SPC BENCHMARK 1C™
FULL DISCLOSURE REPORT

SEAGATE TECHNOLOGY LLC
SEAGATE CONSTELLATION™ ST9500430SS

SPC-1C™ V1.1

Submitted for Review: January 29, 2009
Submission Identifier: C00009

First Edition – January 2009

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AUDIT CERTIFICATION

Storage Performance Council

Gradient SYSTEMS

Craig Paris
Seagate Technology LLC
1280 Disc Drive
Shakopee, MN 55372

January 28, 2009

The SPC Benchmark 1C™ results listed below for the Seagate Constellation™ ST9500430SS were produced in compliance with the SPC Benchmark 1C™ V1.1 Onsite Audit requirements.

SPC Benchmark 1C™ V1.1 Results	
Tested Storage Product:	
Seagate Constellation™ ST9500430SS	
Metric	**Reported Result**
SPC-1C IOPS™	1,001.58
Total ASU Capacity	2,250.484 GB
Data Protection Level	RAID-5
Total Price – Priced Storage Configuration	$8,347

The following SPC Benchmark 1C™ Audit requirements were reviewed and found compliant with V1.1 of the SPC Benchmark 1C™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and 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 (BC)/Tested Storage Configuration (TSC).
- Physical verification of the components to match the above diagram.
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.

Storage Performance Council
643 Bair Island Road, Suite 103
Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9384

AUDIT CERTIFICATION *(CONT.)*

- SPC-1C Workload Generator commands and parameters used for the audited SPC-1C Test Runs.

- The following Host System requirements were verified by physical inspection and 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.

  ✓ The TSC boundary within the Host System.

- The Test Results Files and resultant Summary Results Files for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4, 5 and 6 of the SPC-1C Benchmark Specification:

  ✓ Data Persistence Test
  ✓ Sustainability Test Phase
  ✓ IOPS Test Phase
  ✓ Response Time Ramp Test Phase
  ✓ Repeatability Test

- There were no differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration.

- The submitted pricing information met all of the requirements and constraints of Clause 9 of the SPC-1C Benchmark Specification.

- The Full Disclosure Report (FDR) met all of the requirements in Clause 10 of the SPC-1C 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,
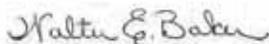
Walter E. Baker

Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

Seagate

Seagate Technology
1280 Disc Drive
Shakopee MN 55379

Date: *01/16/2009*

From: Carla Kennedy

To: *Walter Baker*

Subject: SPC-1C Letter of Good Faith for SEAGATE Constellation ST9500430SS

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

_____   1/12/09
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 55372 Phone: (952) 402-2418 FAX: (952) 402-2695
Test Sponsor Alternate Contact	Seagate Technology LLC – http://www.seagate.com Tom McCaffrey – Tom.R.McCaffrey@seagate.com 1280 Disc Drive Shakopee, MN 55372 Phone: (952) 402-2629 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 Specification revision number	V1.1
SPC-1C Workload Generator revision number	V1.0
Date Results were first used publicly	January 29, 2009
Date the FDR was submitted to the SPC	January 29, 2009
Date the TSC is available for shipment to customers	March 30, 2009
Date the TSC completed audit certification	January 28, 2009

Tested Storage Product (TSP) Description

Seagate's Constellation is the industry's first 2.5" business critical enterprise hard drive. The Constellation model ST9500430SS packs 500GB of storage capacity into the 2.5" x 15mm form factor. Constellation accomplishes the amazing feat of being the lowest power enterprise drive while serving up blazing nearline performance with 7,200 RPM rotational speed and 6Gbps capable SAS. More host controllable options are available to further reduce idle power with PowerChoiceTM from Seagate. Constellation has the enterprise class vibration resistance to intermix in a high density storage environment.

Summary of Results

SPC-1C Results	
Tested Storage Product: Seagate Constellation™ ST9500430SS	
Metric	**Reported Result**
SPC-1C IOPS™	1,001.58
Total ASU Capacity	2,250.484 GB
Data Protection Level	RAID-5
Total Price – Priced Storage Configuration	$8,347

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 "RAID-5" provides data protection by distributing check data corresponding to user data across multiple disks in the form of bit-by-bit parity.

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:

6,001.294 GB *(Physical Storage Capacity)* *** 0.5 = 3,000.647 GB**

2,250.484 GB *(Total ASU Capacity)* **+ 750.161 GB** *(data protection)* **= 3,000.645 GB**

The following diagram documents the various storage capacities, used in this benchmark, and their relationships.
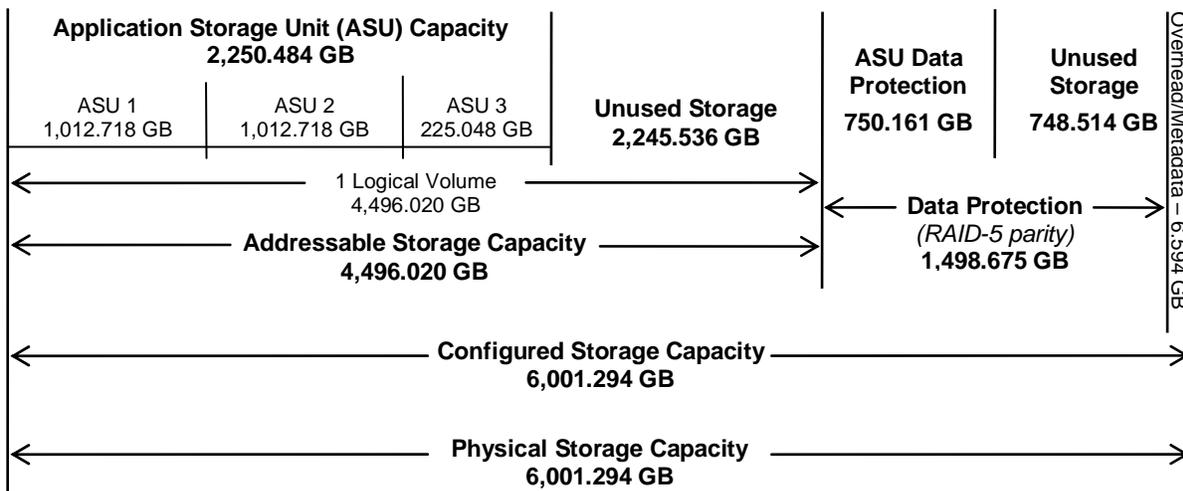
Response Time – Throughput Curve

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.
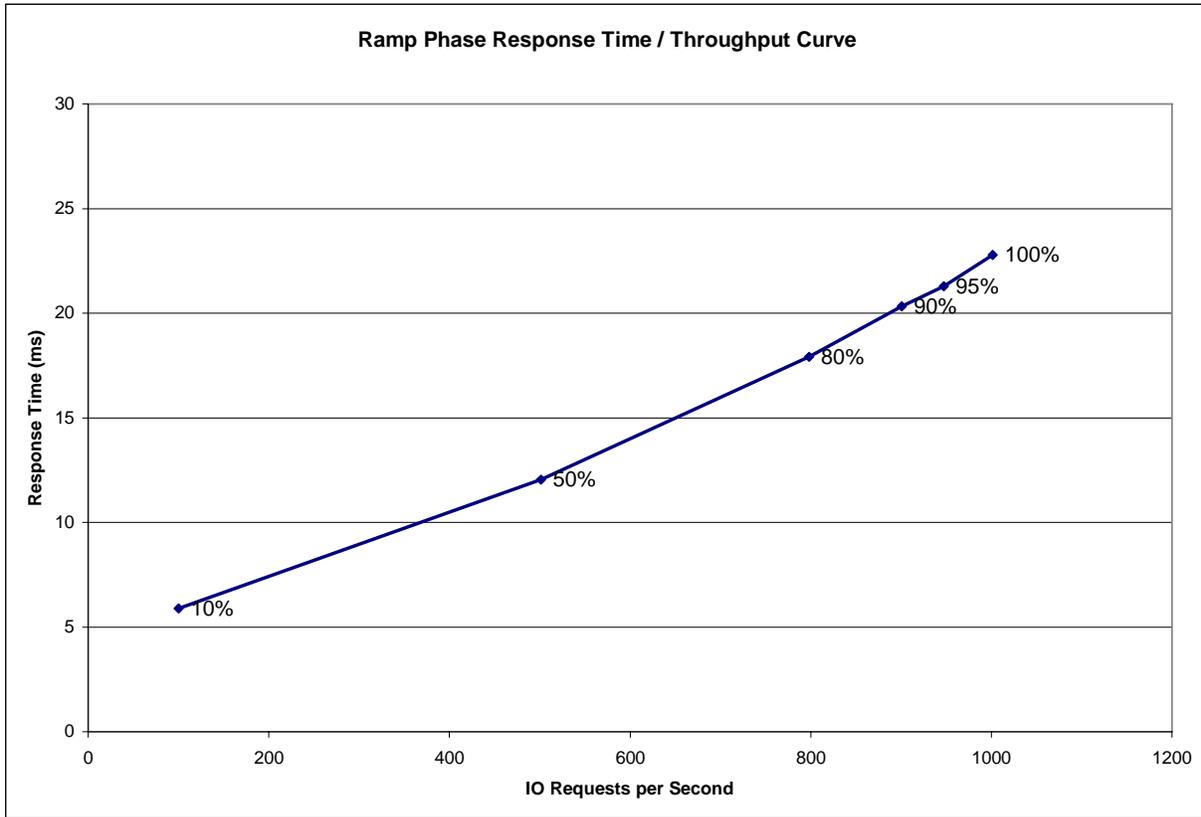
Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	100.41	501.66	798.23	900.84	947.55	1,001.58
Average Response Time (ms):						
All ASUs	5.88	12.04	17.92	20.32	21.28	22.78
ASU-1	7.48	13.74	20.11	23.03	24.07	26.08
ASU-2	7.08	14.92	22.35	25.75	26.61	27.94
ASU-3	1.95	7.12	11.30	12.19	13.03	13.49
Reads	13.17	24.55	35.84	41.02	42.99	46.51
Writes	1.13	3.87	6.16	6.81	7.18	7.31

Tested Storage Configuration Pricing *(Priced Storage Configuration)*

Description		Part Numbers	Qty	Price		Extended Price
500GB SAS 2.5" 7200RPM HDD		ST9500430SS	12	$220		$2,640
2U 24 bay External Storage Array		MD1120	1	$5,707		$5,707
incl PERC 6/e RAID controller						
incl 2 73GB 10K RPM SAS disks						
incl 2 SAS -1M Cables						
incl 24 drive trays						
incl 3 year hardware support				**Total**		**$8,347**

Each 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 twelve (12) priced disk drives.

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

Dell PowerEdge 2950 Server *(Host System)*

**Dell PERC6/e
RAID Controller**

Dell PowerVault MD1120 Disk Storage Enclosure

X4 SAS 1.0 cable

**12 – Seagate Constellation
500 GB SAS Disk Drives**
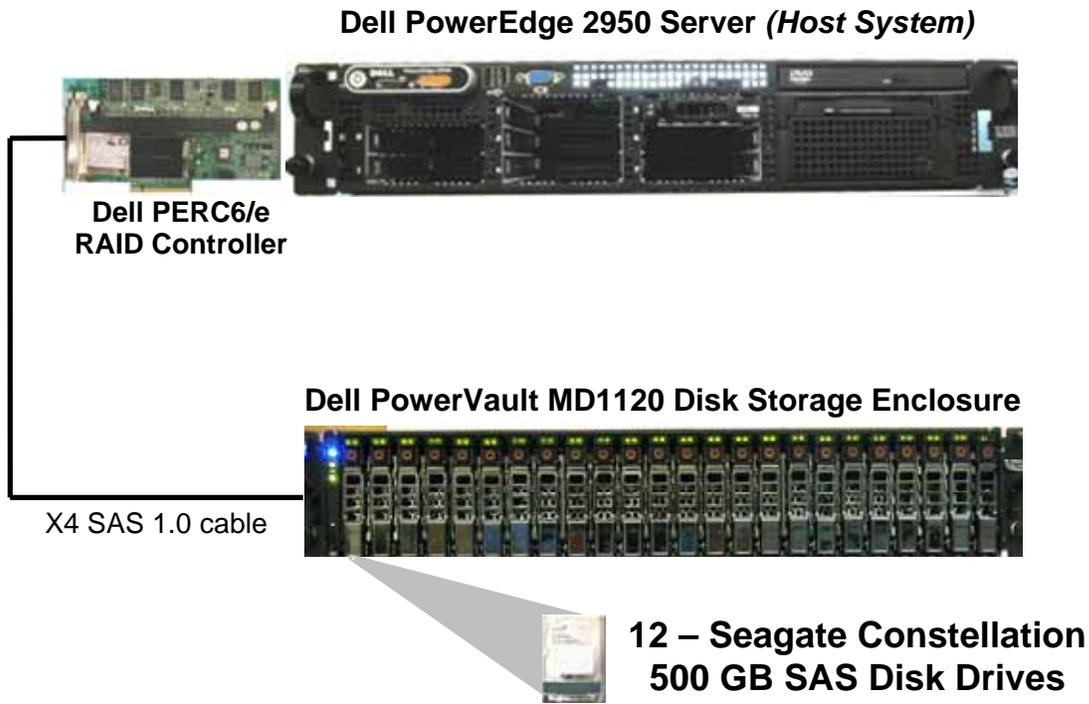
Benchmark Configuration/Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):

Dell PowerEdge 2950 Server
    2 – 2.00 GHz Intel Xeon E5405 processors
        2 x 6144 KB L2 cache
	1 – Dell PERC 6e SAS
	    external RAID controller with:
	        512 MB cache
	        1 - x8 PCIe 1.0 host connect
	        2 - x8 3 Gb/s SAS 1.0 disk connect

2 GB main memory	
Windows 2003 Standard Edition SP2	
PCIe 1.0	1 – Dell PowerVault MD1120 Disk Storage Enclosure
	12 – Seagate Constellation™ 500 GB SAS disks
	1 – x4 1m external SAS cable

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 14 *(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 14 *(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 58 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.2.4.5.2

The FDR must include sufficient information to recreate the logical representation of the 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 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 59 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 61.

