SPC Benchmark 1C™
Full Disclosure Report

Seagate Technology LLC
Seagate Pulsar®.2/ST400FM0002

SPC-1C™ V1.3

Submitted for Review: November 8, 2011
Submission Identifier: C00014

First Edition – November 2011

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Seagate Technology LLC   Submitted for Review: NOVEMBER 8, 2011
Seagate Pulsar®.2/ST400FM0002

AUDIT CERTIFICATION

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

November 7, 2011

The SPC Benchmark 1C™ results listed below for the Seagate Pulsar®.2/ST400FM0002 were produced in compliance with the SPC Benchmark 1C™ V1.3 Audit requirements.

SPC Benchmark 1C™ V1.3 Reported Data	
Tested Storage Product (TSP): Seagate Pulsar®.2/ST400FM0002	
Metric	**Reported Result**
SPC-1C IOPS™	14,008.36
Total ASU Capacity	399.931 GB
Data Protection Level	Unprotected
Total Price – Priced Storage Configuration	$2,945.91

The following SPC Benchmark 1C™ Audit requirements were reviewed and found compliant with V1.3 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.

- The entire Configured Storage Capacity was filled with random data using Vdbench 5.03 Beta prior to the execution of the SPC-1C Tests.

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).

- Physical verification of the components to match the above diagram.

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

AUDIT CERTIFICATION *(CONT.)*
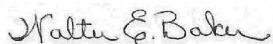
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.

- 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 execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1C Benchmark Specification.

- 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

- The Measurement Interval duration of the Sustainability Test Phase was eight (8) hours.

- 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: *Oct.6th 2011*

From: Daniel Kuhl

To: *Walter Baker*

Subject: SPC-1C Letter of Good Faith for Seagate's Pulsar®.2 ST400FM0002

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 *V1.4* 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: Date:

18/6/2011

Daniel Kuhl
Vice President, Enterprise SSD Development

Seagate Techology
1280 Disc Drive
Shakopee, MN 55379

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
Test Sponsor Alternate Contact	Seagate Technology LLC – http://www.seagate.com Teresa Maria Worth – teresa.m.worth@seagate.com 1280 Disc Drive Shakopee, MN 55379 Phone: (952) 402-3704
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	V1.3
SPC-1C Workload Generator revision number	V1.0
Date Results were first used publicly	November 8, 2011
Date the FDR was submitted to the SPC	November 8, 2011
Date the TSC is available for shipment to customers	currently available
Date the TSC completed audit certification	TBD

Tested Storage Product (TSP) Description

Pulsar.2 is an enterprise class, MLC-enabled, up to 800GB SSD from Seagate that delivers the price/performance, data integrity, and endurance benefits needed by complex, IOPS hungry enterprise environments. Unlike client MLC SSDs designed for simple, read-intensive workloads and low usage (e.g. 8-10 hours a day, 5 days a week, single user), Pulsar.2 was designed from the ground up for enterprises with complex, write-intensive workloads and high usage (e.g. 24 hours a day, 7 days a week, multiple users) and delivers 10 full drive writes per day - every day for the 5 year warranty life of the product.

 Pulsar.2 uses the same, proven enterprise development platform and feature set used by all Seagate mission critical enterprise hard drives, just optimized for solid state technology. This reduces qualification costs for OEMs and systems integrators while simplifying storage management for datacenters.

Summary of Results

SPC-1C Reported Data	
Tested Storage Product: Seagate Pulsar®.2/ST400FM0002	
Metric	**Reported Result**
SPC-1C IOPS™	14,008.36
Total ASU Capacity	399.931 GB
Data Protection Level	Unprotected
Total Price – Priced Storage Configuration	$2,945.91

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* provides no 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.

The TSC meets the "no Unused Storage" requirement as documented below:

> **400.088 GB** *(Physical Storage Capacity)*
>
> **399.931 GB** *(Total ASU Capacity)* **+ 0.157** *(Global Storage Overhead)* **= 400.088 GB**

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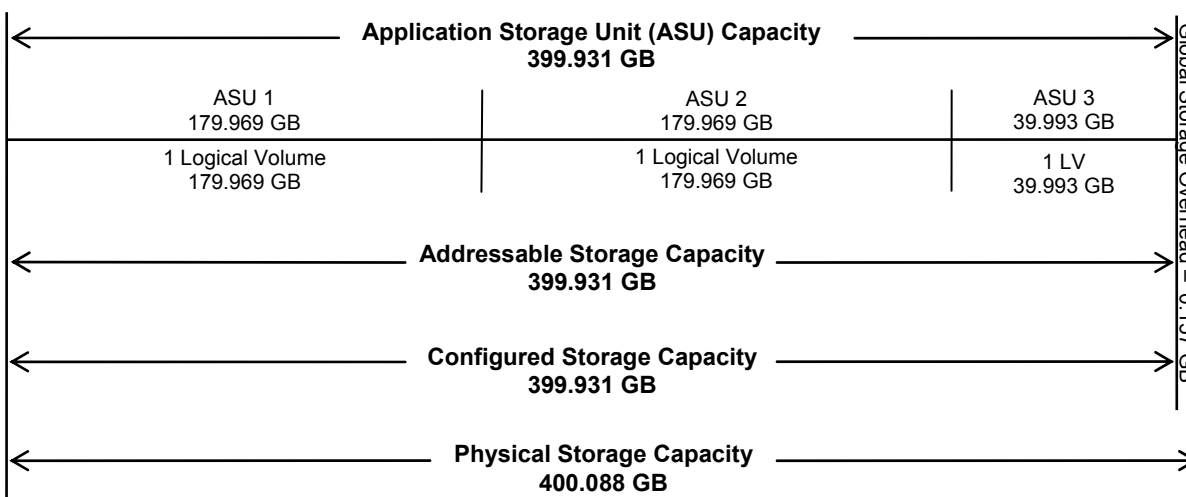
Response Time – Throughput Curve

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.
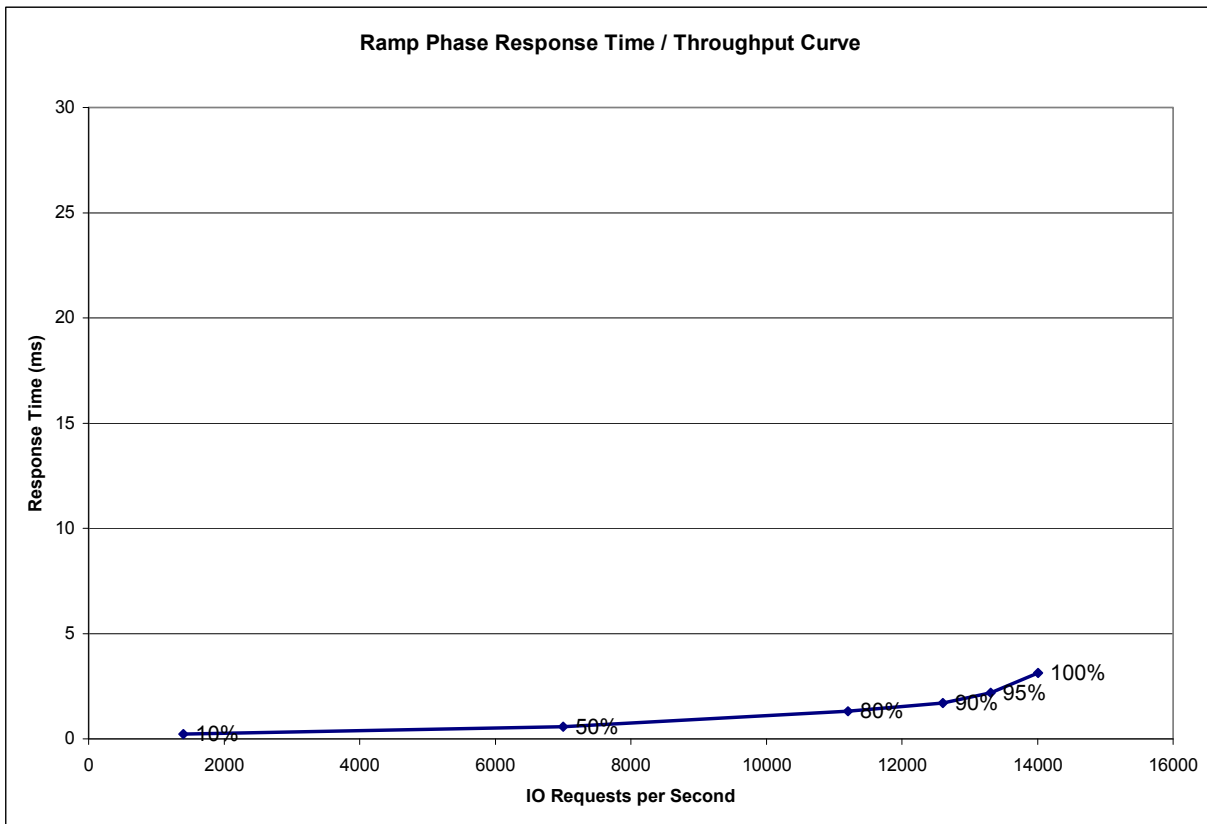
Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	1,400.29	7,004.73	11,202.17	12,605.11	13,307.20	14,008.36
Average Response Time (ms):						
All ASUs	0.22	0.57	1.31	1.69	2.19	3.13
ASU-1	0.24	0.66	1.46	1.88	2.41	3.38
ASU-2	0.25	0.67	1.47	1.88	2.41	3.38
ASU-3	0.17	0.35	0.92	1.20	1.63	2.50
Reads	0.33	0.95	1.95	2.47	3.08	4.15
Writes	0.15	0.32	0.89	1.18	1.61	2.47

Priced Storage Configuration Pricing

Description	Part Numbers	Qty	Price		Extended Price
400GB SAS 2.5" SSD MLC	ST400FM0002	1	$2,540.00		$2,540.00
6Gb SAS Controller *(third party)*	LSI00188	1	$338.99		$338.99
SAS 2.0 1M Cable *(third party)*	MiniSAS	1	$59.99		$59.99
SAS Adaptor *(third party)*	SKU 27652	1	$6.93		$6.93
included 5 year warranty			**Total**		**$2,945.91**

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

**Seagate Pulsar®.2
/ ST400FM0002**
(400 GB)

X4 SAS 2.0 Cable

**LSI SAS 9200-8e
6Gb SAS Controller**

"Generic" Windows 2008 Server
*ASUS P6T6 WS Revolution motherboard
1 – Intel® Xeon® Processor X5570
Windows Server 2008 R2*

Benchmark Configuration/Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):

"Generic" Windows 2008 Server
    ASUS P6T6 WS Revolution motherboard
    1 – Intel® Xeon® Processor X5570
        4 Cores, 2.93 GHz,
        8 MB Intel® Smart Cache
	1 – LSI SAS 9200-8e 6Gb SAS Controller

	1 – Seagate Pulsar®.2 / ST400FM0002 400 GB SSD
	1 – PCIe 2.0 x8 front-end connection
6 GB main memory	2 – 6Gb SAS backend connections *(1 used)*
Windows Server 2008 R2	1 – X4 SAS 2.0 cable
PCIe 2.0	

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 55 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 (TS)C. 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 56 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 57.

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 51 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) will be included in the FDR.

