SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

HITACHI DATA SYSTEMS CORPORATION
HITACHI ADAPTABLE MODULAR STORAGE 2300

SPC-1 V1.10.1

Submitted for Review: March 24, 2009
Submission Identifier: A00077

First Edition – March 2009

Trademarks

Table of Contents

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 2300 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 2300	
Metric	**Reported Result**
SPC-1 IOPS™	42,502.61
SPC-1 Price-Performance	$6.96/SPC-1 IOPS™
Total ASU Capacity	7,955.000 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$295,740

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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Redwood City, CA 94062
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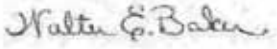
AUDIT CERTIFICATION *(CONT.)*

- 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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www.hds.com

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 2300

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 best combination of price and performance in a model that scales to 240 disk drives. Ideal for large businesses and enterprises, Hitachi Adaptable Modular Storage 2300 is a highly reliable, flexible and 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 2300	
Metric	**Reported Result**
SPC-1 IOPS™	42,502.61
SPC-1 Price-Performance	$6.96/SPC-1 IOPS™
Total ASU Capacity	7,955.000 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$295,740

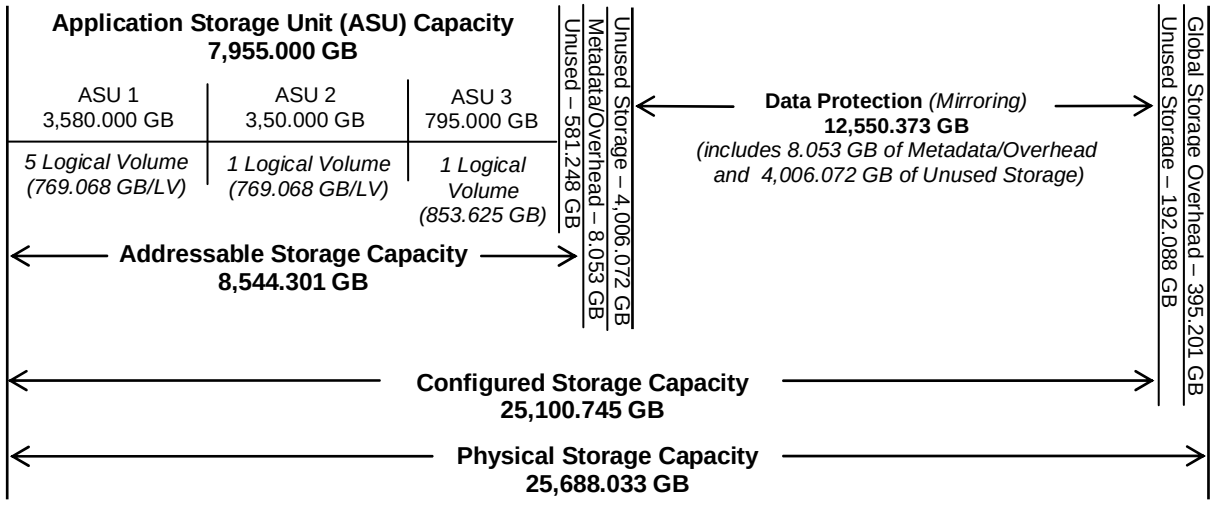
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

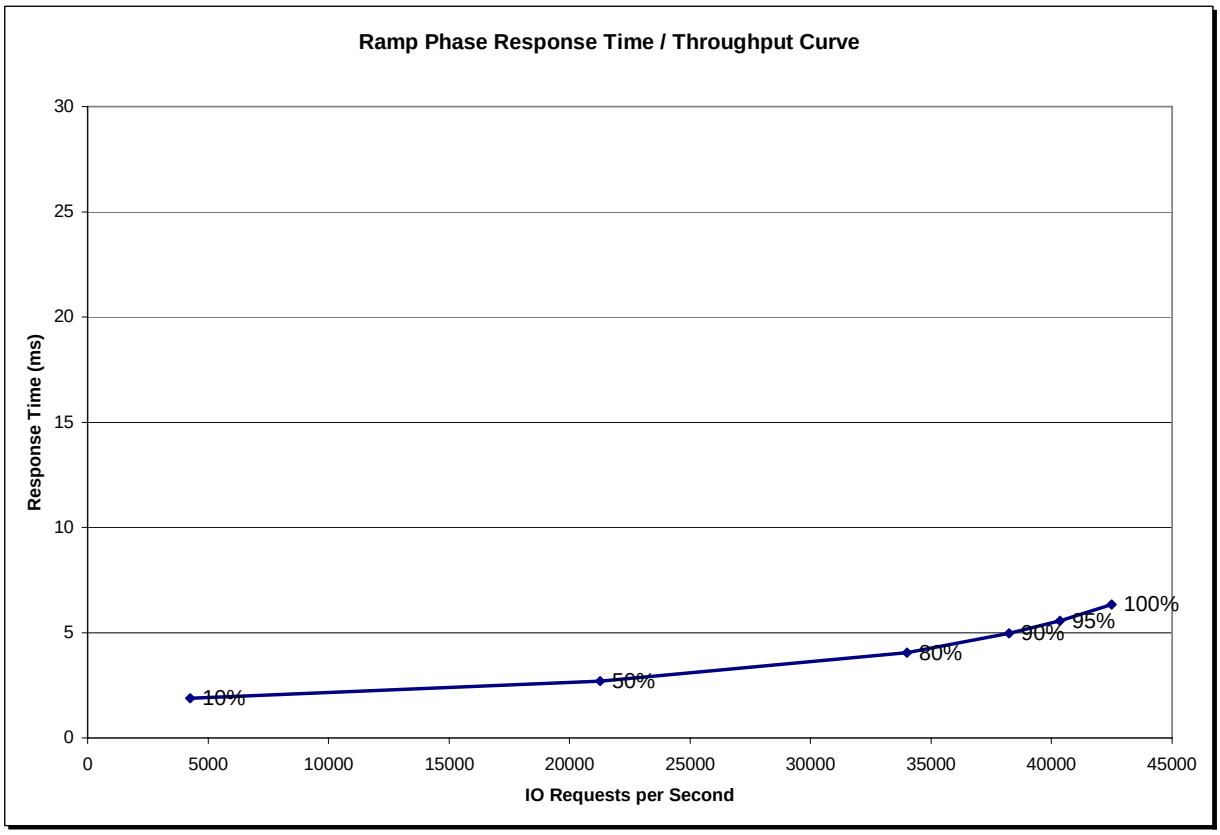
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



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	4,250.60	21,258.89	34,000.14	38,247.63	40,354.67	42,502.61
Average Response Time (ms):						
All ASUs	1.88	2.70	4.05	4.97	5.57	6.33
ASU-1	2.58	3.48	4.98	6.05	6.70	7.55
ASU-2	2.09	3.32	5.00	6.84	8.23	9.87
ASU-3	0.30	0.79	1.64	1.88	2.00	2.19
Reads	4.34	5.69	7.77	9.72	11.04	12.67
Writes	0.28	0.76	1.62	1.88	2.01	2.21

Tested Storage Configuration Pricing *(Priced Storage Configuration)*

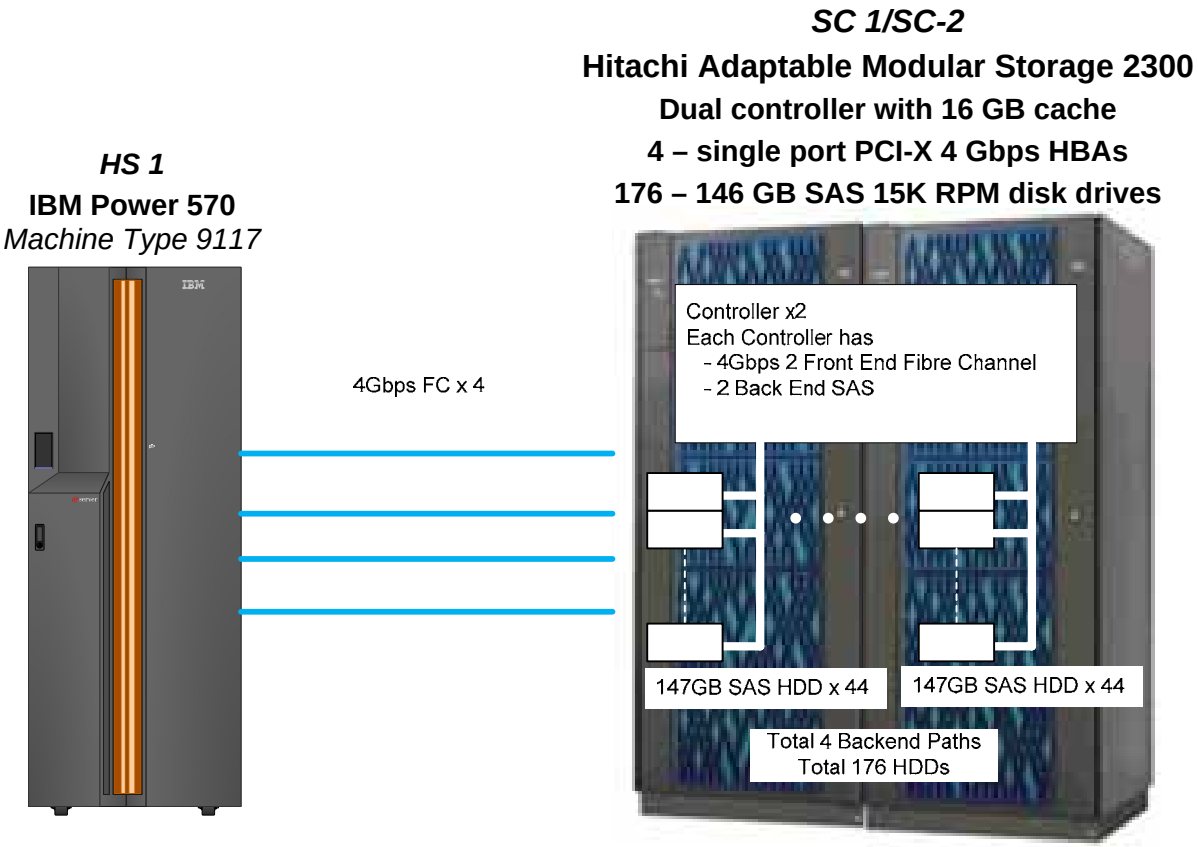
Description	Qty	List	List EXT	List MMC	List MMC Ext
AMS2300 Rack Mount System	1				
AMS 2300 Family Basic Operating System-Modular	1	0	0	0	0
AMS2300 Svc Warranty 1 Mo Yr 1-3	36	0	0	0	0
AMS2300 Svc Uplift to Standard 1Mo	36	0	0	136	4,896.00
AMS2000 Svc RKAK Warranty 1 Mo Yr 1-3	396	0	0	0	0
AMS2000 Svc RKAK Uplift to Standard 1Mo	396	0	0	45	17,820.00
AMS2300 Service Installation	1	0	2,000.00	0	0
Dummy drive for DF600/DF700/DF800/RAID 600	4	0	0	0	0
42U AMS2000 Rack 1050mm Deep w/30amp Nema PDU (4)	1	5,295.00	5,295.00	0	0
AMS2000 146GB SAS 15K RPM HDD	176	610	107,360.00	0	0
AMS2000 SAS/SATA Storage Expansion Tray	11	8,840.00	97,240.00	0	0
AMS2300 Dual Controller, 16GB Cache, 8x4Gbps FC Intf	1	45,240.00	45,240.00	0	0
AMS2100/AMS2300 Chassis	1	6,810.00	6,810.00	0	0
AMS2300 Storage Software Sales	1				
Storage Navigator Modular 2, AMS 2300 Family	1	3,800.00	3,800.00	0	0
SVC Mo Storage Navigator Modular 2, AMS 2300 Family	12	0	0	47.5	570
ezLINE™ LC/LC Uniboot® Jumper, OFNP, 10-ft (50/125) Aqua	4	18.45	73.8		
IBM 4 Gb Single-Port Fibre Channel PCI-X 2.0 DDR Adapter	4	1,158.88	4635.52		
Total			**$ 272,454**		**$ 23,286**
Grand Total					**$ 295,740**

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 2300 Dual controller with 8 GB cache per controller 2 – FC front-end ports per controller *(4 total ports)* 2 – backend SAS interfaces per controller 44 drives per interface *(4 total interfaces)*
64 GB main memory	
AIX 5.3 ML6 SP4	Cache Partition Manager
PCI-X/RIO	11 – AMS2000 SAS/SATA Storage Expansion Trays
AIX Logical Volume Manager	1 – 42U AMS2000 Racks w/30amp Nema PDU *(4)*
WG	176 – 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 66 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 74.

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)	7,955.000
Addressable Storage Capacity	Gigabytes (GB)	8,544.301
Configured Storage Capacity	Gigabytes (GB)	25,100.745
Physical Storage Capacity	Gigabytes (GB)	25,688.033
Data Protection *(Mirroring)*	Gigabytes (GB)	12,550.373
Required Storage *(metadata/overhead)*	Gigabytes (GB)	16.106
Global Storage Overhead	Gigabytes (GB)	395.201
Total Unused Storage	Gigabytes (GB)	9,366.727

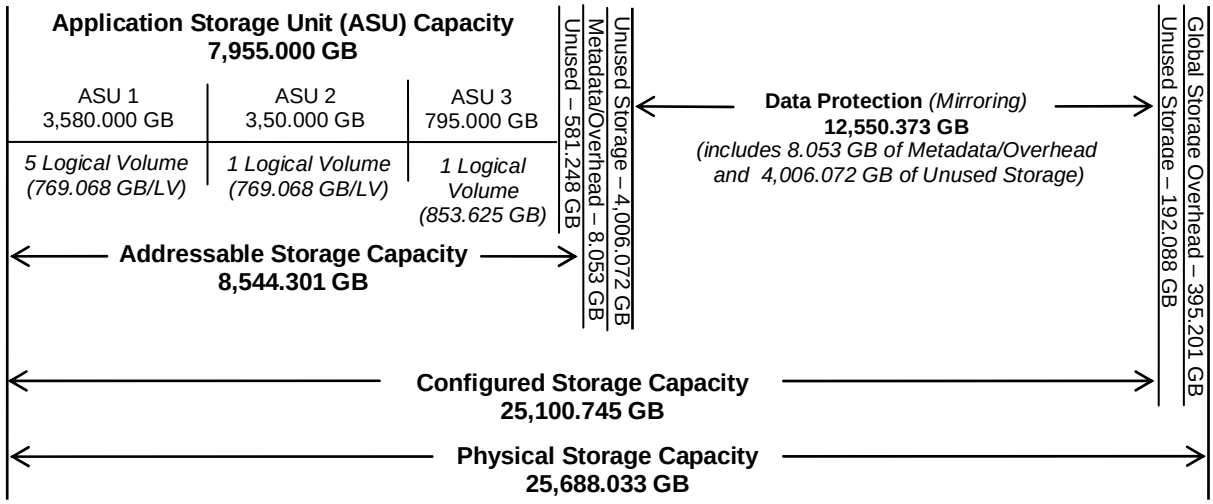
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	93.10%	31.69%	30.97%
Required for Data Protection *(Mirrored)*		50.00%	48.86%
Addressable Storage Capacity		34.04%	33.26%
Required Storage *(metadata/overhead)*		0.06%	0.06%
Configured Storage Capacity			97.71%
Global Storage Overhead			1.54%
Unused Storage:			
Addressable	6.80%		
Configured		31.92%	
Physical			0.75%

The Physical Storage Capacity consisted of 25,688.033 GB distributed over 176 disk drives each with a formatted capacity of 145.955 GB. There was 192 GB (0.75%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 3.95.201 GB (1.54%) of Physical Storage Capacity. There was 8,012.144 GB (31.92%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 93.10% of the Addressable Storage Capacity resulting in 589.301 GB (6.90%) 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 (3,580.000 GB)	**ASU-2 (3,580.000 GB)**	**ASU-3 (795.000 GB)**
5 Logical Volume 769.068 GB per Logical Volume (716.000 GB used per Logical Volume)	5 Logical Volume 769.068 GB per Logical Volume (716.000 GB used per Logical Volume)	1 Logical Volume 853.625 GB per Logical Volume (795.000 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 75.

