SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

IBM CORPORATION
IBM SYSTEM STORAGE DS5300

SPC-1 V1.10.1

Submitted for Review: September 25, 2008
Submission Identifier: A00070

First Edition – September 2008

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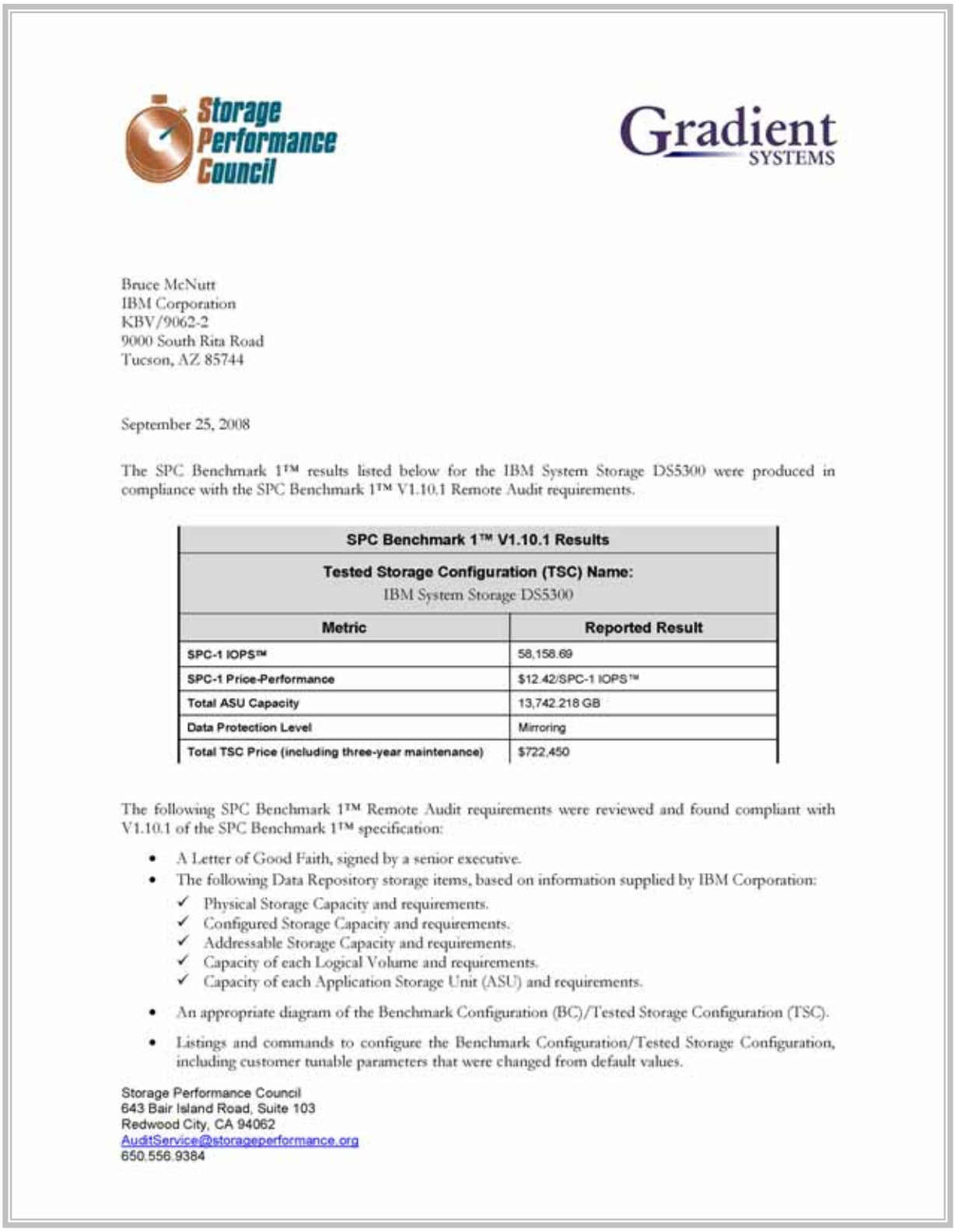
AUDIT CERTIFICATION



Bruce McNutt
IBM Corporation
KBV/9062-2
9000 South Rita Road
Tucson, AZ 85744

September 25, 2008

The SPC Benchmark 1™ results listed below for the IBM System Storage DS5300 were produced in compliance with the SPC Benchmark 1™ V1.10.1 Remote Audit requirements.

SPC Benchmark 1™ V1.10.1 Results	
Tested Storage Configuration (TSC) Name: IBM System Storage DS5300	
Metric	**Reported Result**
SPC-1 IOPS™	58,158.69
SPC-1 Price-Performance	$12.42/SPC-1 IOPS™
Total ASU Capacity	13,742.218 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$722,450

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with V1.10.1 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items, based on information supplied by IBM Corporation:
  - ✓ 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).
- 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

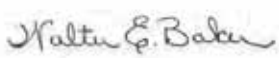
AUDIT CERTIFICATION *(CONT.)*

- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements, based on information supplied by IBM Corporation:
  - ✓ The type of Host System including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each Host System.
- The Test Results Files and resultant Summary Results Files received from IBM Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- The differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration were documented and, if applied to the TSC, would not have a negative impact on the reported SPC-1 performance.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

IBM

Vice President, Disk Systems

IBM Technology & Systems Group
294 Route 100, Somers, NY 10589-3216

Phone 914-766-3010

August 26, 2008

Mr. Walter E. Baker, SPC Auditor
Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94063

Subject: SPC-1 Letter of Good Faith for the IBM System Storage DS5300

IBM Corporation is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with Version 1.10.1 of the SPC-1 benchmark specification.

Our disclosure of the Benchmark configuration and execution of the benchmark includes all items that, to the best of our knowledge and belief, materially affect the reported results, regardless of whether such items are explicitly required to be disclosed by the SPC-1 benchmark specification.

Sincerely,

Robert Cancilla

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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Test Sponsor Alternate Contact	IBM Corporation – http://www.ibm.com Vernon Miller – millerv@us.ibm.com KBV/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-4849 FAX: (520) 799-2009
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-1 Specification revision number	V1.10.1
SPC-1 Workload Generator revision number	V2.00.04a
Date Results were first used publicly	September 25, 2008
Date the FDR was submitted to the SPC	September 25, 2008
Date the TSC is available for shipment to customers	September 5, 2008
Date the TSC completed audit certification	September 24, 2008

Tested Storage Product (TSP) Description

The System Storage DS5000 series disk system is IBM's midrange disk offering, specifically designed to meet the needs of midrange/departmental storage requirements, delivering high performance, advanced function, high availability, modular and scalable storage capacity, with SAN-attached 4 Gbps Fibre Channel (FC) connectivity, and support for RAID 0, 1, 3, 5, 6, and 10, with up to 256 TB physical storage capacity.

The DS5000 series represents the seventh-generation architecture within the midrange disk family.

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: IBM System Storage DS5300	
Metric	**Reported Result**
SPC-1 IOPS™	58,158.69
SPC-1 Price-Performance	$12.42/SPC-1 IOPS™
Total ASU Capacity	13,742.218 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$722,450

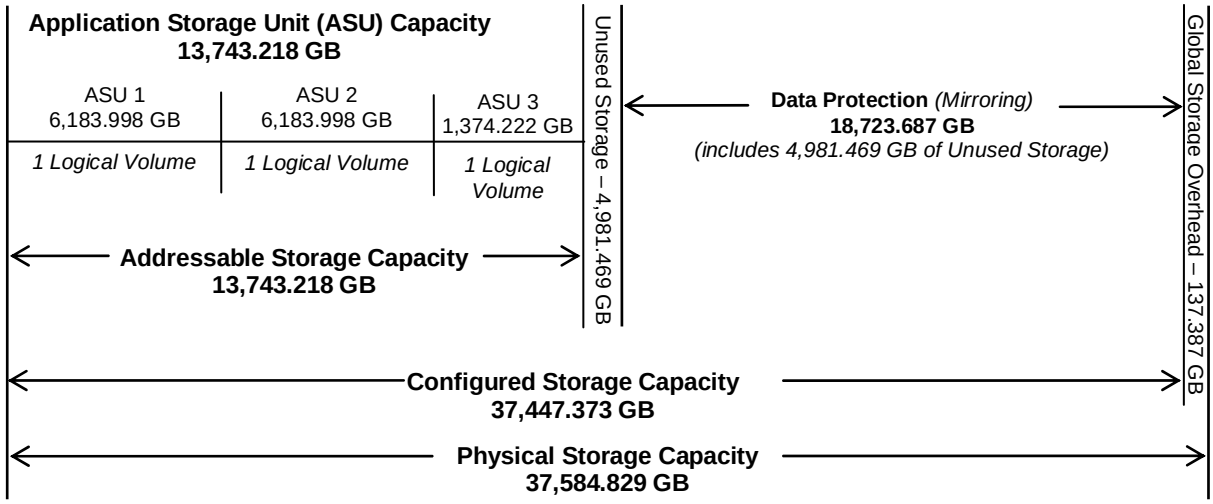
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

A **Data Protection Level** of "Mirroring" configures two or more identical copies of user data.

Storage Capacities and Relationships

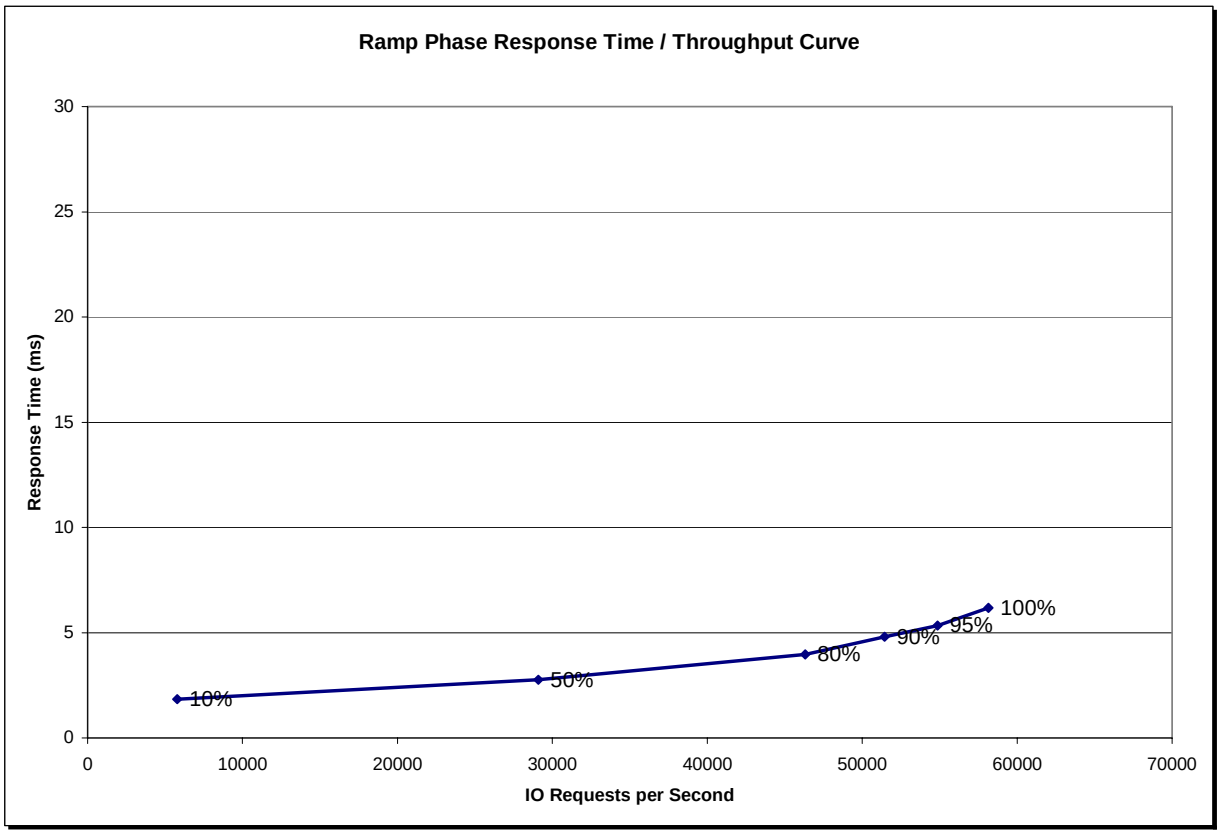
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



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-1 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	5,795.84	29,114.33	46,322.20	51,445.72	54,860.14	58,158.69
Average Response Time (ms):						
All ASUs	1.83	2.76	3.97	4.80	5.33	6.18
ASU-1	2.51	3.73	5.08	5.95	6.50	7.36
ASU-2	2.22	3.52	5.80	7.43	8.44	9.88
ASU-3	0.22	0.37	0.79	1.21	1.48	2.06
Reads	4.34	6.47	8.89	10.36	11.27	12.51
Writes	0.20	0.34	0.76	1.19	1.47	2.06

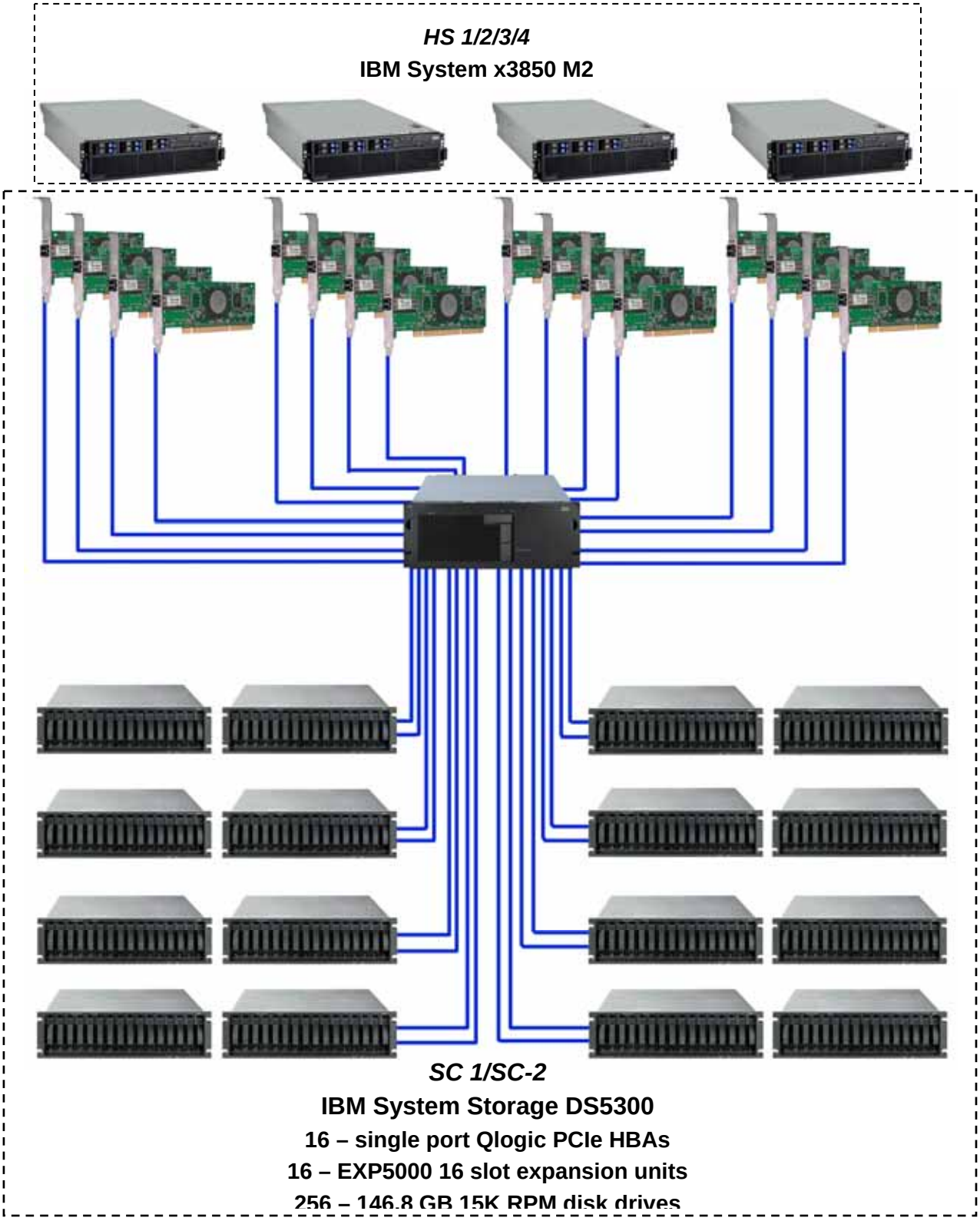
Tested Storage Configuration Pricing *(Priced Storage Configuration)*

Model Type / Feature	Description	List Price	QTY	Extended Price
1818-53A	DS5300 Dual Controller Disk System	$80,000.00	1	$80,000.00
1818-D1A	EXP5000 16 slot Expansion unit	$6,000.00	16	$96,000.00
2031	16GB Cache Memory	$32,000.00	1	$32,000.00
2050	Two Quad 4 Gbps FC Host Port Cards	$10,000.00	2	$20,000.00
2412	Short Wave 4Gbps SFP Transceiver Pair	$998.00	16	$15,968.00
5605	5M LC-LC FIBER OPTIC CABLE	$129.00	48	$6,192.00
7720	DS5000 WINDOWS HOST KIT	$1,250.00	1	$1,250.00
8900	DS5000 8 STG PARTITION-IP0	$10,000.00	1	$10,000.00
5530	16-Pak 146.8 GB/15K DDM	$22,544.00	16	$360,704.00
39R6525	single port Qlogic PCIe - 4GbFC	$1,225	16	$19,600.00
		Total List		$641,714.00
	Std warranty 1 year 24x7x4hr response		incl	
	addtl 2 years 24x7x4			$80,736
		Grand Total		**$722,450.00**

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

The only difference between the Tested Storage Configuration and Priced Storage Configuration is that the priced disk drives are mounted in an IBM drive carrier and each disk drive is configured to self-identify as a DS5000 brand. That difference, if applied to the TSC, would not have a negative impact on the reported SPC-1 performance.