SPC-1C Storage Capacities

SPC-1C Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	399.931
Addressable Storage Capacity	Gigabytes (GB)	399.931
Configured Storage Capacity	Gigabytes (GB)	399.931
Physical Storage Capacity	Gigabytes (GB)	400.088
Data Protection *(Unprotected)*	Gigabytes (GB)	0.000
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	0.157
Total Unused Storage	Gigabytes (GB)	0.000

SPC-1C Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	100.00%	99.96%
Required for Data Protection *(Unprotected)*		0.00%	0.00%
Addressable Storage Capacity		100.00%	99.96%
Required Storage		0.00%	0.00%
Configured Storage Capacity			99.96%
Global Storage Overhead			0.04%
Unused Storage:			
Addressable	0.00%		
Configured		0.00%	
Physical			0.00%

The Physical Storage Capacity consisted of 400.088 GB distributed over one (1) SLC-based solid state device (SSD). There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.157 GB (0.04%) of Physical Storage Capacity. There was 0.00 GB (0.00%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) 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).
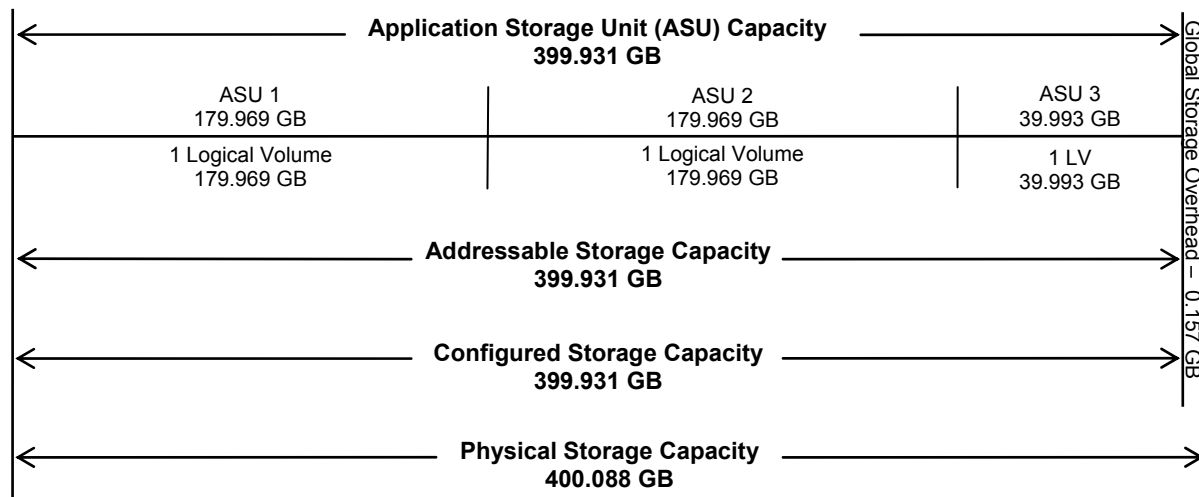
Logical Volume Capacity and ASU Mapping

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 (179.969 GB)	**ASU-2 (179.969 GB)**	**ASU-3 (39.993 GB)**
1 Logical Volume 179.969 GB per Logical Volume (179.969 GB used per Logical Volume)	1 Logical Volume 179.969 GB per Logical Volume (179.969 GB used per Logical Volume)	1 Logical Volume 39.993 GB per Logical Volume (39.993 GB used per Logical Volume)

There was no data protection used for the Logical Volumes 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 52 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

The FDR shall contain the following for the single Test Run in the Sustainability/IOPS Test Phase:

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 58.

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)*

Sustainability – Data Rate Distribution Graph
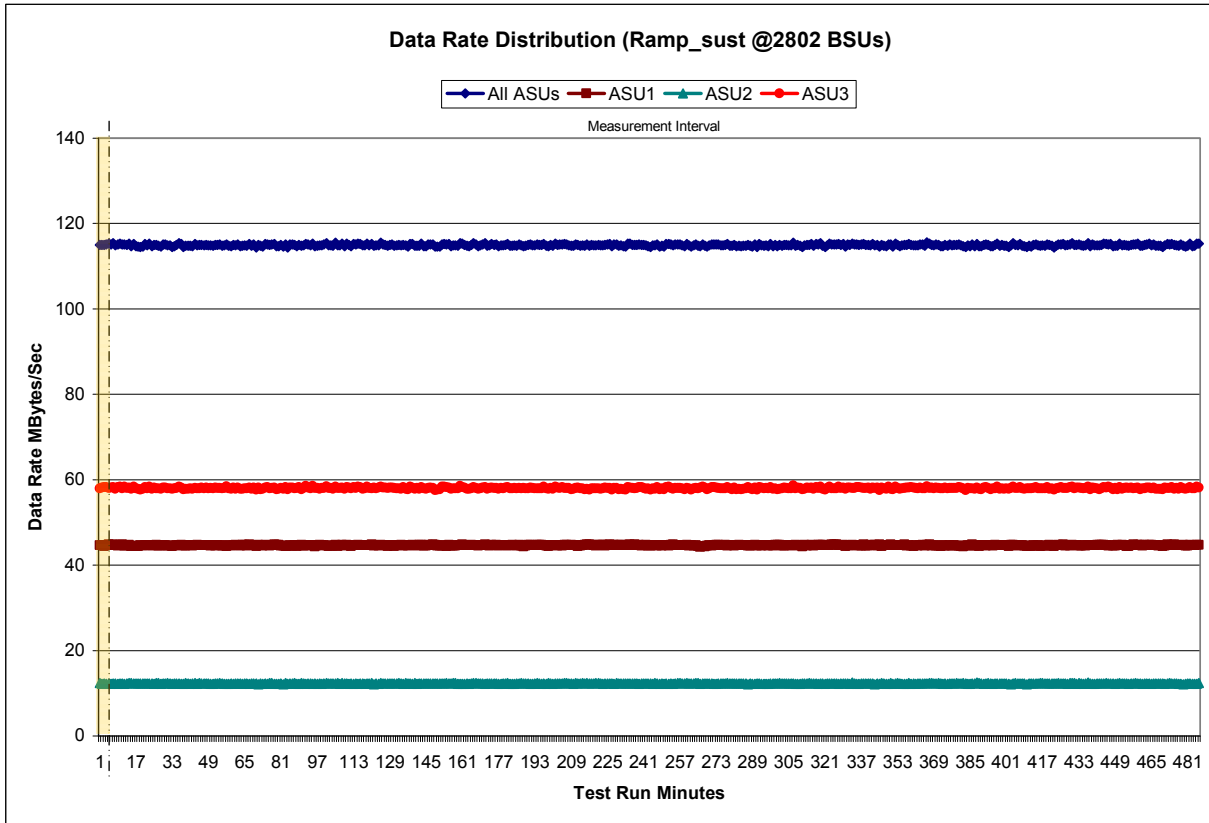
Sustainability – I/O Request Throughput Distribution Data

Sustainability – I/O Request Throughput Distribution Graph
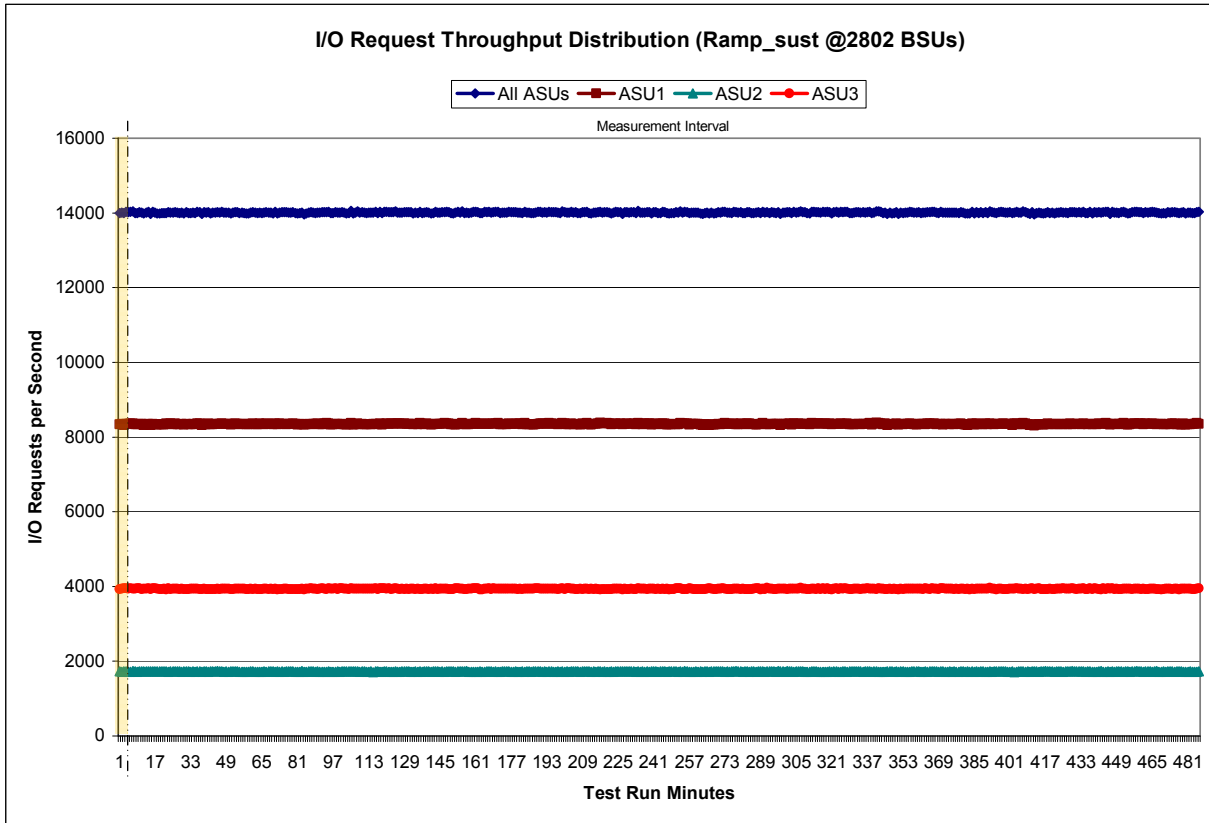
Sustainability – Average Response Time (ms) Distribution Data

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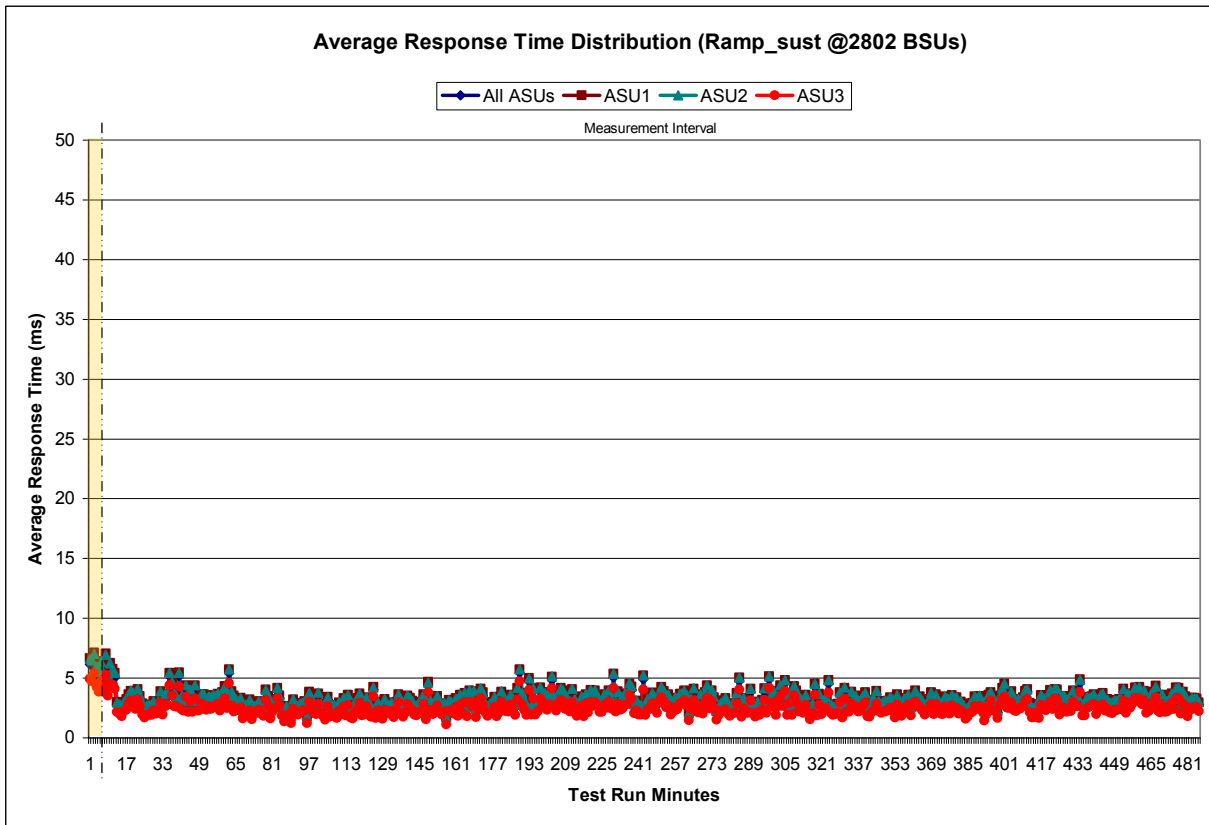
Sustainability – Response Time Frequency Distribution Data