Sustainability Test Results File

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

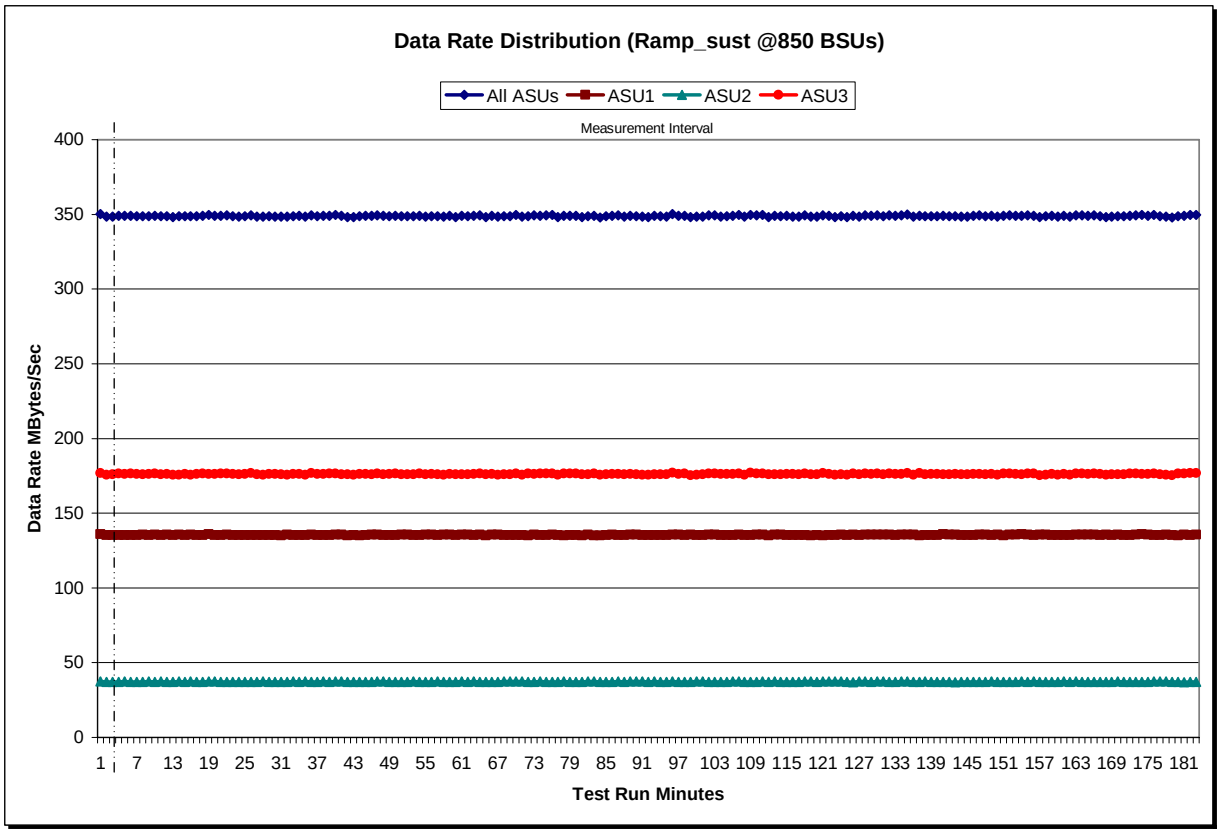
Sustainability Test Results File

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

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	14:15:36	14:18:36	0-2	0:03:00
Measurement Interval	14:18:36	17:18:36	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	350.13	135.98	37.37	176.78	63	349.27	135.65	37.13	176.48	126	348.54	135.32	37.35	175.87
1	348.36	135.28	37.29	175.79	64	348.26	135.19	37.22	175.84	127	349.45	135.63	37.42	176.39
2	348.54	135.40	37.24	175.90	65	349.11	135.52	37.27	176.32	128	349.10	135.60	37.17	176.34
3	349.04	135.41	37.22	176.41	66	348.50	135.55	37.20	175.75	129	349.45	135.55	37.34	176.56
4	348.95	135.45	37.33	176.17	67	348.75	135.24	37.50	176.01	130	348.77	135.53	37.30	175.94
5	349.08	135.43	37.24	176.41	68	348.76	135.47	37.45	175.83	131	349.40	135.59	37.22	176.59
6	348.83	135.42	37.11	176.30	69	349.54	135.44	37.49	176.61	132	348.93	135.42	37.26	176.25
7	348.64	135.65	37.07	175.91	70	348.43	135.24	37.48	175.71	133	349.17	135.66	37.41	176.11
8	348.64	135.24	37.30	176.10	71	348.73	135.01	37.16	176.56	134	349.88	135.57	37.50	176.80
9	349.17	135.50	37.23	176.44	72	349.29	135.68	37.24	176.37	135	348.36	135.50	37.26	175.60
10	348.69	135.33	37.47	175.89	73	349.10	135.31	37.30	176.49	136	348.99	135.05	37.26	176.68
11	348.84	135.57	37.13	176.14	74	349.33	135.47	37.29	176.57	137	348.76	135.30	37.43	176.03
12	348.29	135.41	37.13	175.75	75	349.48	135.70	37.28	176.50	138	348.68	135.26	37.16	176.26
13	348.70	135.58	37.32	175.80	76	348.11	135.45	37.10	175.56	139	348.76	135.43	37.16	176.17
14	348.75	135.34	37.29	176.12	77	348.98	135.15	37.33	176.50	140	349.11	135.85	37.18	176.08
15	348.78	135.62	37.43	175.73	78	348.99	135.32	37.08	176.59	141	348.63	135.63	37.09	175.91
16	348.72	135.39	37.11	176.22	79	349.01	135.42	37.20	176.40	142	348.82	135.50	36.98	176.34
17	349.04	135.43	37.08	176.53	80	348.03	135.17	37.03	175.83	143	348.55	135.43	37.19	175.92
18	349.59	135.85	37.44	176.30	81	348.81	135.61	37.34	175.86	144	348.44	135.28	37.21	175.95
19	348.95	135.32	37.34	176.29	82	348.90	135.16	37.34	176.41	145	348.92	135.30	37.27	176.35
20	349.04	135.36	37.13	176.55	83	347.96	135.17	37.08	175.70	146	349.25	135.69	37.21	176.35
21	349.18	135.55	37.12	176.52	84	348.60	135.39	37.19	176.02	147	348.86	135.55	37.27	176.05
22	348.72	135.34	37.21	176.17	85	349.01	135.52	37.25	176.24	148	348.90	135.32	37.38	176.19
23	348.60	135.39	37.28	175.93	86	349.19	135.45	37.52	176.22	149	348.54	135.59	37.27	175.68
24	348.66	135.34	37.20	176.12	87	348.34	135.24	37.11	175.99	150	349.10	135.20	37.29	176.62
25	349.26	135.32	37.21	176.74	88	349.03	135.61	37.32	176.10	151	349.23	135.53	37.23	176.47
26	348.42	135.35	37.11	175.97	89	348.74	135.54	37.37	175.83	152	349.17	135.64	37.18	176.35
27	348.45	135.45	37.36	175.63	90	348.51	135.42	37.29	175.79	153	349.04	135.84	37.31	175.89
28	348.68	135.32	37.18	176.18	91	348.23	135.47	37.14	175.62	154	349.45	135.54	37.26	176.65
29	348.52	135.25	37.05	176.22	92	348.93	135.48	37.38	176.07	155	349.09	135.34	37.34	176.40
30	348.37	135.18	37.15	176.04	93	348.64	135.41	37.21	176.02	156	348.24	135.67	37.14	175.44
31	348.44	135.50	37.26	175.68	94	348.47	135.27	37.27	175.94	157	348.66	135.72	37.23	175.71
32	348.84	135.31	37.33	176.20	95	350.05	135.61	37.36	177.09	158	349.02	135.43	37.21	176.38
33	348.97	135.42	37.25	176.30	96	348.99	135.53	37.21	176.26	159	348.38	135.49	37.20	175.69
34	348.36	135.35	37.33	175.68	97	349.12	135.36	37.22	176.54	160	348.98	135.44	37.35	176.19
35	349.41	135.54	37.16	176.70	98	348.19	135.52	37.27	175.40	161	348.32	135.46	37.26	175.60
36	348.64	135.21	37.26	176.17	99	348.52	135.43	37.29	175.79	162	349.42	135.68	37.30	176.44
37	348.90	135.27	37.39	176.23	100	348.45	135.33	37.31	175.82	163	349.31	135.74	37.14	176.44
38	349.08	135.46	37.22	176.40	101	349.36	135.67	37.13	176.56	164	349.13	135.59	37.24	176.30
39	349.74	135.71	37.46	176.58	102	349.23	135.73	37.09	176.42	165	349.27	135.55	37.27	176.46
40	348.94	135.73	37.29	175.92	103	348.58	135.28	37.17	176.14	166	348.78	135.41	37.05	176.32
41	348.26	135.15	37.14	175.96	104	348.64	135.33	37.18	176.13	167	348.30	135.49	37.22	175.59
42	348.29	135.39	37.19	175.71	105	349.08	135.43	37.48	176.18	168	348.56	135.41	37.16	175.99
43	348.81	135.15	37.28	176.38	106	349.47	135.51	37.33	176.63	169	348.82	135.64	37.31	175.88
44	349.01	135.45	37.26	176.30	107	348.33	135.32	37.20	175.80	170	348.71	135.46	37.27	175.98
45	348.96	135.61	37.27	176.09	108	349.69	135.42	37.29	176.97	171	348.96	135.36	37.10	176.50
46	349.32	135.56	37.36	176.41	109	349.26	135.52	37.20	176.53	172	349.19	135.54	37.25	176.39
47	349.05	135.48	37.53	176.04	110	349.62	135.55	37.48	176.59	173	349.56	135.96	37.26	176.34
48	348.77	135.40	37.02	176.36	111	348.26	135.10	37.22	175.95	174	349.08	135.62	37.12	176.33
49	349.15	135.35	37.23	176.58	112	349.06	135.69	37.50	175.87	175	349.49	135.48	37.38	176.62
50	348.72	135.53	37.12	176.07	113	348.83	135.53	37.20	176.10	176	348.63	135.21	37.37	176.05
51	348.86	135.59	37.19	176.08	114	348.96	135.48	37.27	176.22	177	348.53	135.58	37.33	175.62
52	348.77	135.39	37.30	176.09	115	348.59	135.39	37.09	176.11	178	348.00	135.45	37.27	175.28
53	349.15	135.28	37.19	176.67	116	348.53	135.25	37.19	176.09	179	348.81	135.18	37.12	176.51
54	348.53	135.54	37.13	175.86	117	349.34	135.43	37.42	176.49	180	349.17	135.70	36.97	176.49
55	348.86	135.54	37.07	176.26	118	348.46	135.12	37.35	175.99	181	349.52	135.40	37.27	176.84
56	348.79	135.48	37.38	175.94	119	348.49	135.40	37.27	175.82	182	349.67	135.60	37.28	176.79
57	348.35	135.58	37.01	175.76	120	349.43	135.09	37.54	176.80					
58	348.93	135.54	37.19	176.20	121	349.10	135.43	37.42	176.26					
59	348.27	135.26	37.11	175.90	122	348.29	135.39	37.34	175.55					
60	349.17	135.59	37.49	176.10	123	348.83	135.60	37.35	175.89					
61	348.76	135.56	37.11	176.09	124	348.27	135.40	37.22	175.65					
62	348.93	135.38	37.45	176.10	125	348.97	135.60	36.82	176.55					

