



**SPC BENCHMARK 1C/ENERGY™
FULL DISCLOSURE REPORT**

**SEAGATE TECHNOLOGY LLC
SEAGATE SAVVIO® 10K.3 ST9300603SS**

SPC-1C/E™ V1.3

**Submitted for Review: June 3, 2009
Submission Identifier: CE00002**

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AUDIT CERTIFICATION



Craig Parris
Seagate Technology LLC
1280 Disc Drive
Shakopee, MN 55379

June 2, 2009

The SPC Benchmark 1C/Energy™ Reported Data listed below for the Seagate Savvio® 10K.3 ST9300603SS were produced in compliance with the SPC Benchmark 1C/Energy™ V1.3 Onsite Audit requirements.

SPC Benchmark 1C/Energy™ V1.3 Reported Data	
Tested Storage Configuration (TSC) Name:	
Seagate Savvio® 10K.3 ST9300603SS	
Metric	Reported Result
SPC-1C IOPS™	8,013.39
Total ASU Capacity	3,600,000 GB
Data Protection Level	Unprotected
Total TSC Price (including three-year maintenance)	\$15,209

	Usage Profile					
	Hours of Use per Day			Nominal Power, W	Nominal Traffic, IOPS	Nominal IOPS/W
	Heavy	Moderate	Idle			
Low Daily Usage:	0	8	16	184.31	1333.97	7.24
Medium Daily Usage:	4	14	6	201.88	3401.18	16.85
High Daily Usage:	18	6	0	218.40	5800.76	26.56
Composite Metrics:				201.53	3,511.97	17.43
Annual Energy Use, kWh:	1,765.41					
Energy Cost, \$/kWh:	\$ 0.12			Annual Energy Cost, \$:	\$ 211.85	

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AUDIT CERTIFICATION (CONT.)

Seagate Savvio® 10K.3 ST9300603SS
SPC-1 Audit Certification

Page 2

The following SPC Benchmark 1C/Energy™ Onsite Audit requirements were reviewed and found compliant with V1.3 of the SPC Benchmark 1C/Energy™ Specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by information supplied by Seagate Technology LLC:
 - ✓ Physical Storage Capacity and requirements.
 - ✓ Configured Storage Capacity and requirements.
 - ✓ Addressable Storage Capacity and requirements.
 - ✓ Capacity of each Logical Volume and requirements.
 - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- An appropriate diagram of the Benchmark Configuration/Tested Storage Configuration.
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1C/E™ Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by Seagate Technology LLC:
 - ✓ The type of Host System including the number of processors and main memory.
 - ✓ The presence and version number of the SPC-1C™ Workload Generator on the Host System.
 - ✓ A valid SPC-1C™ site license.
 - ✓ The TSC boundary within the Host System.
- The Test Results Files and resultant Summary Results Files received from Seagate Technology LLC for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4, 6, and 12 of the SPC Benchmark 1C/Energy™ Specification:
 - ✓ Idle Test
 - Conditioning Phase
 - Application Idle Phase
 - Recovery Phase
 - ✓ Primary Metrics Test:
 - Sustainability Test Phase
 - IOPS Test Phase
 - Response Time Ramp Test Phase
 - ✓ Repeatability Test
 - ✓ Data Persistence Test
- The Yokogawa WT210 Digital Power Meter, used to record power consumption, was verified as an SPC approved "Power Extension apparatus" with a current calibration certificate.
- All power supplies present in the Tested Storage Configuration were verified as active.

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AUDIT CERTIFICATION (CONT.)

Seagate Savvio® 10K.3 ST9300603SS
SPC-1 Audit Certification

Page 3

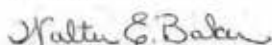
Seagate Technology LLC provided documentation of the following:

- ✓ Voltage (220), amperage (30), and phase characteristics (*single*) of the AC inputs used for powering the Tested Storage Configuration.
- ✓ The configured power supplies were configured for mutual failover.
- Concurrent power measurements were taken at each active AC input so that the total power requirement of the Tested Storage Configuration was recorded.
- The ambient temperature was recorded at the following times in near proximity to the Tested Storage configuration with a precision of at least $\pm 0.1^{\circ}\text{C}$:
 - ✓ During the first one minute of the Idle Test (*Initial Energy Extension temperature*).
 - ✓ During the last one minute of the Primary Metrics Test (*Final Energy Extension temperature*).
- The Benchmark Configuration/Tested Storage Configuration diagram included the electrical metering, which illustrates the measurement apparatus used and the relationship between the active AC inputs and the associated measurement apparatus inputs.
- 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 Benchmark 1C/Energy™ Specification.
- The Full Disclosure Report (*FDR*) met all of the requirements in Clauses 10 and 12 of the SPC Benchmark 1C/Energy™ 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

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LETTER OF GOOD FAITH



Seagate Technology
1280 Disc Drive
Shakopee MN 55379

Date: **05/28/2009**

From: Carla Kennedy

To: **Walter Baker**

Subject: SPC-1C/E Letter of Good Faith for Seagate Savvio 10K.3 ST9300603SS

Seagate Technology is the SPC-1C/E Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1C/E benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with **V1.3** of the SPC-1C 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 above SPC-1C benchmark specification.

Signed:

 _____ 5/28/2009

Carla Kennedy

Vice President, Enterprise Compute Product Management

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Seagate Technology LLC – http://www.seagate.com Craig Parris – Craig.Parris@seagate.com 1280 Disc Drive Shakopee, MN 55379 Phone: (952) 402-2418 FAX: (952) 402-2695
Test Sponsor Alternate Contact	Seagate Technology LLC – http://www.seagate.com Teresa Worth – Teresa.M.Worth@seagate.com 1280 Disc Drive Shakopee, MN 55379 Phone: (952) 402-3704 FAX: (952) 402-2859
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 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	
SPC-1C/E Specification revision number	V1.3
SPC-1C Workload Generator revision number	V1.0
Date Results were first used publicly	June 3, 2009
Date the FDR was submitted to the SPC	June 3, 2009
Date the TSC is available for shipment to customers	currently available
Date the TSC completed audit certification	June 2, 2009

Tested Storage Product (TSP) Description

Seagate® Savvio® 10K.3 drives offer the best combination of enterprise performance and power efficiency, with up to 300-GB capacity for mainstream servers and external storage arrays. This third-generation Savvio drive gives you more than twice the number of drives over 3.5-inch products within the same rack configuration, and delivers system-level performance increase. The Savvio 10K.3 drives are the world's first to operate at 6-Gb/s transfer rates, which is part of the new SAS 2.0 feature set. SAS 2.0 was developed to provide additional signal and data integrity features to enable SAS to be ideally suited for use in high-end network storage applications.

The 2.5-inch footprint enables the lowest power profile of any tier-1 mission-critical drive. The Savvio 10K.3 drive with PowerTrim technology uses less power than a 3.5-inch 15K drive. The lower power footprint of 2.5-inch drives enables lower cooling costs. The 2.5-inch drive advantages translate into greater overall value and reduced total cost of ownership to IT organizations and administrators who want to optimize their data center power and performance efficiency.

Summary of Results

SPC-1C Results	
Tested Storage Product: Seagate Savvio® 10K.3 ST9300603SS	
Metric	Reported Result
SPC-1C IOPS™	8,013.39
Total ASU Capacity	3,600.000 GB
Data Protection Level	Unprotected
Total Price – Priced Storage Configuration	\$15,209

SPC-1C IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

Total ASU (Application Storage Unit) Capacity represents the total storage capacity read and written in the course of executing the SPC-1C benchmark.

A **Data Protection Level** of **UNPROTECTED** makes no claim of data protection in the event of a single point of failure..

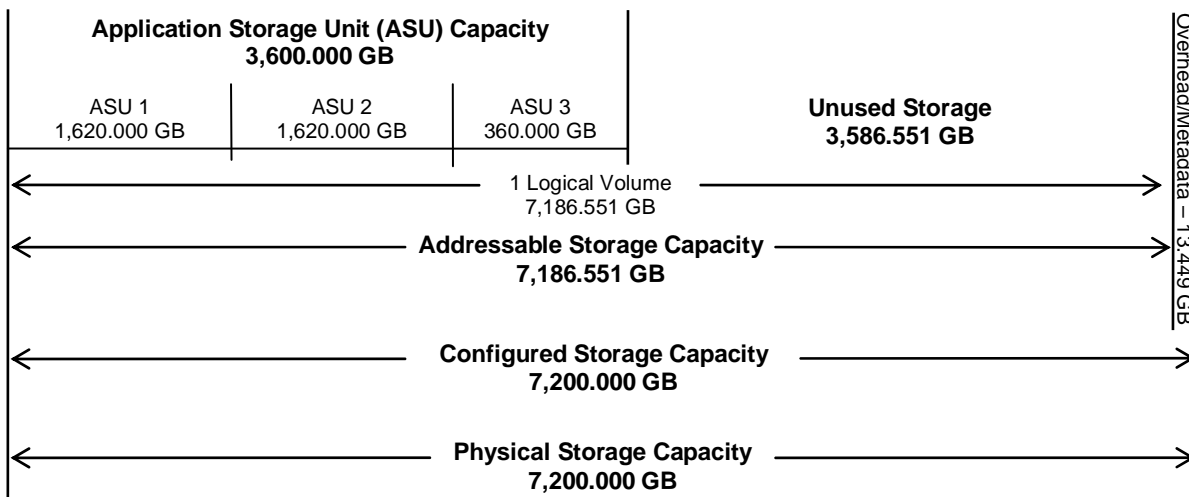
Storage Capacities and Relationships

The Tested Storage Configuration (TSC) must be configured so that there is either no Unused Storage or that the sum of Total ASU Capacity and storage required for data protection equals 50% (+-1 GiB) of the Physical Storage Capacity. This configuration meets the 50% requirement as documented below:

$$7,200.000 \text{ GB (Physical Storage Capacity)} * 0.5 = 3,600.000 \text{ GB}$$

$$3,600.000 \text{ GB (Total ASU Capacity)} + 0.000 \text{ GB (data protection)} = 3,600.000 \text{ GB}$$

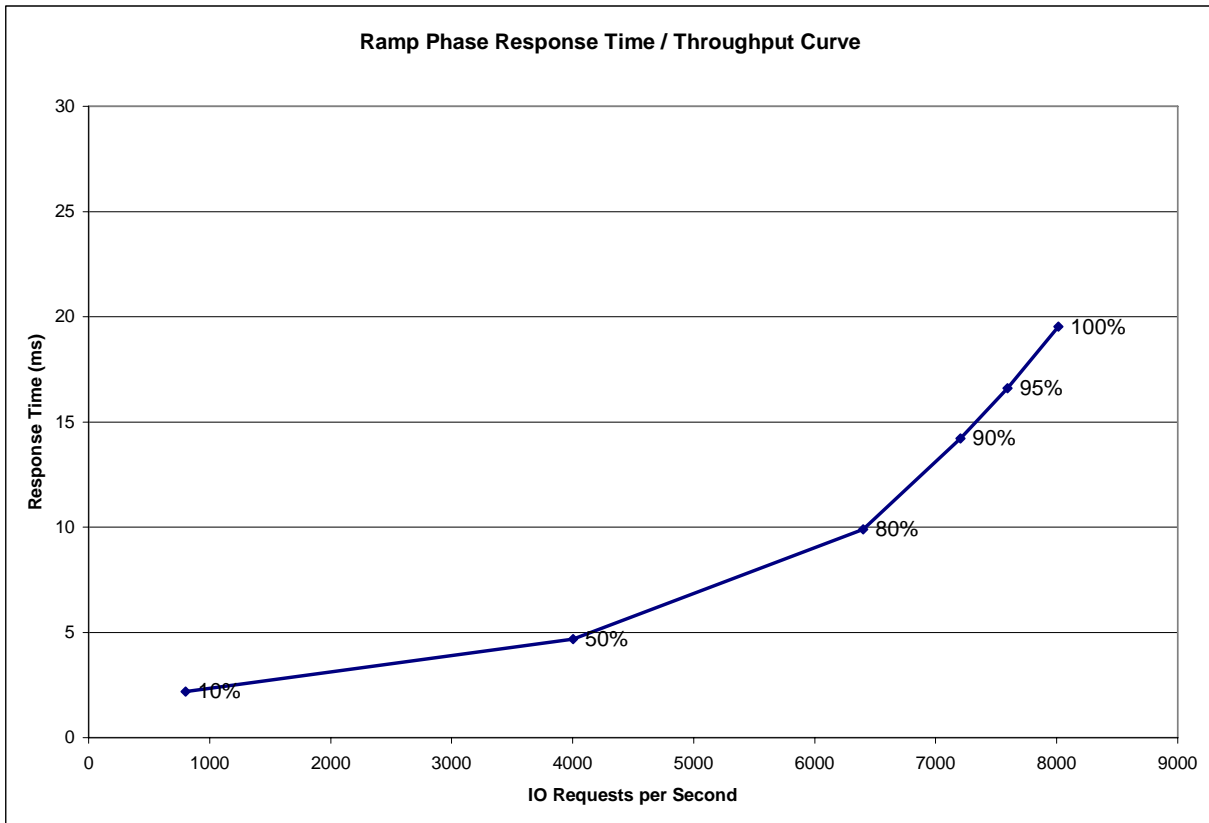
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



Response Time – Throughput Curve

The Response Time-Throughput Curve illustrates the Average Response Time (milliseconds) and I/O Request Throughput at 100%, 95%, 90%, 80%, 50%, and 10% of the workload level used to generate the SPC-1C IOPS™ metric.

The Average Response Time measured at any of the above load points cannot exceed 30 milliseconds or the benchmark measurement is invalid.



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	799.60	4,001.92	6,400.37	7,203.42	7,594.51	8,013.39
Average Response Time (ms):						
All ASUs	2.18	4.68	9.91	14.21	16.60	19.54
ASU-1	3.04	6.15	11.35	15.00	17.36	20.81
ASU-2	2.64	7.08	16.70	23.65	27.89	33.70
ASU-3	0.16	0.49	3.89	8.37	10.05	10.63
Reads	5.30	11.16	21.58	28.67	32.98	38.75
Writes	0.15	0.46	2.29	4.79	5.95	7.03

SPC-1C/E Reported Data

	Usage Profile					
	Hours of Use per Day			Nominal Power, W	Nominal Traffic, IOPS	Nominal IOPS/W
	Heavy	Moderate	Idle			
Low Daily Usage:	0	8	16	184.31	1333.97	7.24
Medium Daily Usage:	4	14	6	201.88	3401.18	16.85
High Daily Usage:	18	6	0	218.40	5800.76	26.56
Composite Metrics:				201.53	3,511.97	17.43
Annual Energy Use, kWh:	1,765.41					
Energy Cost, \$/kWh:	\$ 0.12			Annual Energy Cost, \$:	\$ 211.85	

The above usage profile describes conditions in environments that respectively impose light (“low”), moderate (“medium”), and extensive (“high”) demands on the Tested Storage Configuration (TSC).

HEAVY SPC-1C Workload: 221.50W at 80% of maximum reported performance (*6,400.37 SPC-1C IOPS*).

MODERATE SPC-1C Workload: 209.11W at 50% of maximum reported performance (*4,001.92 SPC-1C IOPS*).

IDLE SPC-1C Workload: 171.92W at 0% of maximum reported performance (*0.00 SPC-1C IOPS*).

LOW DAILY USAGE: Zero (0) hours of **HEAVY** SPC-1C Workload, eight (8) hours of **MODERATE** SPC-1C Workload, and sixteen (16) hours of **IDLE** SPC-1C Workload.

MEDIUM DAILY USAGE: Four (4) hours of **HEAVY** SPC-1C Workload, fourteen (14) hours of **MODERATE** SPC-1C Workload, and six (6) hours of **IDLE** SPC-1C Workload.

HIGH DAILY USAGE: Eighteen (18) hours of **HEAVY** SPC-1C Workload, six (6) hours of **MODERATE** SPC-1C Workload, and zero (0) hours of **IDLE** SPC-1C Workload.

NOMINAL POWER, W: The average power consumption over the course of a day (*24 hours*), taking into account hourly load variations.

NOMINAL TRAFFIC, IOPS: The average level of I/O requests over the course of a day (*24 hours*), taking into account hourly load variations.

NOMINAL IOPS/W: The overall efficiency with which I/O requests can be supported, reflected by the ratio of **NOMINAL TRAFFIC** versus the **NOMINAL POWER**.

COMPOSITE METRICS: The aggregated **NOMINAL POWER**, **NOMINAL TRAFFIC**, and **NOMINAL IOPS/W** for all three environments: **LOW**, **MEDIUM**, and **HIGH DAILY USAGE**.