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	2,259,528	48,543,553	18,251,514	5,740,531	3,233,560	3,792,637	4,878,035	4,321,665
Write	54,564,730	85,624,647	32,805,366	8,606,304	5,113,725	4,564,438	3,935,191	2,952,701
All ASUs	56,824,258	134,168,200	51,056,880	14,346,835	8,347,285	8,357,075	8,813,226	7,274,366
ASU1	28,607,184	77,710,939	28,234,823	8,224,084	4,844,405	5,186,922	5,837,152	4,920,381
ASU2	6,517,036	15,388,029	6,004,142	1,804,100	1,025,892	1,033,757	1,140,281	966,044
ASU3	21,700,038	41,069,232	16,817,915	4,318,651	2,476,988	2,136,396	1,835,793	1,387,941

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	7,077,574	8,585,201	5,587,375	5,188,699	3,475,976	3,575,185	5,715,436	4,529,999
Write	5,209,292	3,974,348	3,171,955	2,494,719	2,286,215	1,904,476	3,390,305	2,792,015
All ASUs	12,286,866	12,559,549	8,759,330	7,683,418	5,762,191	5,479,661	9,105,741	7,322,014
ASU1	8,211,838	8,893,324	6,015,409	5,395,104	3,902,483	3,815,412	6,235,788	4,979,069
ASU2	1,615,415	1,799,626	1,247,224	1,117,454	788,184	772,629	1,283,875	1,037,751
ASU3	2,459,613	1,866,599	1,496,697	1,170,860	1,071,524	891,620	1,586,078	1,305,194

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	3,528,662	2,769,798	2,241,423	6,754,136	3,109,334	1,716,598	1,115,428	3,463,616
Write	2,326,552	1,944,428	1,632,793	5,148,496	2,905,305	1,822,607	1,660,791	4,027,250
All ASUs	5,855,214	4,714,226	3,874,216	11,902,632	6,014,639	3,539,205	2,776,219	7,490,866
ASU1	3,942,130	3,148,687	2,574,674	7,871,288	3,863,477	2,228,695	1,661,046	4,660,154
ASU2	825,553	655,240	534,743	1,625,723	799,085	460,237	346,346	955,785
ASU3	1,087,531	910,299	764,799	2,405,621	1,352,077	850,273	768,827	1,874,927

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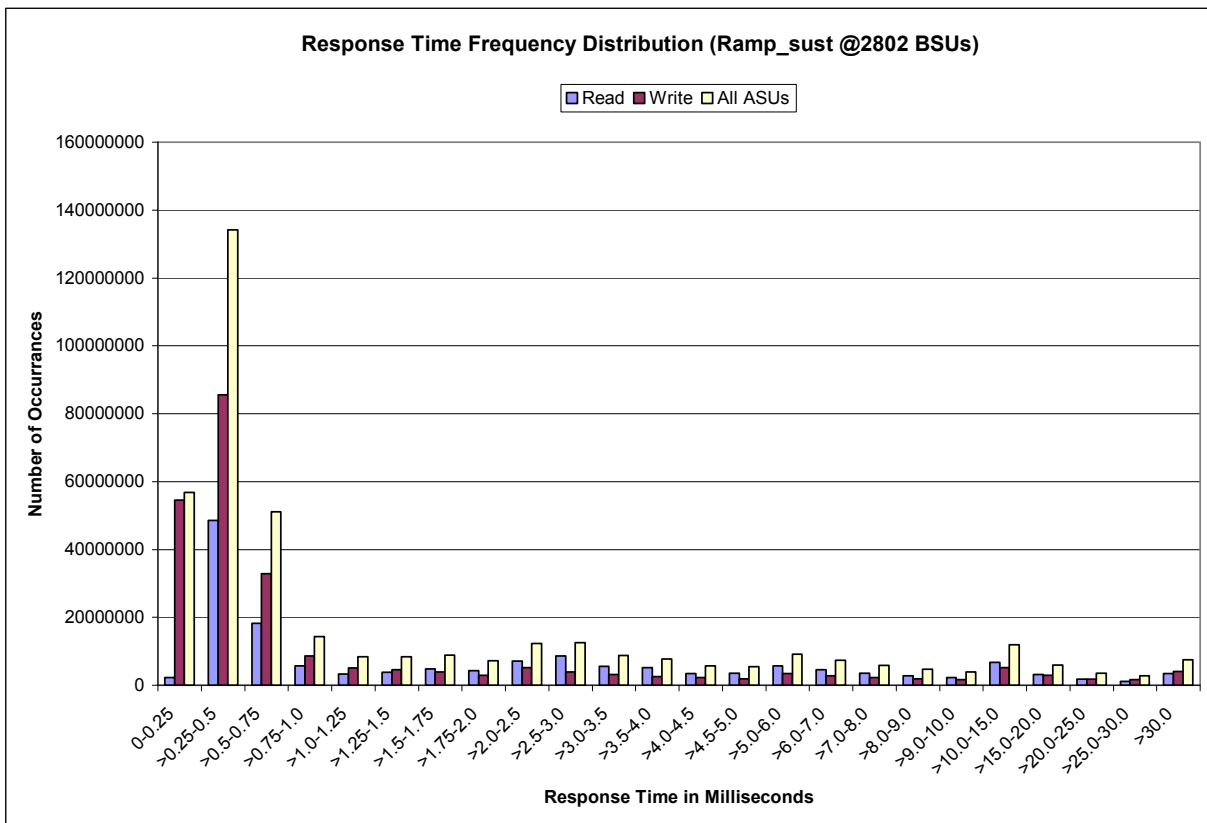
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

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	0.005	0.002	0.004	0.002	0.008	0.004	0.006	0.002

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 58.

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

2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:33:38	0:39:39	0-5	0:06:01
Measurement Interval	0:39:39	0:49:39	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	14,028.15	8,376.20	1,721.43	3,930.52
1	14,035.33	8,362.72	1,729.07	3,943.55
2	14,013.08	8,348.20	1,720.15	3,944.73
3	13,994.32	8,344.97	1,721.92	3,927.43
4	14,030.07	8,353.07	1,729.85	3,947.15
5	14,013.98	8,338.50	1,723.93	3,951.55
6	13,993.45	8,340.37	1,714.68	3,938.40
7	14,021.28	8,359.73	1,723.48	3,938.07
8	13,970.87	8,327.38	1,716.40	3,927.08
9	14,014.67	8,348.52	1,727.82	3,938.33
10	14,021.68	8,345.33	1,724.52	3,951.83
11	14,040.80	8,372.83	1,721.90	3,946.07
12	14,010.30	8,353.73	1,726.02	3,930.55
13	14,011.65	8,339.80	1,730.80	3,941.05
14	14,004.45	8,358.42	1,717.40	3,928.63
15	13,994.40	8,346.08	1,721.85	3,926.47
Average	*14,008.36*	*8,349.22*	*1,722.49*	*3,936.65*

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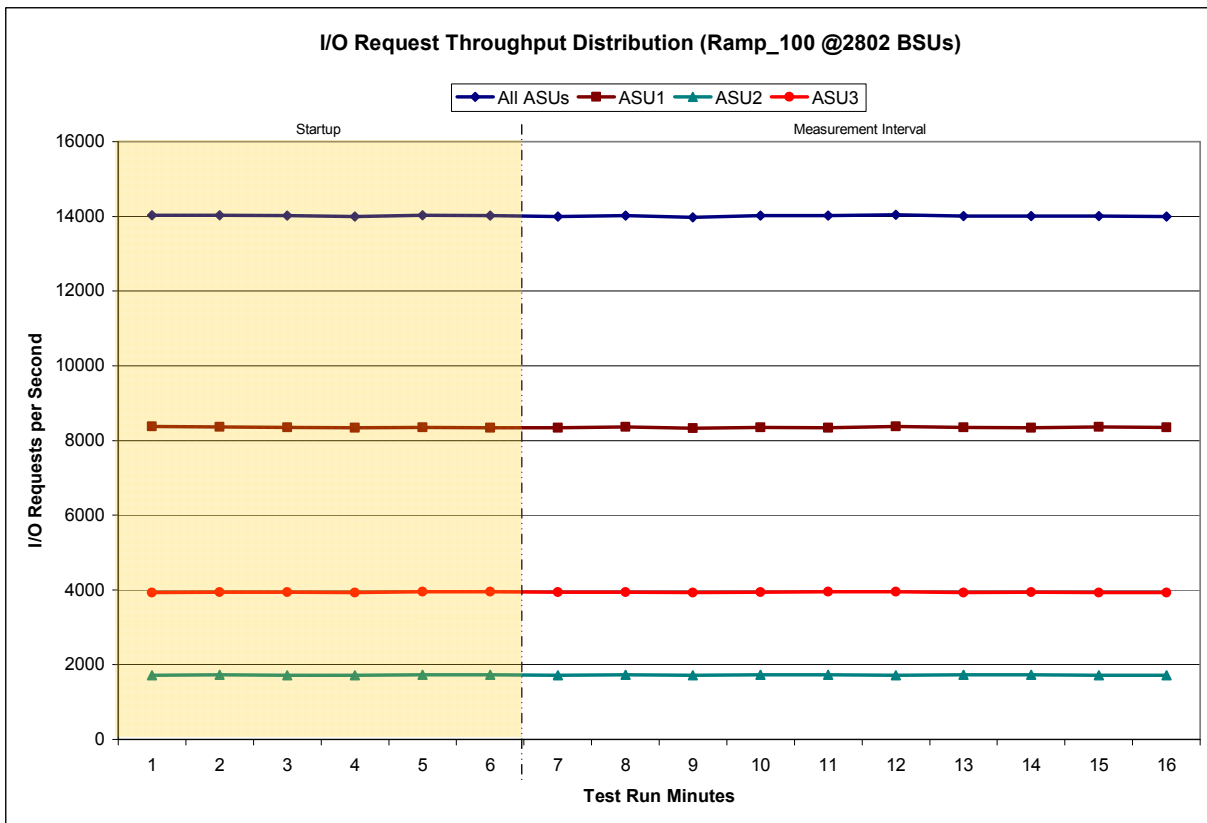
IOPS Test Run – Average Response Time (ms) Distribution Data

2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:33:38	0:39:39	0-5	0:06:01
Measurement Interval	0:39:39	0:49:39	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	4.36	4.62	4.65	3.70
1	3.05	3.33	3.32	2.33
2	2.94	3.15	3.17	2.39
3	4.39	4.67	4.62	3.68
4	3.03	3.26	3.23	2.44
5	3.85	4.13	4.12	3.13
6	3.77	4.01	4.00	3.15
7	3.31	3.57	3.55	2.68
8	2.74	2.96	2.97	2.18
9	4.02	4.32	4.27	3.29
10	4.04	4.32	4.35	3.32
11	2.45	2.69	2.69	1.84
12	2.99	3.23	3.20	2.39
13	2.26	2.46	2.43	1.76
14	3.39	3.70	3.72	2.59
15	2.37	2.61	2.60	1.75
Average	*3.13*	*3.38*	*3.38*	*2.50*