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 54 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)	2,250.484
Addressable Storage Capacity	Gigabytes (GB)	4,496.020
Configured Storage Capacity	Gigabytes (GB)	6,001.294
Physical Storage Capacity	Gigabytes (GB)	6,001.294
Data Protection *(RAID-5 parity)*	Gigabytes (GB)	750.161
Required Storage	Gigabytes (GB)	6.594
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	2,245.537

SPC-1C Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	50.06%	37.50%	37.50%
Required for Data Protection *(RAID-5 parity)*		12.50%	12.50%
Addressable Storage Capacity		74.92%	74.92%
Required Storage		0.11%	0.11%
Configured Storage Capacity			100.00%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	49.94%		
Configured		0.00%	
Physical			0.00%

The Physical Storage Capacity consisted of 6,001.294 GB distributed over 12 disk drives with a formatted capacity of 500.108 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 50.06% of the Addressable Storage Capacity resulting in 2,245.536 GB (49.94%) 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).
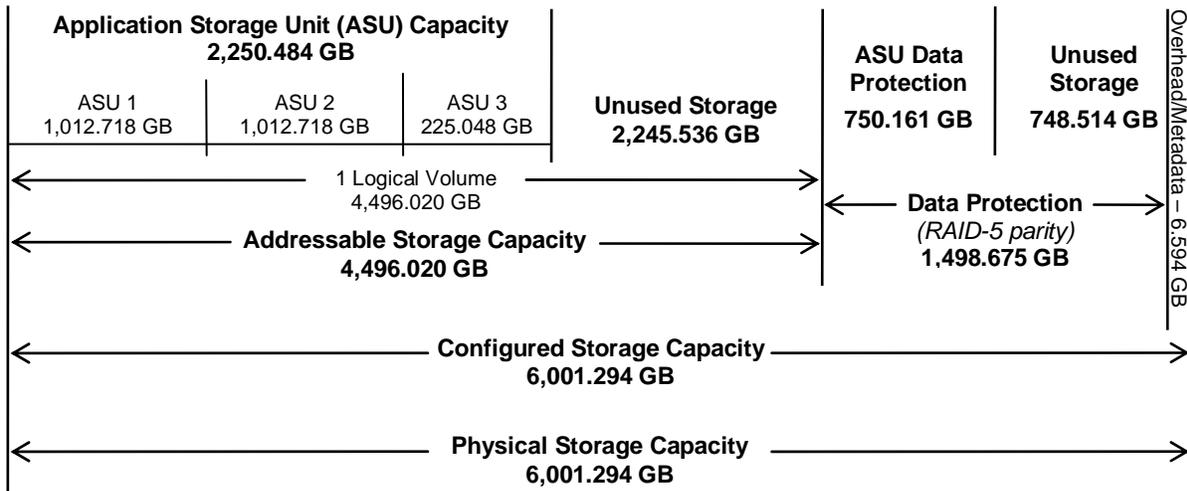
Logical Volume Capacity and ASU Mapping

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 (1,012.718 GB)	ASU-2 (1,012.718 GB)	ASU-3 (225.048 GB)
1 Logical Volume 4,496.020 GB per Logical Volume (1,012.718 GB used per Logical Volume)	1 Logical Volume 4,496.020 GB per Logical Volume (1,012.718 GB used per Logical Volume)	1 Logical Volume 4,496.020 GB per Logical Volume (225.048 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was "RAID-5" as described on page 11. 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 55 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 63.

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	13:29:35	13:32:35	0-2	0:03:00
Measurement Interval	13:32:35	14:32:35	3-62	1:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	8.20	3.18	0.88	4.14	32	8.30	3.25	0.88	4.17
1	8.21	3.20	0.87	4.14	33	8.00	3.11	0.86	4.03
2	8.25	3.21	0.86	4.18	34	8.40	3.29	0.90	4.21
3	8.25	3.17	0.90	4.18	35	8.04	3.11	0.88	4.05
4	8.19	3.13	0.90	4.17	36	8.37	3.25	0.89	4.23
5	8.33	3.27	0.87	4.20	37	8.06	3.10	0.86	4.09
6	8.08	3.12	0.85	4.11	38	8.48	3.27	0.91	4.30
7	8.27	3.24	0.89	4.14	39	8.14	3.16	0.88	4.11
8	8.03	3.13	0.87	4.03	40	8.30	3.24	0.90	4.16
9	8.41	3.22	0.91	4.28	41	8.27	3.21	0.90	4.17
10	8.29	3.17	0.89	4.23	42	8.16	3.16	0.86	4.14
11	8.31	3.22	0.89	4.19	43	8.23	3.24	0.93	4.06
12	8.21	3.20	0.89	4.13	44	8.07	3.10	0.90	4.07
13	8.20	3.14	0.89	4.17	45	8.27	3.24	0.89	4.14
14	8.24	3.22	0.88	4.15	46	8.02	3.12	0.84	4.07
15	8.09	3.12	0.87	4.10	47	8.25	3.23	0.90	4.13
16	8.46	3.25	0.91	4.30	48	8.01	3.12	0.86	4.03
17	8.04	3.14	0.86	4.04	49	8.56	3.33	0.95	4.29
18	8.22	3.17	0.88	4.17	50	8.02	3.13	0.82	4.08
19	8.11	3.13	0.86	4.11	51	8.39	3.22	0.88	4.29
20	8.32	3.23	0.87	4.21	52	8.32	3.25	0.90	4.17
21	8.22	3.21	0.86	4.15	53	8.25	3.18	0.89	4.18
22	8.12	3.16	0.87	4.09	54	8.06	3.10	0.87	4.08
23	8.34	3.22	0.90	4.22	55	8.49	3.31	0.91	4.27
24	8.07	3.14	0.83	4.09	56	8.01	3.09	0.83	4.09
25	8.31	3.27	0.89	4.16	57	8.48	3.27	0.93	4.29
26	8.06	3.14	0.87	4.06	58	8.10	3.11	0.86	4.13
27	8.53	3.29	0.92	4.32	59	8.31	3.23	0.88	4.20
28	8.05	3.06	0.89	4.10	60	8.02	3.13	0.87	4.02
29	8.34	3.26	0.86	4.21	61	8.42	3.24	0.91	4.27
30	8.10	3.17	0.87	4.06	62	8.05	3.17	0.87	4.01
31	8.16	3.20	0.88	4.08					

Sustainability – Data Rate Distribution Graph

Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	13:29:35	13:32:35	0-2	0:03:00
Measurement Interval	13:32:35	14:32:35	3-62	1:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	1,008.60	601.05	125.65	281.90	32	1,010.33	603.58	123.97	282.78
1	1,003.57	599.35	121.70	282.52	33	975.45	582.17	120.75	272.53
2	997.13	594.82	121.53	280.78	34	1,027.40	615.38	126.13	285.88
3	1,000.90	595.87	123.58	281.45	35	977.37	585.17	119.60	272.60
4	983.85	581.32	123.48	279.05	36	1,017.58	605.65	125.17	286.77
5	1,019.72	608.83	125.88	285.00	37	974.78	579.45	122.23	273.10
6	975.78	583.27	118.78	273.73	38	1,028.40	611.68	128.63	288.08
7	1,016.77	605.38	126.97	284.42	39	987.80	585.77	124.07	277.97
8	974.08	582.75	119.73	271.60	40	1,012.95	603.68	126.85	282.42
9	1,013.82	601.65	125.10	287.07	41	1,002.57	597.68	123.45	281.43
10	999.55	593.95	122.87	282.73	42	995.97	592.48	122.02	281.47
11	1,010.13	602.52	124.78	282.83	43	1,011.08	608.23	125.65	277.20
12	1,006.58	600.48	125.28	280.82	44	981.60	581.67	121.97	277.97
13	990.98	585.63	122.60	282.75	45	1,012.13	603.17	124.27	284.70
14	1,007.38	602.58	124.10	280.70	46	983.98	585.65	120.10	278.23
15	979.97	583.35	119.77	276.85	47	1,013.80	601.80	128.58	283.42
16	1,022.33	608.87	124.55	288.92	48	978.92	584.05	120.55	274.32
17	989.95	590.05	122.70	277.20	49	1,030.87	616.28	128.53	286.05
18	1,006.62	601.43	122.38	282.80	50	974.73	580.13	117.73	276.87
19	976.20	581.83	120.47	273.90	51	1,008.27	600.95	120.55	286.77
20	1,019.48	610.20	123.25	286.03	52	1,015.80	607.27	124.93	283.60
21	1,006.63	599.02	123.68	283.93	53	998.68	592.52	122.85	283.32
22	990.82	590.33	122.00	278.48	54	980.20	586.58	119.37	274.25
23	1,005.87	601.35	121.53	282.98	55	1,024.15	611.65	124.80	287.70
24	984.42	587.23	120.00	277.18	56	971.35	577.55	118.63	275.17
25	1,019.32	607.22	127.03	285.07	57	1,021.62	606.97	126.82	287.83
26	979.63	584.80	119.72	275.12	58	978.78	582.43	119.42	276.93
27	1,027.38	609.20	126.12	292.07	59	1,024.25	610.08	126.53	287.63
28	974.27	578.67	120.92	274.68	60	975.63	581.17	119.98	274.48
29	1,019.22	611.37	122.10	285.75	61	1,021.83	606.08	127.50	288.25
30	997.35	596.17	123.02	278.17	62	985.13	589.07	120.43	275.63
31	994.13	591.92	122.57	279.65	**Average**	**999.94**	**595.89**	**123.12**	**280.94**