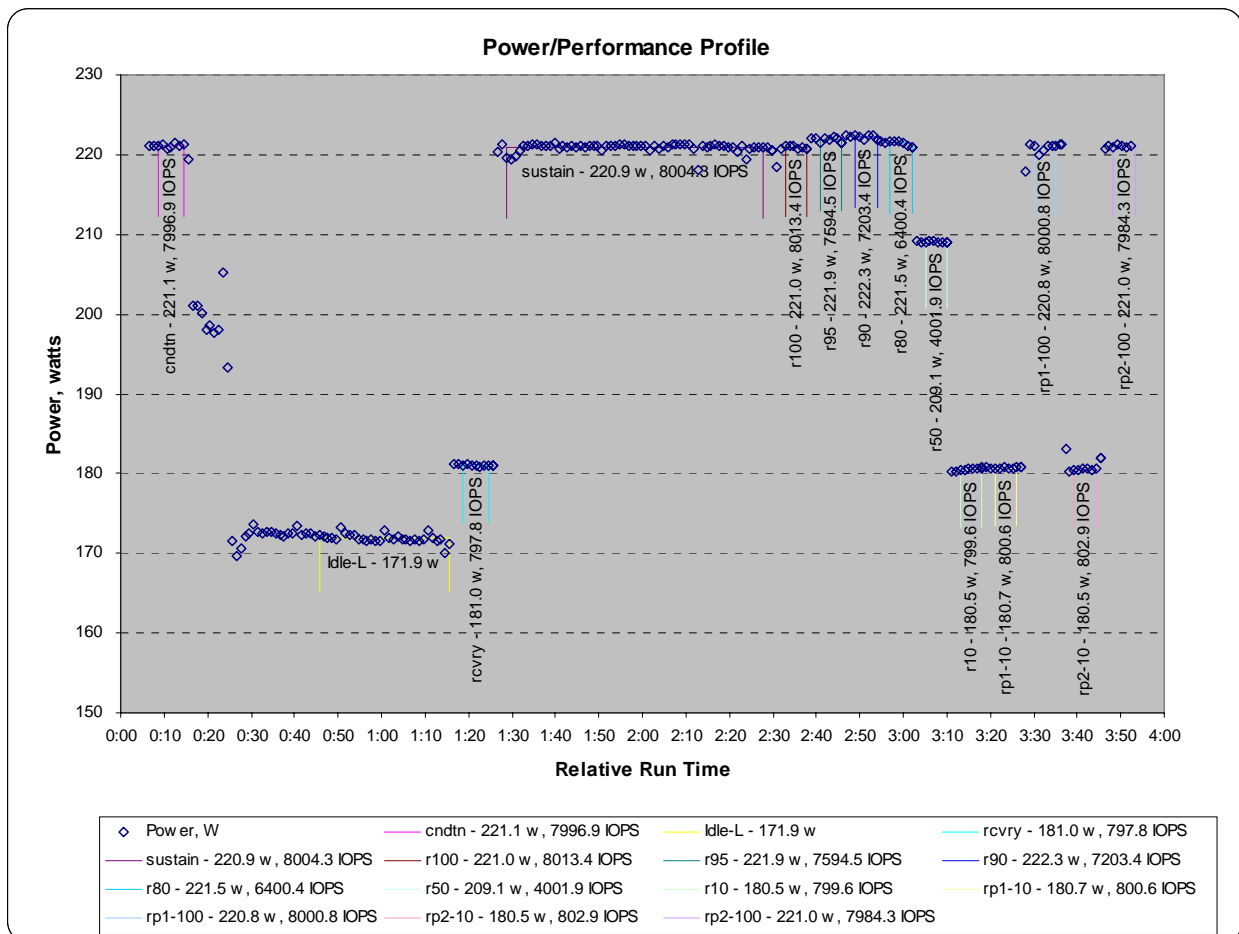
ANNUAL ENERGY USE, kWh: An estimate of the average energy use across the three environments over the course of a year and computed as (NOMINAL POWER * 24 * 0.365).

ENERGY COST, \$/kWh: A standardized energy cost per kilowatt hour.

ANNUAL ENERGY COST: An estimate of the annual energy use across the three environments over the course of a year and computed as (ANNUAL ENERGY USE * ENERGY COST).

SPC-1C/E Power/Performance Profile

The SPC-1C/E Power/Performance Profile chart provides a complete “at a glance” illustration and report for each SPC-1C/E execution component. The power consumption at each step is reported and, where appropriate the measured SPC-1C performance (SPC-1C IOPS) is also reported.



Tested Storage Configuration Pricing (*Priced Storage Configuration*)

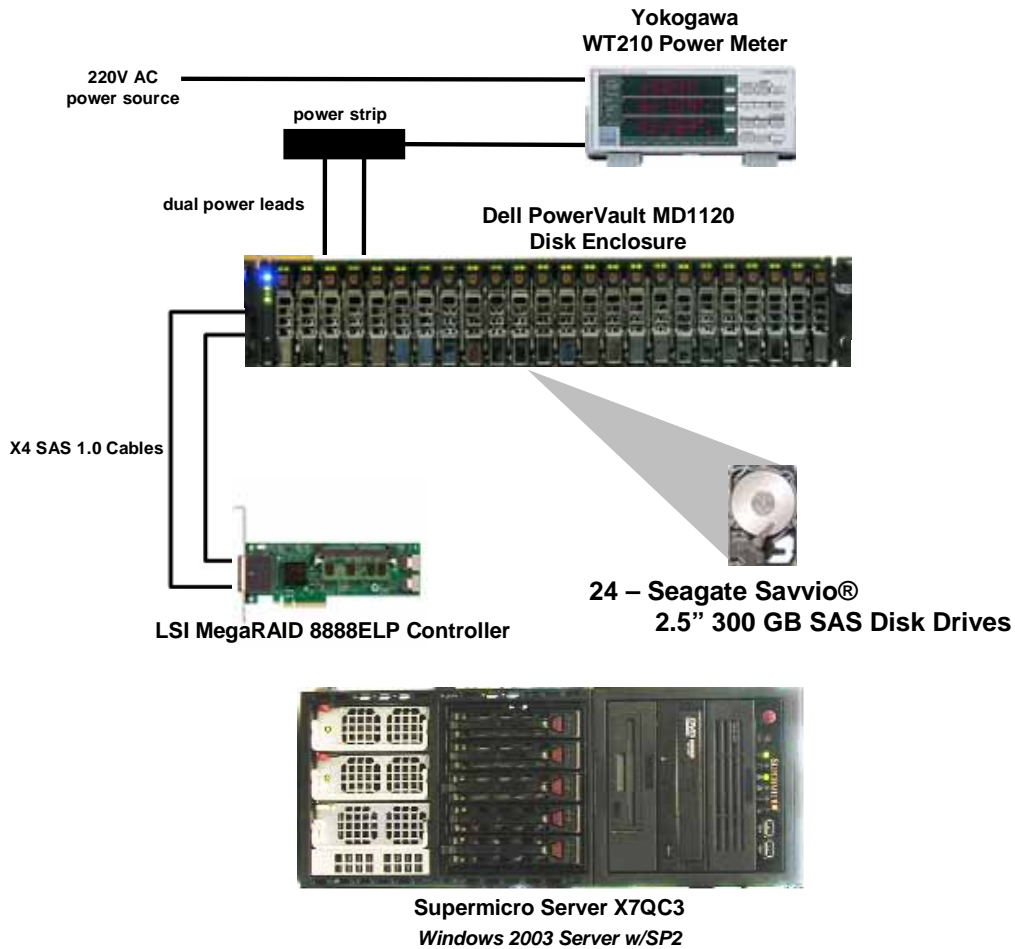
Description		Part Numbers	Qty	Price	Extended Price
300GB SAS 2.5" 10K RPM HDD		ST9300603SS	24	\$404	\$9,689
LSI MegaRAID 8888ELP	<i>third-party</i>	LSI00142	1	\$641	\$641
2U 24 bay External Storage Array	<i>third-party</i>	Dell MD1120	1	\$4,878	\$4,878
incl 2 SAS -2M Cables					
incl 24 drive trays					
incl 3 year hardware support					
				Total	\$15,209

The Dell MD1120 Disk Storage Enclosure order is required to include a minimum of two (2) disk drives. Those two drives were removed from the enclosure and replaced by the twenty-four (24) priced disk drives for the benchmark execution.

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

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

Benchmark Configuration/Tested Storage Configuration Diagram



Benchmark Configuration/Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
Supermicro Server X7QC3 2 – 2.66 GHz Intel Xeon processors 6 cores per processor 2 x 32 KB L1 cache 2 x 3 MB L2 cache	1 – LSI MegaRaid 8888ELP RAID external controller with: 512 MB cache 1 - x8 PCIe 1.0 host connection 2 - 3 Gb/s SAS 1.0 disk connections
8 GB main memory	1 – Dell PowerVault MD1120 Disk Storage Enclosure with
Windows 2003 Standard Edition SP2	2 – 2x2m SAS cables
PCIe 1.0	24 – Seagate Savvio® 300 GB 2.5" SAS disks
Other BC Components	
1 – Yokogawa WT210 Digital Power Meter	
1 – Yokogawa-supplied power strip	

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-1C benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

CONFIGURATION INFORMATION

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

Clause 10.4.5.10

The Executive Summary 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 17 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Host System and Tested Storage Configuration

Clause 10.4.5.11

The Executive Summary will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC).

The table listing the major components of each Host System and the Tested Storage Configuration may be found on page 17 (*Benchmark Configuration/Tested Storage Configuration Components*).

Customer Tunable Parameters and Options

Clause 10.4.6.1

All Benchmark Configuration (BC) components with customer tunable parameters and options that have been altered from their default values must be listed in the Full Disclosure Report (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 61 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 10.4.6.2

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 10.4.6.1), 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 10.4.5.10.*

- *The logical representation of the TSC, configured from the above components that will be presented to the SPC-1C 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 62 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1C Workload Generator Storage Configuration

Clause 10.4.6.3

The Full Disclosure Report will include all SPC-1C Workload Generator storage configuration commands and parameters used in the SPC-1C benchmark measurements.

The SPC-1C Workload Generator storage configuration commands and parameters for this measurement appear in “Appendix D: SPC-1C Workload Generator Storage Commands and Parameters” on page 64.

SPC-1C DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1C storage capacities and mappings used in the Tested Storage Configuration. “SPC-1C Data Repository Definitions” on page 57 contains definitions of terms specific to the SPC-1C Data Repository.

Storage Capacities and Relationships

Clause 10.4.7.1

Two tables and an illustration documenting the storage capacities and relationships of the SPC-1C Storage Hierarchy (Clause 2.1) shall be included in the FDR.

SPC-1C Storage Capacities

SPC-1C Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	3,600.000
Addressable Storage Capacity	Gigabytes (GB)	7,186.551
Configured Storage Capacity	Gigabytes (GB)	7,200.000
Physical Storage Capacity	Gigabytes (GB)	7,200.000
Data Protection (<i>Unprotected</i>)	Gigabytes (GB)	0.000
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	13.449
Total Unused Storage	Gigabytes (GB)	3,586.551

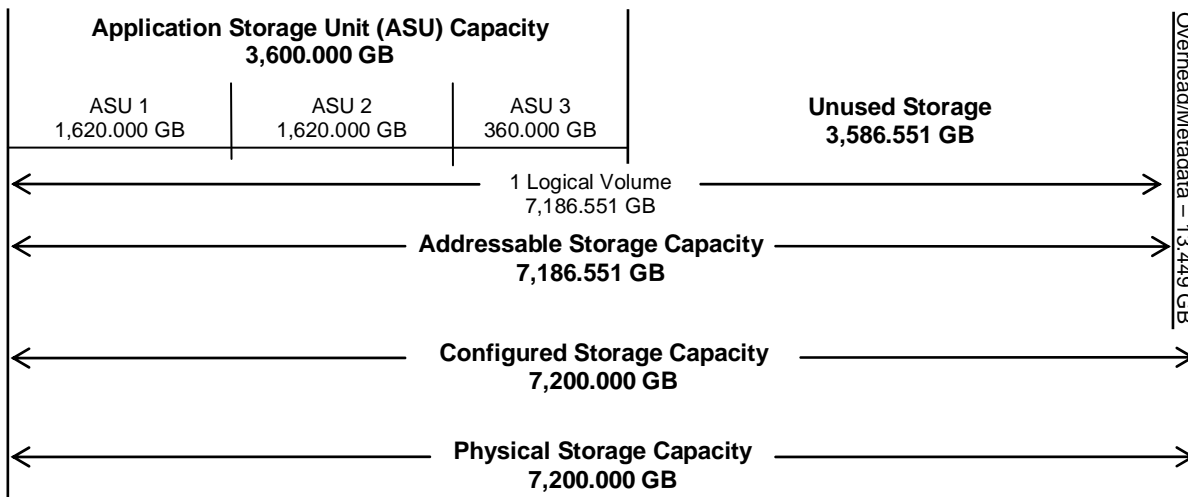
SPC-1C Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	50.09%	50.00%	50.00%
Required for Data Protection (<i>Unprotected</i>)		0.00%	0.00%
Addressable Storage Capacity		99.81%	99.81%
Required Storage		0.00%	0.00%
Configured Storage Capacity			100.00%
Global Storage Overhead			0.19%
Unused Storage:			
Addressable	49.91%		
Configured		0.00%	
Physical			0.00%

The Physical Storage Capacity consisted of 7,200.000 GB distributed over 24 disk drives with a formatted capacity of 300.000 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.000 GB (0.00%) of Physical Storage Capacity. There was 0.000 GB (0.00%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 50.09% of the Addressable Storage Capacity resulting in 3,586.551 GB (49.91%) of Unused Storage within the Addressable Storage Capacity.

SPC-1C Storage Capacities and Relationships Illustration

The various storage capacities configured in the benchmark result are illustrated below (not to scale).



Logical Volume Capacity and ASU Mapping

Clause 10.4.7.2

A table illustrating the capacity of each ASU and the mapping of Logical Volumes to ASUs shall be provided in the FDR. ... Logical Volumes shall be sequenced in the table from top to bottom per its position in the contiguous address space of each ASU. The capacity of each Logical Volume shall be stated. ... In conjunction with this table, the Test Sponsor shall provide a complete description of the type of data protection (see Clause 2.7) used on each Logical Volume.

Logical Volume Capacity and Mapping		
ASU-1 (1,620.000 GB)	ASU-2 (1,620.000 GB)	ASU-3 (360.000 GB)
1 Logical Volume 7,186.551 GB per Logical Volume (1,620.000 GB used per Logical Volume)	1 Logical Volume one Logical Volume for all ASUs (1,620.000 GB used per Logical Volume)	1 Logical Volume one Logical Volume for all ASUs (1,620.000 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was UNPROTECTED as described on page 12. See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

SPC-1C BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1C Tests, Test Phases, and Test Runs. “SPC-1C Test Execution Definitions” on page 58 contains definitions of terms specific to the SPC-1C Tests, Test Phases, and Test Runs.

Clause 6.4.2

The Tests must be executed in the following sequence: Primary Metrics, Repeatability, and Data Persistence. That required sequence must be uninterrupted from the start of Primary Metrics to the completion of Persistence Test Run 1.

Uninterrupted means the Benchmark Configuration shall not be power cycled, restarted, disturbed, altered, or adjusted during the selected Test sequence. If the selected Test sequence is interrupted, the SPC-1C measurement is invalid. This does not apply to the interruption caused by the Host System/TSC power cycle between Persistence Test Run 1 and Persistence Test Run 2.

SPC-1C Tests, Test Phases, and Test Runs

The SPC-1C benchmark consists of the following Tests, Test Phases, and Test Runs:

- **Primary Metrics Test**
 - Sustainability Test Phase and Test Run
 - IOPS Test Phase and Test Run
 - Response Time Ramp Test Phase
 - 95% of IOPS Test Run
 - 90% of IOPS Test Run
 - 80% of IOPS Test Run
 - 50% of IOPS Test Run
 - 10% of IOPS Test Run (LRT)
- **Repeatability Test**
 - Repeatability Test Phase 1
 - 10% of IOPS Test Run (LRT)
 - IOPS Test Run
 - Repeatability Test Phase 2
 - 10% of IOPS Test Run (LRT)
 - IOPS Test Run
- **Data Persistence Test**
 - Data Persistence Test Run 1
 - Data Persistence Test Run 2

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

Primary Metrics Test – Sustainability Test Phase

Clause 6.4.3.2

The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within a continuous one (1) hour Measurement Interval.

Clause 6.4.3.2.6

The computed I/O Request Throughput of the Sustainability Test Run must be no less than 95% of the reported SPC-1C IOPS™ result or the Test Run is invalid.

Clause 6.4.3.2.7

The Average Response Time, as defined in Clause 0, will be computed and reported for the Sustainability Test Run and cannot exceed 30 milliseconds. If the Average Response Time exceeds that 30-millisecond constraint, the Test Run is invalid.

Clause 10.4.8.1

For the Sustainability Test Phase the FDR shall contain:

- 1. A Data Rate Distribution graph and data table.*
- 2. I/O Request Throughput Distribution graph and data table.*
- 3. A Response Time Frequency Distribution graph and table.*
- 4. An Average Response Time Distribution graph and table.*
- 5. The human readable Test Run Results File produced by the Workload Generator (may be included in an appendix).*
- 6. A listing or screen image of all input parameters supplied to the Workload Generator (may be included in an appendix).*
- 7. The Measured Intensity Multiplier for each I/O stream.*
- 8. The variability of the Measured Intensity Multiplier, as defined in Clause 5.3.13.3.*

SPC-1C Workload Generator Input Parameters

The SPC-1C Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1C Workload Generator Input Parameters” on Page 65.

Sustainability Test Results File

A link to the test results file generated from the Sustainability Test Run is listed below.