Benchmark Configuration/Tested Storage Configuration Diagram



Benchmark Configuration/Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
HS-1/2/3/4: IBM System x3850 M2	16 – single port Qlogic PCIe HBAs *(39R6525)*
Each Host System with:	**SC-1/SC-2: IBM System Storage DS5300**
2 – 2.93 GHz Quad Xeon Processors with 8 MB L2 cache	**2 – dual-active controllers with:**
8 GB main memory	16 GB cache
Windows Server 2003 Enterprise Edition 32-bit with SP2	2 – Two Quad 4 Gbps FC Host Port Cards
PCIe:	16 – 4 Gb Fibre Channel front-end connections
WG	16 – 4 Gb Fibre Channel backend connection
	16 – EXP5000 16 slot expansion units
	256 – 146.8 GB 15K RPM disk drives

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-1 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 9.2.4.4.1

A one page Benchmark Configuration (BC)/Tested Storage Configuration (TSC) diagram shall be included in the Executive Summary…

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 14 *(Benchmark Configuration/Tested Storage Configuration Diagram).*

Storage Network Configuration

Clause 9.2.4.4.1

…

5. *If the TSC contains network storage, the diagram will include the network configuration. If a single diagram is not sufficient to illustrate both the Benchmark Configuration and network configuration in sufficient detail, the Benchmark Configuration diagram will include a high-level network illustration as shown in Figure 9-8. In that case, a separate, detailed network configuration diagram will also be included as described in Clause 9.2.4.4.2.*

Clause 9.2.4.4.2

If a storage network was configured as a part of the Tested Storage Configuration and the Benchmark Configuration diagram described in Clause 9.2.4.4.1 contains a high-level illustration of the network configuration, the Executive Summary will contain a one page topology diagram of the storage network as illustrated in Figure 9-9.

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC), including the network configuration, is illustrated on page 14 *(Benchmark Configuration/Tested Storage Configuration Diagram).*

Host System Configuration

Clause 9.2.4.4.3

The FDR shall minimally contain, for each Host System running the Workload Generator, a listing of the following:

1. *Number and type of CPUs.*
2. *Main memory capacity.*
3. *Cache memory capacity.*
4. *Number and type of disk controllers or Host Bus Adapters.*

The details of the Host System configuration may be found on page 14 *(Benchmark Configuration/Tested Storage Configuration Diagram).*

Customer Tunable Parameters and Options

Clause 9.2.4.5.1

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

"Appendix B: Customer Tunable Parameters and Options" on page 59 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 4.2.4.5.3), 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 9.2.4.4.1 and/or the Storage Network Configuration Diagram in Clause 9.2.4.4.2.*
  - *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 61 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.2.4.5.3

The FDR must include all SPC-1 Workload Generator storage configuration commands and parameters.

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in "Appendix D: SPC-1 Workload Generator Storage Commands and Parameters" on page 66.

SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. "SPC-1 Data Repository Definitions" on page 55 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.2.4.6.1

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

SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	13,742.218
Addressable Storage Capacity	Gigabytes (GB)	13,742.218
Configured Storage Capacity	Gigabytes (GB)	37,447.373
Physical Storage Capacity	Gigabytes (GB)	37,584.829
Data Protection *(Mirroring)*	Gigabytes (GB)	18,723.687
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	137.387
Total Unused Storage	Gigabytes (GB)	9,962.938

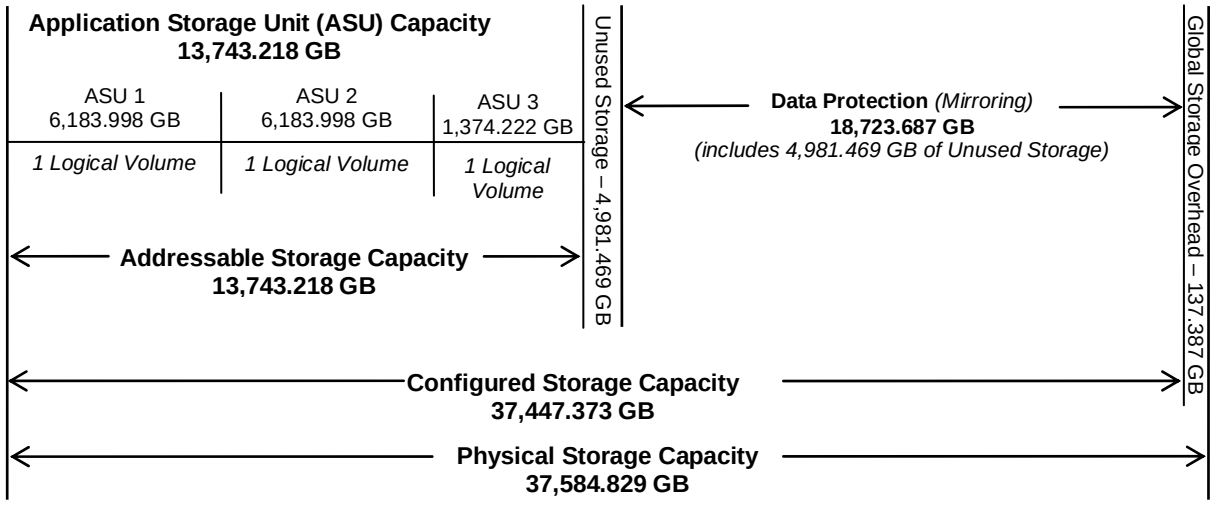
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	100.00%	36.70%	36.56%
Required for Data Protection *(Mirrored)*		50.00%	49.82%
Addressable Storage Capacity		36.70%	36.56%
Required Storage		0.00%	0.00%
Configured Storage Capacity			99.63%
Global Storage Overhead			0.37%
Unused Storage:			
Addressable	0.00%		
Configured		26.71%	
Physical			0.00%

The Physical Storage Capacity consisted of 37,584.829 GB distributed over 256 disk drives each with a formatted capacity of 146.816 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 137.387 GB (0.37%) of Physical Storage Capacity. There was 9,962.938 GB (26.61%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in GB (0.00%) of Unused Storage within the Addressable Storage Capacity.

SPC-1 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 9.2.4.6.2

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 2.4.5) used on each Logical Volume.

Logical Volume Capacity and Mapping		
ASU-1 (6,183.998 GB)	**ASU-2 (6,183.998 GB)**	**ASU-3 (1,374.222 GB)**
1 Logical Volume 6,183.998 GB per Logical Volume (6,183.998 GB used per Logical Volume)	1 Logical Volume 6,183.998 GB per Logical Volume (6,183.998 GB used per Logical Volume)	1 Logical Volume 1,374.222 GB per Logical Volume (1,374.222 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was "Mirrored" as described on page 11. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. "SPC-1 Test Execution Definitions" on page 56 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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 above measurement sequence. If the required sequence is interrupted other than for the Host System/TSC power cycle between the two Persistence Test Runs, the measurement is invalid.

SPC-1 Tests, Test Phases, and Test Runs

The SPC-1 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 5.4.4.1.1

The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous three (3) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).

Clause 5.4.4.1.2

The computed I/O Request Throughput of the Sustainability Test must be within 5% of the reported SPC-1 IOPS™ result.

Clause 5.4.4.1.4

The Average Response Time, as defined in Clause 5.1.1, will be computed and reported for the Sustainability Test Run and cannot exceed 30 milliseconds. If the Average Response time exceeds that 30-milliseconds constraint, the measurement is invalid.

Clause 9.2.4.7.1

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-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

Sustainability Test Results File

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

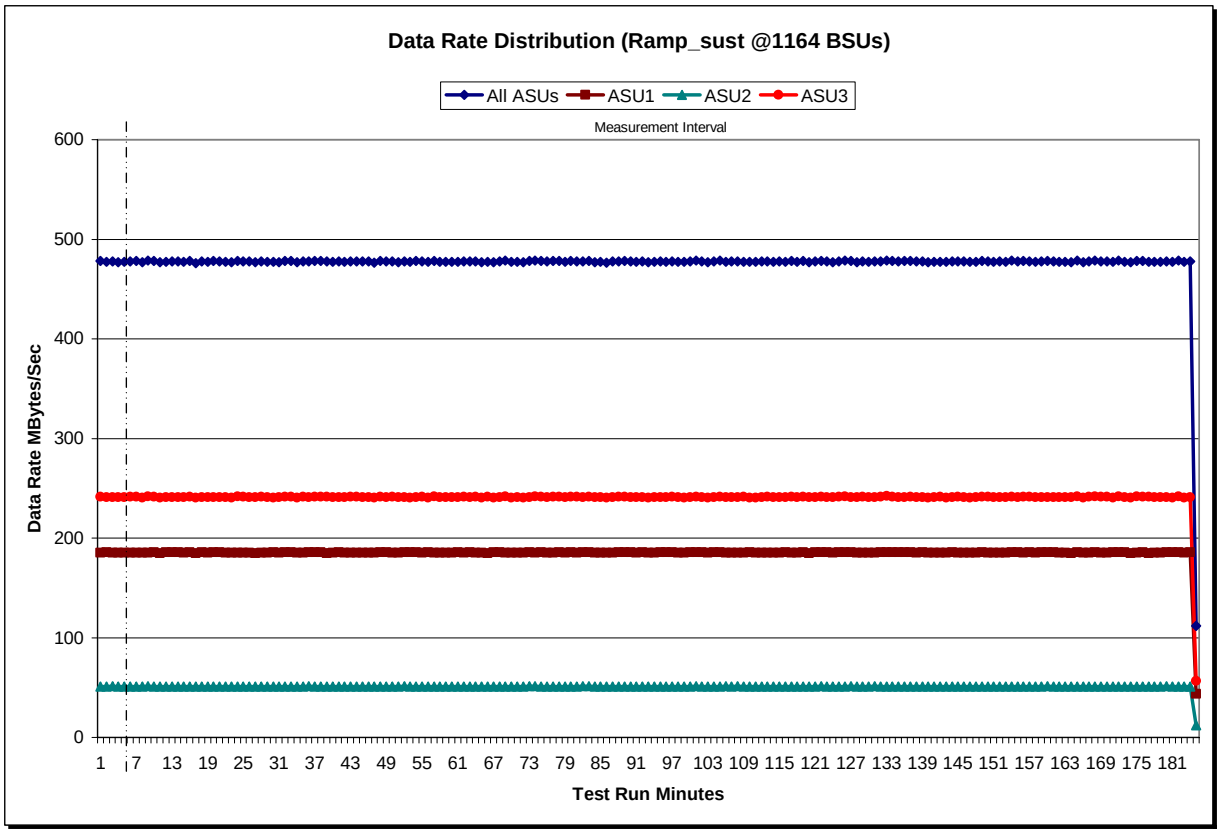
Sustainability Test Results File

Sustainability – Data Rate Distribution Data *(MB / second)*

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	17:46:25	17:51:25	0-4	0:05:00
Measurement Interval	17:51:25	20:51:25	4-184	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	478.13	185.45	51.05	241.62	63	477.54	185.15	50.96	241.43	126	478.16	185.68	51.29	241.18
1	477.49	185.68	50.91	240.90	64	477.10	185.39	50.95	240.76	127	476.86	185.15	50.89	240.83
2	477.80	185.36	51.23	241.20	65	477.17	184.95	50.94	241.28	128	477.58	185.16	51.09	241.33
3	476.90	185.18	50.84	240.87	66	476.94	185.57	50.77	240.60	129	477.54	185.41	51.19	240.94
4	477.50	185.50	50.78	241.22	67	477.79	185.76	50.83	241.19	130	477.82	185.43	51.23	241.15
5	477.83	185.46	51.05	241.32	68	478.50	185.36	51.14	242.00	131	477.82	185.68	50.87	241.27
6	478.16	185.43	51.13	241.61	69	477.25	185.45	51.06	240.73	132	478.60	185.59	50.88	242.13
7	476.96	185.37	50.93	240.66	70	477.23	185.19	50.87	241.16	133	478.00	185.64	51.06	241.30
8	478.69	185.38	51.26	242.05	71	476.82	185.17	50.84	240.80	134	477.74	185.61	50.96	241.18
9	478.26	185.87	51.13	241.26	72	478.15	185.71	51.29	241.16	135	478.12	185.82	51.06	241.24
10	476.81	184.99	51.06	240.76	73	478.55	185.46	51.20	241.90	136	477.98	185.54	50.87	241.57
11	477.50	185.58	51.10	240.82	74	478.05	185.80	50.91	241.35	137	477.61	185.47	50.95	241.19
12	477.84	185.54	51.18	241.12	75	477.57	185.45	51.16	240.96	138	477.54	185.66	50.82	241.07
13	477.86	185.61	51.05	241.20	76	478.02	185.44	51.11	241.47	139	476.81	185.28	51.00	240.52
14	477.39	185.37	51.04	240.98	77	478.10	185.72	50.92	241.45	140	477.44	185.15	51.14	241.16
15	478.09	185.58	50.89	241.62	78	477.44	185.21	51.15	241.08	141	477.52	185.19	51.04	241.29
16	476.23	185.01	50.82	240.39	79	478.01	185.56	51.09	241.36	142	477.25	185.49	51.10	240.66
17	477.56	185.89	50.82	240.85	80	477.94	185.42	51.12	241.40	143	477.72	185.61	51.14	240.97
18	477.39	185.39	50.93	241.07	81	477.92	185.64	51.24	241.04	144	477.77	185.44	51.02	241.31
19	478.03	185.80	51.03	241.21	82	478.35	185.60	51.27	241.48	145	477.59	185.41	51.07	241.11
20	477.95	185.62	51.16	241.18	83	476.94	185.19	50.87	240.88	146	477.14	185.34	51.01	240.80
21	477.35	185.23	51.15	240.97	84	477.40	185.35	51.01	241.03	147	477.52	185.46	50.84	241.22
22	476.97	185.43	50.76	240.78	85	476.66	185.49	50.77	240.41	148	478.36	185.61	51.16	241.58
23	478.17	185.53	50.79	241.85	86	477.72	185.48	51.13	241.11	149	477.93	185.47	51.19	241.28
24	477.96	185.47	51.13	241.37	87	477.90	185.60	51.05	241.26	150	477.49	185.35	51.17	240.97
25	477.65	185.49	51.01	241.15	88	478.03	185.72	50.99	241.33	151	477.58	185.45	50.92	241.21
26	477.00	185.07	51.03	240.90	89	477.67	185.54	51.13	241.00	152	477.37	185.36	51.10	240.91
27	477.60	185.30	50.95	241.35	90	477.42	185.33	51.15	240.94	153	478.41	185.87	51.04	241.51
28	477.37	185.33	50.91	241.12	91	477.96	185.76	50.96	241.23	154	477.93	185.61	51.15	241.17
29	477.44	185.71	51.06	240.68	92	477.02	185.32	51.05	240.64	155	478.16	185.47	51.15	241.54
30	476.97	185.26	50.78	240.93	93	477.24	185.52	50.86	240.86	156	477.92	185.77	50.90	241.26
31	478.12	185.62	51.18	241.32	94	477.90	185.64	51.02	241.23	157	477.36	185.28	50.97	241.11
32	478.13	185.67	51.11	241.35	95	477.42	185.58	51.00	240.84	158	477.61	185.60	50.96	241.05
33	477.04	185.37	51.01	240.66	96	477.84	185.53	51.01	241.29	159	478.09	185.73	51.21	241.15
34	477.66	185.26	50.93	241.47	97	477.42	185.52	51.00	240.90	160	477.87	185.64	51.14	241.09
35	477.93	185.63	51.23	241.07	98	477.18	185.49	50.90	240.79	161	477.19	185.16	50.98	241.04
36	478.18	185.81	51.00	241.36	99	477.85	185.71	50.94	241.20	162	477.15	185.26	50.91	240.98
37	477.99	185.63	51.02	241.34	100	478.53	185.80	51.20	241.53	163	476.99	184.88	50.93	241.18
38	477.58	185.09	51.07	241.42	101	477.56	185.65	50.94	240.96	164	478.47	185.82	50.93	241.73
39	477.43	185.23	51.00	241.19	102	476.98	185.26	51.04	240.69	165	477.06	185.36	50.98	240.71
40	477.72	185.63	51.11	240.99	103	477.80	185.69	51.07	241.04	166	477.91	185.27	50.98	241.67
41	477.27	185.35	51.02	240.90	104	478.57	185.88	51.13	241.55	167	478.83	185.78	51.09	241.96
42	477.70	185.41	51.01	241.28	105	477.48	185.36	51.19	240.93	168	477.61	185.26	50.99	241.37
43	477.84	185.39	51.01	241.43	106	477.71	185.52	50.96	241.23	169	477.68	185.34	51.02	241.32
44	477.64	185.45	51.01	241.18	107	477.74	185.31	51.25	241.19	170	477.52	185.63	51.10	240.79
45	477.58	185.51	51.09	240.98	108	477.46	185.25	50.79	241.42	171	478.59	185.73	51.09	241.77
46	476.65	185.24	50.93	240.48	109	477.19	185.62	50.82	240.74	172	477.48	185.56	51.03	240.89
47	478.13	185.90	50.97	241.26	110	477.21	185.40	51.04	240.77	173	476.80	185.04	51.09	240.67
48	477.90	185.85	51.18	240.87	111	477.74	185.47	51.10	241.17	174	478.20	185.37	51.01	241.82
49	477.88	185.40	51.02	241.46	112	477.94	185.44	51.08	241.41	175	478.16	185.85	50.97	241.33
50	477.11	185.36	50.89	240.86	113	477.27	185.40	50.95	240.92	176	477.39	184.88	51.07	241.43
51	477.82	185.68	51.22	240.92	114	477.64	185.40	51.09	241.15	177	477.37	185.41	50.92	241.04
52	477.52	185.77	51.07	240.69	115	477.52	185.67	50.85	240.99	178	477.39	185.28	51.11	240.99
53	477.97	185.83	51.08	241.06	116	478.07	185.40	51.17	241.51	179	477.61	185.53	51.25	240.83
54	477.55	185.23	50.88	241.44	117	477.52	185.35	51.13	241.04	180	477.13	185.63	50.95	240.55
55	477.11	185.56	51.03	240.53	118	478.12	185.61	51.03	241.48	181	478.65	185.83	51.12	241.69
56	478.03	185.41	50.88	241.74	119	476.94	184.94	50.78	241.23	182	477.12	185.44	50.99	240.70
57	477.31	185.33	51.03	240.95	120	477.72	185.78	50.86	241.08	183	477.86	185.72	51.05	241.10
58	477.44	185.23	50.98	241.22	121	478.16	185.69	51.19	241.28	184	111.85	43.45	11.88	56.52
59	477.46	185.23	51.03	241.20	122	477.64	185.67	51.04	240.93					
60	477.46	185.59	50.91	240.96	123	477.03	185.16	50.99	240.88					
61	477.81	185.37	50.91	241.53	124	477.91	185.78	50.84	241.30					
62	477.75	185.57	51.04	241.15	125	478.77	185.73	51.12	241.92					

