On Demand (VOD) Reported Data				
	Data Rate (MB/second)	Number of Streams	Data Rate per Stream	Price-Performance
	6,606.00	8,400	0.79	\$14.63

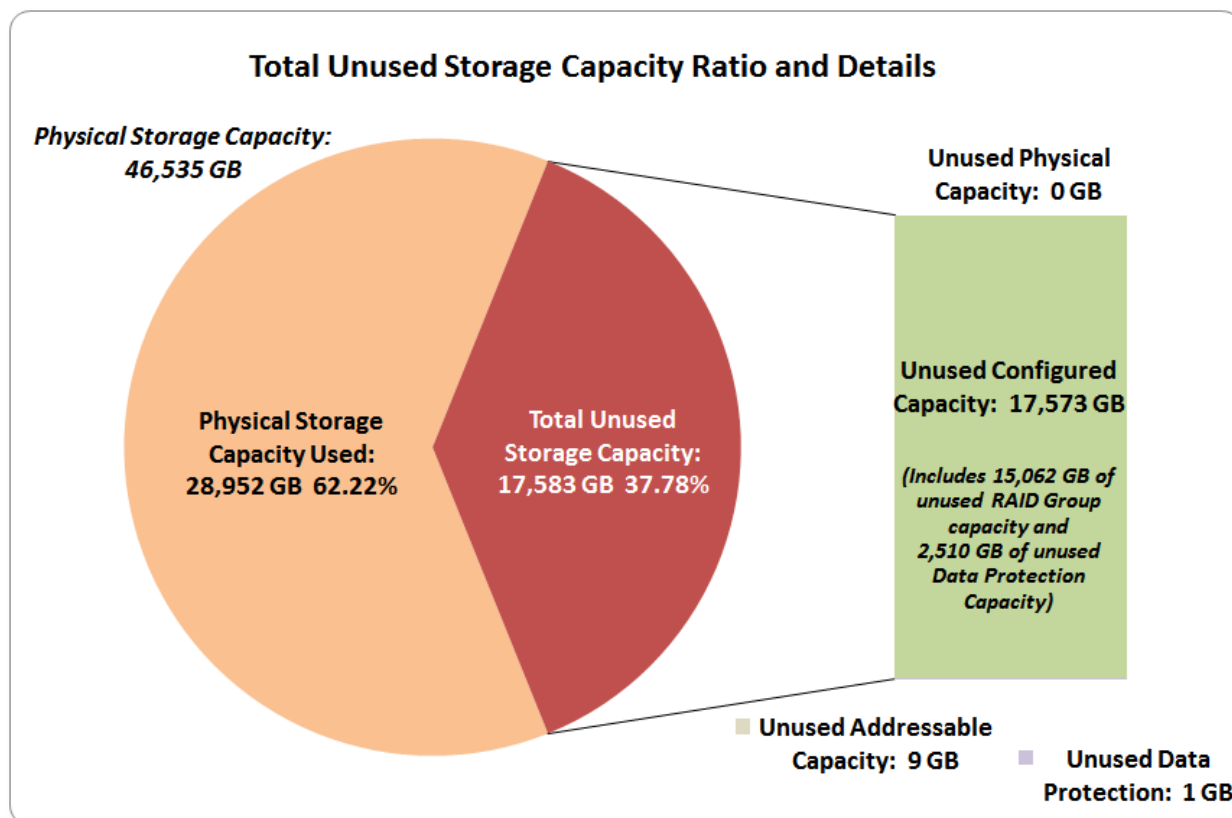
### Storage Capacities, Relationships and Utilization

The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts are listed as integer values, for readability, rather than the decimal values listed elsewhere in this document.







SPC-2 Storage Capacity Utilization	
Application Utilization	50.61%
Protected Application Utilization	59.05%
Unused Storage Ratio	37.78%

**Application Utilization:** Total ASU Capacity (GB) divided by Physical Storage Capacity (GB).

**Protected Application Utilization:** Total ASU Capacity (GB) plus total Data Protection Capacity (GB) minus unused Data Protection Capacity (GB) divided by Physical Storage Capacity (GB).

**Unused Storage Ratio:** Total Unused Capacity (GB) divided by Physical Storage Capacity (GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 25-26 in the Full Disclosure Report.



## Priced Storage Configuration Pricing

Product ID	Product Name	Qty	Unit List Price	Extended LP	Discount %	Discounted Price
ETERD200_ET203AU_182948	ETERNUS DX200 S3 Storage Array	1	\$ 107,219.00	\$107,219.00	30%	\$75,053.30
ET203AU	DX200 S3 Base System Rackmount (AC200V, 2RU) (2.5" type)	1				
ETFEADU	Drive Enclosure - DX100/200 Rackmount (AC200V, 2RU) (2.5" HDD, Dual IOM type)	6				
ETFM42U	Cache Memory - DX200 S3 8GB per CM	2				
ETFCH2F	FC Host Interface, 2 ports DX200 S3 CM & CA#0 (4/8/16Gbps, Host/Remote Connect)	2				
ETFHH2	FC Host Interface, 2 ports - CA#1 (4/8/16Gbps, Host/Remote Connect)	2				
ETFDB3	Disk Drive 2.5" 300GB/10krpm 1x	156				
ETFKM25-L	MiniSAS HD Cable 2.5m	1				
ETFKC05U	AC Power Cords (125V - IEC320-C14, 0.5m)	2				
ETFKC10U	AC Power Cords (125V - IEC320-C14, 1.0m)	3				
ETFKC15U	AC Power Cords (125V - IEC320-C14, 1.5m)	2				
ETFP16U-L	Power Distribution Unit (AC200-240V, 2U, 16 outlets)	1	\$1,370.00	\$1,370.00	30%	\$959.00
LPe16002	Emulex 16Gbps Dual Port Fibre Channel Host Bus Adapter	4	\$2,135.00	\$8,540.00	20%	\$6,832.00
61-343827-003	Fibre Channel Host IF Cable LC/LC - 3m	8	\$132.00	\$1,056.00	30%	\$739.20
	(Provide 24 hour per day / 7days per week 4 hour response maintenance for 36 months)					
ETD200-W025360-AUH	Warranty Service, 36 months Standard, 9x5 phone, NBD response	1	\$0.00	\$0.00		\$0.00
ETD200-U004361-AUH	Warranty Uplift, 36 months Enhanced plus, 24x7 4hr Onsite	1	\$16,326.00	\$16,326.00	20%	\$13,060.80

SFPs are included.

<b>Total:</b>		<b>\$96,644.30</b>
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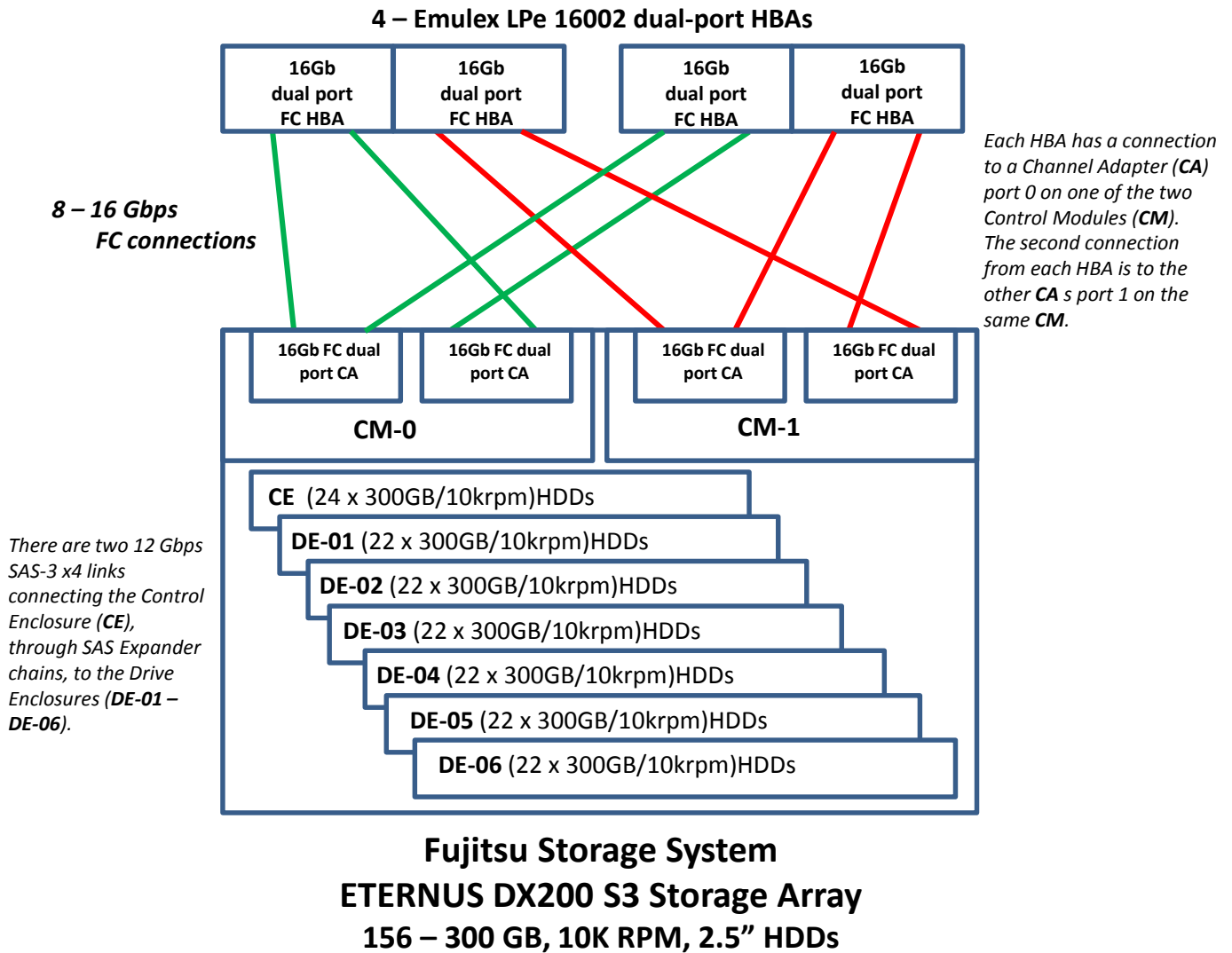
The above pricing includes the following:

- Acknowledgement of new and existing hardware and/or software problems within four hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four hours of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration component.

## Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

There were no differences between the TSC and Priced Storage Configuration.

### Priced Storage Configuration Diagram



## Priced Storage Configuration Components

Priced Storage Configuration
4 – Emulex LPe 16002 dual-port 16 Gbps FC HBAs
<b>Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array</b> 1 – DX200 S3 Control Enclosure with 2 – Control Modules (CM) each with 8 GB cache ( <i>16 GB total</i> ) 2 – Channel Adapters (CA) each with 2 16Gbps FC Host Ports ( <i>4 ports per CA, 8 ports total, 8 ports used</i> ) 1 – SAS Expander Drive Interface with QSFP 12 Gbps SAS-3 ( <i>1 – SAS-3 x4 link per interface, 2 links total, 2 links used</i> ) 24 – 300 GB, 10K RPM, 2.5" HDDs
6 – DX100/200 Drive Enclosures (DE)
156 – 300 GB 10K RPM, 2.5", HDDS ( <i>24 HDDs in the Control Enclosure,                22 HDDs in each Drive Enclosure</i> )
1 – Power Distribution Unit ( <i>AC200-240V, 2U, 16 outlets</i> )

## **CONFIGURATION INFORMATION**

This portion of the Full Disclosure Report documents and illustrates the detailed information necessary to recreate the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC), so that the SPC-2 benchmark result produced by the BC may be independently reproduced.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-2 benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

### **Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram**

#### *Clause 10.6.6*

*The FDR will contain a one page BC/TSC diagram that illustrates all major components of the BC/TSC.*

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page [21 \(Benchmark Configuration \(BC\)/Tested Storage Configuration \(TSC\) Diagram\)](#).

### **Storage Network Configuration**

#### *Clause 10.6.6.1*

*If a storage network was configured as a part of the Tested Storage Configuration and the Benchmark Configuration described in Clause 10.6.6 contains a high-level illustration of the network configuration, the Executive Summary will contain a one page topology diagram of the storage network as illustrated in Figure 10.11.*

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) was configured with local storage and, as such, did not employ a storage network.

### **Host System and Tested Storage Configuration Table**

#### *Clause 10.6.6.2*

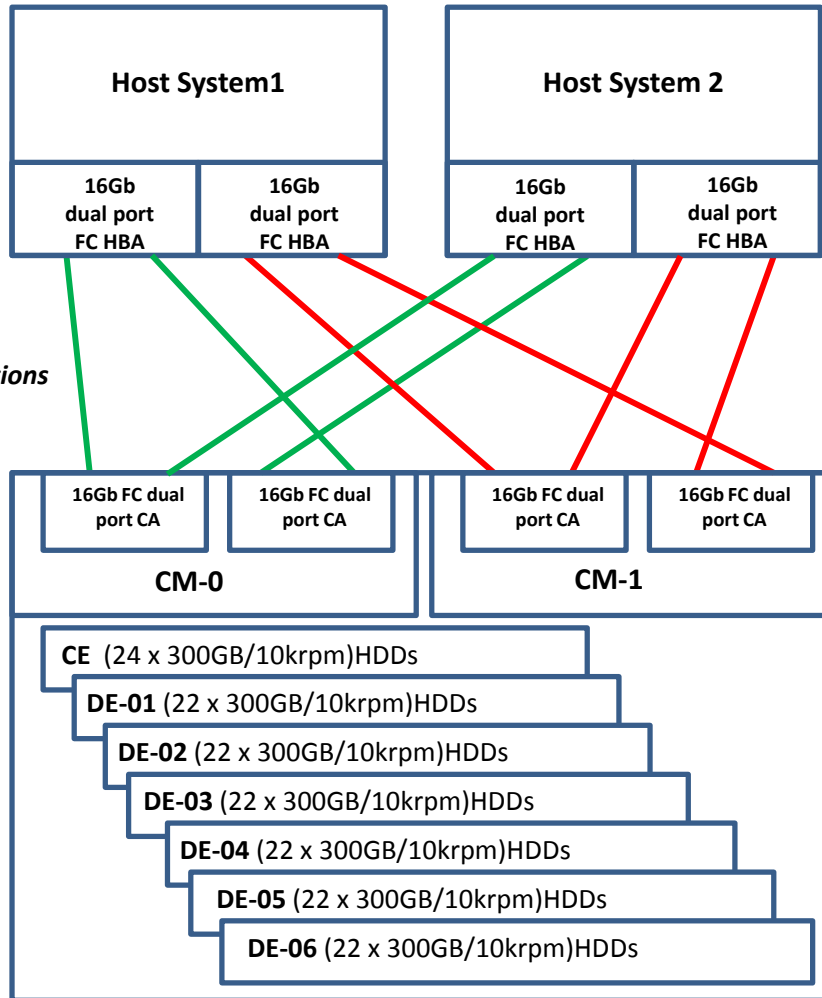
*The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration.*

The components that comprise each Host System and the Tested Storage Configuration are listed in the table that appears on page [22 \(Host System and Tested Storage Configuration Components\)](#).

**Benchmark Configuration/Tested Storage Configuration Diagram**

**2 – Fujitsu PRIMERGY RX300 S8 Servers**

**4 – Emulex LPe 16002 dual-port HBAs (2 HBAs per server)**



**8 – 16 Gbps  
FC connections**

*Each HBA has a connection to a Channel Adapter (CA) port 0 on one of the two Control Modules (CM). The second connection from each HBA is to the other CA's port 1 on the same CM.*

*There are two 12 Gbps SAS-3 x4 links connecting the Control Enclosure (CE), through SAS Expander chains, to the Drive Enclosures (DE-01 – DE-06).*

**Fujitsu Storage System  
ETERNUS DX200 S3 Storage Array  
156 – 300 GB, 10K RPM, 2.5" HDDs**

## Host System and Tested Storage Configuration Components

<p><b>Host Systems</b></p> <p><b>2 – Fujitsu PRIMERGY RX300 S8 Servers</b>, each with:</p> <ul style="list-style-type: none"> <li>2 – Intel® Xeon® E5-2697 v2 2.7 GHz processor each with 12 cores, 768 KB L1 cache, 30p72 KB L2 cache, 20720 KB L3 cache</li> <li>320 GB main memory</li> <li>Microsoft Windows Server 2008 R2 Enterprise (x64) 6.1 Build 7601, Service Pack 1</li> <li>PCI-Express 3.0</li> </ul>
<p><b>Tested Storage Configuration (TSC)</b></p> <p>4 – Emulex LPe 16002 dual-port 16 Gbps FC HBAs</p>
<p><b>Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array</b></p> <ul style="list-style-type: none"> <li>1 – DX200 S3 Control Enclosure with             <ul style="list-style-type: none"> <li>2 – Control Modules (CM) each with 8 GB cache <i>(16 GB total)</i></li> <li>2 – Channel Adapters (CA) each with 2 16Gbps FC Host Ports <i>(4 ports per CA, 8 ports total, 8 ports used)</i></li> <li>1 – SAS Expander Drive Interface with QSFP 12 Gbps SAS-3 <i>(1 – SAS-3 x4 link per interface, 2 links total, 2 links used)</i></li> </ul> </li> <li>24 – 300 GB, 10K RPM, 2.5" HDDs</li> </ul>
<p>6 – DX100/200 Drive Enclosures (DE)</p>
<p>156 – 300 GB 10K RPM, 2.5", HDDS <i>(24 HDDs in the Control Enclosure, 22 HDDs in each Drive Enclosure)</i></p>
<p>1 – Power Distribution Unit <i>(AC200-240V, 2U, 16 outlets)</i></p>

## Customer Tunable Parameters and Options

### Clause 10.6.7.1

All Benchmark Configuration (BC) components with customer tunable parameter and options that have been altered from their default values must be listed in the FDR. The FDR entry for each of those components must include both the name of the component and the altered value of the parameter or option. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use must also be included in the FDR entry.

[Appendix B: Customer Tunable Parameters and Options](#) on page 66 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

## Tested Storage Configuration (TSC) Creation and Configuration

### Clause 10.6.7.2

The Full Disclosure Report must include sufficient information to recreate the logical representation of the Tested Storage Configuration (TSC). In addition to customer tunable parameters and options (Clause 10.6.6.1), that information must include, at a minimum:

- A diagram and/or description of the following:
  - All physical components that comprise the TSC. Those components are also illustrated in the BC Configuration Diagram in Clause 10.6.5.7 and the Storage Network Configuration Diagram in Clause 10.6.5.8.
  - The logical representation of the TSC, configured from the above components that will be presented to the SPC-2 Workload Generator.
- Listings of scripts used to create the logical representation of the TSC.
- If scripts were not used, a description of the process used with sufficient detail to recreate the logical representation of the TSC.

[Appendix C: Tested Storage Configuration \(TSC\) Creation](#) on page 67 contains the detailed information that describes how to create and configure the logical TSC.

## SPC-2 Workload Generator Storage Configuration

### Clause 10.6.7.3

The Full Disclosure Report will include all SPC-2 Workload Generator storage configuration commands and parameters used in the SPC-2 benchmark measurement.

