SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

HITACHI DATA SYSTEMS CORPORATION
HITACHI ADAPTABLE MODULAR STORAGE 2100

SPC-1 V1.10.1

Submitted for Review: March 24, 2009
Submission Identifier: A00076

First Edition – March 2009

Trademarks

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AUDIT CERTIFICATION

Mel Boksenbaum
Hitachi Data Systems Corporation
750 Central Expressway M/S 3275
Santa Clara, CA 95050

March 24, 2009

The SPC Benchmark 1™ results listed below for the Hitachi Adaptable Modular Storage 2100 were produced in compliance with the SPC Benchmark 1™ V1.10.1 Onsite Audit requirements.

SPC Benchmark 1™ V1.10.1 Results	
Tested Storage Configuration (TSC) Name: Hitachi Adaptable Modular Storage 2100	
Metric	**Reported Result**
SPC-1 IOPS™	31,498.58
SPC-1 Price-Performance	$5.85/SPC-1 IOPS™
Total ASU Capacity	3,967.500 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$187,321

The following SPC Benchmark 1™ Onsite 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 were verified by physical inspection and information supplied by Hitachi Data Systems 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).
- Physical verification of the components to mach the above diagram.

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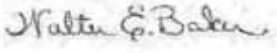
AUDIT CERTIFICATION *(CONT.)*

- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by physical inspection and information supplied by Hitachi Data Systems 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 the Host System.
  - ✓ The TSC boundary within the Host System.
- The execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from Hitachi Data Systems 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
- There were no differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 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:

SPC Auditor approval was granted to reorder the required execution sequence of SPC Tests to better utilize the time spent for onsite audit activities. The following execution sequence was used: Persistence Test Run 1, required TSC power cycle, and uninterrupted execution of Persistence Test Run 2, the Primary Metrics Test *(Sustainability Test Phase, IOP Test Phase, and Response Time Ramp Test Phase)*, and the Repeatability Test *(Repeatability Test Phase 1 and Repeatability Test Phase 2)*.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

HITACHI
Inspire the Next

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February 20, 2009

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 Hitachi Adaptable Modular Storage 2100

Hitachi Data Systems 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 specifications.

Regards,

Alan Cade
Vice President
Technical Operations

Partner Beyond Technology

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Hitachi Data Systems Corporation – http://www.hds.com Alan Davey – alan.davey@hds.com 750 Central Expressway M/S U710 Santa Clara, CA 95050 Phone (425) 427-8858 FAX: (425) 642-8055
Test Sponsor Alternate Contact	Hitachi Data Systems Corporation – http://www.hds.com Mel Boksenbaum – mel.boksenbaum@hds.com 750 Central Expressway M/S 3275 Santa Clara, CA 95050 Phone (408) 970-7922 FAX: (408) 327-3066
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	March 24, 2009
Date the FDR was submitted to the SPC	March 24, 2009
Date the TSC is available for shipment to customers	currently available
Date the TSC completed audit certification	March 23. 2009

Tested Storage Product (TSP) Description

The cost effective option with a rich set of features in a model that scales to 120 disk drives. Ideal for medium and large businesses, Hitachi Adaptable Modular Storage 2100 is an easy-to-use, scalable, storage system for Microsoft® Exchange Server, VMware, databases and other business applications.

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: Hitachi Adaptable Modular Storage 2100	
Metric	**Reported Result**
SPC-1 IOPS™	31,498.58
SPC-1 Price-Performance	$5.85/SPC-1 IOPS™
Total ASU Capacity	3,967.500 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$187,321

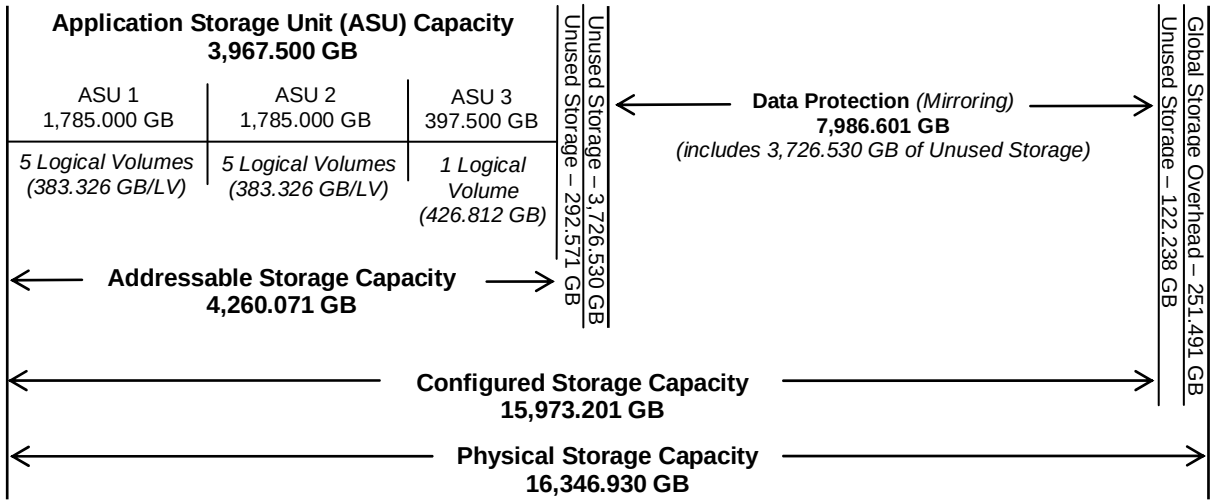
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

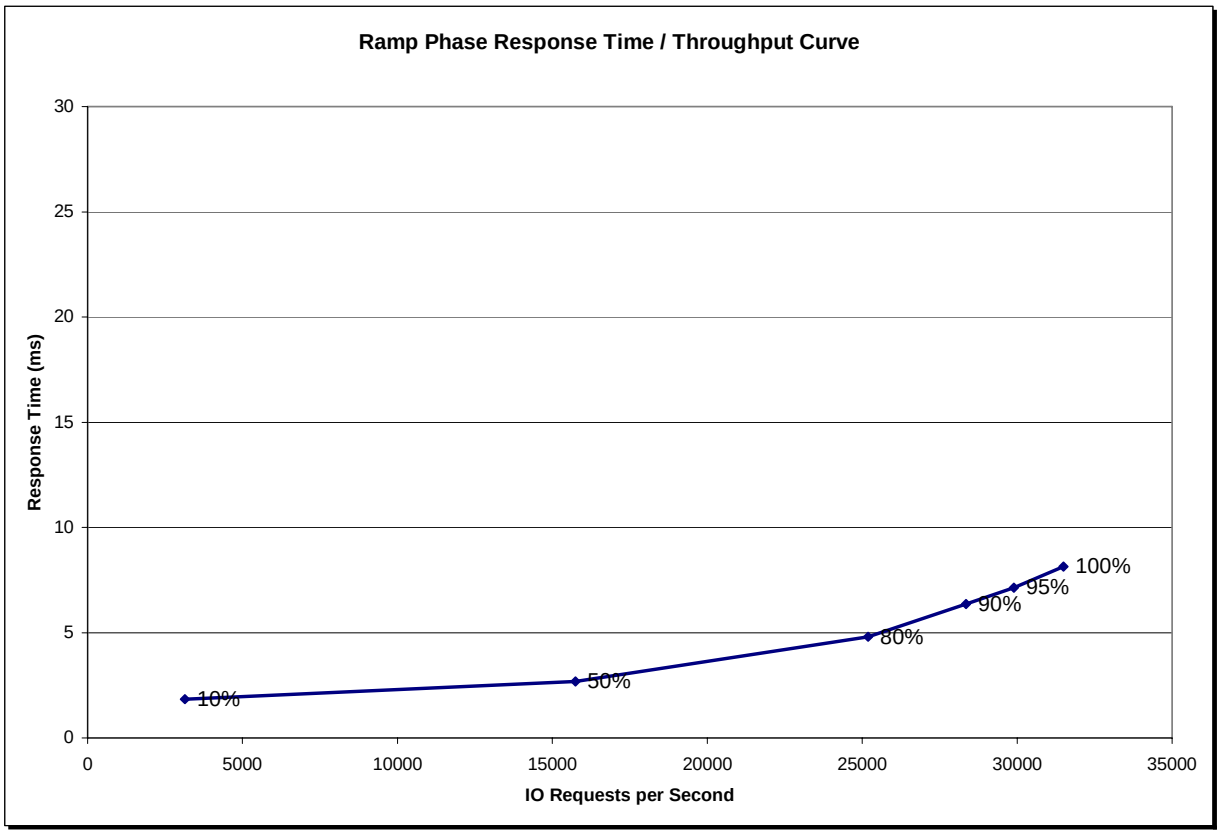
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



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	3,147.80	15,752.82	25,197.99	28,356.17	29,900.01	31,498.58
Average Response Time (ms):						
All ASUs	1.83	2.67	4.80	6.37	7.14	8.15
ASU-1	2.51	3.52	5.92	7.60	8.42	9.49
ASU-2	2.12	3.36	7.47	11.37	13.38	16.00
ASU-3	0.27	0.57	1.26	1.56	1.71	1.86
Reads	4.27	5.93	10.22	13.68	15.41	17.67
Writes	0.24	0.55	1.27	1.61	1.76	1.95

Tested Storage Configuration Pricing *(Priced Storage Configuration)*

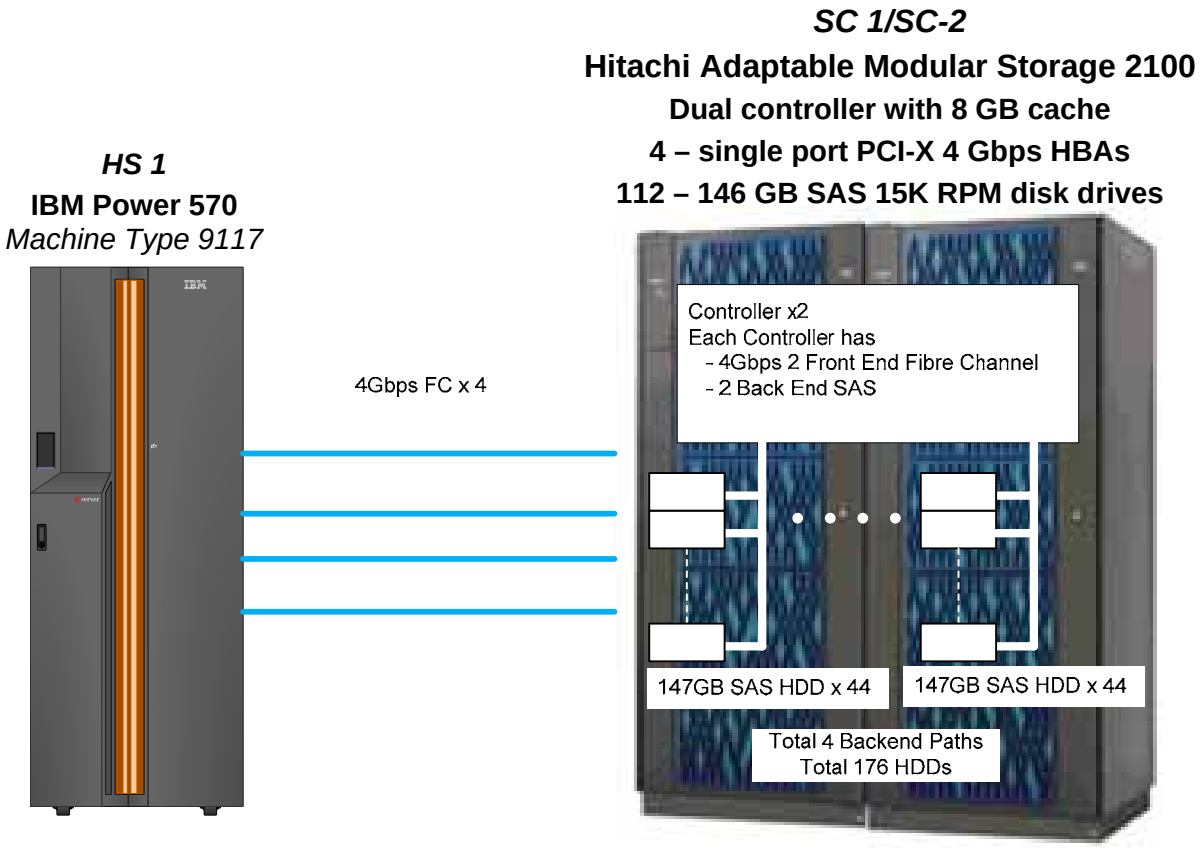
Product Code	Description	Qty	List	List EXT	List MMC	List MMC Ext
AMS2100-A0001.S	AMS2100 Rack Mount System	1				
043-100422-01.P	AMS 2100 Family Basic Operating System-Modular	1	$ -	$ -	$ -	$ -
043-991150-01.P	AMS2100 Svc Warranty 1 Mo Yr 1-3	36	$ -	$ -	$ -	$ -
043-991154-01.P	AMS2100 Svc Uplift to Standard 1Mo	36	$ -	$ -	$ 77	$ 2,772
043-991174-01.P	AMS2000 Svc RKAK Warranty 1 Mo Yr 1-3	252	$ -	$ -	$ -	$ -
043-991178-01.P	AMS2000 Svc RKAK Uplift to Standard 1Mo	252	$ -	$ -	$ 45	$ 11,340
043-991206-01.P	AMS2100 Service Installation	1	$ 1,250	$ 1,250	$ -	$ -
1508441-001.P	Dummy drive for DF600/DF700/DF800/RAID 600	8	$ -	$ -	$ -	$ -
7846630.P	42U AMS2000 Rack 1050mm Deep w/30amp Nema PDU (4)	1	$ 5,295	$ 5,295	$ -	$ -
DF-F800-AKH146.P	AMS2000 146GB SAS 15K RPM HDD	112	$ 610	$ 68,320	$ -	$ -
DF-F800-RKAK.P	AMS2000 SAS/SATA Storage Expansion Tray	7	$ 8,840	$ 61,880	$ -	$ -
HDF-F800-SFC4.P	AMS2100 Dual Controller, 8GB Cache, 4x4Gbps FC Intf	1	$ 23,220	$ 23,220	$ -	$ -
HDF800-BASE.P	AMS2100/AMS2300 Chassis	1	$ 6,810	$ 6,810	$ -	$ -
AMS2100-SOFTWARE.S	AMS2100 Storage Software Sales	1				
043-100409-01.P	AMS 2000 Family Storage Navigator Modular 2	1	$ 1,500	$ 1,500	$ -	$ -
304-100409-01.P	SVC Mo Storage Navigator Modular 2, AMS 2100 Family	12	$ -	$ -	$ 19	$ 225
JD-X50BB010PXF	ezLINE™ LC/LC Uniboot® Jumper, OFNP, 10-ft (50/125) Aqua	4	$ 18	$ 74		
9117-5758	IBM 4 Gb Single-Port Fibre Channel PCI-X 2.0 DDR Adapter	4	$ 1,159	$ 4,636		
	Total			**$ 172,984**		**$ 14,337**
	Grand Total					**$ 187,321**

The above hardware maintenance and software support pricing components provides acknowledgement of new and existing problems within four (4) hours. In addition, the priced components provide onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration that can be remedied by repair or replacement of a Priced Storage Configuration component.

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

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

Benchmark Configuration/Tested Storage Configuration Diagram



Benchmark Configuration/Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
UID=HS-1 IBM Power 570 Server	4 – 9117-5758 IBM DS4000 1-pt PCI-X 4 Gbps HBA
8 - 1.9 GHz CPUs – 2 CPUs/POWER5 chip 32 KB L1 cache, 960 KB L2 cache, and 18 MB L3 cache per CPU	***UID=SC-1/SC-2:*** Hitachi Adaptable Modular Storage 2100 Dual controller with 8 GB cache 2 – FC front-end ports per controller *(4 total ports)* 2 – backend SAS interfaces per controller 28 drives per interface *(4 total interfaces)*
64 GB main memory	
AIX 5.3 ML6 SP4	Cache Partition Manager
PCI-X/RIO	7 – AMS2000 SAS/SATA Storage Expansion Trays
AIX Logical Volume Manager	1 – 42U AMS2000 Racks w/30amp Nema PDU *(4)*
WG	112 – 146 GB SAS 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 58 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.2.4.5.2

The FDR must include sufficient information to recreate the logical representation of the TSC. In addition to customer tunable parameters and options (Clause 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 64 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 72.

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 54 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)	3,967.500
Addressable Storage Capacity	Gigabytes (GB)	4,260.071
Configured Storage Capacity	Gigabytes (GB)	15,973.201
Physical Storage Capacity	Gigabytes (GB)	16,346.930
Data Protection *(Mirroring)*	Gigabytes (GB)	7,986.601
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	251.491
Total Unused Storage	Gigabytes (GB)	8,160.439

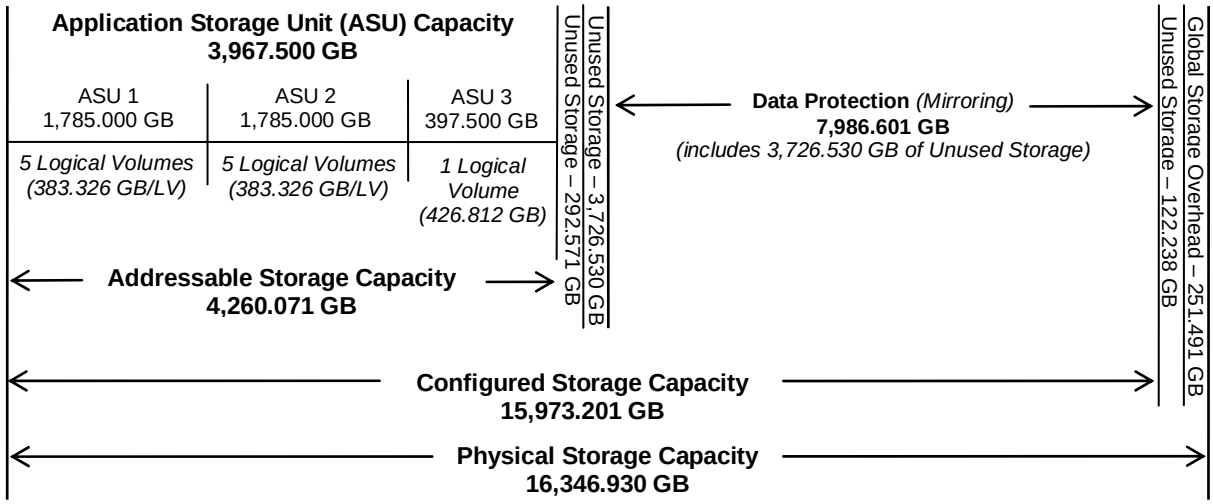
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	93.13%	24.84%	24.27%
Required for Data Protection *(Mirrored)*		50.00%	48.86%
Addressable Storage Capacity		26.67%	26.06%
Required Storage		0.00%	0.00%
Configured Storage Capacity			97.71%
Global Storage Overhead			1.54%
Unused Storage:			
Addressable	6.87%		
Configured		46.66%	
Physical			0.75%

The Physical Storage Capacity consisted of 16,346.930 GB distributed over 112 disk drives each with a formatted capacity of 145.955 GB. There was 122.24 GB (0.75%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 251.491 GB (1.54%) of Physical Storage Capacity. There was 7,453.060 GB (46.66%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 93.13% of the Addressable Storage Capacity resulting in 292.571 GB (6.87%) 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 (1,785.000 GB)	**ASU-2 (1,785.000 GB)**	**ASU-3 (397.500 GB)**
5 Logical Volume 383.326 GB per Logical Volume (357.000 GB used per Logical Volume)	5 Logical Volume 383.326 GB per Logical Volume (357.000 GB used per Logical Volume)	1 Logical Volume 426.812 GB per Logical Volume (397.500 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 55 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 73.