IOPS Test Run – Average Response Time (ms) Distribution Graph
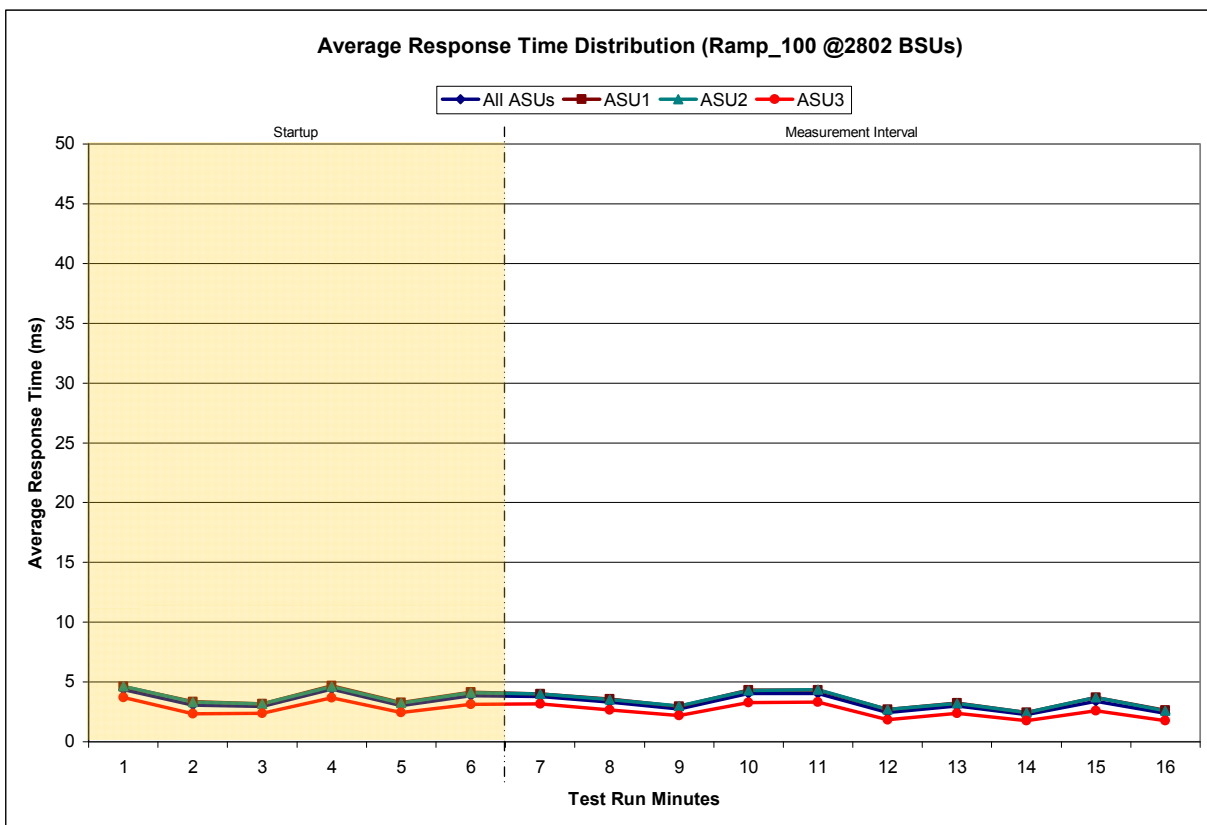
Average Response Time Distribution (Ramp_100 @2802 BSUs)

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	49681	1,058,628	405,120	126,967	74,976	88,049	112,149	99,235
Write	1212767	1,910,529	744,486	199,900	123,205	109,106	94,393	70,852
All ASUs	1262448	2,969,157	1,149,606	326,867	198,181	197,155	206,542	170,087
ASU1	635708	1,713,153	634,742	186,546	114,560	121,804	135,534	114,378
ASU2	145087	339,290	134,129	40,614	24,269	24,134	26,757	22,480
ASU3	481653	916,714	380,735	99,707	59,352	51,217	44,251	33,229

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	166,025	197,478	131,485	121,496	83,704	86,815	138,899	110,941
Write	127,244	97,231	78,277	61,674	57,299	47,899	82,900	70,745
All ASUs	293,269	294,709	209,762	183,170	141,003	134,714	221,799	181,686
ASU1	194,884	207,274	142,805	127,811	94,808	93,301	151,544	123,118
ASU2	38,445	41,934	29,939	26,518	19,084	18,800	31,175	25,626
ASU3	59,940	45,501	37,018	28,841	27,111	22,613	39,080	32,942

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	86,184	69,043	55,870	167,287	76,132	41,021	27,585	72,709
Write	58,637	49,850	40,543	126,363	69,355	43,425	41,454	79,637
All ASUs	144,821	118,893	96,413	293,650	145,487	84,446	69,039	152,346
ASU1	96,885	79,019	64,108	194,340	93,559	53,135	41,053	95,716
ASU2	20,256	16,528	13,204	40,356	19,339	11,085	8,705	19,454
ASU3	27,680	23,346	19,101	58,954	32,589	20,226	19,281	37,176

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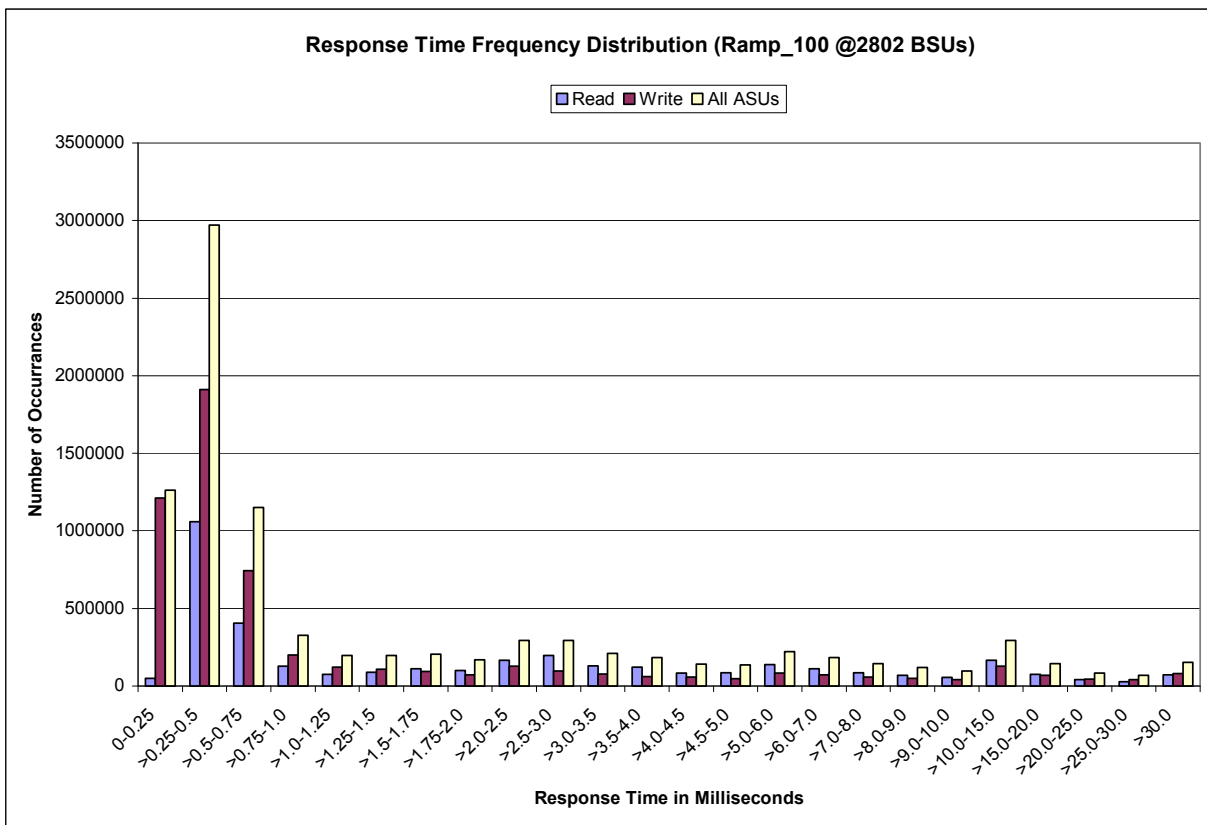
IOPS Test Run – I/O Request Information

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
9,245,250	9,092,904	152,346

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	0.2811	0.0699	0.2099	0.0181	0.0699	0.0350	0.2810
COV	0.006	0.002	0.003	0.002	0.007	0.005	0.006	0.002

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 58.

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 - 2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:33:38	0:39:39	0-5	0:06:01
Measurement Interval	0:39:39	0:49:39	6-15	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	14,028.15	8,376.20	1,721.43	3,930.52
1	14,035.33	8,362.72	1,729.07	3,943.55
2	14,013.08	8,348.20	1,720.15	3,944.73
3	13,994.32	8,344.97	1,721.92	3,927.43
4	14,030.07	8,353.07	1,729.85	3,947.15
5	14,013.98	8,338.50	1,723.93	3,951.55
6	13,993.45	8,340.37	1,714.68	3,938.40
7	14,021.28	8,359.73	1,723.48	3,938.07
8	13,970.87	8,327.38	1,716.40	3,927.08
9	14,014.67	8,348.52	1,727.82	3,938.33
10	14,021.68	8,345.33	1,724.52	3,951.83
11	14,040.80	8,372.83	1,721.90	3,946.07
12	14,010.30	8,353.73	1,726.02	3,930.55
13	14,011.65	8,339.80	1,730.80	3,941.05
14	14,004.45	8,358.42	1,717.40	3,928.63
15	13,994.40	8,346.08	1,721.85	3,926.47
Average	14,008.36	8,349.22	1,722.49	3,936.65

95% Load Level - 2,661 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:50:41	0:56:42	0-5	0:06:01
Measurement Interval	0:56:42	1:06:42	6-15	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	13,303.98	7,938.55	1,630.55	3,734.88
1	13,308.50	7,925.85	1,636.77	3,745.88
2	13,310.28	7,925.52	1,644.08	3,740.68
3	13,326.83	7,948.83	1,638.92	3,739.08
4	13,294.02	7,931.43	1,630.47	3,732.12
5	13,314.40	7,941.88	1,635.32	3,737.20
6	13,312.97	7,932.90	1,630.17	3,749.90
7	13,307.90	7,937.78	1,640.62	3,729.50
8	13,320.77	7,952.92	1,639.15	3,728.70
9	13,296.03	7,913.80	1,637.50	3,744.73
10	13,318.73	7,945.20	1,637.17	3,736.37
11	13,313.62	7,930.37	1,637.93	3,745.32
12	13,306.95	7,933.67	1,639.28	3,734.00
13	13,288.63	7,913.62	1,638.10	3,736.92
14	13,301.20	7,916.12	1,640.98	3,744.10
15	13,305.23	7,921.23	1,639.55	3,744.45
Average	13,307.20	7,929.76	1,638.05	3,739.40

90% Load Level - 2,521 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:07:44	1:13:45	0-5	0:06:01
Measurement Interval	1:13:45	1:23:45	6-15	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	12,615.73	7,528.98	1,547.23	3,539.52
1	12,606.53	7,507.22	1,552.58	3,546.73
2	12,602.08	7,528.50	1,553.10	3,520.48
3	12,600.05	7,504.15	1,550.93	3,544.97
4	12,597.27	7,521.97	1,542.47	3,532.83
5	12,615.80	7,515.10	1,557.48	3,543.22
6	12,597.78	7,505.83	1,551.83	3,540.12
7	12,592.02	7,501.43	1,544.40	3,546.18
8	12,594.00	7,506.40	1,550.38	3,537.22
9	12,614.88	7,526.93	1,551.30	3,536.65
10	12,600.23	7,521.45	1,547.53	3,531.25
11	12,631.17	7,534.73	1,551.97	3,544.47
12	12,606.33	7,499.60	1,552.68	3,554.05
13	12,589.27	7,502.90	1,540.87	3,545.50
14	12,603.52	7,527.58	1,545.83	3,530.10
15	12,621.87	7,521.82	1,548.67	3,551.38
Average	12,605.11	7,514.87	1,548.55	3,541.69