The SPC-2 Workload Generator storage configuration commands and parameters for this measurement appear in [Appendix D: SPC-2 Workload Generator Storage Commands and Parameter Files](#) on page 75.

## ASU Pre-Fill

### Clause 6.3.3

*The SPC-2 ASU is required to be completely filled with specified content prior to the execution of audited SPC-2 Tests. The content is required to consist of random data pattern such as that produced by an SPC recommended tool.*

...

### Clause 6.3.3.3

*The required ASU pre-fill must be executed as the first step in the uninterrupted benchmark execution sequence described in Clause 6.4.2. That uninterrupted sequence will consist of: ASU Pre-Fill, Large File Processing, Large Database Query, Video on Demand Delivery and Persistence Test Run 1. The only exception to this requirement is described in Clause 6.3.3.4.*

### Clause 6.3.3.4

*If approved by the Auditor, the Test Sponsor may complete the required ASU pre-fill prior to the execution of the audited SPC-2 Tests and not as part of the SPC-2 Test execution sequence.*

*The Auditor will verify the required random data pattern content in the ASU prior to the execution of the audited SPC-2 Tests. If that verification fails, the Test Sponsor is required to reload the specified content to the ASU.*

The configuration file used to complete the required ASU pre-fill appears in [Appendix D: SPC-2 Workload Generator Storage Commands and Parameter Files](#) on page [75](#).



## **SPC-2 DATA REPOSITORY**

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-2 storage capacities and mappings used in the Tested Storage Configuration. [SPC-2 Data Repository Definitions](#) on page [61](#) contains definitions of terms specific to the SPC-2 Data Repository.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-2 benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

### **SPC-2 Storage Capacities and Relationships**

#### *Clause 10.6.8.1*

*Two tables and four charts documenting the storage capacities and relationships of the SPC-2 Storage Hierarchy (Clause 2.1) shall be included in the FDR. ... The capacity value in each chart may be listed as an integer value, for readability, rather than the decimal value listed in the table below.*

#### **SPC-2 Storage Capacities**

The Physical Storage Capacity consisted of 46,534.800 GB distributed over 156 disk drives each with a formatted capacity of 298.300 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 722.531 GB (1.55%) of the Physical Storage Capacity. There was 17,572.868 GB (38.36%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 99.96% of the Addressable Storage Capacity resulting in 8.582 GB (0.04%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*RAID-5*) capacity was 6,437.082 GB of which 3,925.242 GB was utilized. The total Unused Storage was 17,582.880 GB.

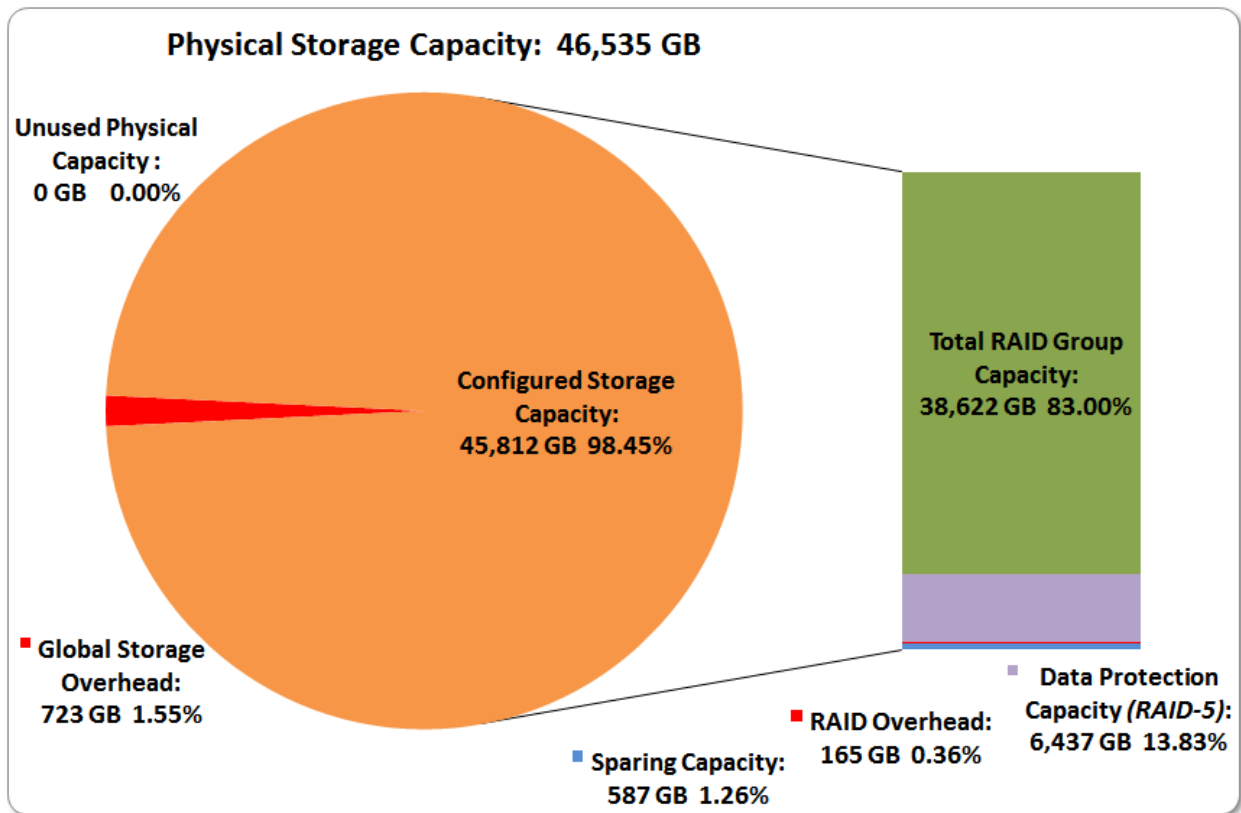
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

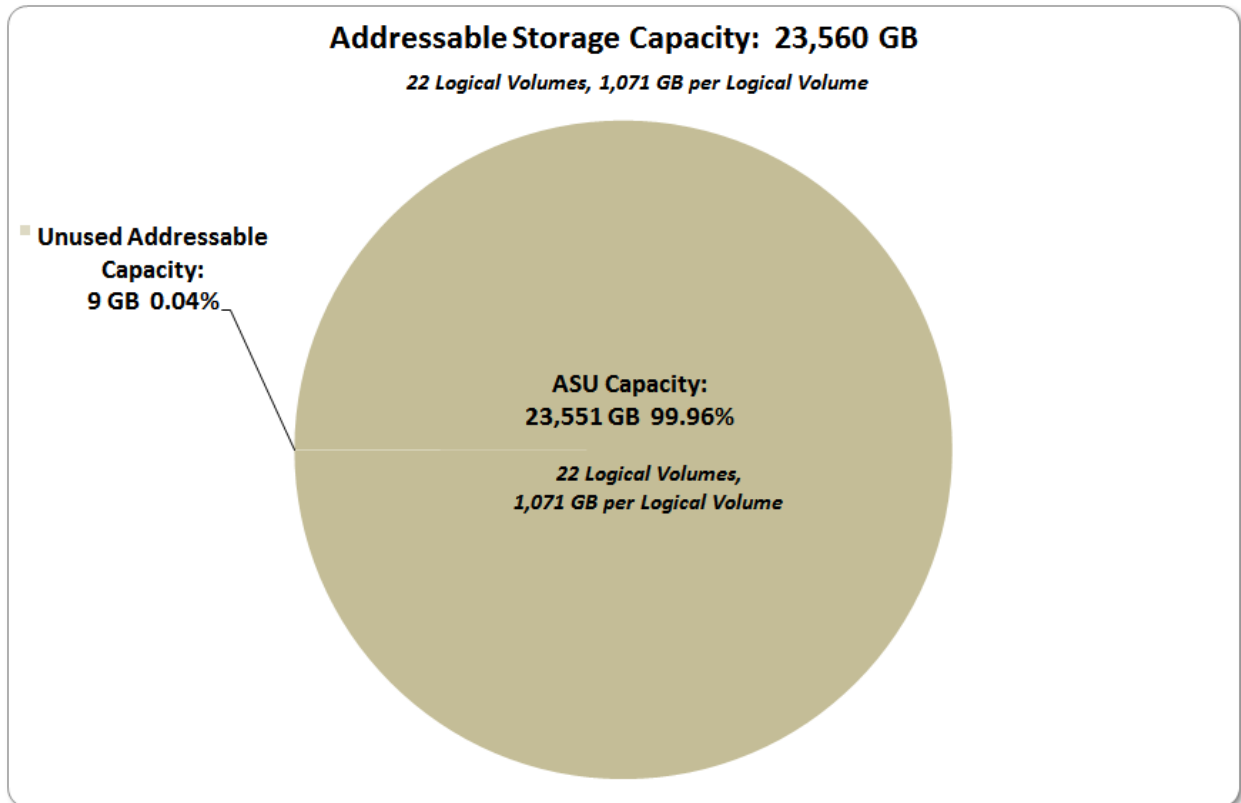
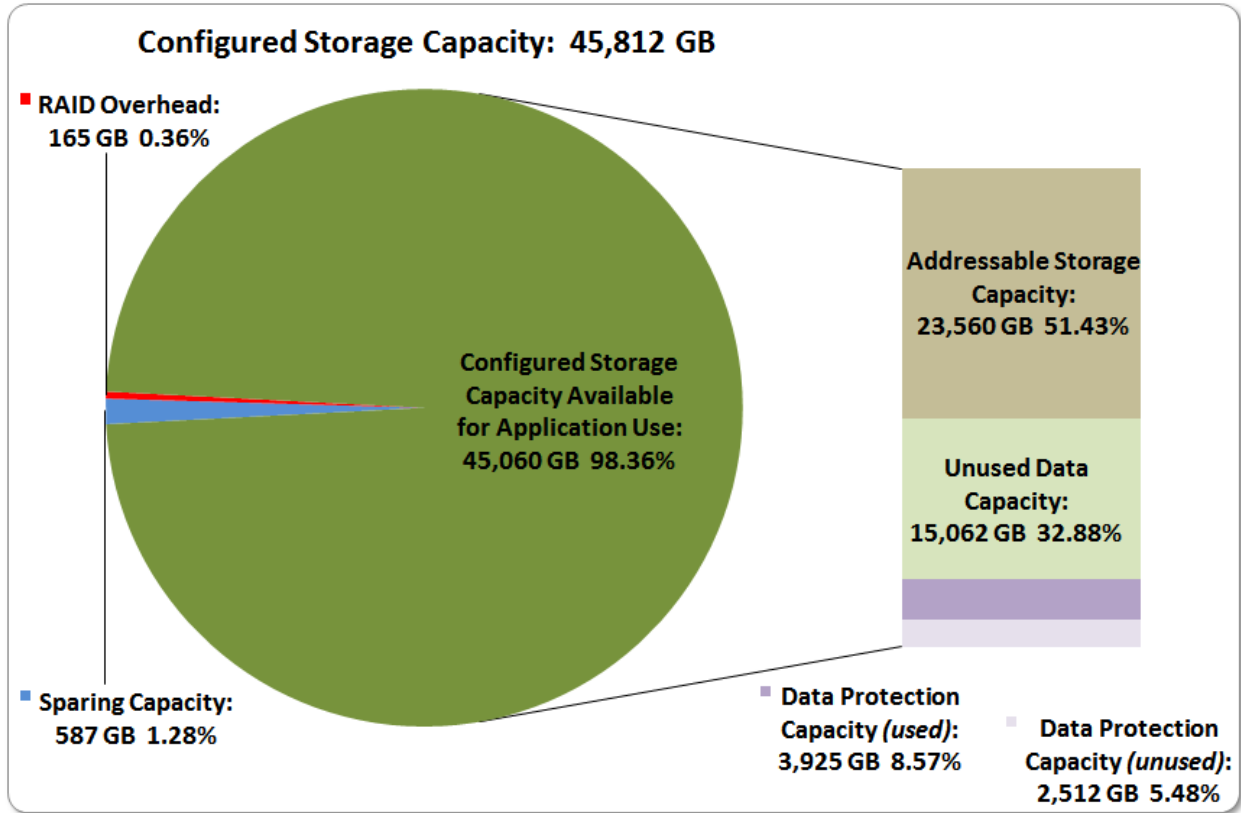
<b>SPC-2 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	23,551.453
Addressable Storage Capacity	Gigabytes (GB)	23,560.035
Configured Storage Capacity	Gigabytes (GB)	45,812.269
Physical Storage Capacity	Gigabytes (GB)	46,534.800
Data Protection ( <i>RAID-5</i> )	Gigabytes (GB)	6,437.082
Required Storage	Gigabytes (GB)	752.693
Global Storage Overhead	Gigabytes (GB)	722.531
Total Unused Storage	Gigabytes (GB)	17,582.880

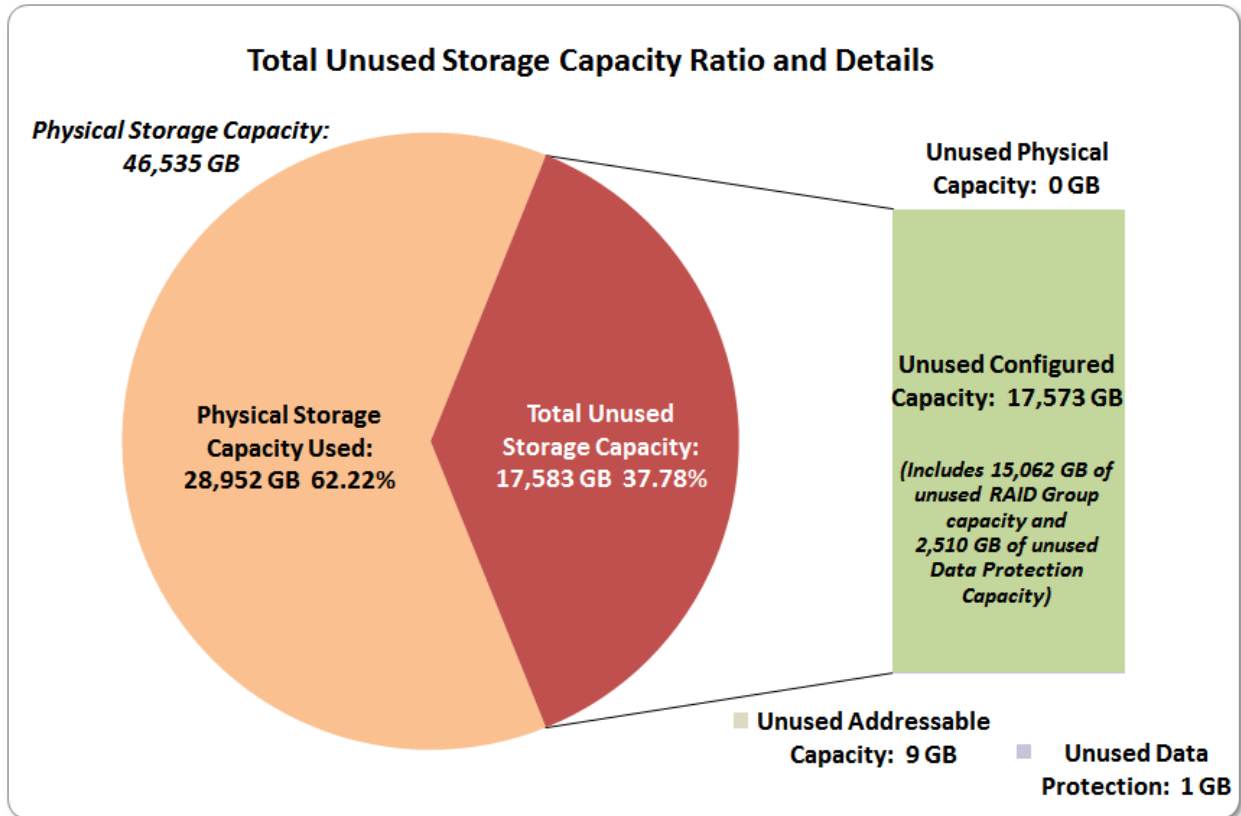
SPC-2 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
<b>Total ASU Capacity</b>	99.96%	51.41%	50.61%
<b>Data Protection (RAID-5)</b>		14.05%	13.83%
<b>Addressable Storage Capacity</b>		51.43%	50.63%
<b>Required Storage (including Sparing)</b>		1.64%	1.62%
<b>Configured Storage Capacity</b>			98.45%
<b>Global Storage Overhead</b>			1.55%
<b>Unused Storage:</b>			
<b>Addressable</b>	0.04%		
<b>Configured</b>		38.36%	
<b>Physical</b>			0.00%

SPC-1 Storage Capacity Charts







## Storage Capacity Utilization

### Clause 10.6.8.2

The FDR will include a table illustrating the storage capacity utilization values defined for Application Utilization (Clause 2.8.1), Protected Application Utilization (Clause 2.8.2), and Unused Storage Ratio (Clause 2.8.3).

### Clause 2.8.1

**Application Utilization** is defined as Total ASU Capacity divided by Physical Storage Capacity.

### Clause 2.8.2

**Protected Application Utilization** is defined as (Total ASU Capacity plus total Data Protection Capacity minus unused Data Protection Capacity) divided by Physical Storage Capacity.

### Clause 2.8.3

**Unused Storage Ratio** is defined as Total Unused Capacity divided by Physical Storage Capacity and may not exceed 45%.

SPC-2 Storage Capacity Utilization	
Application Utilization	50.61%
Protected Application Utilization	59.05%
Unused Storage Ratio	37.78%

## Logical Volume Capacity and ASU Mapping

### Clause 10.6.8.3

A table illustrating the capacity of the Application Storage Unit (ASU) and the mapping of Logical Volumes to ASU will be provided in the FDR. Capacity must be stated in gigabytes (GB) as a value with a minimum of two digits to the right of the decimal point. Each Logical Volume will be sequenced in the table from top to bottom per its position in the contiguous address space of the ASU. Each Logical Volume entry will list its total capacity, the portion of that capacity used for the ASU, and any unused capacity.

<b>Logical Volume (LV) Capacity and Mapping</b>			
<b>ASU (23m551,453 GB)</b>			
	<b>Total Capacity (GB)</b>	<b>Capacity Used (GB)</b>	<b>Capacity Unused (GB)</b>
22 Logical Volumes	1,070.911 per LV	1,070.521 per LV	0.390 per LV

See the Storage Definition (sd) entries in [Appendix D: SPC-2 Workload Generator Storage Commands and Parameter](#) Files on page [75](#) for more detailed configuration information.