Sustainability – Data Rate Distribution Graph

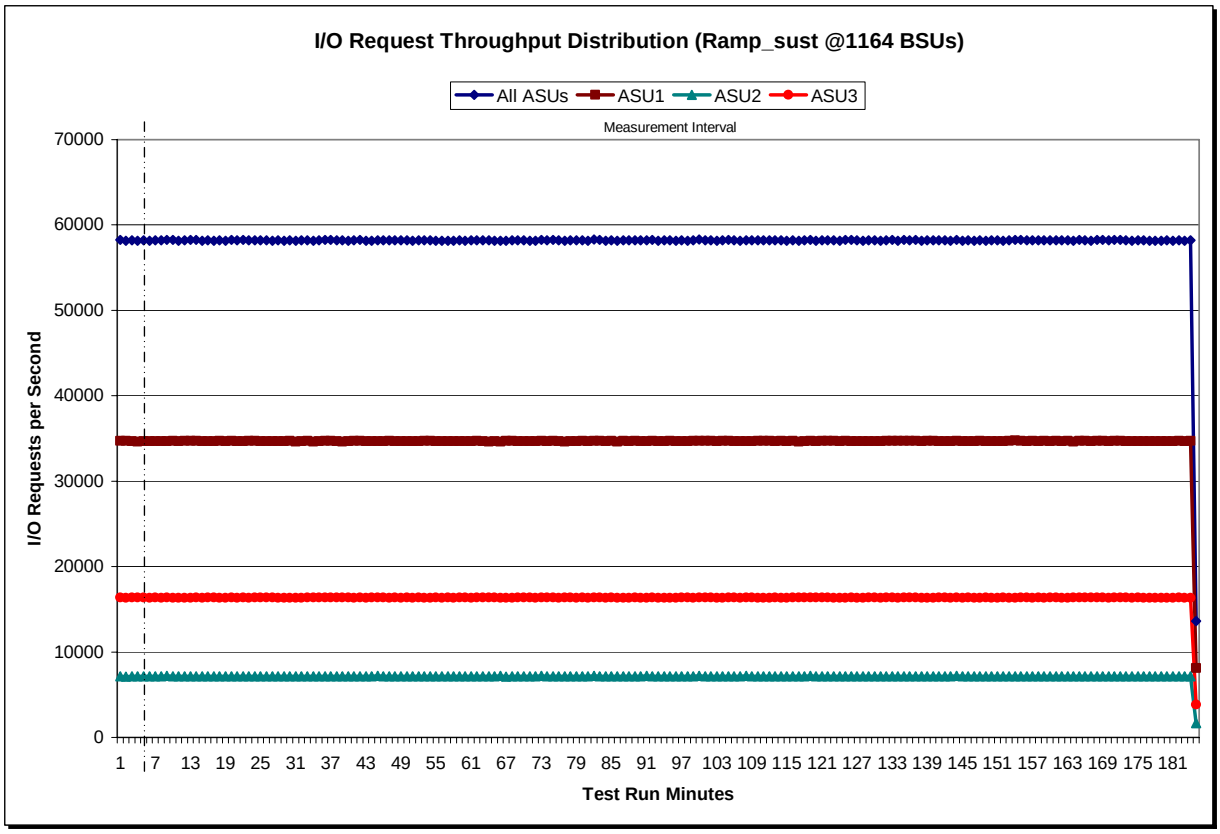


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	17:46:25	17:51:25	0-4	0:05:00
Measurement Interval	17:51:25	20:51:25	5-184	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	58,259.73	34,718.92	7,153.08	16,387.73	63	58,182.23	34,643.60	7,169.83	16,368.80	126	58,199.65	34,682.80	7,179.42	16,337.43
1	58,177.72	34,722.58	7,130.12	16,325.02	64	58,164.67	34,651.73	7,156.85	16,356.08	127	58,167.82	34,653.77	7,162.58	16,351.47
2	58,227.13	34,674.47	7,176.10	16,376.57	65	58,169.48	34,638.10	7,181.83	16,349.55	128	58,194.13	34,657.57	7,157.05	16,379.52
3	58,155.48	34,635.20	7,164.40	16,355.88	66	58,165.78	34,710.97	7,130.33	16,324.48	129	58,225.52	34,695.38	7,156.15	16,373.98
4	58,209.35	34,690.73	7,151.37	16,367.25	67	58,210.25	34,714.80	7,150.62	16,344.83	130	58,181.60	34,684.98	7,168.38	16,328.23
5	58,170.63	34,669.00	7,149.63	16,352.00	68	58,209.88	34,671.53	7,175.33	16,363.02	131	58,220.58	34,705.58	7,140.98	16,374.02
6	58,204.05	34,665.47	7,164.32	16,374.27	69	58,229.30	34,693.48	7,177.90	16,357.92	132	58,247.65	34,711.17	7,163.92	16,372.57
7	58,194.70	34,676.37	7,167.55	16,350.78	70	58,162.58	34,655.48	7,149.10	16,358.00	133	58,171.07	34,711.82	7,141.38	16,317.87
8	58,245.37	34,673.90	7,185.00	16,386.47	71	58,147.30	34,667.17	7,141.77	16,338.37	134	58,235.92	34,710.52	7,155.43	16,369.97
9	58,242.12	34,726.67	7,168.33	16,347.12	72	58,257.90	34,698.20	7,181.57	16,378.13	135	58,222.17	34,704.37	7,156.78	16,361.02
10	58,180.17	34,667.95	7,159.42	16,352.80	73	58,223.82	34,694.05	7,154.53	16,375.23	136	58,267.95	34,718.65	7,149.23	16,400.07
11	58,224.17	34,705.72	7,170.03	16,348.42	74	58,244.40	34,733.93	7,152.12	16,358.35	137	58,169.60	34,664.77	7,160.48	16,344.35
12	58,242.98	34,722.10	7,174.13	16,346.75	75	58,198.15	34,678.32	7,179.77	16,340.07	138	58,195.32	34,711.32	7,149.37	16,334.63
13	58,235.32	34,702.97	7,166.07	16,366.28	76	58,179.52	34,646.72	7,176.45	16,356.35	139	58,209.85	34,700.17	7,158.98	16,350.70
14	58,163.00	34,658.10	7,160.33	16,344.57	77	58,194.05	34,695.45	7,142.67	16,355.93	140	58,218.18	34,651.80	7,169.98	16,396.40
15	58,184.73	34,665.45	7,148.25	16,371.03	78	58,199.15	34,679.10	7,172.33	16,347.72	141	58,186.93	34,669.83	7,161.93	16,355.17
16	58,170.50	34,667.05	7,144.32	16,359.13	79	58,231.25	34,699.00	7,174.43	16,357.82	142	58,160.03	34,672.85	7,162.85	16,324.33
17	58,214.53	34,730.05	7,154.72	16,329.77	80	58,164.30	34,667.00	7,145.58	16,351.72	143	58,272.57	34,724.67	7,182.15	16,365.75
18	58,162.97	34,673.05	7,158.78	16,331.13	81	58,293.45	34,745.30	7,185.58	16,362.57	144	58,181.08	34,691.12	7,152.22	16,337.75
19	58,242.75	34,718.97	7,159.43	16,364.35	82	58,247.82	34,699.55	7,171.25	16,377.02	145	58,198.73	34,661.73	7,172.48	16,364.52
20	58,206.45	34,693.72	7,167.93	16,344.80	83	58,178.35	34,672.02	7,163.75	16,342.58	146	58,175.23	34,672.67	7,154.95	16,347.62
21	58,239.25	34,697.55	7,172.95	16,368.75	84	58,229.90	34,716.28	7,147.53	16,366.08	147	58,221.02	34,712.72	7,156.67	16,351.63
22	58,196.00	34,708.02	7,151.70	16,336.28	85	58,140.22	34,635.40	7,154.63	16,350.18	148	58,176.38	34,654.15	7,159.90	16,362.33
23	58,230.05	34,698.32	7,143.22	16,388.52	86	58,192.73	34,697.80	7,161.72	16,333.22	149	58,198.25	34,683.48	7,163.12	16,351.65
24	58,214.83	34,677.73	7,158.75	16,378.35	87	58,182.98	34,689.30	7,155.65	16,338.03	150	58,182.97	34,692.23	7,177.93	16,312.80
25	58,231.52	34,694.95	7,166.97	16,369.60	88	58,230.08	34,710.73	7,157.43	16,361.92	151	58,170.53	34,671.13	7,140.42	16,358.98
26	58,176.70	34,676.77	7,142.20	16,357.73	89	58,188.02	34,674.57	7,161.18	16,352.27	152	58,185.10	34,705.67	7,151.07	16,328.37
27	58,192.88	34,682.95	7,166.05	16,343.88	90	58,185.53	34,671.42	7,182.87	16,331.25	153	58,264.50	34,748.68	7,163.35	16,352.47
28	58,179.67	34,681.70	7,152.62	16,345.35	91	58,275.13	34,734.62	7,164.88	16,375.63	154	58,253.32	34,719.50	7,167.05	16,366.77
29	58,216.45	34,723.23	7,147.78	16,345.43	92	58,148.58	34,674.17	7,152.10	16,322.32	155	58,214.95	34,687.95	7,166.17	16,360.83
30	58,133.33	34,644.32	7,149.35	16,339.67	93	58,182.33	34,674.63	7,165.28	16,342.42	156	58,221.20	34,726.83	7,149.02	16,345.35
31	58,207.98	34,681.58	7,179.53	16,346.87	94	58,203.05	34,711.45	7,147.37	16,344.23	157	58,216.40	34,695.63	7,158.15	16,362.62
32	58,230.75	34,710.20	7,154.37	16,366.18	95	58,173.23	34,675.20	7,160.58	16,337.45	158	58,211.85	34,712.62	7,162.73	16,336.50
33	58,151.43	34,634.32	7,157.28	16,359.83	96	58,207.77	34,683.72	7,159.73	16,364.32	159	58,224.67	34,685.65	7,179.88	16,359.13
34	58,187.32	34,669.08	7,135.00	16,383.23	97	58,159.93	34,657.82	7,147.57	16,354.55	160	58,223.72	34,699.48	7,152.13	16,372.10
35	58,236.55	34,710.97	7,166.27	16,359.32	98	58,199.75	34,708.50	7,151.17	16,340.08	161	58,192.25	34,684.88	7,169.08	16,338.28
36	58,234.38	34,727.70	7,145.65	16,361.03	99	58,291.97	34,726.75	7,183.68	16,381.53	162	58,190.13	34,697.82	7,147.27	16,345.05
37	58,216.87	34,683.27	7,165.00	16,368.60	100	58,227.63	34,698.45	7,164.83	16,364.35	163	58,135.68	34,609.13	7,157.15	16,369.40
38	58,189.17	34,645.72	7,159.97	16,383.48	101	58,216.27	34,707.12	7,151.33	16,357.82	164	58,239.45	34,709.48	7,150.80	16,379.17
39	58,174.87	34,662.98	7,155.03	16,356.85	102	58,168.15	34,673.18	7,162.13	16,332.83	165	58,214.27	34,701.32	7,156.10	16,356.85
40	58,230.10	34,713.27	7,173.62	16,343.22	103	58,200.10	34,700.40	7,158.03	16,341.67	166	58,172.85	34,664.23	7,139.48	16,369.13
41	58,236.82	34,711.02	7,169.68	16,356.12	104	58,239.42	34,710.60	7,160.37	16,368.45	167	58,241.93	34,713.37	7,150.67	16,377.90
42	58,165.20	34,657.02	7,163.82	16,344.37	105	58,194.38	34,682.90	7,152.02	16,359.47	168	58,236.08	34,704.93	7,154.08	16,377.07
43	58,178.18	34,659.58	7,155.65	16,362.95	106	58,166.68	34,686.42	7,151.08	16,329.18	169	58,192.63	34,689.17	7,151.77	16,351.70
44	58,216.75	34,665.47	7,182.32	16,368.97	107	58,223.02	34,670.40	7,183.00	16,369.62	170	58,248.72	34,714.80	7,178.40	16,355.52
45	58,189.23	34,677.78	7,155.80	16,355.65	108	58,194.45	34,677.92	7,151.23	16,365.30	171	58,247.12	34,703.87	7,150.40	16,392.85
46	58,187.97	34,702.77	7,153.32	16,331.88	109	58,213.40	34,708.97	7,153.92	16,350.52	172	58,187.42	34,683.28	7,148.33	16,355.80
47	58,215.75	34,693.12	7,162.03	16,360.60	110	58,204.63	34,723.73	7,149.05	16,331.85	173	58,164.25	34,655.52	7,171.08	16,337.65
48	58,196.95	34,685.88	7,163.28	16,347.78	111	58,223.37	34,713.02	7,171.98	16,338.37	174	58,222.75	34,694.13	7,155.17	16,373.45
49	58,214.37	34,683.23	7,166.48	16,364.65	112	58,231.53	34,678.27	7,168.88	16,384.38	175	58,193.95	34,686.02	7,157.08	16,350.85
50	58,174.08	34,675.32	7,170.88	16,327.88	113	58,218.92	34,714.05	7,161.63	16,343.23	176	58,151.55	34,656.83	7,146.13	16,348.58
51	58,193.27	34,668.03	7,164.77	16,360.47	114	58,153.13	34,660.93	7,159.13	16,333.07	177	58,166.10	34,692.17	7,153.45	16,320.48
52	58,224.12	34,721.25	7,167.50	16,335.37	115	58,229.17	34,714.23	7,152.48	16,362.45	178	58,166.02	34,665.15	7,162.37	16,338.50
53	58,208.80	34,712.42	7,153.57	16,342.82	116	58,173.82	34,639.88	7,165.97	16,367.97	179	58,189.15	34,697.17	7,168.95	16,323.03
54	58,163.88	34,662.02	7,148.15	16,353.72	117	58,223.98	34,690.38	7,152.05	16,381.55	180	58,169.03	34,696.62	7,152.40	16,320.02
55	58,151.60	34,656.25	7,161.88	16,333.47	118	58,261.80	34,721.57	7,183.43	16,356.80	181	58,212.33	34,703.40	7,150.12	16,358.82
56	58,172.67	34,662.12	7,142.65	16,367.90	119	58,178.35	34,660.32	7,150.53	16,367.50	182	58,140.68	34,679.77	7,133.62	16,327.30
57	58,177.03	34,681.48	7,154.88	16,340.67	120	58,231.03	34,715.85	7,156.98	16,358.20	183	58,218.35	34,721.37	7,156.52	16,340.47
58	58,190.75	34,669.50	7,152.90	16,368.35	121	58,228.67	34,701.95	7,165.43	16,361.28	184	13,601.17	8,114.15	1,672.27	3,814.75
59	58,159.02	34,658.12	7,147.28	16,353.62	122	58,225.10	34,727.37	7,151.48	16,346.25	Average	57,954.73	34,541.02	7,129.03	16,284.68
60	58,200.03	34,695.52	7,161.67	16,342.85	123	58,164.62	34,655.25	7,164.60	16,344.77					
61	58,220.95	34,703.00	7,160.78	16,357.17	124	58,233.58	34,744.38	7,147.52	16,341.68					
62	58,191.53	34,677.30	7,149.17	16,365.07	125	58,237.07	34,696.50	7,162.80	16,377.77					