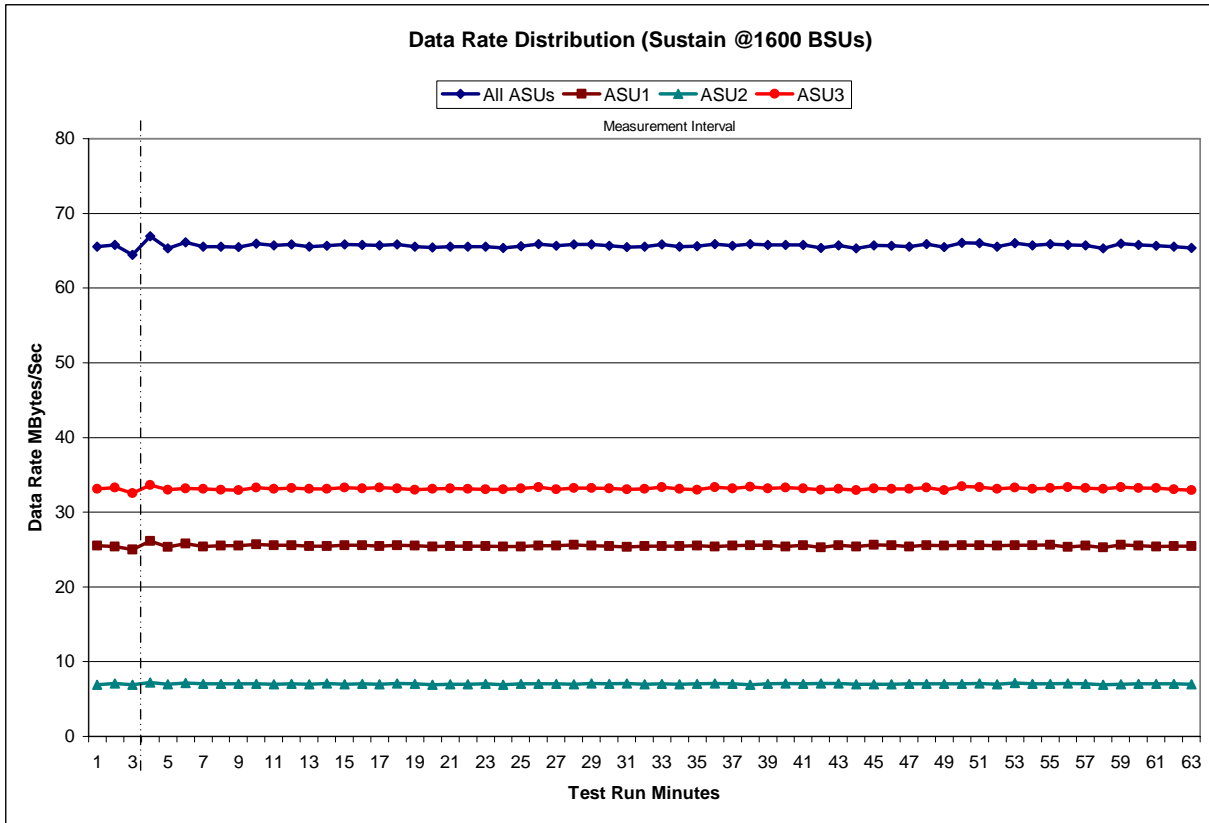
[Sustainability Test Results File](#)

Sustainability – Data Rate Distribution Data (MB/second)

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	12:05:46	12:08:46	0-2	0:03:00
Measurement Interval	12:08:46	13:08:46	3-62	1:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	65.57	25.54	6.92	33.10	32	65.83	25.43	7.04	33.36
1	65.79	25.41	7.10	33.29	33	65.52	25.44	6.95	33.13
2	64.47	24.99	6.91	32.57	34	65.61	25.53	7.05	33.02
3	66.93	26.13	7.19	33.61	35	65.87	25.40	7.11	33.37
4	65.29	25.36	6.96	32.98	36	65.69	25.50	7.01	33.17
5	66.15	25.83	7.13	33.19	37	65.89	25.57	6.94	33.39
6	65.56	25.40	7.05	33.11	38	65.79	25.59	7.01	33.19
7	65.56	25.50	7.04	33.02	39	65.77	25.42	7.06	33.29
8	65.46	25.51	7.01	32.94	40	65.77	25.58	7.03	33.16
9	65.97	25.66	7.01	33.30	41	65.36	25.27	7.10	32.99
10	65.71	25.59	6.98	33.14	42	65.74	25.59	7.06	33.10
11	65.81	25.56	7.01	33.24	43	65.33	25.42	6.95	32.96
12	65.55	25.47	6.99	33.10	44	65.74	25.62	6.97	33.16
13	65.65	25.45	7.09	33.11	45	65.67	25.55	6.99	33.13
14	65.83	25.58	6.97	33.28	46	65.53	25.41	7.03	33.09
15	65.77	25.57	7.02	33.18	47	65.89	25.55	7.05	33.29
16	65.74	25.44	6.98	33.31	48	65.49	25.50	7.03	32.96
17	65.83	25.60	7.08	33.15	49	66.05	25.55	7.03	33.47
18	65.53	25.50	7.01	33.02	50	66.00	25.55	7.11	33.34
19	65.41	25.37	6.92	33.12	51	65.56	25.52	6.94	33.09
20	65.56	25.44	6.95	33.17	52	66.03	25.57	7.16	33.31
21	65.54	25.47	6.95	33.12	53	65.72	25.59	7.02	33.11
22	65.52	25.45	7.02	33.05	54	65.89	25.64	7.01	33.24
23	65.36	25.42	6.90	33.04	55	65.77	25.36	7.06	33.35
24	65.62	25.41	7.05	33.16	56	65.74	25.50	7.00	33.24
25	65.86	25.49	7.04	33.33	57	65.29	25.30	6.91	33.09
26	65.65	25.52	7.06	33.08	58	65.93	25.64	6.95	33.34
27	65.85	25.63	7.00	33.23	59	65.77	25.52	7.03	33.23
28	65.82	25.51	7.08	33.24	60	65.66	25.40	7.03	33.24
29	65.64	25.45	7.01	33.18	61	65.54	25.43	7.05	33.05
30	65.49	25.34	7.06	33.09	62	65.38	25.46	6.99	32.92
31	65.53	25.43	6.98	33.11					

Sustainability – Data Rate Distribution Graph



Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration					
Ramp-Up/Start-Up	12:05:46	12:08:46	0-2	0:03:00					
Measurement Interval	12:08:46	13:08:46	3-62	1:00:00					

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	8,005.68	4,781.85	979.40	2,244.43	32	8,006.52	4,767.05	987.43	2,252.03
1	7,998.13	4,756.68	986.58	2,254.87	33	8,000.27	4,771.00	975.97	2,253.30
2	7,840.57	4,673.50	967.37	2,199.70	34	8,001.77	4,774.23	979.07	2,248.47
3	8,186.18	4,883.47	1,007.25	2,295.47	35	8,010.65	4,754.17	993.37	2,263.12
4	7,951.95	4,738.70	977.07	2,236.18	36	7,996.63	4,771.13	978.75	2,246.75
5	8,062.35	4,811.48	998.02	2,252.85	37	8,018.12	4,781.65	980.22	2,256.25
6	7,966.10	4,746.07	978.77	2,241.27	38	8,006.63	4,771.93	982.40	2,252.30
7	8,000.18	4,777.53	979.35	2,243.30	39	7,994.17	4,763.83	985.15	2,245.18
8	7,998.28	4,778.35	980.80	2,239.13	40	8,007.32	4,774.50	983.47	2,249.35
9	7,998.55	4,772.12	974.32	2,252.12	41	7,989.33	4,752.67	986.27	2,250.40
10	8,015.48	4,781.40	987.57	2,246.52	42	8,016.58	4,774.33	993.23	2,249.02
11	8,008.95	4,771.58	979.23	2,258.13	43	7,988.93	4,754.80	986.42	2,247.72
12	7,999.55	4,770.20	981.60	2,247.75	44	8,006.07	4,775.35	980.13	2,250.58
13	8,009.47	4,769.33	991.43	2,248.70	45	7,996.92	4,781.82	981.67	2,233.43
14	8,020.58	4,776.82	984.80	2,258.97	46	7,958.48	4,737.75	985.53	2,235.20
15	7,991.82	4,759.67	980.33	2,251.82	47	8,044.48	4,785.88	992.12	2,266.48
16	7,998.77	4,758.28	983.98	2,256.50	48	7,994.28	4,773.85	981.23	2,239.20
17	8,012.82	4,777.83	986.38	2,248.60	49	8,013.42	4,777.33	988.28	2,247.80
18	8,009.98	4,783.28	987.65	2,239.05	50	8,018.42	4,780.30	989.43	2,248.68
19	7,979.33	4,756.78	976.48	2,246.07	51	7,988.88	4,756.50	981.02	2,251.37
20	7,994.27	4,770.87	981.12	2,242.28	52	8,018.08	4,774.42	989.88	2,253.78
21	7,985.37	4,765.35	975.58	2,244.43	53	7,998.70	4,768.93	983.70	2,246.07
22	7,980.82	4,751.63	983.58	2,245.60	54	8,015.50	4,788.25	980.75	2,246.50
23	8,010.13	4,777.42	981.85	2,250.87	55	8,003.68	4,749.95	984.40	2,269.33
24	8,007.03	4,773.63	984.55	2,248.85	56	8,004.80	4,772.93	978.25	2,253.62
25	7,997.85	4,756.60	983.03	2,258.22	57	7,944.68	4,734.77	975.62	2,234.30
26	8,020.12	4,779.17	988.73	2,252.22	58	8,029.95	4,780.40	982.05	2,267.50
27	8,005.02	4,778.23	979.30	2,247.48	59	8,014.83	4,776.02	983.95	2,254.87
28	8,019.07	4,777.15	992.68	2,249.23	60	7,996.33	4,765.10	988.57	2,242.67
29	7,981.90	4,765.18	979.13	2,237.58	61	8,001.88	4,770.57	985.35	2,245.97
30	7,985.67	4,756.23	981.73	2,247.70	62	7,983.47	4,759.33	980.40	2,243.73
31	7,989.80	4,771.20	984.22	2,234.38	Average	8,004.29	4,770.94	983.91	2,249.44

Sustainability – I/O Request Throughput Distribution Graph

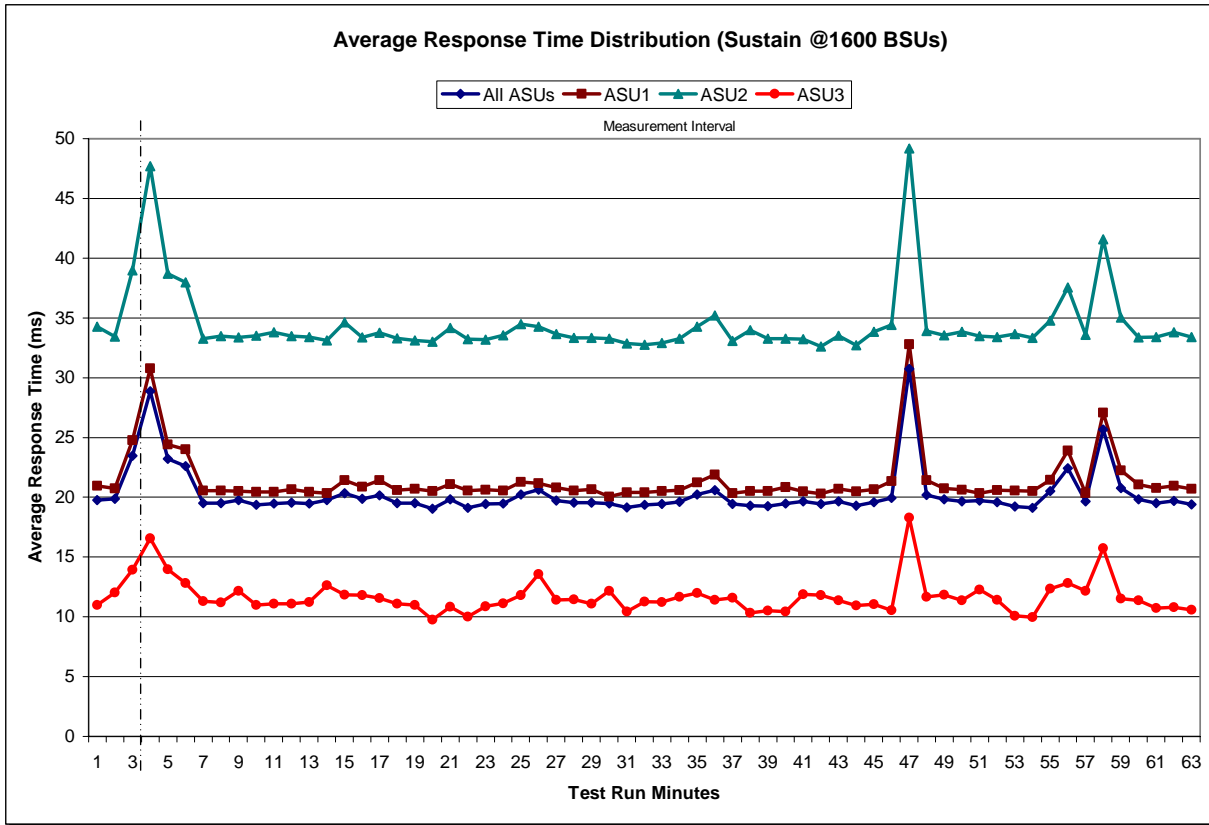


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration					
Ramp-Up/Start-Up	12:05:46	12:08:46	0-2	0:03:00					
Measurement Interval	12:08:46	13:08:46	3-62	1:00:00					

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	19.78	20.94	34.27	10.98	32	19.43	20.51	32.89	11.22
1	19.86	20.75	33.45	12.03	33	19.63	20.60	33.27	11.66
2	23.48	24.77	38.98	13.95	34	20.23	21.23	34.29	11.99
3	28.87	30.78	47.69	16.56	35	20.59	21.90	35.20	11.42
4	23.23	24.41	38.71	13.95	36	19.45	20.35	33.09	11.60
5	22.61	24.02	37.98	12.80	37	19.29	20.51	33.97	10.31
6	19.51	20.56	33.26	11.30	38	19.27	20.53	33.27	10.51
7	19.53	20.57	33.49	11.21	39	19.46	20.85	33.26	10.45
8	19.75	20.51	33.38	12.16	40	19.64	20.50	33.21	11.87
9	19.38	20.46	33.50	10.97	41	19.44	20.31	32.61	11.82
10	19.48	20.46	33.81	11.09	42	19.67	20.70	33.51	11.36
11	19.53	20.67	33.48	11.08	43	19.30	20.47	32.72	10.93
12	19.46	20.46	33.41	11.24	44	19.57	20.66	33.83	11.06
13	19.77	20.35	33.13	12.63	45	19.94	21.36	34.41	10.55
14	20.35	21.43	34.61	11.85	46	30.76	32.81	49.16	18.29
15	19.86	20.89	33.38	11.81	47	20.20	21.41	33.90	11.67
16	20.16	21.43	33.76	11.54	48	19.83	20.75	33.53	11.85
17	19.50	20.60	33.29	11.10	49	19.66	20.63	33.82	11.39
18	19.53	20.71	33.12	10.99	50	19.71	20.35	33.47	12.29
19	19.03	20.53	33.02	9.76	51	19.57	20.59	33.40	11.42
20	19.82	21.09	34.16	10.84	52	19.23	20.56	33.66	10.09
21	19.12	20.54	33.21	9.99	53	19.12	20.51	33.32	9.96
22	19.44	20.64	33.19	10.89	54	20.53	21.45	34.78	12.33
23	19.48	20.54	33.56	11.11	55	22.43	23.90	37.56	12.80
24	20.24	21.27	34.48	11.81	56	19.65	20.32	33.60	12.16
25	20.63	21.17	34.25	13.57	57	25.65	27.05	41.57	15.72
26	19.74	20.79	33.66	11.40	58	20.77	22.24	35.02	11.51
27	19.55	20.54	33.33	11.45	59	19.85	21.06	33.38	11.37
28	19.56	20.68	33.32	11.10	60	19.51	20.76	33.39	10.71
29	19.46	20.04	33.26	12.18	61	19.69	20.96	33.81	10.79
30	19.14	20.43	32.85	10.44	62	19.40	20.69	33.39	10.57
31	19.38	20.41	32.77	11.28	Average	20.26	21.39	34.42	11.66