80% Load Level - 2,241 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:24:47	1:30:48	0-5	0:06:01
Measurement Interval	1:30:48	1:40:48	6-15	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	11,212.98	6,690.17	1,379.13	3,143.68
1	11,213.57	6,682.80	1,382.85	3,147.92
2	11,206.70	6,683.63	1,364.68	3,158.38
3	11,211.13	6,680.57	1,378.15	3,152.42
4	11,194.85	6,675.25	1,372.87	3,146.73
5	11,214.55	6,683.02	1,385.73	3,145.80
6	11,214.97	6,681.85	1,380.38	3,152.73
7	11,221.37	6,692.58	1,372.07	3,156.72
8	11,185.67	6,654.80	1,383.65	3,147.22
9	11,202.27	6,688.72	1,376.08	3,137.47
10	11,221.78	6,674.65	1,378.77	3,168.37
11	11,223.85	6,689.23	1,379.38	3,155.23
12	11,197.57	6,677.35	1,377.38	3,142.83
13	11,183.38	6,662.12	1,383.87	3,137.40
14	11,186.57	6,664.40	1,375.48	3,146.68
15	11,184.32	6,658.83	1,376.45	3,149.03
Average	11,202.17	6,674.45	1,378.35	3,149.37

50% Load Level - 1,401 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:41:49	1:47:50	0-5	0:06:01
Measurement Interval	1:47:50	1:57:50	6-15	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	7,001.22	4,182.97	856.82	1,961.43
1	6,998.53	4,173.97	860.23	1,964.33
2	7,016.85	4,183.07	864.25	1,969.53
3	6,998.70	4,169.60	863.78	1,965.32
4	7,007.03	4,183.35	858.00	1,965.68
5	7,005.88	4,170.75	867.55	1,967.58
6	6,995.30	4,161.20	860.97	1,973.13
7	7,012.18	4,180.57	854.72	1,976.90
8	7,024.75	4,189.85	866.30	1,968.60
9	7,003.73	4,173.02	858.85	1,971.87
10	7,001.82	4,178.37	859.50	1,963.95
11	7,005.93	4,182.92	854.82	1,968.20
12	6,989.77	4,164.87	857.72	1,967.18
13	7,008.52	4,168.92	866.80	1,972.80
14	7,010.32	4,172.10	863.80	1,974.42
15	6,994.93	4,171.23	860.35	1,963.35
Average	7,004.73	4,174.30	860.38	1,970.04

| 10% Load Level - 280 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:58:51	2:04:52	0-5	0:06:01
Measurement Interval	2:04:52	2:14:52	6-15	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,397.97	838.75	170.83	388.38
1	1,405.60	835.83	173.63	396.13
2	1,400.30	833.88	171.65	394.77
3	1,396.92	833.00	170.75	393.17
4	1,403.52	834.88	172.73	395.90
5	1,398.50	836.57	171.52	390.42
6	1,397.82	832.62	171.32	393.88
7	1,399.00	833.70	170.80	394.50
8	1,398.70	836.88	170.77	391.05
9	1,401.48	830.00	174.40	397.08
10	1,402.15	833.25	172.90	396.00
11	1,399.60	831.05	172.42	396.13
12	1,404.30	836.58	171.23	396.48
13	1,402.73	835.32	172.55	394.87
14	1,397.22	834.70	170.33	392.18
15	1,399.87	834.88	171.38	393.60
Average	1,400.29	833.90	171.81	394.58

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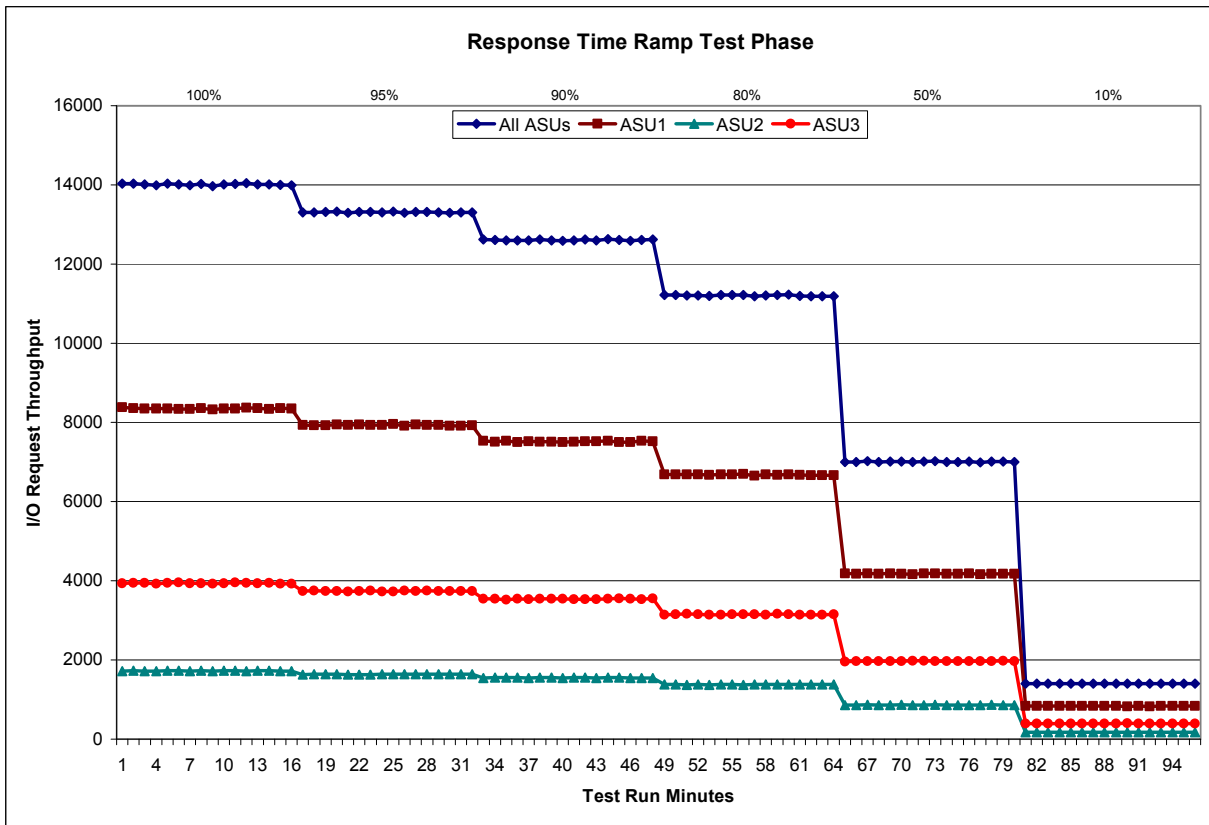
SPC-1C LRT™ Average Response Time (ms) Distribution Data

280 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:58:51	2:04:52	0-5	0:06:01
Measurement Interval	2:04:52	2:14:52	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.24	0.26	0.28	0.17
1	0.22	0.23	0.24	0.17
2	0.22	0.23	0.24	0.17
3	0.21	0.23	0.24	0.17
4	0.24	0.26	0.26	0.18
5	0.22	0.24	0.24	0.17
6	0.21	0.23	0.24	0.17
7	0.22	0.23	0.24	0.17
8	0.23	0.25	0.26	0.17
9	0.23	0.24	0.25	0.18
10	0.23	0.24	0.25	0.18
11	0.21	0.22	0.23	0.17
12	0.23	0.25	0.26	0.17
13	0.23	0.25	0.26	0.18
14	0.22	0.23	0.25	0.18
15	0.22	0.24	0.25	0.17
Average	*0.22*	*0.24*	*0.25*	*0.17*

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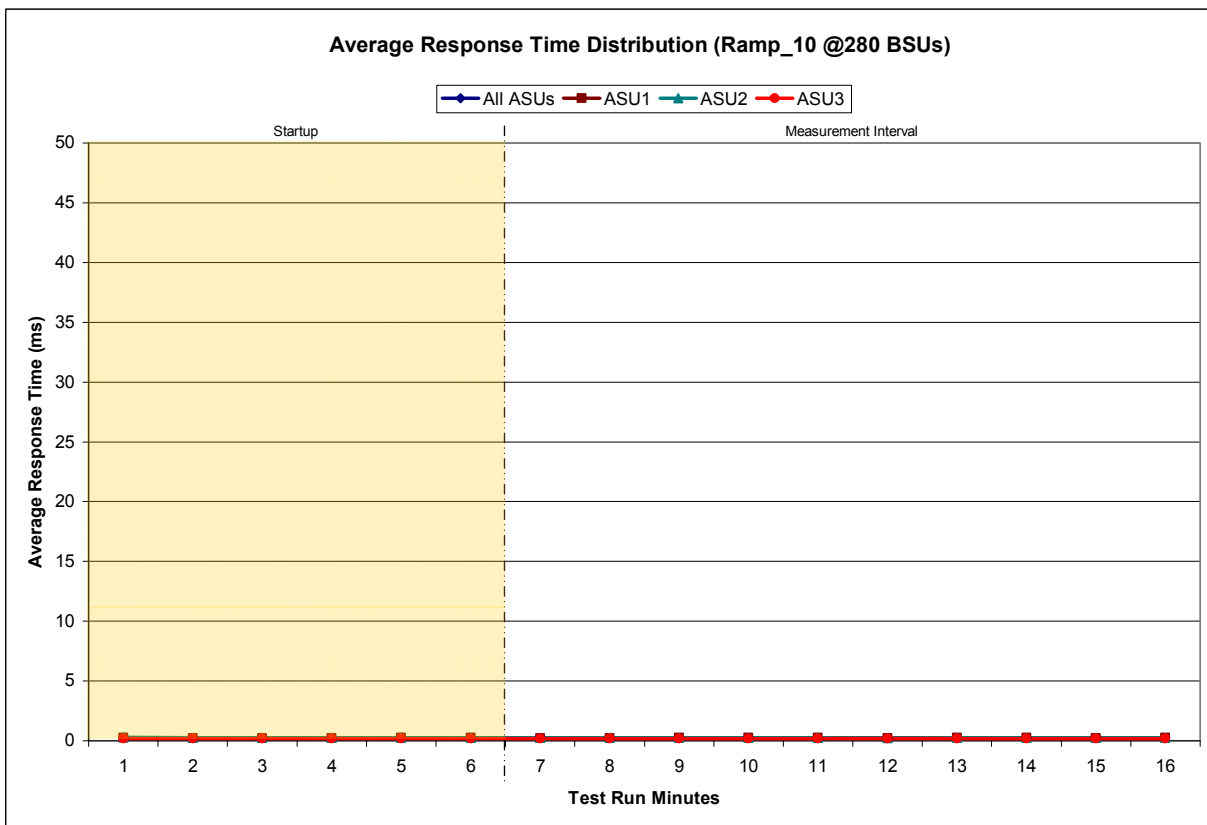
SPC-1C LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

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	0.0351	0.2803	0.0698	0.2103	0.0181	0.0700	0.0347	0.2818
COV	0.021	0.004	0.011	0.005	0.021	0.008	0.019	0.004

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 58.