Sustainability – I/O Request Throughput Distribution Graph

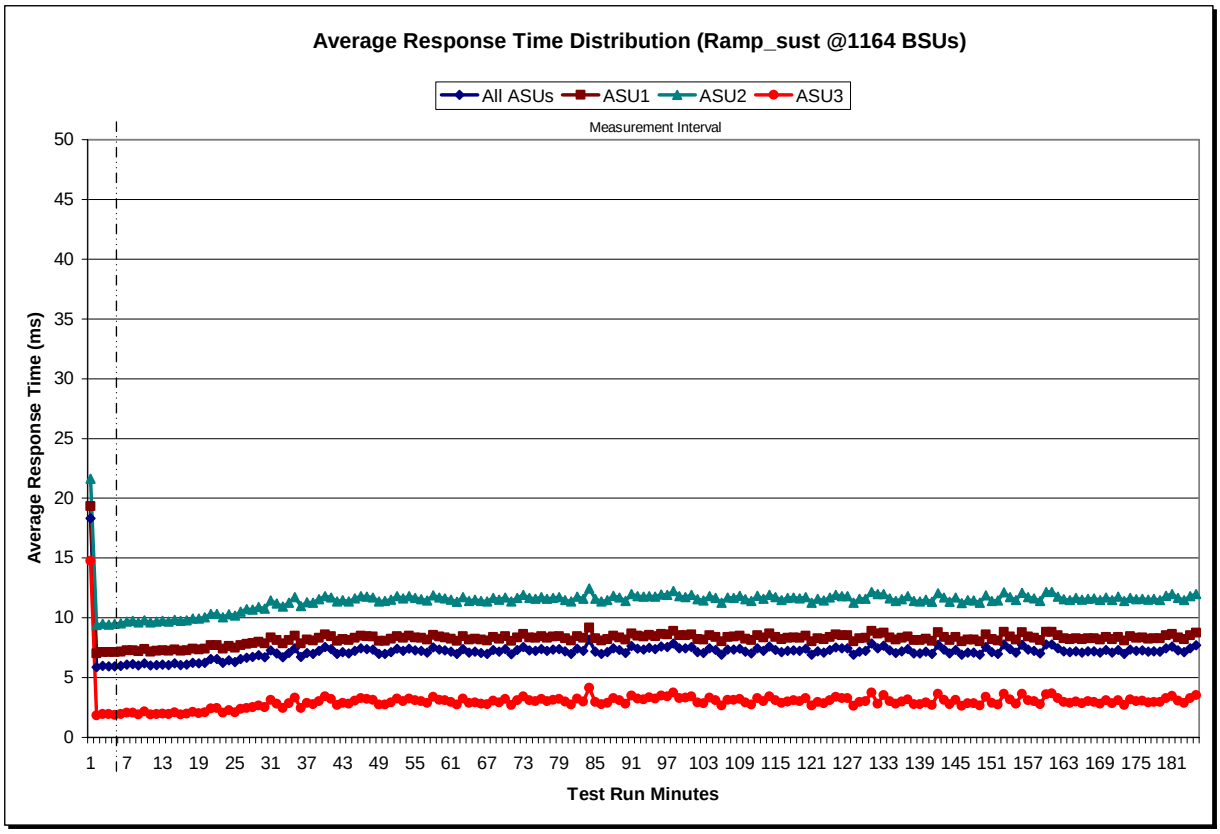


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	17:46:25	17:51:25	0-4	0:05:00
Measurement Interval	17:51:25	20:51:25	4-184	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	18.34	19.34	21.62	14.77	63	7.08	8.18	11.42	2.87	126	7.47	8.54	11.82	3.28
1	5.85	7.02	9.38	1.83	64	7.15	8.24	11.53	2.93	127	6.90	8.01	11.26	2.63
2	5.97	7.14	9.50	1.95	65	7.06	8.15	11.42	2.81	128	7.18	8.27	11.58	2.95
3	5.95	7.12	9.43	1.93	66	7.00	8.09	11.38	2.76	129	7.22	8.31	11.60	3.01
4	5.94	7.11	9.51	1.89	67	7.29	8.37	11.67	3.07	130	7.85	8.89	12.16	3.75
5	5.99	7.16	9.54	1.94	68	7.15	8.24	11.53	2.92	131	7.44	8.69	11.99	2.80
6	6.09	7.27	9.67	2.05	69	7.39	8.47	11.72	3.22	132	7.67	8.74	11.97	3.51
7	6.12	7.29	9.75	2.06	70	6.95	8.05	11.37	2.70	133	7.26	8.35	11.64	3.03
8	6.01	7.19	9.61	1.92	71	7.29	8.37	11.66	3.10	134	7.05	8.16	11.42	2.81
9	6.20	7.37	9.78	2.15	72	7.57	8.63	11.92	3.43	135	7.21	8.30	11.57	2.99
10	6.00	7.18	9.60	1.92	73	7.27	8.35	11.66	3.08	136	7.36	8.43	11.81	3.17
11	6.05	7.23	9.70	1.94	74	7.22	8.31	11.58	3.02	137	7.03	8.14	11.41	2.78
12	6.08	7.26	9.74	1.97	75	7.38	8.45	11.72	3.19	138	7.04	8.14	11.36	2.79
13	6.04	7.23	9.70	1.93	76	7.23	8.31	11.59	3.04	139	7.16	8.25	11.52	2.93
14	6.18	7.35	9.83	2.10	77	7.33	8.41	11.68	3.12	140	6.97	8.08	11.35	2.71
15	6.06	7.25	9.75	1.92	78	7.38	8.45	11.73	3.21	141	7.75	8.79	12.07	3.63
16	6.10	7.29	9.78	1.96	79	7.19	8.29	11.50	2.98	142	7.33	8.40	11.71	3.12
17	6.24	7.41	9.95	2.12	80	6.99	8.09	11.38	2.75	143	7.03	8.14	11.34	2.78
18	6.17	7.35	9.92	2.02	81	7.41	8.47	11.77	3.23	144	7.32	8.38	11.71	3.12
19	6.24	7.42	10.05	2.07	82	7.23	8.32	11.60	3.00	145	6.90	8.01	11.23	2.63
20	6.54	7.70	10.34	2.41	83	8.18	9.20	12.47	4.14	146	7.09	8.18	11.48	2.84
21	6.56	7.71	10.33	2.45	84	7.18	8.26	11.58	2.96	147	7.09	8.18	11.46	2.84
22	6.24	7.42	10.05	2.04	85	7.00	8.09	11.38	2.76	148	6.92	8.04	11.27	2.65
23	6.44	7.61	10.31	2.26	86	7.13	8.22	11.50	2.89	149	7.55	8.62	11.89	3.37
24	6.31	7.50	10.18	2.10	87	7.45	8.51	11.84	3.28	150	7.11	8.22	11.41	2.88
25	6.56	7.72	10.51	2.36	88	7.29	8.36	11.70	3.10	151	7.00	8.09	11.45	2.74
26	6.66	7.81	10.73	2.46	89	7.05	8.16	11.40	2.81	152	7.76	8.81	12.14	3.63
27	6.72	7.87	10.71	2.53	90	7.64	8.69	12.00	3.51	153	7.37	8.44	11.73	3.17
28	6.86	8.00	10.90	2.67	91	7.41	8.48	11.80	3.23	154	7.08	8.17	11.49	2.82
29	6.71	7.86	10.77	2.51	92	7.35	8.41	11.77	3.16	155	7.74	8.78	12.10	3.63
30	7.26	8.35	11.44	3.13	93	7.49	8.56	11.82	3.33	156	7.33	8.41	11.74	3.11
31	7.01	8.12	11.19	2.81	94	7.40	8.45	11.78	3.24	157	7.24	8.33	11.62	3.03
32	6.71	7.85	10.94	2.44	95	7.60	8.65	11.95	3.48	158	7.03	8.13	11.40	2.77
33	7.04	8.15	11.28	2.84	96	7.57	8.62	11.90	3.44	159	7.77	8.82	12.15	3.62
34	7.44	8.50	11.73	3.33	97	7.86	8.89	12.25	3.75	160	7.79	8.83	12.17	3.68
35	6.71	7.84	10.98	2.45	98	7.45	8.51	11.82	3.29	161	7.46	8.54	11.78	3.29
36	7.06	8.16	11.31	2.87	99	7.46	8.53	11.73	3.30	162	7.18	8.27	11.57	2.96
37	6.98	8.08	11.25	2.77	100	7.54	8.59	11.91	3.40	163	7.11	8.22	11.47	2.87
38	7.22	8.32	11.54	3.01	101	7.14	8.23	11.55	2.91	164	7.21	8.29	11.66	2.98
39	7.55	8.62	11.82	3.42	102	7.07	8.17	11.44	2.83	165	7.10	8.19	11.53	2.86
40	7.38	8.45	11.68	3.22	103	7.46	8.52	11.81	3.31	166	7.22	8.30	11.60	3.02
41	6.97	8.07	11.36	2.70	104	7.31	8.40	11.68	3.11	167	7.19	8.27	11.62	2.96
42	7.11	8.20	11.49	2.90	105	6.92	8.03	11.28	2.65	168	7.08	8.18	11.50	2.83
43	7.03	8.13	11.38	2.81	106	7.33	8.40	11.70	3.12	169	7.31	8.39	11.69	3.10
44	7.24	8.32	11.62	3.04	107	7.33	8.41	11.67	3.13	170	7.10	8.20	11.50	2.85
45	7.44	8.51	11.81	3.27	108	7.41	8.48	11.84	3.22	171	7.31	8.38	11.76	3.10
46	7.39	8.45	11.78	3.21	109	7.16	8.25	11.56	2.93	172	6.98	8.08	11.42	2.71
47	7.34	8.42	11.71	3.15	110	7.02	8.12	11.43	2.75	173	7.36	8.44	11.68	3.15
48	6.98	8.08	11.37	2.73	111	7.46	8.52	11.83	3.29	174	7.23	8.33	11.55	3.01
49	6.97	8.05	11.42	2.72	112	7.24	8.33	11.59	3.03	175	7.27	8.35	11.61	3.07
50	7.14	8.23	11.50	2.92	113	7.59	8.66	11.92	3.43	176	7.15	8.25	11.53	2.92
51	7.41	8.46	11.81	3.25	114	7.31	8.38	11.72	3.10	177	7.18	8.26	11.59	2.96
52	7.24	8.32	11.61	3.03	115	7.13	8.22	11.49	2.89	178	7.17	8.27	11.50	2.94
53	7.42	8.48	11.80	3.24	116	7.23	8.31	11.66	2.99	179	7.45	8.52	11.83	3.26
54	7.28	8.35	11.68	3.09	117	7.28	8.36	11.68	3.08	180	7.60	8.64	11.97	3.46
55	7.23	8.31	11.57	3.02	118	7.24	8.33	11.61	3.02	181	7.27	8.34	11.68	3.06
56	7.09	8.19	11.44	2.87	119	7.43	8.50	11.75	3.27	182	7.12	8.21	11.49	2.90
57	7.51	8.56	11.87	3.37	120	6.91	8.03	11.25	2.65	183	7.46	8.54	11.82	3.26
58	7.34	8.41	11.69	3.15	121	7.20	8.29	11.58	2.97	184	7.69	8.76	11.98	3.54
59	7.28	8.35	11.62	3.11	122	7.10	8.21	11.45	2.86	Average	7.13	8.23	11.41	2.94
60	7.16	8.24	11.53	2.94	123	7.30	8.37	11.69	3.09					
61	6.98	8.08	11.35	2.73	124	7.54	8.59	11.90	3.38					
62	7.38	8.44	11.72	3.23	125	7.44	8.51	11.82	3.26					

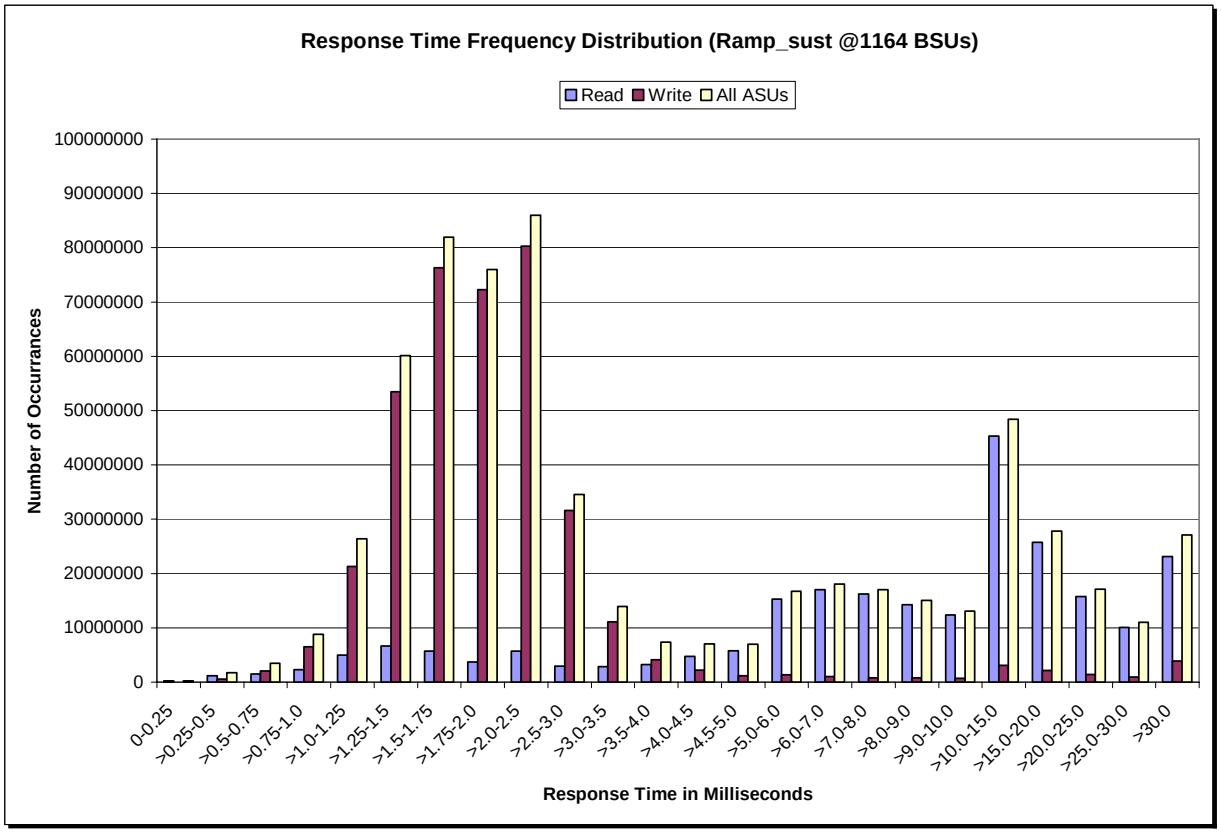
Sustainability – Average Response Time (ms) Distribution Graph



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	204,152	1,180,948	1,493,733	2,316,037	5,029,014	6,640,343	5,696,043	3,757,812
Write	25,780	555,856	2,021,029	6,495,464	21,325,502	53,500,144	76,271,159	72,229,088
All ASUs	229,932	1,736,804	3,514,762	8,811,501	26,354,516	60,140,487	81,967,202	75,986,900
ASU1	207,000	1,374,683	2,273,912	4,815,833	13,374,304	28,984,488	37,993,374	34,294,388
ASU2	16,563	152,070	392,482	1,189,698	3,604,247	7,493,821	9,523,272	8,446,813
ASU3	6,369	210,051	848,368	2,805,970	9,375,965	23,662,178	34,450,556	33,245,699
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	5,730,010	2,948,806	2,867,532	3,280,933	4,782,668	5,764,425	15,311,323	17,026,160
Write	80,273,423	31,579,698	11,085,004	4,092,101	2,230,901	1,211,659	1,369,107	1,001,695
All ASUs	86,003,433	34,528,504	13,952,536	7,373,034	7,013,569	6,976,084	16,680,430	18,027,855
ASU1	37,892,525	15,566,042	7,167,700	4,770,421	5,453,648	5,953,884	14,860,741	16,056,580
ASU2	9,383,242	3,607,039	1,352,574	606,798	471,395	430,838	1,152,390	1,482,720
ASU3	38,727,666	15,355,423	5,432,262	1,995,815	1,088,526	591,362	667,299	488,555
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	16,236,162	14,278,159	12,361,015	45,285,838	25,727,943	15,736,240	10,040,725	23,167,060
Write	802,069	785,213	710,222	3,091,997	2,113,607	1,402,233	978,180	3,896,832
All ASUs	17,038,231	15,063,372	13,071,237	48,377,835	27,841,550	17,138,473	11,018,905	27,063,892
ASU1	15,109,132	13,183,098	11,355,013	41,387,472	22,972,710	13,545,292	8,287,375	16,163,362
ASU2	1,536,888	1,497,656	1,367,764	5,470,055	3,817,456	2,886,862	2,230,765	8,880,144
ASU3	392,211	382,618	348,460	1,520,308	1,051,384	706,319	500,765	2,020,386

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 5.1.0 and 5.3.13.2

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). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.*

Clause 5.3.13.3

COV – Coefficient of Variation: *This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.*

	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	0.003	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Primary Metrics Test – IOPS Test Phase

Clause 5.4.2.2

The IOPS Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of ten (10) minutes. The IOPS Test Phase immediately follows the Sustainability Test Phase without any interruption or manual intervention.

The IOPS Test Run generates the SPC-1 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 9.2.4.7.2

For the IOPS Test Phase the FDR shall contain:

1. *I/O Request Throughput Distribution (data and graph).*
2. *A Response Time Frequency Distribution.*
3. *An Average Response Time Distribution.*
4. *The human readable Test Run Results File produced by the Workload Generator.*
5. *A listing or screen image of all input parameters supplied t the Workload Generator.*
6. *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-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

IOPS Test Results File

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

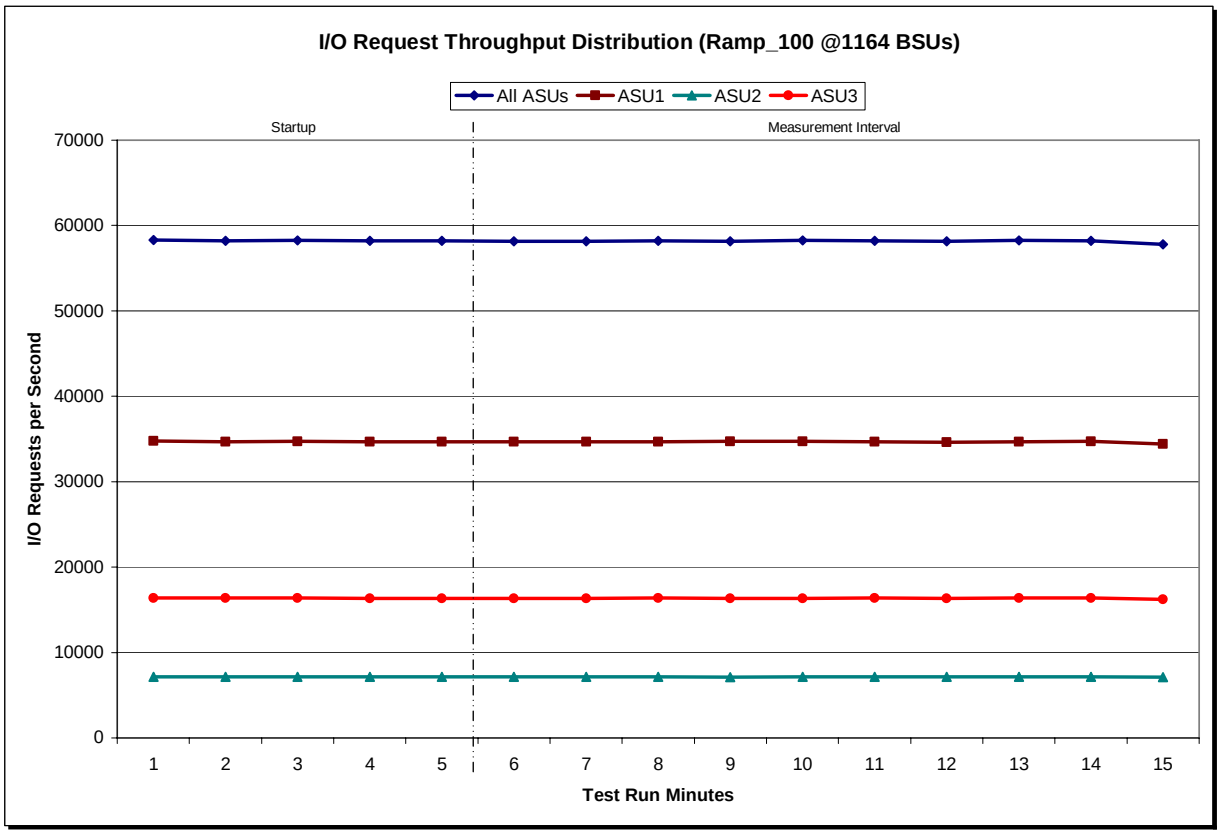
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:51:57	20:56:58	0-4	0:05:01
Measurement Interval	20:56:58	21:06:58	3-14	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	58,319.28	34,774.22	7,179.98	16,365.08
1	58,201.95	34,680.55	7,152.97	16,368.43
2	58,265.25	34,727.88	7,167.85	16,369.52
3	58,222.08	34,694.98	7,175.57	16,351.53
4	58,203.08	34,686.18	7,167.60	16,349.30
5	58,176.52	34,666.75	7,163.40	16,346.37
6	58,163.60	34,653.63	7,157.50	16,352.47
7	58,210.88	34,679.32	7,172.37	16,359.20
8	58,167.15	34,707.58	7,130.12	16,329.45
9	58,237.38	34,723.75	7,166.85	16,346.78
10	58,213.42	34,675.62	7,165.87	16,371.93
11	58,146.95	34,646.30	7,150.82	16,349.83
12	58,256.87	34,695.80	7,178.97	16,382.10
13	58,232.53	34,703.53	7,171.83	16,357.17
14	57,781.60	34,429.28	7,112.08	16,240.23
Average	58,158.69	34,658.16	7,156.98	16,343.55