Sustainability – I/O Request Throughput Distribution Graph

Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	13:29:35	13:32:35	0-2	0:03:00
Measurement Interval	13:32:35	14:32:35	3-62	1:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	21.14	23.62	27.25	13.14	32	25.36	29.47	33.96	12.83
1	23.48	26.43	28.72	14.96	33	25.95	30.41	32.24	13.65
2	22.39	25.21	29.12	13.53	34	24.74	28.92	32.52	12.33
3	22.88	26.27	28.43	13.26	35	26.34	30.68	34.31	13.54
4	23.45	27.03	31.06	12.61	36	24.45	28.54	31.73	12.62
5	21.86	25.37	26.33	12.36	37	26.55	30.37	35.30	14.52
6	23.29	25.40	29.79	15.96	38	25.25	29.09	33.06	13.62
7	21.71	24.79	27.47	12.57	39	25.79	30.44	32.22	13.14
8	23.26	26.03	28.89	14.83	40	24.52	28.46	31.80	12.84
9	21.90	24.87	28.35	12.86	41	27.44	31.85	37.37	13.73
10	23.16	26.43	29.08	13.72	42	25.08	29.18	33.17	12.96
11	22.69	25.87	30.49	12.47	43	25.92	29.90	34.07	13.51
12	23.94	27.33	30.81	13.64	44	25.71	30.22	34.78	12.30
13	23.32	26.78	29.23	13.59	45	24.78	29.28	31.07	12.50
14	23.22	26.72	28.12	13.52	46	25.64	29.31	33.59	14.50
15	24.13	27.65	29.81	14.25	47	24.48	28.35	32.01	12.86
16	23.10	26.38	31.72	12.47	48	25.69	29.46	32.20	14.79
17	24.59	28.03	32.86	13.60	49	24.10	28.21	31.63	11.87
18	22.74	25.76	31.24	12.63	50	26.16	30.75	34.23	13.14
19	24.76	28.74	29.82	14.07	51	25.62	29.50	33.12	14.35
20	22.79	25.99	29.15	13.24	52	23.17	27.00	29.67	12.11
21	24.69	28.05	32.15	14.36	53	23.65	27.25	31.36	12.77
22	24.25	27.53	30.85	14.40	54	24.59	28.01	32.04	14.02
23	24.73	28.38	31.78	13.96	55	22.60	26.20	30.15	11.65
24	25.38	29.51	31.08	14.19	56	24.61	27.96	31.45	14.62
25	24.19	28.16	32.84	11.87	57	22.68	25.89	28.43	13.38
26	25.54	29.52	32.56	14.04	58	24.08	27.36	29.39	14.90
27	24.16	27.65	33.25	12.95	59	22.24	25.16	27.73	13.64
28	26.53	29.64	34.27	16.56	60	24.01	27.59	30.35	13.66
29	24.42	28.70	31.67	12.16	61	22.89	25.94	29.81	13.41
30	25.83	29.44	34.73	14.17	62	23.57	27.07	28.65	13.88
31	25.18	29.37	32.18	13.25	**Average**	**24.32**	**27.99**	**31.39**	**13.45**

Sustainability – Average Response Time (ms) Distribution Graph
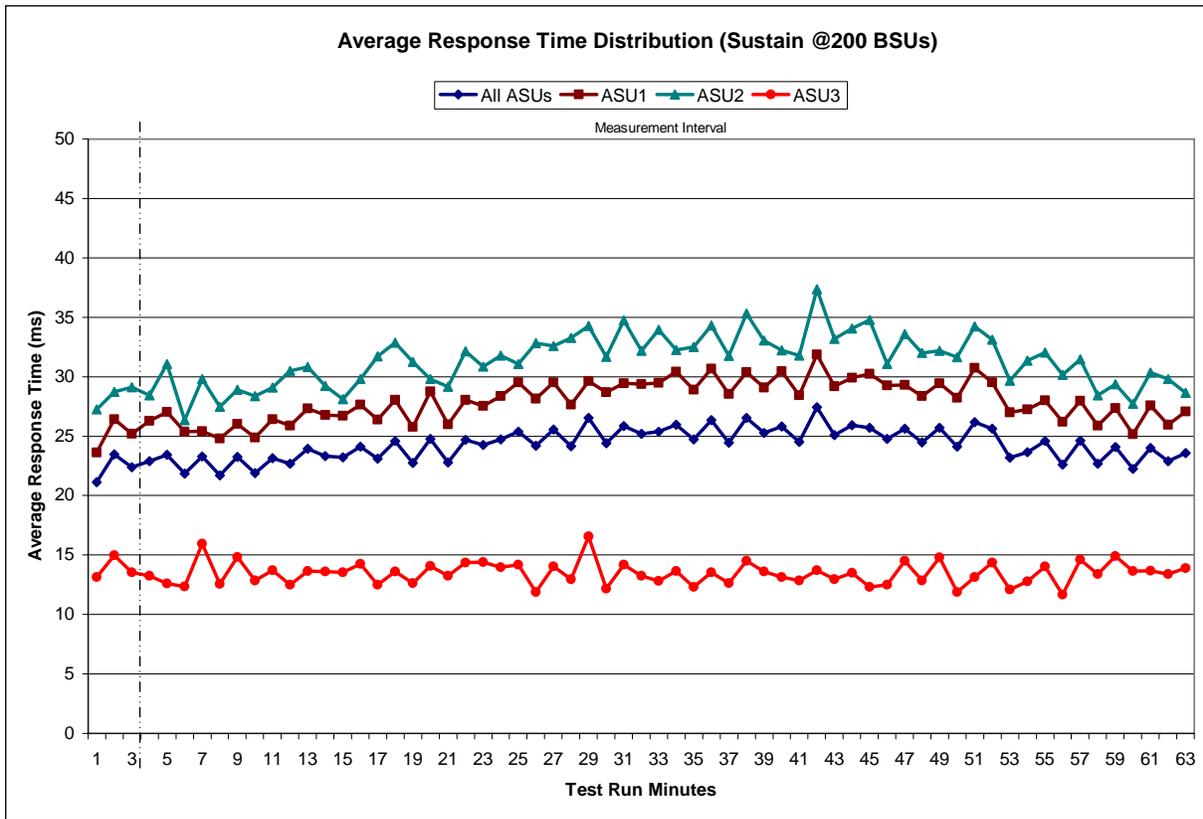
Sustainability – Response Time Frequency Distribution Data

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	13,619	17,598	2,561	1,358	1,057	1,011	1,317	1,686
Write	2,009,924	103,043	11,180	8,195	6,367	4,822	3,688	3,011
All ASUs	2,023,543	120,641	13,741	9,553	7,424	5,833	5,005	4,697
ASU1	889,186	63,414	7,269	4,796	3,780	3,076	2,887	2,985
ASU2	207,813	13,970	1,407	1,001	780	611	474	416
ASU3	926,544	43,257	5,065	3,756	2,864	2,146	1,644	1,296

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	5,092	6,418	7,680	8,826	11,181	12,598	32,375	46,026
Write	8,584	1,945	1,848	815	1,189	559	1,162	1,038
All ASUs	13,676	8,363	9,528	9,641	12,370	13,157	33,537	47,064
ASU1	9,084	6,994	8,092	8,669	11,052	11,999	30,791	42,150
ASU2	1,217	532	692	591	866	911	2,246	4,435
ASU3	3,375	837	744	381	452	247	500	479

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	55,271	63,975	69,008	322,088	195,828	110,665	66,297	389,614
Write	1,019	940	929	4,858	3,968	2,826	1,798	32,435
All ASUs	56,290	64,915	69,937	326,946	199,796	113,491	68,095	422,049
ASU1	49,395	56,528	60,739	274,381	166,452	94,017	55,547	317,409
ASU2	6,437	7,979	8,786	50,340	31,578	18,211	11,702	77,416
ASU3	458	408	412	2,225	1,766	1,263	846	27,224

Sustainability – Response Time Frequency Distribution Graph
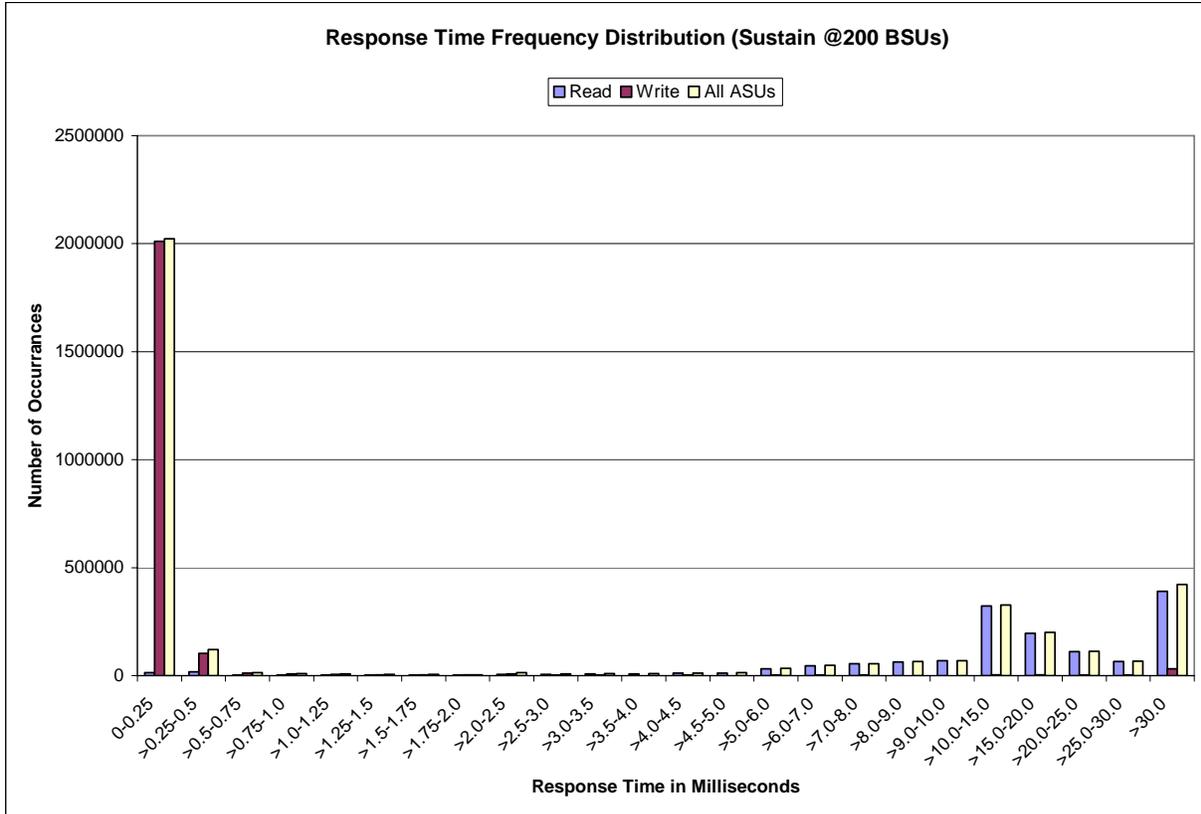
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

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	0.0349	0.2810	0.0699	0.2102	0.0180	0.0700	0.0351	0.2810
COV	0.021	0.007	0.017	0.099	0.030	0.016	0.021	0.007

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 63.

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

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:33:38	14:36:38	0-2	0:03:00
Measurement Interval	14:36:38	14:41:38	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	998.50	597.33	121.97	279.20
1	1,005.60	599.32	124.12	282.17
2	1,004.37	599.15	124.57	280.65
3	983.05	583.48	122.20	277.37
4	1,020.15	609.17	124.43	286.55
5	1,001.93	598.58	124.52	278.83
6	986.80	587.27	123.53	276.00
7	1,015.95	605.07	125.22	285.67
Average	1,001.58	596.71	123.98	280.88

IOPS Test Run – I/O Request Throughput Distribution Graph
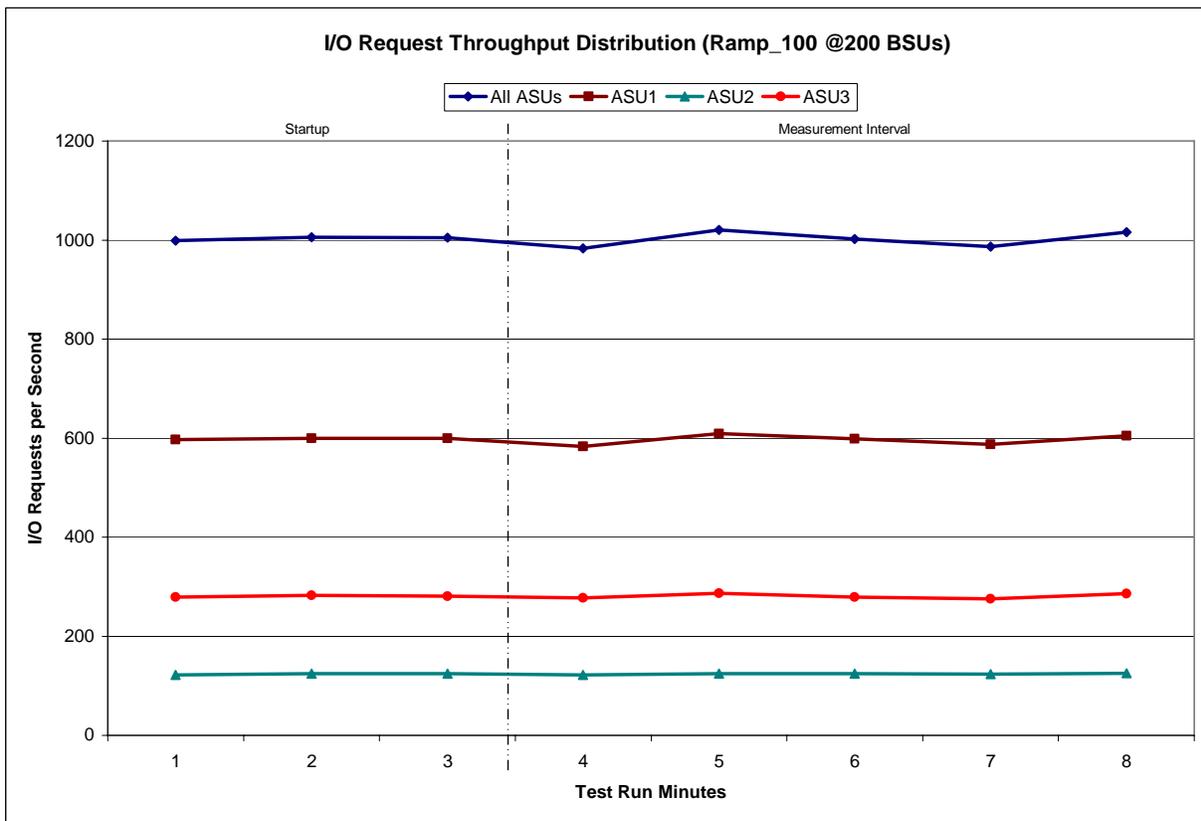
IOPS Test Run – Average Response Time (ms) Distribution Data