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	*14,008.36*
Repeatability Test Phase 1	14,006.96
Repeatability Test Phase 2	14,005.32

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	*0.22 ms*
Repeatability Test Phase 1	0.22 ms
Repeatability Test Phase 2	0.22 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

280 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:15:56	2:21:56	0-5	0:06:00
Measurement Interval	2:21:56	2:31:56	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,399.83	837.80	168.78	393.25
1	1,399.53	832.75	172.47	394.32
2	1,402.25	837.00	171.40	393.85
3	1,397.02	828.35	174.05	394.62
4	1,398.12	835.62	170.98	391.52
5	1,394.77	829.37	174.73	390.67
6	1,397.98	830.95	169.87	397.17
7	1,396.10	832.78	171.22	392.10
8	1,405.43	835.18	175.05	395.20
9	1,397.68	832.92	171.88	392.88
10	1,398.77	833.08	173.93	391.75
11	1,398.12	829.68	171.45	396.98
12	1,398.95	832.92	170.38	395.65
13	1,399.85	832.15	170.70	397.00
14	1,401.98	836.48	171.77	393.73
15	1,400.78	831.13	172.50	397.15
Average	*1,399.57*	*832.73*	*171.88*	*394.96*

Repeatability 1 LRT – I/O Request Throughput Distribution Graph

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

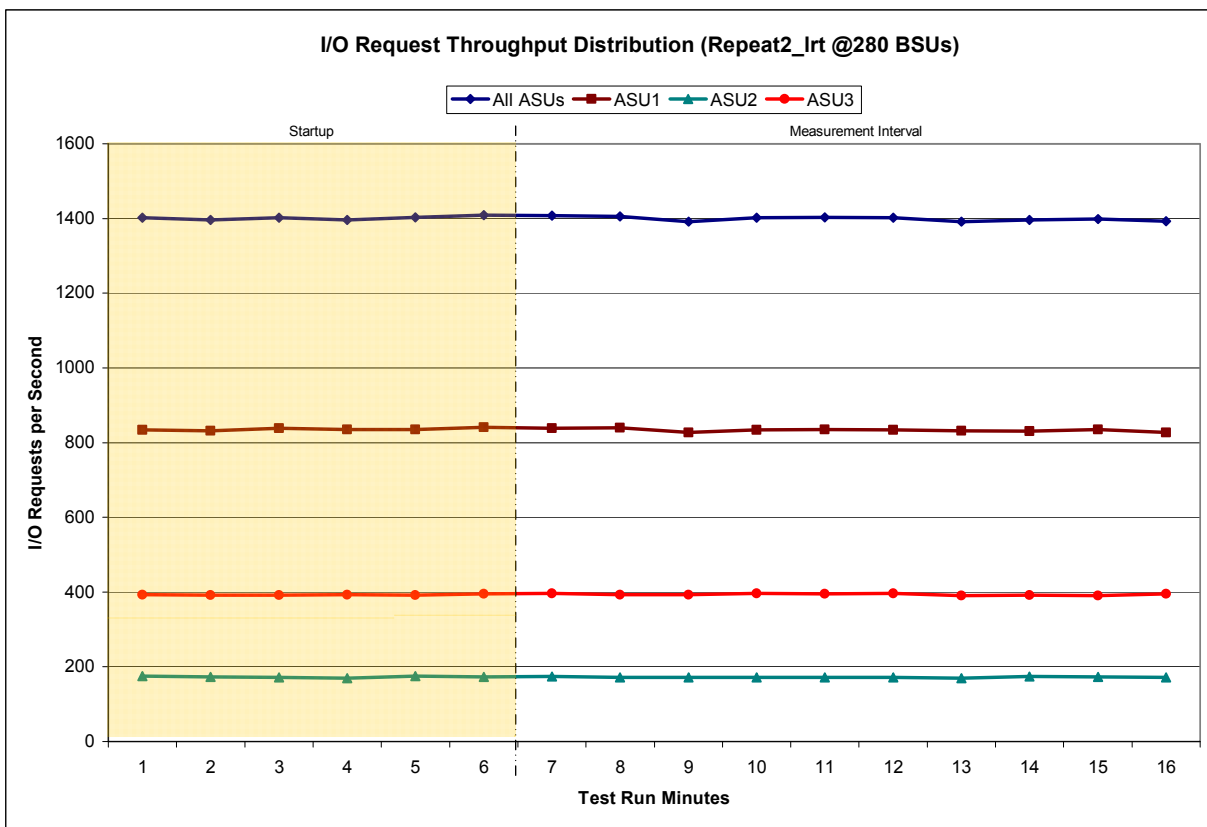| 280 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:15:56	2:21:56	0-5	0:06:00
Measurement Interval	2:21:56	2:31:56	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.22	0.24	0.24	0.18
1	0.23	0.25	0.26	0.18
2	0.22	0.24	0.25	0.17
3	0.24	0.26	0.26	0.18
4	0.23	0.25	0.26	0.18
5	0.22	0.23	0.24	0.17
6	0.23	0.26	0.26	0.17
7	0.22	0.24	0.25	0.17
8	0.22	0.24	0.24	0.17
9	0.23	0.24	0.26	0.17
10	0.23	0.25	0.25	0.18
11	0.21	0.22	0.24	0.17
12	0.24	0.26	0.27	0.18
13	0.22	0.23	0.24	0.17
14	0.23	0.25	0.25	0.17
15	0.22	0.23	0.25	0.18
Average	*0.22*	*0.24*	*0.25*	*0.17*

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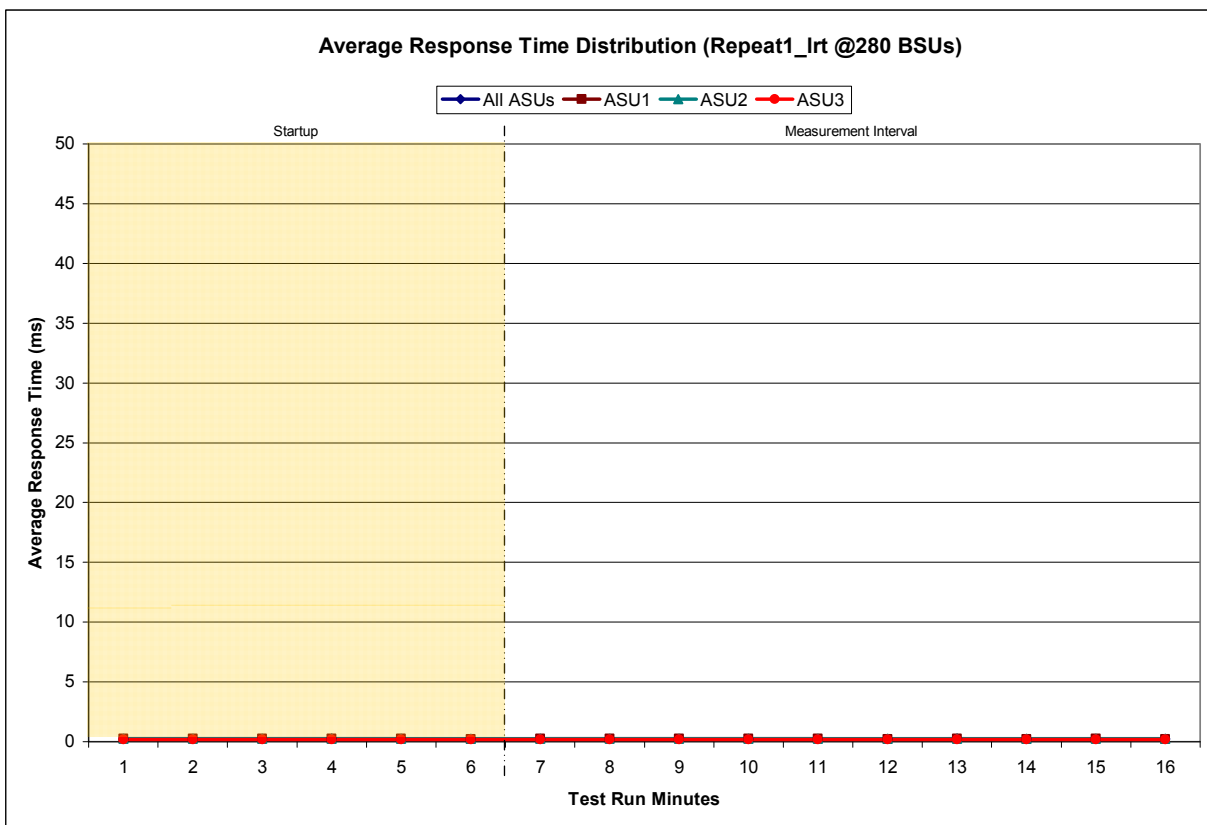
Repeatability 1 IOPS – I/O Request Throughput Distribution Data

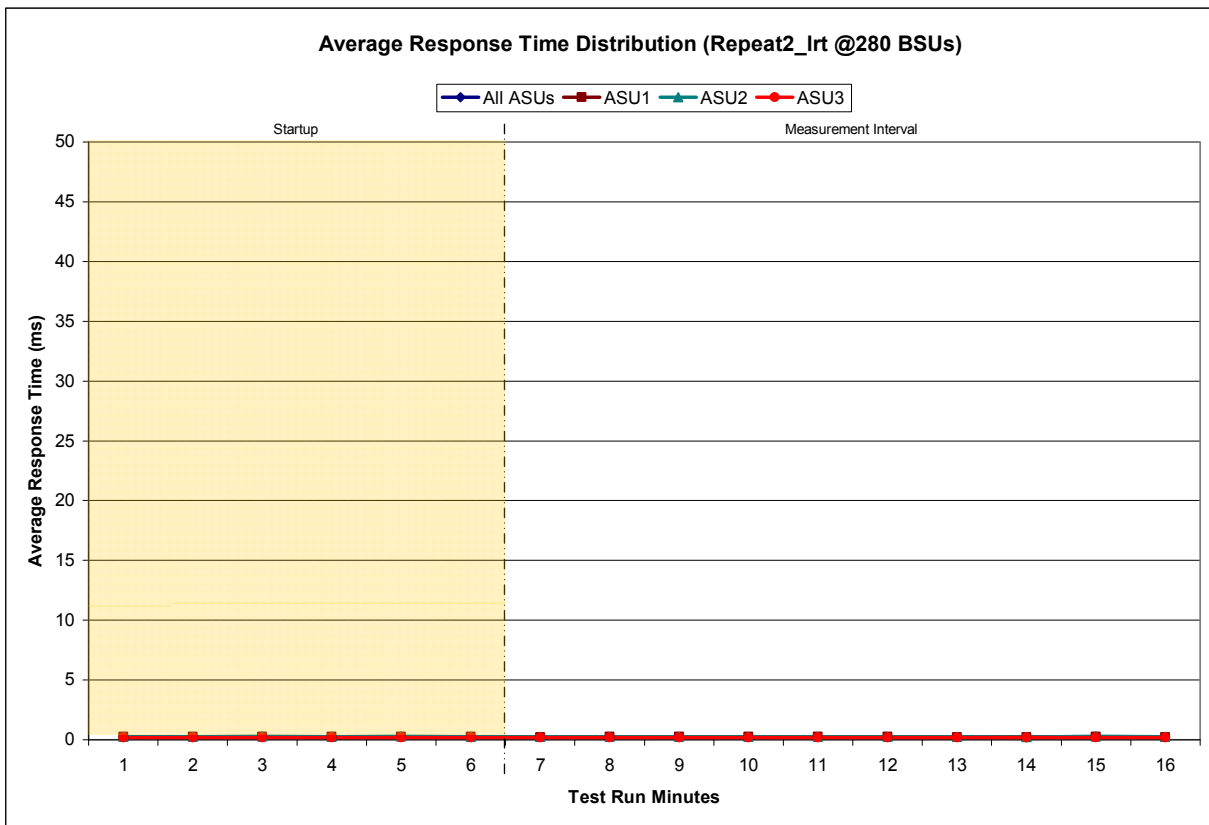| 2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:32:58	2:38:59	0-5	0:06:01
Measurement Interval	2:38:59	2:48:59	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	14,031.25	8,361.17	1,714.28	3,955.80
1	13,996.08	8,359.25	1,710.70	3,926.13
2	13,988.33	8,323.10	1,720.53	3,944.70
3	14,012.78	8,354.28	1,719.78	3,938.72
4	13,995.48	8,352.77	1,717.23	3,925.48
5	14,009.42	8,349.40	1,723.27	3,936.75
6	13,975.28	8,330.27	1,716.77	3,928.25
7	14,032.63	8,360.53	1,725.25	3,946.85
8	14,006.62	8,351.95	1,722.67	3,932.00
9	14,017.30	8,355.08	1,717.78	3,944.43
10	13,994.67	8,357.03	1,716.68	3,920.95
11	14,030.90	8,363.58	1,728.00	3,939.32
12	13,992.35	8,348.95	1,717.58	3,925.82
13	14,016.25	8,362.48	1,731.32	3,922.45
14	14,002.70	8,353.18	1,716.32	3,933.20
15	14,000.90	8,340.68	1,723.42	3,936.80
Average	*14,006.96*	*8,352.38*	*1,721.58*	*3,933.01*