Sustainability Test Results File

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

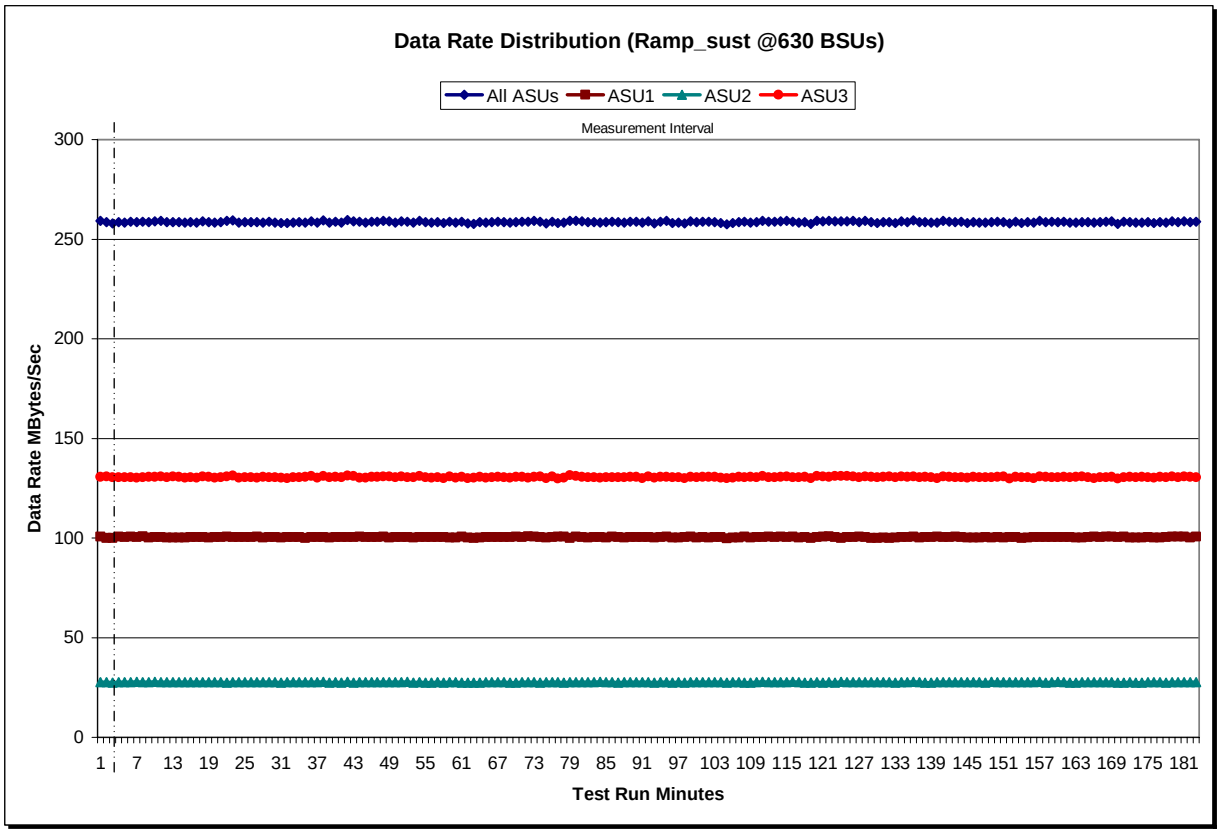
Sustainability Test Results File

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

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	15:33:20	15:36:20	0-2	0:03:00
Measurement Interval	15:36:20	18:36:20	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	259.16	100.72	27.72	130.71	63	258.52	100.30	27.46	130.76	126	258.62	100.64	27.60	130.38
1	258.47	100.01	27.64	130.82	64	258.39	100.43	27.63	130.33	127	259.16	100.53	27.66	130.97
2	257.96	99.90	27.52	130.54	65	258.55	100.44	27.61	130.51	128	258.47	100.09	27.64	130.74
3	258.59	100.55	27.68	130.36	66	258.74	100.36	27.73	130.65	129	258.15	100.06	27.62	130.48
4	258.38	100.35	27.62	130.42	67	258.52	100.34	27.67	130.52	130	258.48	100.25	27.62	130.62
5	258.67	100.64	27.64	130.39	68	258.21	100.39	27.51	130.31	131	258.54	100.09	27.54	130.90
6	258.54	100.41	27.79	130.35	69	258.52	100.55	27.39	130.59	132	258.18	100.31	27.49	130.39
7	258.78	100.82	27.59	130.36	70	258.70	100.41	27.62	130.68	133	258.91	100.49	27.62	130.80
8	258.55	100.26	27.67	130.62	71	258.85	100.86	27.66	130.33	134	258.54	100.34	27.61	130.60
9	258.94	100.44	27.76	130.74	72	259.10	100.75	27.61	130.74	135	259.30	100.62	27.79	130.90
10	259.13	100.52	27.63	130.98	73	258.73	100.47	27.46	130.80	136	258.46	100.29	27.65	130.53
11	258.43	100.31	27.70	130.42	74	257.89	100.13	27.64	130.12	137	258.63	100.41	27.48	130.74
12	258.53	100.12	27.56	130.85	75	258.78	100.44	27.54	130.80	138	258.34	100.42	27.52	130.40
13	258.56	100.26	27.60	130.70	76	258.14	100.59	27.68	129.87	139	258.38	100.58	27.68	130.12
14	258.21	100.21	27.71	130.29	77	258.27	100.61	27.42	130.24	140	259.10	100.53	27.72	130.84
15	258.53	100.53	27.59	130.41	78	259.10	100.07	27.60	131.43	141	258.74	100.44	27.70	130.61
16	258.37	100.45	27.75	130.17	79	259.21	100.57	27.62	131.02	142	258.61	100.60	27.64	130.37
17	259.00	100.49	27.57	130.94	80	258.86	100.49	27.64	130.73	143	258.64	100.52	27.70	130.41
18	258.53	100.25	27.62	130.67	81	258.49	100.26	27.70	130.53	144	258.02	100.19	27.65	130.18
19	258.21	100.37	27.67	130.17	82	258.60	100.42	27.74	130.44	145	258.47	100.19	27.71	130.57
20	258.58	100.51	27.63	130.44	83	258.32	100.35	27.79	130.19	146	258.37	100.22	27.63	130.51
21	259.11	100.61	27.53	130.97	84	258.48	100.26	27.75	130.47	147	258.32	100.36	27.53	130.43
22	259.37	100.46	27.66	131.24	85	258.74	100.75	27.61	130.38	148	258.44	100.24	27.77	130.43
23	258.38	100.39	27.67	130.33	86	258.45	100.49	27.51	130.45	149	258.74	100.44	27.61	130.69
24	258.52	100.46	27.57	130.49	87	258.32	100.11	27.72	130.48	150	258.63	100.23	27.55	130.85
25	258.63	100.40	27.70	130.53	88	258.82	100.50	27.70	130.63	151	257.94	100.50	27.60	129.84
26	258.55	100.63	27.60	130.31	89	258.70	100.47	27.62	130.61	152	258.74	100.40	27.74	130.60
27	258.36	100.17	27.58	130.60	90	258.27	100.49	27.68	130.10	153	258.04	100.06	27.57	130.42
28	258.73	100.49	27.75	130.49	91	259.00	100.40	27.65	130.95	154	258.56	100.28	27.72	130.56
29	258.41	100.39	27.63	130.39	92	257.91	100.24	27.45	130.21	155	258.22	100.42	27.68	130.11
30	258.05	100.19	27.53	130.33	93	258.81	100.49	27.66	130.66	156	259.18	100.49	27.81	130.88
31	258.05	100.43	27.64	129.99	94	259.13	100.65	27.75	130.73	157	258.47	100.40	27.44	130.63
32	258.36	100.38	27.58	130.40	95	257.99	100.13	27.52	130.35	158	258.67	100.50	27.65	130.52
33	258.44	100.44	27.58	130.42	96	258.37	100.25	27.57	130.54	159	258.59	100.33	27.77	130.49
34	258.34	100.08	27.66	130.59	97	257.98	100.37	27.51	130.10	160	258.67	100.44	27.55	130.68
35	258.98	100.37	27.57	131.04	98	258.88	100.68	27.61	130.60	161	258.27	100.34	27.51	130.41
36	258.32	100.34	27.72	130.26	99	258.45	100.31	27.58	130.56	162	258.31	100.28	27.37	130.66
37	259.38	100.47	27.76	131.14	100	258.69	100.43	27.60	130.66	163	258.58	100.14	27.61	130.83
38	258.24	100.29	27.44	130.51	101	258.66	100.23	27.74	130.69	164	258.46	100.52	27.56	130.37
39	258.82	100.49	27.71	130.61	102	258.61	100.46	27.55	130.59	165	258.30	100.68	27.67	129.95
40	258.29	100.43	27.40	130.46	103	258.18	100.37	27.63	130.18	166	258.54	100.50	27.65	130.39
41	259.59	100.46	27.76	131.37	104	257.48	99.89	27.50	130.09	167	258.79	100.55	27.70	130.54
42	258.97	100.43	27.54	131.00	105	258.00	100.16	27.57	130.27	168	258.98	100.62	27.60	130.76
43	258.64	100.68	27.68	130.28	106	258.56	100.29	27.61	130.67	169	257.72	100.44	27.45	129.83
44	258.38	100.37	27.72	130.29	107	258.68	100.68	27.45	130.55	170	258.71	100.62	27.52	130.56
45	258.75	100.45	27.70	130.61	108	258.31	100.21	27.43	130.68	171	258.59	100.18	27.73	130.68
46	258.66	100.38	27.71	130.58	109	258.54	100.37	27.74	130.43	172	258.33	100.30	27.50	130.53
47	259.14	100.57	27.71	130.86	110	259.20	100.39	27.77	131.04	173	258.33	100.24	27.51	130.59
48	258.90	100.27	27.68	130.95	111	258.77	100.58	27.66	130.53	174	258.51	100.54	27.59	130.39
49	258.42	100.36	27.65	130.41	112	258.79	100.50	27.74	130.56	175	258.15	100.22	27.62	130.31
50	259.00	100.50	27.67	130.84	113	258.95	100.60	27.61	130.75	176	258.51	100.14	27.69	130.68
51	258.66	100.42	27.77	130.47	114	259.10	100.49	27.70	130.91	177	258.29	100.40	27.49	130.40
52	258.30	100.30	27.50	130.50	115	258.83	100.56	27.75	130.52	178	259.02	100.56	27.61	130.85
53	259.08	100.36	27.65	131.06	116	258.28	100.27	27.62	130.39	179	258.57	100.57	27.55	130.44
54	258.59	100.53	27.52	130.55	117	258.58	100.39	27.53	130.66	180	259.07	100.60	27.59	130.87
55	258.27	100.42	27.52	130.33	118	257.71	100.08	27.53	130.11	181	258.45	100.12	27.64	130.69
56	258.50	100.36	27.71	130.43	119	259.21	100.44	27.63	131.14	182	258.73	100.71	27.60	130.42
57	257.99	100.43	27.51	130.05	120	259.06	100.62	27.53	130.91					
58	258.82	100.25	27.72	130.85	121	259.20	100.80	27.63	130.78					
59	258.23	100.27	27.67	130.29	122	258.89	100.33	27.53	131.03					
60	258.69	100.58	27.52	130.59	123	258.86	99.94	27.81	131.10					
61	257.83	100.21	27.49	130.12	124	259.02	100.37	27.61	131.04					
62	257.71	99.96	27.43	130.31	125	259.20	100.51	27.71	130.97					

Sustainability – Data Rate Distribution Graph

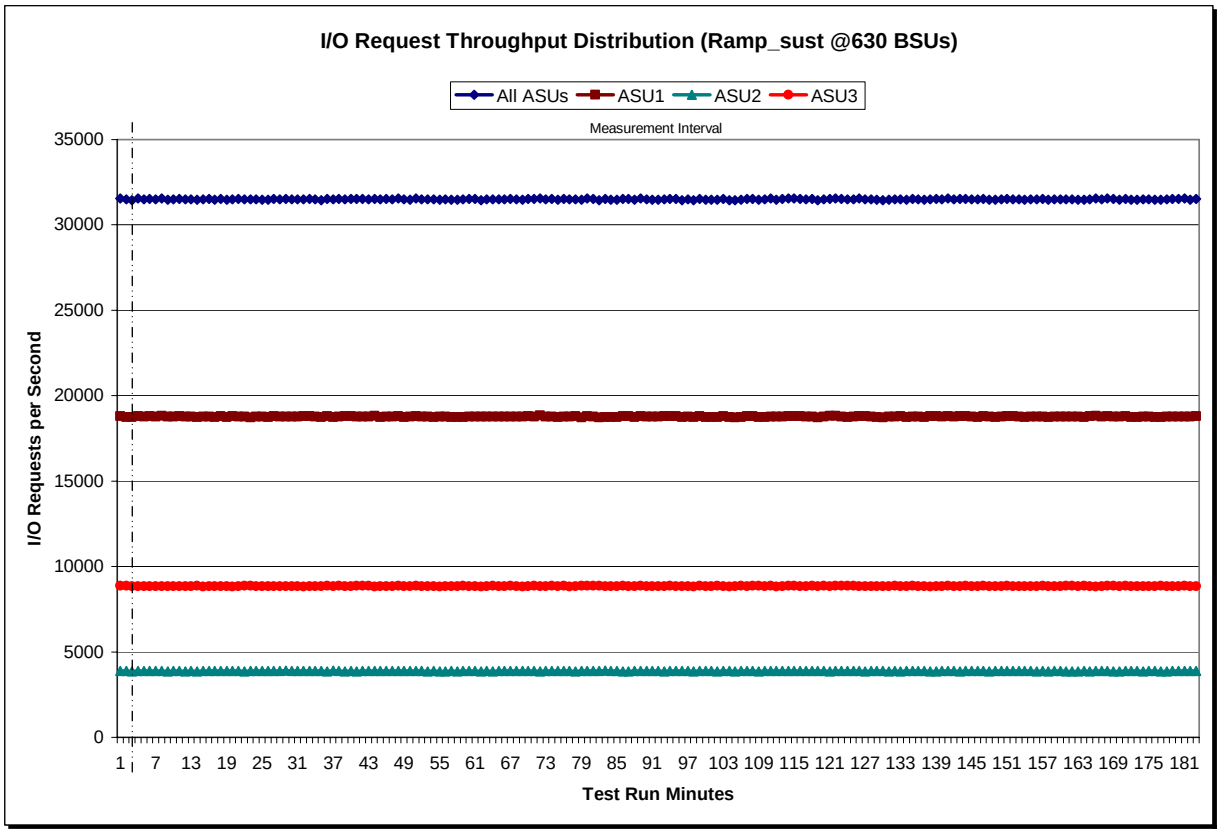


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	15:33:20	15:36:20	0-2	0:03:00
Measurement Interval	15:36:20	18:36:20	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	31,546.37	18,792.53	3,886.67	8,867.17	63	31,501.05	18,773.32	3,867.05	8,860.68	126	31,495.50	18,796.62	3,865.55	8,833.33
1	31,497.48	18,753.13	3,877.03	8,867.32	64	31,497.70	18,773.03	3,885.65	8,839.02	127	31,506.70	18,776.32	3,881.90	8,848.48
2	31,458.75	18,744.77	3,862.45	8,851.53	65	31,502.27	18,779.87	3,878.18	8,844.22	128	31,480.08	18,750.07	3,874.02	8,856.00
3	31,536.65	18,800.48	3,886.27	8,849.90	66	31,511.35	18,778.13	3,870.72	8,862.50	129	31,445.17	18,733.82	3,872.02	8,839.33
4	31,507.43	18,779.90	3,876.32	8,851.22	67	31,496.45	18,772.02	3,868.85	8,855.58	130	31,468.00	18,761.50	3,862.70	8,843.80
5	31,520.13	18,800.52	3,880.85	8,838.77	68	31,471.20	18,770.18	3,879.15	8,821.87	131	31,504.43	18,770.77	3,874.22	8,859.45
6	31,488.62	18,779.03	3,876.02	8,833.57	69	31,530.52	18,806.50	3,872.88	8,851.13	132	31,507.35	18,788.95	3,866.40	8,852.00
7	31,550.42	18,827.22	3,871.05	8,852.15	70	31,522.42	18,771.08	3,877.25	8,874.08	133	31,481.13	18,756.92	3,870.23	8,853.98
8	31,469.65	18,763.58	3,866.52	8,839.55	71	31,542.00	18,836.58	3,864.52	8,840.90	134	31,530.12	18,778.05	3,888.43	8,863.63
9	31,490.38	18,765.62	3,874.58	8,850.18	72	31,508.40	18,774.22	3,879.60	8,854.58	135	31,496.13	18,772.80	3,886.88	8,836.45
10	31,516.33	18,795.37	3,874.37	8,846.60	73	31,511.30	18,778.05	3,875.70	8,857.55	136	31,480.37	18,744.18	3,884.73	8,851.45
11	31,485.52	18,772.78	3,866.08	8,846.65	74	31,472.58	18,744.47	3,878.13	8,849.98	137	31,488.60	18,792.45	3,867.22	8,828.93
12	31,500.77	18,777.17	3,871.93	8,851.67	75	31,519.25	18,772.13	3,870.98	8,876.13	138	31,510.13	18,796.62	3,867.50	8,846.02
13	31,483.05	18,754.95	3,866.13	8,861.97	76	31,488.65	18,772.02	3,886.00	8,830.63	139	31,505.88	18,766.42	3,887.05	8,852.42
14	31,488.82	18,783.15	3,881.87	8,823.80	77	31,505.10	18,797.63	3,859.17	8,848.30	140	31,547.02	18,791.87	3,885.97	8,869.18
15	31,514.93	18,780.37	3,877.60	8,856.97	78	31,476.40	18,731.28	3,873.35	8,871.77	141	31,507.58	18,778.20	3,878.77	8,850.62
16	31,468.22	18,743.27	3,878.93	8,846.02	79	31,546.90	18,809.78	3,878.73	8,858.38	142	31,515.90	18,807.82	3,865.63	8,842.45
17	31,512.57	18,785.70	3,870.85	8,856.02	80	31,522.33	18,782.92	3,876.87	8,862.55	143	31,526.33	18,785.37	3,875.47	8,865.50
18	31,477.77	18,743.58	3,883.55	8,850.63	81	31,456.05	18,730.40	3,868.50	8,857.15	144	31,494.27	18,772.30	3,873.22	8,848.75
19	31,495.03	18,788.53	3,880.77	8,825.73	82	31,511.88	18,759.02	3,896.78	8,856.08	145	31,496.03	18,757.05	3,889.05	8,849.93
20	31,519.18	18,784.72	3,886.78	8,847.68	83	31,480.73	18,758.45	3,880.90	8,841.38	146	31,528.12	18,787.35	3,875.27	8,865.50
21	31,506.43	18,776.27	3,865.07	8,865.10	84	31,475.32	18,752.33	3,875.27	8,847.72	147	31,481.83	18,761.78	3,867.27	8,852.78
22	31,489.90	18,732.83	3,877.10	8,879.97	85	31,525.67	18,797.37	3,867.30	8,861.00	148	31,484.78	18,752.18	3,889.38	8,843.22
23	31,490.20	18,775.62	3,875.47	8,839.12	86	31,520.57	18,798.17	3,865.97	8,856.43	149	31,492.78	18,764.33	3,873.82	8,854.63
24	31,480.45	18,764.08	3,871.95	8,844.42	87	31,484.78	18,745.60	3,882.57	8,856.62	150	31,533.47	18,785.83	3,883.50	8,864.13
25	31,463.53	18,739.17	3,871.28	8,853.08	88	31,547.62	18,803.57	3,884.80	8,859.25	151	31,507.17	18,788.97	3,873.70	8,844.50
26	31,525.73	18,804.07	3,881.88	8,839.78	89	31,498.65	18,784.03	3,868.07	8,846.55	152	31,496.88	18,764.28	3,875.63	8,856.97
27	31,489.15	18,770.85	3,877.20	8,841.10	90	31,484.32	18,770.55	3,873.63	8,840.13	153	31,466.70	18,748.87	3,876.20	8,841.63
28	31,531.60	18,780.55	3,895.02	8,856.03	91	31,482.53	18,773.65	3,868.12	8,840.77	154	31,507.05	18,780.38	3,875.77	8,850.90
29	31,499.80	18,775.27	3,882.60	8,841.93	92	31,488.60	18,786.28	3,863.92	8,838.40	155	31,498.60	18,779.85	3,863.55	8,855.20
30	31,501.90	18,782.67	3,872.55	8,846.68	93	31,528.15	18,788.22	3,875.57	8,864.37	156	31,521.62	18,771.75	3,886.98	8,862.88
31	31,506.65	18,790.87	3,886.87	8,828.92	94	31,533.43	18,795.35	3,881.07	8,857.02	157	31,480.38	18,758.02	3,866.62	8,855.75
32	31,515.78	18,795.10	3,872.03	8,848.65	95	31,442.43	18,735.85	3,868.08	8,838.50	158	31,497.67	18,766.78	3,878.00	8,852.88
33	31,500.07	18,768.22	3,874.82	8,857.03	96	31,504.20	18,779.02	3,871.77	8,853.42	159	31,487.78	18,775.05	3,872.72	8,840.02
34	31,447.23	18,742.67	3,869.05	8,835.52	97	31,451.13	18,758.33	3,863.78	8,829.02	160	31,505.25	18,775.98	3,865.78	8,863.48
35	31,530.67	18,790.13	3,864.48	8,876.05	98	31,527.85	18,790.57	3,872.82	8,864.47	161	31,488.42	18,762.88	3,866.17	8,859.37
36	31,487.00	18,749.08	3,893.12	8,844.80	99	31,468.80	18,742.83	3,876.82	8,849.15	162	31,478.62	18,763.67	3,858.40	8,856.55
37	31,520.20	18,769.20	3,881.97	8,869.03	100	31,482.25	18,758.02	3,878.38	8,845.85	163	31,484.85	18,745.70	3,877.18	8,861.97
38	31,509.22	18,798.28	3,865.67	8,845.27	101	31,482.80	18,753.87	3,863.45	8,865.48	164	31,506.00	18,794.50	3,863.43	8,848.07
39	31,513.55	18,795.38	3,874.23	8,843.93	102	31,513.08	18,793.83	3,867.90	8,851.35	165	31,536.47	18,826.45	3,883.17	8,826.85
40	31,512.58	18,773.73	3,867.32	8,871.53	103	31,441.22	18,737.77	3,872.42	8,831.03	166	31,498.53	18,773.55	3,876.40	8,848.58
41	31,527.28	18,777.53	3,878.90	8,870.85	104	31,436.53	18,733.98	3,867.15	8,835.40	167	31,542.10	18,801.43	3,881.00	8,859.67
42	31,505.22	18,769.77	3,871.17	8,864.28	105	31,484.17	18,744.15	3,880.18	8,859.83	168	31,513.37	18,785.05	3,867.43	8,860.88
43	31,522.72	18,819.50	3,871.37	8,831.85	106	31,521.47	18,785.12	3,888.28	8,848.07	169	31,475.80	18,762.23	3,865.25	8,848.32
44	31,489.48	18,745.90	3,892.62	8,850.97	107	31,531.03	18,802.10	3,868.30	8,860.63	170	31,519.83	18,793.15	3,869.32	8,857.37
45	31,513.80	18,784.70	3,882.60	8,846.50	108	31,476.40	18,753.12	3,864.08	8,859.20	171	31,483.23	18,754.50	3,876.38	8,852.35
46	31,501.40	18,774.37	3,879.63	8,847.40	109	31,488.92	18,758.32	3,888.07	8,842.53	172	31,476.35	18,752.80	3,870.85	8,852.70
47	31,552.72	18,797.82	3,880.32	8,874.58	110	31,538.12	18,782.12	3,889.88	8,866.12	173	31,499.75	18,778.50	3,866.90	8,854.35
48	31,487.45	18,750.78	3,884.30	8,852.37	111	31,483.47	18,772.75	3,880.97	8,829.75	174	31,508.12	18,783.95	3,873.77	8,850.40
49	31,472.43	18,765.55	3,872.52	8,834.37	112	31,511.32	18,776.68	3,881.70	8,852.93	175	31,478.25	18,751.07	3,880.07	8,847.12
50	31,554.68	18,797.77	3,880.67	8,876.25	113	31,558.72	18,801.30	3,883.35	8,874.07	176	31,484.77	18,751.60	3,864.08	8,869.08
51	31,500.27	18,767.22	3,893.00	8,840.05	114	31,547.67	18,785.42	3,887.50	8,874.75	177	31,503.10	18,784.07	3,862.75	8,856.28
52	31,488.50	18,770.03	3,866.05	8,852.42	115	31,514.98	18,795.93	3,873.27	8,845.78	178	31,517.90	18,783.43	3,883.43	8,851.03
53	31,489.28	18,759.15	3,883.40	8,846.73	116	31,504.70	18,775.20	3,877.05	8,852.45	179	31,511.28	18,780.87	3,882.93	8,847.48
54	31,463.20	18,772.85	3,863.38	8,826.97	117	31,523.20	18,776.47	3,880.20	8,866.53	180	31,539.52	18,779.75	3,886.68	8,873.08
55	31,486.12	18,780.62	3,860.58	8,844.92	118	31,437.85	18,722.50	3,877.45	8,837.90	181	31,484.85	18,761.87	3,875.28	8,847.70
56	31,483.38	18,748.12	3,879.57	8,855.70	119	31,508.82	18,772.28	3,874.53	8,862.00	182	31,511.20	18,796.18	3,874.73	8,840.28
57	31,467.32	18,759.85	3,862.88	8,844.58	120	31,516.75	18,812.45	3,863.23	8,841.07	Average	31,501.28	18,774.14	3,875.55	8,851.59
58	31,506.45	18,741.48	3,890.15	8,874.82	121	31,549.60	18,811.12	3,876.42	8,862.07					
59	31,524.05	18,779.88	3,892.42	8,851.75	122	31,523.98	18,773.67	3,875.70	8,874.62					
60	31,516.25	18,781.48	3,881.70	8,853.07	123	31,506.22	18,743.72	3,887.40	8,875.10					
61	31,453.38	18,767.55	3,864.95	8,820.88	124	31,503.30	18,769.08	3,870.65	8,863.57					
62	31,494.12	18,762.50	3,877.63	8,853.98	125	31,539.03	18,800.28	3,886.43	8,852.32					