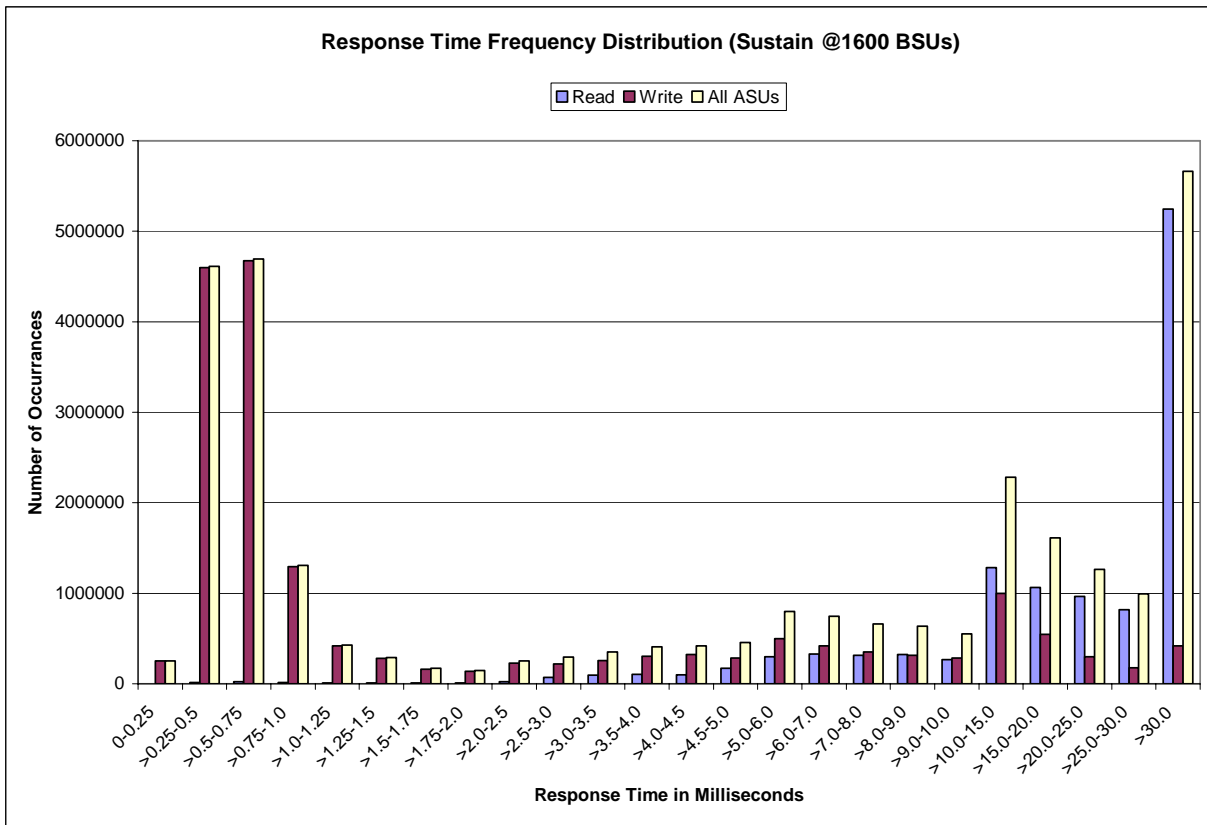
Sustainability – Average Response Time (ms) Distribution Graph



Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	38	12,672	22,898	15,119	7,677	8,897	10,429	11,203
Write	252,519	4,599,835	4,671,352	1,292,539	419,656	281,324	159,576	137,029
All ASUs	252,557	4,612,507	4,694,250	1,307,658	427,333	290,221	170,005	148,232
ASU1	150,885	2,200,179	2,007,954	495,448	152,345	107,414	74,100	69,490
ASU2	17,665	421,809	472,874	161,648	60,879	40,339	19,440	14,900
ASU3	84,007	1,990,519	2,213,422	650,562	214,109	142,468	76,465	63,842
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	23,661	72,457	92,859	106,566	98,746	173,035	298,096	325,862
Write	228,677	220,654	257,781	302,089	321,233	284,481	499,477	419,756
All ASUs	252,338	293,111	350,640	408,655	419,979	457,516	797,573	745,618
ASU1	124,899	165,778	203,437	233,512	232,533	281,231	488,387	477,646
ASU2	22,622	25,918	30,332	37,329	39,617	44,877	79,427	74,633
ASU3	104,817	101,415	116,871	137,814	147,829	131,408	229,759	193,339
Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	311,856	322,084	268,599	1,284,243	1,063,530	964,497	816,913	5,245,002
Write	351,362	313,986	284,862	999,392	547,533	299,767	176,722	417,242
All ASUs	663,218	636,070	553,461	2,283,635	1,611,063	1,264,264	993,635	5,662,244
ASU1	436,294	427,814	365,240	1,586,417	1,183,728	979,334	790,557	4,227,135
ASU2	66,158	64,475	57,656	237,630	173,192	143,240	117,973	1,176,440
ASU3	160,766	143,781	130,565	459,588	254,143	141,690	85,105	258,669

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

IM – Intensity Multiplier: *The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.*

Clauses 6.1.0

MIM – Measured Intensity Multiplier: *The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1).*

Clause 6.3.13.3

COV – Coefficient of Variation: *This measure of variation for the Measured Intensity Multiplier cannot exceed 0.5.*

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.007	0.002	0.006	0.003	0.011	0.005	0.008	0.003

Primary Metrics Test – IOPS Test Phase

Clause 6.4.3.3

The IOPS Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of five (5) minutes. The IOPS Test Phase immediately follows the Sustainability Test Phase without any interruption or manual intervention.

The IOPS Test Run generates the SPC-1C IOPS™ primary metric, which is computed as the I/O Request Throughput for the Measurement Interval of the IOPS Test Run.

The Average Response Time is computed for the IOPS Test Run and cannot exceed 30 milliseconds. If the Average Response Time exceeds the 30 millisecond constraint, the measurement is invalid.

Clause 10.4.8.2

For the IOPS Test Phase the FDR shall contain:

- 1. I/O Request Throughput Distribution (data and graph).*
- 2. Response Time Frequency Distribution (data and graph).*
- 3. Average Response Time Distribution (data and graph).*
- 4. The human readable SPC-1C Test Run Results File produced by the SPC-1C Workload Generator.*
- 5. A listing of all input parameters supplied to the SPC-1C Workload Generator.*
- 6. The Measured Intensity Multiplier for each I/O Stream.*
- 7. The variability of the Measured Intensity Multiplier, as defined in Clause 6.3.13.3.*
- 8. The total number of I/O Requests completed in the Measurement Interval as well as the number of I/O Requests with a Response Time less than or equal to 30 milliseconds and the number of I/O Requests with a Response Time greater than 30 milliseconds.*

SPC-1C Workload Generator Input Parameters

The SPC-1C Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1C Workload Generator Input Parameters” on Page 65.

IOPS Test Results File

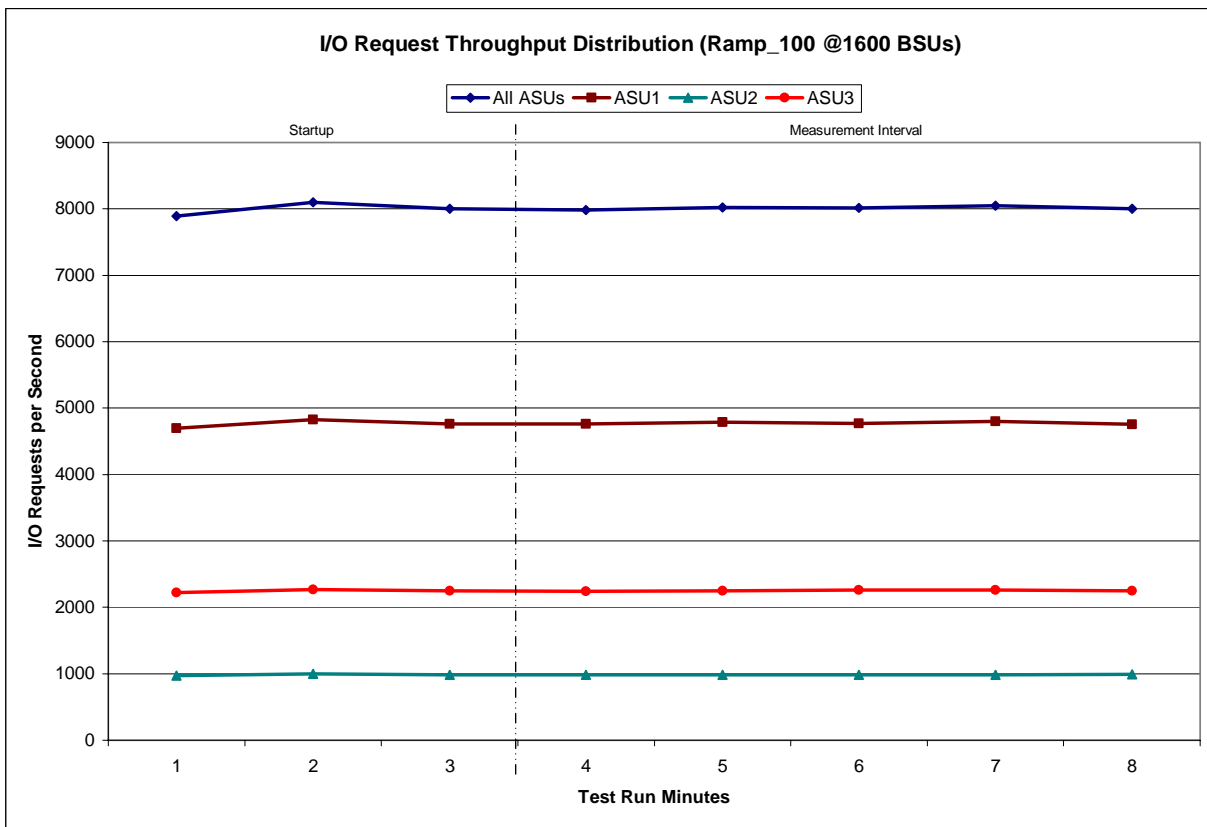
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

1600 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:09:49	13:12:50	0-2	0:03:01
<i>Measurement Interval</i>	13:12:50	13:17:50	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	7,894.75	4,699.45	971.85	2,223.45
1	8,099.18	4,829.75	999.75	2,269.68
2	8,000.70	4,763.05	987.67	2,249.98
3	7,984.15	4,761.33	982.15	2,240.67
4	8,021.68	4,788.15	985.28	2,248.25
5	8,013.68	4,768.13	983.15	2,262.40
6	8,045.57	4,798.20	987.77	2,259.60
7	8,001.88	4,758.97	991.75	2,251.17
Average	8,013.39	4,774.96	986.02	2,252.42

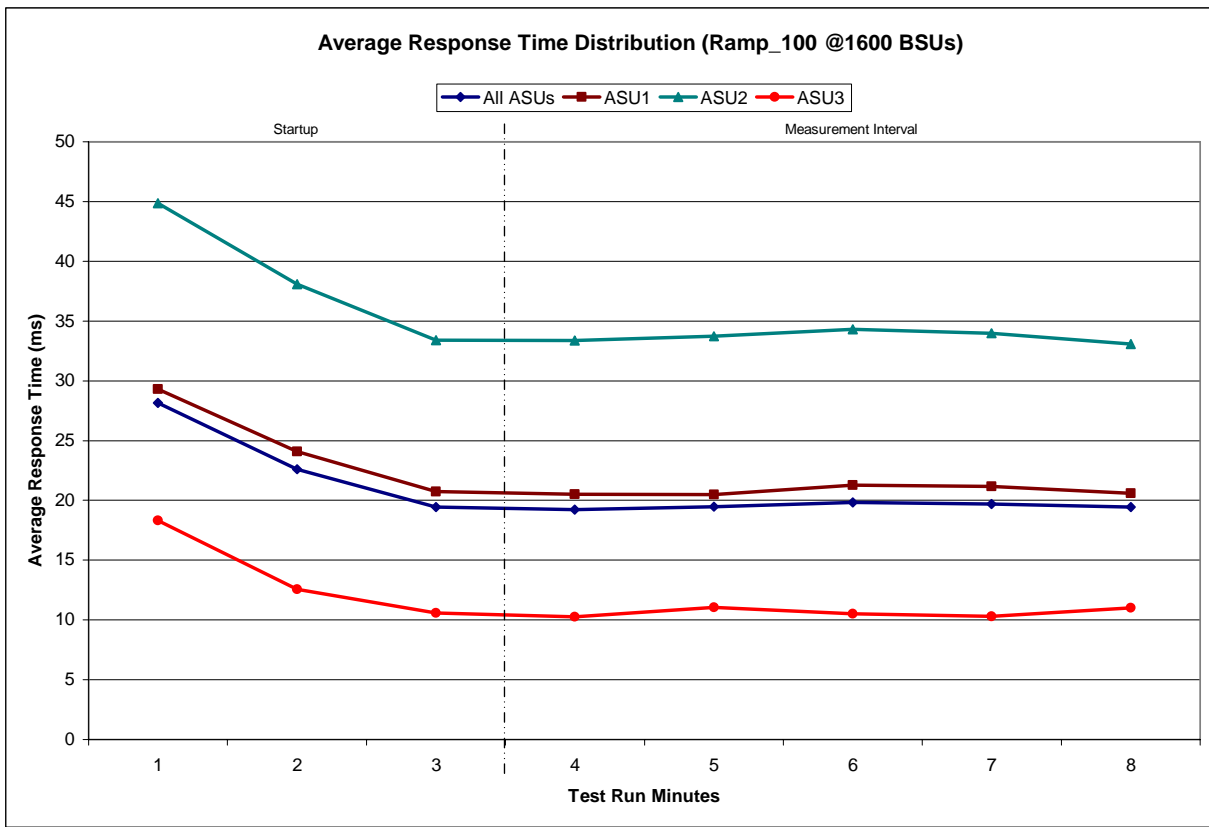
IOPS Test Run – I/O Request Throughput Distribution Graph



IOPS Test Run – Average Response Time (ms) Distribution Data

1600 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:09:49	13:12:50	0-2	0:03:01
<i>Measurement Interval</i>	13:12:50	13:17:50	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	28.13	29.31	44.86	18.33
1	22.59	24.09	38.10	12.57
2	19.44	20.73	33.39	10.60
3	19.22	20.52	33.36	10.26
4	19.48	20.49	33.73	11.06
5	19.84	21.28	34.32	10.52
6	19.68	21.16	33.98	10.30
7	19.45	20.61	33.08	11.01
Average	19.54	20.81	33.70	10.63

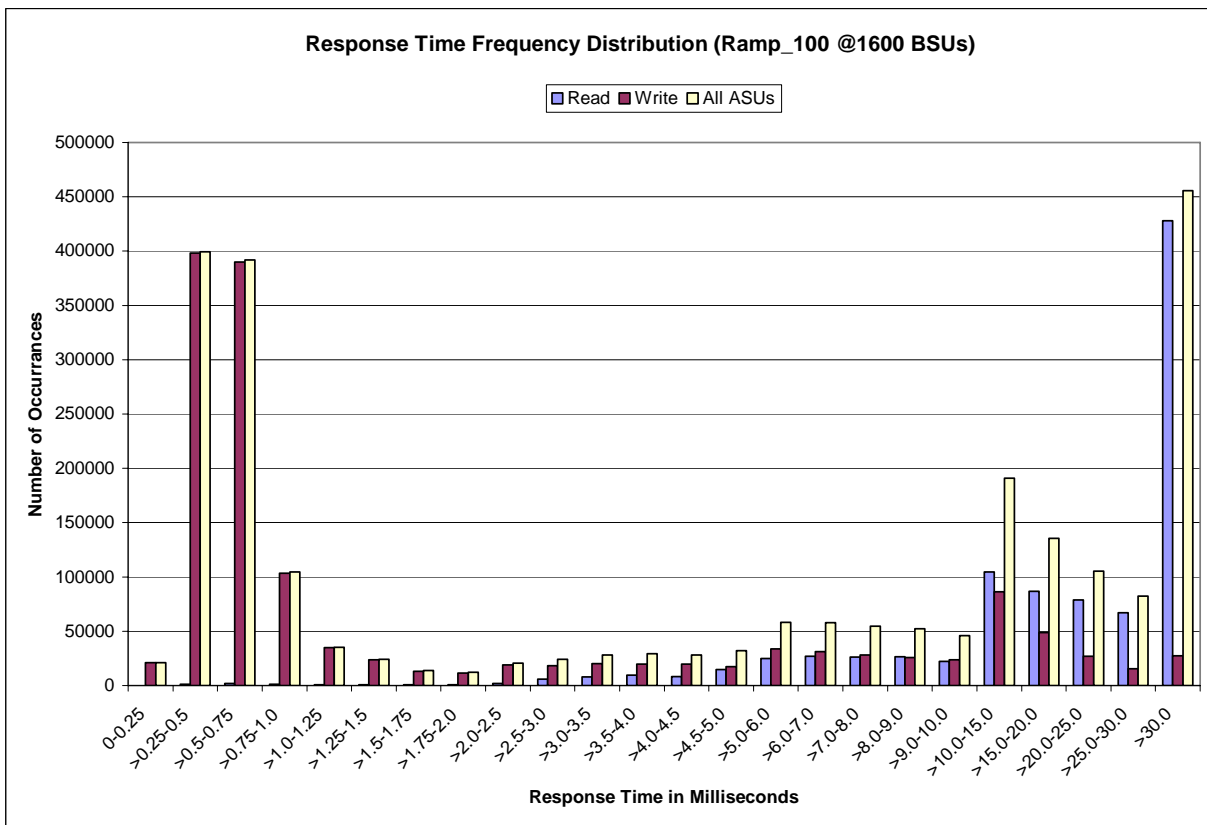
IOPS Test Run – Average Response Time (ms) Distribution Graph



IOPS Test Run – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	1	1,116	1,897	1,295	624	750	889	900
Write	21186	398,152	390,031	103,422	34,683	23,587	12,895	11,346
All ASUs	21187	399,268	391,928	104,717	35,307	24,337	13,784	12,246
ASU1	12625	189,494	170,148	38,030	12,092	9,056	5,909	5,713
ASU2	1451	36,664	38,395	14,150	5,239	3,332	1,611	1,203
ASU3	7111	173,110	183,385	52,537	17,976	11,949	6,264	5,330
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	1,962	6,127	7,950	9,407	8,356	14,686	24,911	26,797
Write	18,831	18,029	20,040	19,804	19,653	17,475	33,527	31,132
All ASUs	20,793	24,156	27,990	29,211	28,009	32,161	58,438	57,929
ASU1	10,334	13,631	16,345	17,535	16,481	20,973	37,473	37,663
ASU2	1,817	2,157	2,457	2,583	2,544	3,183	5,696	5,781
ASU3	8,642	8,368	9,188	9,093	8,984	8,005	15,269	14,485
Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	26,256	26,517	22,131	104,669	86,743	78,687	67,010	428,063
Write	28,228	25,618	23,791	86,186	48,754	26,837	15,413	27,429
All ASUs	54,484	52,135	45,922	190,855	135,497	105,524	82,423	455,492
ASU1	36,121	35,064	30,318	131,015	98,158	80,818	65,103	342,264
ASU2	5,438	5,309	4,775	19,958	14,671	11,939	9,860	95,536
ASU3	12,925	11,762	10,829	39,882	22,668	12,767	7,460	17,692

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
2,403,793	1,948,301	455,492

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

IM – Intensity Multiplier: The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.