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:33:38	14:36:38	0-2	0:03:00
Measurement Interval	14:36:38	14:41:38	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	22.07	24.86	26.09	14.34
1	21.76	24.68	27.06	13.24
2	23.10	26.21	29.03	13.83
3	23.19	26.65	26.42	14.47
4	22.05	25.31	28.52	12.31
5	23.01	26.05	28.93	13.84
6	22.76	26.35	26.57	13.43
7	22.87	26.04	29.24	13.38
Average	22.78	26.08	27.94	13.49

IOPS Test Run – Average Response Time (ms) Distribution Graph
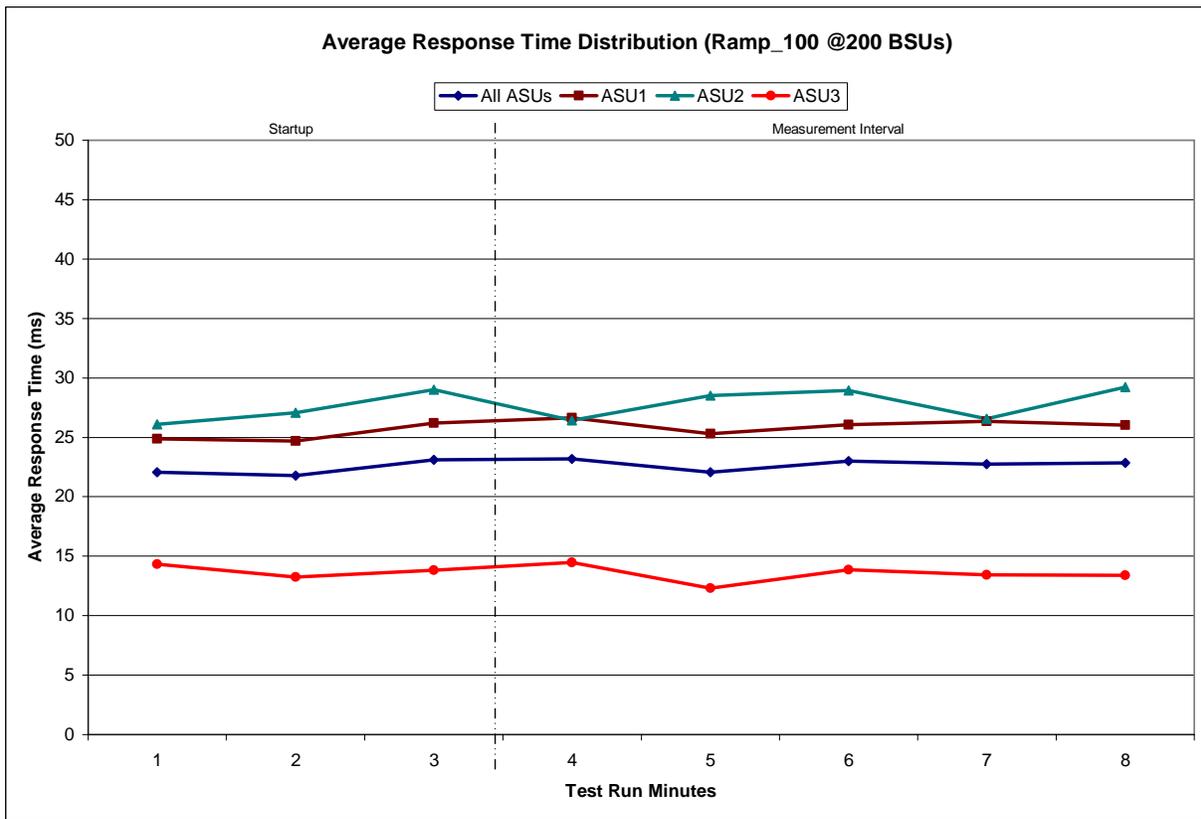
SPC BENCHMARK 1C™ V1.1   FULL DISCLOSURE REPORT   Submission Identifier: C00009
Seagate Technology LLC   Submitted for Review: JANUARY 29, 2009
Seagate Constellation™ ST9500430SS

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	1461	1,886	293	163	117	107	146	166
Write	198449	10,078	973	652	527	361	267	209
All ASUs	199910	11,964	1,266	815	644	468	413	375
ASU1	87899	6,353	632	432	325	266	254	246
ASU2	20823	1,385	152	70	91	40	43	37
ASU3	91188	4,226	482	313	228	162	116	92
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	553	747	812	932	1,153	1,364	3,561	5,219
Write	473	124	110	80	101	49	139	113
All ASUs	1,026	871	922	1,012	1,254	1,413	3,700	5,332
ASU1	744	753	821	898	1,132	1,308	3,390	4,747
ASU2	101	49	49	74	85	85	253	525
ASU3	181	69	52	40	37	20	57	60
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	6,092	7,088	7,604	35,620	20,757	11,030	6,057	28,501
Write	94	111	100	505	420	287	162	3,219
All ASUs	6,186	7,199	7,704	36,125	21,177	11,317	6,219	31,720
ASU1	5,423	6,240	6,643	30,254	17,599	9,311	5,058	23,121
ASU2	725	916	1,010	5,640	3,385	1,878	1,076	5,867
ASU3	38	43	51	231	193	128	85	2,732

IOPS Test Run –Response Time Frequency Distribution Graph
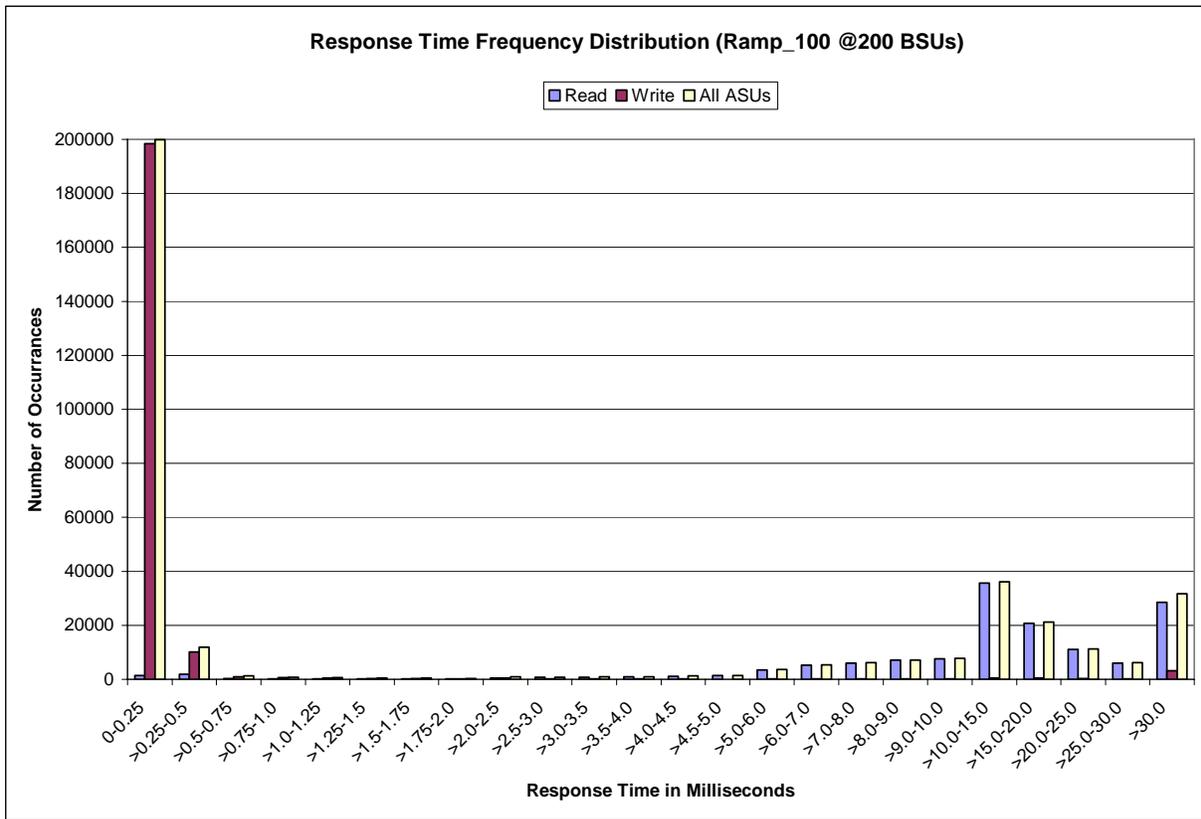
IOPS Test Run – I/O Request Information

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
327,312	359,032	31,720

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	0.0351	0.2807	0.0702	0.2098	0.0184	0.0706	0.0348	0.2804
COV	0.032	0.006	0.020	0.005	0.040	0.018	0.013	0.005

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 12.

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 63.

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 - 200 BSUs	Start	Stop	Interval	Duration	95% Load Level - 190 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:33:38	14:36:38	0-2	0:03:00	Start-Up/Ramp-Up	14:42:41	14:45:41	0-2	0:03:00
Measurement Interval	14:36:38	14:41:38	3-7	0:05:00	Measurement Interval	14:45:41	14:50:41	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	998.50	597.33	121.97	279.20	0	950.62	568.15	115.57	266.90
1	1,005.60	599.32	124.12	282.17	1	951.83	568.00	115.93	267.90
2	1,004.37	599.15	124.57	280.65	2	940.60	564.87	115.65	260.08
3	983.05	583.48	122.20	277.37	3	920.07	547.62	114.12	258.33
4	1,020.15	609.17	124.43	286.55	4	952.00	569.08	116.88	266.03
5	1,001.93	598.58	124.52	278.83	5	955.83	571.90	117.98	265.95
6	986.80	587.27	123.53	276.00	6	961.08	570.42	118.52	272.15
7	1,015.95	605.07	125.22	285.67	7	948.77	567.88	115.00	265.88
Average	1,001.58	596.71	123.98	280.88	Average	947.55	565.38	116.50	265.67
90% Load Level - 180 BSUs	Start	Stop	Interval	Duration	80% Load Level - 160 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:51:44	14:54:44	0-2	0:03:00	Start-Up/Ramp-Up	15:00:47	15:03:47	0-2	0:03:00
Measurement Interval	14:54:44	14:59:44	3-7	0:05:00	Measurement Interval	15:03:47	15:08:47	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	897.20	531.65	110.07	255.48	0	801.32	477.82	99.55	223.95
1	891.17	533.45	109.13	248.58	1	796.90	471.70	99.87	225.33
2	918.02	543.72	114.63	259.67	2	805.73	482.15	98.38	225.20
3	900.97	537.00	111.58	252.38	3	804.62	479.57	99.70	225.35
4	892.45	533.07	108.67	250.72	4	800.68	476.27	100.38	224.03
5	877.38	519.80	108.85	248.73	5	803.65	483.60	95.45	224.60
6	934.83	560.38	113.85	260.60	6	786.73	469.65	97.35	219.73
7	898.57	533.57	112.28	252.72	7	795.48	476.22	97.57	221.70
Average	900.84	536.76	111.05	253.03	Average	798.23	477.06	98.09	223.08
50% Load Level - 100 BSUs	Start	Stop	Interval	Duration	10% Load Level - 20 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:09:51	15:12:51	0-2	0:03:00	Start-Up/Ramp-Up	15:18:55	15:21:55	0-2	0:03:00
Measurement Interval	15:12:51	15:17:51	3-7	0:05:00	Measurement Interval	15:21:55	15:26:55	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	502.37	299.77	60.52	142.08	0	100.30	58.60	11.83	29.87
1	493.67	293.87	62.10	137.70	1	99.50	59.03	11.90	28.57
2	511.10	302.57	63.40	145.13	2	98.57	58.02	13.17	27.38
3	500.23	297.65	61.83	140.75	3	99.27	59.15	12.33	27.78
4	504.23	302.43	61.80	140.00	4	100.60	59.78	11.90	28.92
5	503.82	300.87	63.32	139.63	5	99.57	59.43	12.30	27.83
6	500.78	297.78	62.33	140.67	6	100.80	59.97	12.68	28.15
7	499.22	298.27	61.63	139.32	7	101.83	60.48	13.08	28.27
Average	501.66	299.40	62.18	140.07	Average	100.41	59.76	12.46	28.19