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

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

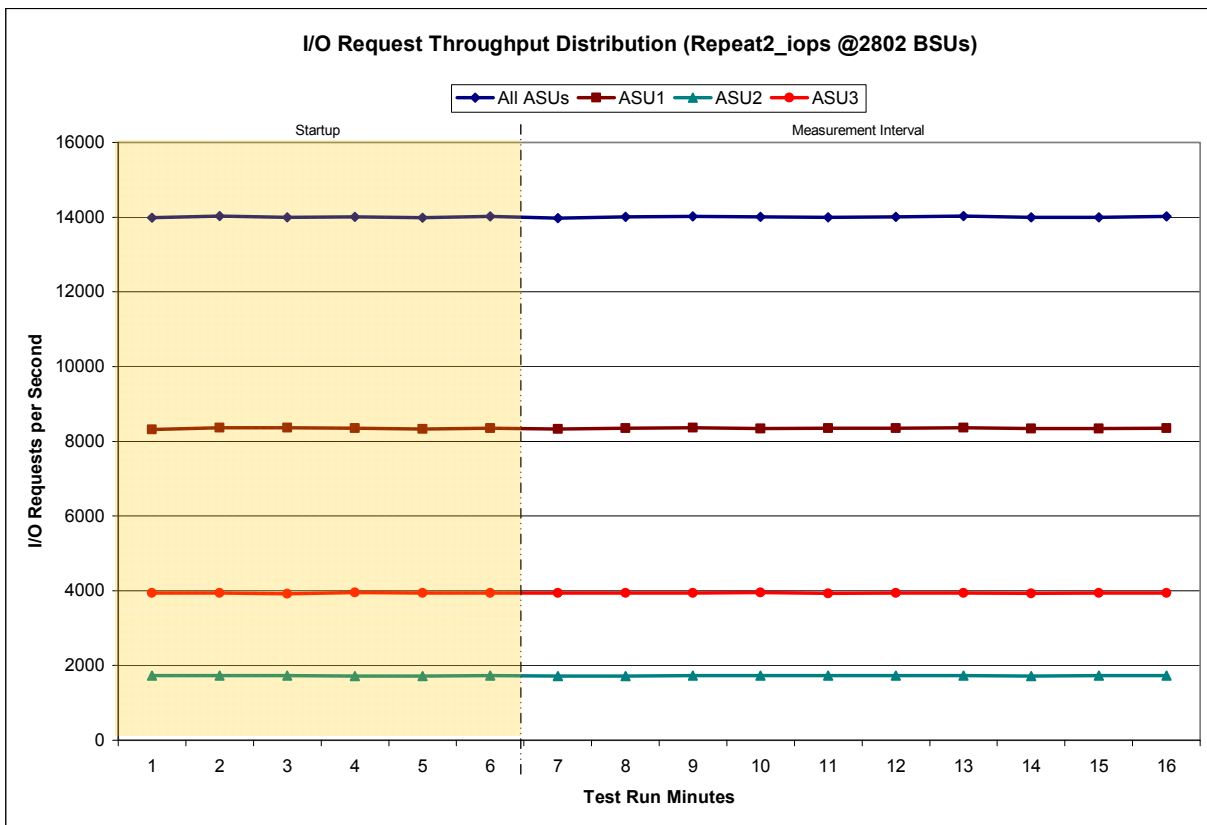| 2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:32:58	2:38:59	0-5	0:06:01
Measurement Interval	2:38:59	2:48:59	6-15	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.51	2.73	2.74	1.92
1	2.13	2.34	2.34	1.59
2	2.45	2.67	2.67	1.90
3	2.17	2.37	2.35	1.67
4	2.73	2.97	2.98	2.12
5	3.56	3.79	3.82	2.97
6	3.19	3.39	3.40	2.67
7	3.39	3.64	3.67	2.74
8	2.62	2.83	2.83	2.09
9	3.50	3.75	3.75	2.86
10	2.89	3.14	3.15	2.25
11	3.04	3.26	3.25	2.48
12	3.49	3.75	3.76	2.82
13	2.33	2.53	2.54	1.81
14	3.21	3.43	3.43	2.63
15	2.82	3.04	3.06	2.23
Average	*3.05*	*3.28*	*3.28*	*2.46*

Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph
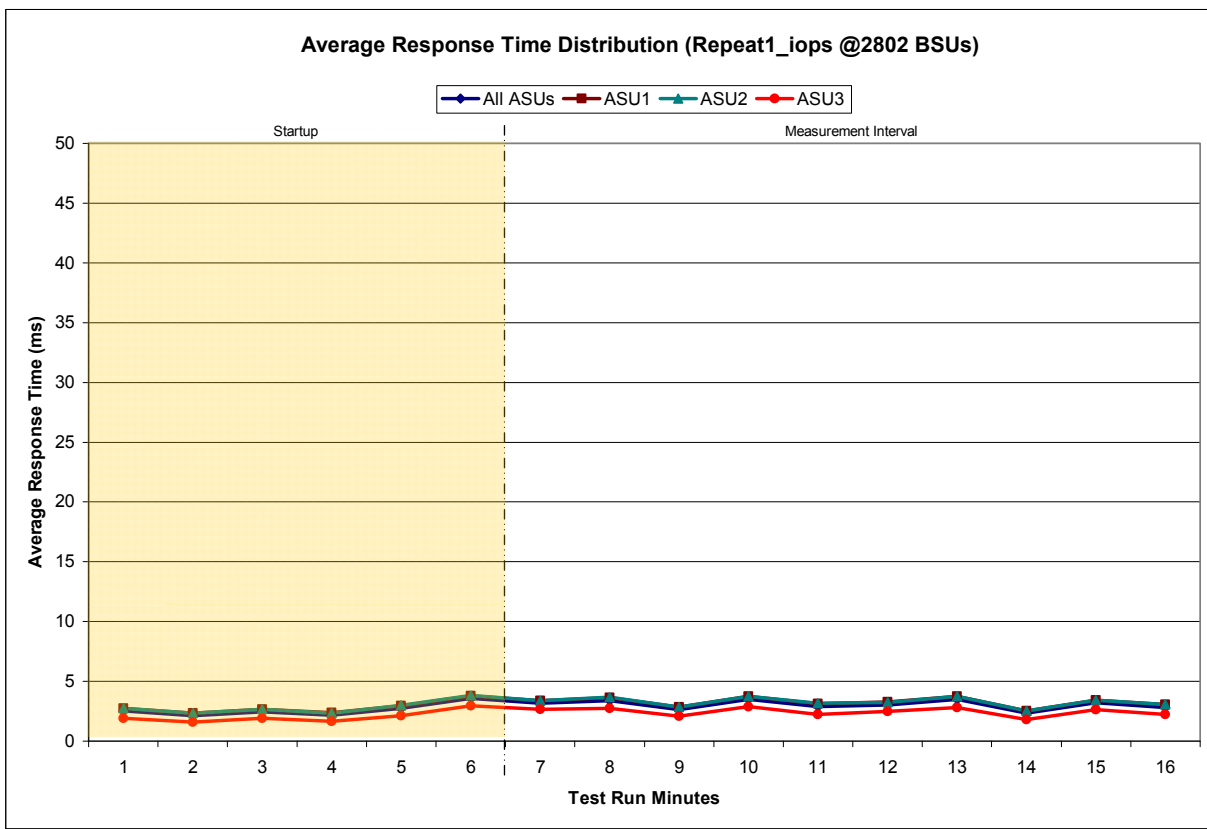
Repeatability 2 LRT – I/O Request Throughput Distribution Data

| 280 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:50:03	2:56:03	0-5	0:06:00
Measurement Interval	2:56:03	3:06:03	6-15	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1,401.62	833.65	174.72	393.25
1	1,396.23	831.93	172.32	391.98
2	1,401.92	838.38	171.42	392.12
3	1,396.68	834.70	169.03	392.95
4	1,402.70	835.27	175.23	392.20
5	1,408.48	840.33	172.52	395.63
6	1,407.73	838.02	173.58	396.13
7	1,405.03	840.07	171.80	393.17
8	1,391.02	827.33	171.38	392.30
9	1,401.82	833.85	171.43	396.53
10	1,402.82	835.28	172.02	395.52
11	1,401.83	833.60	171.65	396.58
12	1,391.63	831.20	169.50	390.93
13	1,396.08	831.03	173.37	391.68
14	1,398.28	835.02	172.80	390.47
15	1,392.95	826.77	171.12	395.07
Average	*1,398.92*	*833.22*	*171.87*	*393.84*

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

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

280 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:50:03	2:56:03	0-5	0:06:00
Measurement Interval	2:56:03	3:06:03	6-15	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.22	0.24	0.24	0.17
1	0.22	0.23	0.24	0.17
2	0.24	0.27	0.27	0.18
3	0.24	0.26	0.27	0.18
4	0.24	0.26	0.28	0.17
5	0.22	0.24	0.25	0.17
6	0.22	0.23	0.25	0.18
7	0.23	0.25	0.26	0.17
8	0.22	0.24	0.26	0.17
9	0.22	0.24	0.25	0.17
10	0.22	0.24	0.25	0.18
11	0.23	0.25	0.26	0.17
12	0.22	0.23	0.24	0.17
13	0.22	0.23	0.23	0.17
14	0.24	0.27	0.27	0.17
15	0.21	0.23	0.24	0.17
Average	*0.22*	*0.24*	*0.25*	*0.17*

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

Repeatability 2 IOPS – I/O Request Throughput Distribution Data

2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:07:05	3:13:06	0-5	0:06:01
Measurement Interval	3:13:06	3:23:06	6-15	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	13,985.75	8,317.78	1,726.97	3,941.00
1	14,029.27	8,368.42	1,727.03	3,933.82
2	13,999.83	8,357.23	1,723.53	3,919.07
3	14,012.27	8,351.03	1,713.13	3,948.10
4	13,986.88	8,326.05	1,721.83	3,939.00
5	14,018.05	8,351.98	1,728.43	3,937.63
6	13,976.28	8,324.65	1,713.02	3,938.62
7	14,001.67	8,349.82	1,716.92	3,934.93
8	14,016.80	8,359.78	1,722.32	3,934.70
9	14,010.82	8,342.68	1,722.18	3,945.95
10	14,001.43	8,347.63	1,725.82	3,927.98
11	14,012.50	8,349.03	1,725.02	3,938.45
12	14,028.88	8,359.37	1,731.32	3,938.20
13	13,990.92	8,336.53	1,720.90	3,933.48
14	13,997.75	8,340.08	1,723.87	3,933.80
15	14,016.13	8,353.85	1,725.80	3,936.48
Average	*14,005.32*	*8,346.34*	*1,722.72*	*3,936.26*

Repeatability 2 IOPS – I/O Request Throughput Distribution Graph

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

2,802 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:07:05	3:13:06	0-5	0:06:01
Measurement Interval	3:13:06	3:23:06	6-15	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.76	2.97	2.96	2.24
1	2.88	3.10	3.10	2.34
2	2.46	2.69	2.69	1.89
3	2.40	2.60	2.62	1.88
4	3.12	3.33	3.31	2.58
5	2.64	2.86	2.85	2.10
6	1.96	2.17	2.17	1.41
7	2.68	2.89	2.90	2.14
8	3.52	3.74	3.78	2.95
9	3.29	3.54	3.51	2.67
10	2.20	2.43	2.42	1.62
11	2.90	3.12	3.14	2.34
12	2.78	3.02	3.00	2.17
13	3.50	3.76	3.73	2.85
14	1.94	2.15	2.13	1.44
15	3.00	3.20	3.22	2.49
Average	*2.78*	*3.00*	*3.00*	*2.21*