Sustainability – Data Rate Distribution Graph

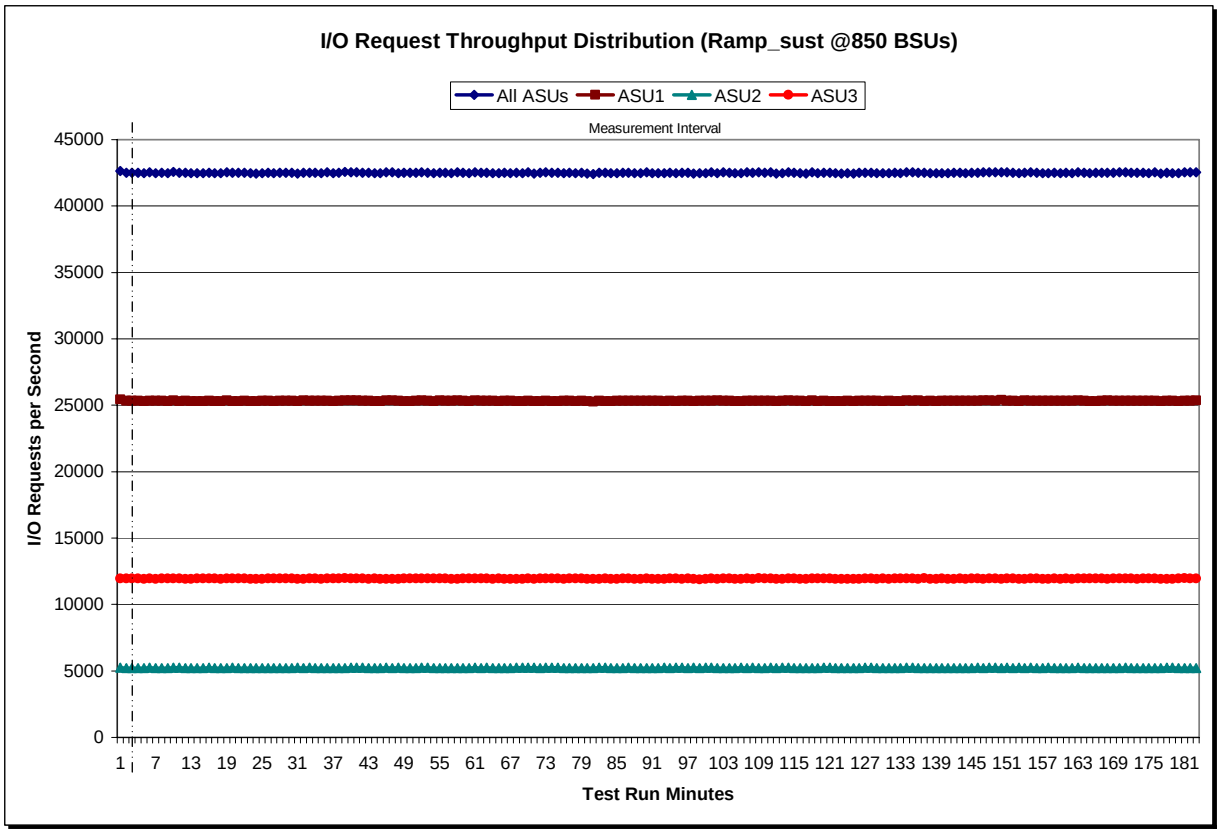


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	14:15:36	14:18:36	0-2	0:03:00
Measurement Interval	14:18:36	17:18:36	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	42,628.55	25,431.42	5,239.65	11,957.48	63	42,465.65	25,322.90	5,207.13	11,935.62	126	42,505.17	25,327.48	5,236.23	11,941.45
1	42,498.55	25,333.97	5,226.02	11,938.57	64	42,472.78	25,312.73	5,214.08	11,945.97	127	42,517.50	25,342.20	5,233.00	11,942.30
2	42,497.87	25,329.83	5,228.45	11,939.58	65	42,496.37	25,334.55	5,229.23	11,932.58	128	42,484.12	25,335.85	5,214.43	11,933.83
3	42,508.55	25,336.75	5,227.70	11,944.10	66	42,469.02	25,321.28	5,212.58	11,935.15	129	42,478.88	25,302.42	5,223.57	11,952.90
4	42,473.62	25,314.85	5,226.22	11,932.55	67	42,491.38	25,308.83	5,244.12	11,938.43	130	42,481.53	25,336.23	5,225.22	11,920.08
5	42,527.32	25,343.20	5,240.55	11,943.57	68	42,474.20	25,310.85	5,247.65	11,915.70	131	42,493.22	25,312.52	5,226.48	11,954.22
6	42,466.02	25,323.50	5,209.65	11,932.87	69	42,526.80	25,346.53	5,234.12	11,946.15	132	42,482.50	25,317.57	5,225.23	11,939.70
7	42,517.30	25,350.15	5,224.58	11,942.57	70	42,453.18	25,291.32	5,252.10	11,909.77	133	42,553.65	25,363.43	5,236.40	11,953.82
8	42,476.35	25,311.75	5,221.77	11,942.83	71	42,500.22	25,309.07	5,227.87	11,963.28	134	42,542.10	25,348.37	5,233.03	11,960.70
9	42,581.13	25,369.30	5,247.47	11,964.37	72	42,546.20	25,348.25	5,234.45	11,963.50	135	42,499.12	25,360.62	5,220.33	11,918.17
10	42,500.75	25,317.52	5,239.73	11,943.50	73	42,492.80	25,313.92	5,238.18	11,940.70	136	42,500.90	25,293.95	5,231.85	11,975.10
11	42,489.75	25,332.23	5,225.10	11,932.42	74	42,507.15	25,316.38	5,236.65	11,954.12	137	42,485.20	25,320.22	5,228.97	11,936.02
12	42,477.62	25,317.45	5,227.80	11,932.37	75	42,476.48	25,326.63	5,212.15	11,937.70	138	42,469.48	25,314.27	5,223.60	11,931.62
13	42,474.28	25,306.10	5,218.88	11,949.30	76	42,489.77	25,319.77	5,224.55	11,945.45	139	42,481.58	25,324.03	5,216.78	11,940.77
14	42,485.32	25,315.67	5,230.30	11,939.35	77	42,483.48	25,310.28	5,231.23	11,941.97	140	42,482.78	25,333.95	5,224.38	11,924.45
15	42,516.32	25,339.15	5,234.65	11,942.52	78	42,495.00	25,333.20	5,211.70	11,950.10	141	42,506.27	25,347.73	5,223.87	11,934.67
16	42,462.00	25,302.97	5,218.00	11,941.03	79	42,449.90	25,288.98	5,223.80	11,937.12	142	42,492.18	25,331.40	5,214.85	11,945.93
17	42,459.92	25,306.53	5,219.58	11,933.80	80	42,415.28	25,281.53	5,222.47	11,911.28	143	42,471.63	25,330.98	5,214.07	11,926.58
18	42,544.55	25,370.15	5,227.58	11,946.82	81	42,498.48	25,334.23	5,236.85	11,927.40	144	42,490.60	25,321.43	5,219.63	11,949.53
19	42,500.93	25,311.03	5,235.52	11,954.38	82	42,509.15	25,306.77	5,242.58	11,959.80	145	42,500.10	25,322.45	5,232.50	11,945.15
20	42,495.52	25,309.47	5,225.67	11,960.38	83	42,460.78	25,307.22	5,219.18	11,934.38	146	42,534.73	25,373.72	5,226.42	11,934.60
21	42,510.65	25,331.82	5,215.43	11,963.40	84	42,487.78	25,330.63	5,230.25	11,926.90	147	42,531.82	25,357.38	5,232.42	11,942.02
22	42,468.28	25,315.10	5,229.85	11,923.33	85	42,512.60	25,338.03	5,220.18	11,954.38	148	42,528.72	25,330.05	5,243.12	11,955.55
23	42,426.32	25,289.52	5,220.35	11,916.45	86	42,509.70	25,319.12	5,242.70	11,947.88	149	42,540.28	25,387.73	5,226.43	11,926.12
24	42,473.17	25,319.90	5,214.95	11,938.32	87	42,477.12	25,324.03	5,215.63	11,937.45	150	42,524.68	25,321.68	5,241.18	11,961.82
25	42,511.67	25,327.95	5,222.02	11,961.70	88	42,484.45	25,328.80	5,226.00	11,929.65	151	42,513.17	25,341.97	5,222.12	11,949.08
26	42,476.90	25,313.10	5,220.73	11,943.07	89	42,523.38	25,344.40	5,222.93	11,956.05	152	42,480.28	25,316.62	5,234.08	11,929.58
27	42,502.40	25,329.65	5,227.20	11,945.55	90	42,476.78	25,323.42	5,222.25	11,931.12	153	42,504.28	25,354.80	5,223.28	11,926.20
28	42,502.48	25,331.32	5,228.43	11,942.73	91	42,482.23	25,323.67	5,225.60	11,932.97	154	42,540.05	25,338.68	5,233.25	11,968.12
29	42,492.62	25,335.17	5,208.83	11,948.62	92	42,486.50	25,316.72	5,241.55	11,928.23	155	42,506.85	25,331.95	5,221.83	11,953.07
30	42,454.67	25,300.15	5,232.88	11,921.63	93	42,506.48	25,328.02	5,229.53	11,948.93	156	42,471.12	25,335.53	5,213.22	11,922.37
31	42,501.35	25,353.25	5,224.22	11,923.88	94	42,482.78	25,309.07	5,232.92	11,940.80	157	42,481.77	25,330.38	5,233.30	11,918.08
32	42,506.18	25,319.87	5,232.55	11,953.77	95	42,493.02	25,319.95	5,234.93	11,938.13	158	42,490.08	25,324.32	5,215.28	11,950.48
33	42,504.25	25,328.15	5,231.08	11,945.02	96	42,502.75	25,350.28	5,212.48	11,939.98	159	42,483.55	25,342.40	5,217.22	11,923.93
34	42,489.20	25,328.43	5,226.55	11,934.22	97	42,454.12	25,288.15	5,237.05	11,928.92	160	42,510.32	25,344.02	5,226.52	11,939.78
35	42,523.12	25,346.82	5,215.70	11,960.60	98	42,459.18	25,336.93	5,221.13	11,901.12	161	42,481.78	25,323.70	5,226.02	11,932.07
36	42,463.12	25,295.08	5,221.87	11,946.17	99	42,482.95	25,336.67	5,234.07	11,912.22	162	42,535.45	25,359.10	5,234.73	11,941.62
37	42,493.93	25,326.38	5,221.60	11,945.95	100	42,534.68	25,349.68	5,235.40	11,949.60	163	42,505.80	25,333.50	5,219.07	11,953.23
38	42,562.98	25,359.93	5,224.10	11,978.95	101	42,489.07	25,351.73	5,226.88	11,910.45	164	42,481.15	25,315.15	5,217.48	11,948.52
39	42,537.92	25,355.58	5,235.35	11,946.98	102	42,523.05	25,338.55	5,231.98	11,952.52	165	42,489.72	25,306.00	5,229.87	11,953.85
40	42,533.02	25,351.00	5,238.82	11,943.20	103	42,506.78	25,331.25	5,231.33	11,944.20	166	42,498.93	25,321.22	5,219.60	11,958.12
41	42,496.32	25,321.23	5,236.43	11,938.65	104	42,463.02	25,315.65	5,211.07	11,936.30	167	42,504.28	25,357.98	5,216.10	11,930.20
42	42,507.17	25,348.97	5,228.38	11,929.82	105	42,480.15	25,308.20	5,240.07	11,931.88	168	42,493.87	25,325.12	5,226.02	11,942.73
43	42,462.37	25,297.52	5,225.62	11,939.23	106	42,524.67	25,345.35	5,218.62	11,960.70	169	42,527.45	25,349.07	5,228.60	11,949.78
44	42,465.95	25,315.25	5,217.95	11,932.75	107	42,504.17	25,341.23	5,240.47	11,922.47	170	42,524.73	25,340.75	5,240.23	11,943.75
45	42,522.40	25,354.22	5,239.35	11,928.83	108	42,528.60	25,334.98	5,219.97	11,973.65	171	42,499.70	25,339.62	5,212.60	11,947.48
46	42,526.67	25,360.97	5,229.07	11,936.63	109	42,511.50	25,330.30	5,227.93	11,953.27	172	42,489.32	25,331.97	5,222.55	11,934.80
47	42,480.23	25,319.40	5,243.92	11,916.92	110	42,536.58	25,340.68	5,238.70	11,957.20	173	42,505.53	25,342.90	5,218.35	11,944.28
48	42,508.83	25,317.68	5,225.73	11,965.42	111	42,434.92	25,294.28	5,213.23	11,927.40	174	42,487.05	25,328.85	5,205.13	11,953.07
49	42,489.82	25,317.68	5,223.00	11,949.13	112	42,473.03	25,323.42	5,238.55	11,911.07	175	42,523.38	25,338.17	5,227.47	11,957.75
50	42,516.38	25,345.97	5,231.03	11,939.38	113	42,553.47	25,368.20	5,240.37	11,944.90	176	42,448.10	25,297.52	5,218.45	11,932.13
51	42,542.33	25,353.10	5,240.12	11,949.12	114	42,490.45	25,320.52	5,227.47	11,942.47	177	42,505.48	25,343.83	5,235.68	11,925.97
52	42,506.90	25,326.03	5,233.52	11,947.35	115	42,471.77	25,338.18	5,212.82	11,920.77	178	42,480.48	25,320.88	5,238.57	11,921.03
53	42,479.00	25,286.80	5,223.23	11,968.97	116	42,437.50	25,298.42	5,222.92	11,916.17	179	42,476.60	25,290.55	5,217.00	11,969.05
54	42,515.23	25,351.70	5,215.35	11,948.18	117	42,521.80	25,352.40	5,226.13	11,943.27	180	42,533.05	25,344.18	5,216.97	11,971.90
55	42,516.42	25,341.85	5,226.03	11,948.53	118	42,476.62	25,297.30	5,231.83	11,947.48	181	42,522.83	25,332.42	5,231.92	11,958.50
56	42,488.15	25,330.97	5,224.25	11,932.93	119	42,510.20	25,324.37	5,234.25	11,951.58	182	42,527.95	25,356.02	5,218.92	11,953.02
57	42,523.47	25,366.40	5,228.15	11,928.92	120	42,518.65	25,311.77	5,240.70	11,966.18	Average	42,496.63	25,328.68	5,226.69	11,941.26
58	42,506.27	25,335.43	5,217.78	11,953.05	121	42,472.52	25,315.97	5,222.75	11,933.80					
59	42,469.47	25,302.35	5,219.10	11,948.02	122	42,448.87	25,303.47	5,228.03	11,917.37					
60	42,531.98	25,356.02	5,237.30	11,938.67	123	42,484.48	25,321.40	5,228.53	11,934.55					
61	42,507.23	25,343.30	5,208.30	11,955.63	124	42,443.12	25,315.05	5,218.65	11,909.42					
62	42,509.58	25,330.63	5,235.03	11,943.92	125	42,491.80	25,350.42	5,206.88	11,934.50					