## **SPC-2 BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-2 Tests, Test Phases, Test Run Sequences, and Test Runs. An [SPC-2 glossary](#) on page [61](#) contains definitions of terms specific to the SPC-2 Data Repository.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-2 benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

### **SPC-2 Tests, Test Phases, Test Run Sequences, and Test Runs**

The SPC-2 benchmark consists of the following Tests, Test Phases, Test Run Sequences, and Test Runs:

- **Data Persistence Test**
  - Data Persistence Test Run 1
  - Data Persistence Test Run 2
- **Large File Processing Test**
  - WRITE ONLY Test Phase
    - Test Run Sequence 1
      - ✓ Test Run 1 – 1024 KiB Transfer – maximum number of Streams
      - ✓ Test Run 2 – 1024 KiB Transfer – 50% of Test Run 1’s Streams value
      - ✓ Test Run 3 – 1024 KiB Transfer – 25% of Test Run 1’s Streams value
      - ✓ Test Run 4 – 1024 KiB Transfer – 12.5% of Test Run 1’s Streams value
      - ✓ Test Run 5 – 1024 KiB Transfer – single (1) Stream
    - Test Run Sequence 2
      - ✓ Test Run 6 – 256 KiB Transfer – maximum number of Streams
      - ✓ Test Run 7 – 256 KiB Transfer – 50% of Test Run 6’s Streams value
      - ✓ Test Run 8 – 256 KiB Transfer – 25% of Test Run 6’s Streams value
      - ✓ Test Run 9 – 256 KiB Transfer – 12.5% of Test Run 6’s Streams value
      - ✓ Test Run 10 – 256 KiB Transfer – single (1) Stream
  - READ-WRITE Test Phase
    - Test Run Sequence 3
      - ✓ Test Run 11 – 1024 KiB Transfer – maximum number of Streams
      - ✓ Test Run 12 – 1024 KiB Transfer – 50% of Test Run 11’s Streams value
      - ✓ Test Run 13 – 1024 KiB Transfer – 25% of Test Run 11’s Streams value
      - ✓ Test Run 14 – 1024 KiB Transfer – 12.5% of Test Run 11’s Streams value
      - ✓ Test Run 15 – 1024 KiB Transfer – single (1) Stream
    - Test Run Sequence 4
      - ✓ Test Run 16 – 256 KiB Transfer – maximum number of Streams
      - ✓ Test Run 17 – 256 KiB Transfer – 50% of Test Run 16’s Streams value
      - ✓ Test Run 18 – 256 KiB Transfer – 25% of Test Run 16’s Streams value
      - ✓ Test Run 19 – 256 KiB Transfer – 12.5% of Test Run 16’s Streams value
      - ✓ Test Run 20 – 256 KiB Transfer – single (1) Stream
  - READ ONLY Test Phase
    - Test Run Sequence 5
      - ✓ Test Run 21 – 1024 KiB Transfer – maximum number of Streams

- ✓ Test Run 22 – 1024 KiB Transfer – 50% of Test Run 21’s Streams value
- ✓ Test Run 23 – 1024 KiB Transfer – 25% of Test Run 21’s Streams value
- ✓ Test Run 24 – 1024 KiB Transfer – 12.5% of Test Run 21’s Streams value
- ✓ Test Run 25 – 1024 KiB Transfer – single (1) Stream
- Test Run Sequence 6
  - ✓ Test Run 26 – 256 KiB Transfer – maximum number of Streams
  - ✓ Test Run 27 – 256 KiB Transfer – 50% of Test Run 26’s Streams value
  - ✓ Test Run 28 – 256 KiB Transfer – 25% of Test Run 26’s Streams value
  - ✓ Test Run 29 – 256 KiB Transfer – 12.5% of Test Run 26’s Streams value
  - ✓ Test Run 30 – 256 KiB Transfer – single (1) Stream
- **Large Database Query Test**
  - 1024 KIB TRANSFER SIZE Test Phase
    - Test Run Sequence 1
      - ✓ Test Run 1 – 4 I/O Requests Outstanding – maximum number of Streams
      - ✓ Test Run 2 – 4 I/O Requests Outstanding – 50% of Test Run 1’s Streams value
      - ✓ Test Run 3 – 4 I/O Requests Outstanding – 25% of Test Run 1’s Streams value
      - ✓ Test Run 4 – 4 I/O Requests Outstanding – 12.5% of Test Run 1’s Streams value
      - ✓ Test Run 5 – 4 I/O Requests Outstanding – single (1) Stream
    - Test Run Sequence 2
      - ✓ Test Run 6 – 1 I/O Request Outstanding – maximum number of Streams
      - ✓ Test Run 7 – 1 I/O Request Outstanding – 50% of Test Run 6’s Streams value
      - ✓ Test Run 8 – 1 I/O Request Outstanding – 25% of Test Run 6’s Streams value
      - ✓ Test Run 9 – 1 I/O Request Outstanding – 12.5% of Test Run 6’s Streams value
      - ✓ Test Run 10 – 1 I/O Request Outstanding – single (1) Stream
  - 64 KIB TRANSFER SIZE Test Phase
    - Test Run Sequence 3
      - ✓ Test Run 11 – 4 I/O Requests Outstanding – maximum number of Streams
      - ✓ Test Run 12 – 4 I/O Requests Outstanding – 50% of Test Run 11’s Streams value
      - ✓ Test Run 13 – 4 I/O Requests Outstanding – 25% of Test Run 11’s Streams value
      - ✓ Test Run 14 – 4 I/O Requests Outstanding – 12.5% of Test Run 11’s Streams value
      - ✓ Test Run 15 – 4 I/O Requests Outstanding – single (1) Stream
    - Test Run Sequence 4
      - ✓ Test Run 16 – 1 I/O Request Outstanding – maximum number of Streams
      - ✓ Test Run 17 – 1 I/O Request Outstanding – 50% of Test Run 16’s Streams value
      - ✓ Test Run 18 – 1 I/O Request Outstanding – 25% of Test Run 16’s Streams value
      - ✓ Test Run 19 – 1 I/O Request Outstanding – 12.5% of Test Run 16’s Streams value
      - ✓ Test Run 20 – 1 I/O Request Outstanding – single (1) Stream
- **Video on Demand Delivery Test**
  - Video on Demand Delivery Test Run

Each Test is an atomic unit that must be executed from start to finish before any other Test, Test Phase, or Test Run may be executed. The Tests may be executed in any sequence.

The results from each Test, Test Phase, and Test Run are listed below along with a more detailed explanation of each component.

## Large File Processing Test

### Clause 6.4.3.1

*The Large File Processing Test consists of the I/O operations associated with the type of applications, in a wide range of fields, which require simple sequential processing of one or more large files. Specific examples of those types of applications include scientific computing and large-scale financial processing*

### Clause 6.4.3.2

*The Large File Processing Test has three Test Phases, which shall be executed in the following uninterrupted sequence:*

1. *WRITE ONLY*
2. *READ-WRITE*
3. *READ ONLY*

*The BC shall not be restarted or manually disturbed, altered, or adjusted during the execution of the Large File Processing Test. If power is lost to the BC during this Test all results shall be rendered invalid and the Test re-run in its entirety.*

### Clause 10.6.9.1

*The Full Disclosure Report will contain the following content for the Large File Processing Test:*

1. *A listing of the SPC-2 Workload Generator commands and parameters used to execute each of the Test Runs in the Large File Processing Test.*
2. *The human readable SPC-2 Test Results File for each of the Test Runs in the Large File Processing Test.*
3. *The following three tables:*
  - *Average Data Rate: The average Data Rate, in MB per second for the Measurement Interval of each Test Run in the Large File Processing Test.*
  - *Average Data Rate per Stream: The average Data Rate per Stream, in MB per second, for the Measurement Interval of each Test Run in the Large File Processing Test.*
  - *Average Response Time: The average response time, in milliseconds (ms), for the Measurement Interval of each Test Run in the Large File Processing Test.*
4. *Average Data Rate, Average Data Rate per Stream and Average Response Time graphs as defined in Clauses 10.1.1, 10.1.2 and 10.1.3.*

## SPC-2 Workload Generator Commands and Parameters

The SPC-2 Workload Generator commands and parameters for the Large File Processing Test Runs are documented in [Appendix E: SPC-2 Workload Generator Execution Commands and Parameters](#) on Page [81](#).



### SPC-2 Test Results File

A link to the SPC-2 Test Results file generated from the Large File Processing Test Runs is listed below.

[SPC-2 Large File Processing Test Results File](#)

### SPC-2 Large File Processing Average Data Rates (MB/s)

The average Data Rate (MB/s) for each Test Run in the three Test Phases of the SPC-2 Large File Processing Test is listed in the table below as well as illustrated in the following graph.

<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
Write 1024KiB	635.04	1,897.67	2,636.19	3,554.74	4,152.50
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
Write 256KiB	391.14	2,766.83	3,698.03	4,176.40	4,209.62
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>
Read/Write 1024KiB	708.12	3,696.75	4,434.74	4,928.18	5,261.03
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>18 Streams</b>	<b>36 Streams</b>	<b>72 Streams</b>	<b>144 Streams</b>
Read/Write 256KiB	417.36	3,924.16	4,060.91	4,315.94	5,114.87
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
Read 1024KiB	787.60	2,979.10	4,952.45	6,618.26	6,951.44
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
Read 256KiB	435.18	5,699.67	6,910.66	6,921.51	6,925.44

**SPC-2 Large File Processing Average Data Rates Graph**

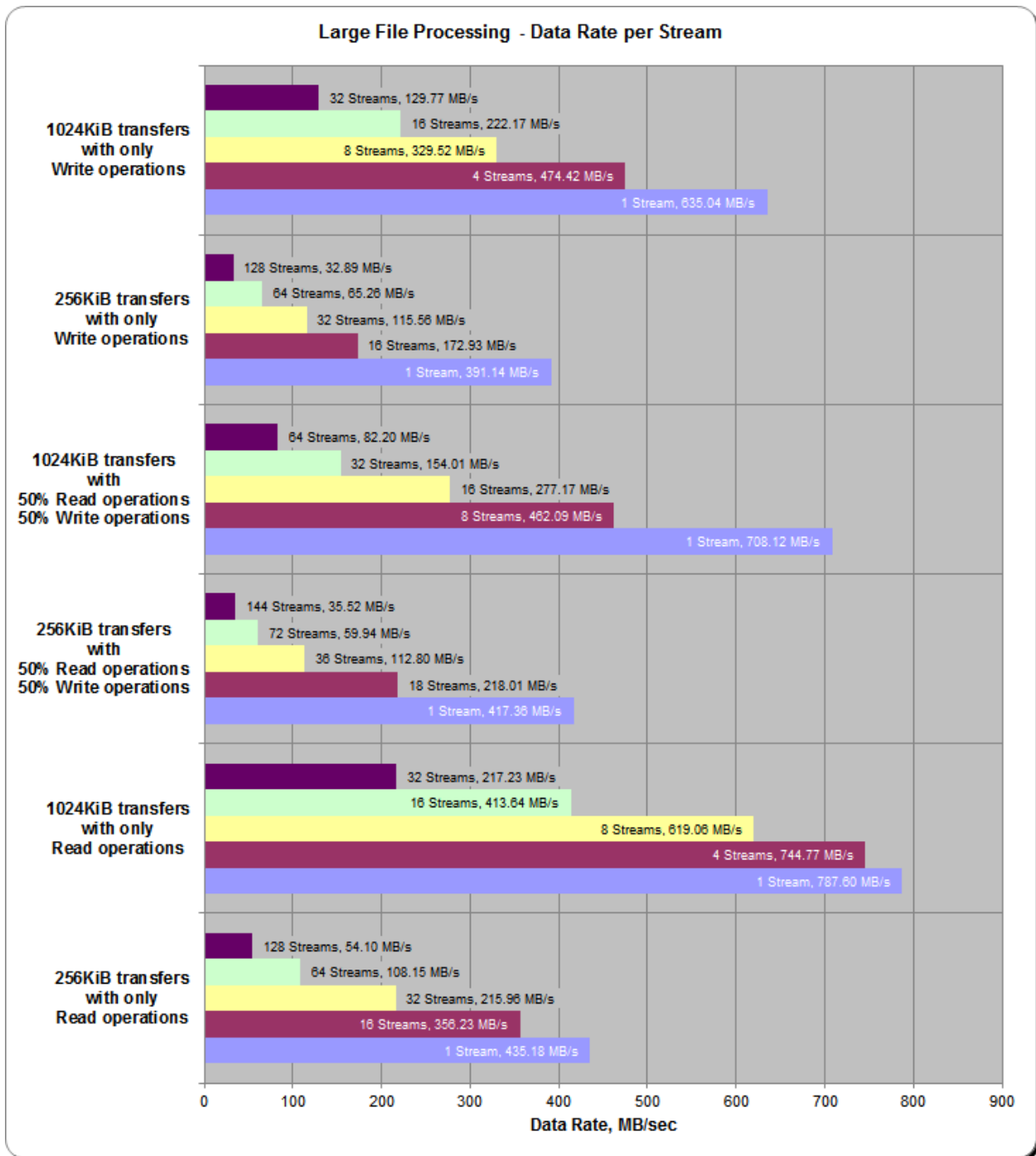


**SPC-2 Large File Processing Average Data Rate per Stream**

The average Data Rate per Stream for each Test Run in the three Test Phases of the SPC-2 Large File Processing Test is listed in the table below as well as illustrated in the following graph.

<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
Write 1024KiB	635.04	474.42	329.52	222.17	129.77
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
Write 256KiB	391.14	172.93	115.56	65.26	32.89
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>
Read/Write 1024KiB	708.12	462.09	277.17	154.01	82.20
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>18 Streams</b>	<b>36 Streams</b>	<b>72 Streams</b>	<b>144 Streams</b>
Read/Write 256KiB	417.36	218.01	112.80	59.94	35.52
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
Read 1024KiB	787.60	744.77	619.06	413.64	217.23
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
Read 256KiB	435.18	356.23	215.96	108.15	54.10

**SPC-2 Large File Processing Average Data Rate per Stream Graph**

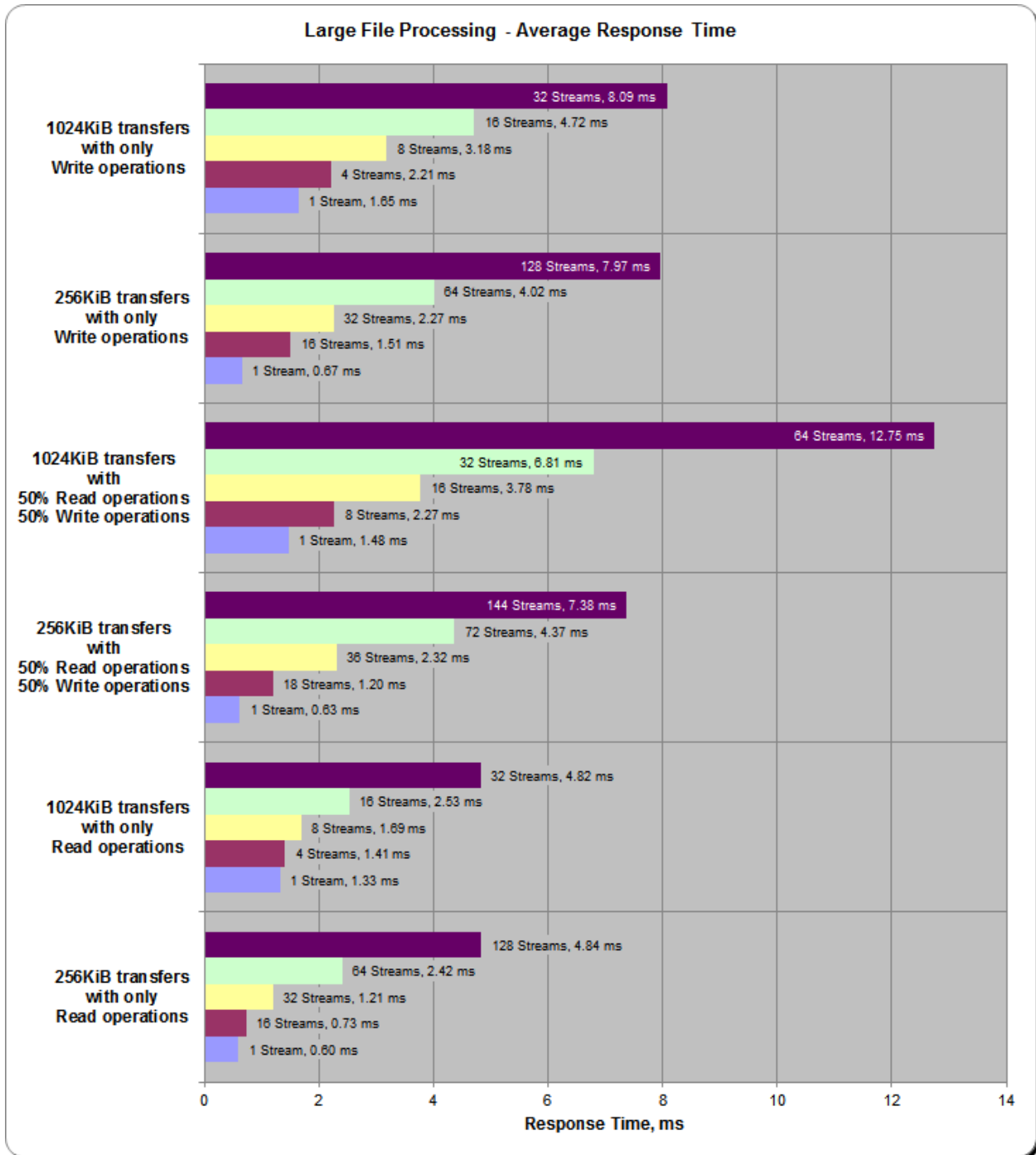


### SPC-2 Large File Processing Average Response Time

The average Response Time, milliseconds (ms), for each Test Run in the three Test Phases of the SPC-2 Large File Processing Test is listed in the table below as well as illustrated in the following graph.

<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
Write 1024KiB	1.65	2.21	3.18	4.72	8.09
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
Write 256KiB	0.67	1.51	2.27	4.02	7.97
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>
Read/Write 1024KiB	1.48	2.27	3.78	6.81	12.75
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>18 Streams</b>	<b>36 Streams</b>	<b>72 Streams</b>	<b>144 Streams</b>
Read/Write 256KiB	0.63	1.20	2.32	4.37	7.38
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
Read 1024KiB	1.33	1.41	1.69	2.53	4.82
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
Read 256KiB	0.60	0.73	1.21	2.42	4.84

**SPC-2 Large File Processing Average Response Time Graph**



## Large File Processing Test – WRITE ONLY Test Phase

### Clause 10.6.9.1.1

1. *A table that will contain the following information for each "WRITE ONLY, 1024 KiB Transfer Size" Test Run:*
  - *The number of Streams specified.*
  - *The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.*
2. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "WRITE ONLY, 1024 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "WRITE ONLY, 256 KiB Transfer Size" Test Run:*
  - *The number of Streams specified.*
  - *The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.*
4. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "WRITE ONLY, 256 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

*A hyperlink for each of the above tables and graphs may appear in the FDR to provide access to the table or graph.*

A hyperlink to a table with the SPC-2 "Large File Processing/WRITE ONLY/1024 KiB Transfer Size" Test Run data appears on the next page. That entry is followed by hyperlinks to graphs illustrating the average Data Rate, average Data Rate per Stream, and average Response Time produced by the same Test Runs. The table and graphs present the data at five-second intervals.