Sustainability – I/O Request Throughput Distribution Graph

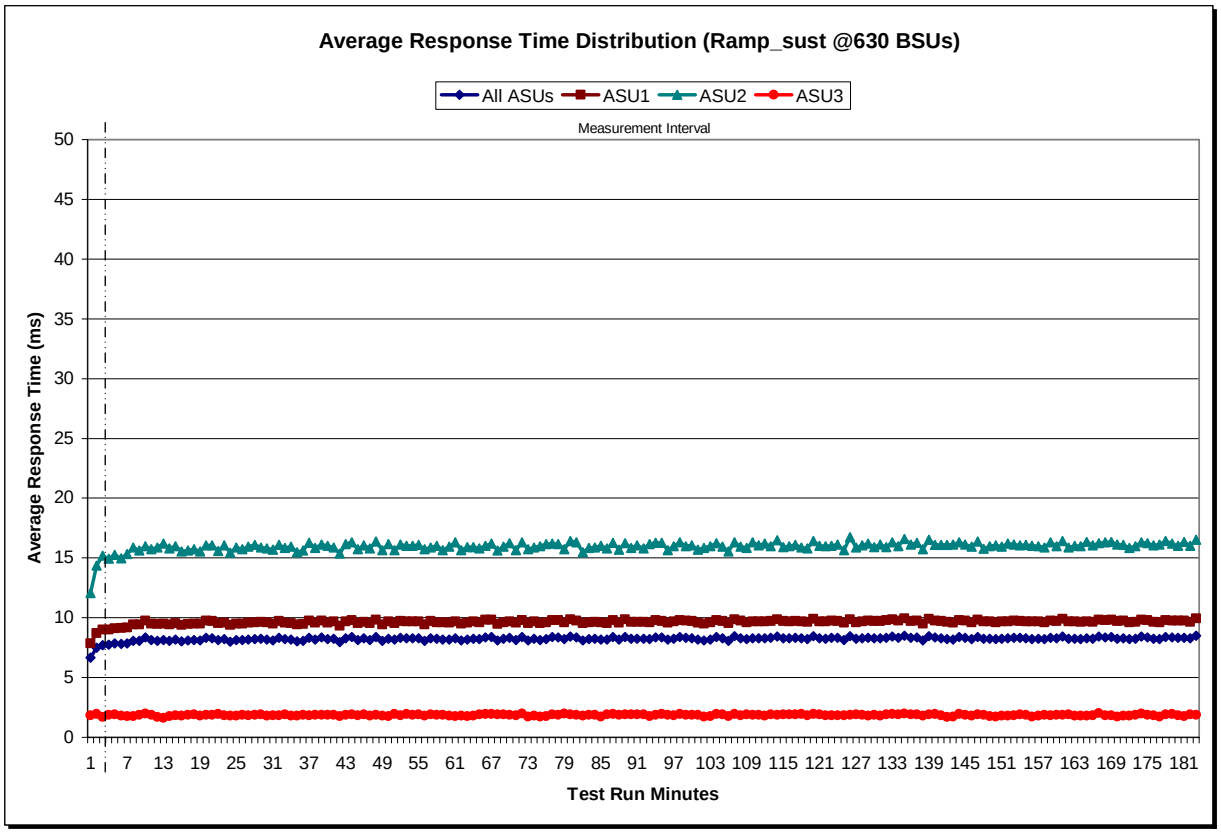


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	15:33:20	15:36:20	0-2	0:03:00
Measurement Interval	15:36:20	18:36:20	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	6.67	7.84	12.06	1.83	63	8.23	9.68	15.92	1.81	126	8.23	9.63	15.89	1.91
1	7.50	8.71	14.35	1.94	64	8.20	9.59	15.80	1.91	127	8.28	9.69	16.05	1.87
2	7.70	8.99	15.19	1.70	65	8.37	9.82	16.03	1.93	128	8.30	9.74	16.20	1.79
3	7.73	8.99	14.95	1.88	66	8.40	9.83	16.19	1.95	129	8.26	9.70	15.90	1.87
4	7.85	9.12	15.27	1.91	67	8.09	9.45	15.64	1.89	130	8.27	9.71	16.13	1.78
5	7.80	9.14	14.98	1.79	68	8.23	9.60	15.95	1.92	131	8.31	9.78	15.91	1.89
6	7.85	9.17	15.32	1.76	69	8.30	9.69	16.22	1.88	132	8.42	9.86	16.30	1.93
7	8.07	9.42	15.88	1.77	70	8.14	9.56	15.66	1.84	133	8.31	9.75	15.99	1.92
8	8.07	9.42	15.64	1.89	71	8.40	9.79	16.31	1.97	134	8.51	9.92	16.60	1.96
9	8.35	9.77	16.00	1.99	72	8.11	9.55	15.73	1.73	135	8.32	9.72	16.11	1.92
10	8.13	9.51	15.74	1.87	73	8.23	9.68	15.89	1.80	136	8.36	9.77	16.27	1.92
11	8.06	9.45	15.87	1.70	74	8.14	9.54	15.97	1.74	137	8.11	9.50	15.75	1.81
12	8.12	9.52	16.21	1.62	75	8.20	9.61	16.17	1.76	138	8.46	9.88	16.51	1.92
13	8.07	9.44	15.81	1.77	76	8.38	9.80	16.20	1.91	139	8.35	9.76	16.08	1.96
14	8.18	9.56	15.98	1.83	77	8.35	9.79	16.18	1.88	140	8.29	9.72	16.11	1.85
15	8.02	9.40	15.54	1.79	78	8.22	9.62	15.74	1.99	141	8.21	9.66	16.10	1.68
16	8.09	9.47	15.61	1.88	79	8.43	9.86	16.42	1.91	142	8.17	9.56	16.12	1.73
17	8.14	9.52	15.74	1.89	80	8.34	9.75	16.29	1.88	143	8.39	9.81	16.29	1.94
18	8.08	9.49	15.56	1.81	81	8.09	9.53	15.48	1.80	144	8.33	9.75	16.14	1.88
19	8.32	9.76	16.06	1.87	82	8.21	9.62	15.84	1.86	145	8.21	9.63	15.95	1.80
20	8.29	9.71	16.07	1.86	83	8.24	9.67	15.89	1.86	146	8.41	9.83	16.37	1.90
21	8.14	9.53	15.57	1.95	84	8.18	9.61	16.01	1.72	147	8.24	9.68	15.77	1.88
22	8.20	9.59	16.05	1.83	85	8.17	9.54	15.81	1.92	148	8.24	9.69	15.97	1.76
23	8.00	9.39	15.43	1.80	86	8.38	9.80	16.28	1.93	149	8.19	9.63	16.06	1.72
24	8.12	9.50	15.87	1.78	87	8.15	9.57	15.69	1.86	150	8.24	9.68	15.96	1.81
25	8.13	9.52	15.72	1.86	88	8.40	9.85	16.23	1.91	151	8.28	9.69	16.20	1.80
26	8.18	9.56	15.93	1.83	89	8.24	9.65	15.83	1.92	152	8.31	9.75	16.14	1.83
27	8.23	9.60	16.08	1.86	90	8.26	9.63	16.07	1.91	153	8.31	9.74	16.07	1.90
28	8.25	9.66	15.86	1.89	91	8.24	9.66	15.82	1.92	154	8.28	9.69	16.09	1.87
29	8.17	9.59	15.81	1.80	92	8.21	9.61	16.17	1.77	155	8.22	9.68	16.03	1.73
30	8.10	9.50	15.68	1.82	93	8.36	9.79	16.26	1.86	156	8.25	9.69	15.99	1.81
31	8.30	9.72	16.08	1.85	94	8.34	9.72	16.27	1.93	157	8.20	9.61	15.87	1.86
32	8.20	9.59	15.85	1.91	95	8.16	9.59	15.65	1.86	158	8.33	9.76	16.29	1.82
33	8.16	9.55	15.95	1.81	96	8.25	9.67	15.97	1.84	159	8.29	9.73	15.99	1.86
34	8.04	9.45	15.48	1.80	97	8.40	9.80	16.30	1.95	160	8.43	9.89	16.41	1.86
35	8.08	9.46	15.62	1.88	98	8.30	9.74	15.99	1.87	161	8.25	9.68	15.88	1.91
36	8.33	9.74	16.26	1.83	99	8.29	9.72	16.05	1.86	162	8.24	9.68	16.04	1.80
37	8.18	9.59	15.83	1.87	100	8.17	9.57	15.71	1.89	163	8.22	9.64	15.98	1.81
38	8.33	9.76	16.13	1.89	101	8.09	9.51	15.82	1.73	164	8.30	9.70	16.35	1.81
39	8.20	9.57	16.02	1.86	102	8.18	9.60	15.98	1.75	165	8.23	9.63	16.05	1.82
40	8.25	9.69	15.87	1.88	103	8.38	9.80	16.22	1.94	166	8.43	9.84	16.24	2.01
41	7.95	9.33	15.38	1.78	104	8.29	9.70	15.95	1.92	167	8.36	9.78	16.32	1.85
42	8.28	9.69	16.15	1.85	105	8.08	9.52	15.55	1.76	168	8.38	9.83	16.33	1.84
43	8.38	9.80	16.30	1.90	106	8.44	9.87	16.30	1.96	169	8.26	9.71	16.12	1.74
44	8.15	9.56	15.73	1.85	107	8.28	9.75	15.94	1.83	170	8.28	9.74	16.08	1.79
45	8.27	9.66	16.06	1.91	108	8.20	9.61	15.83	1.89	171	8.19	9.63	15.85	1.80
46	8.14	9.55	15.79	1.80	109	8.29	9.67	16.30	1.86	172	8.26	9.66	15.99	1.89
47	8.39	9.82	16.37	1.89	110	8.28	9.69	16.06	1.88	173	8.41	9.81	16.30	1.98
48	8.06	9.44	15.66	1.81	111	8.29	9.70	16.21	1.81	174	8.36	9.80	16.24	1.87
49	8.26	9.68	16.17	1.77	112	8.31	9.73	15.98	1.93	175	8.24	9.65	16.05	1.83
50	8.16	9.54	15.66	1.94	113	8.43	9.86	16.49	1.87	176	8.20	9.62	16.11	1.74
51	8.30	9.73	16.11	1.83	114	8.27	9.70	15.91	1.90	177	8.38	9.78	16.43	1.90
52	8.28	9.68	16.00	1.95	115	8.27	9.69	15.98	1.90	178	8.36	9.77	16.21	1.93
53	8.28	9.69	16.03	1.89	116	8.32	9.73	16.09	1.92	179	8.30	9.75	16.01	1.84
54	8.30	9.69	16.07	1.92	117	8.27	9.68	15.86	1.95	180	8.33	9.77	16.33	1.78
55	8.07	9.45	15.73	1.79	118	8.20	9.64	15.79	1.83	181	8.27	9.66	16.02	1.92
56	8.27	9.71	15.87	1.90	119	8.48	9.91	16.43	1.95	182	8.49	9.95	16.52	1.88
57	8.23	9.62	16.03	1.88	120	8.29	9.69	16.04	1.92	Average	8.24	9.65	15.99	1.86
58	8.18	9.60	15.66	1.88	121	8.25	9.68	15.98	1.84					
59	8.17	9.57	15.95	1.79	122	8.31	9.77	16.03	1.84					
60	8.27	9.68	16.29	1.77	123	8.30	9.74	16.12	1.84					
61	8.09	9.49	15.65	1.81	124	8.15	9.57	15.67	1.85					
62	8.16	9.58	15.92	1.76	125	8.46	9.85	16.73	1.88					

Sustainability – Average Response Time (ms) Distribution Graph



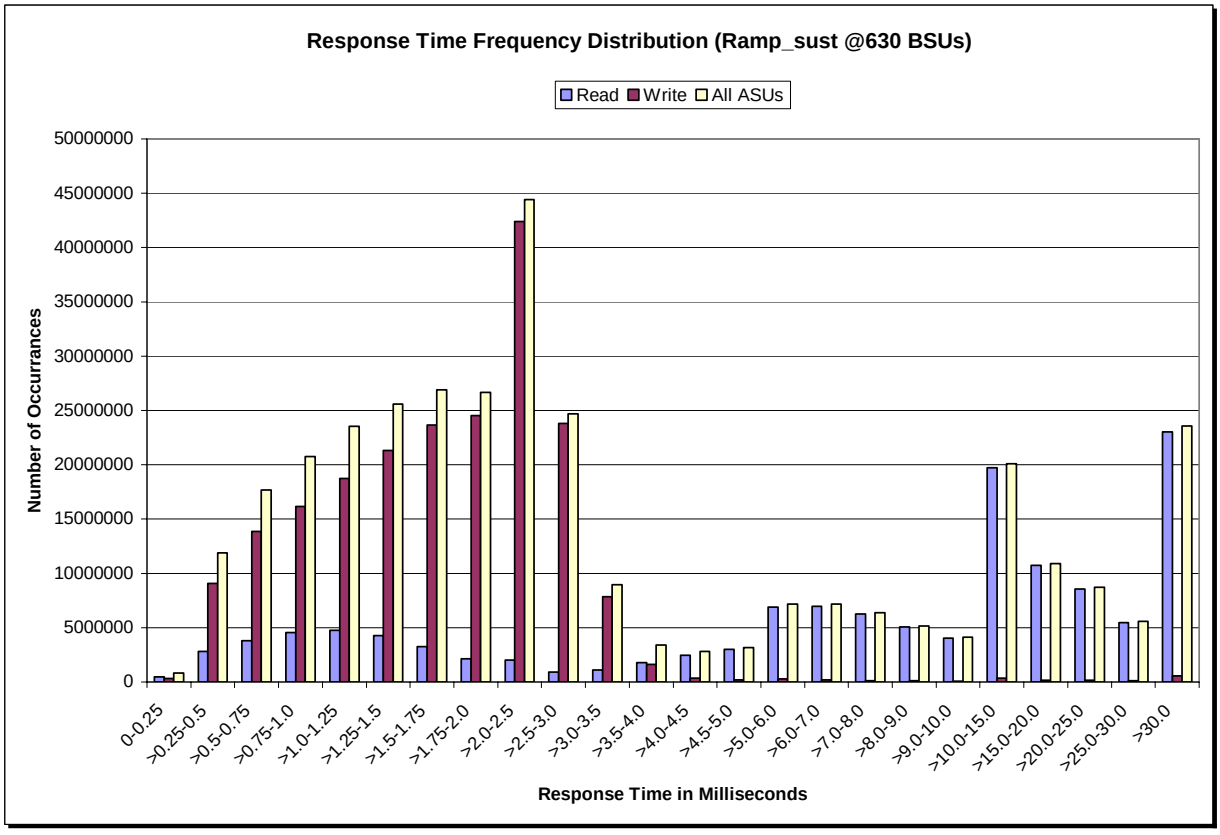
Sustainability – Response Time Frequency Distribution Data

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	494,809	2,809,077	3,792,431	4,567,241	4,769,405	4,262,776	3,259,842	2,151,917
Write	334,606	9,064,729	13,879,254	16,180,026	18,748,950	21,314,842	23,652,341	24,523,735
All ASUs	829,415	11,873,806	17,671,685	20,747,267	23,518,355	25,577,618	26,912,183	26,675,652
ASU1	573,601	6,623,300	9,228,724	10,750,734	11,982,321	12,634,959	12,789,514	12,215,668
ASU2	134,465	1,580,273	2,227,264	2,606,496	2,912,585	3,080,175	3,115,847	2,975,421
ASU3	121,349	3,670,233	6,215,697	7,390,037	8,623,449	9,862,484	11,006,822	11,484,563

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	2,015,218	901,598	1,110,775	1,782,723	2,465,053	3,005,770	6,896,592	6,981,712
Write	42,406,038	23,792,933	7,851,586	1,633,726	363,223	178,690	275,896	186,066
All ASUs	44,421,256	24,694,531	8,962,361	3,416,449	2,828,276	3,184,460	7,172,488	7,167,778
ASU1	19,551,897	10,628,156	4,222,379	2,371,363	2,525,077	2,953,847	6,619,145	6,540,841
ASU2	4,749,779	2,520,349	829,659	227,335	136,128	156,483	439,305	549,332
ASU3	20,119,580	11,546,026	3,910,323	817,751	167,071	74,130	114,038	77,605

Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	6,256,229	5,057,995	4,048,848	19,737,867	10,721,365	8,575,814	5,454,679	23,007,888
Write	132,513	107,630	90,176	362,649	174,945	145,374	116,874	569,034
All ASUs	6,388,742	5,165,625	4,139,024	20,100,516	10,896,310	8,721,188	5,571,553	23,576,922
ASU1	5,779,884	4,626,449	3,694,060	17,831,081	9,524,928	7,515,813	4,708,945	16,867,797
ASU2	556,071	496,256	407,744	2,163,346	1,340,952	1,183,515	843,031	6,624,061
ASU3	52,787	42,920	37,220	106,089	30,430	21,860	19,577	85,064

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	0.004	0.001	0.003	0.001	0.005	0.003	0.004	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 73.