Sustainability – I/O Request Throughput Distribution Graph

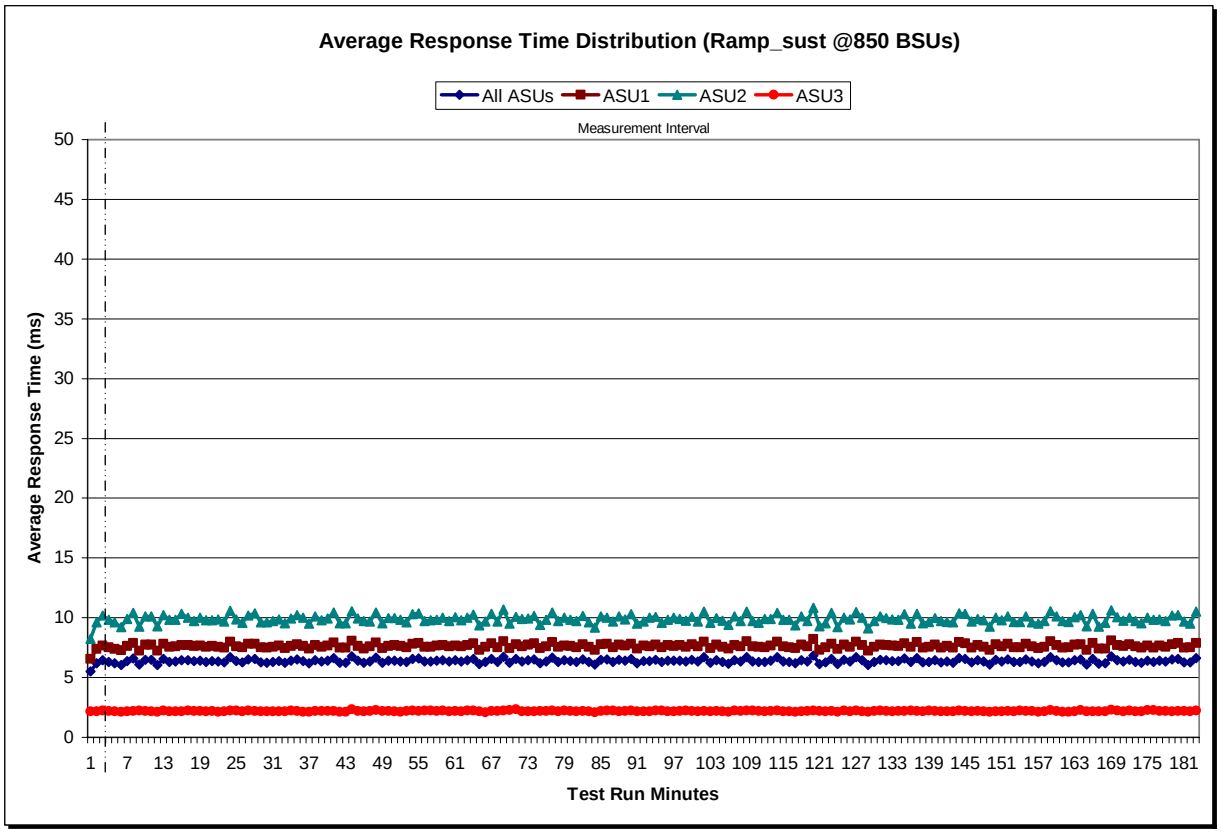


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	14:15:36	14:18:36	0-2	0:03:00
Measurement Interval	14:18:36	17:18:36	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	5.52	6.54	8.26	2.14	63	6.56	7.84	10.25	2.24	126	6.69	8.01	10.48	2.24
1	6.19	7.37	9.62	2.18	64	6.12	7.32	9.37	2.15	127	6.44	7.72	10.01	2.14
2	6.45	7.66	10.19	2.25	65	6.28	7.55	9.67	2.10	128	6.04	7.25	9.12	2.13
3	6.31	7.53	9.82	2.18	66	6.55	7.84	10.32	2.18	129	6.31	7.55	9.72	2.18
4	6.18	7.38	9.60	2.14	67	6.29	7.52	9.70	2.18	130	6.49	7.74	10.13	2.22
5	6.06	7.26	9.22	2.14	68	6.73	8.04	10.69	2.22	131	6.43	7.69	9.98	2.19
6	6.36	7.63	9.89	2.15	69	6.24	7.43	9.52	2.26	132	6.39	7.65	9.87	2.17
7	6.59	7.87	10.41	2.20	70	6.55	7.79	10.09	2.34	133	6.39	7.65	9.84	2.20
8	6.09	7.25	9.24	2.24	71	6.34	7.58	9.90	2.17	134	6.57	7.86	10.30	2.21
9	6.47	7.74	10.11	2.18	72	6.44	7.74	9.92	2.18	135	6.30	7.55	9.51	2.24
10	6.47	7.75	10.13	2.17	73	6.53	7.83	10.15	2.18	136	6.63	7.96	10.32	2.20
11	6.06	7.25	9.29	2.12	74	6.21	7.45	9.39	2.19	137	6.26	7.50	9.55	2.17
12	6.54	7.82	10.21	2.23	75	6.34	7.59	9.83	2.19	138	6.31	7.54	9.63	2.24
13	6.31	7.56	9.82	2.15	76	6.66	7.96	10.43	2.24	139	6.45	7.73	9.98	2.20
14	6.34	7.60	9.82	2.15	77	6.31	7.57	9.73	2.15	140	6.27	7.50	9.70	2.15
15	6.46	7.69	10.32	2.16	78	6.44	7.68	10.01	2.24	141	6.34	7.62	9.66	2.17
16	6.43	7.69	10.01	2.21	79	6.36	7.62	9.82	2.18	142	6.24	7.48	9.61	2.15
17	6.37	7.64	9.71	2.20	80	6.29	7.53	9.71	2.15	143	6.64	7.94	10.35	2.24
18	6.42	7.67	10.01	2.20	81	6.50	7.78	10.15	2.20	144	6.55	7.83	10.31	2.19
19	6.31	7.55	9.79	2.15	82	6.29	7.55	9.63	2.17	145	6.26	7.49	9.69	2.16
20	6.38	7.65	9.79	2.20	83	6.07	7.30	9.16	2.10	146	6.44	7.72	9.91	2.20
21	6.32	7.57	9.87	2.12	84	6.49	7.77	10.12	2.19	147	6.32	7.56	9.80	2.17
22	6.26	7.49	9.70	2.14	85	6.51	7.81	9.99	2.23	148	6.10	7.32	9.27	2.12
23	6.70	8.00	10.58	2.25	86	6.31	7.52	9.70	2.24	149	6.47	7.77	10.01	2.17
24	6.36	7.59	9.86	2.22	87	6.47	7.74	10.10	2.17	150	6.34	7.60	9.80	2.17
25	6.26	7.51	9.59	2.17	88	6.40	7.65	9.87	2.20	151	6.51	7.80	10.13	2.19
26	6.52	7.80	10.17	2.22	89	6.54	7.80	10.29	2.23	152	6.29	7.54	9.66	2.17
27	6.55	7.81	10.38	2.20	90	6.20	7.42	9.50	2.18	153	6.30	7.53	9.65	2.22
28	6.28	7.53	9.60	2.16	91	6.37	7.66	9.70	2.17	154	6.51	7.80	10.11	2.19
29	6.24	7.48	9.59	2.14	92	6.37	7.61	9.99	2.17	155	6.32	7.58	9.60	2.20
30	6.31	7.56	9.73	2.15	93	6.47	7.73	10.09	2.22	156	6.21	7.45	9.49	2.13
31	6.39	7.65	9.87	2.17	94	6.29	7.53	9.58	2.22	157	6.31	7.56	9.72	2.17
32	6.22	7.46	9.53	2.15	95	6.40	7.70	9.83	2.15	158	6.71	8.02	10.55	2.27
33	6.40	7.64	9.94	2.22	96	6.40	7.64	10.02	2.17	159	6.44	7.69	10.13	2.18
34	6.51	7.78	10.22	2.18	97	6.41	7.69	9.89	2.18	160	6.25	7.49	9.72	2.12
35	6.36	7.62	10.00	2.11	98	6.33	7.55	9.74	2.22	161	6.26	7.51	9.66	2.12
36	6.18	7.41	9.50	2.13	99	6.49	7.77	10.08	2.20	162	6.46	7.74	10.03	2.17
37	6.45	7.70	10.10	2.18	100	6.32	7.59	9.67	2.17	163	6.53	7.78	10.21	2.27
38	6.32	7.57	9.78	2.18	101	6.68	8.00	10.50	2.20	164	6.10	7.30	9.29	2.15
39	6.40	7.65	9.93	2.18	102	6.23	7.47	9.57	2.15	165	6.57	7.87	10.32	2.17
40	6.62	7.91	10.43	2.20	103	6.45	7.73	9.97	2.20	166	6.16	7.41	9.26	2.16
41	6.22	7.47	9.53	2.12	104	6.31	7.56	9.76	2.15	167	6.20	7.42	9.56	2.16
42	6.24	7.49	9.52	2.14	105	6.17	7.42	9.38	2.11	168	6.78	8.10	10.62	2.30
43	6.76	8.06	10.56	2.33	106	6.45	7.69	10.11	2.22	169	6.46	7.71	10.06	2.23
44	6.40	7.65	9.95	2.19	107	6.33	7.58	9.74	2.18	170	6.35	7.62	9.77	2.14
45	6.22	7.42	9.71	2.14	108	6.71	8.05	10.51	2.23	171	6.50	7.79	10.02	2.22
46	6.33	7.60	9.68	2.18	109	6.35	7.60	9.72	2.24	172	6.32	7.58	9.73	2.14
47	6.66	7.93	10.44	2.29	110	6.31	7.58	9.58	2.19	173	6.24	7.48	9.53	2.18
48	6.23	7.46	9.55	2.20	111	6.31	7.53	9.89	2.17	174	6.42	7.65	9.99	2.26
49	6.39	7.64	9.97	2.19	112	6.40	7.66	9.89	2.18	175	6.31	7.50	9.81	2.25
50	6.42	7.69	9.98	2.17	113	6.68	8.01	10.42	2.23	176	6.40	7.66	9.88	2.21
51	6.35	7.62	9.81	2.14	114	6.34	7.59	9.82	2.17	177	6.33	7.57	9.72	2.20
52	6.28	7.53	9.61	2.19	115	6.31	7.53	9.82	2.18	178	6.50	7.78	10.19	2.16
53	6.55	7.82	10.30	2.23	116	6.19	7.45	9.35	2.12	179	6.56	7.87	10.21	2.19
54	6.59	7.89	10.37	2.18	117	6.46	7.73	10.12	2.17	180	6.27	7.49	9.68	2.20
55	6.32	7.54	9.72	2.24	118	6.33	7.59	9.71	2.18	181	6.25	7.52	9.49	2.16
56	6.34	7.56	9.78	2.24	119	6.84	8.19	10.82	2.23	182	6.62	7.89	10.52	2.22
57	6.40	7.67	9.82	2.19	120	6.11	7.31	9.30	2.19	Average	6.38	7.64	9.88	2.19
58	6.46	7.71	10.02	2.24	121	6.26	7.51	9.55	2.15					
59	6.34	7.61	9.73	2.17	122	6.55	7.81	10.40	2.18					
60	6.44	7.69	10.06	2.21	123	6.13	7.38	9.20	2.13					
61	6.33	7.59	9.80	2.16	124	6.47	7.73	10.01	2.22					
62	6.45	7.70	10.02	2.22	125	6.34	7.57	9.86	2.17					

Sustainability – Average Response Time (ms) Distribution Graph



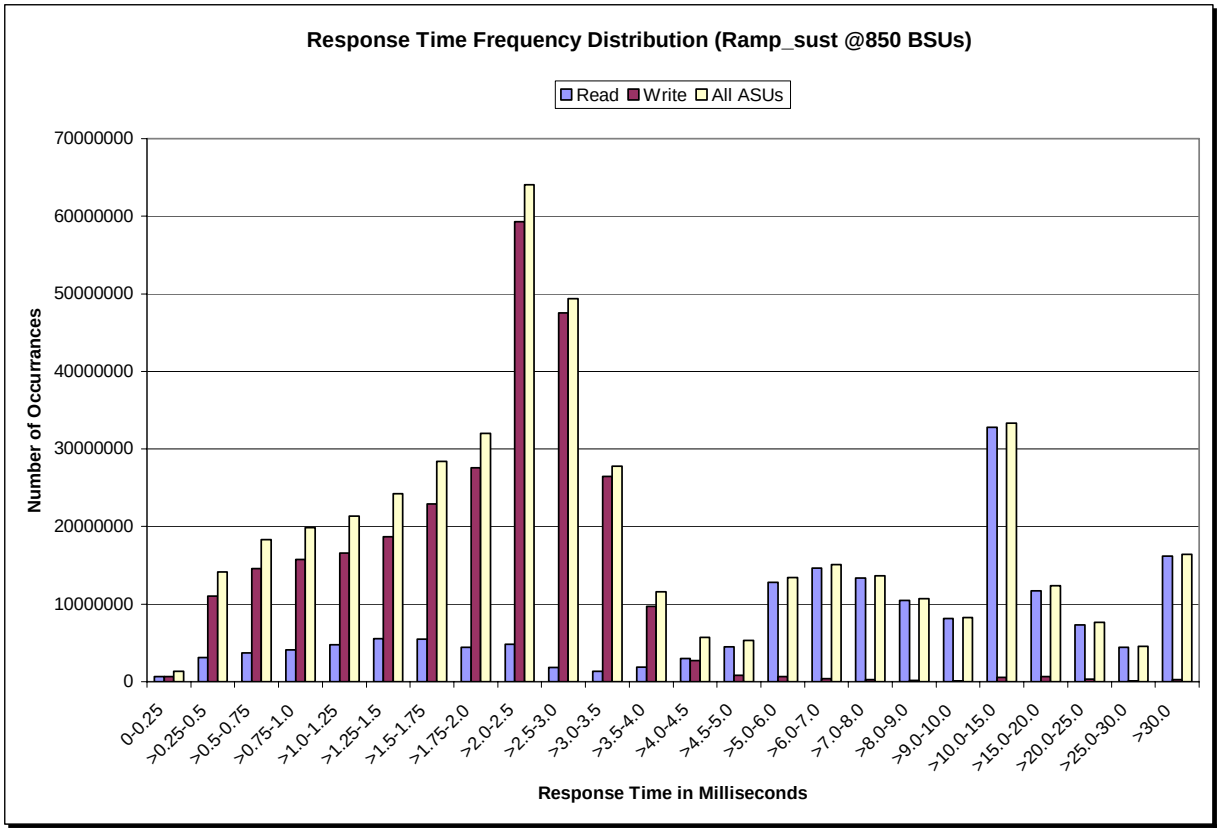
Sustainability – Response Time Frequency Distribution Data

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	642,884	3,092,187	3,707,293	4,077,915	4,762,862	5,520,486	5,511,619	4,448,713
Write	661,985	11,062,129	14,611,482	15,761,092	16,606,473	18,700,186	22,885,598	27,578,334
All ASUs	1,304,869	14,154,316	18,318,775	19,839,007	21,369,335	24,220,672	28,397,217	32,027,047
ASU1	872,912	7,798,650	9,504,351	10,196,245	11,072,560	12,594,087	14,405,494	15,549,906
ASU2	202,056	1,846,632	2,271,838	2,447,621	2,671,013	3,048,638	3,493,275	3,769,199
ASU3	229,901	4,509,034	6,542,586	7,195,141	7,625,762	8,577,947	10,498,448	12,707,942

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	4,807,796	1,855,920	1,309,734	1,879,888	2,993,263	4,472,831	12,794,546	14,670,790
Write	59,283,143	47,515,892	26,462,786	9,698,763	2,742,261	836,754	648,831	411,509
All ASUs	64,090,939	49,371,812	27,772,520	11,578,651	5,735,524	5,309,585	13,443,377	15,082,299
ASU1	29,281,898	21,551,464	12,128,439	5,712,650	3,971,179	4,625,621	12,268,111	13,499,962
ASU2	7,104,235	5,225,094	2,831,713	1,079,251	405,194	286,640	898,344	1,417,295
ASU3	27,704,806	22,595,254	12,812,368	4,786,750	1,359,151	397,324	276,922	165,042

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	13,342,959	10,499,823	8,145,832	32,767,479	11,728,718	7,299,456	4,445,176	16,170,503
Write	295,671	184,924	125,215	555,082	664,183	329,164	118,201	274,918
All ASUs	13,638,630	10,684,747	8,271,047	33,322,561	12,392,901	7,628,620	4,563,377	16,445,421
ASU1	11,941,955	9,161,211	7,016,791	28,013,564	10,082,232	6,230,119	3,741,329	12,328,724
ASU2	1,574,897	1,444,563	1,199,822	5,096,014	2,018,514	1,236,304	781,996	4,098,081
ASU3	121,778	78,973	54,434	212,983	292,155	162,197	40,052	18,616

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	0.035	0.2810
COV	0.003	0.001	0.002	0.001	0.005	0.002	0.003	0.001

Primary Metrics Test – IOPS Test Phase

Clause 5.4.2.2

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

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

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

Clause 9.2.4.7.2

For the IOPS Test Phase the FDR shall contain:

1. *I/O Request Throughput Distribution (data and graph).*
2. *A Response Time Frequency Distribution.*
3. *An Average Response Time Distribution.*
4. *The human readable Test Run Results File produced by the Workload Generator.*
5. *A listing or screen image of all input parameters supplied t the Workload Generator.*
6. *The total number of I/O Requests completed in the Measurement Interval as well as the number of I/O Requests with a Response Time less than or equal to 30 milliseconds and the number of I/O Requests with a Response Time greater than 30 milliseconds.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 75.