Immediately following the above SPC-2 "Large File Processing/WRITE ONLY/1024 KiB Transfer Size" entries will be hyperlinks for SPC-2 "Large File Processing/WRITE ONLY/256 KiB Transfer Size" table and graphs. The table contains the Test Run data and the graphs illustrate the average Data Rate, average Data Rate per Stream, and average Response Time produced by the Test Runs.

**SPC-2 “Large File Processing/WRITE ONLY/1024 KiB Transfer Size” Test Run Data**

[SPC-2 “Large File Processing/WRITE ONLY/1024 KiB Transfer Size” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

**SPC-2 “Large File Processing/WRITE ONLY/1024 KiB Transfer Size” Graphs**

**Average Data Rate – Complete Test Run**

**Average Data Rate – Measurement Interval (MI) Only**

**Average Data Rate per Stream**

**Average Response Time**

[SPC-2 “Large File Processing/WRITE ONLY/1024 KiB Transfer Size” graphs](#)  
(four pages, 1 graph per page)

**SPC-2 “Large File Processing/WRITE ONLY/256 KiB Transfer Size” Test Run Data**

[SPC-2 “Large File Processing/WRITE ONLY/256 KiB Transfer Size” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

**SPC-2 “Large File Processing/WRITE ONLY/256 KiB Transfer Size” Graphs**

**Average Data Rate – Complete Test Run**

**Average Data Rate – Measurement Interval (MI) Only**

**Average Data Rate per Stream**

**Average Response Time**

[SPC-2 “Large File Processing/WRITE ONLY/256 KiB Transfer Size” graphs](#)  
(four pages, 1 graph per page)



## Large File Processing Test – READ-WRITE Test Phase

### Clause 10.6.9.1.2

1. *A table that will contain the following information for each "READ-WRITE, 1024 KiB Transfer Size" Test Run:*
  - *The number of Streams specified.*
  - *The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.*
2. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "READ-WRITE, 1024 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "READ-WRITE, 256 KiB Transfer Size" Test Run:*
  - *The number of Streams specified.*
  - *The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.*
4. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "READ-WRITE, 256 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

*A hyperlink for each of the above tables and graphs may appear in the FDR to provide access to the table or graph.*

A hyperlink to a table with the SPC-2 "Large File Processing/READ-WRITE/1024 KiB Transfer Size" Test Run data appears on the next page. That entry is followed by hyperlinks to graphs illustrating the average Data Rate, average Data Rate per Stream, and average Response Time produced by the same Test Runs. The table and graphs present the data at five-second intervals.

Immediately following the above SPC-2 "Large File Processing/READ-WRITE/1024 KiB Transfer Size" entries will be hyperlinks for SPC-2 "Large File Processing/READ-WRITE/256 KiB Transfer Size" table and graphs. The table contains the Test Run data and the graphs illustrate the average Data Rate, average Data Rate per Stream, and average Response Time produced by the Test Runs.

## SPC-2 “Large File Processing/READ-WRITE/1024 KiB Transfer Size” Test Run Data

[SPC-2 “Large File Processing/READ-WRITE/1024 KiB Transfer Size” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

## SPC-2 “Large File Processing/READ-WRITE/1024 KiB Transfer Size” Graphs

Average Data Rate – Complete Test Run

Average Data Rate – Measurement Interval (MI) Only

Average Data Rate per Stream

Average Response Time

[SPC-2 “Large File Processing/READ-WRITE/1024 KiB Transfer Size” graphs](#)  
(four pages, 1 graph per page)

## SPC-2 “Large File Processing/READ-WRITE/256 KiB Transfer Size” Test Run Data

[SPC-2 “Large File Processing/READ-WRITE/256 KiB Transfer Size” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

## SPC-2 “Large File Processing/READ-WRITE/256 KiB Transfer Size” Graphs

Average Data Rate – Complete Test Run

Average Data Rate – Measurement Interval (MI) Only

Average Data Rate per Stream

Average Response Time

[SPC-2 “Large File Processing/READ-WRITE/256 KiB Transfer Size” graphs](#)  
(four pages, 1 graph per page)

## Large File Processing Test – READ ONLY Test Phase

### Clause 10.6.9.1.3

1. *A table that will contain the following information for each "READ ONLY, 1024 KiB Transfer Size" Test Run:*
  - *The number of Streams specified.*
  - *The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.*
2. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "READ ONLY, 1024 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "READ ONLY, 256 KiB Transfer Size" Test Run:*
  - *The number of Streams specified.*
  - *The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.*
4. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "READ ONLY, 256 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

*A hyperlink for each of the above tables and graphs may appear in the FDR to provide access to the table or graph.*

A hyperlink to a table with the SPC-2 "Large File Processing/READ ONLY/1024 KiB Transfer Size" Test Run data appears on the next page. That entry is followed by hyperlinks to graphs illustrating the average Data Rate, average Data Rate per Stream, and average Response Time produced by the same Test Runs. The table and graphs present the data at five-second intervals.

Immediately following the above SPC-2 "Large File Processing/READ ONLY/1024 KiB Transfer Size" entries will be hyperlinks for SPC-2 "Large File Processing/READ ONLY/256 KiB Transfer Size" table and graphs. The table contains the Test Run data and the graphs illustrate the average Data Rate, average Data Rate per Stream, and average Response Time produced by the Test Runs.

## SPC-2 “Large File Processing/READ ONLY/1024 KiB Transfer Size” Test Run Data

[SPC-2 “Large File Processing/READ ONLY/1024 KiB Transfer Size” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

## SPC-2 “Large File Processing/READ ONLY/1024 KiB Transfer Size” Graphs

Average Data Rate – Complete Test Run

Average Data Rate – Measurement Interval (MI) Only

Average Data Rate per Stream

Average Response Time

[SPC-2 “Large File Processing/READ ONLY/1024 KiB Transfer Size” graphs](#)  
(four pages, 1 graph per page)

## SPC-2 “Large File Processing/READ ONLY/256 KiB Transfer Size” Test Run Data

[SPC-2 “Large File Processing/READ ONLY/256 KiB Transfer Size” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

## SPC-2 “Large File Processing/READ ONLY/256 KiB Transfer Size” Graphs

Average Data Rate – Complete Test Run

Average Data Rate – Measurement Interval (MI) Only

Average Data Rate per Stream

Average Response Time

[SPC-2 “Large File Processing/READ ONLY/256 KiB Transfer Size” graphs](#)  
(four pages, 1 graph per page)

## Large Database Query Test

### Clause 6.4.4.1

*The Large Database Query Test is comprised of a set of I/O operations representative of scans or joins of large relational tables such as those performed for data mining or business intelligence.*

### Clause 6.4.4.2

*The Large Database Query Test has two Test Phases, which shall be executed in the following uninterrupted sequence:*

- 1. 1024 KiB TRANSFER SIZE*
- 2. 64 KiB TRANSFER SIZE*

*The BC shall not be restarted or manually disturbed, altered, or adjusted during the execution of the Large File Processing Test. If power is lost to the BC during this Test all results shall be rendered invalid and the Test re-run in its entirety.*

### Clause 10.6.9.2

*The Full Disclosure Report will contain the following content for the Large Database Query Test:*

- 1. A listing of the SPC-2 Workload Generator commands and parameters used to execute each of the Test Runs in the Large Database Query Test.*
- 2. The human readable SPC-2 Test Results File for each of the Test Runs in the Large Database Query Test.*
- 3. A table that contains the following information for each Test Run in the two Test Phases of the Large Database Query Test:*
  - Average Data Rate: The average Data Rate, in MB per second for the Measurement Interval of each Test Run in the Large Database Query Test.*
  - Average Data Rate per Stream: The average Data Rate per Stream, in MB per second, for the Measurement Interval of each Test Run in the Large Database Query Test.*
  - Average Response Time: The average response time, in milliseconds (ms), for the Measurement Interval of each Test Run in the Large Database Query Test.*
- 4. Average Data Rate, Average Data Rate per Stream and Average Response time graphs as defined in Clauses 10.1.1, 10.1.2 and 10.1.3.*

## SPC-2 Workload Generator Commands and Parameters

The SPC-2 Workload Generator commands and parameters for the Large Database Query Test Runs are documented in [Appendix E: SPC-2 Workload Generator Execution Commands and Parameters](#) on Page [81](#).

## SPC-2 Test Results File

A link to the SPC-2 Test Results file generated from the Large Database Query Test Runs is listed below.

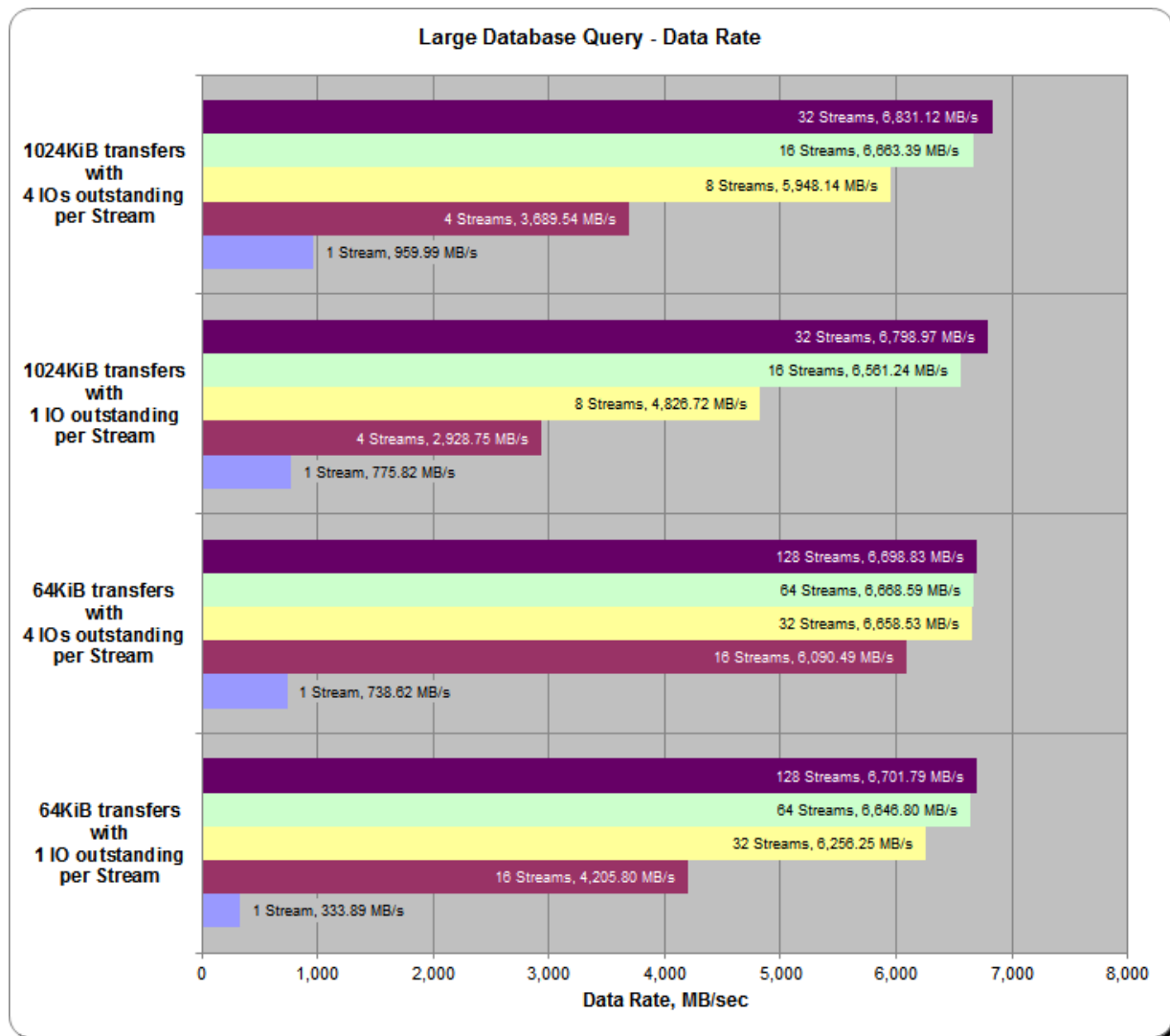
### [SPC-2 Large Database Query Test Results File](#)

### SPC-2 Large Database Query Average Data Rates (MB/s)

The average Data Rate (MB/s) for each Test Run in the two Test Phases of the SPC-2 Large Database Query Test is listed in the table below as well as illustrated in the following graph.

<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
1024KiB w/ 4 IOs/Stream	959.99	3,689.54	5,948.14	6,663.39	6,831.12
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>4 Streams</b>	<b>8 Streams</b>	<b>16 Streams</b>	<b>32 Streams</b>
1024KiB w/ 1 IO/Stream	775.82	2,928.75	4,826.72	6,561.24	6,798.97
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
64KiB w/ 4 IOs/Stream	738.62	6,090.49	6,658.53	6,668.59	6,698.83
<b>Test Run Sequence</b>	<b>1 Stream</b>	<b>16 Streams</b>	<b>32 Streams</b>	<b>64 Streams</b>	<b>128 Streams</b>
64KiB w/ 1 IO/Stream	333.89	4,205.80	6,256.25	6,646.80	6,701.79

### SPC-2 Large Database Query Average Data Rates Graph

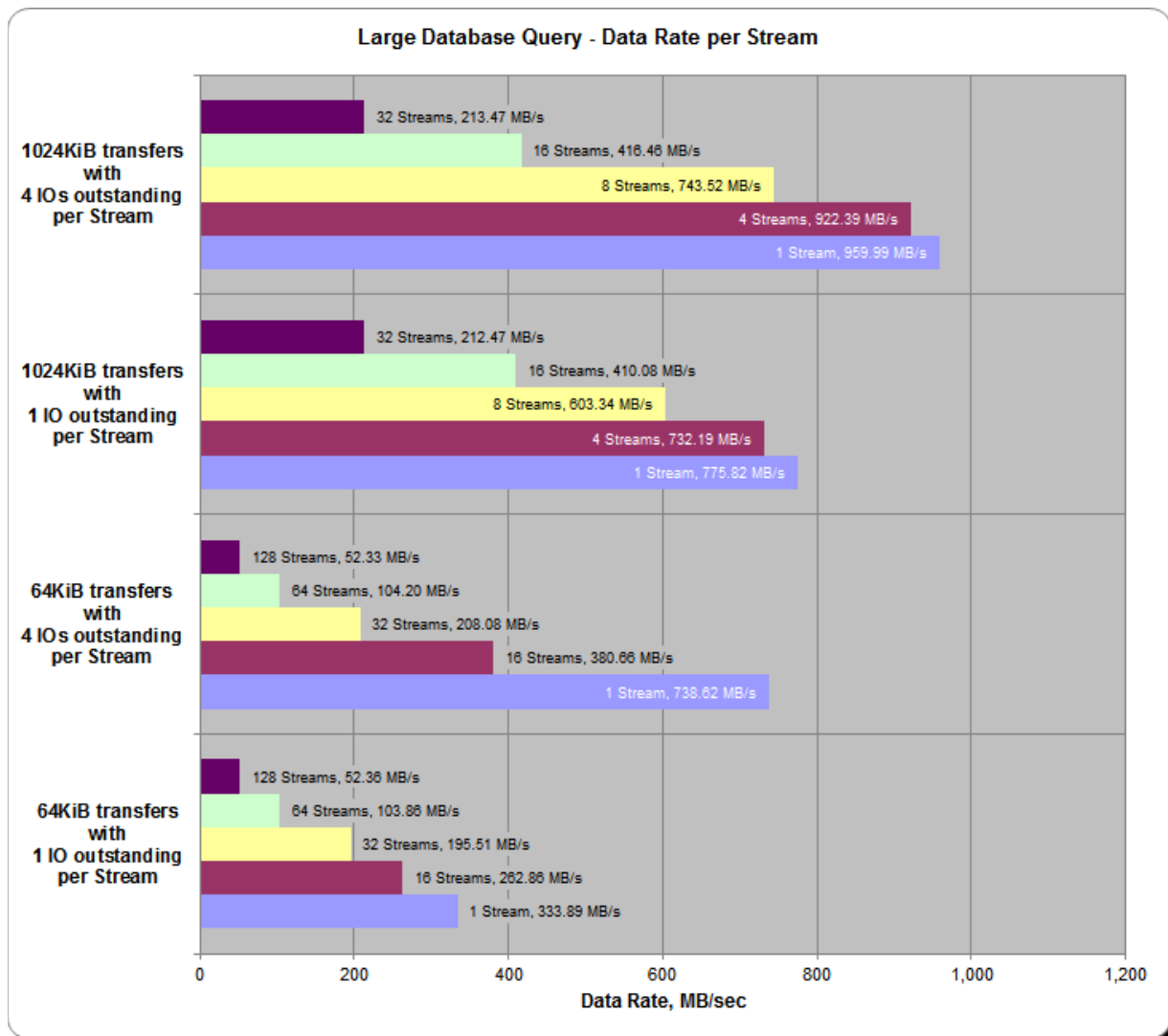


### SPC-2 Large Database Query Average Data Rate per Stream

The average Data Rate per Stream for each Test Run in the two Test Phases of the SPC-2 Large Database Query Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	4 Streams	8 Streams	16 Streams	32 Streams
1024KiB w/ 4 IOs/Stream	959.99	922.39	743.52	416.46	213.47
Test Run Sequence	1 Stream	4 Streams	8 Streams	16 Streams	32 Streams
1024KiB w/ 1 IO/Stream	775.82	732.19	603.34	410.08	212.47
Test Run Sequence	1 Stream	16 Streams	32 Streams	64 Streams	128 Streams
64KiB w/ 4 IOs/Stream	738.62	380.66	208.08	104.20	52.33
Test Run Sequence	1 Stream	16 Streams	32 Streams	64 Streams	128 Streams
64KiB w/ 1 IO/Stream	333.89	262.86	195.51	103.86	52.36