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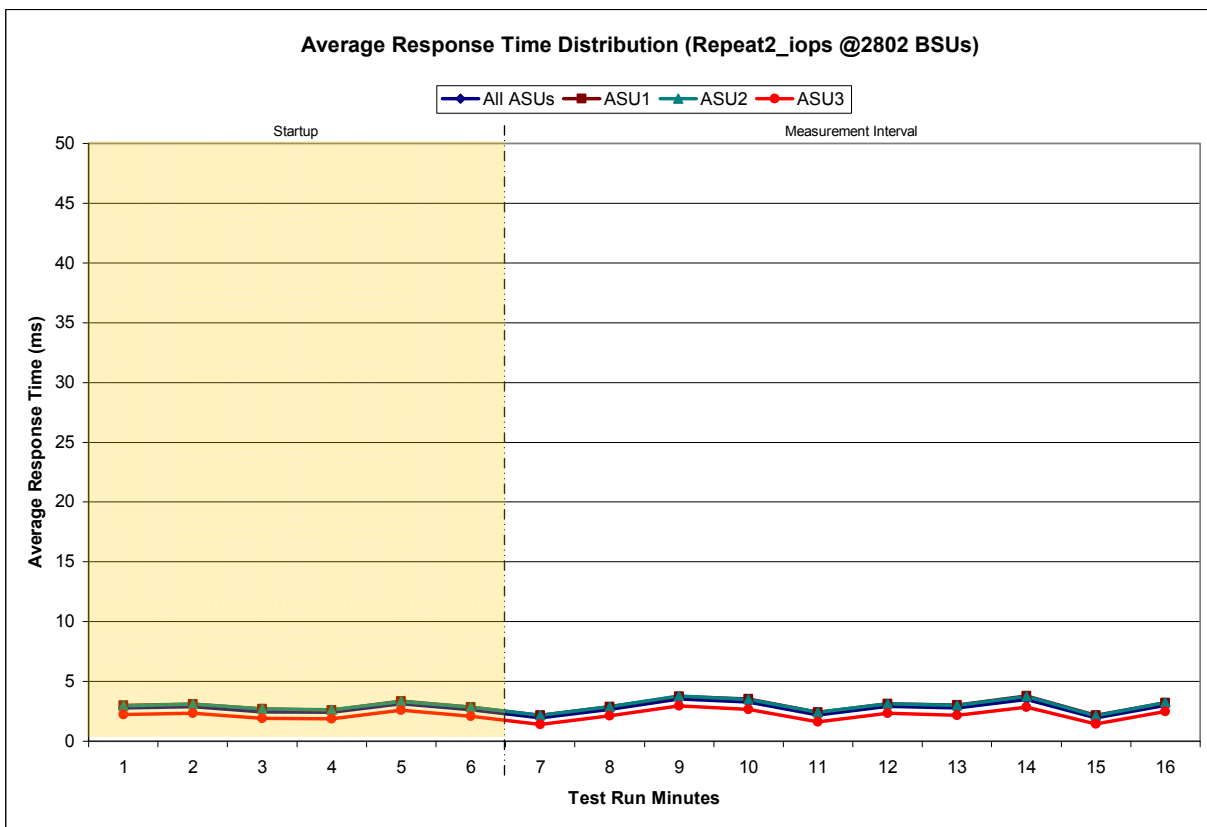
Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

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	0.0347	0.2802	0.0705	0.2097	0.0180	0.698	0.0350	0.2822
COV	0.023	0.006	0.012	0.008	0.019	0.009	0.017	0.005

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	0.2812	0.0700	0.2101	0.0179	0.0700	0.0350	0.2808
COV	0.005	0.002	0.007	0.002	0.010	0.003	0.005	0.002

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	0.0350	0.2811	0.0701	0.2095	0.0180	0.0694	0.0354	0.2815
COV	0.019	0.006	0.008	0.006	0.028	0.010	0.015	0.005

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	0.0351	0.2809	0.0701	0.2098	0.0181	0.0699	0.0350	0.2811
COV	0.006	0.001	0.003	0.002	0.008	0.002	0.004	0.001

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 58.

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	33,546,704
Total Number of Logical Blocks Verified	24,219,840
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 Pulsar®.2/ST400FM0002 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 Pulsar®.2/ST400FM0002.

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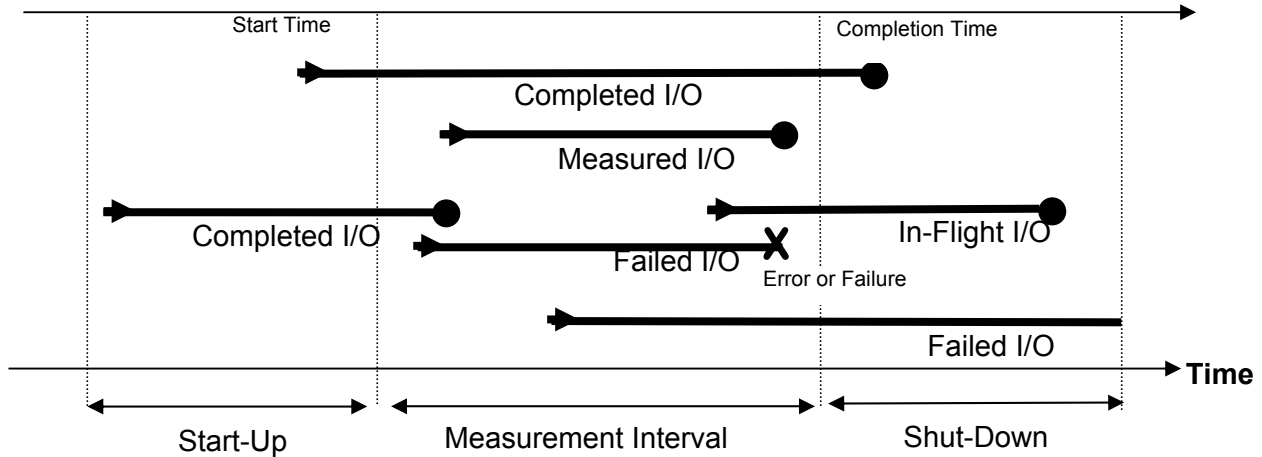
SPC-1C Test Run Components
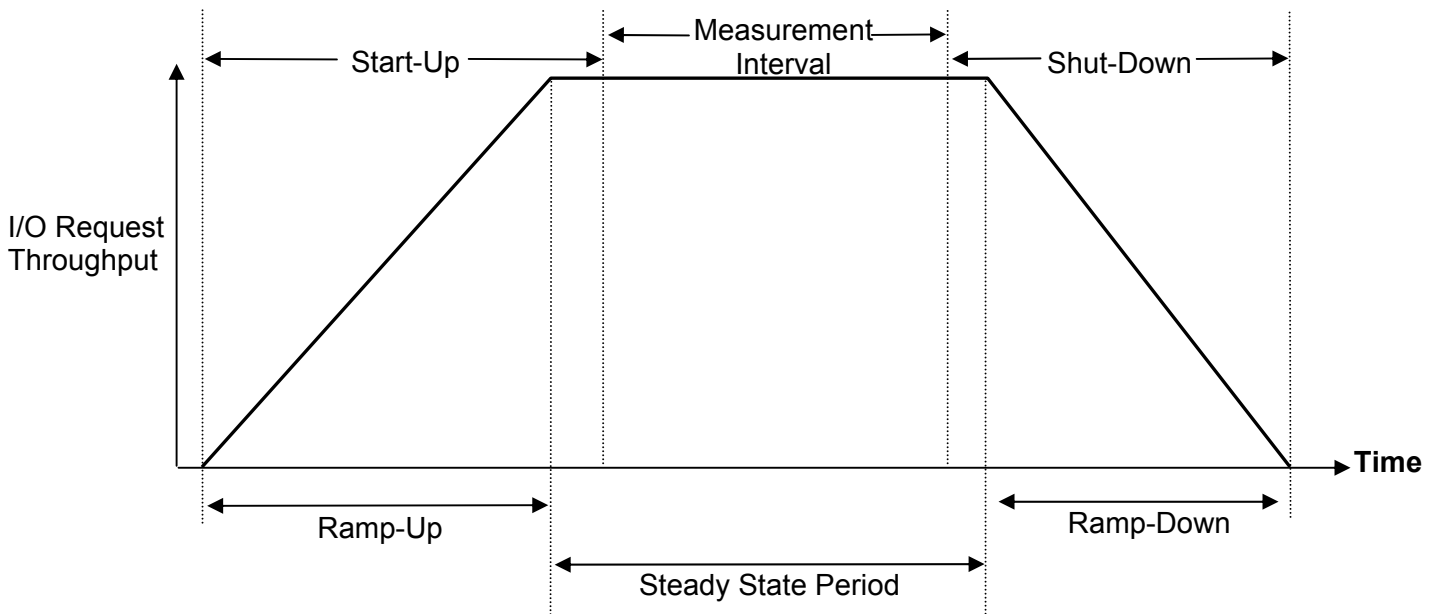
APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

There were no customer tunable parameter or options changed from their default values.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

ASU Pre-Fill

The following command was issued in a Windows command session to invoke the script listed below. The script will fill the entire Configured Storage Capacity with random data using Vdbench 5.03 Beta.

vdbench –f prepssd.txt –o ssdprep

prefill.txt

```
*
* This will produce a random data pattern of the entire LBA range using LSFR 32bit
*
pattern=random
*
*
sd=sd1,lun=\\.\physicaldrive0,threads=32,align=4k
wd=wd1,sd=sd*,rdpct=0,seek=-1,xfersize=64k

*=================================
* Use 10 hours as a max elapse time
*=================================
*
rd=Prefill,wd=wd*,iorate=max,elapsed=36000,interval=30
```

Create the SPC-1C ASUs

The following command was issued in a Windows command session to invoke the script listed below. Execution of the script will create the three SPC-1 ASUs to be used in the benchmark measurement.

diskpart /s diskmkssd.txt

diskmkssd.txt

```
select disk 0
clean
convert gpt
create partition primary size=171632 align=1024
create partition primary size=171632 align=1024
create partition primary size=38140 align=1024
select volume 1
assign letter=x
select volume 2
assign letter=y
select volume 3
assign letter=z
list volume
exit
```

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

The content of SPC-1C Workload Generator command and parameter file, used in this benchmark to execute the Primary Metrics, Repeatability, and Persistence Tests, is listed below.

```
sd=asu1_1,lun=\\.\x:,size=179969196032
sd=asu2_1,lun=\\.\y:,size=179969196032
sd=asu3_1,lun=\\.\z:,size=39992688640
```

APPENDIX E: SPC-1C WORKLOAD GENERATOR INPUT PARAMETERS

Metrics Test, Repeatability Test, and Persistence

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.

When the Persistence Test Run 1 completes, the script will "pause" to all the required power-off cycle. When that step is completed, the operated will signal the script to resume and execute Persistence Test Run 2.

```
rem spc-1C
set /a bsu=2802
set /a startup=360
set Outdir=%bsu%
set java=c:\java\jre6\bin\java
echo
%java% -Xmx1g -Xss128k -Xms128m metrics -b %bsu% -t 28860 -r 660 -s %startup%
%java% -Xmx1g -Xss128k -Xms128m repeat1 -b %bsu% -t 660 -s %startup%

%java% -Xmx1g -Xss128k -Xms128m repeat2 -b %bsu% -t 660 -s %startup%
%java% -Xmx1g -Xss128k -Xms128m persist1 -b %bsu%
echo power cycle device
pause
%java% -Xmx1g -Xss128k -Xms128m persist2
```

APPENDIX F: THIRD-PARTY QUOTATION

LSI SAS9200-8e 6Gb Controller Card

X4 SAS 2.0 Cable

SAS Adapter