IOPS Test Results File

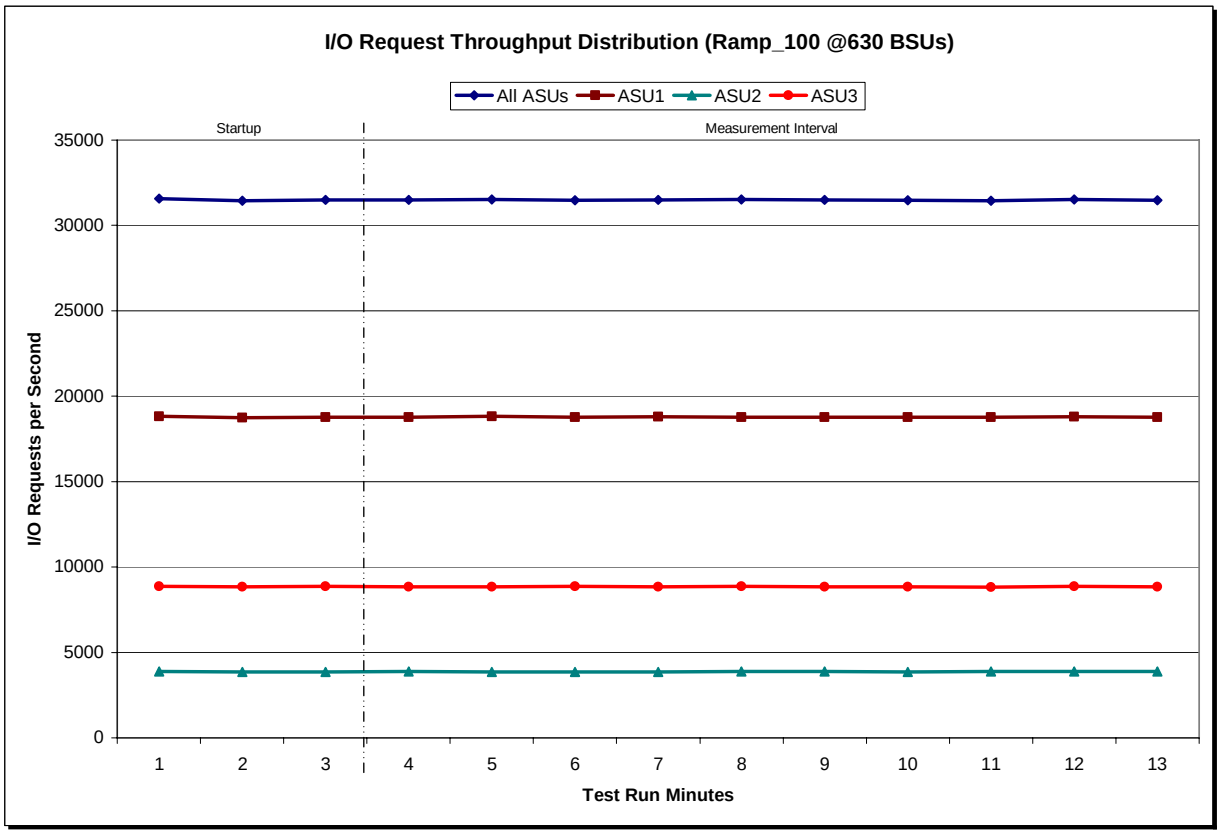
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:36:31	18:39:32	0-2	0:03:01
Measurement Interval	18:39:32	18:49:32	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	31,563.37	18,812.68	3,879.97	8,870.72
1	31,456.80	18,747.38	3,862.25	8,847.17
2	31,504.17	18,782.85	3,861.90	8,859.42
3	31,503.63	18,782.53	3,872.58	8,848.52
4	31,527.23	18,813.17	3,863.67	8,850.40
5	31,482.78	18,759.97	3,863.23	8,859.58
6	31,503.95	18,794.77	3,867.80	8,841.38
7	31,527.52	18,782.70	3,877.43	8,867.38
8	31,503.50	18,774.47	3,886.92	8,842.12
9	31,466.70	18,767.02	3,849.82	8,849.87
10	31,456.58	18,760.00	3,872.80	8,823.78
11	31,532.78	18,785.95	3,880.32	8,866.52
12	31,481.08	18,772.30	3,874.63	8,834.15
Average	31,498.58	18,779.29	3,870.92	8,848.37

IOPS Test Run – I/O Request Throughput Distribution Graph

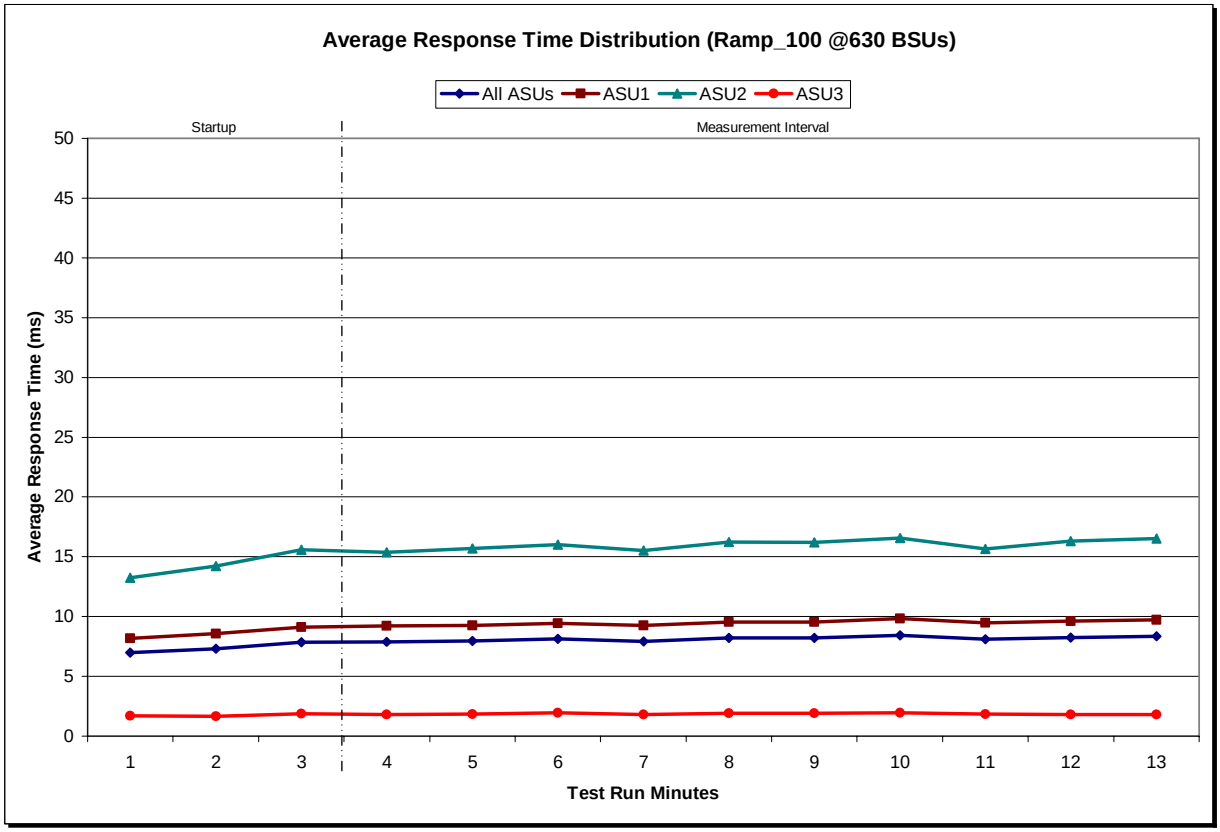


IOPS Test Run – Average Response Time (ms) Distribution Data

630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:36:31	18:39:32	0-2	0:03:01
Measurement Interval	18:39:32	18:49:32	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6.97	8.17	13.24	1.69
1	7.32	8.58	14.22	1.65
2	7.86	9.10	15.59	1.85
3	7.89	9.21	15.36	1.81
4	7.97	9.26	15.69	1.84
5	8.13	9.43	16.01	1.96
6	7.93	9.24	15.51	1.81
7	8.22	9.55	16.23	1.91
8	8.22	9.55	16.18	1.90
9	8.43	9.82	16.57	1.95
10	8.09	9.47	15.66	1.83
11	8.23	9.61	16.31	1.79
12	8.33	9.73	16.51	1.79
Average	8.15	9.49	16.00	1.86

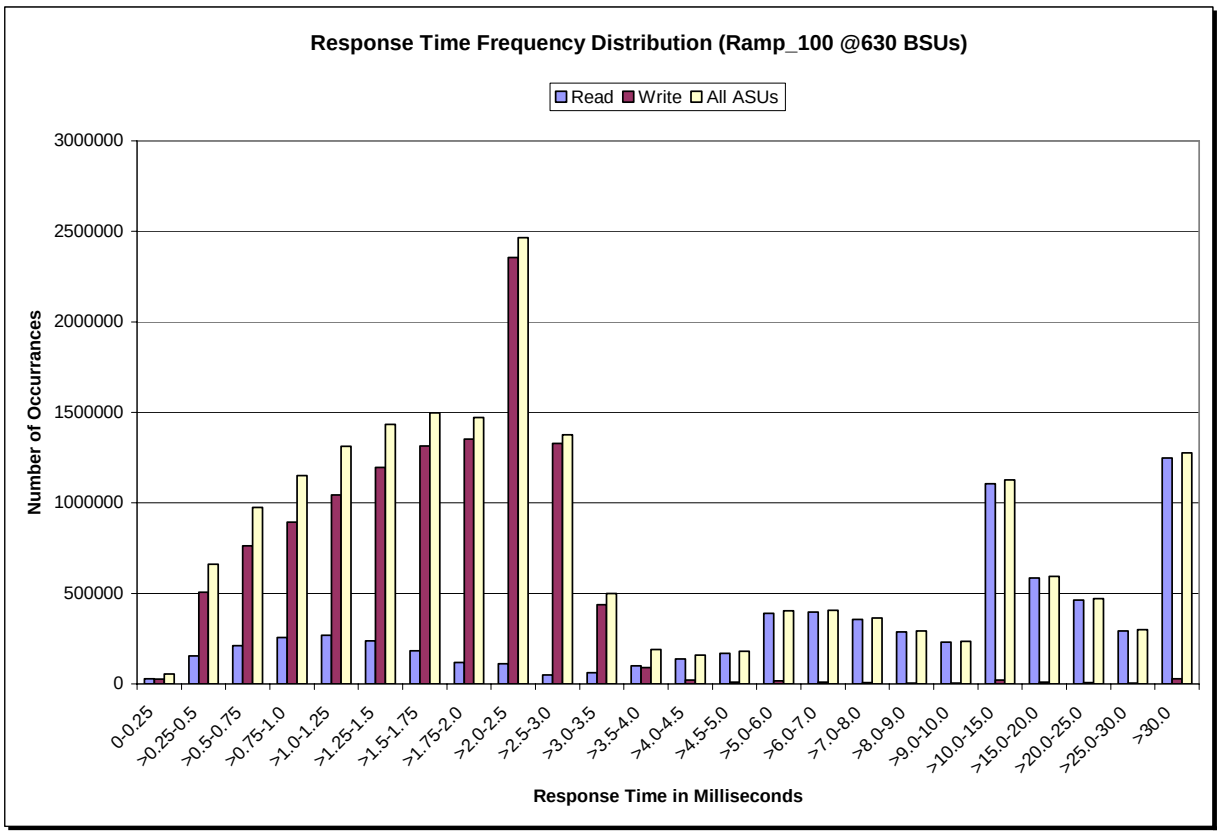
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	29,382	155,554	212,359	257,426	268,456	237,386	182,090	119,155
Write	25,885	505,786	763,170	893,521	1,044,190	1,196,163	1,315,208	1,353,310
All ASUs	55,267	661,340	975,529	1,150,947	1,312,646	1,433,549	1,497,298	1,472,465
ASU1	37,514	369,595	514,849	601,680	673,987	711,997	714,986	675,858
ASU2	8,390	86,269	120,237	141,893	159,469	169,149	171,151	162,963
ASU3	9,363	205,476	340,443	407,374	479,190	552,403	611,161	633,644
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	110,851	49,597	61,922	99,298	138,068	169,632	389,509	396,435
Write	2,354,986	1,327,853	437,282	90,829	20,218	10,224	15,548	9,894
All ASUs	2,465,837	1,377,450	499,204	190,127	158,286	179,856	405,057	406,329
ASU1	1,088,192	592,221	235,659	131,626	141,105	166,307	372,435	369,377
ASU2	262,782	140,378	46,191	12,824	7,715	9,191	25,841	32,693
ASU3	1,114,863	644,851	217,354	45,677	9,466	4,358	6,781	4,259
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	357,256	287,594	230,054	1,105,239	585,879	463,750	293,447	1,248,607
Write	6,014	5,066	5,427	20,662	8,634	7,049	5,702	27,350
All ASUs	363,270	292,660	235,481	1,125,901	594,513	470,799	299,149	1,275,957
ASU1	327,946	260,814	208,610	992,080	516,602	403,862	251,463	908,651
ASU2	32,900	29,834	24,604	126,902	76,191	65,731	46,539	362,648
ASU3	2,424	2,012	2,267	6,919	1,720	1,206	1,147	4,658

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
18,898,917	17,622,960	1,275,957

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	0.2811	0.0701	0.2100	0.0180	0.0700	0.0349	0.2809
COV	0.004	0.001	0.003	0.002	0.004	0.003	0.004	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 73.

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 - 630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:36:31	18:39:32	0-2	0:03:01
Measurement Interval	18:39:32	18:49:32	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	31,563.37	18,812.68	3,879.97	8,870.72
1	31,456.80	18,747.38	3,862.25	8,847.17
2	31,504.17	18,782.85	3,861.90	8,859.42
3	31,503.63	18,782.53	3,872.58	8,848.52
4	31,527.23	18,813.17	3,863.67	8,850.40
5	31,482.78	18,759.97	3,863.23	8,859.58
6	31,503.95	18,794.77	3,867.80	8,841.38
7	31,527.52	18,782.70	3,877.43	8,867.38
8	31,503.50	18,774.47	3,886.92	8,842.12
9	31,466.70	18,767.02	3,849.82	8,849.87
10	31,456.58	18,760.00	3,872.80	8,823.78
11	31,532.78	18,785.95	3,880.32	8,866.52
12	31,481.08	18,772.30	3,874.63	8,834.15
Average	31,498.58	18,779.29	3,870.92	8,848.37

95% Load Level - 598 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:49:38	18:52:39	0-2	0:03:01
Measurement Interval	18:52:39	19:02:39	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	29,914.52	17,827.80	3,678.08	8,408.63
1	29,899.62	17,818.00	3,674.58	8,407.03
2	29,931.15	17,842.52	3,680.53	8,408.10
3	29,900.47	17,824.88	3,671.28	8,404.30
4	29,879.27	17,817.75	3,678.52	8,383.00
5	29,897.12	17,803.10	3,681.12	8,412.90
6	29,907.60	17,826.33	3,686.02	8,395.25
7	29,926.20	17,847.80	3,671.48	8,406.92
8	29,912.75	17,811.27	3,690.63	8,410.85
9	29,884.75	17,822.68	3,665.70	8,396.37
10	29,866.97	17,796.38	3,676.33	8,394.25
11	29,901.62	17,814.92	3,686.10	8,400.60
12	29,923.32	17,826.70	3,685.32	8,411.30
Average	29,900.01	17,819.18	3,679.25	8,401.57

90% Load Level - 567 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:02:45	19:05:46	0-2	0:03:01
Measurement Interval	19:05:46	19:15:46	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	28,361.07	16,894.02	3,502.98	7,964.07
1	28,340.72	16,900.95	3,462.92	7,976.85
2	28,367.05	16,897.45	3,498.15	7,971.45
3	28,344.52	16,897.12	3,489.27	7,958.13
4	28,336.97	16,890.77	3,485.88	7,960.32
5	28,393.12	16,899.85	3,492.80	8,000.47
6	28,342.67	16,896.92	3,485.05	7,960.70
7	28,335.30	16,877.05	3,497.48	7,960.77
8	28,378.25	16,890.32	3,501.95	7,985.98
9	28,362.98	16,903.08	3,490.73	7,969.17
10	28,397.57	16,924.63	3,498.10	7,974.83
11	28,306.20	16,856.67	3,466.27	7,983.27
12	28,364.15	16,882.60	3,493.63	7,987.92
Average	28,356.17	16,891.90	3,490.12	7,974.16

80% Load Level - 504 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:15:51	19:18:52	0-2	0:03:01
Measurement Interval	19:18:52	19:28:52	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	25,251.97	15,054.87	3,103.18	7,093.92
1	25,219.02	15,024.33	3,103.00	7,091.68
2	25,245.67	15,053.17	3,090.50	7,102.00
3	25,181.10	15,000.37	3,096.75	7,083.98
4	25,194.55	15,022.82	3,093.98	7,077.75
5	25,226.70	15,046.15	3,095.07	7,085.48
6	25,227.33	15,031.95	3,099.08	7,096.30
7	25,197.63	15,019.47	3,103.72	7,074.45
8	25,189.72	15,011.87	3,103.37	7,074.48
9	25,199.15	15,017.23	3,094.25	7,087.67
10	25,173.32	15,005.18	3,100.67	7,067.47
11	25,213.58	15,027.35	3,105.42	7,080.82
12	25,176.78	15,018.27	3,093.18	7,065.33
Average	25,197.99	15,020.07	3,098.55	7,079.37