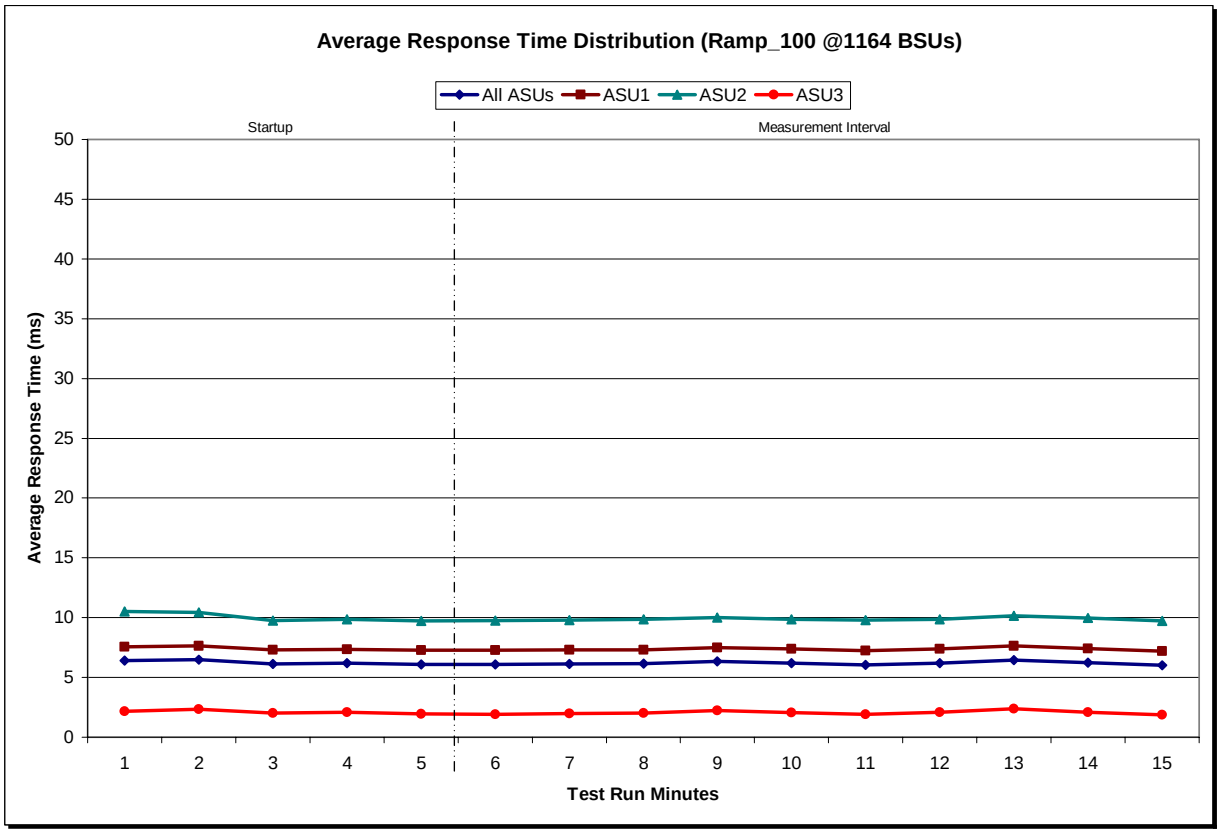
IOPS Test Run – I/O Request Throughput Distribution Graph



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

1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:51:57	20:56:58	0-4	0:05:01
Measurement Interval	20:56:58	21:06:58	3-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.40	7.56	10.52	2.14
1	6.47	7.62	10.42	2.33
2	6.12	7.29	9.76	2.03
3	6.18	7.36	9.85	2.08
4	6.07	7.26	9.72	1.94
5	6.07	7.26	9.76	1.93
6	6.11	7.30	9.78	1.99
7	6.15	7.32	9.86	2.02
8	6.32	7.49	10.00	2.23
9	6.19	7.38	9.86	2.06
10	6.06	7.25	9.79	1.92
11	6.20	7.38	9.88	2.07
12	6.46	7.62	10.15	2.37
13	6.23	7.41	9.98	2.08
14	6.02	7.21	9.73	1.88
Average	6.18	7.36	9.88	2.06

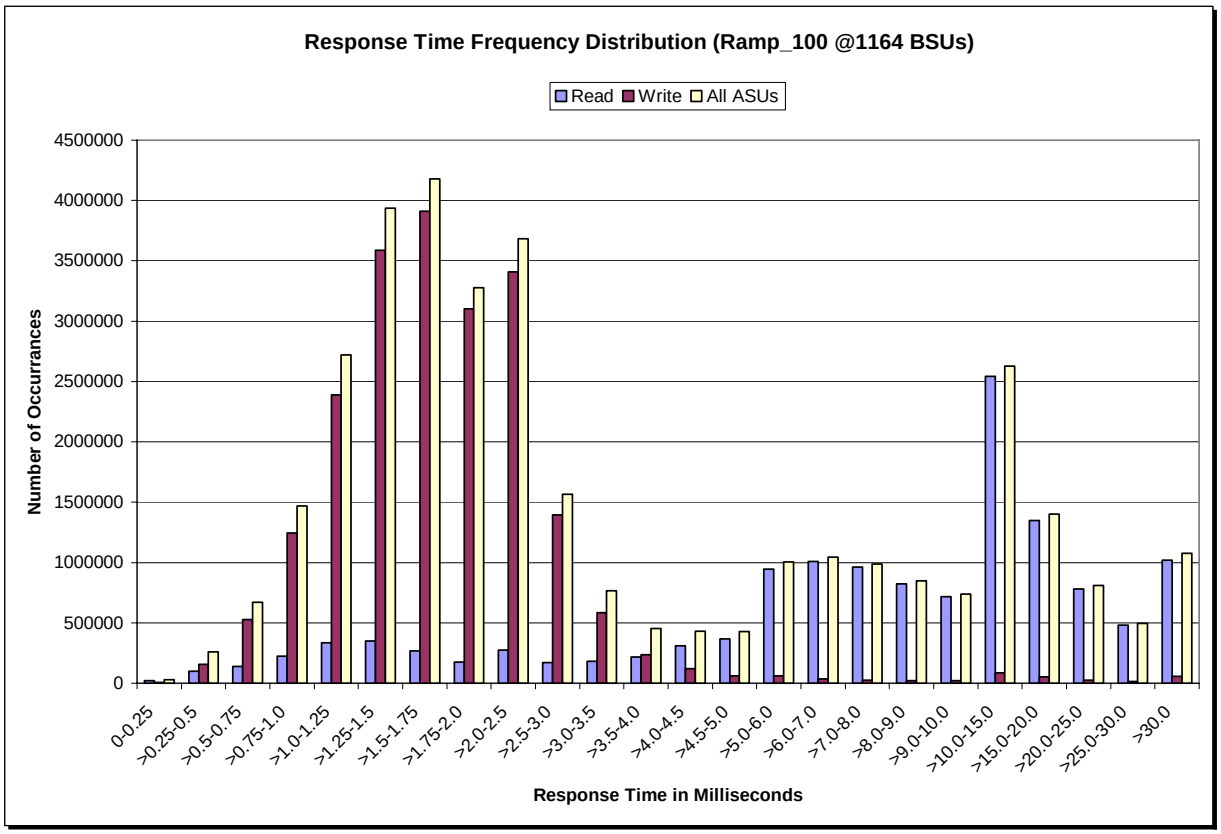
IOPS Test Run – Average Response Time (ms) Distribution Graph



IOPS Test Run – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	21888	101,482	140,045	226,395	333,706	349,509	267,183	173,222
Write	7326	158,606	528,756	1,243,357	2,388,214	3,587,790	3,910,968	3,102,526
All ASUs	29214	260,088	668,801	1,469,752	2,721,920	3,937,299	4,178,151	3,275,748
ASU1	25030	172,759	362,604	737,699	1,315,636	1,840,211	1,892,591	1,457,501
ASU2	2359	27,414	82,721	188,291	342,271	469,068	472,939	358,864
ASU3	1825	59,915	223,476	543,762	1,064,013	1,628,020	1,812,621	1,459,383
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	274,904	170,768	180,943	217,271	309,998	366,096	945,139	1,008,145
Write	3,407,781	1,393,988	585,191	234,147	122,765	61,412	60,145	35,054
All ASUs	3,682,685	1,564,756	766,134	451,418	432,763	427,508	1,005,284	1,043,199
ASU1	1,623,553	720,851	404,906	300,381	343,676	370,017	901,319	934,210
ASU2	398,318	161,501	72,924	36,218	29,289	27,564	75,227	92,567
ASU3	1,660,814	682,404	288,304	114,819	59,798	29,927	28,738	16,422
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	962,310	825,058	717,196	2,541,866	1,346,819	781,816	480,158	1,020,372
Write	24,127	22,283	19,800	86,693	54,317	26,358	14,302	56,998
All ASUs	986,437	847,341	736,996	2,628,559	1,401,136	808,174	494,460	1,077,370
ASU1	879,131	744,264	645,552	2,268,687	1,167,595	647,528	377,440	661,744
ASU2	96,354	93,046	82,477	321,035	209,531	149,770	111,390	393,046
ASU3	10,952	10,031	8,967	38,837	24,010	10,876	5,630	22,580

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
34,895,193	1,077,370	33,817,823

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 5.1.0 and 5.3.13.2

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). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.*

Clause 5.3.13.3

COV – Coefficient of Variation: *This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.*

	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	0.0701	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.2.3

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-1 IOPS™ primary metric. Each of the five Test Runs has a Measurement Interval of ten (10) 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-1 LRT™ metric. That value represents the Average Response Time of a lightly loaded TSC.

Clause 9.2.4.7.3

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

1. *A Response Time Ramp Distribution.*
2. *The human readable Test Run Results File produced by the Workload Generator for each Test Run within the Response Time Ramp Test Phase.*
3. *For the 10% Load Level Test Run (SPC-1 LRT™ metric) an Average Response Time Distribution.*
4. *A listing or screen image of all input parameters supplied to the Workload Generator.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

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-1 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 - 1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:51:57	20:56:58	0-4	0:05:01
Measurement Interval	20:56:58	21:06:58	5-14	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	58,319.28	34,774.22	7,179.98	16,365.08
1	58,201.95	34,680.55	7,152.97	16,368.43
2	58,265.25	34,727.88	7,167.85	16,369.52
3	58,222.08	34,694.98	7,175.57	16,351.53
4	58,203.08	34,686.18	7,167.60	16,349.30
5	58,176.52	34,666.75	7,163.40	16,346.37
6	58,163.60	34,653.63	7,157.50	16,352.47
7	58,210.88	34,679.32	7,172.37	16,359.20
8	58,167.15	34,707.58	7,130.12	16,329.45
9	58,237.38	34,723.75	7,166.85	16,346.78
10	58,213.42	34,675.62	7,165.87	16,371.93
11	58,146.95	34,646.30	7,150.82	16,349.83
12	58,256.87	34,695.80	7,178.97	16,382.10
13	58,232.53	34,703.53	7,171.83	16,357.17
14	57,781.60	34,429.28	7,112.08	16,240.23
Average	58,158.69	34,658.16	7,156.98	16,343.55

95% Load Level - 1105 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:07:27	21:12:28	0-4	0:05:01
Measurement Interval	21:12:28	21:22:28	5-14	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	55,861.82	33,295.33	6,870.18	15,696.30
1	55,261.42	32,939.35	6,809.12	15,512.95
2	55,262.95	32,924.82	6,800.03	15,538.10
3	55,257.35	32,930.27	6,781.70	15,545.38
4	55,245.52	32,931.92	6,786.98	15,526.62
5	55,266.33	32,936.63	6,789.07	15,540.63
6	55,221.55	32,889.55	6,794.30	15,537.70
7	55,194.98	32,863.75	6,793.20	15,538.03
8	55,223.90	32,908.15	6,793.50	15,522.25
9	55,234.75	32,917.12	6,790.72	15,526.92
10	55,280.55	32,941.42	6,796.93	15,542.20
11	55,255.62	32,942.05	6,799.98	15,513.58
12	55,274.63	32,968.70	6,787.57	15,518.37
13	55,271.20	32,940.12	6,796.72	15,534.37
14	51,377.83	30,634.55	6,312.62	14,430.67
Average	54,860.14	32,694.20	6,745.46	15,420.47

90% Load Level - 1047 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:22:58	21:27:59	0-4	0:05:01
Measurement Interval	21:27:59	21:37:59	5-14	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	52,939.63	31,551.68	6,498.10	14,889.85
1	52,358.32	31,215.85	6,445.83	14,696.63
2	52,331.13	31,175.97	6,452.73	14,702.43
3	52,344.02	31,175.35	6,453.92	14,714.75
4	52,360.78	31,207.92	6,445.73	14,707.13
5	52,368.52	31,213.97	6,445.03	14,709.52
6	52,330.82	31,190.57	6,436.38	14,703.87
7	52,376.60	31,205.98	6,446.45	14,724.17
8	52,327.95	31,197.25	6,422.67	14,708.03
9	52,370.60	31,232.40	6,436.58	14,701.62
10	52,390.48	31,218.72	6,443.62	14,728.15
11	52,377.33	31,221.55	6,455.37	14,700.42
12	52,334.15	31,149.30	6,444.20	14,740.65
13	52,370.63	31,212.23	6,441.67	14,716.73
14	43,210.15	25,767.20	5,308.78	12,134.17
Average	51,445.72	30,660.92	6,328.08	14,456.73

80% Load Level - 931 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:38:29	21:43:30	0-4	0:05:01
Measurement Interval	21:43:30	21:53:30	5-14	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	48,770.35	29,074.33	5,998.30	13,697.72
1	46,539.98	27,738.45	5,725.55	13,075.98
2	46,552.33	27,737.15	5,720.98	13,094.20
3	46,570.42	27,736.37	5,734.82	13,099.23
4	46,566.45	27,759.63	5,719.40	13,087.42
5	46,540.50	27,775.78	5,704.52	13,060.20
6	46,520.40	27,712.92	5,740.58	13,066.90
7	46,561.98	27,740.35	5,726.72	13,094.92
8	46,559.50	27,764.98	5,711.47	13,083.05
9	46,586.93	27,770.95	5,741.08	13,074.90
10	46,529.30	27,723.40	5,729.40	13,076.50
11	46,531.82	27,728.58	5,714.45	13,088.78
12	46,552.35	27,727.75	5,736.15	13,088.45
13	46,524.53	27,753.78	5,717.32	13,053.43
14	44,314.63	26,389.55	5,459.73	12,465.35
Average	46,322.20	27,608.81	5,698.14	13,015.25

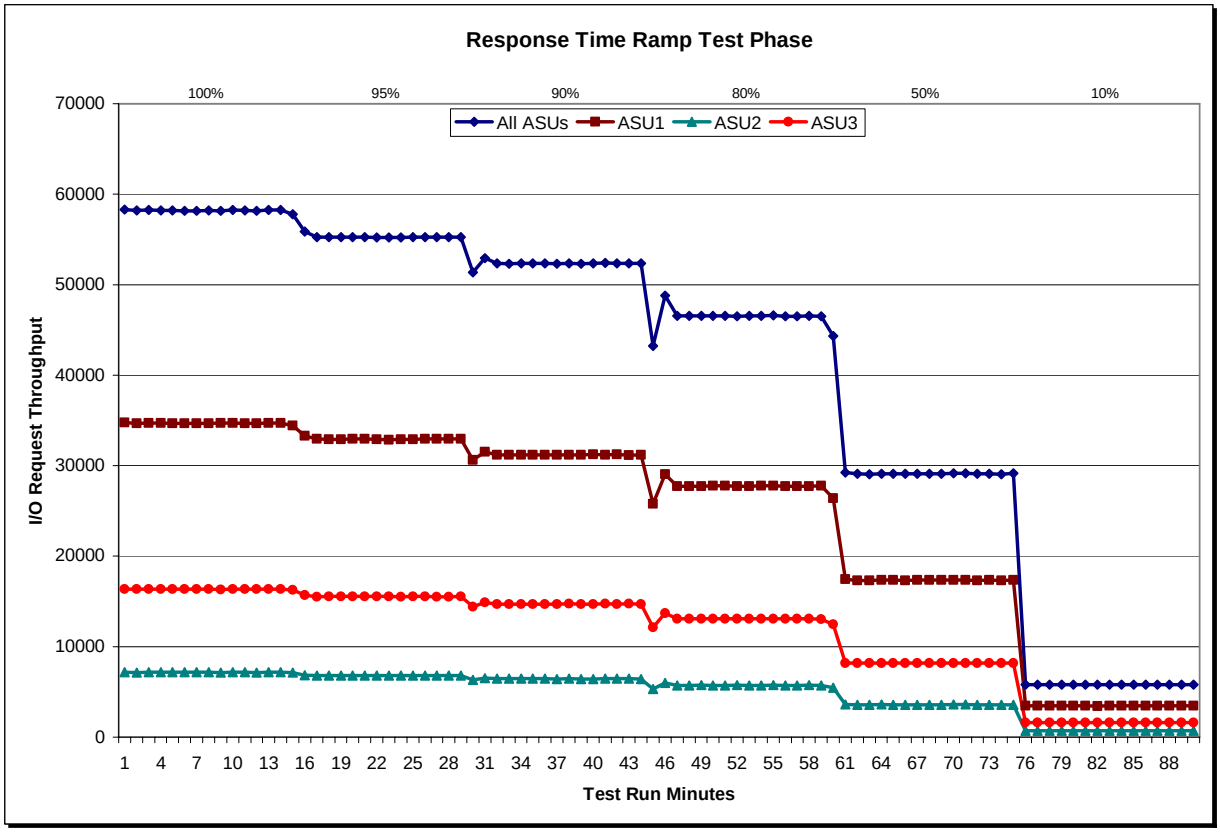
50% Load Level - 582 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:53:58	21:58:59	0-4	0:05:01
Measurement Interval	21:58:59	22:08:59	5-14	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	29,260.28	17,446.53	3,611.18	8,202.57
1	29,100.62	17,332.82	3,575.67	8,192.13
2	29,045.93	17,315.93	3,561.25	8,168.75
3	29,096.45	17,341.35	3,591.32	8,163.78
4	29,113.32	17,344.98	3,574.22	8,194.12
5	29,102.72	17,323.22	3,586.12	8,193.38
6	29,103.68	17,346.32	3,575.27	8,182.10
7	29,119.67	17,367.02	3,576.15	8,176.50
8	29,101.27	17,334.63	3,580.68	8,185.95
9	29,138.87	17,352.50	3,599.37	8,187.00
10	29,138.82	17,360.17	3,590.63	8,188.02
11	29,092.28	17,329.98	3,581.90	8,180.40
12	29,120.87	17,351.37	3,585.25	8,184.25
13	29,074.18	17,323.08	3,574.97	8,176.13
14	29,150.97	17,366.35	3,582.07	8,202.55
Average	29,114.33	17,345.46	3,583.24	8,185.63

10% Load Level - 116 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:09:26	22:14:27	0-4	0:05:01
Measurement Interval	22:14:27	22:24:27	5-14	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	5,806.78	3,468.38	712.15	1,626.25
1	5,802.88	3,451.28	714.77	1,636.83
2	5,789.92	3,452.15	712.30	1,625.47
3	5,800.55	3,464.05	707.10	1,629.40
4	5,797.13	3,457.50	713.27	1,626.37
5	5,801.13	3,453.87	715.62	1,631.65
6	5,793.62	3,447.47	710.92	1,635.23
7	5,798.48	3,452.77	714.90	1,630.82
8	5,791.78	3,448.77	714.03	1,628.98
9	5,779.75	3,447.85	708.32	1,623.58
10	5,789.95	3,453.40	712.37	1,624.18
11	5,804.53	3,463.95	704.85	1,635.73
12	5,803.45	3,452.08	715.97	1,635.40
13	5,807.45	3,466.52	709.75	1,631.18
14	5,788.22	3,456.93	708.10	1,623.18
Average	5,795.84	3,454.36	711.48	1,630.00