### SPC-2 Large Database Query Average Data Rate per Stream Graph

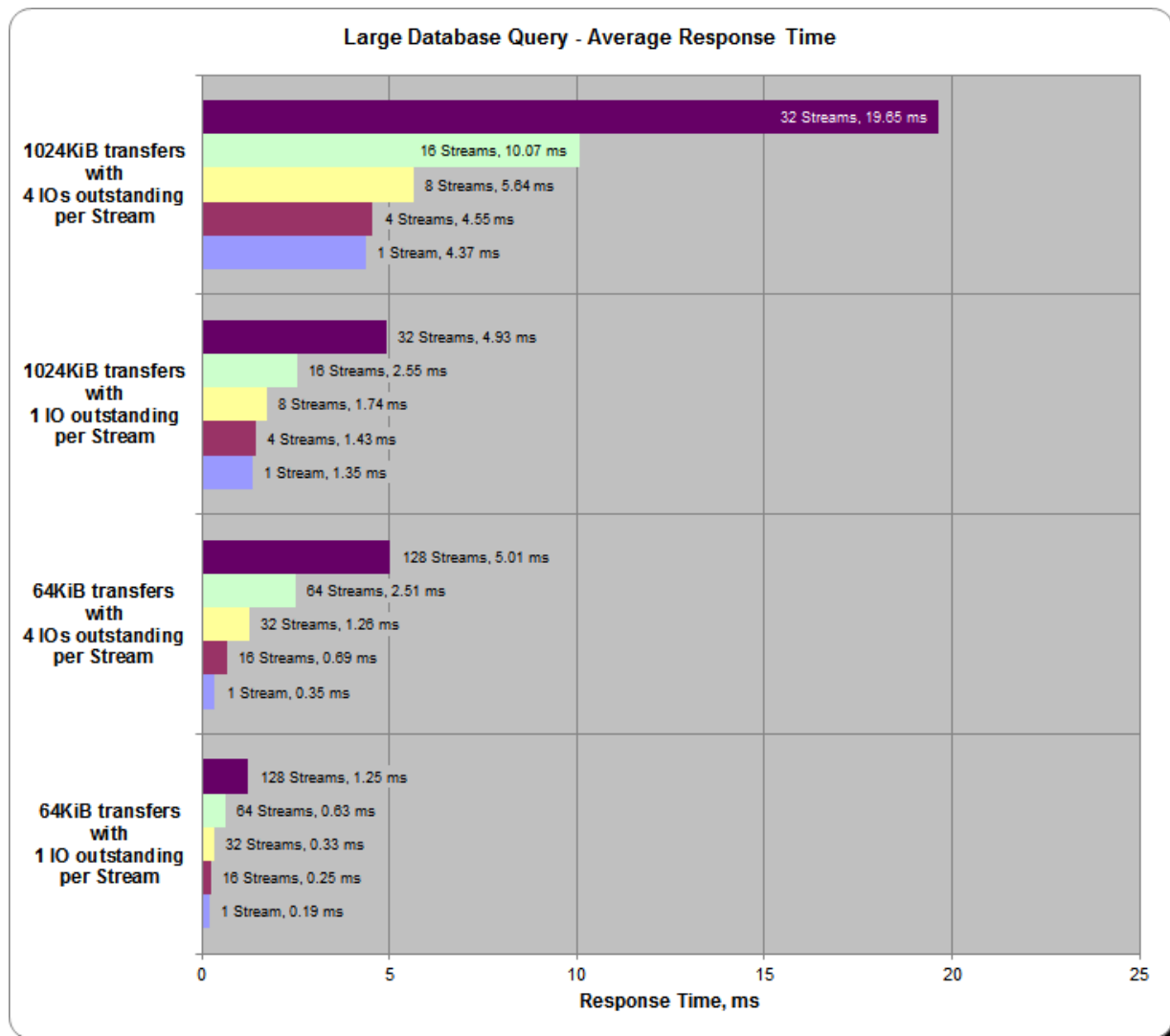


### SPC-2 Large Database Query Average Response Time

The average Response Time, in milliseconds, for each Test Run in the two Test Phases of the SPC-2 Large Database Query Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	4 Streams	8 Streams	16 Streams	32 Streams
1024KiB w/ 4 IOs/Stream	4.37	4.55	5.64	10.07	19.65
Test Run Sequence	1 Stream	4 Streams	8 Streams	16 Streams	32 Streams
1024KiB w/ 1 IO/Stream	1.35	1.43	1.74	2.55	4.93
Test Run Sequence	1 Stream	16 Streams	32 Streams	64 Streams	128 Streams
64KiB w/ 4 IOs/Stream	0.35	0.69	1.26	2.51	5.01
Test Run Sequence	1 Stream	16 Streams	32 Streams	64 Streams	128 Streams
64KiB w/ 1 IO/Stream	0.19	0.25	0.33	0.63	1.25

### SPC-2 Large Database Query Average Response Time Graph





## Large Database Query Test – 1024 KiB TRANSFER SIZE Test Phase

### Clause 10.6.9.2.1

1. A table that will contain the following information for each "1024 KiB Transfer Size, 4 Outstanding I/Os" Test Run:
  - The number of Streams specified.
  - The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.
2. Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "1024 KiB Transfer Size, 4 Outstanding I/Os" Test Runs as specified in Clauses 10.1.4 – 10.1.6.
3. A table that will contain the following information for each "1024 KiB Transfer Size, 1 Outstanding I/O" Test Run:
  - The number of Streams specified.
  - The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.
4. Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "1024 KiB Transfer Size, 1 Outstanding I/O" Test Runs as specified in Clauses 10.1.4 – 10.1.6.

A hyperlink for each of the above tables and graphs may appear in the FDR to provide access to the table or graph.

A hyperlink to a table with the SPC-2 "Large Database Query/1024 KiB TRANSFER SIZE/4 Outstanding I/Os" Test Run data appears on the next page. That entry is followed by hyperlinks to graphs illustrating the average Data Rate, average Data Rate per Stream, and average Response Time produced by the same Test Runs. The table and graphs present the data at five-second intervals.

Immediately following the above SPC-2 "Large Database Query/1024 KiB TRANSFER SIZE/4 Outstanding I/Os" entries will be hyperlinks for SPC-2 "Large Database Query/1024 KiB TRANSFER SIZE/1 Outstanding I/O" table and graphs. The table contains the Test Run data and the graphs illustrate the average Data Rate, average Data Rate per Stream, and average Response Time produced by the Test Runs.

**SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/4 Outstanding I/Os” Test Run Data**

[SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/4 Outstanding I/Os” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)

*(3 pages)*

**SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/4 Outstanding I/Os” Graphs**

**Average Data Rate – Complete Test Run**

**Average Data Rate – Measurement Interval (MI) Only**

**Average Data Rate per Stream**

**Average Response Time**

[SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/4 Outstanding I/Os” graphs](#)

*(four pages, 1 graph per page)*

**SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/1 Outstanding I/O” Test Run Data**

[SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/1 Outstanding I/O” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)

*(3 pages)*

**SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/1 Outstanding I/O” Graphs**

**Average Data Rate – Complete Test Run**

**Average Data Rate – Measurement Interval (MI) Only**

**Average Data Rate per Stream**

**Average Response Time**

[SPC-2 “Large Database Query/1024 KIB TRANSFER SIZE/1 Outstanding I/O” graphs](#)

*(four pages, 1 graph per page)*

## Large Database Query Test – 64 KiB TRANSFER SIZE Test Phase

### Clause 10.6.9.2.2

1. A table that will contain the following information for each "64 KiB Transfer Size, 4 Outstanding I/Os" Test Run:
  - The number of Streams specified.
  - The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.
2. Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "64 KiB Transfer Size, 4 Outstanding I/Os" Test Runs as specified in Clauses 10.1.4 – 10.1.6.
3. A table that will contain the following information for each "64 KiB Transfer Size, 1 Outstanding I/O" Test Run:
  - The number of Streams specified.
  - The Average Data Rate, Average Data Rate per Stream, and Average Response Time reported at five second intervals.
4. Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "64 KiB Transfer Size, 1 Outstanding I/O" Test Runs as specified in Clauses 10.1.4 – 10.1.6.

A hyperlink for each of the above tables and graphs may appear in the FDR to provide access to the table or graph.

A hyperlink to a table with the SPC-2 "Large Database Query/64 KiB TRANSFER SIZE/4 Outstanding I/Os" Test Run data appears on the next page. That entry is followed by hyperlinks to graphs illustrating the average Data Rate, average Data Rate per Stream, and average Response Time produced by the same Test Runs. The table and graphs present the data at five-second intervals.

Immediately following the above SPC-2 "Large Database Query/64 KiB TRANSFER SIZE/4 Outstanding I/Os" entries will be hyperlinks for SPC-2 "Large Database Query/64 KiB TRANSFER SIZE/1 Outstanding I/O" table and graphs. The table contains the Test Run data and the graphs illustrate the average Data Rate, average Data Rate per Stream, and average Response Time produced by the Test Runs.

**SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/4 Outstanding I/Os” Test Run Data**

[SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/4 Outstanding I/Os” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

**SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/4 Outstanding I/Os” Graphs**

**Average Data Rate – Complete Test Run**

**Average Data Rate – Measurement Interval (MI) Only**

**Average Data Rate per Stream**

**Average Response Time**

[SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/4 Outstanding I/Os” graphs](#)  
(four pages, 1 graph per page)

**SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/1 Outstanding I/O” Test Run Data**

[SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/1 Outstanding I/O” Test Run Data Tables: Ramp-Up, Measurement Interval, Run-Out, and Ramp-Down Periods](#)  
(3 pages)

**SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/1 Outstanding I/O” Graphs**

**Average Data Rate – Complete Test Run**

**Average Data Rate – Measurement Interval (MI) Only**

**Average Data Rate per Stream**

**Average Response Time**

[SPC-2 “Large Database Query/64 KiB TRANSFER SIZE/1 Outstanding I/O” graphs](#)  
(four pages, 1 graph per page)

## Video on Demand Delivery Test

### Clause 6.4.5.1

*The Video on Demand Delivery Test represents the I/O operations required to enable individualized video entertainment for a community of subscribers, which draw from a digital film library.*

### Clause 6.4.5.2

*The Video on Demand Delivery Test consists of one (1) Test Run.*

*The BC shall not be restarted or manually disturbed, altered, or adjusted during the execution of the Video on Demand Delivery Test. If power is lost to the BC during this Test all results shall be rendered invalid and the Test re-run in its entirety.*

### Clause 10.6.9.3

*The Full Disclosure Report will contain the following content for the Video on Demand Delivery Test:*

- 1. A listing of the SPC-2 Workload Generator commands and parameters used to execute the Test Run in the Video on Demand Delivery Test.*
- 2. The human readable SPC-2 Test Results File for the Test Run in the Video on Demand Delivery Test.*
- 3. A table that contains the following information for the Test Run in the Video on Demand Delivery Test:*
  - The number Streams specified.*
  - The Ramp-Up duration in seconds.*
  - The Measurement Interval duration in seconds.*
  - The average data rate, in MB per second, for the Measurement Interval.*
  - The average data rate, in MB per second, per Stream for the Measurement Interval.*
- 4. A table that contains the following information for the single Video on Demand Delivery Test Run:*
  - The number Streams specified.*
  - The average data rate, average data rate per stream, average Response Time, and Maximum Response Time reported at 60 second intervals.*
- 5. Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the single Video on Demand Delivery Test Run as specified in Clause 10.1.8.*
- 6. A Maximum Response Time (intervals) graph as specified in Clause 10.1.8.*

## SPC-2 Workload Generator Commands and Parameters

The SPC-2 Workload Generator commands and parameters for the Video on Demand Delivery Test Run are documented in [Appendix E: SPC-2 Workload Generator Execution Commands and Parameters](#) on Page 81..

### SPC-2 Test Results File

A link to the SPC-2 Test Results file generated from the Video on Demand Delivery Test Run is listed below.

[SPC-2 Video on Demand Delivery Test Results File](#)

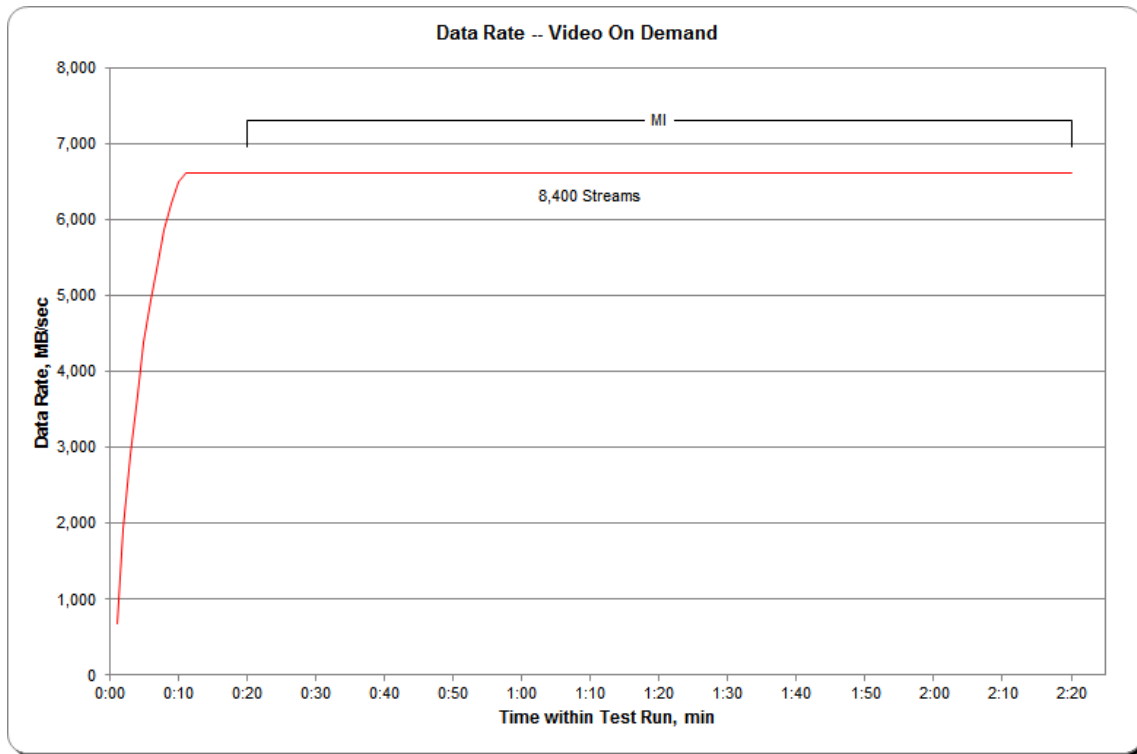
### SPC-2 Video on Demand Delivery Test Run Data

The number of Streams specified, Ramp-Up duration in seconds, Measurement Interval duration in seconds, average Data Rate for the Measurement Interval, and average Data Rate per Stream for the Measurement Interval are listed in the following table.

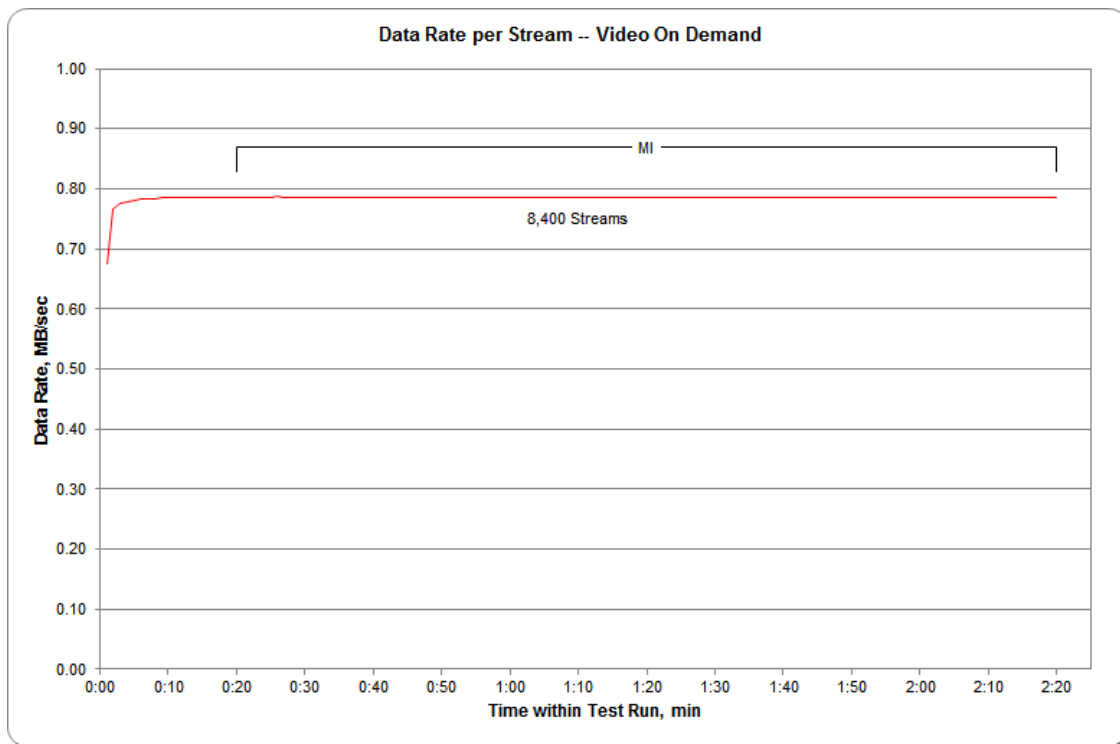
SPC-2-VOD	TR1
Number of Streams	8,400
Ramp-up Time, sec	1,200
Measurement Interval, sec	7,200
Average Data Rate, MB/sec	6,606.00
Per Stream Data Rate, MB/sec	0.79
Average Response Time, ms	29.56
Average Max Response Time, ms	422.72