IOPS Test Results File

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

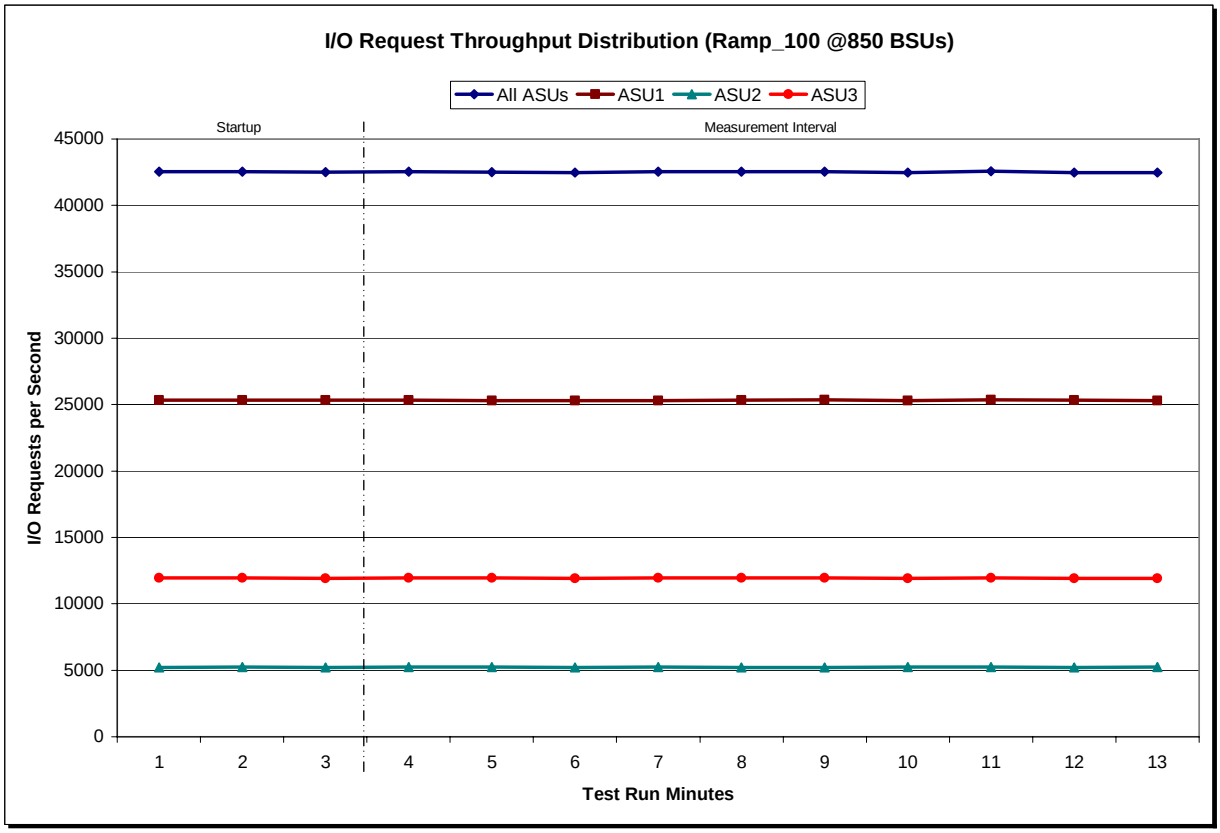
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:18:51	17:21:52	0-2	0:03:01
Measurement Interval	17:21:52	17:31:52	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	42,534.90	25,346.73	5,226.57	11,961.60
1	42,534.57	25,345.95	5,233.60	11,955.02
2	42,503.72	25,345.30	5,226.35	11,932.07
3	42,534.55	25,343.70	5,237.57	11,953.28
4	42,494.08	25,305.45	5,245.53	11,943.10
5	42,467.95	25,316.47	5,224.62	11,926.87
6	42,522.43	25,312.43	5,253.10	11,956.90
7	42,525.53	25,346.08	5,218.50	11,960.95
8	42,534.45	25,362.40	5,228.07	11,943.98
9	42,457.45	25,298.77	5,235.15	11,923.53
10	42,555.43	25,357.85	5,238.73	11,958.85
11	42,467.98	25,322.93	5,210.92	11,934.13
12	42,466.20	25,295.67	5,238.03	11,932.50
Average	42,502.61	25,326.18	5,233.02	11,943.41

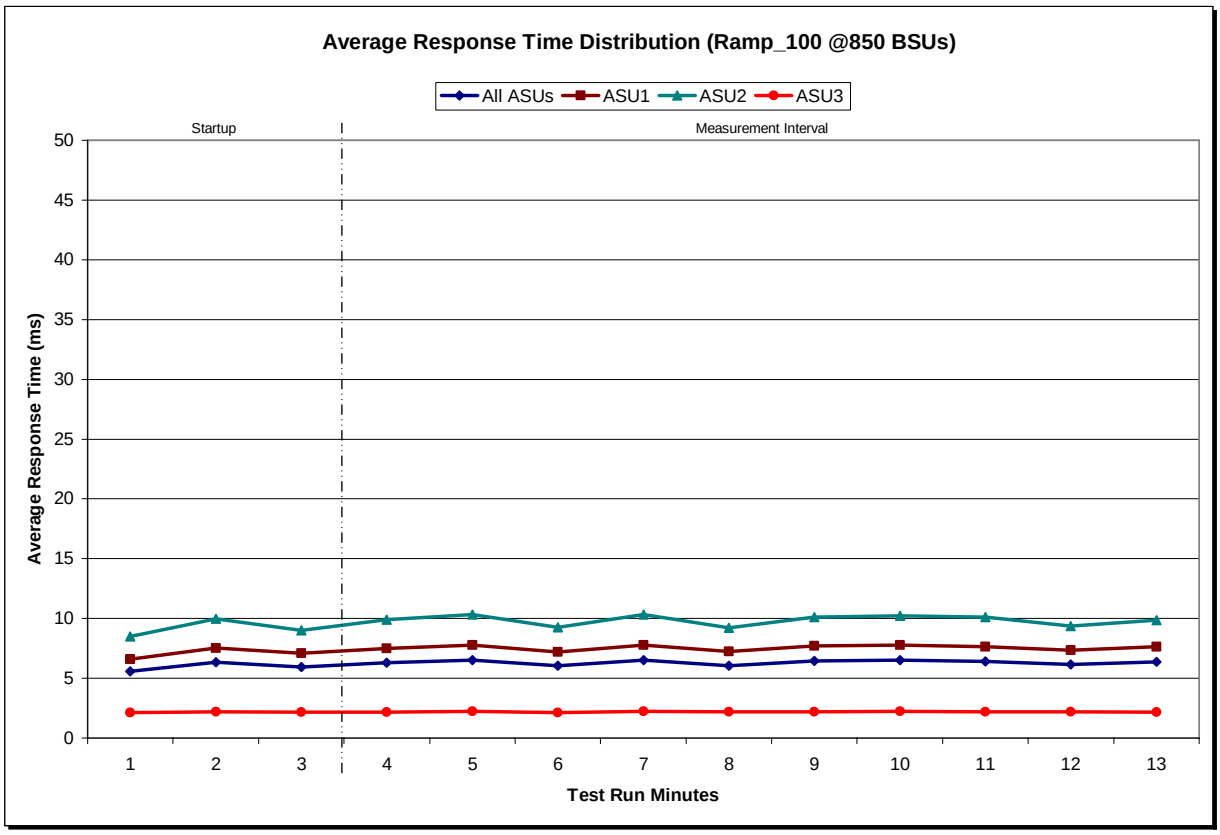
IOPS Test Run – I/O Request Throughput Distribution Graph



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

850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:18:51	17:21:52	0-2	0:03:01
Measurement Interval	17:21:52	17:31:52	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	5.58	6.60	8.50	2.14
1	6.33	7.54	9.98	2.18
2	5.94	7.08	9.02	2.15
3	6.30	7.50	9.89	2.17
4	6.53	7.77	10.33	2.24
5	6.03	7.21	9.26	2.13
6	6.52	7.76	10.34	2.22
7	6.06	7.24	9.22	2.18
8	6.44	7.69	10.10	2.18
9	6.52	7.78	10.22	2.24
10	6.40	7.63	10.11	2.18
11	6.14	7.34	9.36	2.20
12	6.37	7.63	9.86	2.17
Average	6.33	7.55	9.87	2.19

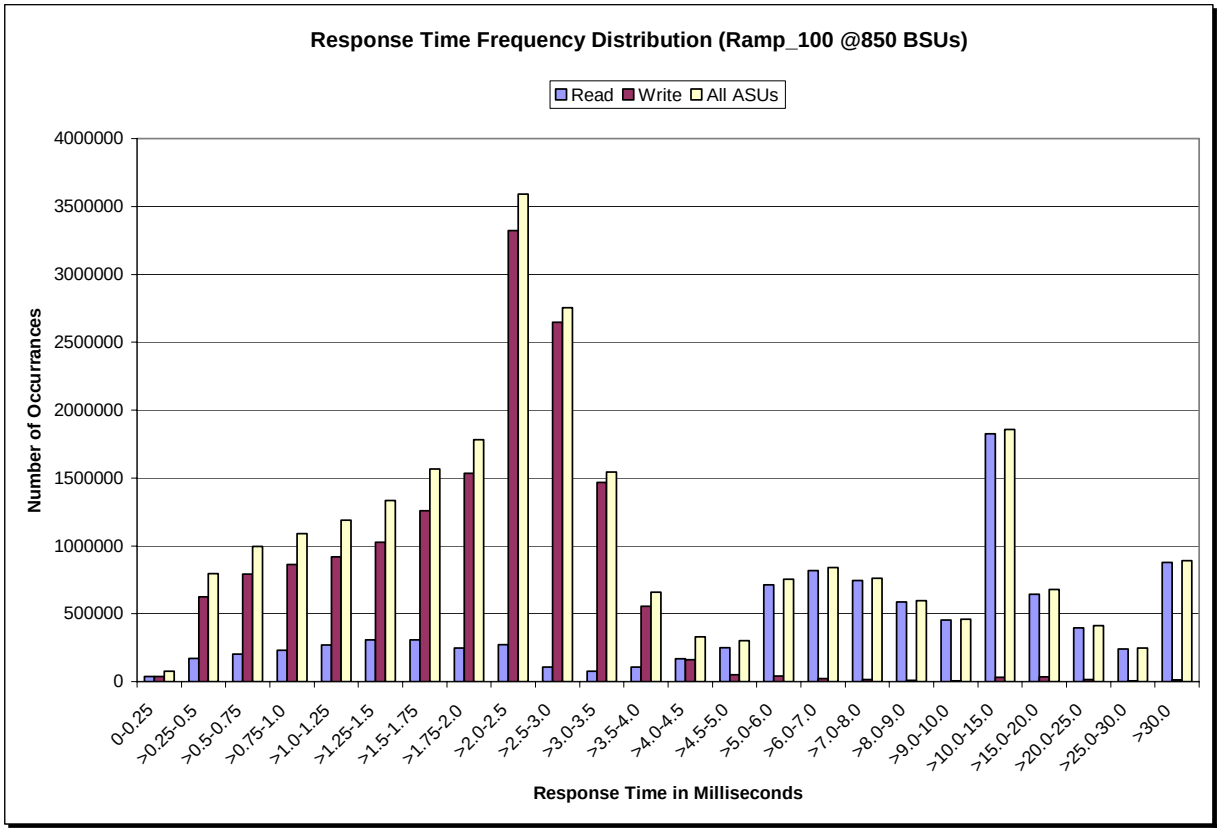
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	37,009	172,157	203,362	230,531	268,446	308,808	306,528	248,269
Write	38,631	622,950	792,279	861,168	919,933	1,025,506	1,258,875	1,533,864
All ASUs	75,640	795,107	995,641	1,091,699	1,188,379	1,334,314	1,565,403	1,782,133
ASU1	50,681	438,229	516,433	564,952	617,990	696,225	797,434	866,596
ASU2	11,485	102,757	123,481	134,567	148,228	167,549	191,158	209,645
ASU3	13,474	254,121	355,727	392,180	422,161	470,540	576,811	705,892
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	271,045	108,361	75,380	106,238	168,644	250,002	714,151	817,644
Write	3,320,703	2,645,790	1,466,980	553,971	160,878	52,239	39,729	21,630
All ASUs	3,591,748	2,754,151	1,542,360	660,209	329,522	302,241	753,880	839,274
ASU1	1,644,470	1,204,824	673,984	325,321	225,976	260,211	685,834	751,069
ASU2	398,617	291,531	157,034	61,946	23,750	16,894	50,776	79,441
ASU3	1,548,661	1,257,796	711,342	272,942	79,796	25,136	17,270	8,764
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	744,456	585,858	451,798	1,826,143	642,619	397,031	240,144	877,613
Write	15,169	10,050	7,052	31,592	35,674	16,024	5,681	12,735
All ASUs	759,625	595,908	458,850	1,857,735	678,293	413,055	245,825	890,348
ASU1	664,895	510,604	388,589	1,557,626	550,231	337,294	201,223	664,867
ASU2	88,352	80,788	67,093	287,613	111,894	67,788	42,614	224,765
ASU3	6,378	4,516	3,168	12,496	16,168	7,973	1,988	716

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
25,501,340	24,610,992	890,348

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.0 and 5.3.13.2

MIM – Measured Intensity Multiplier: *The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.*

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.02099	0.0180	0.0701	0.0351	0.2810
COV	0.003	0.001	0.002	0.001	0.006	0.003	0.003	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.2.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 12.