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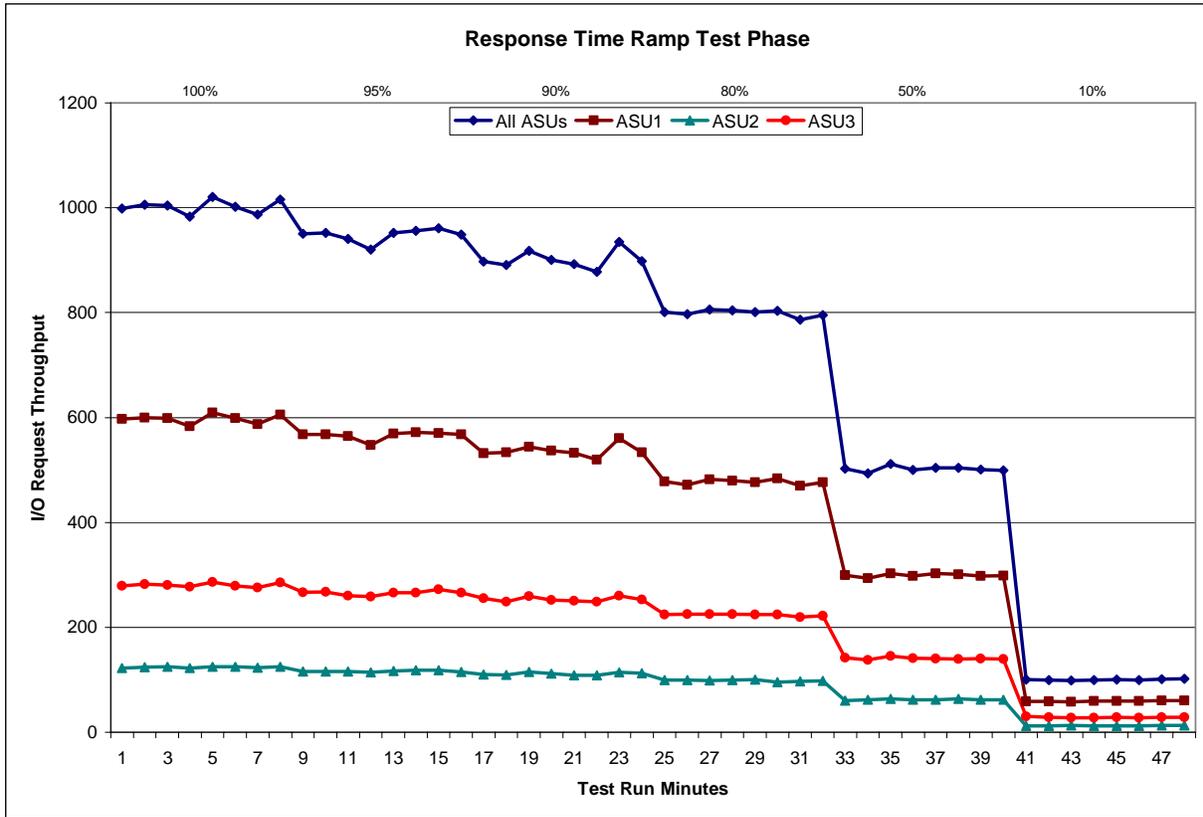
SPC-1C LRT™ Average Response Time (ms) Distribution Data

20 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:18:55	15:21:55	0-2	0:03:00
Measurement Interval	15:21:55	15:26:55	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	3.97	5.74	4.92	0.12
1	5.94	7.39	8.71	1.80
2	6.40	8.25	7.53	1.92
3	6.09	7.74	7.45	1.96
4	5.72	7.53	5.17	2.21
5	5.84	7.09	6.69	2.78
6	5.95	7.44	7.96	1.89
7	5.82	7.61	8.14	0.90
Average	5.88	7.48	7.08	1.95

SPC-1C LRT™ Average Response Time (ms) Distribution Graph
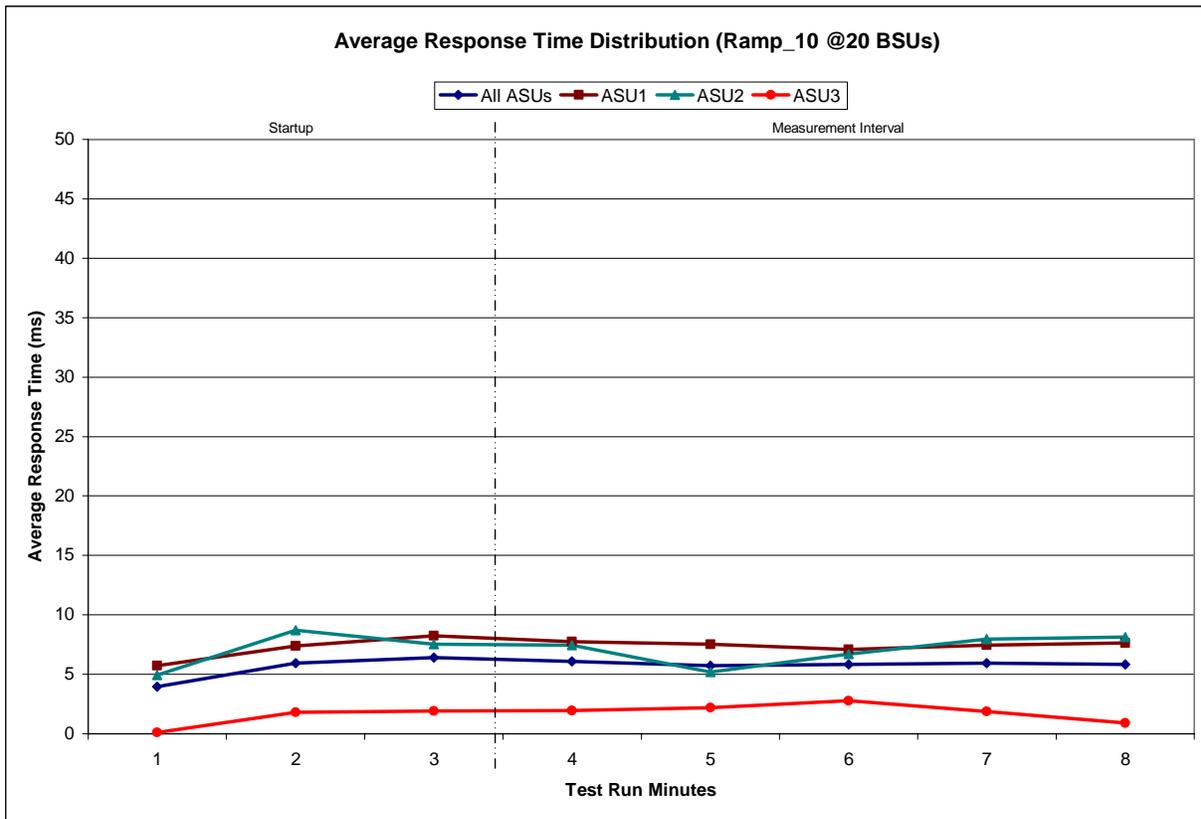
SPC-1C LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

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	0.0355	0.2812	0.0696	0.2088	0.0186	0.0697	0.0358	0.2807
COV	0.037	0.010	0.056	0.020	0.117	0.037	0.061	0.014

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 63.

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™
Primary Metrics	*1,001.58*
Repeatability Test Phase 1	1,002.35
Repeatability Test Phase 2	997.78

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 greater than 95% of the reported SPC-1C IOPS™ Primary Metric.

	SPC-1C LRT™
Primary Metrics	*5.88 ms*
Repeatability Test Phase 1	5.92 ms
Repeatability Test Phase 2	5.95 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

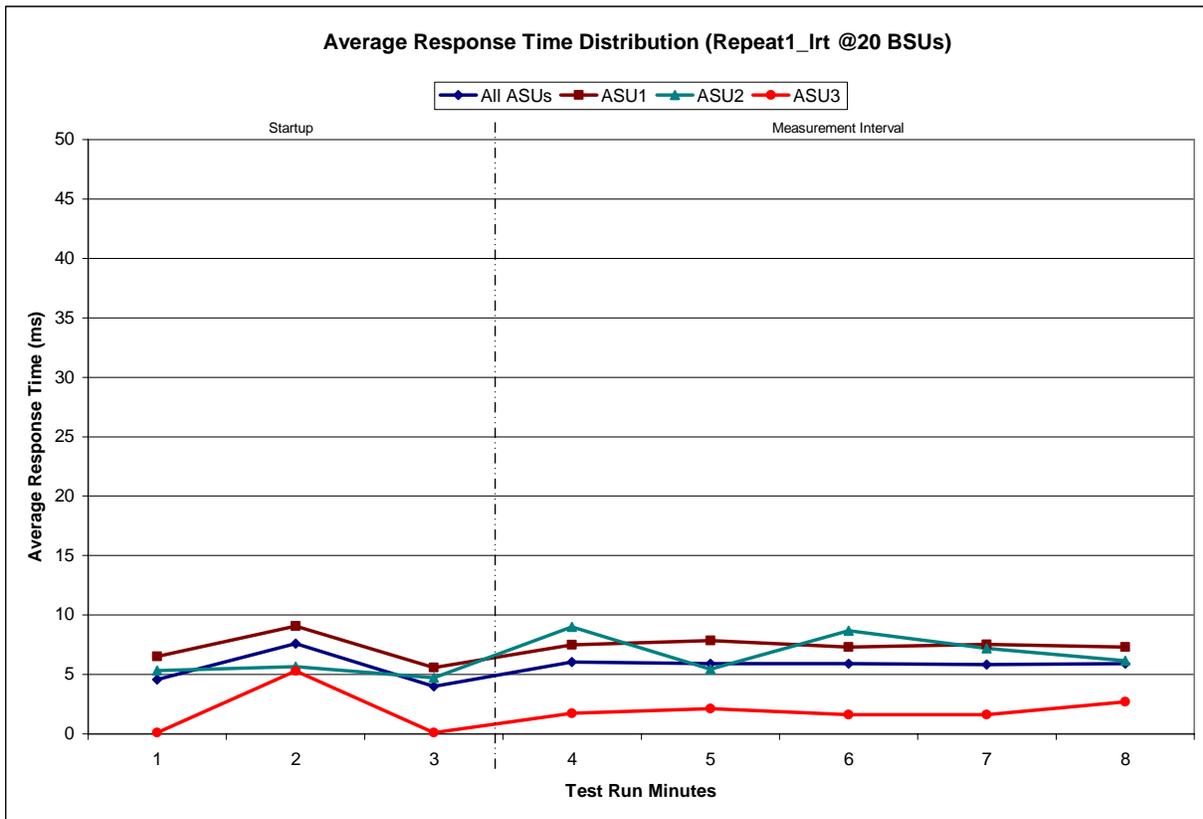| 20 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:27:58	15:30:58	0-2	0:03:00
Measurement Interval	15:30:58	15:35:58	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	100.95	60.42	12.18	28.35
1	98.73	58.55	11.75	28.43
2	99.73	60.83	11.87	27.03
3	98.85	59.25	11.85	27.75
4	100.15	59.12	12.60	28.43
5	99.78	59.78	12.23	27.77
6	100.82	60.33	12.13	28.35
7	98.80	59.02	12.37	27.42
Average	99.68	59.50	12.24	27.94