### SPC-2 Video on Demand Delivery Average Data Rate Graph

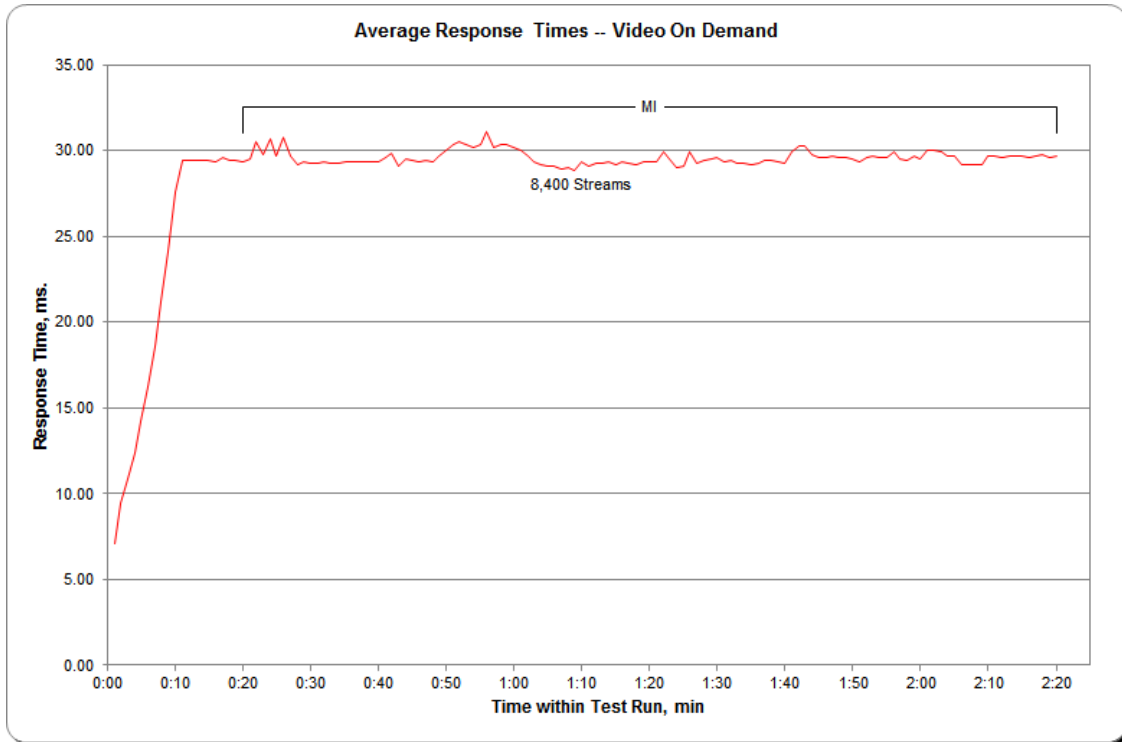


### SPC-2 Video on Demand Delivery Average Data Rate per Stream Graph

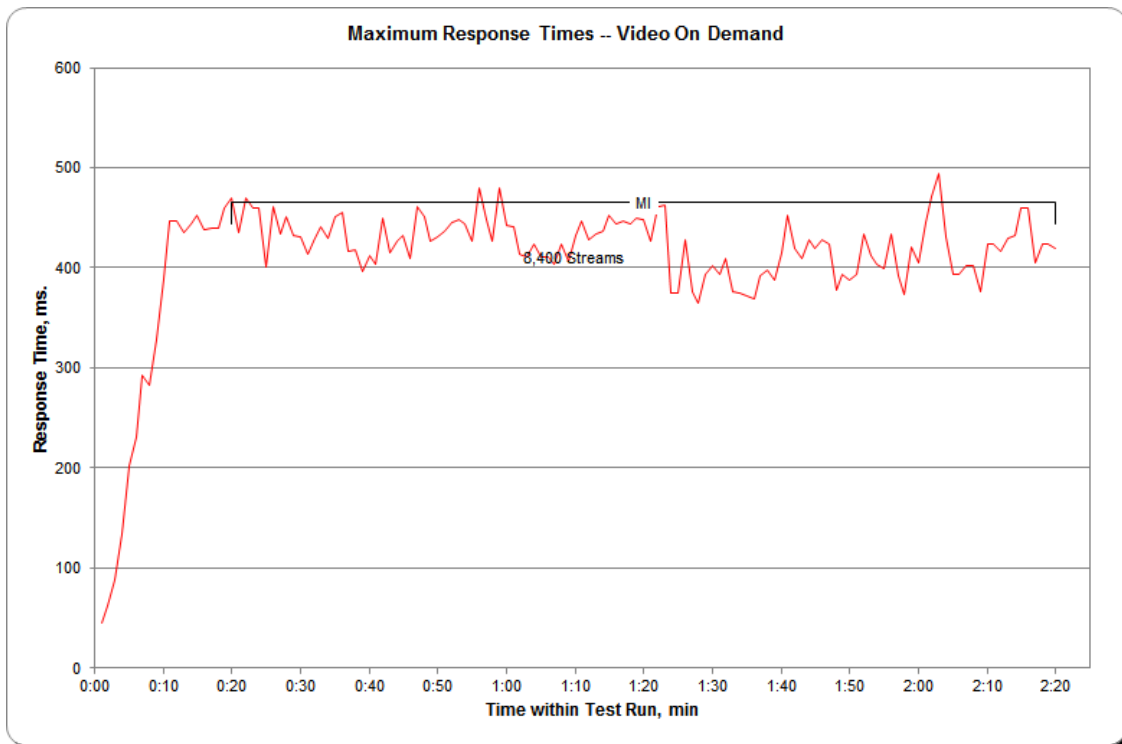




### SPC-2 Video on Demand Delivery Average Response Time Graph



### SPC-2 Video on Demand Delivery Maximum Response Time Graph



## Data Persistence Test

### Clause 7

*The Data Persistence Test demonstrates the Tested Storage Configuration (TSC):*

- *Is capable of maintain data integrity across a power cycle.*
- *Ensures the transfer of data between Logical Volumes and host systems occurs without corruption or loss.*

*The SPC-2 Workload Generator will write a specific pattern at randomly selected locations throughout the Total ASU Capacity (Persistence Test Run 1). The SPC-2 Workload Generator will retain the information necessary to later validate the pattern written at each location.*

*The Tested Storage Configuration will be shutdown and restarted using a power off/power on cycle at the end of the above sequence of write operations. In addition, any caches employing battery backup must be flushed/emptied.*

*Restart the TSC, and if the Host System(s) were shutdown and powered off, restart the Host System(s).*

*The SPC-2 Workload Generator will utilize the retained data from Persistence Test Run 1 to verify (Persistence Run 2) the bit patterns written in Persistence Test Run 1 and their corresponding location.*

### Clause 10.6.9.4

*The Full Disclosure Report will contain the following content for the Data Persistence Test:*

1. *A listing of the SPC-2 Workload Generator commands and parameters used to execute each of the Test Runs in the Persistence Test.*
2. *The human readable SPC-2 Test Results File for each of the Test Runs in the Data Persistence Test.*
3. *A table from the successful Persistence Test, which contains the results from the test.*

## SPC-2 Workload Generator Commands and Parameters

The SPC-2 Workload Generator commands and parameters for the Persistence Test Runs are documented in [Appendix E: SPC-2 Workload Generator Execution Commands and Parameters](#) on Page [81](#).

## Data Persistence Test Results File

A link to the test result file generated from each Data Persistence Test Run is listed below.

[Persistence 1 Test Run \(write phase\) Results File](#)

[Persistence 2 Test Run \(read phase\) Results File](#)

### Data Persistence Test Results

<b>Data Persistence Test Results</b>	
Data Persistence Test Number: 1	
Total Number of Logical Blocks Written	1,064,343
Total Number of Logical Blocks Re-referenced	24,629
Total Number of Logical Blocks Verified	1,039,714
Total Number of Logical Blocks that Failed Verification	0
Number of Failed I/O Requests in the process of the Test	0

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 10.6.9**

*The committed delivery date for general availability (Availability Date) of all products that comprise the Priced Storage Configuration must be reported. When the Priced Storage Configuration includes products or components with different availability dates, the reported Availability Date must be the date at which all components are committed to be available. All availability dates, whether for individual components or for the Priced Storage Configuration as a whole, must be disclosed to a precision of one day.*

*The Availability Data shall be stated in either a combination of specific alphanumeric month, numeric day and numeric year or as “Currently Available”.*

The Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array, as documented in this SPC-2 Full Disclosure Report, is currently available for customer purchase and shipment.

## **ANOMALIES OR IRREGULARITIES**

### **Clause 10.6.12**

*The FDR shall include a clear and complete description of any anomalies or irregularities encountered in the course of executing the SPC-2 benchmark that may in any way call into question the accuracy, verifiability, or authenticity of information published in this FDR.*

There were no anomalies or irregularities encountered during the SPC-2 Remote Audit of the Fujitsu Storage Systems ETERNUS DX200 S3 Storage Array.

## **APPENDIX A: SPC-2 GLOSSARY**

### **“Decimal” (*powers of ten*) Measurement Units**

In the storage industry, the terms “kilo”, “mega”, “giga”, “tera”, “peta”, and “exa” are commonly used prefixes for computing performance and capacity. For the purposes of the SPC workload definitions, all of the following terms are defined in “powers of ten” measurement units.

- A kilobyte (KB) is equal to 1,000 ( $10^3$ ) bytes.
- A megabyte (MB) is equal to 1,000,000 ( $10^6$ ) bytes.
- A gigabyte (GB) is equal to 1,000,000,000 ( $10^9$ ) bytes.
- A terabyte (TB) is equal to 1,000,000,000,000 ( $10^{12}$ ) bytes.
- A petabyte (PB) is equal to 1,000,000,000,000,000 ( $10^{15}$ ) bytes
- An exabyte (EB) is equal to 1,000,000,000,000,000,000 ( $10^{18}$ ) bytes

### **“Binary” (*powers of two*) Measurement Units**

The sizes reported by many operating system components use “powers of two” measurement units rather than “power of ten” units. The following standardized definitions and terms are also valid and may be used in this document.

- A kibibyte (KiB) is equal to 1,024 ( $2^{10}$ ) bytes.
- A mebibyte (MiB) is equal to 1,048,576 ( $2^{20}$ ) bytes.
- A gibibyte (GiB) is equal to 1,073,741,824 ( $2^{30}$ ) bytes.
- A tebibyte (TiB) is equal to 1,099,511,627,776 ( $2^{40}$ ) bytes.
- A pebibyte (PiB) is equal to 1,125,899,906,842,624 ( $2^{50}$ ) bytes.
- An exbibyte (EiB) is equal to 1,152,921,504,606,846,967 ( $2^{60}$ ) bytes.

## **SPC-2 Data Repository Definitions**

**Total ASU Capacity:** The total storage capacity read and written in the course of executing the SPC-2 benchmark.

**Application Storage Unit (ASU):** The logical interface between the storage and SPC-2 Workload Generator. The ASU is implemented on one or more Logical Volume.

**Logical Volume:** The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-2 benchmark. Each Logical Volume is implemented as a single, contiguous address space.

**Addressable Storage Capacity:** The total storage (sum of Logical Volumes) that can be read and written by application programs such as the SPC-2 Workload Generator.

**Configured Storage Capacity:** This capacity includes the Addressable Storage Capacity and any other storage (parity disks, hot spares, etc.) necessary to implement the Addressable Storage Capacity.

**Physical Storage Capacity:** The formatted capacity of all storage devices physically present in the Tested Storage Configuration (TSC).

**Data Protection Overhead:** The storage capacity required to implement the selected level of data protection.

**Required Storage:** The amount of Configured Storage Capacity required to implement the Addressable Storage Configuration, excluding the storage required for the ASU.

**Global Storage Overhead:** The amount of Physical Storage Capacity that is required for storage subsystem use and unavailable for use by application programs.

**Total Unused Storage:** The sum of unused storage capacity within the Physical Storage Capacity, Configured Storage Capacity, and Addressable Storage Capacity.

## SPC-2 Data Protection Levels

**Protected 1:** The single point of failure of any *storage device* in the configuration will not result in permanent loss of access to or integrity of the SPC-2 Data Repository.

**Protected 2:** The single point of failure of any *component* in the configuration will not result in permanent loss of access to or integrity of the SPC-2 Data Repository.

## SPC-2 Test Execution Definitions

**Completed I/O Request:** An I/O Request with a Start Time and a Completion Time (see [“I/O Completion Types”](#) illustrated below).

**Completion Time:** The time recorded by the Workload Generator when an I/O Request is completed by the Tested Storage Configuration (TSC) as signaled by System Software.

**Data Rate:** The data volume, in MB, transferred by all Measured I/O Requests in an SPC-2 Test Run divided by the length of the Test Run in seconds.

**Failed I/O Request:** Any I/O Request issued by the SPC-2 Workload Generator that meets one of the following conditions (see [“I/O Completion Types”](#) illustrated below):

- The I/O Request was signaled as failed by System Software.
- The I/O Request started within the Measurement Interval, but did not complete prior to the end of the appropriate Run-Out period..
- The I/O Request started within the Run-Out period, but did not complete prior to the end of the appropriate Ramp-Down period.

**I/O Request Throughput:** The total number of Measured I/O Requests in an SPC-2 Test Run divided by the duration of the Measurement Interval in seconds.

**Measured I/O Request:** A Completed I/O Request that begins (Start Time) within a Measurement Interval and completes (Completion Time) prior to the end of the appropriate Ramp Down (see [“I/O Completion Types”](#) illustrated below).

**Measurement Interval:** A specified, contiguous period of time, after the TSC has reached Steady State, when data is collected by the Workload Generator to produce the test results for a SPC-2 Test Run (see [“SPC-2 Test Run Components”](#) illustrated below, *Test Run 1:  $T_2-T_3$  and Test Run 2:  $T_7-T_8$* ).

**Outstanding I/O Requests:** The Outstanding I/O Requests parameter specifies the maximum number of concurrent I/O Requests, associated with a give Stream, which have been issued but not yet completed. (*Clause 3.4.4 of the SPC-2 Benchmark Specification*).

**Ramp-Down:** A specified, contiguous period of time in which the TSC is required to complete I/O Requests started but not completed during the preceding Run-Out period. Ramp-Down begins at the end of the preceding Run-Out period (see [“SPC-2 Test Run Components”](#) illustrated below, *Test Run 1:  $T_4-T_5$  and Test Run 2:  $T_9-T_{10}$* ). The Workload Generator will not submit any I/O Requests during the Ramp-Down.

**Ramp-Up:** A specified, contiguous period of time required for the Benchmark Configuration (BC) to produce Steady State throughput after the Workload Generator begins submitting I/O Requests to the TSC for execution. The Ramp-Up period ends at the beginning of the Measurement Interval (see [“SPC-2 Test Run Components”](#) illustrated below, *Test Run 1:  $T_0-T_2$  and Test Run 2:  $T_5-T_7$* ).

**Response Time:** The Response Time of a Measured I/O Request is its Completion Time minus its Start Time.

**Run-Out:** A specified, contiguous period of time in which the TSC is required to complete I/O Requests started but not completed during the preceding Measurement Interval. The Run-Out period begins at the end of the preceding Measurement Interval and is a component of the Steady State period (see [“SPC-2 Test Run Components”](#) illustrated below, *Test Run 1:  $T_3-T_4$  and Test Run 2:  $T_9-T_{10}$* ). The Workload Generator will continue to submit I/O Requests at the Test Run’s specified rate during the Run-Out period.

**Start Time:** The time recorded by the Workload Generator when an I/O Request is submitted, by the Workload Generator, to the System Software for execution on the TSC.

**Steady State:** The period during which the workload presented to the TSC by the SPC-2 Workload Generator is constant and the resulting TSC I/O Request Throughput is both consistent and sustainable. The Steady State period includes both the Measurement Interval and Run-Out periods (see [“SPC-2 Test Run Components”](#) illustrated below, *Test Run 1:  $T_1-T_4$  and Test Run 2:  $T_6-T_9$* ).

Steady State is achieved only after caches in the TSC have filled and as a result the I/O Request Throughput of the TSC has stabilized.

**Stream:** A collection of Stream Segments that started within a Test Run.

**Stream Segment:** A sequentially organized pattern of I/O requests, which transfers a contiguous range of data.

**Test:** A collection of Test Phases and or Test Runs sharing a common objective.

**Test Phase:** A collection of one or more SPC-2 Test Runs sharing a common objective and intended to be run in a specific sequence.

**Test Run:** The execution of SPC-2 that produces specific SPC-2 test results. SPC-2 Test Runs have specified, measured Ramp-Up, Measurement Interval, Run-Out and Ramp-Down periods. "[SPC-2 Test Run Components](#)" (*see below*) illustrates the Ramp-Up, Steady State, Measurement Interval, Run-Out, and Ramp-Down components contained in two uninterrupted SPC-2 Test Runs (*Test Run 1:  $T_0-T_5$  and Test Run 2:  $T_5-T_{10}$* ).

**Test Run Sequence:** A related sequence of Large File Processing (LFP) or Large Database Query (LDQ) Test Runs. Each Test Run Sequence will consist of five Test Runs, which vary the number of Streams as follows:

- Test Run 1: Maximum number of Streams, which is selected by the Test Sponsor
- Test Run 2: 50% of the maximum number of Streams used in Test Run 1.
- Test Run 3: 25% of the maximum number of Streams used in Test Run 1.
- Test Run 4: 12.5% of the maximum number of Streams used in Test Run 1.
- Test Run 5: 1 Stream.

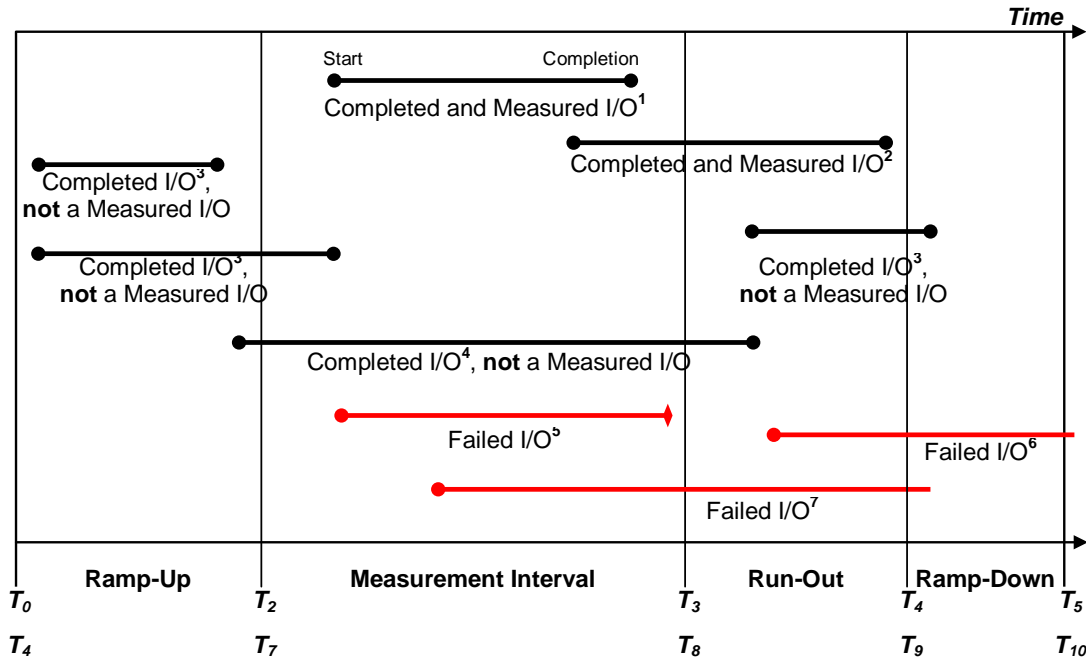
Each of the five Test Runs in a Test Run Sequence will share the same attributes with the exception of the number of Streams. For example:

- Large File Processing, Read, 1024 KiB Transfer Size: Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 50% of Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 25% of Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 12.5% of Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 1 Stream

**Transfer Size:** The Transfer Size parameter specifies the number of bytes in KiB to transfer. (*Clause 3.4.7 of the SPC-2 Benchmark Specification*)

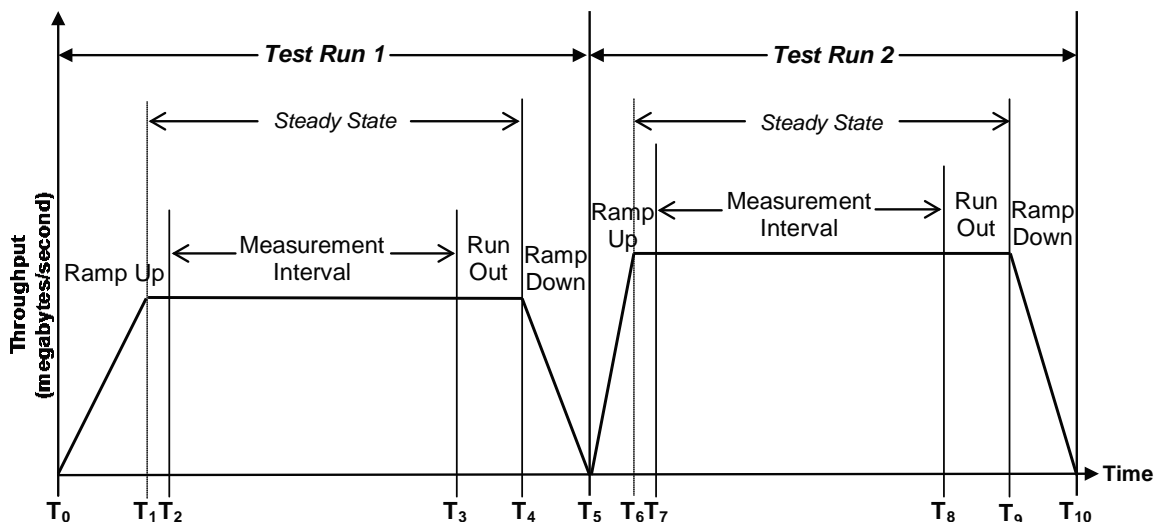


### I/O Completion Types



- Completed and Measured I/O<sup>1</sup>:** I/O started and completed within the Measurement Interval.
- Completed and Measured I/O<sup>2</sup>:** I/O started within the Measurement Interval and completed within Ramp Down.
- Completed I/O<sup>3</sup>:** I/O started before or after the Measurement Interval – not measured.
- Completed I/O<sup>4</sup>:** I/O started before and completed after the Measurement Interval – not measured.
- Failed I/O<sup>5</sup>:** Signaled as failed by System Software.
- Failed I/O<sup>6</sup>:** I/O did not complete prior to the end of Ramp-Down.
- Failed I/O<sup>7</sup>:** I/O did not complete prior to the end of Run-Out.