Clauses 6.1.0

MIM – Measured Intensity Multiplier: The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1).

Clause 6.3.13.3

COV – Coefficient of Variation: This measure of variation for the Measured Intensity Multiplier cannot exceed 0.5.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2808	0.0702	0.2099	0.0181	0.0699	0.0350	0.2811
COV	0.010	0.000	0.004	0.004	0.004	0.005	0.012	0.003

Primary Metrics Test – Response Time Ramp Test Phase

Clause 6.4.3.4

The Response Time Ramp Test Phase consists of five Test Runs, one each at 95%, 90%, 80%, 50%, and 10% of the load point (100%) used to generate the SPC-1C IOPS™ primary metric. Each of the five Test Runs has a Measurement Interval of five (5) minutes. The Response Time Ramp Test Phase immediately follows the IOPS Test Phase without any interruption or manual intervention.

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 13.

In addition, the Average Response Time measured during the 10% Test Run is the value for the SPC-1C LRT™ metric. That value represents the Average Response Time of a lightly loaded TSC.

Clause 10.4.8.3

The following content shall appear in the FDR for the Response Time Ramp Phase:

- 1. A Response Time Ramp Distribution graph.*
- 2. The human readable Test Run Results File produced by the SPC-1C C Workload Generator for each Test Run within the Response Time Ramp Test Phase.*
- 3. An Average Response Time Distribution graph and table for the 10% BSU Level Test Run (the SPC-1C LRT™ metric).*
- 4. A listing of all input parameters supplied to the SPC-1C Workload Generator.*

SPC-1C Workload Generator Input Parameters

The SPC-1C Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1C Workload Generator Input Parameters” on Page 65.

Response Time Ramp Test Results File

A link to each test result file generated from each Response Time Ramp Test Run list listed below.

[95% Load Level](#)

[90% Load Level](#)

[80% Load Level](#)

[50% Load Level](#)

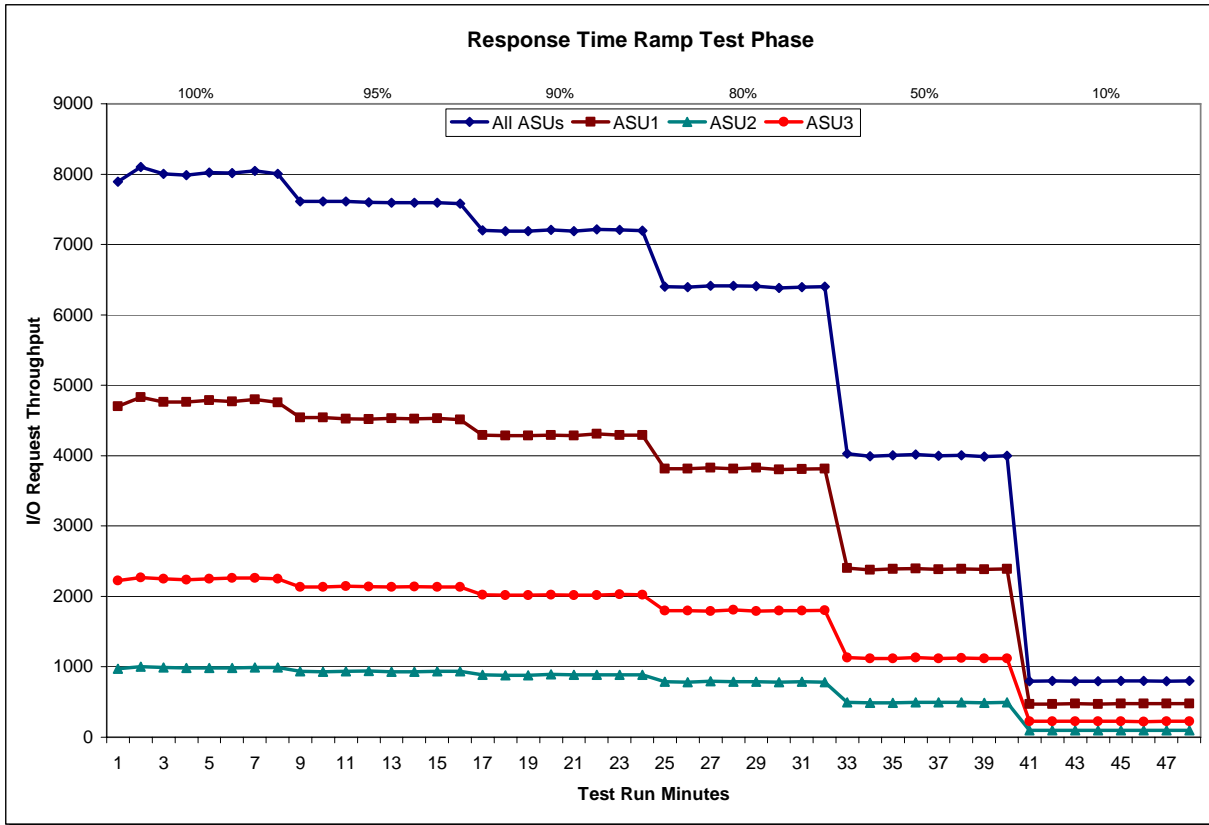
[10% Load Level](#)

Response Time Ramp Distribution (IOPS) Data

The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1C IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data tables and graphs for completeness.

100% Load Level - 1600 BSUs					95% Load Level - 1520 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:09:49	13:12:50	0-2	0:03:01	Start-Up/Ramp-Up	13:17:52	13:20:53	0-2	0:03:01
Measurement Interval	13:12:50	13:17:50	3-7	0:05:00	Measurement Interval	13:20:53	13:25:53	3-7	0:05:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	7,894.75	4,699.45	971.85	2,223.45	0	7,611.70	4,541.07	936.25	2,134.38
1	8,099.18	4,829.75	999.75	2,269.68	1	7,611.32	4,542.95	932.07	2,136.30
2	8,000.70	4,763.05	987.67	2,249.98	2	7,610.87	4,527.32	937.83	2,145.72
3	7,984.15	4,761.33	982.15	2,240.67	3	7,600.30	4,516.02	941.40	2,142.88
4	8,021.68	4,788.15	985.28	2,248.25	4	7,596.12	4,532.32	929.77	2,134.03
5	8,013.68	4,768.13	983.15	2,262.40	5	7,595.98	4,522.95	931.72	2,141.32
6	8,045.57	4,798.20	987.77	2,259.60	6	7,595.70	4,529.63	935.02	2,131.05
7	8,001.88	4,758.97	991.75	2,251.17	7	7,584.45	4,515.15	934.15	2,135.15
Average	8,013.39	4,774.96	986.02	2,252.42	Average	7,594.51	4,523.21	934.41	2,136.89
90% Load Level - 1440 BSUs					80% Load Level - 1280 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:25:55	13:28:56	0-2	0:03:01	Start-Up/Ramp-Up	13:33:58	13:36:59	0-2	0:03:01
Measurement Interval	13:28:56	13:33:56	3-7	0:05:00	Measurement Interval	13:36:59	13:41:59	3-7	0:05:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	7,204.02	4,295.05	887.23	2,021.73	0	6,402.08	3,815.72	791.08	1,795.28
1	7,190.75	4,288.65	881.77	2,020.33	1	6,398.28	3,817.50	784.38	1,796.40
2	7,189.43	4,288.18	882.42	2,018.83	2	6,412.40	3,825.20	792.82	1,794.38
3	7,209.67	4,294.40	892.22	2,023.05	3	6,412.03	3,817.80	787.07	1,807.17
4	7,187.60	4,285.58	886.32	2,015.70	4	6,407.88	3,826.55	787.07	1,794.27
5	7,212.42	4,307.92	886.57	2,017.93	5	6,382.37	3,800.97	785.30	1,796.10
6	7,210.08	4,294.98	885.18	2,029.92	6	6,397.02	3,811.95	787.08	1,797.98
7	7,197.32	4,289.40	886.20	2,021.72	7	6,402.53	3,817.25	784.20	1,801.08
Average	7,203.42	4,294.46	887.30	2,021.66	Average	6,400.37	3,814.90	786.14	1,799.32
50% Load Level - 800 BSUs					10% Load Level - 160 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:42:01	13:45:02	0-2	0:03:01	Start-Up/Ramp-Up	13:50:04	13:53:05	0-2	0:03:01
Measurement Interval	13:45:02	13:50:02	3-7	0:05:00	Measurement Interval	13:53:05	13:58:05	3-7	0:05:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	4,027.45	2,399.88	497.88	1,129.68	0	796.02	472.07	98.38	225.57
1	3,989.85	2,380.93	487.92	1,121.00	1	799.40	473.67	97.62	228.12
2	4,005.62	2,392.75	492.13	1,120.73	2	796.77	475.95	96.77	224.05
3	4,018.82	2,394.10	492.72	1,132.00	3	796.68	470.15	98.78	227.75
4	3,997.67	2,383.58	494.20	1,119.88	4	800.88	474.85	99.42	226.62
5	4,006.35	2,388.90	492.68	1,124.77	5	800.73	477.73	100.18	222.82
6	3,986.42	2,382.28	488.02	1,116.12	6	796.87	476.93	96.57	223.37
7	4,000.37	2,388.58	492.83	1,118.95	7	802.85	477.57	99.83	225.45
Average	4,001.92	2,387.49	492.09	1,122.34	Average	799.60	475.45	98.96	225.20

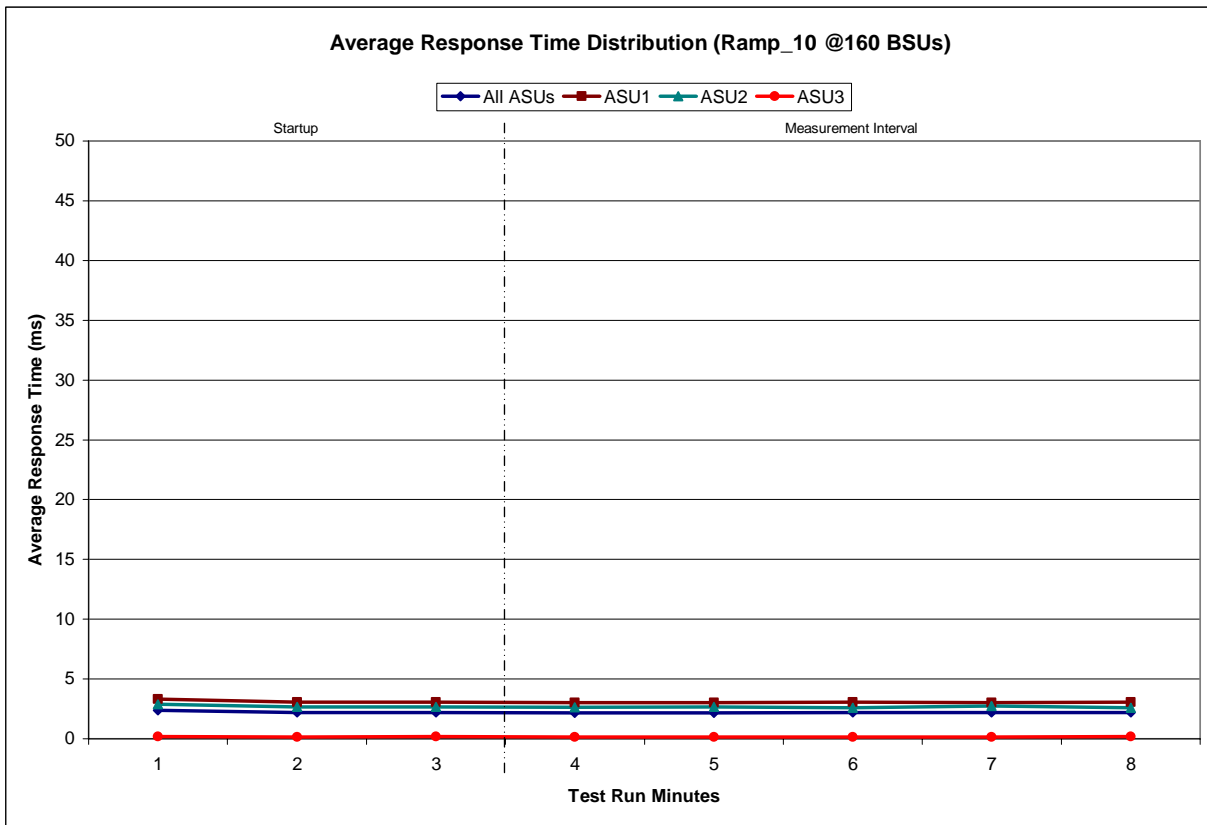
Response Time Ramp Distribution (IOPS) Graph



SPC-1C LRT™ Average Response Time (ms) Distribution Data

160 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:50:04	13:53:05	0-2	0:03:01
<i>Measurement Interval</i>	13:53:05	13:58:05	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.38	3.32	2.88	0.20
1	2.18	3.05	2.66	0.16
2	2.19	3.04	2.65	0.16
3	2.16	3.04	2.62	0.16
4	2.16	3.01	2.65	0.16
5	2.20	3.07	2.59	0.16
6	2.19	3.03	2.74	0.16
7	2.18	3.05	2.60	0.16
Average	2.18	3.04	2.64	0.16

SPC-1C LRT™ Average Response Time (ms) Distribution Graph



SPC-1C LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

IM – Intensity Multiplier: *The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.*

Clauses 6.1.0

MIM – Measured Intensity Multiplier: *The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1).*

Clause 6.3.13.3

COV – Coefficient of Variation: *This measure of variation for the Measured Intensity Multiplier cannot exceed 0.5.*

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0348	0.2822	0.0700	0.2077	0.0178	0.0705	0.0355	0.2816
COV	0.037	0.005	0.014	0.012	0.009	0.013	0.024	0.010

Repeatability Test

Clause 6.4.4

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1C IOPS™ primary metric and SPC-1C LRT™ metric generated in earlier Test Runs.

There are two identical Repeatability Test Phases. Each Test Phase contains two Test Runs. Each of the Test Runs will have a Measurement Interval of no less than five (5) minutes. The two Test Runs in each Test Phase will be executed without interruption or any type of manual intervention.

The first Test Run in each Test Phase is executed at the 10% load point. The Average Response Time from each of the Test Runs is compared to the SPC-1C LRT™ metric. Each Average Response Time value must be less than the SPC-1C LRT™ metric plus 5%.

The second Test Run in each Test Phase is executed at the 100% load point. The I/O Request Throughput from the Test Runs is compared to the SPC-1C IOPS™ primary metric. Each I/O Request Throughput value must be greater than the SPC-1C IOPS™ primary metric minus 5%. In addition, the Average Response Time for each Test Run cannot exceed 30 milliseconds.

If any of the above constraints are not met, the benchmark measurement is invalid.

Clause 10.4.8.4

The FDR shall contain the following for the Repeatability Test:

- 1. A table containing the results of the Repeatability Test.*
- 2. I/O Request Throughput Distribution graph and table for each Repeatability Test Run.*
- 3. An Average Response Time Distribution graph and table for each Repeatability Test Run.*
- 4. The human readable Test Run Results File produced by the Workload Generator. The human readable Test Run Results File produced by the SPC-1C C Workload Generator.*
- 5. A listing of all input parameters supplied to the SPC-1C Workload Generator.*

SPC-1C Workload Generator Input Parameters

The SPC-1C Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1C Workload Generator Input Parameters” on Page 65.

Repeatability Test Results File

The values for the SPC-1C IOPS™, SPC-1C LRT™, and the Repeatability Test measurements are listed in the tables below.

	SPC-1C IOPS™
<i>Primary Metrics</i>	8,013.39
Repeatability Test Phase 1	8,000.76
Repeatability Test Phase 2	7,984.28

The SPC-1C IOPS™ values in the above table were generated using 100% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1C IOPS™ must be greater than 95% of the reported SPC-1C IOPS™ Primary Metric.