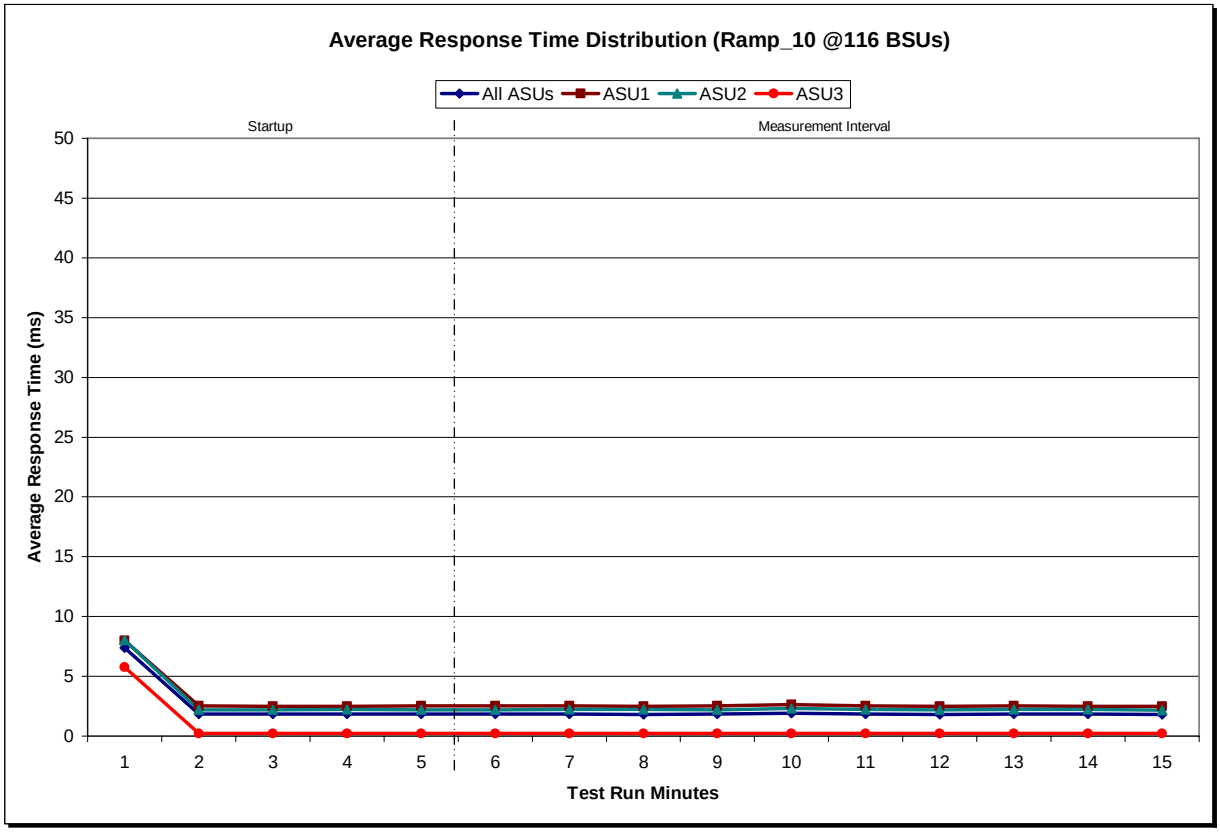
Response Time Ramp Distribution (IOPS) Graph



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

116 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:09:26	22:14:27	0-4	0:05:01
Measurement Interval	22:14:27	22:24:27	5-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	7.37	7.98	8.03	5.77
1	1.83	2.52	2.20	0.22
2	1.82	2.50	2.21	0.22
3	1.82	2.49	2.23	0.22
4	1.83	2.52	2.20	0.22
5	1.82	2.51	2.19	0.21
6	1.83	2.51	2.23	0.22
7	1.81	2.48	2.22	0.22
8	1.82	2.51	2.18	0.22
9	1.91	2.62	2.31	0.22
10	1.83	2.51	2.22	0.22
11	1.81	2.49	2.19	0.22
12	1.84	2.52	2.22	0.22
13	1.82	2.49	2.22	0.22
14	1.82	2.50	2.17	0.21
Average	1.83	2.51	2.22	0.22

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



SPC-1 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 5.1.0 and 5.3.13.2

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). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.*

Clause 5.3.13.3

COV – Coefficient of Variation: *This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.*

	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	0.2807	0.0702	0.2102	0.0181	0.0699	0.0348	0.2812
COV	0.007	0.004	0.009	0.003	0.009	0.007	0.007	0.002

Repeatability Test

Clause 5.4.5

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ primary metric and SPC-1 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 ten (10) 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-1 LRT™ metric. Each Average Response Time value must be less than the SPC-1 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-1 IOPS™ primary metric. Each I/O Request Throughput value must be greater than the SPC-1 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 9.2.4.7.4

The following content shall appear in the FDR for each Test Run in the two Repeatability Test Phases:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

Repeatability Test Results File

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

	SPC-1 IOPS™
Primary Metrics	***58,158.69***
Repeatability Test Phase 1	57,875.88
Repeatability Test Phase 2	57,941.99

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

	SPC-1 LRT™
Primary Metrics	***1.83 ms***
Repeatability Test Phase 1	1.83 ms
Repeatability Test Phase 2	1.83 ms

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

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

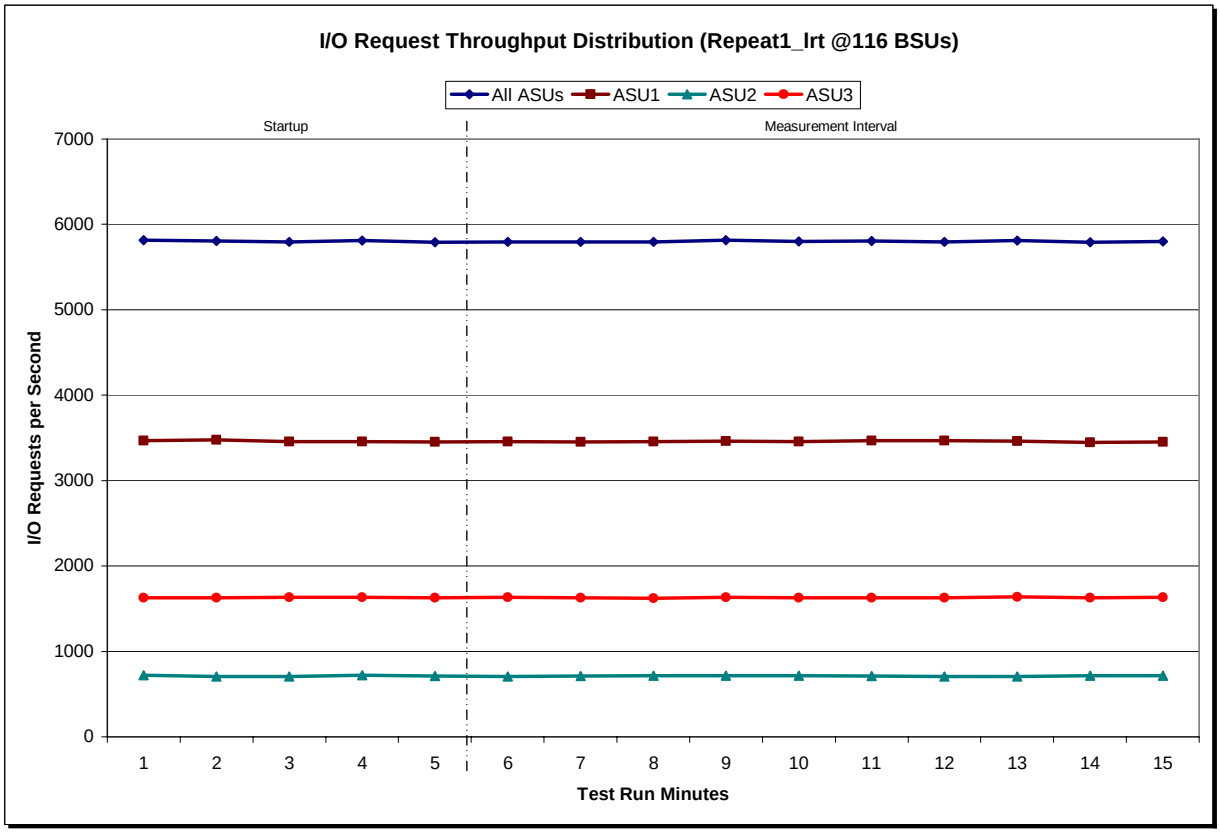
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

116 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:25:00	22:30:00	0-4	0:05:00
Measurement Interval	22:30:00	22:40:00	3-14	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5,814.30	3,466.20	718.18	1,629.92
1	5,807.85	3,475.67	704.48	1,627.70
2	5,795.97	3,457.00	706.95	1,632.02
3	5,812.43	3,457.63	720.33	1,634.47
4	5,791.67	3,449.78	712.43	1,629.45
5	5,795.93	3,455.43	706.40	1,634.10
6	5,793.98	3,452.95	712.80	1,628.23
7	5,796.20	3,458.10	714.37	1,623.73
8	5,813.67	3,463.40	716.50	1,633.77
9	5,798.30	3,456.23	713.82	1,628.25
10	5,805.87	3,466.70	709.92	1,629.25
11	5,796.72	3,465.62	704.38	1,626.72
12	5,810.42	3,464.45	705.90	1,640.07
13	5,792.97	3,448.83	716.37	1,627.77
14	5,801.13	3,452.48	714.38	1,634.27
Average	5,800.52	3,458.42	711.48	1,630.62

Repeatability 1 LRT – I/O Request Throughput Distribution Graph

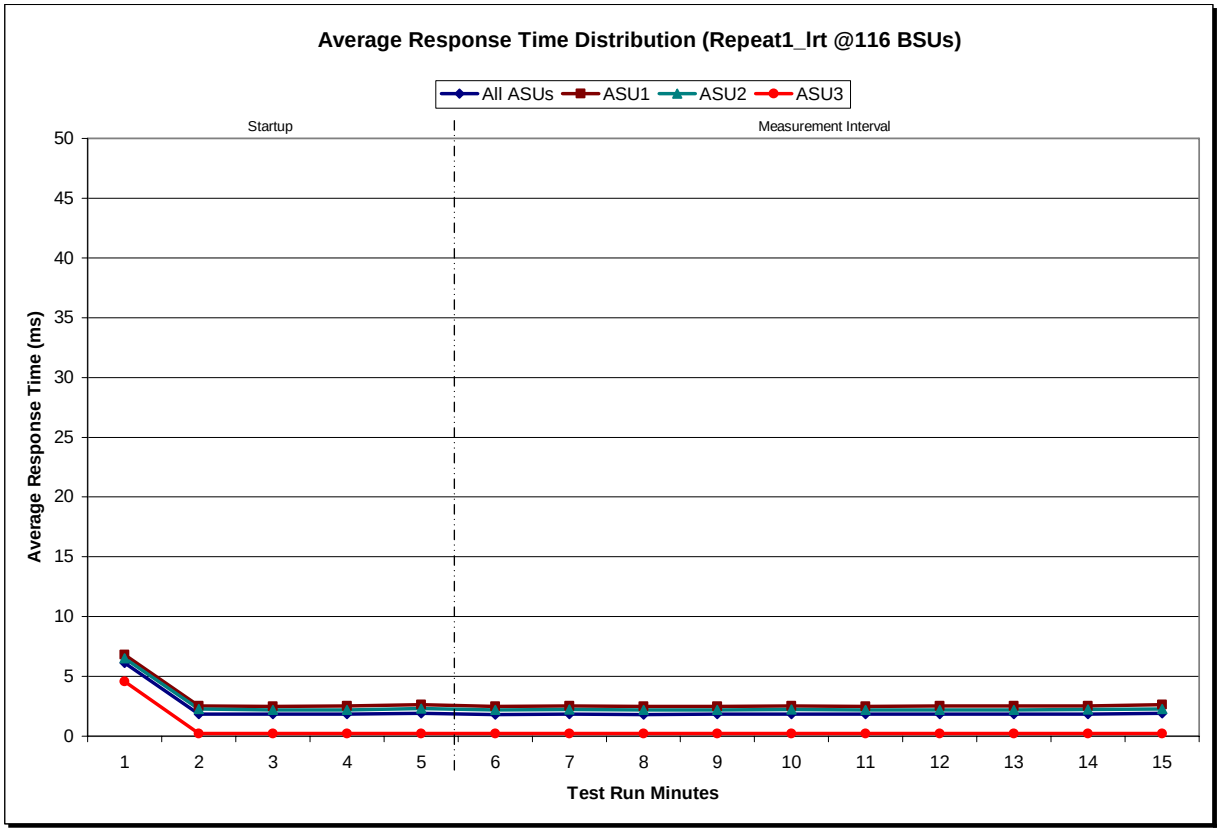


Repeatability 1 LRT –Average Response Time (ms) Distribution Data

116 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:25:00	22:30:00	0-4	0:05:00
Measurement Interval	22:30:00	22:40:00	3-14	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6.14	6.81	6.50	4.55
1	1.84	2.51	2.26	0.22
2	1.82	2.50	2.20	0.22
3	1.82	2.51	2.20	0.22
4	1.91	2.63	2.31	0.22
5	1.81	2.48	2.20	0.22
6	1.84	2.52	2.24	0.23
7	1.81	2.48	2.18	0.22
8	1.82	2.50	2.20	0.22
9	1.83	2.52	2.22	0.22
10	1.82	2.50	2.20	0.22
11	1.83	2.51	2.20	0.22
12	1.82	2.51	2.21	0.22
13	1.83	2.51	2.24	0.22
14	1.90	2.62	2.28	0.22
Average	1.83	2.51	2.22	0.22

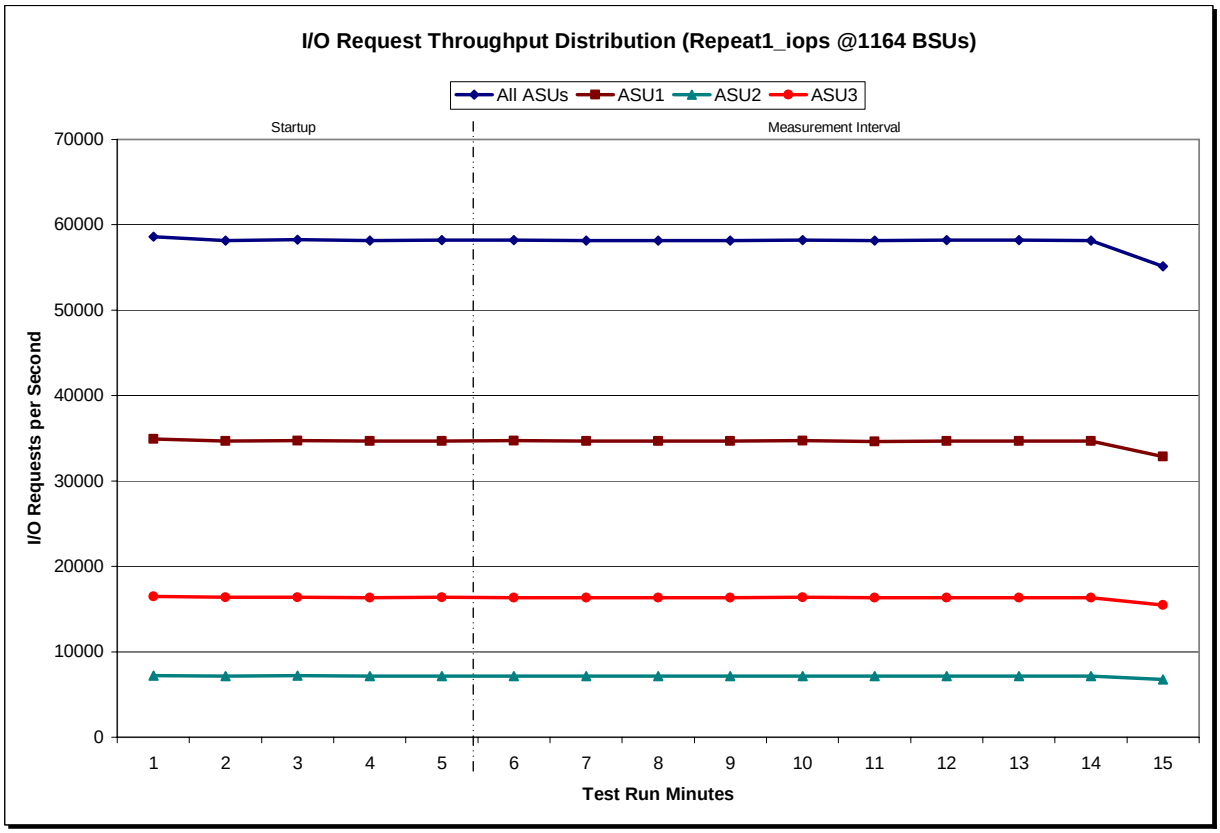
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:40:29	22:45:30	0-4	0:05:01
Measurement Interval	22:45:30	22:55:30	3-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	58,611.75	34,919.87	7,227.23	16,464.65
1	58,178.67	34,670.70	7,139.62	16,368.35
2	58,277.28	34,703.45	7,184.58	16,389.25
3	58,154.98	34,657.78	7,150.75	16,346.45
4	58,209.70	34,682.47	7,161.52	16,365.72
5	58,211.93	34,710.88	7,153.32	16,347.73
6	58,168.20	34,675.40	7,156.00	16,336.80
7	58,174.10	34,662.05	7,160.68	16,351.37
8	58,171.23	34,690.80	7,157.30	16,323.13
9	58,221.03	34,709.38	7,138.35	16,373.30
10	58,152.05	34,641.78	7,174.80	16,335.47
11	58,188.37	34,687.13	7,158.53	16,342.70
12	58,185.85	34,681.18	7,157.30	16,347.37
13	58,168.35	34,683.25	7,173.15	16,311.95
14	55,117.67	32,862.05	6,764.10	15,491.52
Average	57,875.88	34,500.39	7,119.35	16,256.13