### SPC-2 Test Run Components



## **APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS**

The **expect** script [DX200S3\\_TUNE\\_20141112.exp](#) was executed, as documented in [Appendix C](#), to adjust the “ordered-cut” parameter for all of the RAID Groups from the default of 400 to 100.

This parameter is available to users via the GUI or CLI. The value in this parameter is used to determine the frequency with which a command to each of the disc drives in the RAID Group will be issued with and the ORDERED task attribute rather than the SIMPLE task attribute. This will force completion of any previously issued commands within the drive.

By changing the parameter to a lower value, Ordered Tag commands will be issued more frequently. This choice is used when there are applications that have tight maximum latency requirements

## **APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION**

In preparation for the benchmark a planning workbook was prepared [DX200s3 Conf Plan.xlsx](#). There is a section within the workbook that provides additional details on the planning sections. In the plan for the SPC-2 benchmark, there were 22 RAID-5 (6+1) groups identified as groups of 7 drives, with each group assigned a name. A single Logical Volume was defined within each group for use in the benchmark. A portion of a worksheet was used to define the mapping of the Logical Volumes to Host Interface Channel Adapter ports on each of the two Control Modules used in the storage array.

From this planning information, a standard Fujitsu Command Line tool (CLI) script was defined, using the [cygwin](#) packages **expect** and **openssh**. That script, [DX200S3 20140821.exp](#), included the **docli** procedure, which was used to issue the CLI commands to the array. That procedure used **ssh** for communication with the array. A second procedure in the script, **doexit**, was used to conclude the execution sequence at the end of the script.

The **expect** script [DX200S3 20140821.exp](#) is called by a parent bash script [doFDRcfg.sh](#) which invokes the **expect** script and then waits for the physical format to complete by polling the format status every 20 minutes. The physical format status is returned by calling another **expect** script [showFormatStatus.exp](#).

After completion of the storage creation script the Windows2008 R2 System will make initial discovery of the target LUNs. Since the Windows 2008 R2 system places the physical disk in Offline state after initial discovery it is necessary to issue explicit command to place each drive in Online state. This is done by executing **bash** script [diskOnline.sh](#), which calls Windows DISKPART utility to force Offline disks into Online status.

Steps 1-4, detailed below, document the items completed within the **expect** script [DX200S3 20140821.exp](#) to create the SPC-2 Tested Storage Configuration.

The [Ordered Cut Parameter](#) section documents the customer parameter that was changed for the benchmark execution.

The [Crosscheck on LV Addressing](#) section documents the validation step to ensure the correct mapping was implemented as part of the TSC creation/configuration process.

All scripts referenced in this section appear in the [Referenced Scripts](#) section.

### **Step 1 – Creation of the RAID Groups**

A total of 22 RAID Groups were created, per the plan. Each RAID Group was made up of 7 disk drives in a RAID-5(6+1) configuration, and assigned to a specific Control Module (CM) with the stripe depth set to 256KiB. The RAID Groups were named RG000 through RG015.

### **Step 2 – Creation of the Global Hot Spares**

Two drives were designated as Global Hot Spare drives in slots 22 & 23 of the CE, per the configuration plan.

### Step 3 – Creation of the Logical Volumes

Within each of the RAID Groups, one Logical Volume was created with a size of 102130MiB, per the plan. The names, LV000 through LV015, were assigned to the volumes as part of their creation.

### Step 4 – Assignment of LUN Mapping for Host Access

The port LUN mapping was assigned, using the configuration plan – two ports for each set of LUNs. The LUN numbers were assigned to the corresponding Logical Volume numbers according to the plan. Both ports on each of the two CAs on each of the two CMs were assigned for a total of eight (8) ports. Four of the ports had six (6) LUNs assigned and four of the ports had five (5) LUNs assigned, balancing the 22 volumes across the CMs. Each of the two servers was connected to one complete set of LUNs providing access to the entire data space.

### Ordered Cut Parameter

The ordered-cut parameter, described in [Appendix B: Customer Tunable Parameters and Options](#), was modified with the [DX200S3\\_TUNE\\_20141112.exp](#) script after successful completion of Steps 1-4, described above.

### Crosscheck on LV Addressing

The benchmark execution script, [dofdr1.bat](#), includes executing the [saveHostInfo.sh](#) script that in turns executes the [getHostInfo.sh](#) script, which contains Emulex commands to obtain detailed information from each of the HBAs on both Host Systems for Target Mapping, HBA Attribute and Port Attributes and creates the **Master\_2014-22-13-05-01-18\_P12.txt** and **Slave-1\_2014-11-13-05-01-18\_P12.txt** files. Those files contain the detailed HBA information, which is used to construct the **Host-Links** spreadsheet in the [DX200s3 Conf Plan.xlsx](#) workbook to document and confirm the correct mapping.

## Referenced Scripts

### doFDRcfg.sh

```
#!/bin/bash
#
# Do the configuration steps required for the SPC2 benchmark
#
# create tmp directory for spc2 if it does not exist
if [ ! -d /tmp/spc2 ]; then
mkdir /tmp/spc2
fi
ROOT=/cygdrive/c/spc/work
SCRIPTS=${ROOT}/07_Execution
CONFIGURE=${ROOT}/05_Creation
#
# confID uniquely identifies the configuration of the array
confID=DX200S3_20140821
#
# obtain cjobID based on the timestamp
# cjobID uniquely identifies the configuration job
cjobID=C`date +%y%m%d%H%M%S`
#
echo job start time `date` > /tmp/spc2/${cjobID}_message.txt
echo This is an array configuration job >> /tmp/spc2/${cjobID}_message.txt
echo job confID=${confID} >> /tmp/spc2/${cjobID}_message.txt
echo job cjobID=${cjobID} >> /tmp/spc2/${cjobID}_message.txt
${SCRIPTS}/recordStatus.sh "Starting Configuration Job=${cjobID}"
${cjobID}_message.txt
#
# Configure Array using the Expect script to issue CLI commands
#
${SCRIPTS}/recordStatus.sh "Starting Eternus CLI script for configuration
Job=${cjobID}" ${cjobID}_message.txt
${CONFIGURE}/${confID}.exp
${SCRIPTS}/recordStatus.sh "Completed Eternus CLI script for configuration
Job=${cjobID}" ${cjobID}_message.txt
#
#
# Wait for physical format to complete
#
PollingInterval=1200 #wait 20 minutes to check format status
#
LUNS=999
while [ $LUNS -gt 0 ]; do
cat /tmp/spc2/fmt_${cjobID}.txt >> /tmp/spc2/${cjobID}_message.txt
${CONFIGURE}/showFormatStatus.exp dx200s3 root root /tmp/spc2/fmt_${cjobID}.txt
LUNS=`grep Available /tmp/spc2/fmt_${cjobID}.txt |wc |awk '{print $1}'`
echo "-----" >>
/tmp/spc2/${cjobID}_message.txt
${SCRIPTS}/recordStatus.sh "Currently formatting $LUNS LUNS Job=${cjobID}"
${cjobID}_message.txt
sleep $PollingInterval
done
${SCRIPTS}/recordStatus.sh "Physical format complete please proceed. Job=${cjobID}"
${cjobID}_message.txt
```

### DX200S3\_20140821.exp

```
#!/usr/bin/expect
# script to setup initial configuration for dx200s3
# for SPC-2 benchmark
# Requirement: ssh public key for this server registered to the array
set timeout 600
set user root
spawn ssh dx200s3 -l $user
expect "password: "
send "root\r"
expect "CLI>"
# procedure to execute dx200s3 cli command
proc docli { cmd args } {
send "$cmd $args\r"
expect "CLI>"
}
# procedure to exit
proc doexit {} {
send "exit\r"
}
#DX200S3 Configuration

## Create RAID ##
docli create raid-group -name RG000 -disks 0000,0100,0200,0300,0400,0500,0600 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG001 -disks 0001,0101,0201,0301,0401,0501,0601 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG002 -disks 0002,0102,0202,0302,0402,0502,0602 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG003 -disks 0003,0103,0203,0303,0403,0503,0603 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG004 -disks 0004,0104,0204,0304,0404,0504,0604 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG005 -disks 0005,0105,0205,0305,0405,0505,0605 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG006 -disks 0006,0106,0206,0306,0406,0506,0606 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG007 -disks 0007,0107,0207,0307,0407,0507,0607 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG008 -disks 0008,0108,0208,0308,0408,0508,0608 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG009 -disks 0009,0109,0209,0309,0409,0509,0609 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG00a -disks 0010,0110,0210,0310,0410,0510,0610 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG00b -disks 0011,0111,0211,0311,0411,0511,0611 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG00c -disks 0012,0112,0212,0312,0412,0512,0612 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG00d -disks 0013,0113,0213,0313,0413,0513,0613 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG00e -disks 0014,0114,0214,0314,0414,0514,0614 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG00f -disks 0015,0115,0215,0315,0415,0515,0615 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG010 -disks 0016,0116,0216,0316,0416,0516,0616 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG011 -disks 0017,0117,0217,0317,0417,0517,0617 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG012 -disks 0018,0118,0218,0318,0418,0518,0618 -level
5 -assigned-cm 0 -stripe-depth 256kb
```

```
docli create raid-group -name RG013 -disks 0019,0119,0219,0319,0419,0519,0619 -level
5 -assigned-cm 1 -stripe-depth 256kb
docli create raid-group -name RG014 -disks 0020,0120,0220,0320,0420,0520,0620 -level
5 -assigned-cm 0 -stripe-depth 256kb
docli create raid-group -name RG015 -disks 0021,0121,0221,0321,0421,0521,0621 -level
5 -assigned-cm 1 -stripe-depth 256kb

## Set Global Hot Spare ##
docli set global-spare -disks 0022,0023

## Create Volumes ##
docli create volume -name LV000 -count 1 -rg-name RG000 -type open -size 1021300mb
docli create volume -name LV001 -count 1 -rg-name RG001 -type open -size 1021300mb
docli create volume -name LV002 -count 1 -rg-name RG002 -type open -size 1021300mb
docli create volume -name LV003 -count 1 -rg-name RG003 -type open -size 1021300mb
docli create volume -name LV004 -count 1 -rg-name RG004 -type open -size 1021300mb
docli create volume -name LV005 -count 1 -rg-name RG005 -type open -size 1021300mb
docli create volume -name LV006 -count 1 -rg-name RG006 -type open -size 1021300mb
docli create volume -name LV007 -count 1 -rg-name RG007 -type open -size 1021300mb
docli create volume -name LV008 -count 1 -rg-name RG008 -type open -size 1021300mb
docli create volume -name LV009 -count 1 -rg-name RG009 -type open -size 1021300mb
docli create volume -name LV00a -count 1 -rg-name RG00a -type open -size 1021300mb
docli create volume -name LV00b -count 1 -rg-name RG00b -type open -size 1021300mb
docli create volume -name LV00c -count 1 -rg-name RG00c -type open -size 1021300mb
docli create volume -name LV00d -count 1 -rg-name RG00d -type open -size 1021300mb
docli create volume -name LV00e -count 1 -rg-name RG00e -type open -size 1021300mb
docli create volume -name LV00f -count 1 -rg-name RG00f -type open -size 1021300mb
docli create volume -name LV010 -count 1 -rg-name RG010 -type open -size 1021300mb
docli create volume -name LV011 -count 1 -rg-name RG011 -type open -size 1021300mb
docli create volume -name LV012 -count 1 -rg-name RG012 -type open -size 1021300mb
docli create volume -name LV013 -count 1 -rg-name RG013 -type open -size 1021300mb
docli create volume -name LV014 -count 1 -rg-name RG014 -type open -size 1021300mb
docli create volume -name LV015 -count 1 -rg-name RG015 -type open -size 1021300mb

## Set LUN Mapping ##
docli set mapping -port 000 -volume-number 0,4,8,12,16,20 -lun 0,4,8,12,16,20
docli set mapping -port 001 -volume-number 2,6,10,14,18 -lun 2,6,10,14,18
docli set mapping -port 100 -volume-number 1,5,9,13,17,21 -lun 1,5,9,13,17,21
docli set mapping -port 101 -volume-number 3,7,11,15,19 -lun 3,7,11,15,19
docli set mapping -port 010 -volume-number 0,4,8,12,16,20 -lun 0,4,8,12,16,20
docli set mapping -port 011 -volume-number 2,6,10,14,18 -lun 2,6,10,14,18
docli set mapping -port 110 -volume-number 1,5,9,13,17,21 -lun 1,5,9,13,17,21
docli set mapping -port 111 -volume-number 3,7,11,15,19 -lun 3,7,11,15,19

## Logout ##
doexit
```

### showFormatStatus.exp

```
#!/usr/bin/expect -f
# Create volumes from the array
# getFormatStatus <array> <arrayid> <arraypass> <file>
# assumption: array's ssh port has ssh-key-pre-registered no no password is required
# please register ssh-keys
# procedure to execute commands
proc docli {cmd args} {
    send "$cmd $args\r"
    expect "CLI>"
}
# procedure to exit
proc doexit {} {
    send "exit \r"
}
set array [lindex $argv 0]
set arrayid [lindex $argv 1]
set arraypass [lindex $argv 2]
set file [lindex $argv 3]
#set file /tmp/formatstatus.txt
# login
spawn ssh $arrayid@$array
expect "password: "
send "$arraypass\r"
set timeout 40
expect "CLI>"
if [catch {open $file "w" } output] {
    puts "$output"
    exit
}
send "show volume-progress\r"
expect "CLI>"
puts $output "Output = $expect_out(buffer)"
close $output
doexit
close
```

### diskOnline.sh

```
#!/bin/bash
diskpart <<HERE > /tmp/diskpart$$
LIST DISK
EXIT
HERE
NUMDISKS=`awk 'BEGIN {cnt = 0} /^ *Disk *[0-9]* *O/{cnt=cnt+1 } END {print cnt}'
/tmp/diskpart$$`
cp /dev/null /tmp/diskonline$$
for (( pd=0 ; pd < $NUMDISKS ; pd += 1 ))
do
echo SELECT DISK $pd > /tmp/diskselect$$
printf "DETAIL DISK\nEXIT\n" >> /tmp/diskselect$$
diskpart < /tmp/diskselect$$ > /tmp/diskdetail$$
isOffline=`awk 'BEGIN {isOffline="NO"} /^Status *:/{ if($3 == "Offline" )
{isOffline="YES"} } END {print isOffline}' /tmp/diskdetail$$`
if [ $isOffline == "YES" ]
then
echo "SELECT DISK=$pd" >> /tmp/diskonline$$
printf "ONLINE DISK\n" >> /tmp/diskonline$$
```



```
printf "ATTRIBUTES DISK CLEAR READONLY\n" >> /tmp/diskonline$$
fi
done
printf "EXIT\n" >> /tmp/diskonline$$
echo "Executing Script : /tmp/diskonline$$"
diskpart < /tmp/diskonline$$
```

### DX200S3\_TUNE\_20141112.exp

```
#!/usr/bin/expect
# script to tune DX200S3
# for SPC-2 benchmark
set timeout 600
set user root
spawn ssh dx200s3 -l $user
expect "password: "
send "root\r"
expect "CLI>"
# procedure to execute dx200s3 cli command
proc docli { cmd args } {
send "$cmd $args\r"
expect "CLI>"
}
# procedure to exit
proc doexit {} {
send "exit\r"
}
#DX200S3 Tuning

## Set Ordered Cut value to 100 (Default 400)
docli set raid-tuning -rg-number 0-21 -ordered-cut 100

## Logout ##
doexit
```

### saveHostInfo.sh

```
. .bashrc
#
# Function to save Host information
function saveHostInfo() {
savedir=$1
TimeStamp=`cat /tmp/spc2/TimeStamp`
# save host environment information from master
./getHostInfo.sh Master
mv /tmp/spc2/*${TimeStamp}* $savedir
scp .bashrc slave-1:/tmp/
scp getHostInfo.sh slave-1:/tmp/
ssh Administrator@slave-1 /tmp/getHostInfo.sh Slave-1
scp Administrator@slave-1:/tmp/spc2/*${TimeStamp}* $savedir
}
saveHostInfo $1
```

## getHostInfo.sh

```
. .bashrc
#
# Functions for SPC2 jobs definitions
# Fileprefix=$1
function GetHostInfo()
{
    #
    #Get enviornment info for the host system.
    #
    TimeStamp=`cat /tmp/spc2/TimeStamp`
    OutFile=/tmp/spc2/${1}_${TimeStamp}
    tmpprefix=/tmp/gest_$$

    PCSYSSCN=/cygdrive/c/Program\ Files/Fujitsu/ServerView\
Suite/PrimeCollect/Tools/PCSysScan.exe
    "${PCSYSSCN}" -htmlreport `cygpath -w ${OutFile}_Pt1.html`
    # Java information
    echo "-----Java Information (Oracle Java SE) -----" >
${OutFile}_Pt2.txt
    /cygdrive/c/Java/bin/java -version &>> ${OutFile}_Pt2.txt
    # HBA information
    echo "-----HBA Information (Emulex) -----" >>
${OutFile}_Pt2.txt
    HC=/cygdrive/c/Program\ Files/Emulex/Util/OCManager/HbaCmd.exe
    "${HC}" ListHBAs >> ${OutFile}_Pt2.txt
    for i in `"${HC}" ListHBAs |awk '/Port WWN/{print $4}'`
    do
        "${HC}" TargetMapping $i |tee ${tmpprefix}_${i}.txt >> ${OutFile}_Pt2.txt
        "${HC}" HBAAttributes $i >> ${OutFile}_Pt2.txt
        "${HC}" PortAttributes $i >> ${OutFile}_Pt2.txt
    done
    echo "-----Disk LUN Mapping (Sorted by LUN) -----" >>
${OutFile}_Pt2.txt
    grep Lun --no-filename ${tmpprefix}*.txt > ${tmpprefix}_luns.txt
    sed -n '/^SCSI/{
N
s/\n/ /p
}' ${tmpprefix}_luns.txt > ${tmpprefix}_etluns.txt
    /usr/bin/sort -k5.1n ${tmpprefix}_etluns.txt >> ${OutFile}_Pt2.txt
}
GetHostInfo $1
```