Repeatability 1 LRT – I/O Request Throughput Distribution Graph
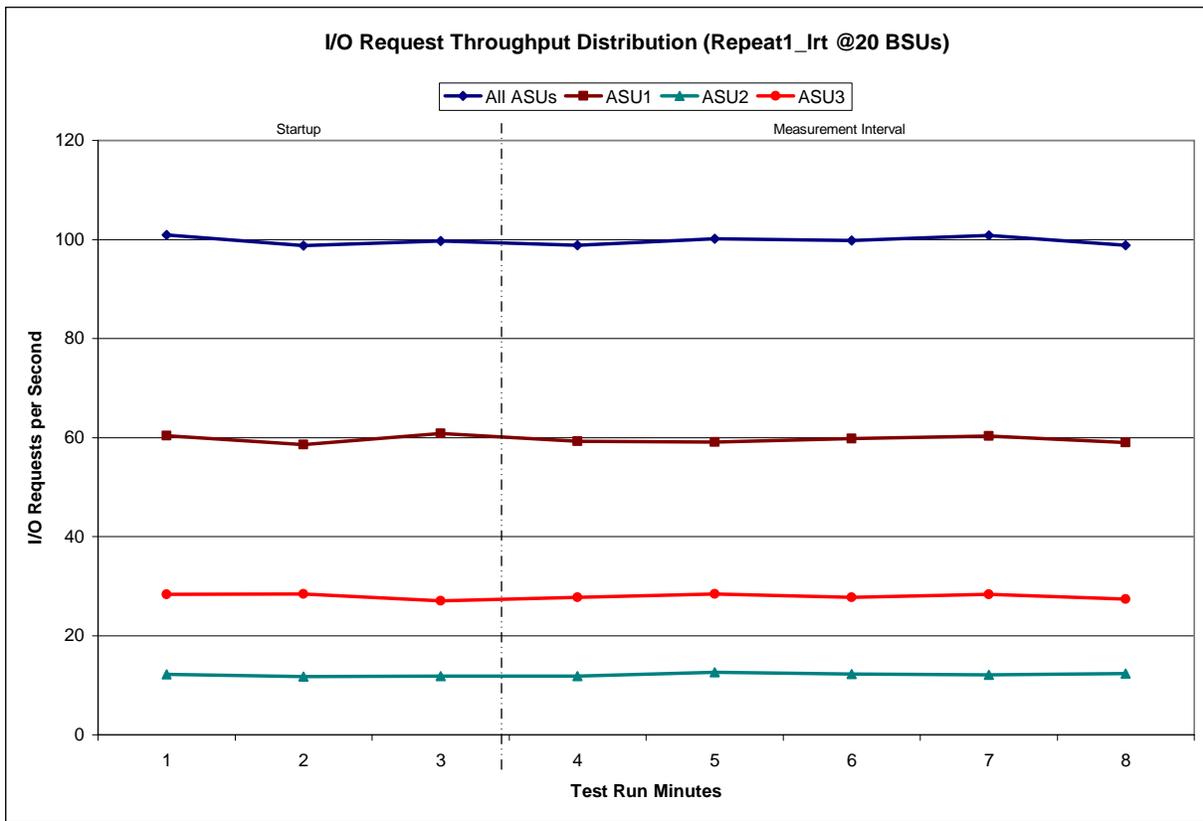
Repeatability 1 LRT –Average Response Time (ms) Distribution Data

20 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:27:58	15:30:58	0-2	0:03:00
Measurement Interval	15:30:58	15:35:58	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	4.57	6.50	5.32	0.12
1	7.59	9.09	5.63	5.30
2	4.00	5.58	4.73	0.12
3	6.06	7.49	8.98	1.73
4	5.91	7.83	5.45	2.13
5	5.89	7.32	8.66	1.61
6	5.84	7.54	7.20	1.62
7	5.90	7.32	6.14	2.71
Average	5.92	7.50	7.29	1.96

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

Repeatability 1 IOPS – I/O Request Throughput Distribution Data

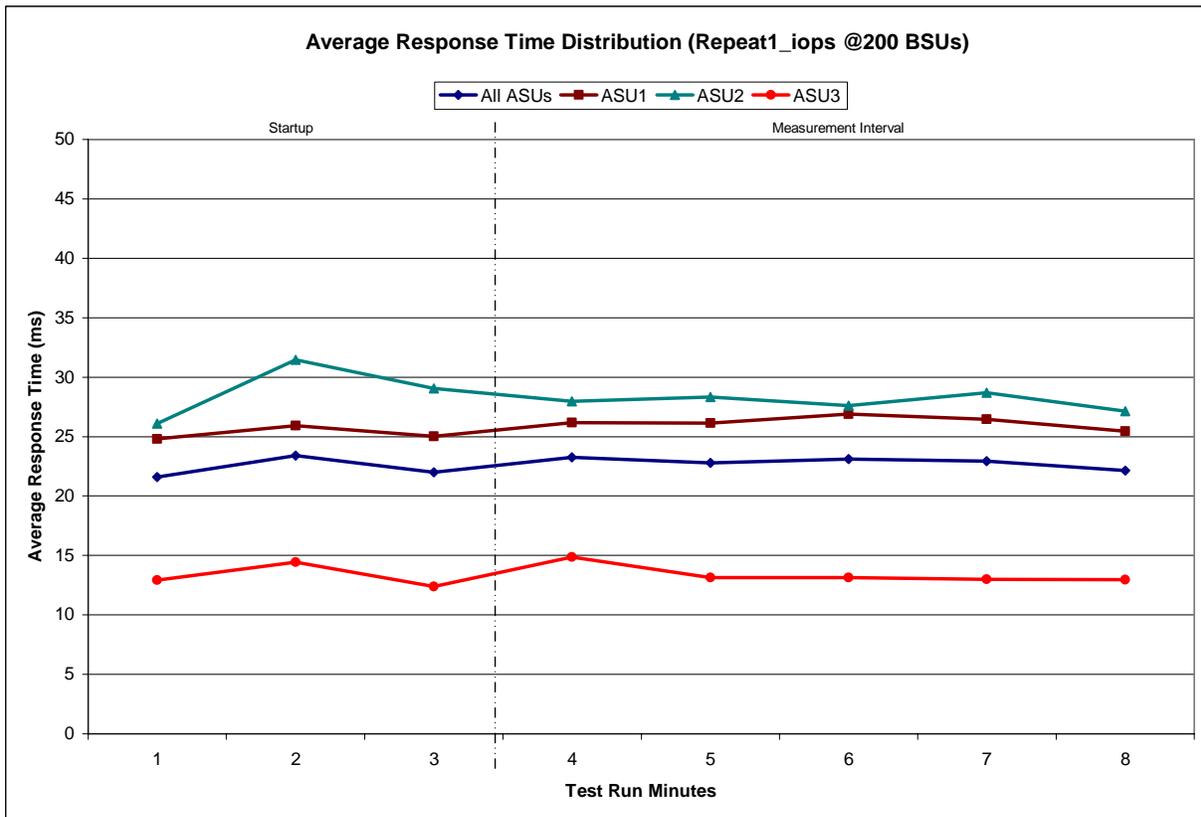| 200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:37:01	15:40:01	0-2	0:03:00
Measurement Interval	15:40:01	15:45:01	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	999.97	593.20	125.28	281.48
1	984.03	586.35	122.48	275.20
2	1,015.95	607.77	124.60	283.58
3	996.58	596.08	123.30	277.20
4	1,003.35	598.53	124.70	280.12
5	1,001.55	595.45	123.35	282.75
6	990.15	590.03	120.15	279.97
7	1,020.13	606.58	124.72	288.83
Average	1,002.35	597.34	123.24	281.77

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph
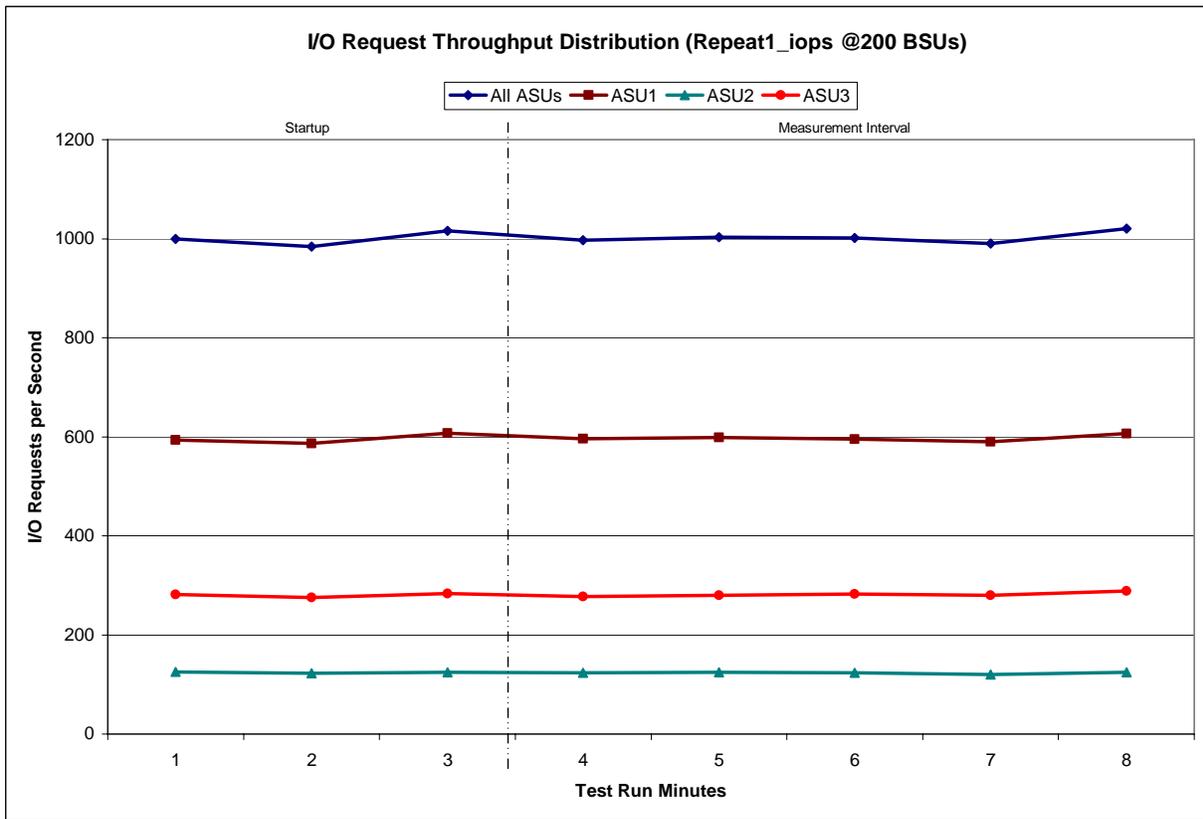
Repeatability 1 IOPS –Average Response Time (ms) Distribution Data

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:37:01	15:40:01	0-2	0:03:00
Measurement Interval	15:40:01	15:45:01	3-7	0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	21.61	24.79	26.11	12.91
1	23.39	25.91	31.46	14.42
2	22.00	25.03	29.05	12.40
3	23.25	26.17	27.98	14.87
4	22.78	26.13	28.33	13.15
5	23.10	26.89	27.61	13.15
6	22.94	26.47	28.71	13.01
7	22.13	25.47	27.12	12.95
Average	22.84	26.22	27.95	13.43

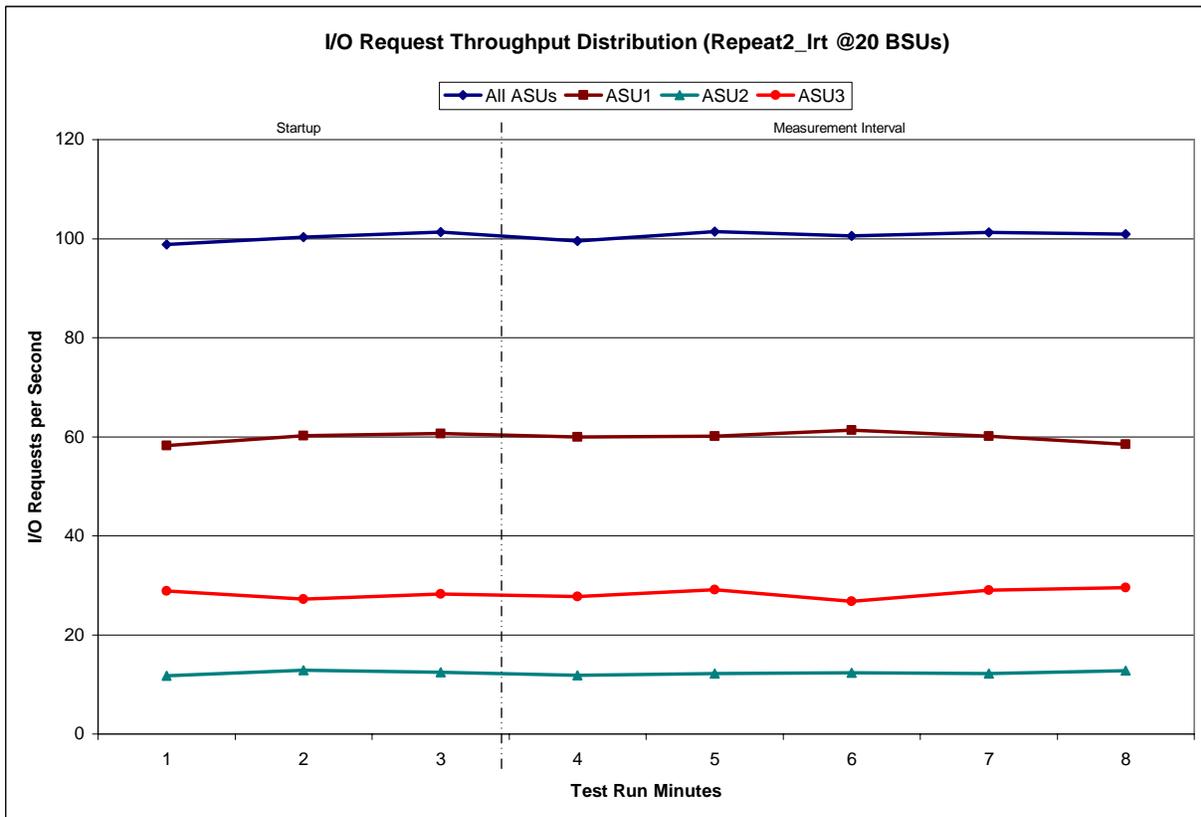## Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph