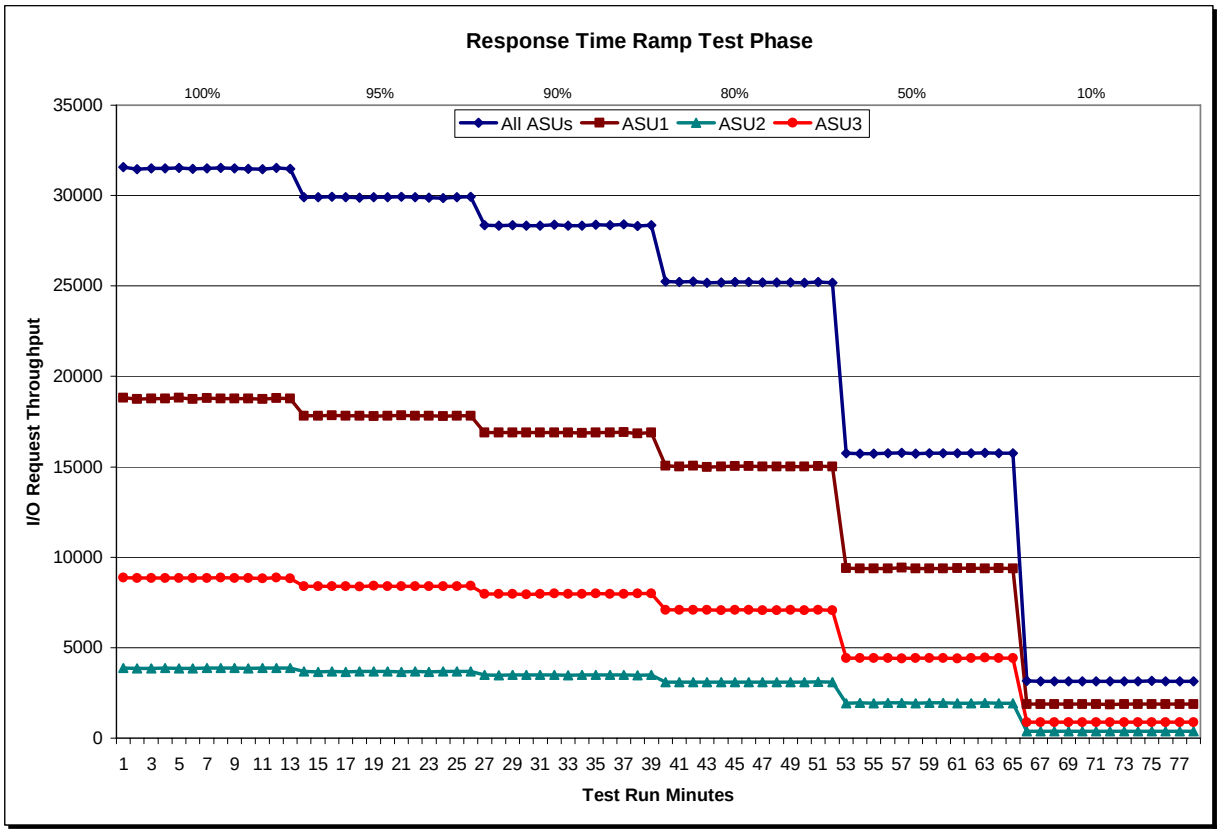
50% Load Level - 315 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:28:57	19:31:58	0-2	0:03:01
Measurement Interval	19:31:58	19:41:58	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	15,754.53	9,390.60	1,930.67	4,433.27
1	15,738.28	9,367.63	1,952.35	4,418.30
2	15,725.45	9,372.58	1,937.03	4,415.83
3	15,749.40	9,384.03	1,939.45	4,425.92
4	15,771.65	9,418.48	1,941.03	4,412.13
5	15,737.65	9,373.80	1,935.80	4,428.05
6	15,752.28	9,374.85	1,940.15	4,437.28
7	15,752.30	9,384.87	1,945.37	4,422.07
8	15,739.72	9,393.25	1,933.82	4,412.65
9	15,760.75	9,397.92	1,928.97	4,433.87
10	15,764.17	9,379.68	1,944.25	4,440.23
11	15,748.92	9,395.23	1,931.05	4,422.63
12	15,751.37	9,384.67	1,934.42	4,432.28
Average	15,752.82	9,388.68	1,937.43	4,426.71

10% Load Level - 63 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:42:02	19:45:03	0-2	0:03:01
Measurement Interval	19:45:03	19:55:03	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	3,153.62	1,880.43	387.93	885.25
1	3,147.45	1,871.83	386.65	888.97
2	3,151.20	1,878.55	387.28	885.37
3	3,149.32	1,877.53	386.75	885.03
4	3,151.67	1,873.47	387.25	890.95
5	3,145.60	1,877.58	381.55	886.47
6	3,141.98	1,865.20	391.03	885.75
7	3,149.97	1,879.80	386.60	883.57
8	3,151.67	1,879.68	388.08	883.90
9	3,155.83	1,882.23	389.30	884.30
10	3,143.73	1,872.85	385.75	885.13
11	3,144.03	1,872.78	384.48	886.77
12	3,144.22	1,870.45	386.83	886.93
Average	3,147.80	1,875.16	386.76	885.88

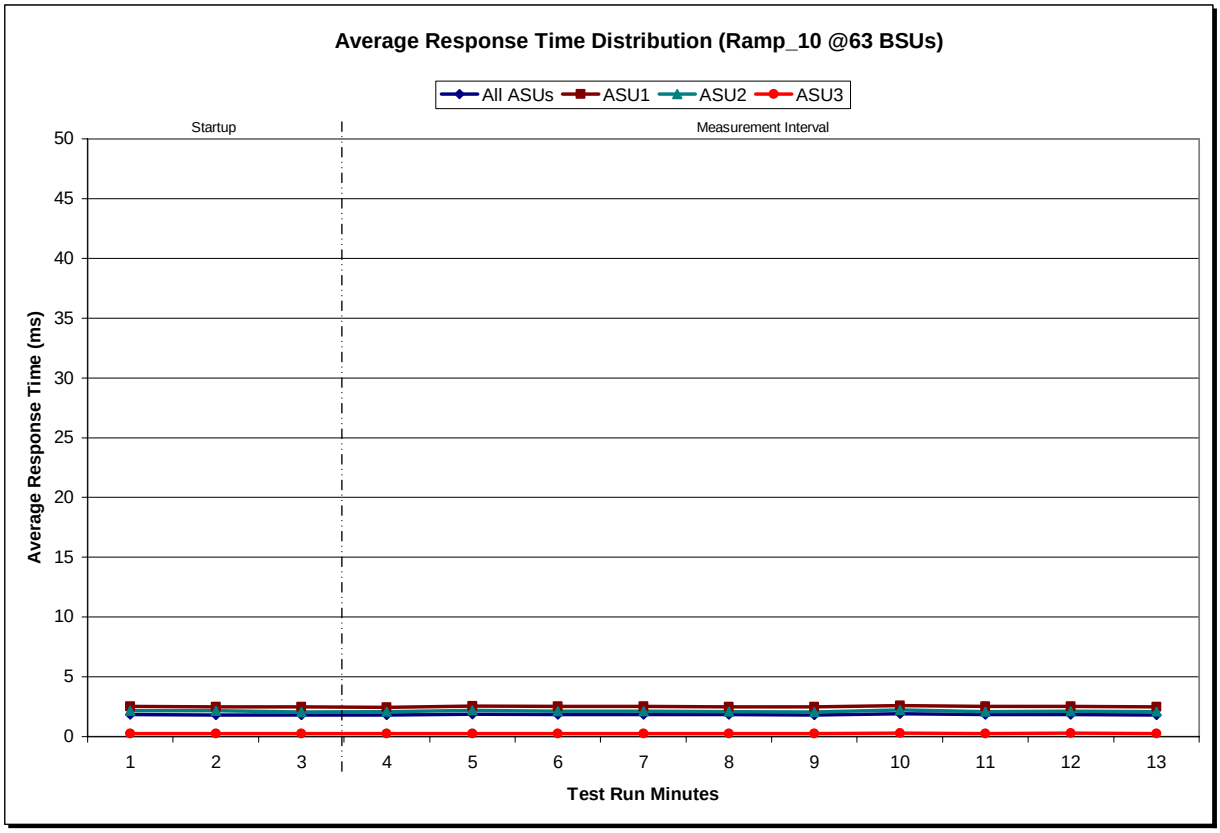
Response Time Ramp Distribution (IOPS) Graph



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

63 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:42:02	19:45:03	0-4	0:03:01
Measurement Interval	19:45:03	19:55:03	5-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.84	2.52	2.16	0.26
1	1.81	2.48	2.16	0.26
2	1.81	2.48	2.07	0.26
3	1.79	2.46	2.08	0.26
4	1.86	2.55	2.19	0.26
5	1.84	2.52	2.13	0.27
6	1.83	2.51	2.11	0.27
7	1.82	2.50	2.10	0.26
8	1.81	2.48	2.05	0.26
9	1.90	2.59	2.22	0.28
10	1.84	2.52	2.10	0.27
11	1.83	2.51	2.12	0.27
12	1.81	2.49	2.08	0.27
Average	1.83	2.51	2.12	0.27

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	0.0349	0.2809	0.0702	0.2097	0.0180	0.0696	0.0352	0.2814
COV	0.007	0.004	0.005	0.006	0.017	0.009	0.012	0.003

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 73.

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	***31,498.58***
Repeatability Test Phase 1	31.508.54
Repeatability Test Phase 2	31,484.32

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	1.85 ms
Repeatability Test Phase 2	1.84 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.

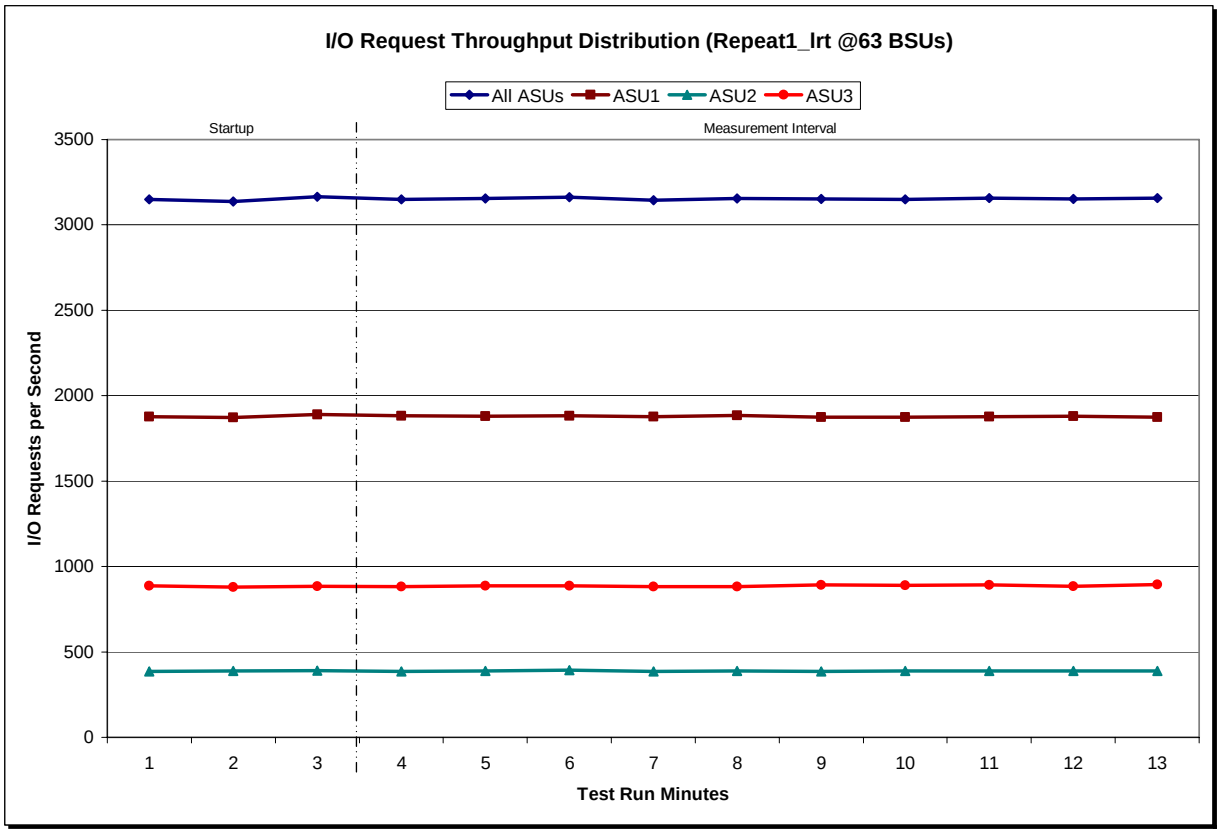
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

63 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:55:19	19:58:19	0-2	0:03:00
Measurement Interval	19:58:19	20:08:19	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	3,149.37	1,877.02	386.55	885.80
1	3,138.30	1,871.50	388.08	878.72
2	3,164.90	1,890.32	389.68	884.90
3	3,149.63	1,881.10	385.85	882.68
4	3,154.90	1,880.68	388.43	885.78
5	3,161.12	1,881.35	392.97	886.80
6	3,143.57	1,876.53	384.53	882.50
7	3,155.15	1,884.80	387.80	882.55
8	3,151.38	1,874.05	385.72	891.62
9	3,150.62	1,873.65	387.62	889.35
10	3,157.50	1,876.98	389.00	891.52
11	3,151.67	1,879.58	388.50	883.58
12	3,157.20	1,875.03	387.98	894.18
Average	3,153.27	1,878.38	387.84	887.06

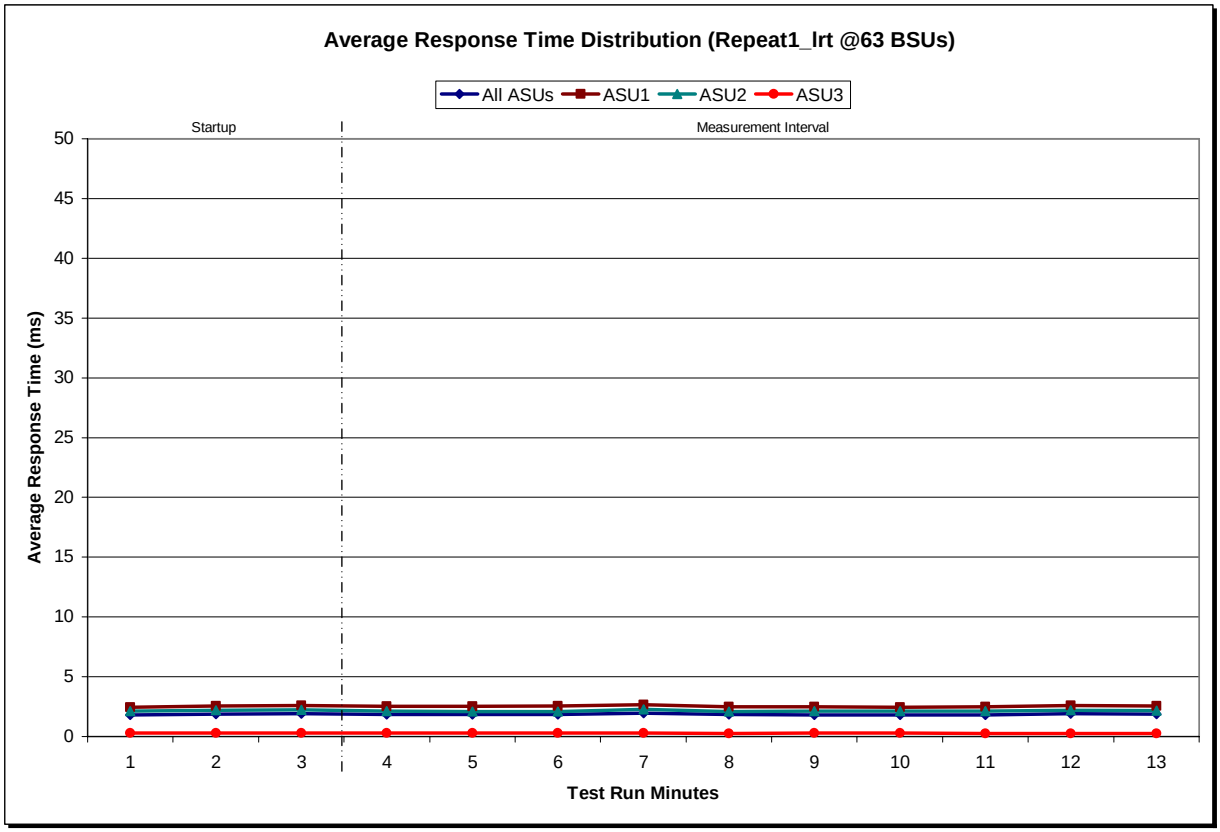
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

63 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:55:19	19:58:19	0-2	0:03:00
Measurement Interval	19:58:19	20:08:19	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.80	2.44	2.14	0.29
1	1.87	2.55	2.18	0.30
2	1.89	2.57	2.21	0.29
3	1.85	2.52	2.13	0.28
4	1.84	2.53	2.07	0.27
5	1.85	2.54	2.09	0.27
6	1.95	2.67	2.28	0.28
7	1.82	2.49	2.10	0.27
8	1.81	2.47	2.12	0.28
9	1.80	2.46	2.11	0.28
10	1.81	2.49	2.13	0.26
11	1.89	2.60	2.18	0.26
12	1.87	2.57	2.17	0.27
Average	1.85	2.54	2.14	0.27

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

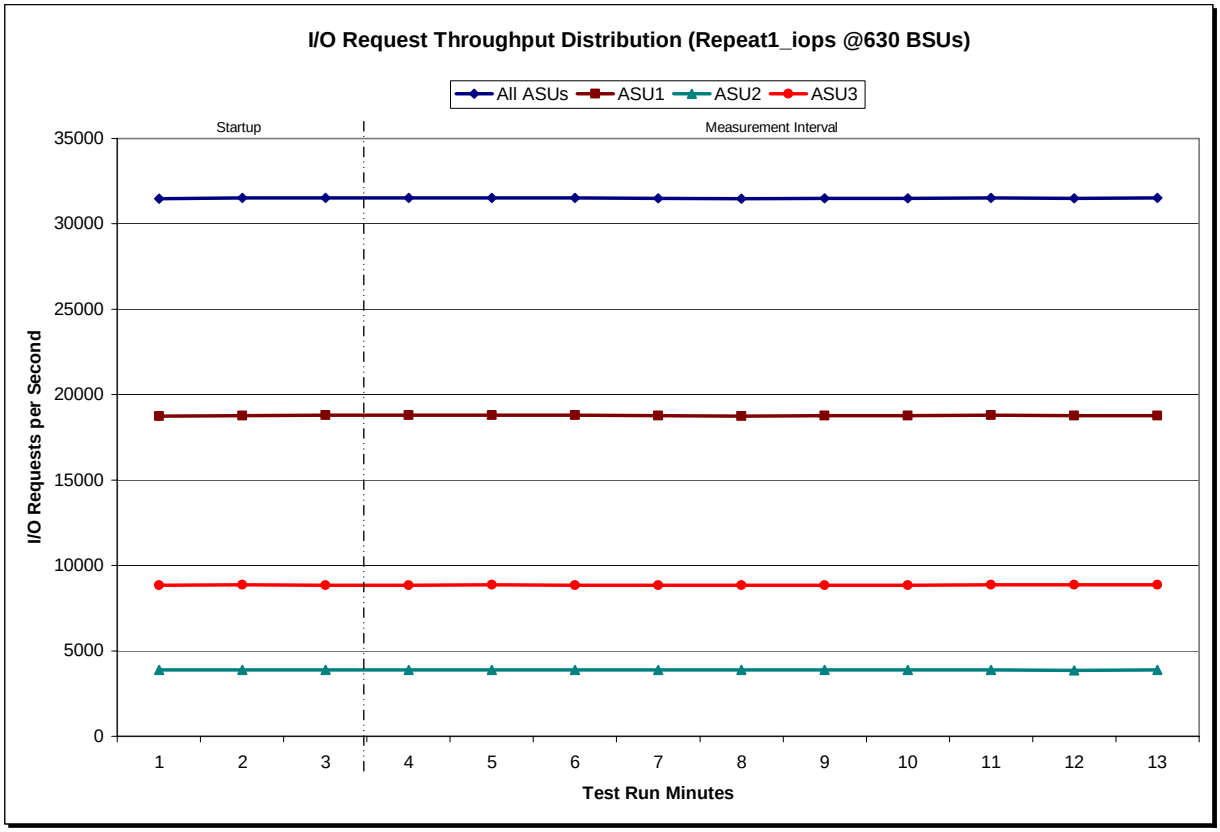


Repeatability 1 IOPS – I/O Request Throughput Distribution Data

630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:08:27	20:11:28	0-2	0:03:01
Measurement Interval	20:11:28	20:21:28	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	31,474.83	18,746.70	3,875.43	8,852.70
1	31,515.72	18,767.27	3,871.27	8,877.18
2	31,517.70	18,790.35	3,885.37	8,841.98
3	31,512.45	18,791.78	3,868.70	8,851.97
4	31,530.20	18,799.47	3,871.32	8,859.42
5	31,520.08	18,796.93	3,875.33	8,847.82
6	31,499.47	18,765.05	3,887.25	8,847.17
7	31,482.33	18,750.70	3,890.38	8,841.25
8	31,493.22	18,782.52	3,873.82	8,836.88
9	31,499.90	18,777.68	3,873.42	8,848.80
10	31,527.18	18,793.78	3,871.85	8,861.55
11	31,506.87	18,776.75	3,861.53	8,868.58
12	31,513.73	18,771.43	3,875.12	8,867.18
Average	31,508.54	18,780.61	3,874.87	8,853.06