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

Clause 9.2.4.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 75.

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 - 850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:18:51	17:21:52	0-2	0:03:01
Measurement Interval	17:21:52	17:31:52	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	42,534.90	25,346.73	5,226.57	11,961.60
1	42,534.57	25,345.95	5,233.60	11,955.02
2	42,503.72	25,345.30	5,226.35	11,932.07
3	42,534.55	25,343.70	5,237.57	11,953.28
4	42,494.08	25,305.45	5,245.53	11,943.10
5	42,467.95	25,316.47	5,224.62	11,926.87
6	42,522.43	25,312.43	5,253.10	11,956.90
7	42,525.53	25,346.08	5,218.50	11,960.95
8	42,534.45	25,362.40	5,228.07	11,943.98
9	42,457.45	25,298.77	5,235.15	11,923.53
10	42,555.43	25,357.85	5,238.73	11,958.85
11	42,467.98	25,322.93	5,210.92	11,934.13
12	42,466.20	25,295.67	5,238.03	11,932.50
Average	42,502.61	25,326.18	5,233.02	11,943.41

95% Load Level - 807 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:32:00	17:35:01	0-2	0:03:01
Measurement Interval	17:35:01	17:45:01	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	40,394.58	24,065.40	4,969.03	11,360.15
1	40,394.55	24,077.48	4,962.68	11,354.38
2	40,354.68	24,061.60	4,960.12	11,332.97
3	40,357.60	24,044.85	4,966.57	11,346.18
4	40,330.75	24,031.95	4,954.27	11,344.53
5	40,359.12	24,042.72	4,977.52	11,338.88
6	40,318.53	24,020.88	4,956.00	11,341.65
7	40,385.80	24,057.88	4,963.68	11,364.23
8	40,357.13	24,065.12	4,963.68	11,328.33
9	40,386.23	24,074.40	4,964.73	11,347.10
10	40,379.30	24,075.60	4,969.33	11,334.37
11	40,309.70	24,006.60	4,971.25	11,331.85
12	40,362.52	24,054.58	4,972.25	11,335.68
Average	40,354.67	24,047.46	4,965.93	11,341.28

90% Load Level - 765 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:45:08	17:48:09	0-2	0:03:01
Measurement Interval	17:48:09	17:58:09	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	38,276.00	22,811.78	4,710.95	10,753.27
1	38,228.50	22,778.07	4,707.48	10,742.95
2	38,261.75	22,794.47	4,706.18	10,761.10
3	38,256.37	22,782.78	4,702.85	10,770.73
4	38,239.52	22,792.70	4,715.65	10,731.17
5	38,266.95	22,811.40	4,697.80	10,757.75
6	38,234.78	22,781.23	4,707.97	10,745.58
7	38,211.00	22,754.83	4,696.05	10,760.12
8	38,278.62	22,805.45	4,709.98	10,763.18
9	38,229.12	22,779.28	4,707.50	10,742.33
10	38,283.13	22,800.70	4,717.63	10,764.80
11	38,219.87	22,779.37	4,710.75	10,729.75
12	38,256.95	22,796.90	4,699.97	10,760.08
Average	38,247.63	22,788.47	4,706.62	10,752.55

80% Load Level - 680 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:58:16	18:01:17	0-2	0:03:01
Measurement Interval	18:01:17	18:11:17	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	34,044.08	20,288.02	4,192.05	9,564.02
1	34,020.95	20,278.28	4,174.05	9,568.62
2	34,038.17	20,286.00	4,187.82	9,564.35
3	33,989.25	20,262.80	4,178.20	9,548.25
4	34,028.95	20,254.53	4,201.17	9,573.25
5	33,978.68	20,256.05	4,166.97	9,555.67
6	34,054.05	20,299.17	4,192.40	9,562.48
7	33,994.48	20,276.70	4,182.40	9,535.38
8	33,962.25	20,228.20	4,175.90	9,558.15
9	33,980.55	20,250.40	4,187.23	9,542.92
10	33,987.38	20,244.00	4,195.98	9,547.40
11	33,994.90	20,263.22	4,181.00	9,550.68
12	34,030.87	20,289.08	4,181.22	9,560.57
Average	34,000.14	20,262.42	4,184.25	9,553.48

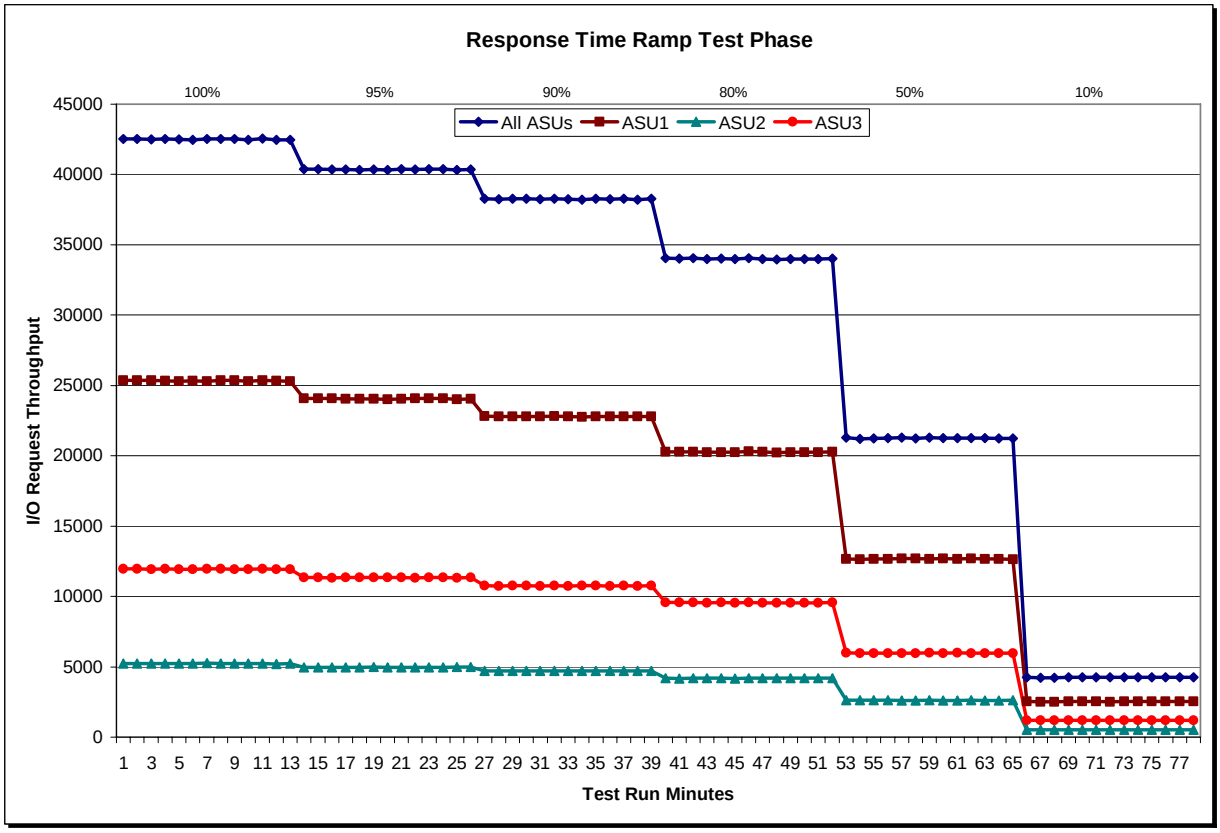
50% Load Level - 425 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:11:23	18:14:24	0-2	0:03:01
Measurement Interval	18:14:24	18:24:24	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	21,290.90	12,678.42	2,630.78	5,981.70
1	21,213.52	12,641.05	2,616.27	5,956.20
2	21,244.08	12,651.18	2,617.15	5,975.75
3	21,248.27	12,657.53	2,615.92	5,974.82
4	21,288.47	12,699.20	2,615.25	5,974.02
5	21,245.40	12,691.30	2,600.05	5,954.05
6	21,281.55	12,677.68	2,616.93	5,986.93
7	21,268.57	12,686.60	2,615.08	5,966.88
8	21,258.22	12,662.52	2,606.28	5,989.42
9	21,252.52	12,681.25	2,619.52	5,951.75
10	21,262.60	12,667.37	2,614.87	5,980.37
11	21,240.05	12,653.00	2,608.95	5,978.10
12	21,243.23	12,644.95	2,619.60	5,978.68
Average	21,258.89	12,672.14	2,613.25	5,973.50

10% Load Level - 85 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:24:29	18:27:30	0-2	0:03:01
Measurement Interval	18:27:30	18:37:30	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	4,259.28	2,541.52	520.83	1,196.93
1	4,235.17	2,523.10	519.70	1,192.37
2	4,235.88	2,515.38	526.35	1,194.15
3	4,247.78	2,527.53	526.73	1,193.52
4	4,244.55	2,532.93	525.93	1,185.68
5	4,266.67	2,541.90	529.63	1,195.13
6	4,249.50	2,521.62	525.17	1,202.72
7	4,249.58	2,534.07	526.62	1,188.90
8	4,259.07	2,545.02	523.97	1,190.08
9	4,244.38	2,540.52	518.53	1,185.33
10	4,241.83	2,526.53	526.28	1,189.02
11	4,254.65	2,542.20	524.15	1,188.30
12	4,247.98	2,526.10	525.75	1,196.13
Average	4,250.60	2,533.84	525.28	1,191.48

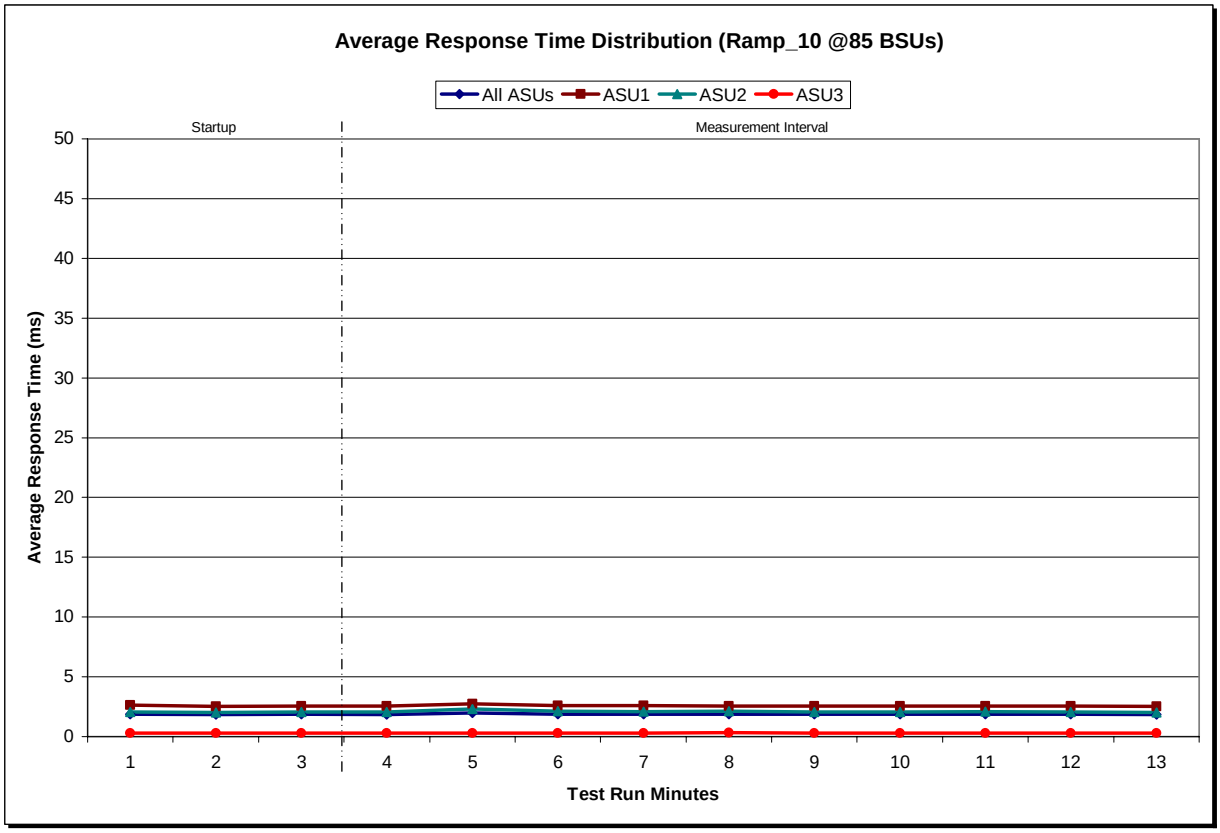
Response Time Ramp Distribution (IOPS) Graph



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

85 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:24:29	18:27:30	0-4	0:03:01
Measurement Interval	18:27:30	18:37:30	5-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.89	2.61	2.04	0.29
1	1.83	2.52	2.03	0.30
2	1.86	2.56	2.06	0.30
3	1.85	2.54	2.06	0.29
4	1.99	2.72	2.30	0.29
5	1.89	2.59	2.11	0.30
6	1.89	2.61	2.08	0.30
7	1.88	2.56	2.13	0.31
8	1.87	2.57	2.06	0.30
9	1.87	2.56	2.06	0.30
10	1.86	2.54	2.09	0.30
11	1.86	2.56	2.05	0.29
12	1.83	2.52	2.00	0.29
Average	1.88	2.58	2.09	0.30

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	0.0698	0.2105	0.0182	0.0702	0.0352	0.2803
COV	0.006	0.005	0.007	0.004	0.010	0.007	0.011	0.004

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 75.