Repeatability 2 LRT – I/O Request Throughput Distribution Data

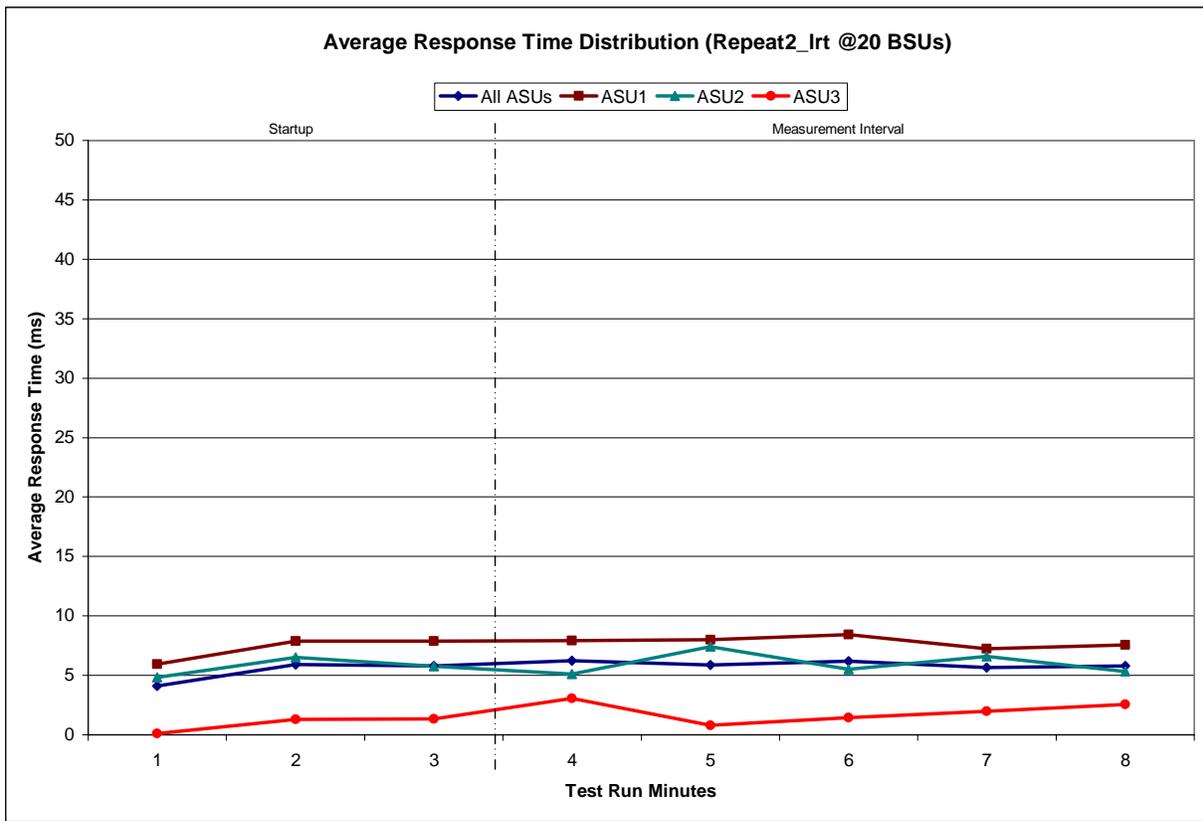| 20 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:46:05	15:49:05	0-2	0:03:00
Measurement Interval	15:49:05	15:54:05	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	98.87	58.27	11.75	28.85
1	100.30	60.23	12.87	27.20
2	101.37	60.63	12.47	28.27
3	99.52	59.95	11.83	27.73
4	101.38	60.10	12.20	29.08
5	100.55	61.35	12.38	26.82
6	101.28	60.10	12.17	29.02
7	100.87	58.50	12.80	29.57
Average	100.72	60.00	12.28	28.44

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

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

20 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:46:05	15:49:05	0-2	0:03:00
Measurement Interval	15:49:05	15:54:05	3-7	0:05:00

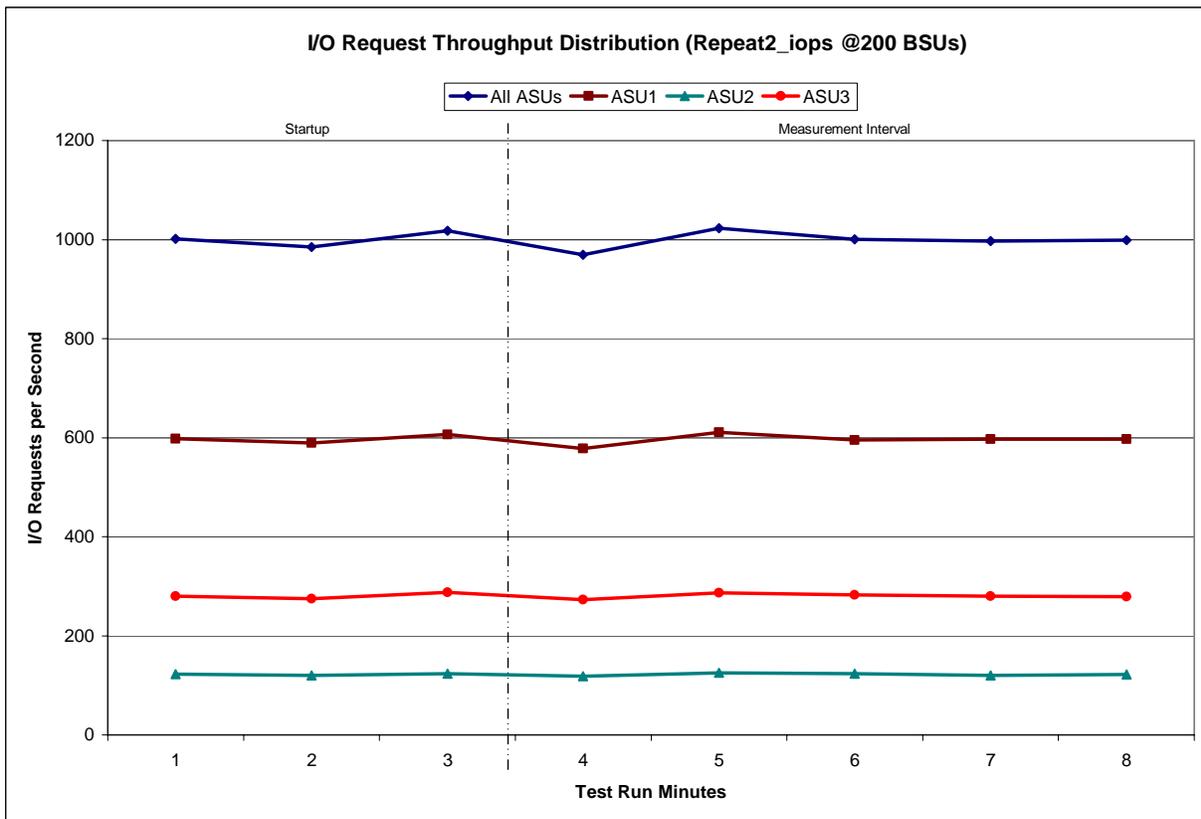| 60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4.10	5.93	4.83	0.12
1	5.92	7.88	6.51	1.29
2	5.80	7.90	5.74	1.32
3	6.23	7.93	5.12	3.04
4	5.86	8.00	7.42	0.80
5	6.21	8.44	5.51	1.42
6	5.65	7.24	6.60	1.97
7	5.81	7.57	5.31	2.55
Average	5.95	7.83	5.99	1.96

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

Repeatability 2 IOPS – I/O Request Throughput Distribution Data

| 200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:55:08	15:58:08	0-2	0:03:00
Measurement Interval	15:58:08	16:03:08	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,000.87	598.13	122.62	280.12
1	984.92	589.50	120.35	275.07
2	1,018.00	606.78	123.52	287.70
3	969.43	577.80	118.43	273.20
4	1,023.25	610.78	125.68	286.78
5	1,000.82	594.95	123.58	282.28
6	996.83	597.25	119.83	279.75
7	998.57	596.90	122.23	279.43
Average	997.78	595.54	121.95	280.29

Repeatability 2 IOPS – I/O Request Throughput Distribution Graph

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

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:55:08	15:58:08	0-2	0:03:00
Measurement Interval	15:58:08	16:03:08	3-7	0:05:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	21.80	25.08	26.53	12.73
1	22.93	25.68	30.22	13.85
2	21.89	24.85	27.72	13.14
3	23.65	26.74	30.81	14.03
4	21.45	24.06	26.11	13.86
5	23.13	26.14	30.29	13.67
6	22.02	25.24	27.50	12.79
7	23.28	26.72	29.96	13.01
Average	22.71	25.78	28.94	13.47

Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph
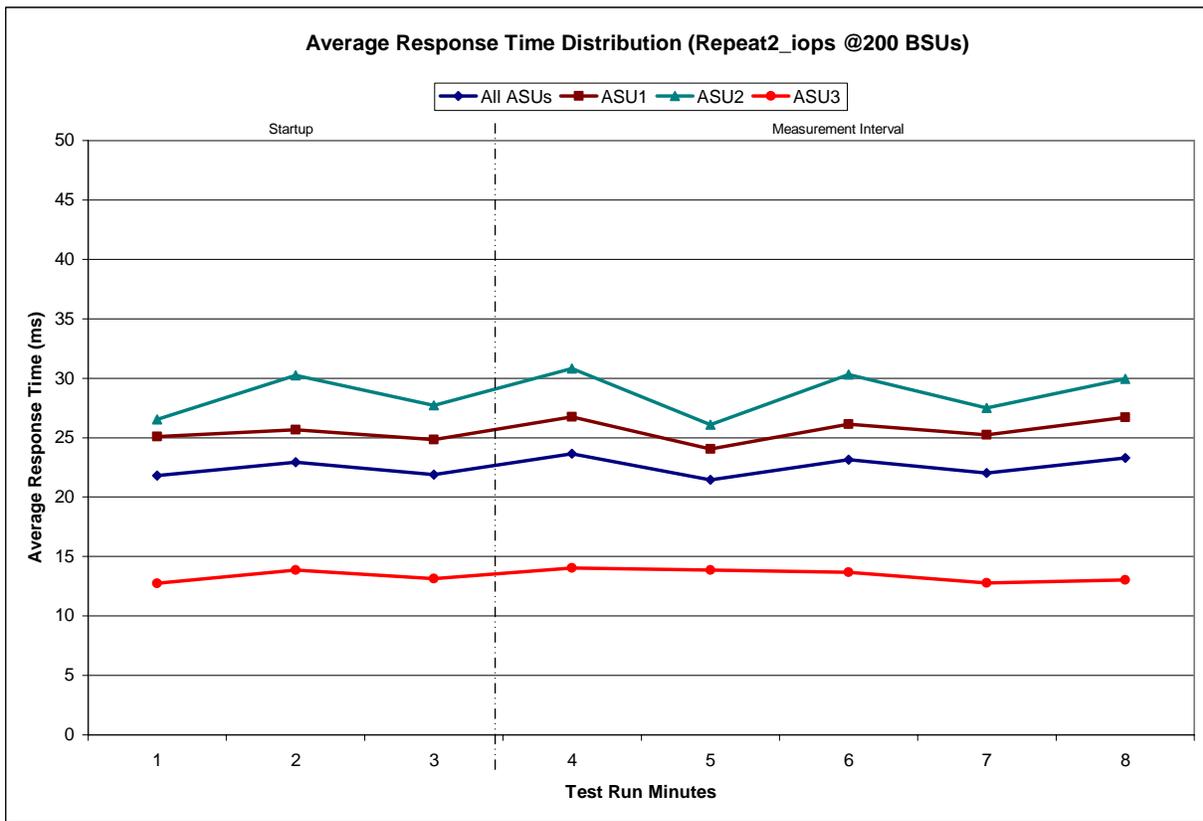
Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

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	0.0341	0.2814	0.0706	0.2108	0.0177	0.0698	0.0352	0.2803
COV	0.093	0.020	0.037	0.020	0.099	0.022	0.074	0.009

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	0.0351	0.2815	0.0701	0.2092	0.0179	0.0706	0.0345	0.2811
COV	0.019	0.005	0.025	0.006	0.024	0.020	0.012	0.008

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	0.0339	0.2780	0.0719	0.2119	0.0177	0.0683	0.0359	0.2824
COV	0.073	0.016	0.062	0.026	0.080	0.029	0.085	0.036

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
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2819	0.0704	0.2096	0.0177	0.0693	0.0352	0.2809
COV	0.022	0.006	0.024	0.007	0.017	0.016	0.009	0.003

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 63.