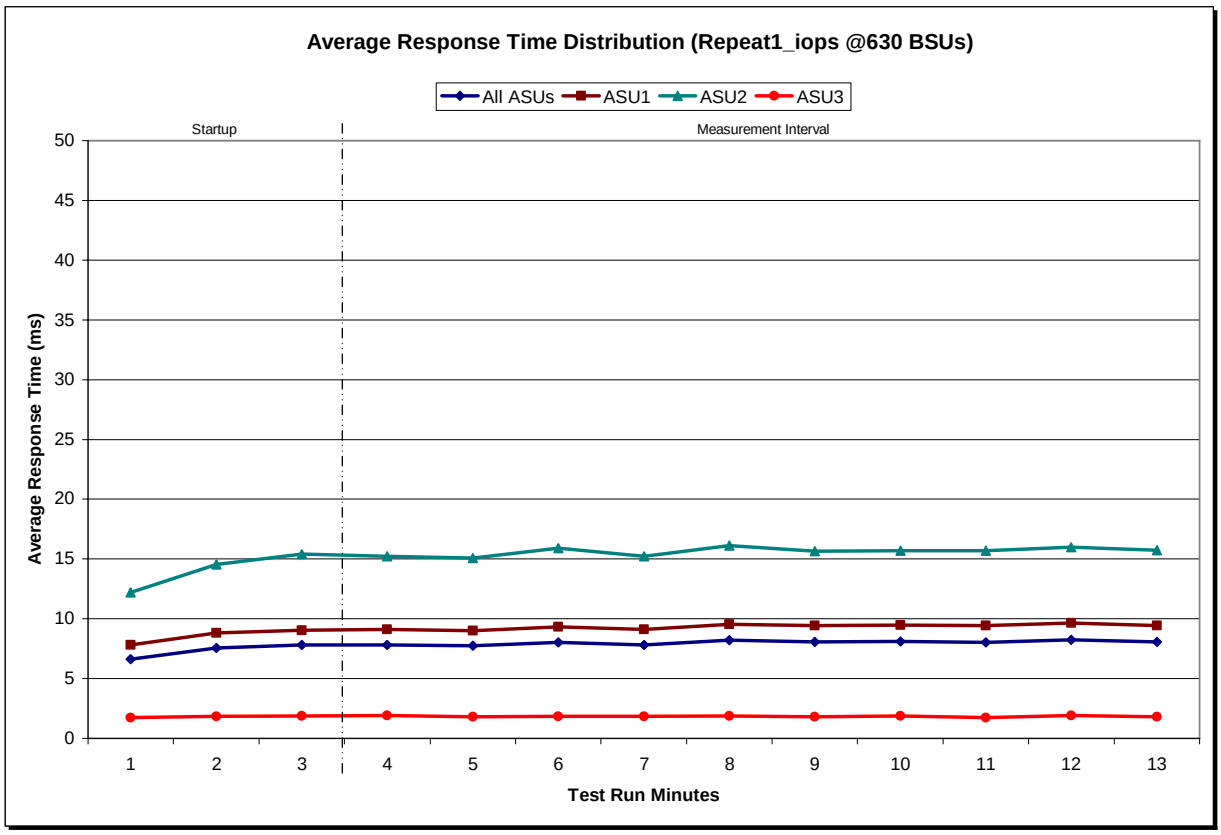
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:08:27	20:11:28	0-2	0:03:01
Measurement Interval	20:11:28	20:21:28	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.63	7.79	12.21	1.73
1	7.55	8.81	14.53	1.85
2	7.81	9.02	15.40	1.88
3	7.82	9.09	15.22	1.90
4	7.72	9.00	15.07	1.80
5	8.04	9.34	15.91	1.83
6	7.81	9.10	15.22	1.83
7	8.21	9.56	16.13	1.88
8	8.05	9.42	15.66	1.80
9	8.10	9.48	15.68	1.87
10	8.03	9.42	15.68	1.74
11	8.24	9.64	15.99	1.90
12	8.06	9.43	15.73	1.80
Average	8.01	9.35	15.63	1.83

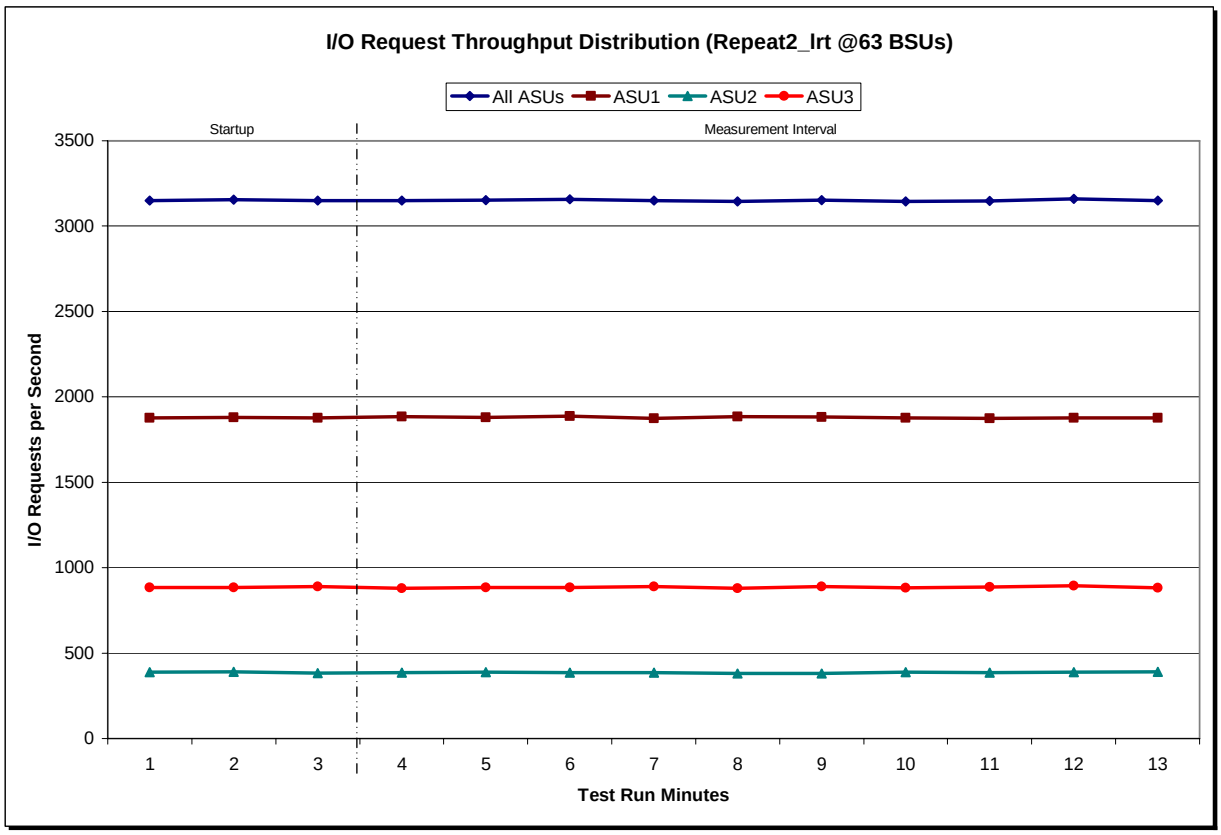
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

63 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:21:44	20:24:44	0-2	0:03:00
Measurement Interval	20:24:44	20:34:44	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	3,149.73	1,877.43	387.02	885.28
1	3,155.38	1,880.63	391.17	883.58
2	3,150.95	1,878.45	383.47	889.03
3	3,149.12	1,883.95	385.07	880.10
4	3,153.17	1,879.88	388.55	884.73
5	3,156.48	1,888.25	384.97	883.27
6	3,150.77	1,875.77	385.15	889.85
7	3,144.28	1,883.68	381.55	879.05
8	3,153.42	1,883.08	381.08	889.25
9	3,145.97	1,877.22	386.92	881.83
10	3,147.67	1,874.35	385.35	887.97
11	3,160.35	1,877.60	387.53	895.22
12	3,149.82	1,878.27	390.82	880.73
Average	3,151.10	1,880.21	385.70	885.20

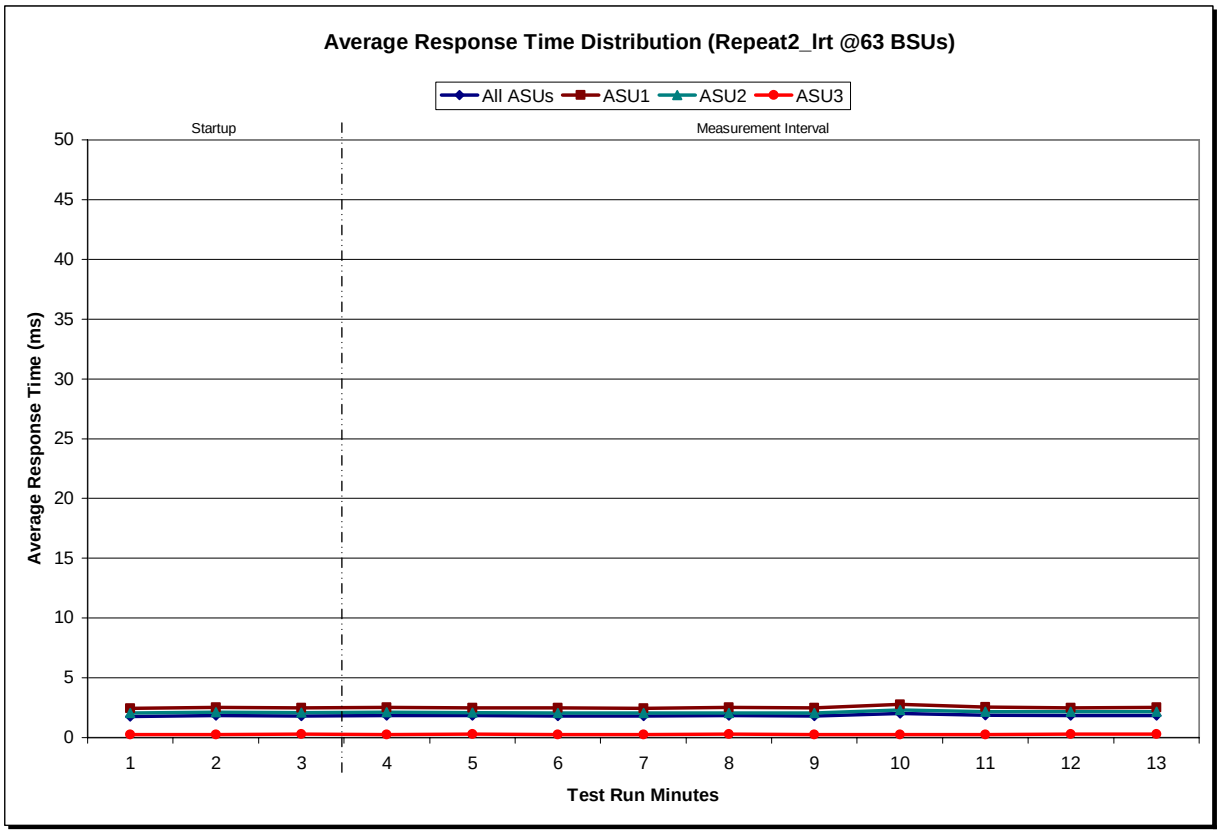
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

63 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:21:44	20:24:44	0-2	0:03:00
Measurement Interval	20:24:44	20:34:44	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.78	2.44	2.04	0.26
1	1.83	2.52	2.11	0.26
2	1.80	2.47	2.07	0.27
3	1.84	2.51	2.14	0.27
4	1.82	2.50	2.09	0.27
5	1.80	2.48	2.04	0.26
6	1.79	2.46	2.04	0.26
7	1.83	2.51	2.07	0.27
8	1.80	2.48	2.06	0.27
9	2.02	2.78	2.32	0.27
10	1.86	2.55	2.16	0.26
11	1.82	2.50	2.15	0.27
12	1.84	2.51	2.16	0.28
Average	1.84	2.53	2.12	0.27

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

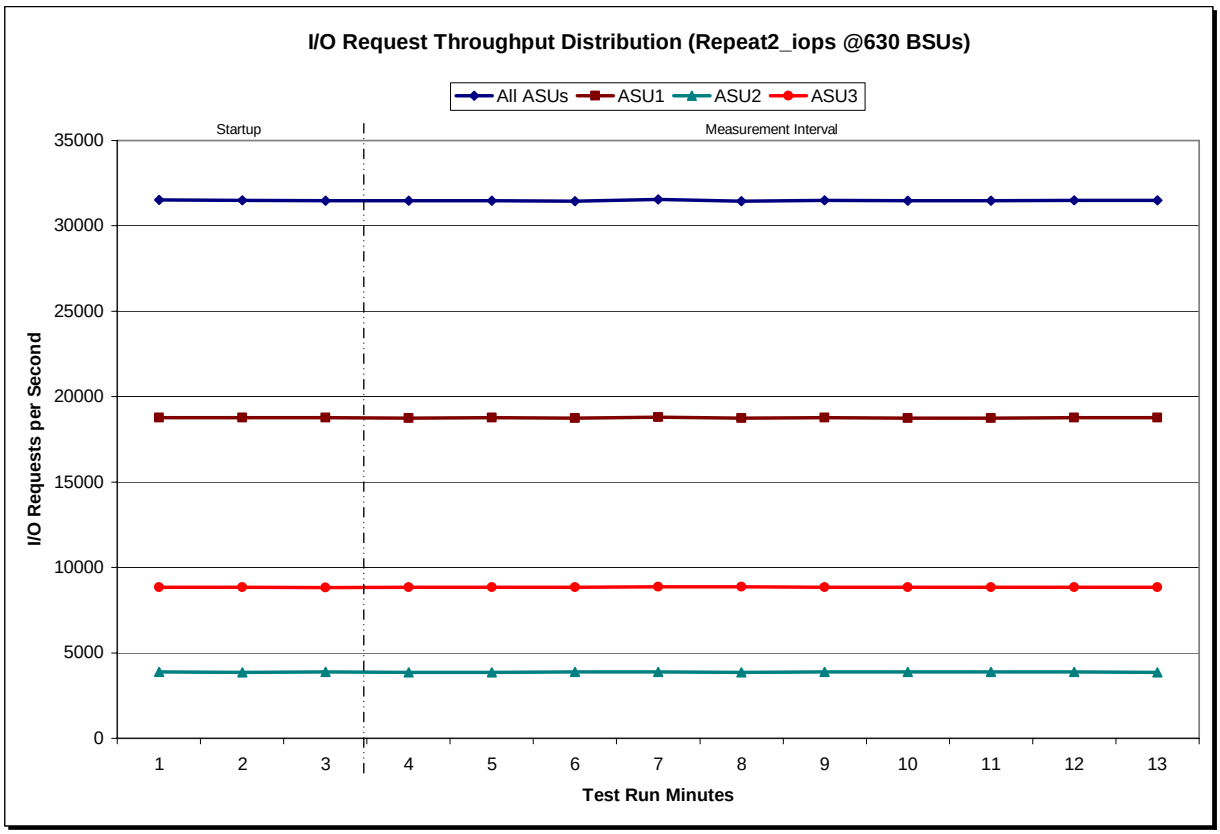


Repeatability 2 IOPS – I/O Request Throughput Distribution Data

630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:34:52	20:37:53	0-2	0:03:01
Measurement Interval	20:37:53	20:47:53	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	31,513.20	18,778.98	3,886.23	8,847.98
1	31,496.43	18,783.70	3,860.85	8,851.88
2	31,470.10	18,761.35	3,880.82	8,827.93
3	31,463.93	18,758.08	3,859.70	8,846.15
4	31,477.83	18,776.50	3,866.30	8,835.03
5	31,459.18	18,738.27	3,879.67	8,841.25
6	31,544.37	18,798.42	3,871.00	8,874.95
7	31,459.40	18,734.87	3,861.78	8,862.75
8	31,498.92	18,767.28	3,879.45	8,852.18
9	31,460.03	18,748.40	3,872.27	8,839.37
10	31,484.58	18,758.88	3,881.33	8,844.37
11	31,502.00	18,763.02	3,885.93	8,853.05
12	31,492.95	18,776.95	3,861.48	8,854.52
Average	31,484.32	18,762.07	3,871.89	8,850.36

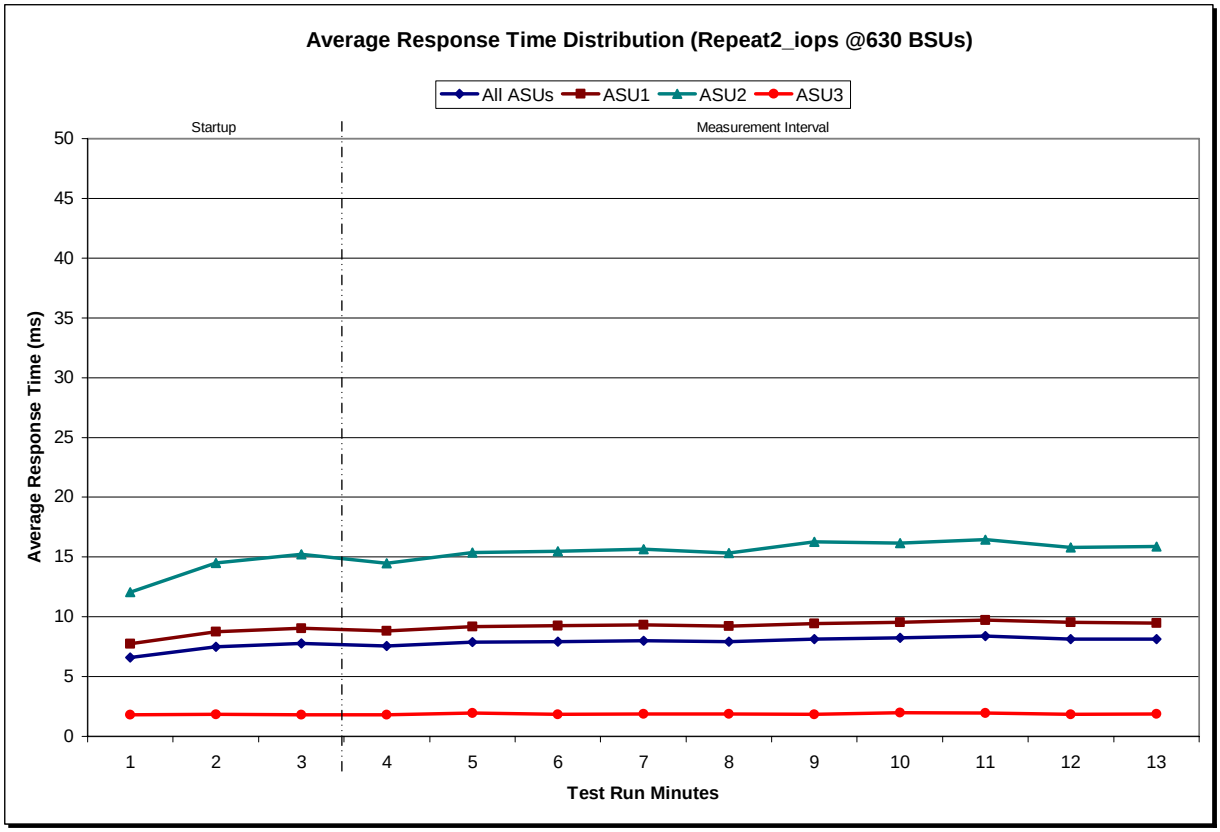
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

630 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:34:52	20:37:53	0-2	0:03:01
Measurement Interval	20:37:53	20:47:53	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.60	7.72	12.07	1.80
1	7.50	8.74	14.50	1.82
2	7.78	9.04	15.22	1.81
3	7.55	8.84	14.46	1.81
4	7.90	9.16	15.37	1.94
5	7.94	9.25	15.46	1.85
6	8.00	9.32	15.64	1.86
7	7.91	9.23	15.35	1.87
8	8.15	9.45	16.27	1.83
9	8.23	9.53	16.18	1.99
10	8.37	9.73	16.47	1.94
11	8.13	9.52	15.81	1.82
12	8.12	9.47	15.89	1.88
Average	8.03	9.35	15.69	1.88

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	0.2810	0.0698	0.2100	0.0179	0.0699	0.0352	0.2813
COV	0.016	0.004	0.008	0.005	0.019	0.006	0.008	0.004

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	0.0349	0.2811	0.0701	0.2100	0.0180	0.0700	0.0349	0.2810
COV	0.005	0.001	0.002	0.002	0.005	0.002	0.004	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	0.0351	0.2811	0.0700	0.2106	0.0180	0.0696	0.0348	0.2809
COV	0.013	0.003	0.012	0.004	0.016	0.010	0.014	0.005

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0699	0.2101	0.0180	0.0700	0.0350	0.2811
COV	0.004	0.001	0.002	0.001	0.007	0.003	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 73.