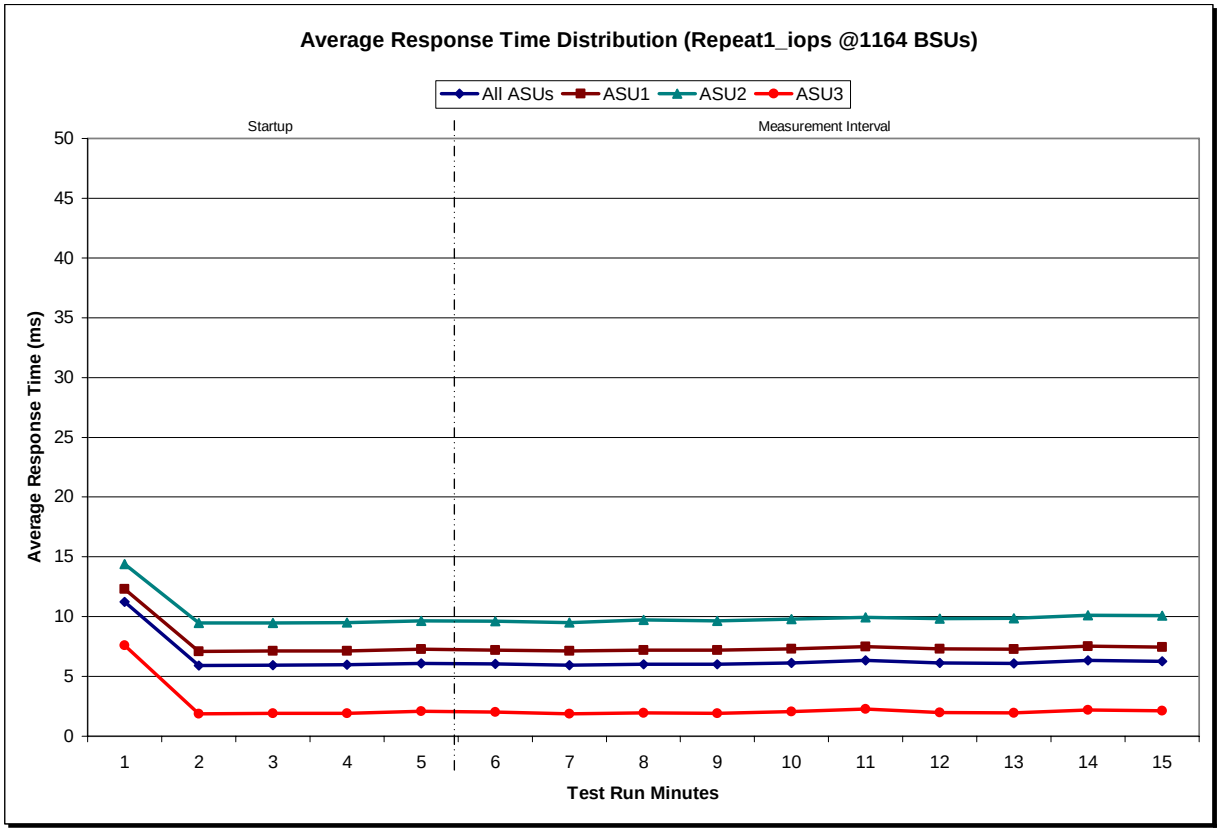
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:40:29	22:45:30	0-4	0:05:01
Measurement Interval	22:45:30	22:55:30	3-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	11.24	12.30	14.41	7.59
1	5.91	7.09	9.45	1.88
2	5.95	7.12	9.47	1.92
3	5.96	7.14	9.52	1.91
4	6.09	7.26	9.64	2.07
5	6.05	7.22	9.61	2.01
6	5.94	7.12	9.50	1.86
7	6.02	7.20	9.71	1.93
8	6.02	7.20	9.64	1.92
9	6.13	7.31	9.79	2.03
10	6.32	7.49	9.93	2.26
11	6.12	7.30	9.82	1.99
12	6.09	7.27	9.86	1.93
13	6.34	7.51	10.11	2.20
14	6.28	7.46	10.09	2.11
Average	6.13	7.31	9.81	2.02

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

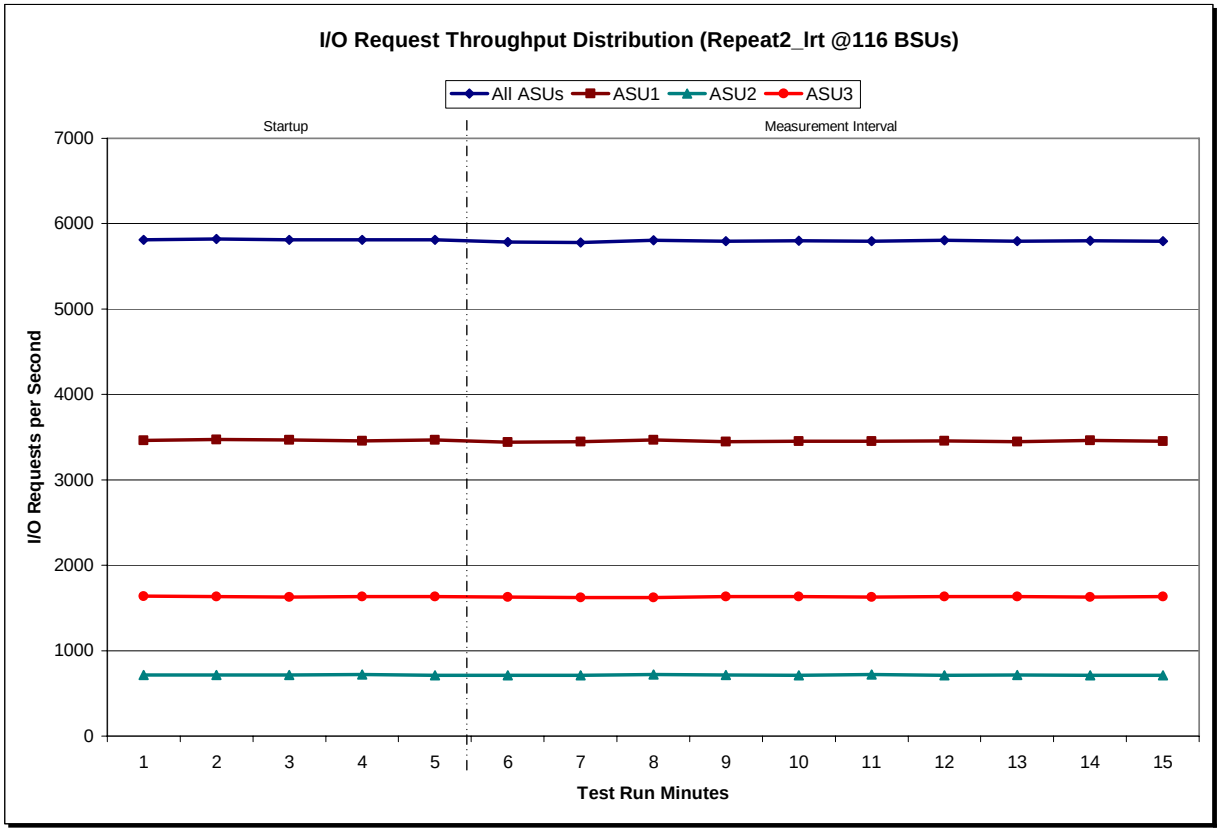


Repeatability 2 LRT – I/O Request Throughput Distribution Data

116 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:56:03	23:01:03	0-4	0:05:00
Measurement Interval	23:01:03	23:11:03	3-14	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5,810.88	3,459.70	715.68	1,635.50
1	5,818.97	3,472.87	715.33	1,630.77
2	5,810.63	3,468.63	714.15	1,627.85
3	5,810.28	3,457.27	719.60	1,633.42
4	5,811.55	3,469.23	711.77	1,630.55
5	5,784.28	3,444.23	711.38	1,628.67
6	5,778.80	3,446.02	711.53	1,621.25
7	5,807.05	3,468.15	718.18	1,620.72
8	5,794.13	3,449.18	713.33	1,631.62
9	5,799.42	3,451.72	712.83	1,634.87
10	5,797.75	3,450.80	718.73	1,628.22
11	5,803.53	3,457.90	712.15	1,633.48
12	5,797.23	3,449.35	715.93	1,631.95
13	5,801.60	3,460.25	711.12	1,630.23
14	5,795.18	3,451.98	712.58	1,630.62
Average	5,795.90	3,452.96	713.78	1,629.16

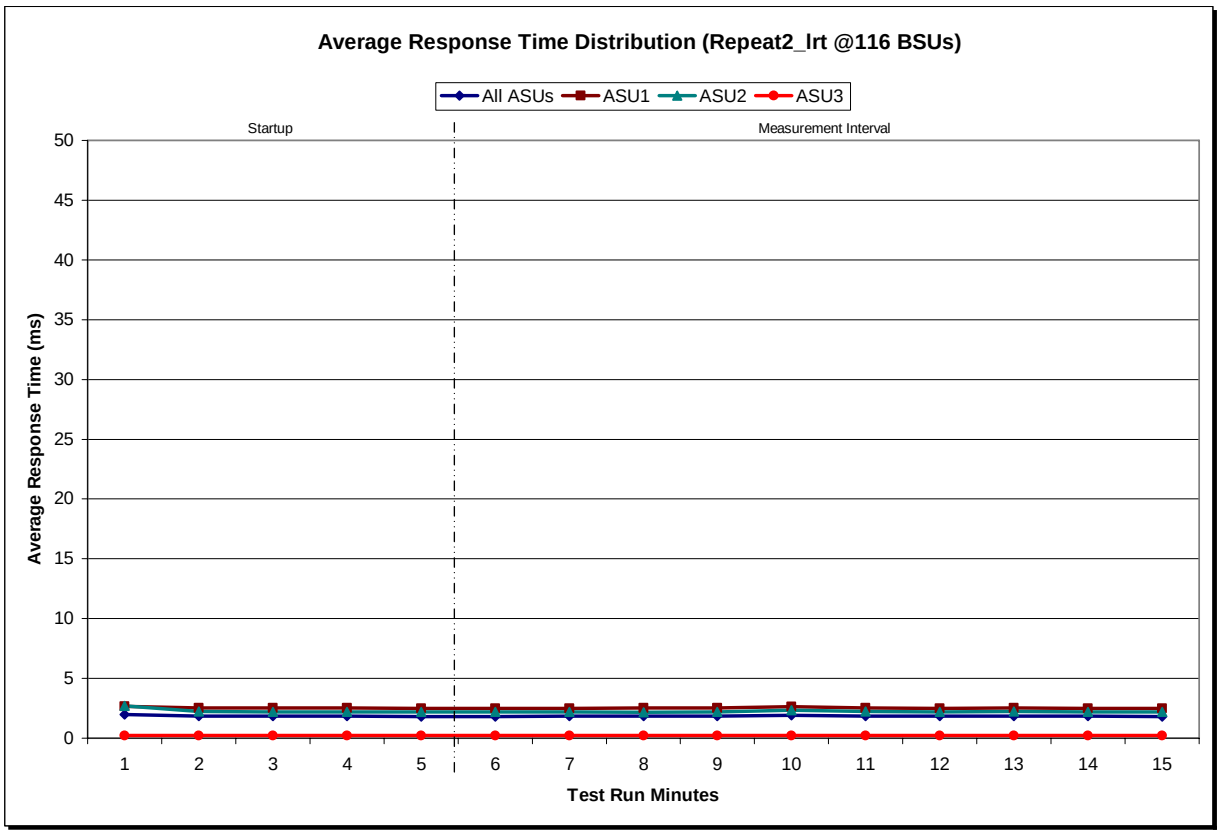
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

116 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:56:03	23:01:03	0-4	0:05:00
Measurement Interval	23:01:03	23:11:03	3-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.99	2.68	2.69	0.22
1	1.85	2.53	2.22	0.22
2	1.83	2.52	2.19	0.22
3	1.83	2.51	2.19	0.22
4	1.82	2.49	2.19	0.22
5	1.81	2.49	2.19	0.22
6	1.82	2.49	2.21	0.22
7	1.83	2.51	2.17	0.22
8	1.83	2.52	2.20	0.22
9	1.92	2.63	2.33	0.22
10	1.84	2.53	2.22	0.22
11	1.82	2.50	2.20	0.22
12	1.83	2.51	2.23	0.22
13	1.82	2.50	2.20	0.22
14	1.82	2.50	2.18	0.22
Average	1.83	2.52	2.21	0.22

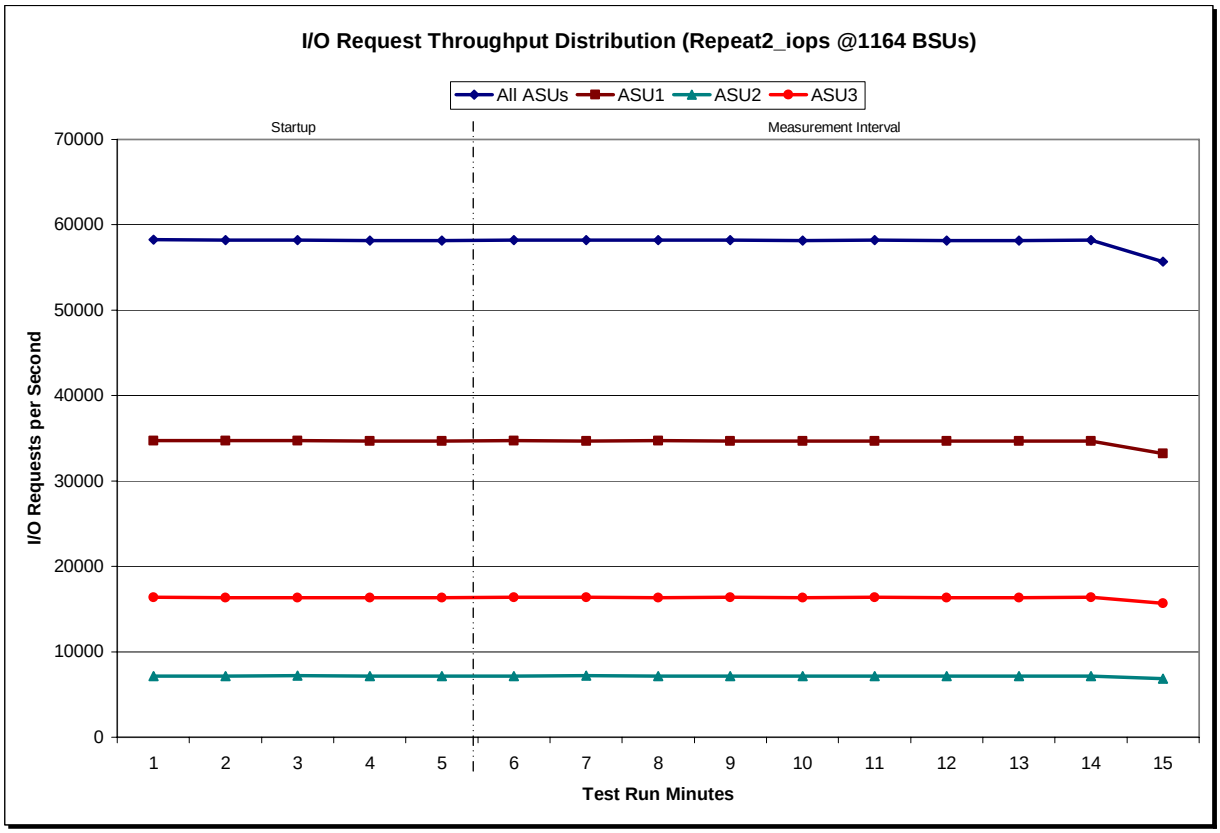
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:11:32	23:16:33	0-4	0:05:01
Measurement Interval	23:16:33	23:26:33	3-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	58,241.65	34,720.05	7,158.98	16,362.62
1	58,206.57	34,711.57	7,163.13	16,331.87
2	58,197.77	34,697.85	7,185.18	16,314.73
3	58,174.03	34,695.35	7,148.83	16,329.85
4	58,179.27	34,665.18	7,163.50	16,350.58
5	58,202.28	34,698.70	7,131.28	16,372.30
6	58,219.55	34,673.23	7,183.60	16,362.72
7	58,213.18	34,716.43	7,144.20	16,352.55
8	58,213.13	34,669.42	7,158.27	16,385.45
9	58,161.88	34,666.35	7,152.22	16,343.32
10	58,186.20	34,687.08	7,142.12	16,357.00
11	58,148.45	34,655.48	7,154.28	16,338.68
12	58,176.00	34,688.33	7,148.93	16,338.73
13	58,199.20	34,658.17	7,154.22	16,386.82
14	55,699.98	33,191.68	6,848.05	15,660.25
Average	57,941.99	34,530.49	7,121.72	16,289.78

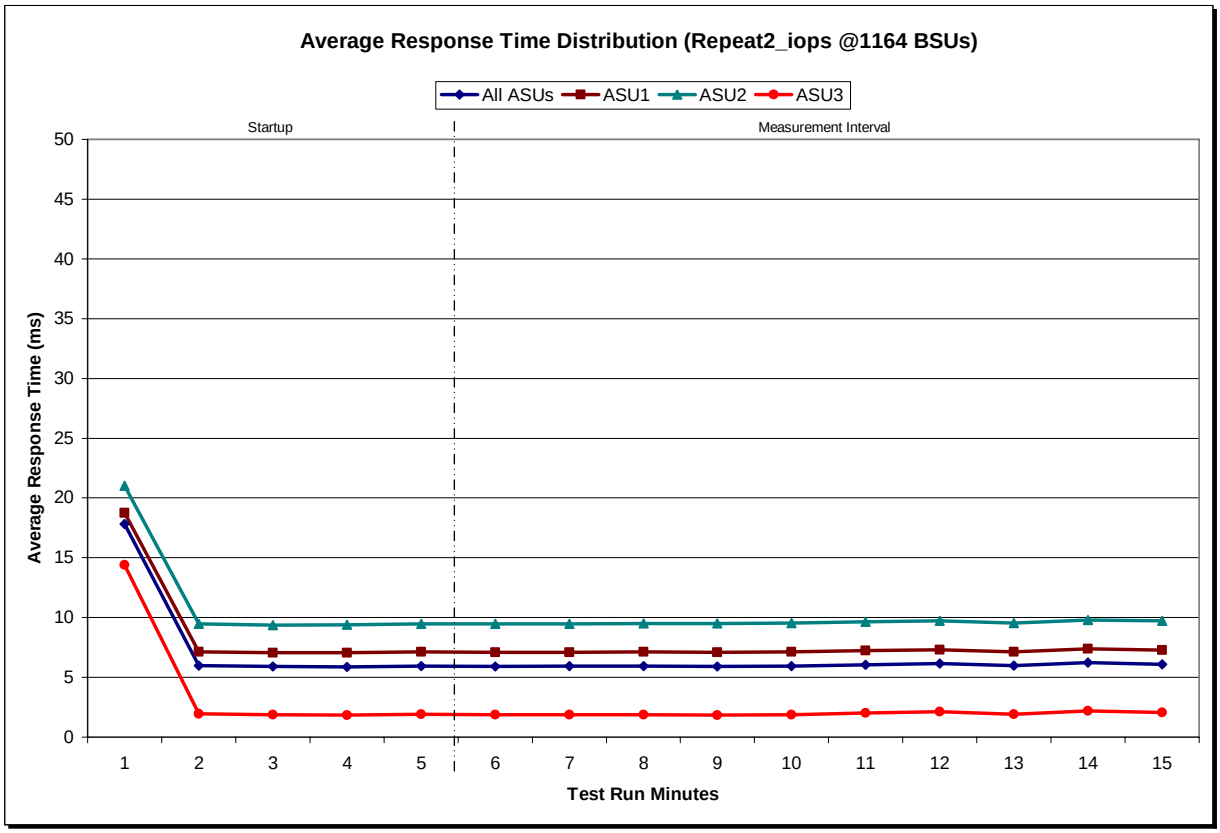
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

1164 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:11:32	23:16:33	0-4	0:05:01
Measurement Interval	23:16:33	23:26:33	3-14	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	17.81	18.76	21.02	14.41
1	5.96	7.13	9.45	1.95
2	5.89	7.06	9.35	1.86
3	5.88	7.06	9.39	1.85
4	5.94	7.11	9.48	1.90
5	5.92	7.10	9.47	1.88
6	5.93	7.11	9.48	1.89
7	5.94	7.12	9.51	1.89
8	5.90	7.08	9.49	1.84
9	5.94	7.13	9.52	1.87
10	6.06	7.24	9.63	2.00
11	6.15	7.32	9.73	2.12
12	5.96	7.14	9.53	1.89
13	6.22	7.39	9.77	2.20
14	6.09	7.26	9.70	2.05
Average	6.01	7.19	9.58	1.96

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 5.1.0 and 5.3.13.2

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). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.*

Clause 5.3.13.3

COV – Coefficient of Variation: *This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.*

	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	0.2811	0.0701	0.2101	0.0180	0.0698	0.0349	0.2811
COV	0.011	0.003	0.006	0.003	0.011	0.009	0.007	0.002

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	0.2811	0.0700	0.2100	0.0180	0.0701	0.0350	0.2809
COV	0.003	0.001	0.002	0.001	0.004	0.003	0.003	0.001

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	0.0349	0.2809	0.0698	0.2102	0.0181	0.0701	0.0350	0.2811
COV	0.010	0.003	0.005	0.004	0.012	0.005	0.007	0.003

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	0.2810	0.0699	0.2100	0.0179	0.0700	0.0350	0.2811
COV	0.003	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Data Persistence Test

Clause 6

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-1 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-1 IOP™ 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 Benchmark 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-1 Workload Generator will then use the above log file to verify each block written contains the correct bit pattern.