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	2,890,000
Total Number of Logical Blocks Verified	2,874,960
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 Constellation™ ST9500430SS as documented in this Full Disclosure Report will become available on March 30, 2009 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 Constellation™ ST9500430SS.

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 gigibyte (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
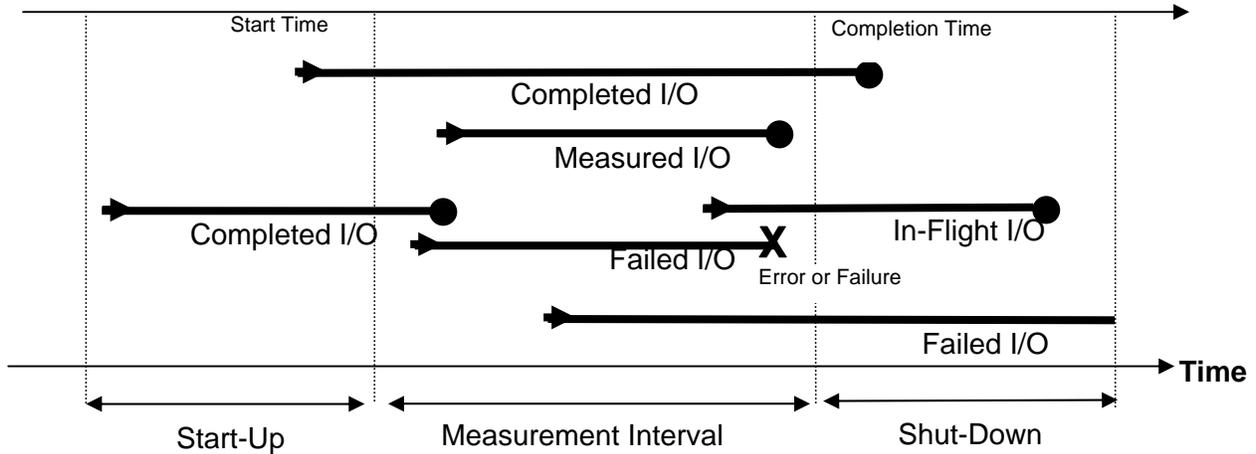
SPC-1C Test Run Components
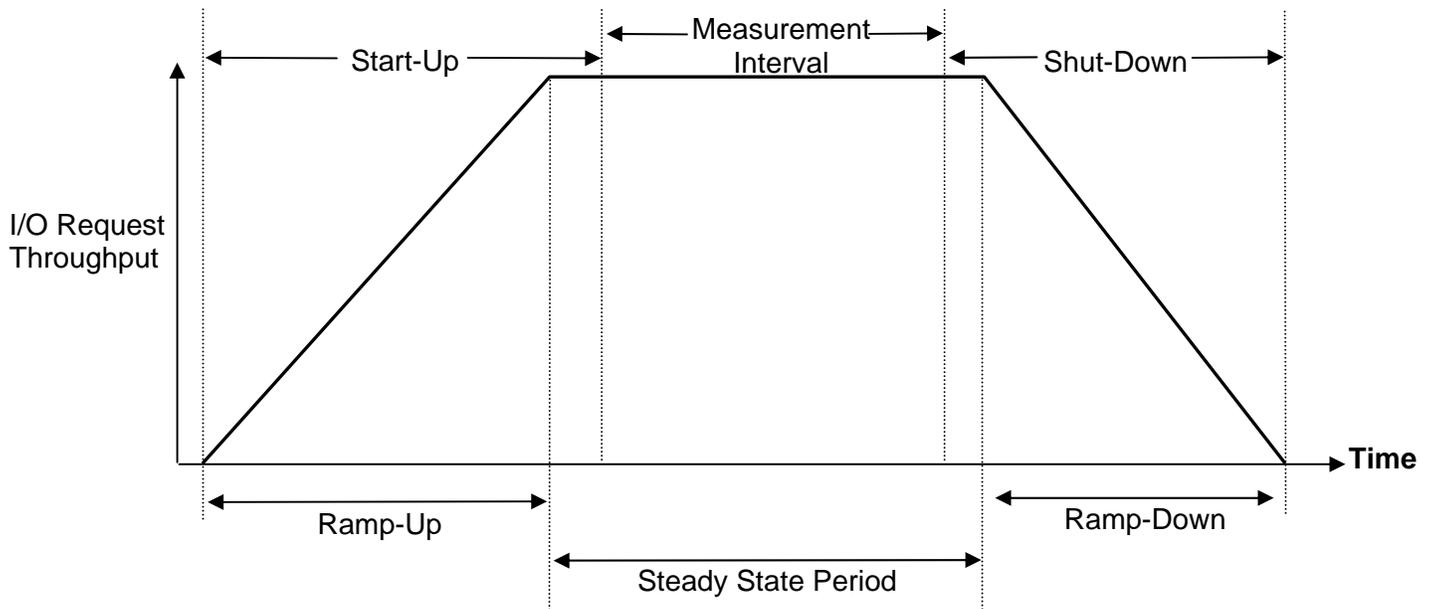
APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

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 MegaCLI script was executed to disable Volume Initialization and disable the Write Cache on each of the twelve disk drives.

Tuneparm.cmd

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

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Create RAID-5 Volumes

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 MegaCLI script was used to:

- **Clear any existing RAID volumes**
- **Define three arrays, each with four physical disks**
- **Create a single, striped RAID-5 volume using the above three arrays**

MakeRAID.cmd

Configure ASU-1, ASU-2, and ASU-3 from the RAID-5 Volume

Three SPC-1 Logical Volumes were created from the single, striped RAID-5 volume using the Windows **diskpart** utility as documented below. The three volumes were assigned the SPC-1 ASUs as follows: Drive x – ASU-1, Drive y – ASU-2, and Drive z – ASU-3.

```
diskpart /s diskmk.txt
```

diskmk.txt

```
REM ******Clear All ****************************
MegaCLI -cfgclr -aALL
REM
REM Phys HDD List : 0,1,2,3 etc
REM Spares : NO
REM Encryption : NO
REM RAID Level : 50
REM Stripe Size : 64 KB
REM Array set  Name :A0-A2
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 : disable
REM Initialization : Quick Init
REM ********************************************************
set adptr=0
set A0=-Array0[17:0, 17:1, 17:2, 17:3]
set A1=-Array1[17:4, 17:5, 17:6, 17:7]
set A2=-Array2[17:8, 17:9, 17:10, 17:11]
set Arraylist=%A0% %A1% %A2%
set level=50
set stripe=64
set ReadCache=NORD
set WriteCache=WB
Set BBU=CachedBadBBU
set IOpolicy=Direct
set access=RW
```

```
set BI=-Dsbl
@echo on
REM ************* Create RAID 50  ***************************
MegaCli -CfgSpanAdd -R%level% %ArrayList% %WriteCache% %ReadCache% %IOpolicy% %BBU%
-strpsz%stripe% -a%adptr%
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.

metrics.txt

```
sd=asu1_1,lun=\\.\x:,size=1012.718g
sd=asu2_1,lun=\\.\y:,size=1012.718g
sd=asu3_1,lun=\\.\z:,size=225.048g

* Sustainability Test Run
*
*  Required parameter values for audit:

rd=sustain,bsus=200,startup=180,elapsed=3660,interval=60

*95%, 90%, 80%, 50%, and 10% Test Runs

*  Required parameter values for audit:
*  startup=identical to Sustainability Test Run
*  elapsed=360 (6 minutes)

rd=ramp_100,bsus=200,startup=180,elapsed=360,interval=60
rd=ramp_95,bsus=190,startup=180,elapsed=360,interval=60
rd=ramp_90,bsus=180,startup=180,elapsed=360,interval=60
rd=ramp_80,bsus=160,startup=180,elapsed=360,interval=60
rd=ramp_50,bsus=100,startup=180,elapsed=360,interval=60
rd=ramp_10,bsus=20,startup=180,elapsed=360,interval=60
```

repeat1.txt

```
sd=asu1_1,lun=\\.\x:,size=1012.718g
sd=asu2_1,lun=\\.\y:,size=1012.718g
sd=asu3_1,lun=\\.\z:,size=225.048g

* Repeatability Test Phase 1

* Repeatability Test Run 1 (LRT)

*  Required parameter values for audit:
*  bsus=(10% of the value used in the Sustainability Test Run)

rd=repeat1_lrt,bsus=20,startup=180,elapsed=360,interval=60

* Repeatability Test Run 2 (IOPS)

*  Required parameter values for audit:
*  bsus=(100% of the value used in the Sustainability Test Run)

rd=repeat1_iops,bsus=200,startup=180,elapsed=360,interval=60
```

repeat2.txt

```
sd=asu1_1,lun=\\.\x:,size=1012.718g
sd=asu2_1,lun=\\.\y:,size=1012.718g
sd=asu3_1,lun=\\.\z:,size=225.048g

* Repeatability Test Phase 2
* Repeatability Test Run 1 (LRT)

*  Required parameter values for audit:

rd=repeat2_lrt,bsus=20,startup=180,elapsed=360,interval=60

* Repeatability Test Run 2 (IOPS)
*  Required parameter values for audit:

rd=repeat2_iops,bsus=200,startup=180,elapsed=360,interval=60
```

persist1.txt

```
sd=asu1_1,lun=\\.\x:,size=1012.718g
sd=asu2_1,lun=\\.\y:,size=1012.718g
sd=asu3_1,lun=\\.\z:,size=225.048g

* Persistence Test Run 1 (write phase)

*  Required parameter values for audit:
*   bsus=(25% minimum of the value used in the Sustainability Test Run)

rd=pers_1,bsus=55,elapsed=600,interval=60
```

persist2.txt

```
sd=asu1_1,lun=\\.\x:,size=1012.718g
sd=asu2_1,lun=\\.\y:,size=1012.718g
sd=asu3_1,lun=\\.\z:,size=225.048g

* Persistence Test Run 1 (write phase)

*  Required parameter values for audit:
*   no parameters required

rd=pers_2
```

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 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.**

```
rem SPC-1C FULL RUN
rem
set java="C:\Java\jre6\bin\java"
set class=c:\spc-1c_a

%Java% spc1 -fmetrics.txt -ometrics SPCOut -br 5
%Java% spc1 -frepeat1.txt -orepeatability1 SPCOut -br 5
%Java% spc1 -frepeat2.txt -orepeatability2 SPCOut -br 5
%Java% spc1 -fpersist1.txt -opersistence1 SPCOut -br 5
@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% spc1 -fpersist2.txt -opersistence2 SPCOut -br 5
```

APPENDIX F: THIRD-PARTY QUOTES

Dell PowerVault MD 1120

The Dell Online Store: Build Your System   Page 1 of 2

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Print Summary

PowerVault MD1120
Starting Price   **$5,707**

My Selections   All Options

- PowerVault MD1120

| Date | 1/8/2009 7:02:16 PM 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: PERC 6/E SAS external RAID adapter, 512MB Cache, for MD1120	P6E512	1	[341-6489]	24
Cables: 2 SAS cables, 1 meter, connects MD1120 to PERC or another MD1120	2SAS1M	1	[310-7082][310-7082]	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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