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	***42,502.61***
Repeatability Test Phase 1	42,508.23
Repeatability Test Phase 2	42,497.29

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	***1.88 ms***
Repeatability Test Phase 1	1.88 ms
Repeatability Test Phase 2	1.89 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.

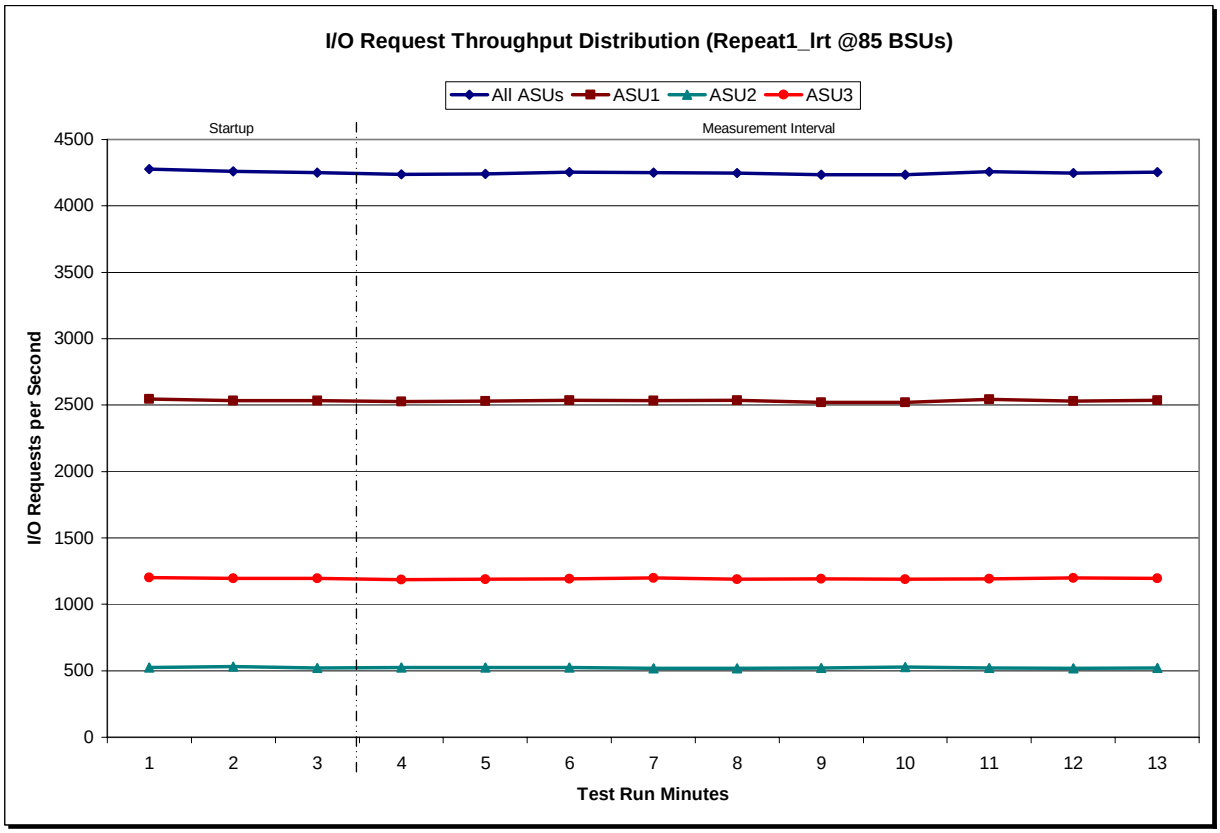
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

85 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:37:49	18:40:49	0-2	0:03:00
Measurement Interval	18:40:49	18:50:49	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4,275.17	2,546.92	525.40	1,202.85
1	4,259.32	2,534.43	530.92	1,193.97
2	4,251.73	2,532.93	522.55	1,196.25
3	4,238.82	2,527.92	524.53	1,186.37
4	4,241.62	2,529.50	523.60	1,188.52
5	4,252.90	2,537.93	523.68	1,191.28
6	4,249.33	2,532.17	518.35	1,198.82
7	4,246.03	2,537.03	519.87	1,189.13
8	4,234.95	2,521.22	521.85	1,191.88
9	4,233.65	2,519.07	526.70	1,187.88
10	4,256.22	2,542.28	522.10	1,191.83
11	4,247.03	2,530.62	517.98	1,198.43
12	4,252.75	2,535.52	521.48	1,195.75
Average	4,245.33	2,531.33	522.02	1,191.99

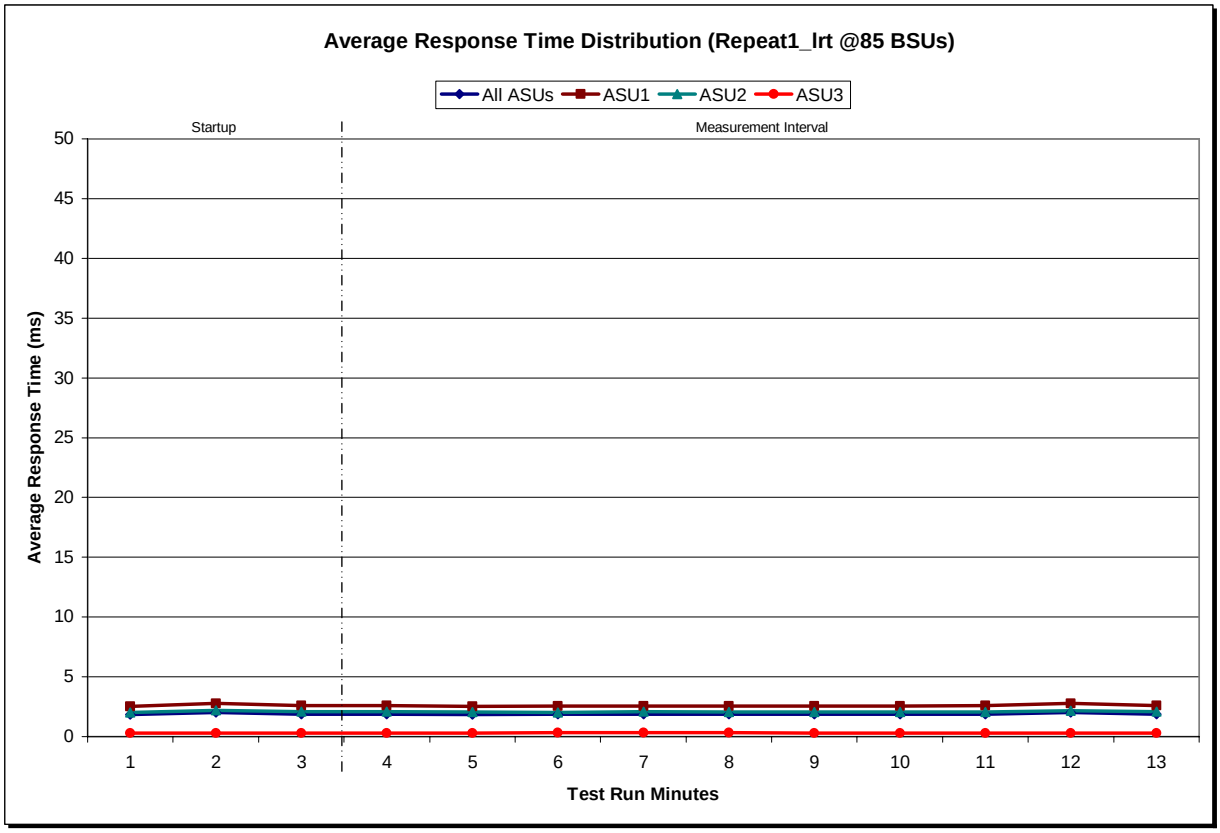
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

85 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:37:49	18:40:49	0-2	0:03:00
Measurement Interval	18:40:49	18:50:49	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.84	2.53	2.03	0.30
1	2.01	2.77	2.19	0.30
2	1.89	2.59	2.10	0.30
3	1.88	2.58	2.08	0.31
4	1.84	2.53	2.04	0.30
5	1.87	2.56	2.03	0.31
6	1.87	2.56	2.09	0.31
7	1.87	2.56	2.06	0.31
8	1.86	2.55	2.07	0.30
9	1.86	2.56	2.04	0.30
10	1.87	2.57	2.06	0.30
11	2.00	2.78	2.15	0.30
12	1.89	2.60	2.09	0.30
Average	1.88	2.59	2.07	0.30

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

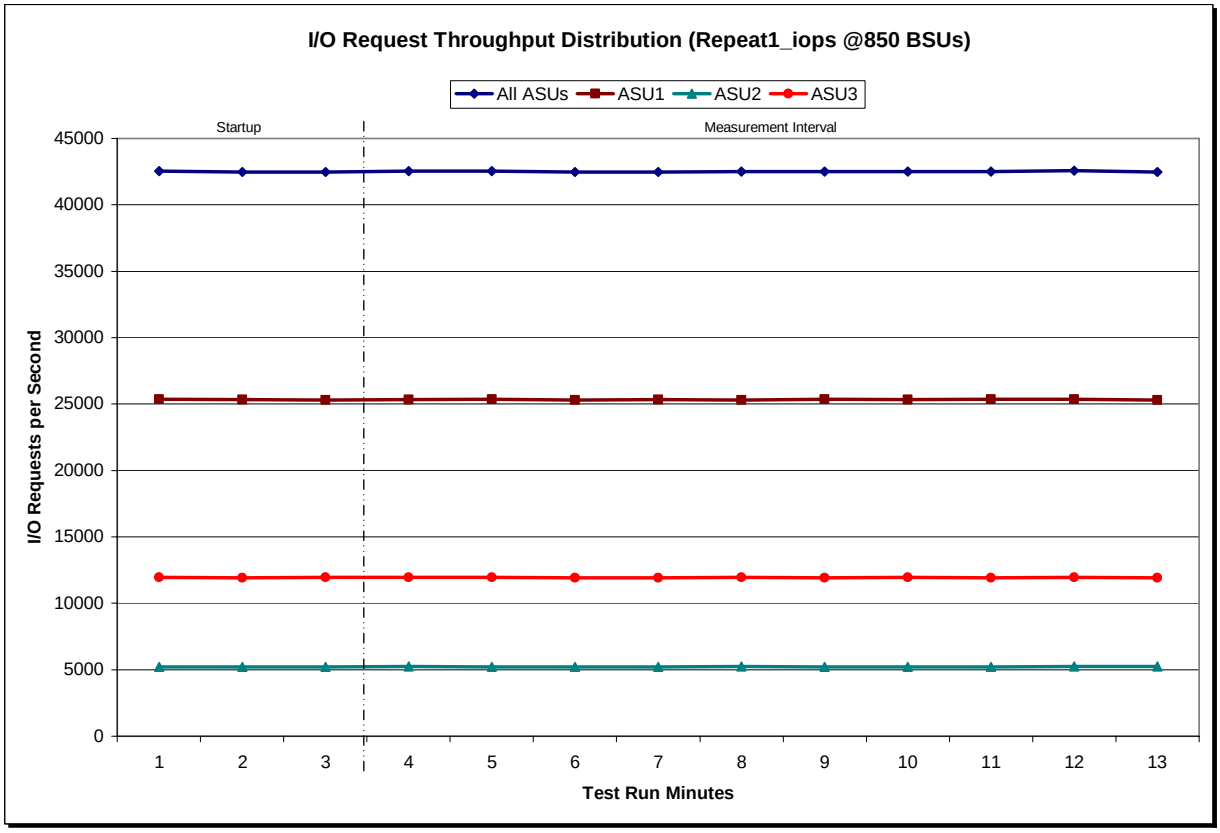


Repeatability 1 IOPS – I/O Request Throughput Distribution Data

850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:51:00	18:54:01	0-2	0:03:01
Measurement Interval	18:54:01	19:04:01	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	42,544.73	25,364.80	5,222.22	11,957.72
1	42,480.15	25,333.78	5,224.62	11,921.75
2	42,486.77	25,308.65	5,223.45	11,954.67
3	42,529.42	25,323.63	5,256.95	11,948.83
4	42,542.98	25,361.77	5,218.98	11,962.23
5	42,462.03	25,302.93	5,229.80	11,929.30
6	42,474.40	25,326.65	5,222.65	11,925.10
7	42,518.45	25,317.05	5,242.08	11,959.32
8	42,516.20	25,366.57	5,213.13	11,936.50
9	42,506.60	25,334.48	5,232.10	11,940.02
10	42,500.32	25,363.18	5,210.00	11,927.13
11	42,556.93	25,361.28	5,244.33	11,951.32
12	42,475.00	25,302.77	5,251.07	11,921.17
Average	42,508.23	25,336.03	5,232.11	11,940.09