Clause 9.2.4.8

The following content shall appear in this section of the FDR:

1. *A listing or screen image of all input parameters supplied to the Workload Generator.*
2. *For the successful Data Persistence Test Run, a table illustrating key results. The content, appearance, and format of this table are specified in Table 9-12. Information displayed in this table shall be obtained from the Test Run Results File referenced below in #3.*
3. *For the successful Data Persistence Test Run, the human readable Test Run Results File produced by the Workload Generator.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

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	26,691,280
Total Number of Logical Blocks Verified	25,228,736
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 9.2.4.9

The committed delivery data 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.

The FDR shall state: "The Priced Storage Configuration, as documented in this Full Disclosure Report will be available for shipment to customers on MMMM DD, YYYY." Where Priced Storage Configuration is the TSC Configuration Name as described in Clause 9.2.4.3.3 and MMMM is the alphanumeric month, DD is the numeric day, and YYYY is the numeric year of the date that the Priced Storage Configuration, as documented, is available for shipment to customers as described above.

The IBM System Storage DS5300 as documented in this Full Disclosure Report will become September 5, 2008 for customer purchase and shipment.

PRICING INFORMATION

Clause 9.2.4.11

A statement of the respective calculations for pricing must be included.

Clause 9.2.4.11.3

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration must be included.

Pricing information may found in the Tested Storage Configuration Pricing section on page 13. A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 13.

ANOMALIES OR IRREGULARITIES

Clause 9.2.4.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the IBM System Storage DS5300.

APPENDIX A: SPC-1 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-1 Data Repository Definitions

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

Application Storage Unit (ASU): The logical interface between the storage and SPC-1 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-1 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-1 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-1 Data Protection Levels

RAID5: User data is distributed across the disks in the array. Check data corresponding to user data is distributed across multiple disks in the form of bit-by-bit parity.

Mirroring: Two or more identical copies of user data are maintained on separate disks.

Other Protection Level: Any data protection other than **RAID5** or **Mirroring**.

Unprotected: There is no data protection provided.

SPC-1 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-1 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-1 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-1 test result or support an SPC-1 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.

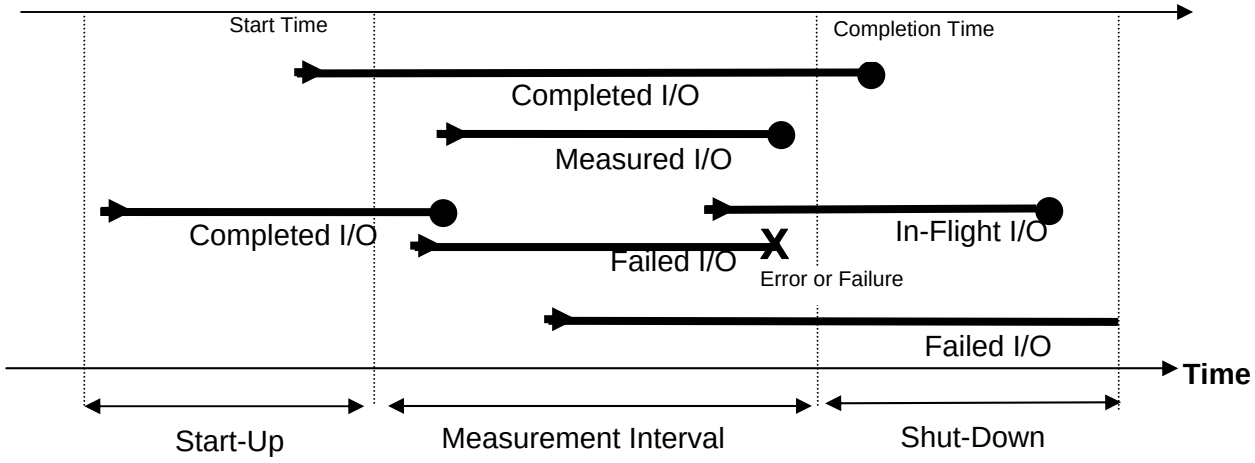
Test: A collection of Test Phases and or Test Runs sharing a common objective.

Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up

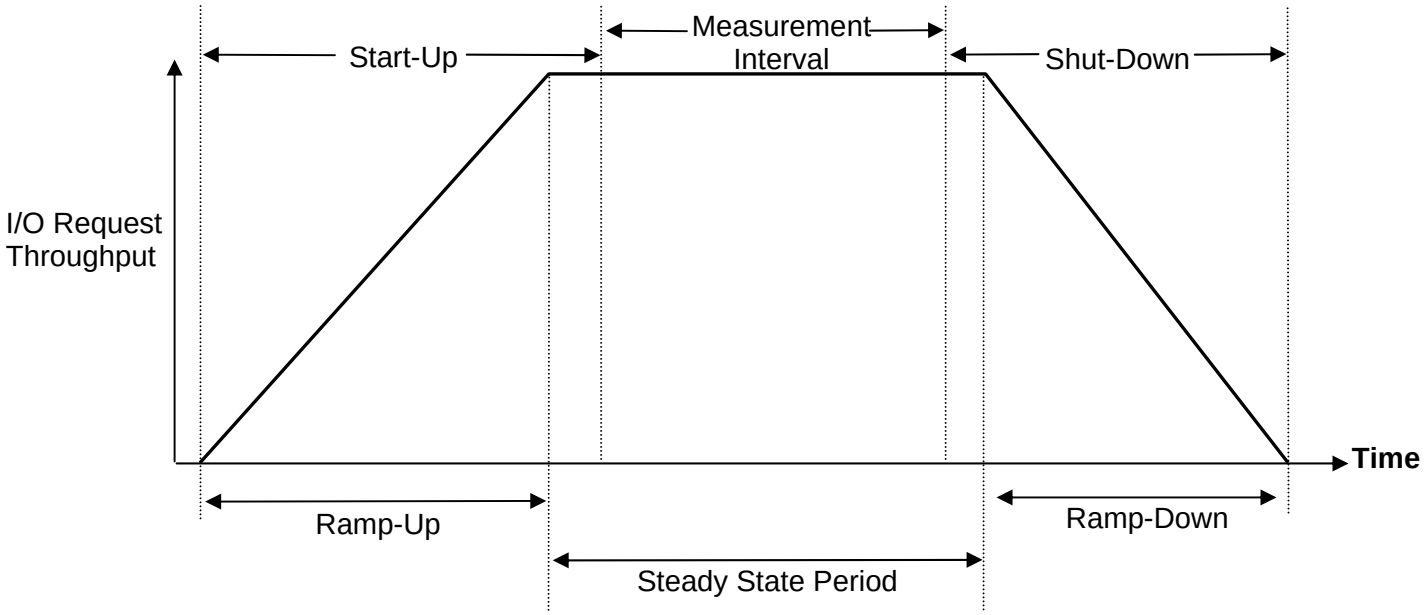
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

Windows 2003 Registry Changes

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\
ql2300\Device\MaximumSGList=0xff

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\
ql2300\Device\NumberOfRequests=0xfe

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\
Disk\TimeOutValue=0x78

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\
ql2300\Device\DriverParameters=UseSameNN=1;BusChange=0;
```

Storage Array Cache Flush Settings

Start Flush: changed from default of 80 to new value of 50

Stop Flush: changed from default of 80 to new value of 50

RDAC Failover Options

Host Region	Offset	Default	New Value
3	0x24	1	0
9	0x24	1	0
10	0x24	1	0
11	0x24	1	0
12	0x24	1	0
13	0x24	1	0
14	0x24	1	0

Host Bus Adapter Options

The table below lists the Host Bus Adapter BIOS options that were changed from their default values.

Host Bus Adapter Settings		
Item	**Default**	**New Value**
Adapter Settings:		
Loop Reset Delay	5	8
Adapter Hard Loop ID	Disabled	Enabled
Hard Loop ID (unique for each)	0	Eg. 22
Fibre Channel Tape Support	Enabled	Disabled
Advanced Adapter Settings:		
Execution Throttle	16	255
LUNs per Target	8	0
Login Retry Count	8	30
Port Down Retry Count	8	70
Link Down Timeout	30	60

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The storage management utility, SANtricity, was used to create sixteen volume groups on the storage subsystem, each volume group contains a single volume. The SANtricity script is included in this section. These sixteen volumes are visible by each of the attached hosts. There are four hosts used in this benchmark. One host is the "master". The other three are "slave" hosts. Each host is configured with three JVM's. The steps that follow are required to define the Windows partitions, volumes, and stripe sets that will be used by the SPC-1 benchmark. Steps 1-8 below are performed on only one of the hosts.

1. Use diskpar.exe to set the starting offset for each of the storage system volumes. Starting offset is 65536. Use all of the remaining capacity in the partition.
2. Start Windows Disk Administrator.
3. Convert all of the storage system volumes to Dynamic Disks.
4. Create a Windows Striped (RAID 0) volume using all sixteen 32MB volumes.
5. Delete the large volume on each of the Dynamic Disks.
6. Create a Windows Striped (RAID 0) volume for ASU 3.
   a. Select all sixteen volumes.
   b. Set capacity to 81910MB.
   c. Assign drive letter "N" to the volume. Do not format the volume.
7. Create the Windows Striped (RAID0) volume for ASU 1.
   a. Select all sixteen volumes.
   b. Set capacity to 368595MB.
   c. Assign drive letter "L" to the volume. Do not format the volume.
8. Create the Windows Striped (RAID 0) volume for ASU 2.
   a. Select all sixteen volumes.
   b. Set capacity to 368595MB.
   c. Assign drive letter "M" to the volume. Do not format the volume.
9. Reboot all four host systems.
10. After reboot completes, start Disk Administrator on each of the host systems.
11. Import foreign disks, or reactive the Windows stripe sets as necessary. On each host, assign drive letters to the stripe sets as they were assigned in steps 6, 7, and 8.

SPC1_XBB2_16_8plus8r1_128kseg_16tray

```
/* 16 8+8 drive groups for XBB-2  */

create volume drives[ 10,1 10,2  30,1 30,2  50,1 50,2  70,1 70,2  10,3 10,4  30,3
30,4  50,3 50,4  70,3 70,4 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_0"
volumeGroupUserLabel="VolumeGroup_0"
capacity=899 gb
```

```
owner = A;

create volume drives[ 10,5 10,6  30,5 30,6  50,5 50,6  70,5 70,6  10,7 10,8  30,7
30,8  50,7 50,8  70,7 70,8 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_1"
volumeGroupUserLabel="VolumeGroup_1"
capacity=899 gb
owner = A;

create volume drives[ 10,9 10,10  30,9 30,10  50,9 50,10  70,9 70,10  10,11 10,12
30,11 30,12  50,11 50,12  70,11 70,12 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_2"
volumeGroupUserLabel="VolumeGroup_2"
capacity=899 gb
owner = A;

create volume drives[ 10,13 10,14  30,13 30,14  50,13 50,14  70,13 70,14  10,15
10,16  30,15 30,16  50,15 50,16  70,15 70,16 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_3"
volumeGroupUserLabel="VolumeGroup_3"
capacity=899 gb
owner = A;

create volume drives[ 11,1 11,2  31,1 31,2  51,1 51,2  71,1 71,2  11,3 11,4  31,3
31,4  51,3 51,4  71,3 71,4 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_4"
volumeGroupUserLabel="VolumeGroup_4"
capacity=899 gb
owner = A;

create volume drives[ 11,5 11,6  31,5 31,6  51,5 51,6  71,5 71,6  11,7 11,8  31,7
31,8  51,7 51,8  71,7 71,8 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_5"
volumeGroupUserLabel="VolumeGroup_5"
capacity=899 gb
owner = A;

create volume drives[ 11,9 11,10  31,9 31,10  51,9 51,10  71,9 71,10  11,11 11,12
31,11 31,12  51,11 51,12  71,11 71,12 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_6"
volumeGroupUserLabel="VolumeGroup_6"
capacity=899 gb
owner = A;

create volume drives[ 11,13 11,14  31,13 31,14  51,13 51,14  71,13 71,14  11,15
11,16  31,15 31,16  51,15 51,16  71,15 71,16 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_7"
volumeGroupUserLabel="VolumeGroup_7"
capacity=899 gb
```

```
  owner = A;

  create volume drives[ 20,1 20,2  40,1 40,2  60,1 60,2  80,1 80,2  20,3 20,4  40,3
  40,4  60,3 60,4  80,3 80,4 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_8"
  volumeGroupUserLabel="VolumeGroup_8"
  capacity=899 gb
  owner = b;

  create volume drives[ 20,5 20,6  40,5 40,6  60,5 60,6  80,5 80,6  20,7 20,8  40,7
  40,8  60,7 60,8  80,7 80,8 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_9"
  volumeGroupUserLabel="VolumeGroup_9"
  capacity=899 gb
  owner = b;

  create volume drives[ 20,9 20,10  40,9 40,10  60,9 60,10  80,9 80,10  20,11 20,12
  40,11 40,12  60,11 60,12  80,11 80,12 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_10"
  volumeGroupUserLabel="VolumeGroup_10"
  capacity=899 gb
  owner = b;

  create volume drives[ 20,13 20,14  40,13 40,14  60,13 60,14  80,13 80,14  20,15
  20,16  40,15 40,16  60,15 60,16  80,15 80,16 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_11"
  volumeGroupUserLabel="VolumeGroup_11"
  capacity=899 gb
  owner = b;

  create volume drives[ 21,1 21,2  41,1 41,2  61,1 61,2  81,1 81,2  21,3 21,4  41,3
  41,4  61,3 61,4  81,3 81,4 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_12"
  volumeGroupUserLabel="VolumeGroup_12"
  capacity=899 gb
  owner = b;

  create volume drives[ 21,5 21,6  41,5 41,6  61,5 61,6  81,5 81,6  21,7 21,8  41,7
  41,8  61,7 61,8  81,7 81,8 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_13"
  volumeGroupUserLabel="VolumeGroup_13"
  capacity=899 gb
  owner = b;

  create volume drives[ 21,9 21,10  41,9 41,10  61,9 61,10  81,9 81,10  21,11 21,12
  41,11 41,12  61,11 61,12  81,11 81,12 ]
  RAIDLevel=1
  segmentSize=128
  userLabel="LUN_14"
  volumeGroupUserLabel="VolumeGroup_14"
  capacity=899 gb
```

```
owner = b;

create volume drives[ 21,13 21,14  41,13 41,14  61,13 61,14  81,13 81,14  21,15
21,16  41,15 41,16  61,15 61,16  81,15 81,16 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_15"
volumeGroupUserLabel="VolumeGroup_15"
capacity=899 gb
owner = b;

set volume["LUN_0"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_1"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_2"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_3"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_4"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_5"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_6"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_7"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_8"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_9"]  mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_10"] mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_11"] mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_12"] mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_13"] mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_14"] mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;
set volume["LUN_15"] mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = True readAheadMultiplier = 0;

set storageArray cacheBlockSize  = 8;
set storageArray cacheFlushStart = 50 cacheFlushStop  = 50;

set storageArray defaultHostType = "Windows 2000/Server 2003/Server 2008 Non-
Clustered";

set controller[a] HostNVSRAMByte[0x01, 0x17]=0x01;
set controller[b] HostNVSRAMByte[0x01, 0x17]=0x01;

/* Setup for RDAC failover environment */

set controller[a] HostNVSRAMByte[0x00, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x01, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x02, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x03, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x04, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x05, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x06, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x07, 0x24]=0x00;
```

```
set controller[a] HostNVSRAMByte[0x08, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x09, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0a, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0b, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0c, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0d, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0e, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0f, 0x24]=0x00;

set controller[b] HostNVSRAMByte[0x00, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x01, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x02, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x03, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x04, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x05, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x06, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x07, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x08, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x09, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0a, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0b, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0c, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0d, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0e, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0f, 0x24]=0x00;
```

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

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

```
host=master
slaves=(bm3850a_s1,bm3850a_s2,bm3850a_s3,bm3850b_s1,bm3850b_s2,bm3850b_s3,bm
3850c_s1,bm3850c_s2,bm3850c_s3,bm3850d_s1,bm3850d_s2,bm3850d_s3)

javaparms="-Xmx512m -Xms512m"

sd=asu1_1,lun=\\.\L:,size=6183997931520
sd=asu2_1,lun=\\.\M:,size=6183997931520
sd=asu3_1,lun=\\.\N:,size=1374221762560

eof
```

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

```
javaparms="-Xmx512m -Xms512m"

sd=asu1_1,lun=\\.\L:,size=6183997931520
sd=asu2_1,lun=\\.\M:,size=6183997931520
sd=asu3_1,lun=\\.\N:,size=1374221762560

eof
```

APPENDIX E: SPC-1 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.

```
copy /Y spc1_iops.cfg spc1.cfg

java -Xmx640m -Xms640m metrics -b 1164 -s 300

java -Xmx640m -Xms640m repeat1 -b 1164 -s 300

java -Xmx640m -Xms640m repeat2 -b 1164 -s 300

copy /Y spc1_persist.cfg spc1.cfg

java -Xmx640m -Xms640m persist1 -b 1164
```

Persistence Test Run 2

The following script was used to execute Persistence Test Run 2.

```
java -Xmx640m -Xms640m persist2
```