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	75,401,184
Total Number of Logical Blocks Verified	65,039,904
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 Hitachi Adaptable Modular Storage 2100 as documented in this Full Disclosure Report is currently available 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.

SPC Auditor approval was granted to reorder to required execution sequence of SPC Tests to better utilize the time spent for onsite audit activities. The following execution sequence was used: Persistence Test Run 1, required TSC power cycle, and uninterrupted execution of Persistence Test Run 2, the Primary Metrics Test *(Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase)*, and Repeatability Test *(Repeatability Test Phase 1 and Repeatability Test Phase 2)*.

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.

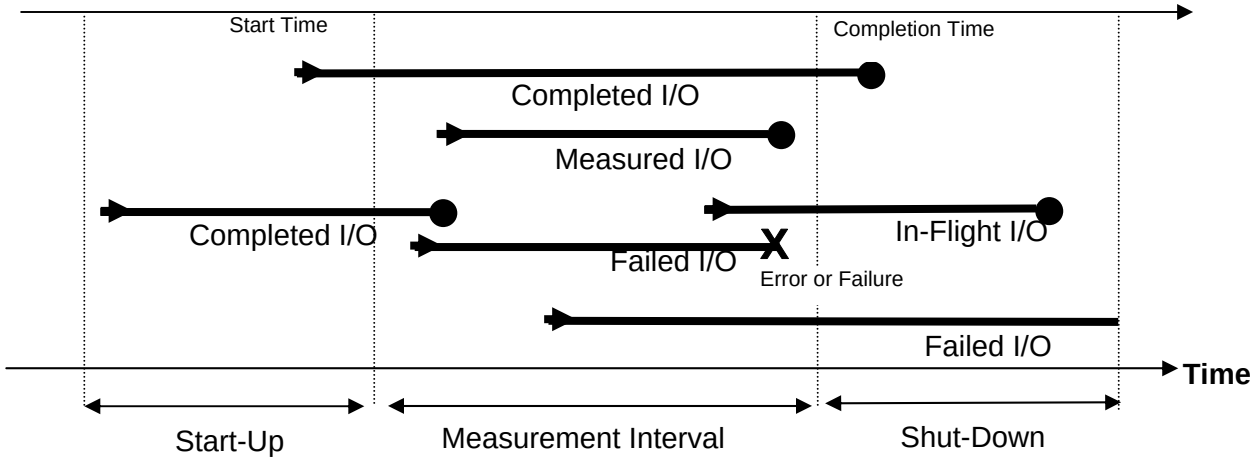
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

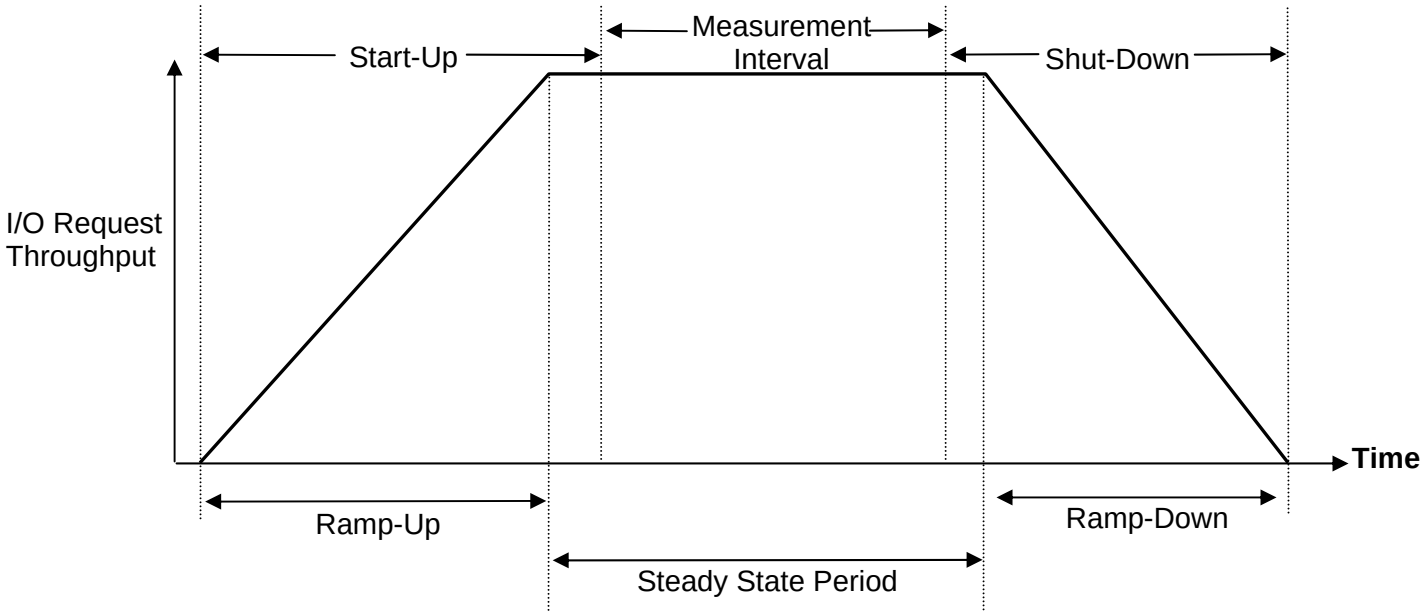
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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

1. Change Queue Depth

Change the "hdisk" ***queue depth*** to 32 in AIX.

2. Turn off trace, online verify test and monitoring information

Set ***Detailed Trace Mode*** from default "ON" to "OFF".

Set ***Online Verify Test*** from default "Yes" to "No".

Set following performance monitoring parameters from default "Start" to "Stop"

Monitoring items	Default	New
Port Information	Start	Stop
RAID Group/Logical Unit Information	Start	Stop
Cache Information	Start	Stop
Processor Information	Start	Stop
Drive Information	Start	Stop
Drive Operating Information	Start	Stop
Back-end Information	Start	Stop

3. Change cache management strategy

Change the cache configuration as illustrated below.

Partition #	Default		New	
	Partition size[MB]	Segment size[KB]	Partition size[MB]	Segment size[KB]
Partition 0	1760	16	1400	16
Partition 1	1760	16	1400	16
Partition 2	-	-	360	16
Partition 3	-	-	360	16

Change the cache de-staging parameter settings as illustrated below.

Parameter	Default	New
Dirty Data Opportunity	5	20
Dirty Data Stop Opportunity	5	10

Change each Logical Unit's (LU) pre-fetch parameters for multi-stream I/O as illustrated below.

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
All LU	Read	Enable	Base	256	128	3

LU #	New					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
0	Read	Enable	Base	256KB	128KB	0
1	Read	Disable	Fixed	128KB	128KB	1
2	Read	Disable	Fixed	128KB	128KB	1
3	Read	Enable	Base	256KB	128KB	0
4	Read	Enable	Base	256KB	128KB	0
5	Read	Enable	Base	256KB	128KB	0
6	Read	Disable	Fixed	128KB	128KB	1
7	Read	Enable	Base	256KB	128KB	0
8	Read	Enable	Base	256KB	128KB	0
9	Read	Enable	Base	256KB	128KB	0
10	Read	Enable	Base	256KB	128KB	0
11	Read	Disable	Fixed	128KB	128KB	1
12	Read	Disable	Fixed	128KB	128KB	1
13	Read	Enable	Base	256KB	128KB	0
14	Read	Enable	Base	256KB	128KB	0
15	Read	Enable	Base	256KB	128KB	0
16	Read	Disable	Fixed	128KB	128KB	1
17	Read	Enable	Base	256KB	128KB	0
18	Read	Enable	Base	256KB	128KB	0
19	Read	Enable	Base	256KB	128KB	0
20	Read	Enable	Base	256KB	128KB	0
21	Read	Disable	Fixed	128KB	128KB	1

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
22	Read	Disable	Fixed	128KB	128KB	1
23	Read	Enable	Base	256KB	128KB	0
24	Read	Enable	Base	256KB	128KB	0
25	Read	Enable	Base	256KB	128KB	0
26	Read	Disable	Fixed	128KB	128KB	1
27	Read	Enable	Base	256KB	128KB	0
28	Read	Enable	Base	256KB	128KB	0
29	Read	Enable	Base	256KB	128KB	0
30	Read	Enable	Base	256KB	128KB	0
31	Read	Disable	Fixed	128KB	128KB	1
32	Read	Disable	Fixed	128KB	128KB	1
33	Read	Enable	Base	256KB	128KB	0
34	Read	Enable	Base	256KB	128KB	0
35	Read	Enable	Base	256KB	128KB	0
36	Read	Disable	Fixed	128KB	128KB	1
37	Read	Enable	Base	256KB	128KB	0
38	Read	Enable	Base	256KB	128KB	0
39	Read	Enable	Base	256KB	128KB	0
40	Read	Enable	Base	256KB	128KB	0
41	Read	Disable	Fixed	128KB	128KB	1
42	Read	Disable	Fixed	128KB	128KB	1
43	Read	Enable	Base	256KB	128KB	0
44	Read	Enable	Base	256KB	128KB	0
45	Read	Enable	Base	256KB	128KB	0
46	Read	Disable	Fixed	128KB	128KB	1
47	Read	Enable	Base	256KB	128KB	0
48	Read	Enable	Base	256KB	128KB	0
49	Read	Enable	Base	256KB	128KB	0
50	Read	Enable	Base	256KB	128KB	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
51	Read	Disable	Fixed	128KB	128KB	1
52	Read	Disable	Fixed	128KB	128KB	1
53	Read	Enable	Base	256KB	128KB	0
54	Read	Enable	Base	256KB	128KB	0
55	Read	Enable	Base	256KB	128KB	0
56	Read	Disable	Fixed	128KB	128KB	1
57	Read	Enable	Base	256KB	128KB	0
58	Read	Enable	Base	256KB	128KB	0
59	Read	Enable	Base	256KB	128KB	0
60	Read	Enable	Base	256KB	128KB	0
61	Read	Disable	Fixed	128KB	128KB	1
62	Read	Disable	Fixed	128KB	128KB	1
63	Read	Enable	Base	256KB	128KB	0
64	Read	Enable	Base	256KB	128KB	0
65	Read	Enable	Base	256KB	128KB	0
66	Read	Disable	Fixed	128KB	128KB	1
67	Read	Enable	Base	256KB	128KB	0
68	Read	Enable	Base	256KB	128KB	0
69	Read	Enable	Base	256KB	128KB	0
70	Read	Enable	Base	256KB	128KB	0
71	Read	Disable	Fixed	128KB	128KB	1
72	Read	Disable	Fixed	128KB	128KB	1
73	Read	Enable	Base	256KB	128KB	0
74	Read	Enable	Base	256KB	128KB	0
75	Read	Enable	Base	256KB	128KB	0
76	Read	Disable	Fixed	128KB	128KB	1
77	Read	Enable	Base	256KB	128KB	0
78	Read	Enable	Base	256KB	128KB	0
79	Read	Enable	Base	256KB	128KB	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
80	Read	Enable	Base	256KB	128KB	0
81	Read	Disable	Fixed	128KB	128KB	1
82	Read	Disable	Fixed	128KB	128KB	1
83	Read	Enable	Base	256KB	128KB	0
84	Read	Enable	Base	256KB	128KB	0
85	Read	Enable	Base	256KB	128KB	0
86	Read	Disable	Fixed	128KB	128KB	1
87	Read	Enable	Base	256KB	128KB	0
88	Read	Enable	Base	256KB	128KB	0
89	Read	Enable	Base	256KB	128KB	0
90	Read	Enable	Base	256KB	128KB	0
91	Read	Disable	Fixed	128KB	128KB	1
92	Read	Disable	Fixed	128KB	128KB	1
93	Read	Enable	Base	256KB	128KB	0
94	Read	Enable	Base	256KB	128KB	0
95	Read	Enable	Base	256KB	128KB	0
96	Read	Disable	Fixed	128KB	128KB	1
97	Read	Enable	Base	256KB	128KB	0
98	Read	Enable	Base	256KB	128KB	0
99	Read	Enable	Base	256KB	128KB	0
100	Read	Enable	Base	256KB	128KB	0
101	Read	Disable	Fixed	128KB	128KB	1
102	Read	Disable	Fixed	128KB	128KB	1
103	Read	Enable	Base	256KB	128KB	0
104	Read	Enable	Base	256KB	128KB	0
105	Read	Enable	Base	256KB	128KB	0
106	Read	Disable	Fixed	128KB	128KB	1
107	Read	Enable	Base	256KB	128KB	0
108	Read	Enable	Base	256KB	128KB	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
109	Read	Enable	Base	256KB	128KB	0
110	Read	Enable	Base	256KB	128KB	0
111	Read	Disable	Fixed	128KB	128KB	1
112	Read	Disable	Fixed	128KB	128KB	1
113	Read	Enable	Base	256KB	128KB	0
114	Read	Enable	Base	256KB	128KB	0
115	Read	Enable	Base	256KB	128KB	0
116	Read	Disable	Fixed	128KB	128KB	1
117	Read	Enable	Base	256KB	128KB	0
118	Read	Enable	Base	256KB	128KB	0
119	Read	Enable	Base	256KB	128KB	0
120	Read/Write	Enable	Base	256KB	128KB	1
121	Read/Write	Enable	Base	256KB	128KB	1
122	Read/Write	Enable	Base	256KB	128KB	1
123	Read/Write	Enable	Base	256KB	128KB	1

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The following Storage Navigator Modular2 (SNM2) scripts/commands were used to create and configure the Tested Storage Configuration (TSC).

1. Registration of the unit

The AMS2100 was registered by using the following command:

```
set UNAME=(Your Unit Name)
auunitadd  -unit %UNAME%  -LAN -ctl0  (IP address of controller0) –ctl1 (IP
address of controller1)
Unit (Unit Name) has been registered.
```

2. Cache Partition Configuration

The AMS2100 cache was divided into four (4) partitions. “Partition 0” and “Partition 1” were used for ASU-1 and ASU-2. “Partition 2” and “Partition 3” were used for ASU-3. After each command, SNM2 will request a reboot of the AMS2100, but a reboot is only needed after the last command to enable the newly configured cache partitioning.

```
set UNAME=PE78

REM==========================================================================
======================
REM Cache Partition Configuration
REM==========================================================================
======================
auopt -unit %UNAME% -lock off -keycode "Password"
REM When Cache size is 4GB per CTL
set ASU1_2size=140
aucachept -unit %UNAME% -chg -pt 0 -ptsize %ASU1_2size%
aucachept -unit %UNAME% -chg -pt 1 -ptsize %ASU1_2size%
set ASU3size=36
set segsize=16
aucachept -unit %UNAME% -add -ptsize %ASU3size% -segsize %segsize% -ctl0
aucachept -unit %UNAME% -add -ptsize %ASU3size% -segsize %segsize% -ctl1
```

3. RAID Group (RG) Creation

Twelve (12) RAID Groups *(0-11, 4D+4D, RAID1+0)* were created and used for ASU-1 and ASU-2. Four (4) RAID Groups *(12-15, 2D+2D, RAID1+0)* were created and used for ASU-3. The RAID Groups were created using the following commands:

```
set UNAME=PE78

REM==========================================================================
======================
REM RG Configuration
REM==========================================================================
======================
aurgadd -unit %UNAME% -rg 0 -RAID10 -drive 0.0-0.7 -pnum 1
aurgadd -unit %UNAME% -rg 1 -RAID10 -drive 1.0-1.7 -pnum 1
aurgadd -unit %UNAME% -rg 2 -RAID10 -drive 2.0-2.7 -pnum 1
aurgadd -unit %UNAME% -rg 3 -RAID10 -drive 3.0-3.7 -pnum 1
aurgadd -unit %UNAME% -rg 4 -RAID10 -drive 0.8-0.14 4.0 -pnum 1
```

```
aurgadd -unit %UNAME% -rg 5 -RAID10 -drive 1.8-1.14 5.0 -pnum 1
aurgadd -unit %UNAME% -rg 6 -RAID10 -drive 2.8-2.14 6.0 -pnum 1
aurgadd -unit %UNAME% -rg 7 -RAID10 -drive 3.8-3.14 7.0 -pnum 1
aurgadd -unit %UNAME% -rg 8 -RAID10 -drive 4.1-4.8 -pnum 1
aurgadd -unit %UNAME% -rg 9 -RAID10 -drive 5.1-5.8 -pnum 1
aurgadd -unit %UNAME% -rg 10 -RAID10 -drive 6.1-6.8 -pnum 1
aurgadd -unit %UNAME% -rg 11 -RAID10 -drive 7.1-7.8 -pnum 1
aurgadd -unit %UNAME% -rg 12 -RAID10 -drive 4.9-4.12 -pnum 1
aurgadd -unit %UNAME% -rg 13 -RAID10 -drive 5.9-5.12 -pnum 1
aurgadd -unit %UNAME% -rg 14 -RAID10 -drive 6.9-6.12 -pnum 1
aurgadd -unit %UNAME% -rg 15 -RAID10 -drive 7.9-7.12 -pnum 1
```

4. Logical Unit (LU) Creation

There were 60 logical devices (Logical Unit, LU) created on RAID Groups 0-11 for ASU-1. A second set of 60 LUs were also created the same RAID Groups for ASU-2. Four (4) LUs were created on RAID Groups 12-15 for ASU-3.

The following commands were used to create the LUs:

```
set UNAME=PE78

REM============================================================================
======================
REM LU Configuration
REM============================================================================
======================
for /L %%I IN ( 0, 1, 9) DO auluadd -unit %UNAME% -lu %%I -rg 0 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (10, 1,19) DO auluadd -unit %UNAME% -lu %%I -rg 1 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (20, 1,29) DO auluadd -unit %UNAME% -lu %%I -rg 2 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (30, 1,39) DO auluadd -unit %UNAME% -lu %%I -rg 3 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (40, 1,49) DO auluadd -unit %UNAME% -lu %%I -rg 4 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (50, 1,59) DO auluadd -unit %UNAME% -lu %%I -rg 5 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (60, 1,69) DO auluadd -unit %UNAME% -lu %%I -rg 6 -size 75497472 -
cachept 1 -noluformat
for /L %%I IN (70, 1,79) DO auluadd -unit %UNAME% -lu %%I -rg 7 -size 75497472 -
cachept 1 -noluformat
for /L %%I IN (80, 1,89) DO auluadd -unit %UNAME% -lu %%I -rg 8 -size 75497472 -
cachept 1 -noluformat
for /L %%I IN (90, 1,99) DO auluadd -unit %UNAME% -lu %%I -rg 9 -size 75497472 -
cachept 1 -noluformat
for /L %%I IN (100, 1,109) DO auluadd -unit %UNAME% -lu %%I -rg 10 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (110, 1,119) DO auluadd -unit %UNAME% -lu %%I -rg 11 -size 75497472
-cachept 1 -noluformat
auluadd -unit %UNAME% -lu 120 -rg 12 -size 417595392 -stripesize 512 -cachept 2 -
noluformat
auluadd -unit %UNAME% -lu 121 -rg 13 -size 417595392 -stripesize 512 -cachept 2 -
noluformat
auluadd -unit %UNAME% -lu 122 -rg 14 -size 417595392 -stripesize 512 -cachept 3 -
noluformat
auluadd -unit %UNAME% -lu 123 -rg 15 -size 417595392 -stripesize 512 -cachept 3 -
noluformat
```

5. Map LUs to Front-End Ports

Each of the four front-end ports is assigned thirty-one (31) LUs as follows: fifteen (15) LUs for ASU-1, fifteen (15) LUs for ASU-2, and one (1) LU for ASU-3.