	SPC-1C LRT™
<i>Primary Metrics</i>	2.18 ms
Repeatability Test Phase 1	2.20 ms
Repeatability Test Phase 2	2.22 ms

The average response time values in the SPC-1C LRT™ column were generated using 10% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1C LRT™ must be less than 105% of the reported SPC-1C LRT™ Primary Metric.

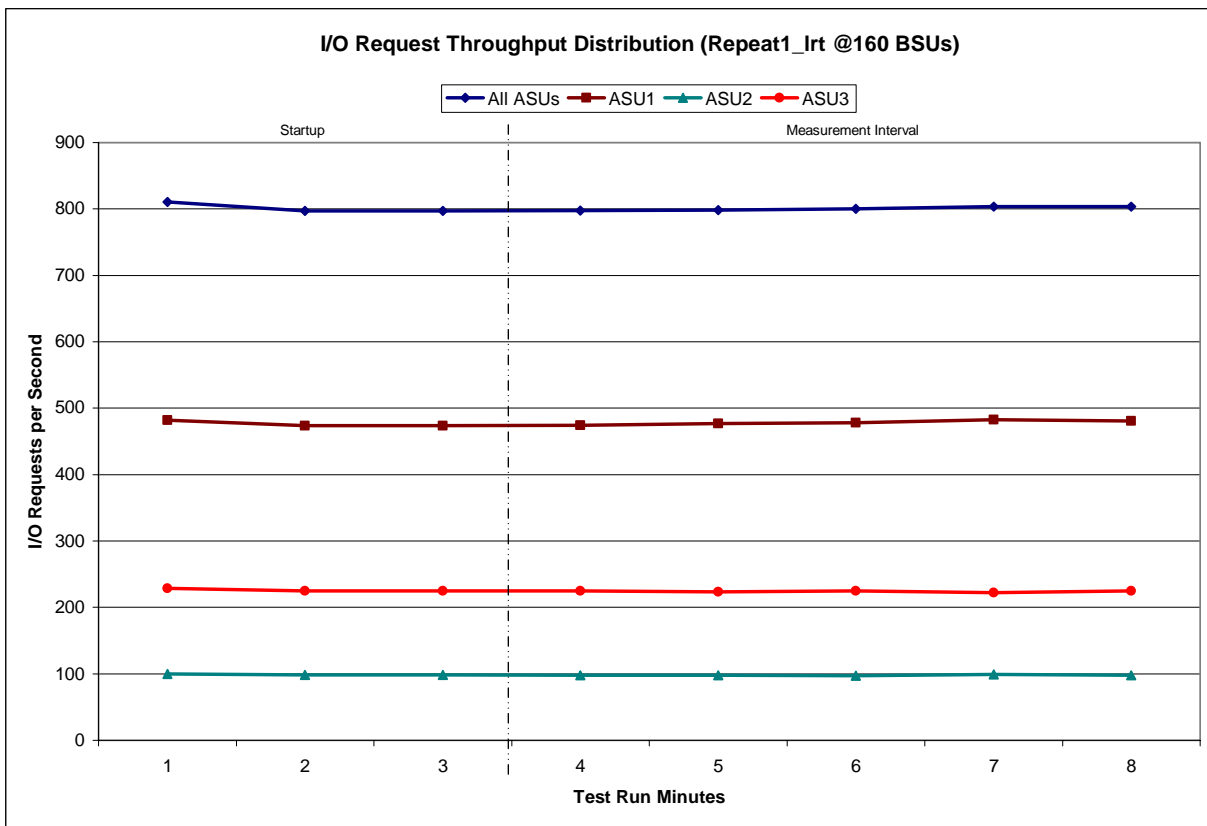
A link to the test result file generated from each Repeatability Test Run is listed below.

- [Repeatability Test Phase 1, Test Run 1 \(LRT\)](#)
- [Repeatability Test Phase 1, Test Run 2 \(IOPS\)](#)
- [Repeatability Test Phase 2, Test Run 1 \(LRT\)](#)
- [Repeatability Test Phase 2, Test Run 2 \(IOPS\)](#)

Repeatability 1 LRT - I/O Request Throughput Distribution Data

160 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:58:09	14:01:09	0-2	0:03:00
<i>Measurement Interval</i>	14:01:09	14:06:09	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	810.35	482.25	99.52	228.58
1	796.97	473.75	98.45	224.77
2	796.93	473.35	98.80	224.78
3	797.37	474.52	97.80	225.05
4	798.27	477.17	97.75	223.35
5	800.23	478.23	97.22	224.78
6	803.65	482.40	99.05	222.20
7	803.53	480.68	98.12	224.73
Average	800.61	478.60	97.99	224.02

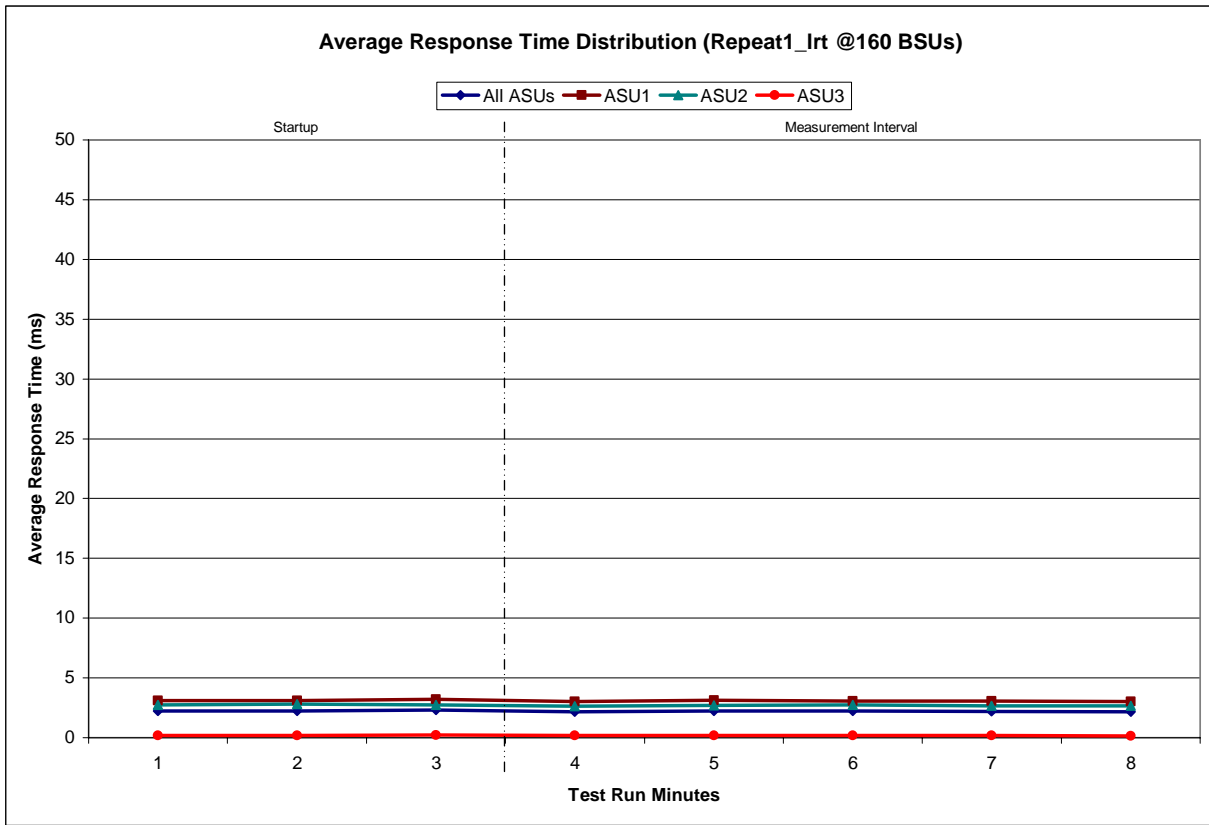
Repeatability 1 LRT - I/O Request Throughput Distribution Graph



Repeatability 1 LRT –Average Response Time (ms) Distribution Data

160 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:58:09	14:01:09	0-2	0:03:00
<i>Measurement Interval</i>	14:01:09	14:06:09	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.23	3.10	2.74	0.16
1	2.24	3.11	2.83	0.16
2	2.30	3.20	2.72	0.20
3	2.17	3.02	2.64	0.16
4	2.24	3.12	2.68	0.18
5	2.22	3.07	2.75	0.17
6	2.20	3.05	2.66	0.16
7	2.18	3.02	2.65	0.16
Average	2.20	3.06	2.68	0.17

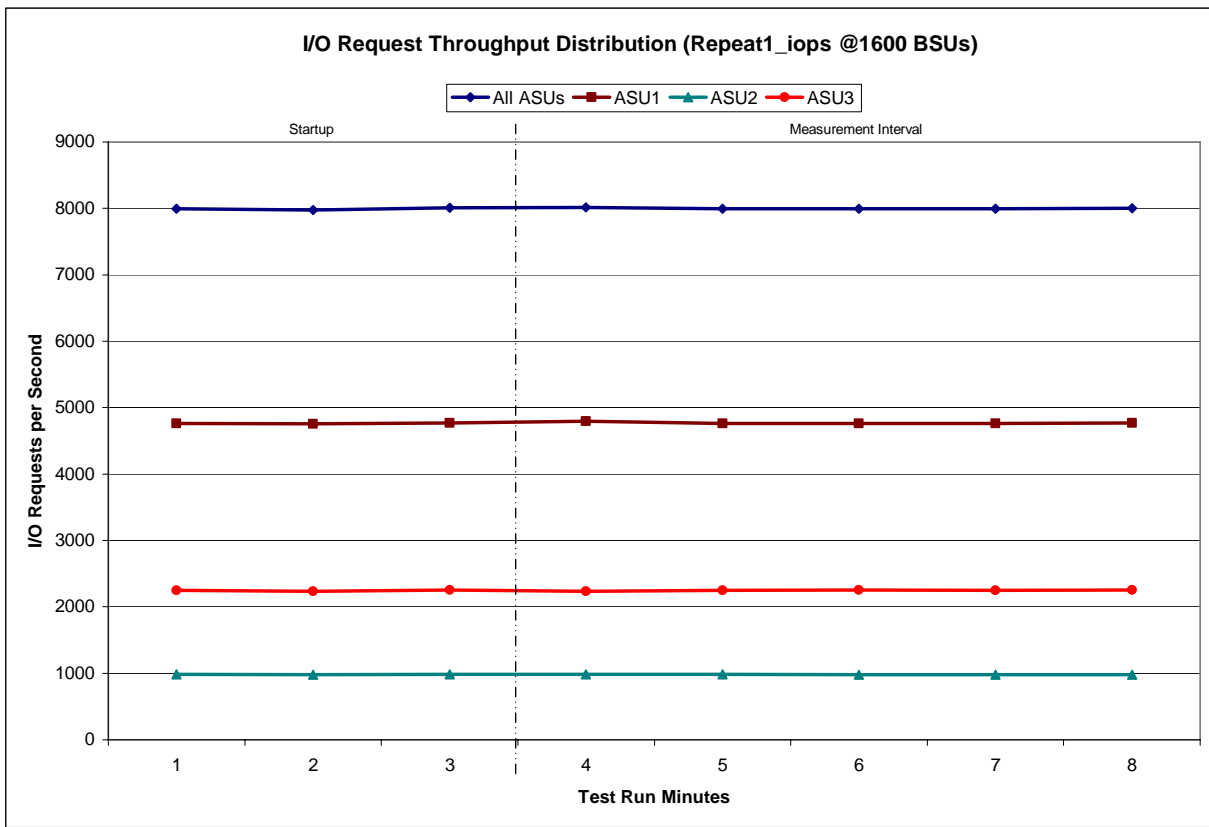
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS - I/O Request Throughput Distribution Data

1600 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:07:11	14:10:12	0-2	0:03:01
<i>Measurement Interval</i>	14:10:12	14:15:12	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	7,995.60	4,762.57	983.97	2,249.07
1	7,973.62	4,756.95	979.52	2,237.15
2	8,006.85	4,767.98	985.57	2,253.30
3	8,014.73	4,792.32	985.13	2,237.28
4	7,995.93	4,765.57	983.00	2,247.37
5	7,996.13	4,761.47	980.35	2,254.32
6	7,994.92	4,765.03	980.70	2,249.18
7	8,002.10	4,771.13	976.83	2,254.13
Average	8,000.76	4,771.10	981.20	2,248.46

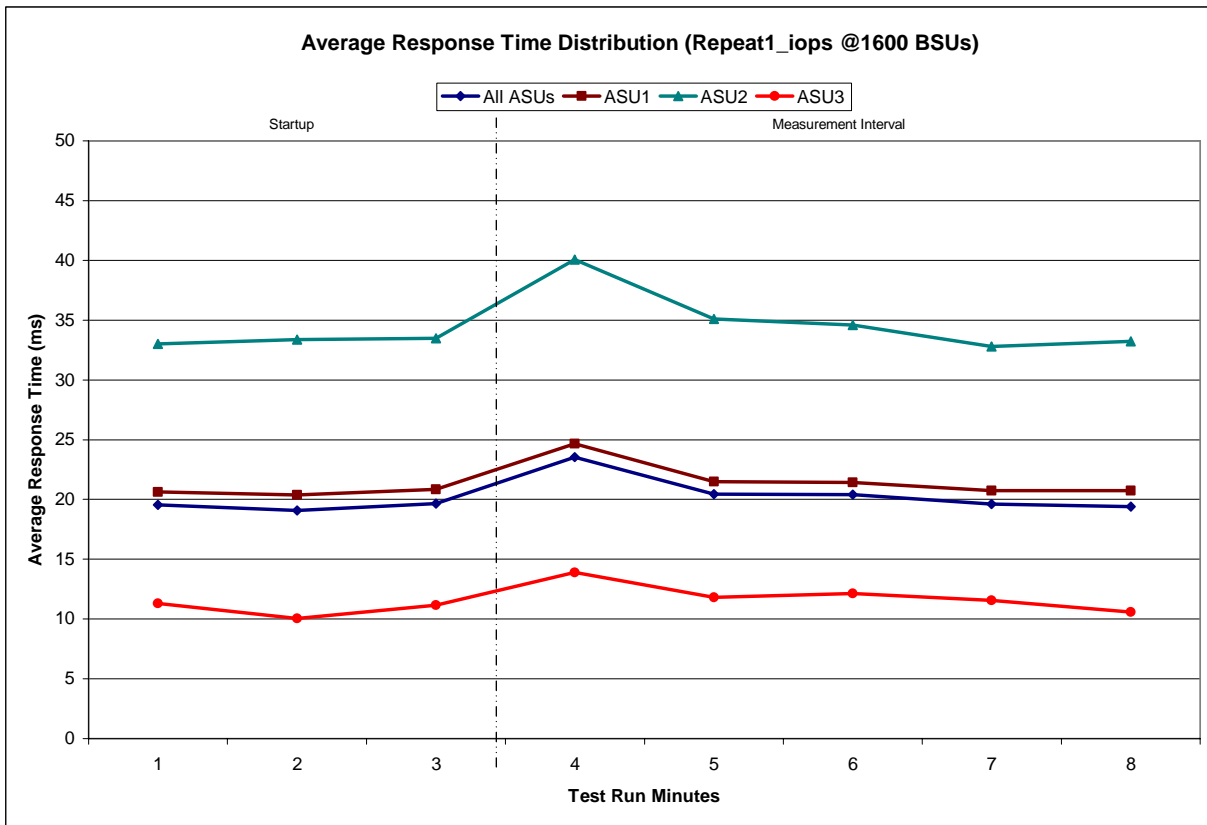
Repeatability 1 IOPS - I/O Request Throughput Distribution Graph



Repeatability 1 IOPS –Average Response Time (ms) Distribution Data

1600 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:07:11	14:10:12	0-2	0:03:01
<i>Measurement Interval</i>	14:10:12	14:15:12	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19.54	20.64	33.00	11.30
1	19.07	20.36	33.38	10.05
2	19.67	20.83	33.46	11.18
3	23.54	24.64	40.07	13.90
4	20.44	21.49	35.09	11.81
5	20.41	21.41	34.61	12.14
6	19.63	20.74	32.78	11.54
7	19.39	20.72	33.22	10.59
Average	20.68	21.80	35.15	11.99