## APPENDIX D: SPC-2 WORKLOAD GENERATOR STORAGE COMMANDS AND PARAMETER FILES

### ASU Pre-Fill

```
*
* Prefill vdbench parameter file for SPC2 DX200S3 2014/10/22
*
* This will produce a random data pattern of the entire LBA range using LSF
* 32 bit
*
compratio=1
*
sd=default,host=localhost,size=997g,threads=32
sd=sd0,lun=\\.PhysicalDrive0
sd=sd1,lun=\\.PhysicalDrive1
sd=sd2,lun=\\.PhysicalDrive2
sd=sd3,lun=\\.PhysicalDrive3
sd=sd4,lun=\\.PhysicalDrive4
sd=sd5,lun=\\.PhysicalDrive5
sd=sd6,lun=\\.PhysicalDrive6
sd=sd7,lun=\\.PhysicalDrive7
sd=sd8,lun=\\.PhysicalDrive8
sd=sd9,lun=\\.PhysicalDrive9
sd=sd10,lun=\\.PhysicalDrive10
sd=sd11,lun=\\.PhysicalDrive11
sd=sd12,lun=\\.PhysicalDrive12
sd=sd13,lun=\\.PhysicalDrive13
sd=sd14,lun=\\.PhysicalDrive14
sd=sd15,lun=\\.PhysicalDrive15
sd=sd16,lun=\\.PhysicalDrive16
sd=sd17,lun=\\.PhysicalDrive17
sd=sd18,lun=\\.PhysicalDrive18
sd=sd19,lun=\\.PhysicalDrive19
sd=sd20,lun=\\.PhysicalDrive20
sd=sd21,lun=\\.PhysicalDrive21

*
wd=wd0,sd=sd0,rdpct=0,seek=-1,xfersize=16K
wd=wd1,sd=sd1,rdpct=0,seek=-1,xfersize=16K
wd=wd2,sd=sd2,rdpct=0,seek=-1,xfersize=16K
wd=wd3,sd=sd3,rdpct=0,seek=-1,xfersize=16K
wd=wd4,sd=sd4,rdpct=0,seek=-1,xfersize=16K
wd=wd5,sd=sd5,rdpct=0,seek=-1,xfersize=16K
wd=wd6,sd=sd6,rdpct=0,seek=-1,xfersize=16K
wd=wd7,sd=sd7,rdpct=0,seek=-1,xfersize=16K
wd=wd8,sd=sd8,rdpct=0,seek=-1,xfersize=16K
wd=wd9,sd=sd9,rdpct=0,seek=-1,xfersize=16K
wd=wd10,sd=sd10,rdpct=0,seek=-1,xfersize=16K
wd=wd11,sd=sd11,rdpct=0,seek=-1,xfersize=16K
wd=wd12,sd=sd12,rdpct=0,seek=-1,xfersize=16K
wd=wd13,sd=sd13,rdpct=0,seek=-1,xfersize=16K
wd=wd14,sd=sd14,rdpct=0,seek=-1,xfersize=16K
wd=wd15,sd=sd15,rdpct=0,seek=-1,xfersize=16K
wd=wd16,sd=sd16,rdpct=0,seek=-1,xfersize=16K
wd=wd17,sd=sd17,rdpct=0,seek=-1,xfersize=16K
wd=wd18,sd=sd18,rdpct=0,seek=-1,xfersize=16K
wd=wd19,sd=sd19,rdpct=0,seek=-1,xfersize=16K
wd=wd20,sd=sd20,rdpct=0,seek=-1,xfersize=16K
wd=wd21,sd=sd21,rdpct=0,seek=-1,xfersize=16K
```

```
*
*=====
* Use 10 hours as a maximum elapsed time,
* which should ensure the entire LBA range
* will be written before the time elapses
*=====
rd=asu_prefill,wd=wd*,iorate=max,elapsed=36000,interval=10
* The above "elapsed=36000" may have to be increased to ensure that the utility will
reach
* the end of the LUN ("seek=-1") prior to the end of the specified elapsed time
```

## Common Commands/Parameters – LFP, LDQ and VOD Tests

The following command/parameter lines appear in each of the command and parameter files for the Large File Processing (LFP), Large Database Query (LDQ) and Video on Demand Delivery Tests. The command lines are only listed below to eliminate redundancy.

```
sd=default,host=localhost,size=997g
sd=sd0,lun=\\.\PhysicalDrive0
sd=sd1,lun=\\.\PhysicalDrive1
sd=sd2,lun=\\.\PhysicalDrive2
sd=sd3,lun=\\.\PhysicalDrive3
sd=sd4,lun=\\.\PhysicalDrive4
sd=sd5,lun=\\.\PhysicalDrive5
sd=sd6,lun=\\.\PhysicalDrive6
sd=sd7,lun=\\.\PhysicalDrive7
sd=sd8,lun=\\.\PhysicalDrive8
sd=sd9,lun=\\.\PhysicalDrive9
sd=sd10,lun=\\.\PhysicalDrive10
sd=sd11,lun=\\.\PhysicalDrive11
sd=sd12,lun=\\.\PhysicalDrive12
sd=sd13,lun=\\.\PhysicalDrive13
sd=sd14,lun=\\.\PhysicalDrive14
sd=sd15,lun=\\.\PhysicalDrive15
sd=sd16,lun=\\.\PhysicalDrive16
sd=sd17,lun=\\.\PhysicalDrive17
sd=sd18,lun=\\.\PhysicalDrive18
sd=sd19,lun=\\.\PhysicalDrive19
sd=sd20,lun=\\.\PhysicalDrive20
sd=sd21,lun=\\.\PhysicalDrive21
sd=default,host=slave-1,size=997g
sd=sd0,lun=\\.\PhysicalDrive0
sd=sd1,lun=\\.\PhysicalDrive1
sd=sd2,lun=\\.\PhysicalDrive2
sd=sd3,lun=\\.\PhysicalDrive3
sd=sd4,lun=\\.\PhysicalDrive4
sd=sd5,lun=\\.\PhysicalDrive5
sd=sd6,lun=\\.\PhysicalDrive6
sd=sd7,lun=\\.\PhysicalDrive7
sd=sd8,lun=\\.\PhysicalDrive8
sd=sd9,lun=\\.\PhysicalDrive9
sd=sd10,lun=\\.\PhysicalDrive10
sd=sd11,lun=\\.\PhysicalDrive11
sd=sd12,lun=\\.\PhysicalDrive12
sd=sd13,lun=\\.\PhysicalDrive13
sd=sd14,lun=\\.\PhysicalDrive14
sd=sd15,lun=\\.\PhysicalDrive15
sd=sd16,lun=\\.\PhysicalDrive16
```

```
sd=sd17,lun=\\.PhysicalDrive17
sd=sd18,lun=\\.PhysicalDrive18
sd=sd19,lun=\\.PhysicalDrive19
sd=sd20,lun=\\.PhysicalDrive20
sd=sd21,lun=\\.PhysicalDrive21
```

## Large File Processing Test (LFP)

```
* Large File Processing
host=localhost,
java=("C:/Java/bin/java.exe", "-d64 -Xmx4096m -Xms4096m -Xss104k -Xincgc"),
jvms=4,
maxstreams=80
host=(10.21.151.112,slave-1),
java=("C:/Java/bin/java.exe", "-d64 -Xmx4096m -Xms4096m -Xss104k -Xincgc" ),
shell=spc2,
jvms=4,
output=C:/spc/output/out_lfp_slave-1,
maxstreams=80
```

### Common Commands/Parameters – LFP, LDQ and VOD

```
maxlatestart=1
reportinginterval=5
segmentlength=512m

rd=default,rampup=180,periods=90,measurement=180,runout=45,rampdown=15,buffers=1
```

#### \* LFP, Write Phase

```
rd=default,rdpct=0,xfersize=1024k
rd=TR1_SPC-2-FP,streams=32
rd=TR2_SPC-2-FP,streams=16
rd=TR3_SPC-2-FP,streams=8
rd=TR4_SPC-2-FP,streams=4
rd=TR5_SPC-2-FP,streams=1
```

```
rd=default,rdpct=0,xfersize=256k
rd=TR6_SPC-2-FP,streams=128
rd=TR7_SPC-2-FP,streams=64
rd=TR8_SPC-2-FP,streams=32
rd=TR9_SPC-2-FP,streams=16
rd=TR10_SPC-2-FP,streams=1
```

#### \* LFP, Read/Write Phase

```
rd=default,rdpct=50,xfersize=1024k
rd=TR11_SPC-2-FP,streams=64
rd=TR12_SPC-2-FP,streams=32
rd=TR13_SPC-2-FP,streams=16
rd=TR14_SPC-2-FP,streams=8
rd=TR15_SPC-2-FP,streams=1
```

```
rd=default,rdpct=50,xfersize=256k
rd=TR16_SPC-2-FP,streams=144
rd=TR17_SPC-2-FP,streams=72
rd=TR18_SPC-2-FP,streams=36
rd=TR19_SPC-2-FP,streams=18
rd=TR20_SPC-2-FP,streams=1
```

\* LFP, Read Phase

```
rd=default,rdpct=100,xfersize=1024k
rd=TR21_SPC-2-FP,streams=32
rd=TR22_SPC-2-FP,streams=16
rd=TR23_SPC-2-FP,streams=8
rd=TR24_SPC-2-FP,streams=4
rd=TR25_SPC-2-FP,streams=1
```

```
rd=default,rdpct=100,xfersize=256k
rd=TR26_SPC-2-FP,streams=128
rd=TR27_SPC-2-FP,streams=64
rd=TR28_SPC-2-FP,streams=32
rd=TR29_SPC-2-FP,streams=16
rd=TR30_SPC-2-FP,streams=1
```

## Large Database Query Test (LDQ)

\* Large Data Query

\* Master host

```
host=localhost,
java=("C:/Java/bin/java.exe", "-d64 -Xmx4096m -Xms4096m -Xss104k -Xincgc"),
jvms=4,
maxstreams=80
```

\* Slave-1 host

```
host=(10.21.151.112,slave-1),
java=("C:/Java/bin/java.exe", "-d64 -Xmx4096m -Xms4096m -Xss104k -Xincgc" ),
shell=spc2,
jvms=4,
output=C:/spc/output/out_ldq_slave-1,
maxstreams=80
```

### Common Commands/Parameters – LFP, LDQ and VOD

\* Run Definitions

```
maxlatestart=1
reportinginterval=5
segmentlength=512m
```

```
rd=default,rampup=180,periods=90,measurement=180,runout=45,rampdown=15,rdpct=99
```

\* LDQ, 1024KiB Phase

```
rd=default,buffers=4,xfersize=1024k
rd=TR1_SPC-2-DQ,streams=32
rd=TR2_SPC-2-DQ,streams=16
rd=TR3_SPC-2-DQ,streams=8
rd=TR4_SPC-2-DQ,streams=4
rd=TR5_SPC-2-DQ,streams=1
```

```
rd=default,buffers=1,xfersize=1024k
rd=TR6_SPC-2-DQ,streams=32
rd=TR7_SPC-2-DQ,streams=16
rd=TR8_SPC-2-DQ,streams=8
rd=TR9_SPC-2-DQ,streams=4
rd=TR10_SPC-2-DQ,streams=1
```

\* LDQ, 64KiB Phase

```
rd=default,buffers=4,xfersize=64k
rd=TR11_SPC-2-DQ,streams=128
rd=TR12_SPC-2-DQ,streams=64
rd=TR13_SPC-2-DQ,streams=32
rd=TR14_SPC-2-DQ,streams=16
rd=TR15_SPC-2-DQ,streams=1

rd=default,buffers=1,xfersize=64k
rd=TR16_SPC-2-DQ,streams=128
rd=TR17_SPC-2-DQ,streams=64
rd=TR18_SPC-2-DQ,streams=32
rd=TR19_SPC-2-DQ,streams=16
rd=TR20_SPC-2-DQ,streams=1
```

## Video on Demand Delivery (VOD)

```
* Video On Demand
host=localhost,
java=("C:/Java/bin/java.exe", "-d64 -Xmx4096m -Xms4096m -Xss104k -Xincgc"),
jvms=32,
maxstreams=200

host=(10.21.151.112,slave-1),
java=("C:/Java/bin/java.exe", "-d64 -Xmx4096m -Xms4096m -Xss104k -Xincgc" ),
shell=spc2,
jvms=32,
output=C:/spc/output/out_vod_slave-1,
maxstreams=200
```

### Common Commands/Parameters – LFP, LDQ and VOD

```
maxlatestart=10
reportinginterval=5
maxlatevod=0
videosegmentduration=1200

rd=default,rampup=1200,periods=600,measurement=7200,runout=45,rampdown=15,buffers=8

rd=TR1_SPC-2-VOD,streams=8400
```

## SPC-2 Persistence Test Run 1 (*write phase*)

```
* Persistence Write
host=localhost,jvms=16,java=("C:/Java/bin/java.exe", "-d64 -Xmx2048m -Xms2048m -
Xss104k")
sd=default,host=localhost,size=997g
sd=sd0,lun=\\.\PhysicalDrive0
sd=sd1,lun=\\.\PhysicalDrive1
sd=sd2,lun=\\.\PhysicalDrive2
sd=sd3,lun=\\.\PhysicalDrive3
sd=sd4,lun=\\.\PhysicalDrive4
sd=sd5,lun=\\.\PhysicalDrive5
sd=sd6,lun=\\.\PhysicalDrive6
sd=sd7,lun=\\.\PhysicalDrive7
sd=sd8,lun=\\.\PhysicalDrive8
sd=sd9,lun=\\.\PhysicalDrive9
```

```
sd=sd10,lun=\\.\PhysicalDrive10
sd=sd11,lun=\\.\PhysicalDrive11
sd=sd12,lun=\\.\PhysicalDrive12
sd=sd13,lun=\\.\PhysicalDrive13
sd=sd14,lun=\\.\PhysicalDrive14
sd=sd15,lun=\\.\PhysicalDrive15
sd=sd16,lun=\\.\PhysicalDrive16
sd=sd17,lun=\\.\PhysicalDrive17
sd=sd18,lun=\\.\PhysicalDrive18
sd=sd19,lun=\\.\PhysicalDrive19
sd=sd20,lun=\\.\PhysicalDrive20
sd=sd21,lun=\\.\PhysicalDrive21
maxlatestart=1
reportinginterval=5
segmentlength=512m

rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0
rd=default,buffers=1,rdpct=0,xfersize=1024k

rd=TR1_SPC-2-persist-w,streams=128
```

### SPC-2 Persistence Test Run 2 (*read phase*)

```
* Persistence Read
host=localhost,jvms=4,java=("C:/Java/bin/java.exe",-d64 -Xmx2048m -Xms2048m -
Xss104k")
sd=default,host=localhost,size=997g
sd=sd0,lun=\\.\PhysicalDrive0
sd=sd1,lun=\\.\PhysicalDrive1
sd=sd2,lun=\\.\PhysicalDrive2
sd=sd3,lun=\\.\PhysicalDrive3
sd=sd4,lun=\\.\PhysicalDrive4
sd=sd5,lun=\\.\PhysicalDrive5
sd=sd6,lun=\\.\PhysicalDrive6
sd=sd7,lun=\\.\PhysicalDrive7
sd=sd8,lun=\\.\PhysicalDrive8
sd=sd9,lun=\\.\PhysicalDrive9
sd=sd10,lun=\\.\PhysicalDrive10
sd=sd11,lun=\\.\PhysicalDrive11
sd=sd12,lun=\\.\PhysicalDrive12
sd=sd13,lun=\\.\PhysicalDrive13
sd=sd14,lun=\\.\PhysicalDrive14
sd=sd15,lun=\\.\PhysicalDrive15
sd=sd16,lun=\\.\PhysicalDrive16
sd=sd17,lun=\\.\PhysicalDrive17
sd=sd18,lun=\\.\PhysicalDrive18
sd=sd19,lun=\\.\PhysicalDrive19
sd=sd20,lun=\\.\PhysicalDrive20
sd=sd21,lun=\\.\PhysicalDrive21
maxlatestart=1
reportinginterval=5
segmentlength=512m

maxpersistenceerrors=10

rd=default,buffers=1,rdpct=100,xfersize=1024k

rd=TR1_SPC-2-persist-r
```



## **APPENDIX E: SPC-2 WORKLOAD GENERATOR EXECUTION COMMANDS AND PARAMETERS**

### **ASU Pre-Fill, Large File Processing Test, Large Database Query Test, Video on Demand Delivery Test, and SPC-2 Persistence Test Run 1**

The following script was invoked to execute the required ASU pre-fill, the Large File Processing (LFP), Large Database Query (LDQ) and Video on Demand Delivery (VOD) Test plus SPC-2 Persistence Test Run 1 (*write phase*). In addition, the script invoked additional command/scripts to capture the details TSC profile listings required for a Remote Audit.

#### **dofdr1.bat**

```
rem setup timestamp
c:\cygwin\bin\bash.exe setup.sh

rem save host information
c:\cygwin\bin\bash.exe saveHostInfo.sh "/cygdrive/c/spc/fdr/spc2reference"

rem chdir to vdbench 504 directory
chdir c:\spc\vdbench504

rem run prefill script
call vdbench.bat -f c:\spc\fdr\spc2param\DX200S3_20140821_prefill.txt -o
c:\spc\fdr\spc2output\prefill

rem chdir to home directory
chdir c:\spc\fdr

rem save before log
c:\cygwin\bin\bash.exe c:\spc\fdr\exportLog.sh Before

rem chdir to spc2 directory
chdir c:\spc\spc2

rem init volumes
call spc2.bat -f c:\spc\fdr\spc2param\param_doFDR_lfp.txt -o
c:\spc\fdr\spc2output\init -init

rem lfp test
call spc2.bat -f c:\spc\fdr\spc2param\param_doFDR_lfp.txt -o c:\spc\fdr\spc2output\lfp

rem ldq test
call spc2.bat -f c:\spc\fdr\spc2param\param_doFDR_ldq.txt -o c:\spc\fdr\spc2output\ldq

rem vod test
call spc2.bat -f c:\spc\fdr\spc2param\param_doFDR_vod.txt -o c:\spc\fdr\spc2output\vod

rem pers-w test
call spc2.bat -f c:\spc\fdr\spc2param\param_doFDR_pers-w.txt -o
c:\spc\fdr\spc2output\prstw
```

## SPC-2 Persistence Test Run 2

This second script was invoked to execute the SPC-2 Persistence Test Run 2 (*read phase*). In addition, the script invoked additional command/scripts to capture the details TSC profile listings required for a Remote Audit.

### dofdr2.bat

```
rem chdir to spc2 directory
chdir c:\spc\spc2

rem pers-r test
call spc2.bat -f c:\spc\fdr\spc2parm\param_dofDR_pers-r.txt -o
c:\spc\fdr\spc2output\pers-r

rem chdir to home directory
chdir c:\spc\fdr

rem save After Log
c:\cygwin\bin\bash.exe exportLog.sh After

rem zipup the data and send to repository
c:\cygwin\bin\bash.exe zipUp.sh
```