The following commands were used to map each LU to the appropriate front-end port:

```
set UNAME=PE78



REM============================================================================
======================REM LU Mapping Configuration
REM============================================================================
======================
auhgmap -unit %UNAME% -MappingMode off
auhgmap -unit %UNAME% -MappingMode on

REM port1A

for /L %%I IN (  60, 1,  89) DO auhgmap -unit %UNAME% -add 1 A 0 %%I %%I

REM port1C
for /L %%I IN (90, 1, 119) DO auhgmap -unit %UNAME% -add 1 B 0 %%I %%I
REM port0A
for /L %%I IN (  0, 1,  29) DO auhgmap -unit %UNAME% -add 0 A 0 %%I %%I
REM port0B
for /L %%I IN (  30, 1, 59) DO auhgmap -unit %UNAME% -add 0 B 0 %%I %%I
REM for ASU3
auhgmap -unit %UNAME% -add 0 A 0 120 120
auhgmap -unit %UNAME% -add 0 B 0 121 121
auhgmap -unit %UNAME% -add 1 A 0 122 122
auhgmap -unit %UNAME% -add 1 B 0 123 123
```

6. Set Host Connection Option

Change the Host connection option settings for the AIX Host System using the following commands:

```
auhgopt -unit %uname% -set 0 A -gno 0  -NACA enable
auhgopt -unit %uname% -set 0 B -gno 0  -NACA enable
auhgopt -unit %uname% -set 1 A -gno 0  -NACA enable
auhgopt -unit %uname% -set 1 B -gno 0  -NACA enable
```

7. Turn Off Trace and Monitoring Information – AMS2100 Tuning Parameter

Turn off the collection of trace and performance monitor information to reduce CPU overhead using the following commands:

```
aupfmstatiscfg -unit %UNAME% -set -port stop -rglu stop -cache stop -processor
stop -drive stop -driveopr stop -backend stop
auonlineverify -unit %UNAME% -set -verify disable
ausystuning -unit %UNAME% -set -detailedtrace off
```

8. Change Cache Management Strategy – AMS2100 Tuning Parameter

Optimize the cache management strategy for multi-stream I/O by using the following commands:

```
ausystuning -unit %UNAME% -set -dtystart 20 -dtystop 10
autuningmultistream -unit %UNAME% -default
autuningmultistream -unit %UNAME% -set -scope lu -lu 0-123 -seqcount 0
for /L %%I IN ( 1, 10, 119) DO autuningmultistream -unit %UNAME% -set -scope lu
-lu %%I -seqcount 1 -next disable -criteria fixed
for /L %%I IN ( 2, 10, 119) DO autuningmultistream -unit %UNAME% -set -scope lu
-lu %%I -seqcount 1 -next disable -criteria fixed
for /L %%I IN ( 6, 10, 119) DO autuningmultistream -unit %UNAME% -set -scope lu
-lu %%I -seqcount 1 -next disable -criteria fixed
autuningmultistream -unit %UNAME% -set -scope lu -lu 120 -readwrite enable -
seqcount 1 -criteria base
autuningmultistream -unit %UNAME% -set -scope lu -lu 121 -readwrite enable -
seqcount 1 -criteria base
autuningmultistream -unit %UNAME% -set -scope lu -lu 122 -readwrite enable -
seqcount 1 -criteria base
autuningmultistream -unit %UNAME% -set -scope lu -lu 123 -readwrite enable -
seqcount 1 -criteria base

set PREF_SIZE=128
set PREB_SIZE=128
for /L %%I IN ( 1, 10, 119) DO autuningmultistream -unit %UNAME% -set -scope lu
-lu %%I -fixedsize %PREF_SIZE% -basesize %PREF_SIZE%
for /L %%I IN ( 2, 10, 119) DO autuningmultistream -unit %UNAME% -set -scope lu
-lu %%I -fixedsize %PREF_SIZE% -basesize %PREF_SIZE%
for /L %%I IN ( 6, 10, 119) DO autuningmultistream -unit %UNAME% -set -scope lu
-lu %%I -fixedsize %PREF_SIZE% -basesize %PREF_SIZE%
```

The following TSC creation/configuration steps result in the creation of the final SPC-1 Logical Volumes, which comprise ASU-1, ASU-2, and ASU-3. Those volumes are visible to accessible by the AIX Host System.

9. Discover LUNs

Use the AIX command, ***cfgmgr***, to discover the LUNs, followed by the AIX command ***lsdev –Cc disk*** to confirm that 124 "hdisks" exist.

10. Change "hdisk" Queue Depth Settings

Change the "hdisk" queue depth setting to thirty-two (32) using the following script:

```
#!/bin/sh

# Remove all attached Hitachi hdisks

hdisk_list=`lsdev -Cc disk | grep Hitachi | awk '{print $1}'`
for hd in $hdisk_list
do
  rmdev -dl $hd -R
done
lsdev -Cc disk

hdisk_list=`lsdev -Cc disk |  awk '{print $1}'`

for hd in $hdisk_list
do
  chdev -l $hd -a queue_depth='32'
done

for hd in $hdisk_list
do
queue_depth=`lsattr -l $hd -a queue_depth -E | awk '{print $2}'`
echo "$hd  $queue_depth"
done
```

11. Create Volume Groups and Logical Volumes for ASUs

Volume Groups are created using the native AIX Logical Volume Manager. The first step is to edit **env.cfg.pe78.df800s.112d146g15k.livg.rsd**. This file is used as an environment file which identifies the name of the Volume Group, the "hdisks" which belong to each Volume Group, the names of the Logical Volumes, the size of the Logical Volumes, and the number of logical partitions. After editing the environment file, **env.cfg**, execute the **mkvg.rsd_spc1.ksh** script to create the Volume Groups, and **mklv.rsd_spc1.ksh** to create the Logical Volumes.

The content of **env.cfg.pe78.df800s.112d146g15k.livg.rsd**, **mkvg.rsd_spc1.ksh**, and **mklv.rsd_spc1.ksh** are listed below.

env.cfg.pe78.df800s.112d146g15k.livg.rsd

```
# Volume Group Name
ASU11FS=asu11
ASU12FS=asu12
ASU13FS=asu13
ASU14FS=asu14
ASU15FS=asu15
ASU21FS=asu21
ASU22FS=asu22
ASU23FS=asu23
ASU24FS=asu24
ASU25FS=asu25
ASU31FS=asu31

# List of hdisk to create volume group.
ASU11DISK="hdisk63 hdisk73 hdisk83 hdisk94 hdisk104 hdisk114 hdisk32 hdisk42
hdisk52 hdisk1 hdisk11 hdisk21"

ASU12DISK="hdisk64 hdisk74 hdisk84 hdisk95 hdisk105 hdisk115 hdisk33 hdisk43
hdisk53 hdisk2 hdisk12 hdisk22"

ASU13DISK="hdisk65 hdisk75 hdisk85 hdisk96 hdisk106 hdisk116 hdisk34 hdisk44
hdisk54 hdisk3 hdisk13 hdisk23"

ASU14DISK="hdisk66 hdisk76 hdisk86 hdisk97 hdisk107 hdisk117 hdisk35 hdisk45
hdisk55 hdisk4 hdisk14 hdisk24"

ASU15DISK="hdisk67 hdisk77 hdisk87 hdisk98 hdisk108 hdisk118 hdisk36 hdisk46
hdisk56 hdisk5 hdisk15 hdisk25"

ASU21DISK="hdisk68 hdisk78 hdisk88 hdisk99 hdisk109 hdisk119 hdisk37 hdisk47
hdisk57 hdisk6 hdisk16 hdisk26"

ASU22DISK="hdisk69 hdisk79 hdisk89 hdisk100 hdisk110 hdisk120 hdisk38 hdisk48
hdisk58 hdisk7 hdisk17 hdisk27"

ASU23DISK="hdisk70 hdisk80 hdisk90 hdisk101 hdisk111 hdisk121 hdisk39 hdisk49
hdisk59 hdisk8 hdisk18 hdisk28"

ASU24DISK="hdisk71 hdisk81 hdisk91 hdisk102 hdisk112 hdisk122 hdisk40 hdisk50
hdisk60 hdisk9 hdisk19 hdisk29"

ASU25DISK="hdisk72 hdisk82 hdisk92 hdisk103 hdisk113 hdisk123 hdisk41 hdisk51
hdisk61 hdisk10 hdisk20 hdisk30"

ASU31DISK="hdisk93 hdisk124 hdisk62 hdisk31"

# Volume Group Name
ASU11VG=vg$ASU11FS
ASU12VG=vg$ASU12FS
ASU13VG=vg$ASU13FS
ASU14VG=vg$ASU14FS
ASU15VG=vg$ASU15FS
ASU21VG=vg$ASU21FS
ASU22VG=vg$ASU22FS
ASU23VG=vg$ASU23FS
ASU24VG=vg$ASU24FS
ASU25VG=vg$ASU25FS
ASU31VG=vg$ASU31FS
```

```
# Logical Volume Group Name
ASU11LV=lv$ASU11FS
ASU12LV=lv$ASU12FS
ASU13LV=lv$ASU13FS
ASU14LV=lv$ASU14FS
ASU15LV=lv$ASU15FS
ASU21LV=lv$ASU21FS
ASU22LV=lv$ASU22FS
ASU23LV=lv$ASU23FS
ASU24LV=lv$ASU24FS
ASU25LV=lv$ASU25FS
ASU31LV=lv$ASU31FS

# Logical Volume Size
ASU11LVSIZE=5712
ASU12LVSIZE=5712
ASU13LVSIZE=5712
ASU14LVSIZE=5712
ASU15LVSIZE=5712
ASU21LVSIZE=5712
ASU22LVSIZE=5712
ASU23LVSIZE=5712
ASU24LVSIZE=5712
ASU25LVSIZE=5712
ASU31LVSIZE=6360

# Maximum Number of Logical Partition
ASU11LP=12
ASU12LP=12
ASU13LP=12
ASU14LP=12
ASU15LP=12
ASU21LP=12
ASU22LP=12
ASU23LP=12
ASU24LP=12
ASU25LP=12
ASU31LP=4
```

mkvg.rsd_spc1.ksh

```
#!/bin/ksh


. /home/perf/spc1/env.cfg.pe78.df800s.112d146g15k.livg.rsd

mkvg -f -y $ASU11VG -s '64' $ASU11DISK
mkvg -f -y $ASU12VG -s '64' $ASU12DISK
mkvg -f -y $ASU13VG -s '64' $ASU13DISK
mkvg -f -y $ASU14VG -s '64' $ASU14DISK
mkvg -f -y $ASU15VG -s '64' $ASU15DISK
mkvg -f -y $ASU21VG -s '64' $ASU21DISK
mkvg -f -y $ASU22VG -s '64' $ASU22DISK
mkvg -f -y $ASU23VG -s '64' $ASU23DISK
mkvg -f -y $ASU24VG -s '64' $ASU24DISK
mkvg -f -y $ASU25VG -s '64' $ASU25DISK
mkvg -f -y $ASU31VG -s '64' $ASU31DISK

lsvg –o
```

mklv.rsd_spc1.ksh

```
#!/bin/ksh

. /home/perf/spc1/env.cfg.pe78.df800s.112d146g15k.livg.rsd

mklv -y $ASU11LV -t 'rawio' -u $ASU11LP -w 'n' -S '4M' $ASU11VG $ASU11LVSIZE
$ASU11DISK
mklv -y $ASU12LV -t 'rawio' -u $ASU12LP -w 'n' -S '4M' $ASU12VG $ASU12LVSIZE
$ASU12DISK
mklv -y $ASU13LV -t 'rawio' -u $ASU13LP -w 'n' -S '4M' $ASU13VG $ASU13LVSIZE
$ASU13DISK
mklv -y $ASU14LV -t 'rawio' -u $ASU14LP -w 'n' -S '4M' $ASU14VG $ASU14LVSIZE
$ASU14DISK
mklv -y $ASU15LV -t 'rawio' -u $ASU15LP -w 'n' -S '4M' $ASU15VG $ASU15LVSIZE
$ASU15DISK
mklv -y $ASU21LV -t 'rawio' -u $ASU21LP -w 'n' -S '4M' $ASU21VG $ASU21LVSIZE
$ASU21DISK
mklv -y $ASU22LV -t 'rawio' -u $ASU22LP -w 'n' -S '4M' $ASU22VG $ASU22LVSIZE
$ASU22DISK
mklv -y $ASU23LV -t 'rawio' -u $ASU23LP -w 'n' -S '4M' $ASU23VG $ASU23LVSIZE
$ASU23DISK
mklv -y $ASU24LV -t 'rawio' -u $ASU24LP -w 'n' -S '4M' $ASU24VG $ASU24LVSIZE
$ASU24DISK
mklv -y $ASU25LV -t 'rawio' -u $ASU25LP -w 'n' -S '4M' $ASU25VG $ASU25LVSIZE
$ASU25DISK
mklv -y $ASU31LV -t 'rawio' -u $ASU31LP -w 'n' -S '4M' $ASU31VG $ASU31LVSIZE
$ASU31DISK

lsvg -o
```

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, is listed below.

```
# SPC1 uses three different ASUs (Application Storage Unit)
# The storage definition must start with asu1, or asu2 or
# asu3.  Each of the asu luns will be concatenated together for
# for form 1 logical piece of storage.  The storage must be in the
# following proportion.
#     ASU1 = 45%
#     ASU2 = 45%
#     ASU3 = 10%

# The sd statement can have an optional size.  For example:
# Use only the first 30GMs of the storage for each LUN.
#     sd=asu1_1,lun=/dev/rdsk/c2t129d0s6,size=33g

javaparms="-Xms384m -Xmx768m -Xss128k -Xgcpolicy:optavgpause"

sd=asu1_1,lun=/dev/rlvasu11,size=357g
sd=asu1_2,lun=/dev/rlvasu12,size=357g
sd=asu1_3,lun=/dev/rlvasu13,size=357g
sd=asu1_4,lun=/dev/rlvasu14,size=357g
sd=asu1_5,lun=/dev/rlvasu15,size=357g
sd=asu2_1,lun=/dev/rlvasu21,size=357g
sd=asu2_2,lun=/dev/rlvasu22,size=357g
sd=asu2_3,lun=/dev/rlvasu23,size=357g
sd=asu2_4,lun=/dev/rlvasu24,size=357g
sd=asu2_5,lun=/dev/rlvasu25,size=357g
sd=asu3_1,lun=/dev/rlvasu31,size=397.5g
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

Persistence Test Run 1

The following script was used to execute Persistence Test Run 1.

```
#!/bin/ksh

# Logic when passing arguments from the command line.

if [ $# -ne 1 ];then
   echo "Usage: $0 [BSU]"
   exit 1
   else
   BSU=$1
fi

# Global Variable
DATE=`date +%y%m%d.%H%M`
SPCDIR=/home/benchmark/spc1
OUTDIR=$SPCDIR/output/$DATE.bsu$BSU

# Create Output Directory
mkdir -p $OUTDIR

# SPC Configruation Variable
# MEASURE:
#    Number of seconds for the measurement
#    interval of the Sustainability Test Phase.
# RAMP:
#    Number of seconds for the measurement
#    intervals for the Response Ramp Test Phase.
# STARTUP:
#    Number of seconds of startup time for each
#    measurement interval.
MEASURE=10800
RAMP=600
STARTUP=180

# Need to setup LD_LIBRARY_PATH in .kshrc
export LIBPATH=/home/benchmark/spc1/aix

# Path where java resides:
java=/usr/java14/jre/bin/java

# IBM Java Environment Setting
export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false

################################################################################
################################################################################

################################################################################
#
# Metric Test
# Metric Test Time: 4 Hours and 30 Minutes.
#
# It is recommened that you restart both the Benchmark Configuration
# and Tested Storage Configuration.  The metrics test actually consists
# of the sustainability test phase and the ramp test phase.
```

```
#
################################################################################

# Run Metric Test
#java -Xoptionsfile=javaopts.cfg metrics -b $BSU
#java -Xoptionsfile=javaopts.cfg range -b $BSU -t $MEASURE

################################################################################
#
# Repeatability Test
# Repeatability Test Time: 30 Minutes.
#
# The Repeatability Test may be run before or after the metrics and/or
# persistence test, but it is recommended that the Repeatability Test be
# executed following the Response Time Ramp Test Phase (Metrics).  The two
# Test Phases ('repeat1' and 'repeat2') that comprise the Repeatability Test
# must be executed in an uninterrupted sequence.
#
################################################################################

# Run Repeatability 1 Test
#java -Xoptionsfile=javaopts.cfg repeat1 -b $BSU

# Run Repeatability 2 Test
#java -Xoptionsfile=javaopts.cfg repeat2 -b $BSU

################################################################################
#
# Persistence Test
# Persistence Test Time: 30 Minutes + Time to power off system.
#
# It is recommended to run the Persistence Test as the
# first item of an Audit.  The first stage (persist1), pwer
# off/restart, and second stage (persist2) must be run
# in an uninterrupted sequence.
#
################################################################################

# Run Persistence 1 Test
java -Xoptionsfile=javaopts.cfg persist1 -b $BSU

# It is now necessary to completely power off and restart
# both the Benchmark COnfiguration and the Tested Storage
# Configuration machine so that all caches are completely
# emptied.

# Run Persistence 2 Test
#java -Xoptionsfile=javaopts.cfg persist2

################################################################################
#
# Clean up process
#
################################################################################

cp $SPCDIR/SPC1.cfg $OUTDIR
mv $SPCDIR/SPC1.parm $OUTDIR
#mv $SPCDIR/*.jnl $OUTDIR
#mv $SPCDIR/*.map $OUTDIR
#mv $SPCDIR/metrics/ $OUTDIR
#mv $SPCDIR/repeatability1/ $OUTDIR
#mv $SPCDIR/repeatability2/ $OUTDIR
mv $SPCDIR/persistence1/ $OUTDIR
```

```
#mv $SPCDIR/persistence2/ $OUTDIR
mv $SPCDIR/SPCOut/ $OUTDIR
```

Persistence Test Run 2, Primary Metrics Test, and Repeatability Test

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

```
#!/bin/ksh

# Logic when passing arguments from the command line.

if [ $# -ne 1 ];then
   echo "Usage: $0 [BSU]"
   exit 1
   else
   BSU=$1
fi

# Global Variable
DATE=`date +%y%m%d.%H%M`
SPCDIR=/home/benchmark/spc1
OUTDIR=$SPCDIR/output/$DATE.bsu$BSU

# Create Output Directory
mkdir -p $OUTDIR

# SPC Configruation Variable
# MEASURE:
#    Number of seconds for the measurement
#    interval of the Sustainability Test Phase.
# RAMP:
#    Number of seconds for the measurement
#    intervals for the Response Ramp Test Phase.
# STARTUP:
#    Number of seconds of startup time for each
#    measurement interval.
MEASURE=10800
RAMP=600
STARTUP=180

# Need to setup LD_LIBRARY_PATH in .kshrc
export LIBPATH=/home/benchmark/spc1/aix

# Path where java resides:
java=/usr/java14/jre/bin/java

# IBM Java Environment Setting
export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false

################################################################################
################################################################################

# Run Persistence 2 Test
java -Xoptionsfile=javaopts.cfg persist2
```

```
###############################################################################
#
# Metric Test
# Metric Test Time: 4 Hours and 30 Minutes.
#
# It is recommened that you restart both the Benchmark Configuration
# and Tested Storage Configuration.  The metrics test actually consists
# of the sustainability test phase and the ramp test phase.
#
###############################################################################

# Run Metric Test
java -Xoptionsfile=javaopts.cfg metrics -b $BSU

###############################################################################
#
# Repeatability Test
# Repeatability Test Time: 30 Minutes.
#
# The Repeatability Test may be run before or after the metrics and/or
# persistence test, but it is recommended that the Repeatability Test be
# executed following the Response Time Ramp Test Phase (Metrics).  The two
# Test Phases ('repeat1' and 'repeat2') that comprise the Repeatability Test
# must be executed in an uninterrupted sequence.
#
###############################################################################

# Run Repeatability 1 Test
java -Xoptionsfile=javaopts.cfg repeat1 -b $BSU

# Run Repeatability 2 Test
java -Xoptionsfile=javaopts.cfg repeat2 -b $BSU

###############################################################################
#
# Persistence Test
# Persistence Test Time: 30 Minutes + Time to power off system.
#
# It is recommended to run the Persistence Test as the
# first item of an Audit.  The first stage (persist1), pwer
# off/restart, and second stage (persist2) must be run
# in an uninterrupted sequence.
#
###############################################################################

# Run Persistence 1 Test
#java -Xoptionsfile=javaopts.cfg persist1 -b $BSU

# It is now necessary to completely power off and restart
# both the Benchmark COnfiguration and the Tested Storage
# Configuration machine so that all caches are completely
# emptied.

# Run Persistence 2 Test
#java -Xoptionsfile=javaopts.cfg persist2

###############################################################################
#
# Clean up process
#
###############################################################################
```

```
cp $SPCDIR/SPC1.cfg $OUTDIR
mv $SPCDIR/SPC1.parm $OUTDIR
mv $SPCDIR/*.jnl $OUTDIR
mv $SPCDIR/*.map $OUTDIR
mv $SPCDIR/metrics/ $OUTDIR
mv $SPCDIR/repeatability1/ $OUTDIR
mv $SPCDIR/repeatability2/ $OUTDIR
mv $SPCDIR/persistence1/ $OUTDIR
mv $SPCDIR/persistence2/ $OUTDIR
mv $SPCDIR/SPCOut/ $OUTDIR
```