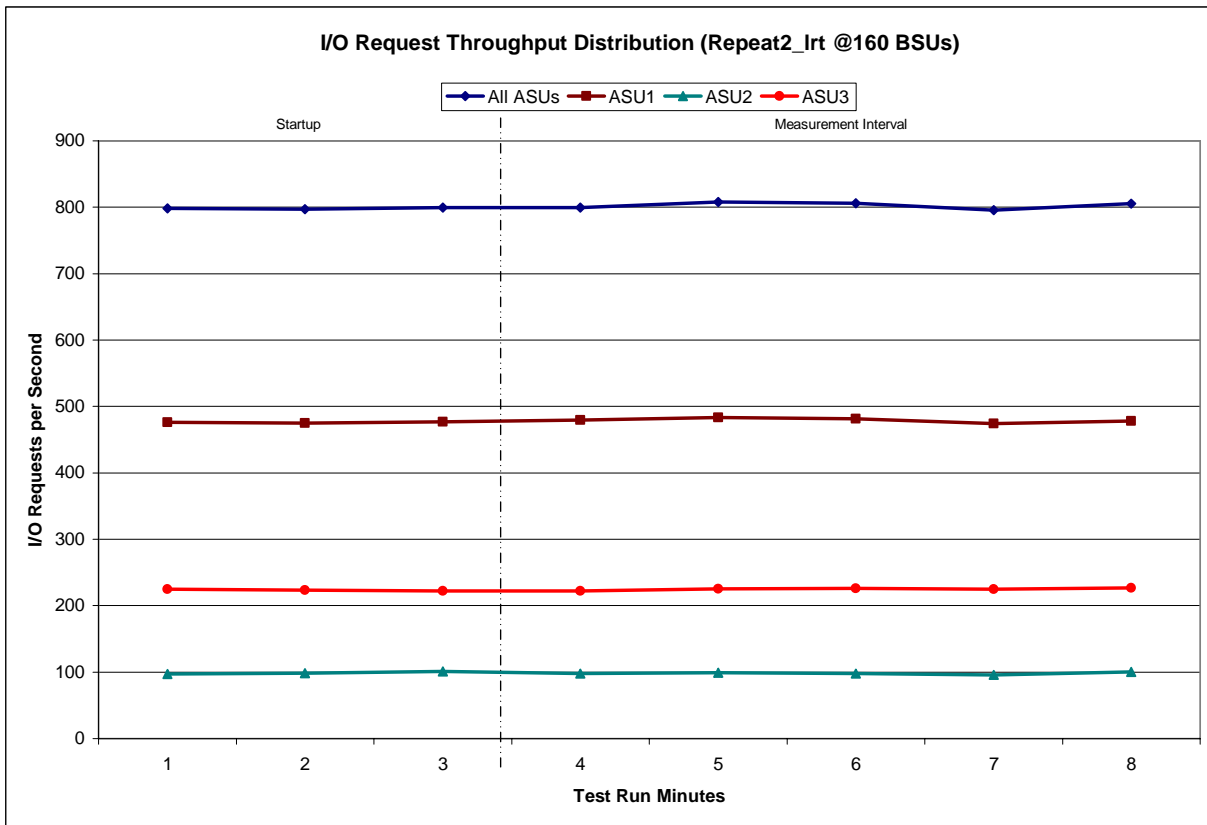
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT - I/O Request Throughput Distribution Data

160 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:16:17	14:19:17	0-2	0:03:00
<i>Measurement Interval</i>	14:19:17	14:24:17	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	798.22	476.48	97.02	224.72
1	796.98	474.88	98.40	223.70
2	799.82	476.98	100.80	222.03
3	799.70	479.47	97.90	222.33
4	808.22	483.25	99.38	225.58
5	806.08	481.65	98.02	226.42
6	795.40	474.47	95.88	225.05
7	805.08	477.97	100.25	226.87
<i>Average</i>	802.90	479.36	98.29	225.25

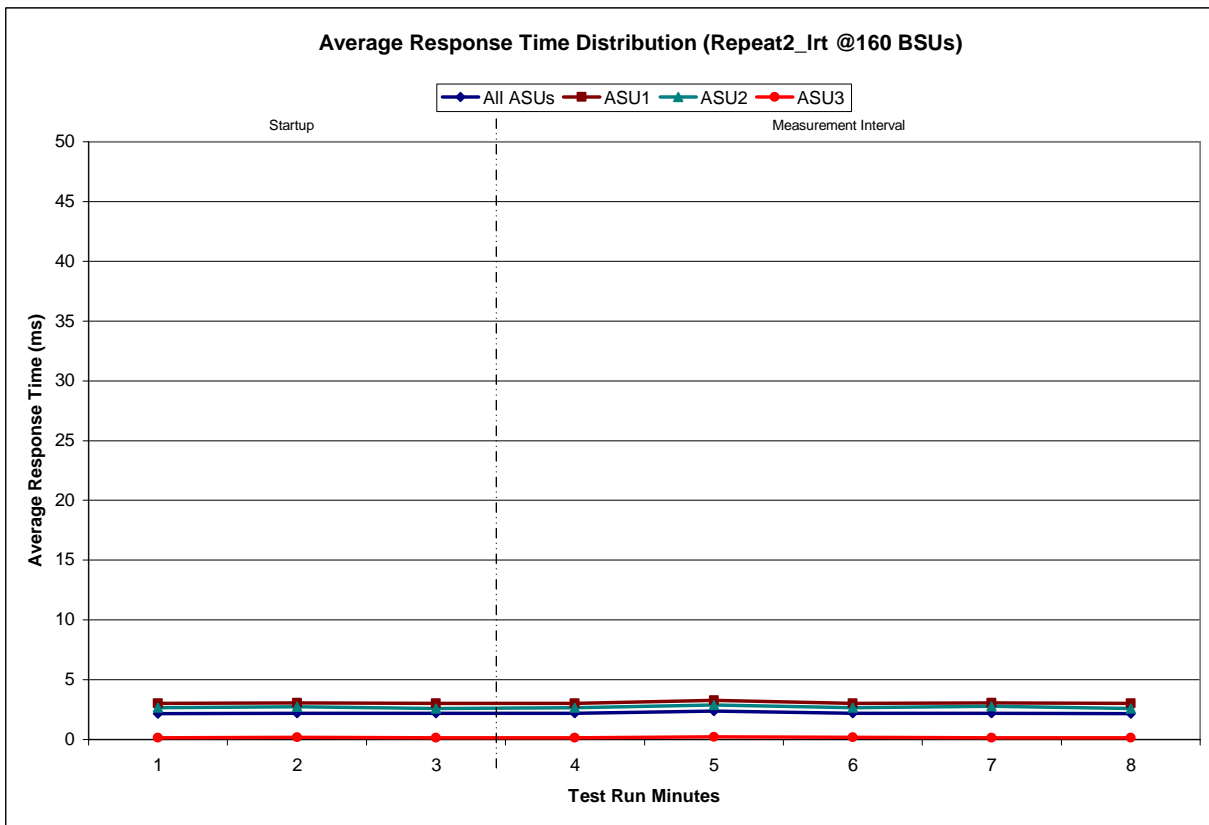
Repeatability 2 LRT - I/O Request Throughput Distribution Graph



Repeatability 2 LRT –Average Response Time (ms) Distribution Data

160 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:16:17	14:19:17	0-2	0:03:00
<i>Measurement Interval</i>	14:19:17	14:24:17	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.17	3.02	2.67	0.16
1	2.21	3.06	2.74	0.16
2	2.18	3.04	2.60	0.16
3	2.18	3.03	2.65	0.16
4	2.37	3.27	2.86	0.22
5	2.18	3.02	2.67	0.17
6	2.20	3.05	2.78	0.16
7	2.17	3.03	2.60	0.16
<i>Average</i>	<i>2.22</i>	<i>3.08</i>	<i>2.71</i>	<i>0.17</i>

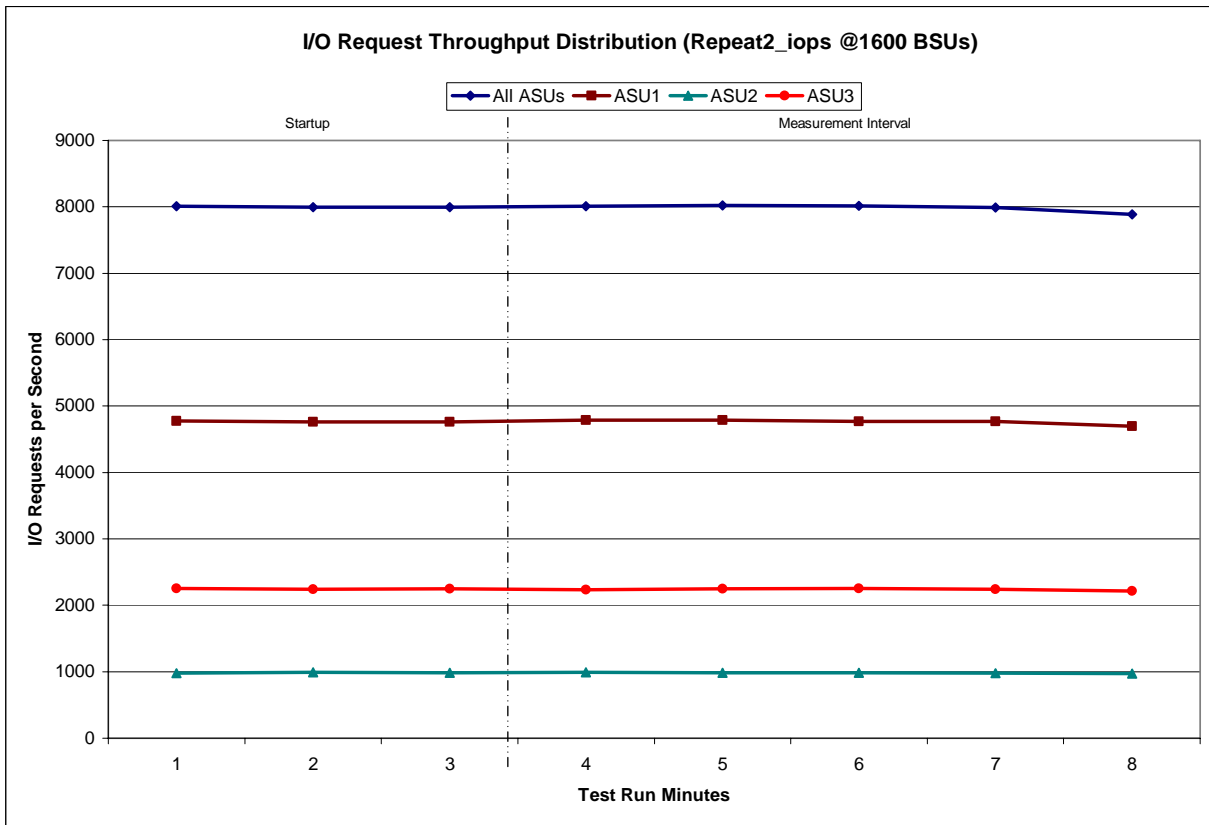
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS - I/O Request Throughput Distribution Data

1600 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:25:19	14:28:20	0-2	0:03:01
<i>Measurement Interval</i>	14:28:20	14:33:20	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	8,006.25	4,773.05	978.73	2,254.47
1	7,996.85	4,765.23	991.18	2,240.43
2	7,993.13	4,760.70	983.63	2,248.80
3	8,011.73	4,788.60	989.95	2,233.18
4	8,019.82	4,786.47	986.72	2,246.63
5	8,014.10	4,769.77	987.88	2,256.45
6	7,991.38	4,770.03	981.40	2,239.95
7	7,884.38	4,695.78	973.93	2,214.67
Average	7,984.28	4,762.13	983.98	2,238.18

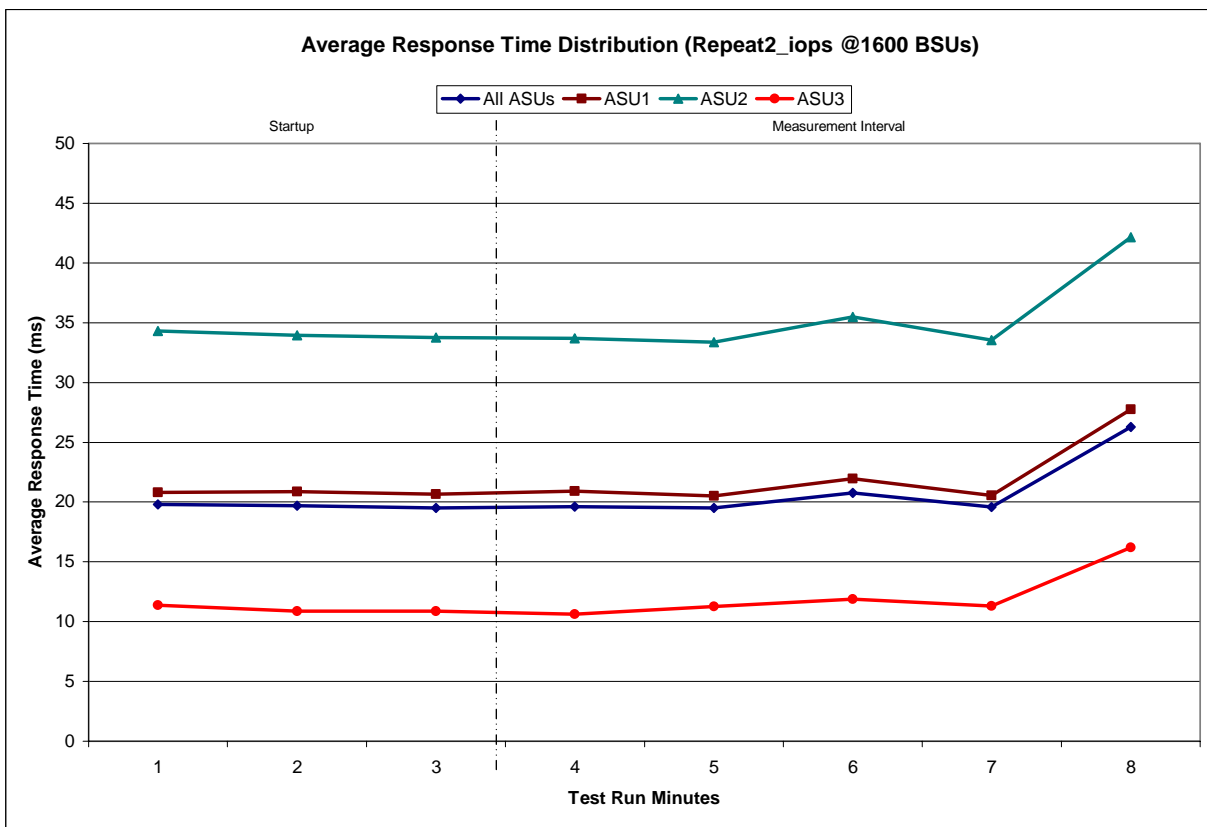
Repeatability 2 IOPS - I/O Request Throughput Distribution Graph



Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

1600 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:25:19	14:28:20	0-2	0:03:01
<i>Measurement Interval</i>	14:28:20	14:33:20	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19.79	20.80	34.29	11.37
1	19.70	20.88	33.95	10.89
2	19.52	20.66	33.78	10.86
3	19.63	20.92	33.68	10.63
4	19.50	20.50	33.39	11.25
5	20.79	21.95	35.49	11.89
6	19.57	20.57	33.56	11.30
7	26.29	27.77	42.17	16.19
<i>Average</i>	<i>21.15</i>	<i>22.34</i>	<i>35.66</i>	<i>12.25</i>

Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

IM – Intensity Multiplier: The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.

Clauses 6.1.0

MIM – Measured Intensity Multiplier: The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1).

Clause 6.3.13.3

COV – Coefficient of Variation: This measure of variation for the Measured Intensity Multiplier cannot exceed 0.5.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0354	0.2825	0.0697	0.2102	0.0177	0.0696	0.0351	0.2798
COV	0.011	0.003	0.016	0.007	0.021	0.004	0.017	0.008

Repeatability 1 (IOPS)
Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2813	0.0701	0.2099	0.0179	0.0698	0.0350	0.2810
COV	0.006	0.002	0.003	0.001	0.015	0.004	0.009	0.004

Repeatability 2 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0352	0.2803	0.0703	0.2113	0.0180	0.0693	0.0351	0.2805
COV	0.025	0.008	0.014	0.009	0.017	0.011	0.031	0.007

Repeatability 2 (IOPS)
Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2810	0.0701	0.2104	0.0181	0.0701	0.0350	0.2803
COV	0.006	0.003	0.006	0.003	0.010	0.004	0.003	0.004

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-1C Workload Generator will write 16 block I/O requests at random over the total Addressable Storage Capacity of the TSC for ten (10) minutes at a minimum of 25% of the load used to generate the SPC-1C IOPS™ primary metric. The bit pattern selected to be written to each block as well as the address of the block will be retained in a log file.

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.

The SPC-1C Workload Generator will then use the above log file to verify each block written contains the correct bit pattern.

Clause 10.4.8.5

The FDR shall contain the following for the Data Persistence Test:

1. *A listing of the SPC-1C Workload Generator commands and parameters used to execute each of the Test Runs in the Persistence Test.*
2. *The human readable SPC-1C 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-1C Workload Generator Input Parameters

The SPC-1C Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1C Workload Generator Input Parameters” on Page 65.

Data Persistence Test Results File

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

[Persistence 1 Test Results File](#)

[Persistence 2 Test Results File](#)

Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	19,117,792
Total Number of Logical Blocks Verified	18,365,024
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

In some cases the same address was the target of multiple writes, which resulted in more Logical Blocks Written than Logical Blocks Verified. In the case of multiple writes to the same address, the pattern written and verified must be associated with the last write to that address.

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 10.4.9

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 Date shall be stated in the FDR by either a combination of specific alphanumeric month, numeric day, and numeric year or as "Currently Available" in the case where all components that comprise the Priced Storage Configuration are currently available for customer order and shipment.

The Seagate Savvio® 10K.3 ST9300603SS as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

ANOMALIES OR IRREGULARITIES

Clause 10.4.10

The FDR shall include a clear and complete description of any anomalies or irregularities encountered in the course of executing the SPC-1C benchmark that may in any way call into question the accuracy, verifiability, or authenticity of information published in the FDR.

There were no anomalies or irregularities encountered during the SPC-1C Onsite Audit of the Seagate Savvio® 10K.3 ST9300603SS.

APPENDIX A: SPC-1C 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-1C Data Repository Definitions

Total ASU Capacity: The total storage capacity read and written in the course of executing the SPC-1C benchmark.

Application Storage Unit (ASU): The logical interface between the storage and SPC-1C Workload Generator. The three ASUs (Data, User, and Log) are typically 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-1C 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-1C 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 three ASUs.

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 amount of storage capacity available for use by application programs but not included in the Total ASU Capacity.

SPC-1C Data Protection Levels

Protected: Data protection in the event of a single point of failure of any of the configured storage devices.

Unprotected: The Test Sponsor asserts no claim of data protection in the event of a single point of failure.

SPC-1C Test Execution Definitions

Average Response Time: The sum of the Response Times for all Measured I/O Requests divided by the total number of Measured I/O Requests.

Completed I/O Request: An I/O Request with a Start Time and a Completion Time (see "I/O Completion Types" below).

Completion Time: The time recorded by the Workload Generator when an I/O Request is satisfied by the TSC as signaled by System Software.

Data Rate: The data transferred in all Measured I/O Requests in an SPC-1C Test Run divided by the length of the Test Run in seconds.

Expected I/O Count: For any given I/O Stream and Test Phase, the product of 50 times the BSU level, the duration of the Test Phase in seconds, and the Intensity Multiplier for that I/O Stream.

Failed I/O Request: Any I/O Request issued by the Workload Generator that could not be completed or was signaled as failed by System Software. A Failed I/O Request has no Completion Time (see "I/O Completion Types" below).

I/O Request Throughput: The total number of Measured I/O requests in an SPC-1C Test Run divided by the duration of the Measurement Interval in seconds.

In-Flight I/O Request: An I/O Request issued by the I/O Command Generator to the TSC that has a recorded Start Time, but does not complete within the Measurement Interval (see “I/O Completion Types” below).

Measured I/O Request: A Completed I/O Request with a Completion Time occurring within the Measurement Interval (see “I/O Completion Types” below).

Measured Intensity Multiplier: The percentage of all Measured I/O Requests that were issued by a given I/O Stream.

Measurement Interval: The finite and contiguous time period, after the TSC has reached Steady State, when data is collected by a Test Sponsor to generate an SPC-1C test result or support an SPC-1C test result.

Ramp-Up: The 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.

Ramp-Down: The time required for the BC to complete all I/O Requests issued by the Workload Generator. The Ramp-Down period begins when the Workload Generator ceases to issue new I/O Requests to the TSC.

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

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 Tested Storage Configuration (TSC).

Start-Up: The period that begins after the Workload Generator starts to submit I/O requests to the TSC and ends at the beginning of the Measurement Interval.

Shut-Down: The period between the end of the Measurement Interval and the time when all I/O Requests issued by the Workload Generator have completed or failed.

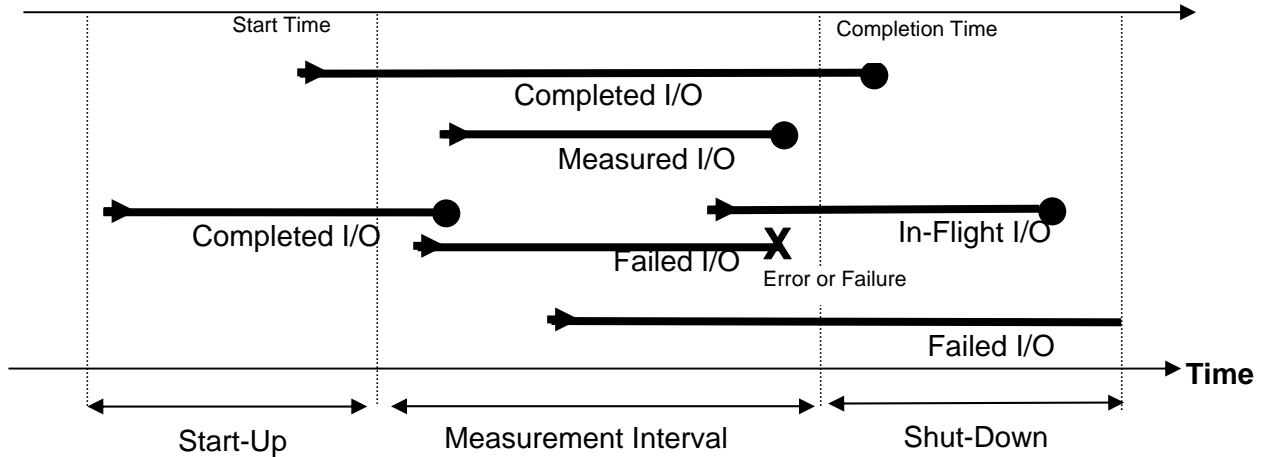
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

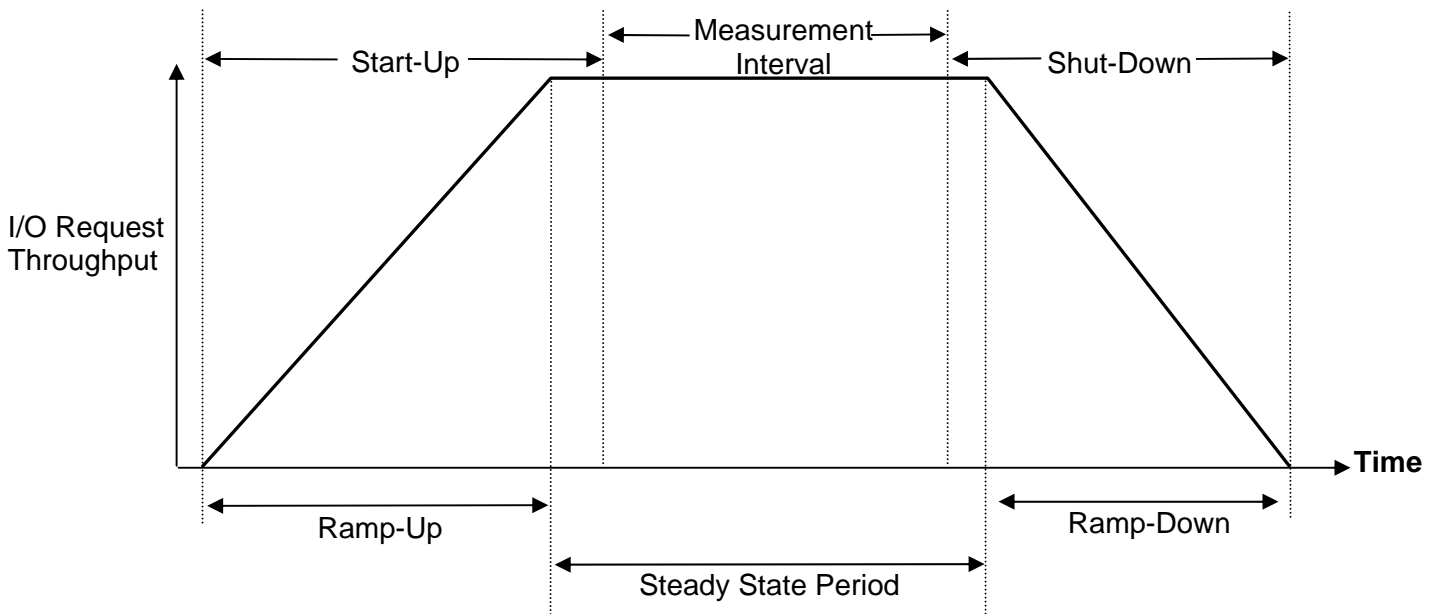
Test Run: The execution of SPC-1C for the purpose of producing or supporting an SPC-1C test result. SPC-1C Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1C Test Run Components” below. All SPC-1C Test Runs shall have a Steady State period and a Measurement Interval.

Test Phase: A collection of one or more SPC-1C Test Runs sharing a common objective and intended to be run in a specific sequence.

I/O Completion Types



SPC-1C Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

Volume initialization was disabled and disk drive write caching was enabled as documented in the “Set Customer Tunable Parameters” section of *Appendix C: Tested Storage Configuration (TSC) Creation* on page 63.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Enclosure Setting

For maximum throughput, the MD1120 front left hand bottom switch was placed in the down position, which changes the enclosure into two banks of twelve disks each.

Create RAID 0 Volume

The MegaCLI utility can be used to create, delete, and manage RAID volumes through a command line interface. The utility is available on the LSI website at:

http://www.lsi.com/storage_home/products_home/internal_raid/megaraid_sas/megaraid_sas_8888elp/index.html

The following batch file was executed to clear, then create the RAID 0 striped volume.

MakeRAID0.cmd

```
REM *****Clear All RAID Volumes *****
MegaCLI -cfgclr -aALL
MegaCLI -AdpSetProp CoercionMode -0 -a0
REM
REM
REM ***** Create RAID 0 Volumes *****
REM Span : NO
REM # HDD in Vol : 24
REM Phys HDD List : 0,1,2,etc
REM Spares : NO
REM Encryption : NO
REM RAID Level : 0 striped
REM Stripe Size : 256 KB
REM Array set Name :A0
REM LD Read Policy : NoRead look ahead
REM LD Write Policy : Write Back, Bad BBU
REM LD IO Policy : Direct IO
REM Access Policy : Read / Write
REM Disk Cache Policy : Enable
REM Initialization : Quick Init
REM *****
set adptr=0
set
A0=[135:12,219:0,135:13,219:1,135:14,219:2,135:15,219:3,135:16,219:4,135:17,219:5,13
5:18,219:6,135:19,219:7,135:20,219:9,135:21,219:8,135:22,219:10,135:23,219:11]
set Arraylist=%A0%
set level=0
set stripe=256
set ReadCache=NORA
set WriteCache=WB
Set BBU=CachedBadBBU
set IOpolicy=Direct
set access=RW
set DiskCache=-EnDskCache
set BI=-Dsbl
@echo on
REM ***** Create Volume RAID 0 striped *****
MegaCli -CfgLDAdd -R%level%%Arraylist% %WriteCache% %ReadCache% %IOpolicy% %BBU% -
strpsz%stripe% -a%adptr%
```

REM

Create SPC-1 ASUs

The three SPC-1 ASUs were created using the following CLI command, referencing the script listed below:

diskpart /s diskmk.txt

diskmk.txt

```
select disk 1
clean
convert gpt
create partition primary align=64 size=1658881
create partition primary align=64 size=368641
create partition primary align=64 size=1658881

select volume 1
assign letter=x
select volume 2
assign letter=z
select volume 3
assign letter=y
exit
```

Set Customer Tunable Parameters

The following batch file was executed to disable volume initialization and enable disk drive write caching.

tuneparm.cmd

```
REM ***** Disable Volume Initialization *****
REM
MegaCLI -LDBI -abort -Lall -aALL
MegaCLI -LDBI -dsbl -Lall -aALL
REM
REM ***** Enable Drive Cache WCD *****
REM
MegaCLI -LDSetProp -EnDskCache -Lall -aALL
REM
```

APPENDIX D: SPC-1C WORKLOAD GENERATOR STORAGE COMMANDS AND PARAMETERS

The content of SPC-1C Workload Generator command and parameter files, used in this benchmark, is listed below.

```
sd=asu1_1,lun=\\.x:,size=1620G  
sd=asu2_1,lun=\\.y:,size=1620G  
sd=asu3_1,lun=\\.z:,size=360G
```


APPENDIX E: SPC-1C WORKLOAD GENERATOR INPUT PARAMETERS

Primary Metrics Test, Repeatability Test, and Persistence Test Run 1

The following script was used to execute the Idle Test (*Conditioning Phase, Application Idle Phase, and Recovery Phase*) Primary Metrics Test (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*), Repeatability Test (*Repeatability Test Phase 1 and Repeatability Test Phase 2*), and Persistence Test Run 1 in an uninterrupted sequence.

```
@echo off
set runname=%1
REM =====
REM SPC-1C Energy RUN
REM =====
set MaxBSU=1600
set PIBSU=165
set java=C:\Java\jre6\bin\java
set spath=c:\spc\spc1c
REM =====
@echo Please Start WT210 Viewer and load setup
pause
@echo Start WT210 Sampling
pause
REM =====
REM Precondition phase
REM =====
REM
%Java% -Xms512m -Xmx512m -Xss512K range -b %MaxBSU% -t 360
ren %spath%\rangetest PreI_%runname%
rem copy %spath%\rangetest\*. * %spath%\PreI_%runname%
REM
REM =====
REM Idle Phase 60 mins
REM =====
REM
sleep 3600
REM
REM =====
REM Post Idle Precondition 10% Sustain and Ramp
REM =====
REM
%Java% -Xms512m -Xmx512m -Xss512K range -b %PIBSU% -t 360
ren %spath%\rangetest PostI_%runname%
REM copy %spath%\rangetest\*. * %spath%\PostI_%runname%
REM
%Java% -Xms512m -Xmx512m -Xss512K metrics -b %MaxBSU% -t 3660
REM
REM =====
REM Repeat 1 & 2
REM =====
%Java% -Xms512m -Xmx512m -Xss512K repeat1 -b %MaxBSU% -t 360
%Java% -Xms512m -Xmx512m -Xss512K repeat2 -b %MaxBSU% -t 360
@echo Stop WT210 Sampling
Pause
REM =====
REM Persist 1
REM =====
%Java% -Xms512m -Xmx512m persist1 -b %MaxBSU%
REM
```

```
@echo shutdown host and power down, once host is powered down
@echo power cycle the storage subsystem , restart the host
@echo once up and ready run persist2
pause
rem Manually power cycle
```

Persistence Test Run 2

The following script was used to execute Persistence Test Run 2 after the above execution sequence and the required power-off cycle, which followed successful completion of Persistence Test Run 1.

```
set java="C:\Java\jre6\bin\java"
set class=c:\spc-1c_a
@echo once up and ready run
pause
%Java% -Xms512m -Xmx512m persist2
```

APPENDIX F: THIRD-PARTY QUOTES


LSI Mega RAID 8888ELP


PROVANTAGE: LSI Logic LSI00142 SAS8888ELP MegaRAID 8-Port SAS 3G PCI-E ... Page 1 of 2

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LSI Logic
SAS8888ELP MegaRAID 8-Port SAS 3G PCI-E 512MB LP RoHS6 KIT
Manufacturer Part# LSI00142

- ▶ Product Type: SAS RAID Controller
- ▶ Form Factor: Half-length Low-profile Plug-in Card
- ▶ Data Transfer Rate: Up to 300MBps Per Port
- ▶ Host Interface: PCI Express x8
- ▶ Standard Memory: 512MB DDR2

Manufacturer's Warranty LSIG04W

Only **\$641.33**

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Abstract

Flexibility best summarizes the features of the SAS 8888ELP. With selectable connectors, one card serves three deployment needs. Users can choose two connectors: two internal, two external or one each. System builders can attach up to 240 disks; choose high performance SAS disks or high capacity SATA drives or a combination of both for greater system design flexibility. Finally, this adapter features replaceable DDR II 256MB mini DIMM cache module, with two battery backup options. An investment in the 8888ELP brings piece of mind, with its unique ability to operate with both internal or external disk equipment.


Product Specifications [Compare with other products.](#)

Product Name	SAS8888ELP MegaRAID 8-Port SAS 3G PCI-E 512MB LP RoHS6 KIT
Product Type	SAS RAID Controller
Data Transfer Rate	Up to 300MBps Per Port
Standard Memory	512MB DDR2
Ports	2 x SFF-8088 SAS 300 - Serial Attached SCSI External 2 x SFF-8087 SAS 300 - Serial Attached SCSI Internal
RAID Levels	0 1

<http://www.provantage.com/lsi-logic-lsi00142-7LSIG04W.htm> 5/5/2009

Dell PowerVault MD1120


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Print Summary


PowerVault MD1120
Starting Price **\$4,878**



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- PowerVault MD1120

Date	5/5/2009 10:59:03 AM Central Standard Time			
Catalog Number	5 Retail 555			
Catalog Number / Description	Product Code	Qty	SKU	Id
PowerVault MD1120: PowerVault MD1120 Rack 2U, 24 Bay External Storage Array with Locking Bezel	MD1120	1	[223-6716]	1
Environmental Information: Initial DAS purchase. MD1120 will be stand alone.	1JBOD	1	[467-4068]	4
Enclosure Management Module: 2 Enclosure Management Modules, PowerVault MD1120, SAS only	2EMM	1	[341-6492]	9
Server RAID Controller: I already have a PERC6/E Adapter (Required to operate MD1120)	HASP6	1	[341-6487]	24
Cables: 2 SAS cables, 2 meters, connects MD1120 to PERC or another MD1120	2SAS2M	1	[310-7083][310-7083]	20
Hard Drive Multi-Select: Single Blank Hard Drive Filler, MD1120	1HDBLK	22	[341-6493]	608
Hard Drive Multi-Select: 73GB 10K RPM Serial-Attach SCSI 3Gbps 2.5-in HotPlug Hard Drive	73A125	2	[341-6497]	608
Rails: No Rails Included	NORAIL	1	[330-0368]	27
Hardware Support Services: 3 Year ProSupport for IT and NBD On-site Service	U3IP	1	[988-8362][988-8402][989-1450][989-3439][990-7938][990-7947]	29
Installation Services: No Installation	NOINSTL	1	[900-9997]	32

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