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

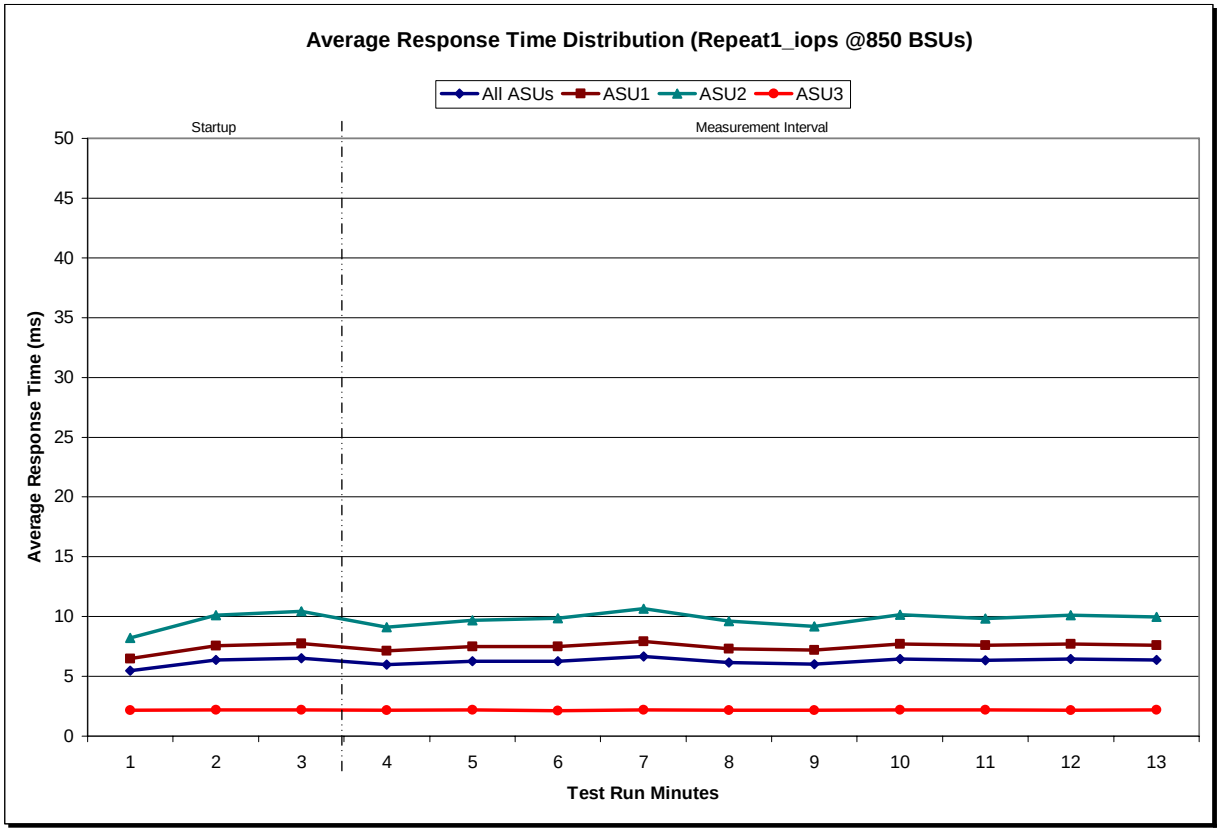


Repeatability 1 IOPS –Average Response Time (ms) Distribution Data

850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:51:00	18:54:01	0-2	0:03:01
Measurement Interval	18:54:01	19:04:01	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5.49	6.50	8.19	2.16
1	6.37	7.55	10.10	2.21
2	6.52	7.75	10.43	2.20
3	5.97	7.11	9.11	2.16
4	6.27	7.48	9.69	2.20
5	6.27	7.48	9.87	2.12
6	6.66	7.93	10.66	2.21
7	6.15	7.32	9.60	2.17
8	6.03	7.21	9.18	2.14
9	6.46	7.70	10.14	2.21
10	6.35	7.59	9.83	2.21
11	6.44	7.69	10.11	2.16
12	6.39	7.61	9.97	2.21
Average	6.30	7.51	9.82	2.18

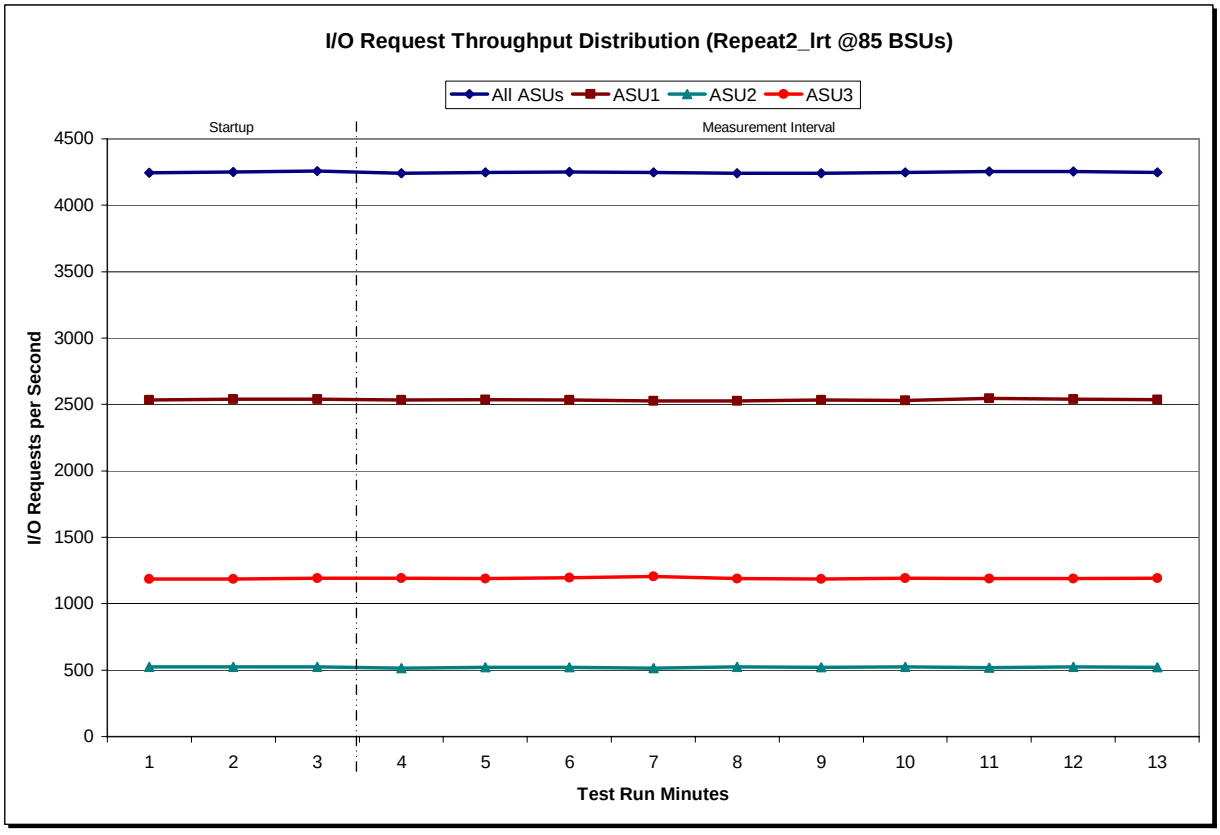
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

85 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:04:20	19:07:20	0-2	0:03:00
Measurement Interval	19:07:20	19:17:20	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	4,243.85	2,533.82	524.67	1,185.37
1	4,249.08	2,539.52	523.83	1,185.73
2	4,255.62	2,539.03	523.43	1,193.15
3	4,241.83	2,534.12	515.23	1,192.48
4	4,247.08	2,535.37	522.97	1,188.75
5	4,252.10	2,535.08	522.05	1,194.97
6	4,246.88	2,528.38	514.77	1,203.73
7	4,239.70	2,525.55	524.08	1,190.07
8	4,242.37	2,532.53	522.73	1,187.10
9	4,246.60	2,529.65	525.57	1,191.38
10	4,254.28	2,546.88	519.23	1,188.17
11	4,252.93	2,539.20	524.70	1,189.03
12	4,248.87	2,536.95	520.80	1,191.12
Average	4,247.27	2,534.37	521.21	1,191.68

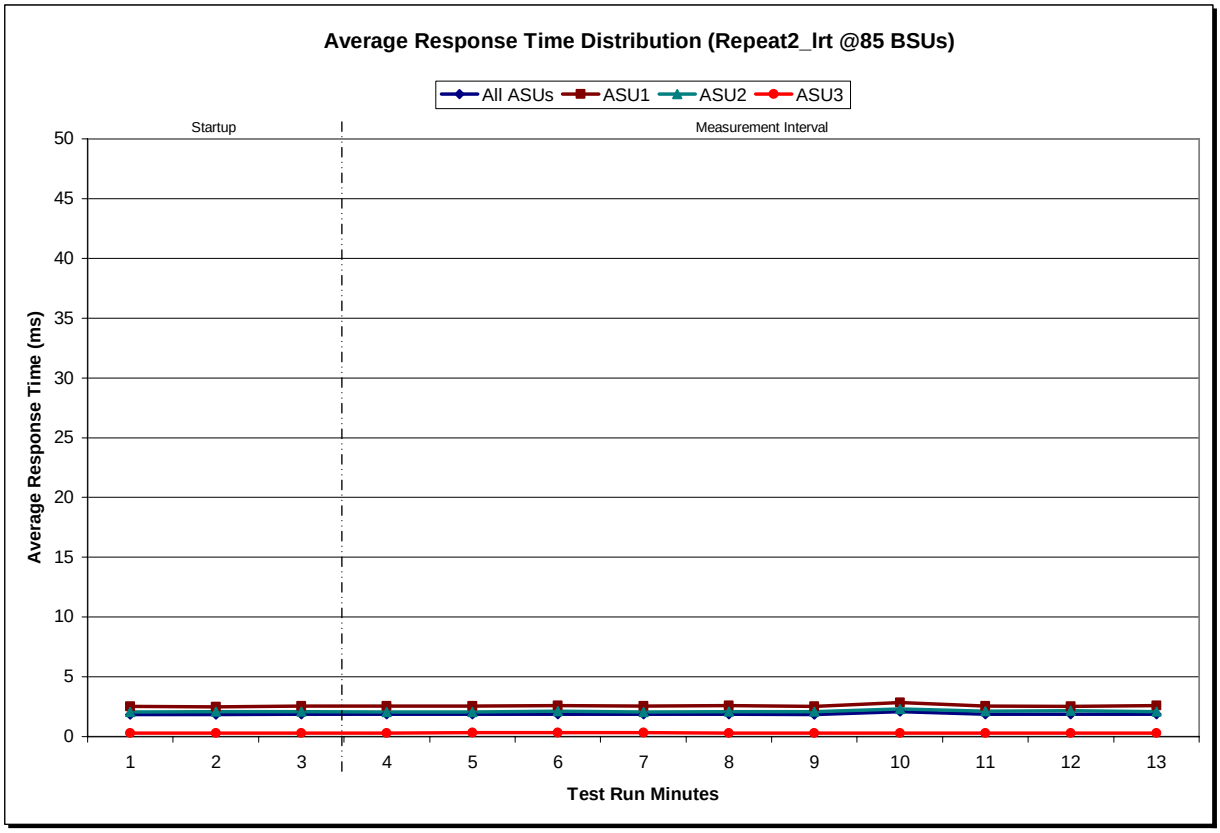
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

85 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:04:20	19:07:20	0-2	0:03:00
Measurement Interval	19:07:20	19:17:20	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.84	2.53	2.04	0.30
1	1.83	2.50	2.07	0.30
2	1.87	2.57	2.09	0.30
3	1.86	2.55	2.06	0.30
4	1.86	2.55	2.05	0.32
5	1.89	2.58	2.11	0.31
6	1.86	2.56	2.07	0.31
7	1.87	2.58	2.07	0.30
8	1.85	2.53	2.08	0.29
9	2.07	2.86	2.32	0.30
10	1.87	2.55	2.12	0.30
11	1.86	2.53	2.16	0.30
12	1.88	2.57	2.09	0.30
Average	1.89	2.59	2.11	0.30

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

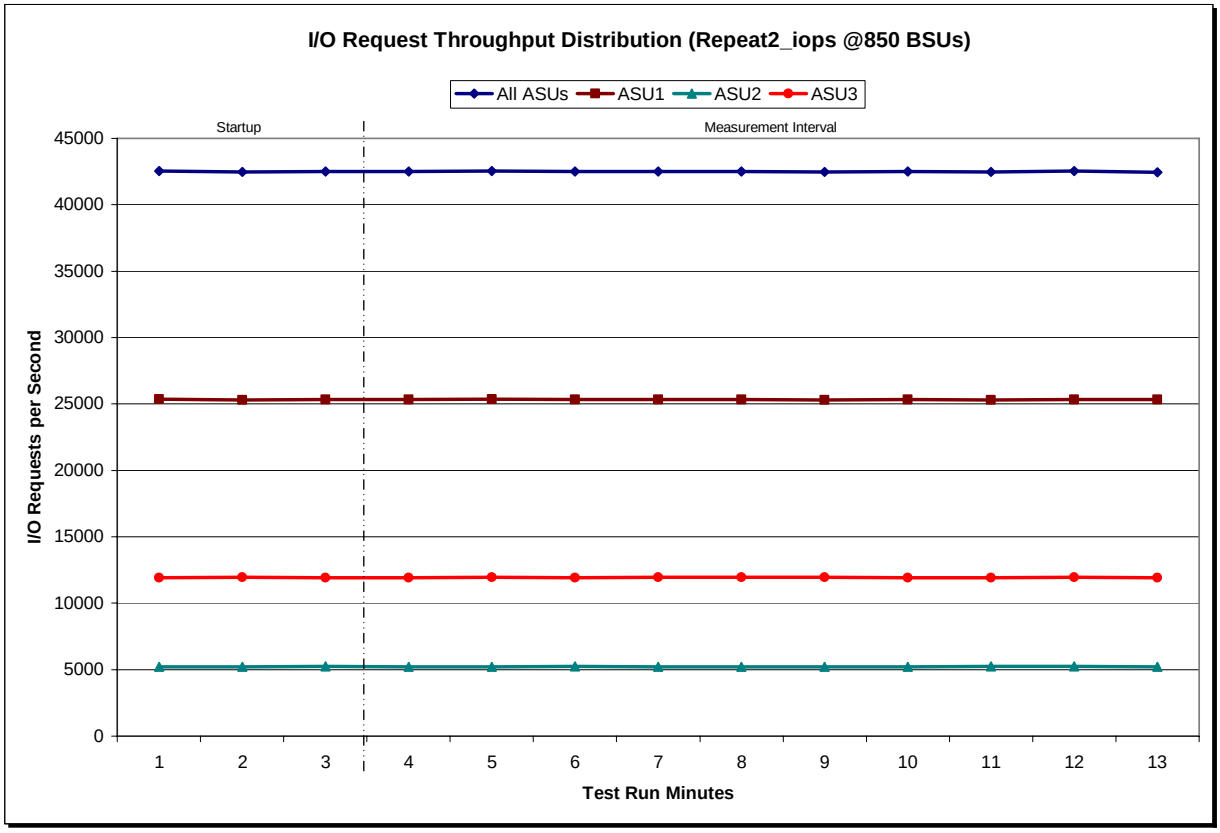


Repeatability 2 IOPS – I/O Request Throughput Distribution Data

850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:17:31	19:20:32	0-2	0:03:01
Measurement Interval	19:20:32	19:30:32	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	42,522.60	25,357.33	5,228.02	11,937.25
1	42,487.22	25,304.23	5,226.47	11,956.52
2	42,509.77	25,337.52	5,240.45	11,931.80
3	42,504.12	25,339.90	5,228.47	11,935.75
4	42,526.07	25,356.37	5,222.83	11,946.87
5	42,494.43	25,336.53	5,237.67	11,920.23
6	42,510.13	25,333.32	5,226.08	11,950.73
7	42,513.73	25,332.53	5,227.72	11,953.48
8	42,470.47	25,301.48	5,228.55	11,940.43
9	42,508.35	25,348.48	5,226.42	11,933.45
10	42,472.13	25,301.42	5,236.35	11,934.37
11	42,522.15	25,342.45	5,239.57	11,940.13
12	42,451.28	25,328.68	5,213.28	11,909.32
Average	42,497.29	25,332.12	5,228.69	11,936.48

Repeatability 2 IOPS – I/O Request Throughput Distribution Graph

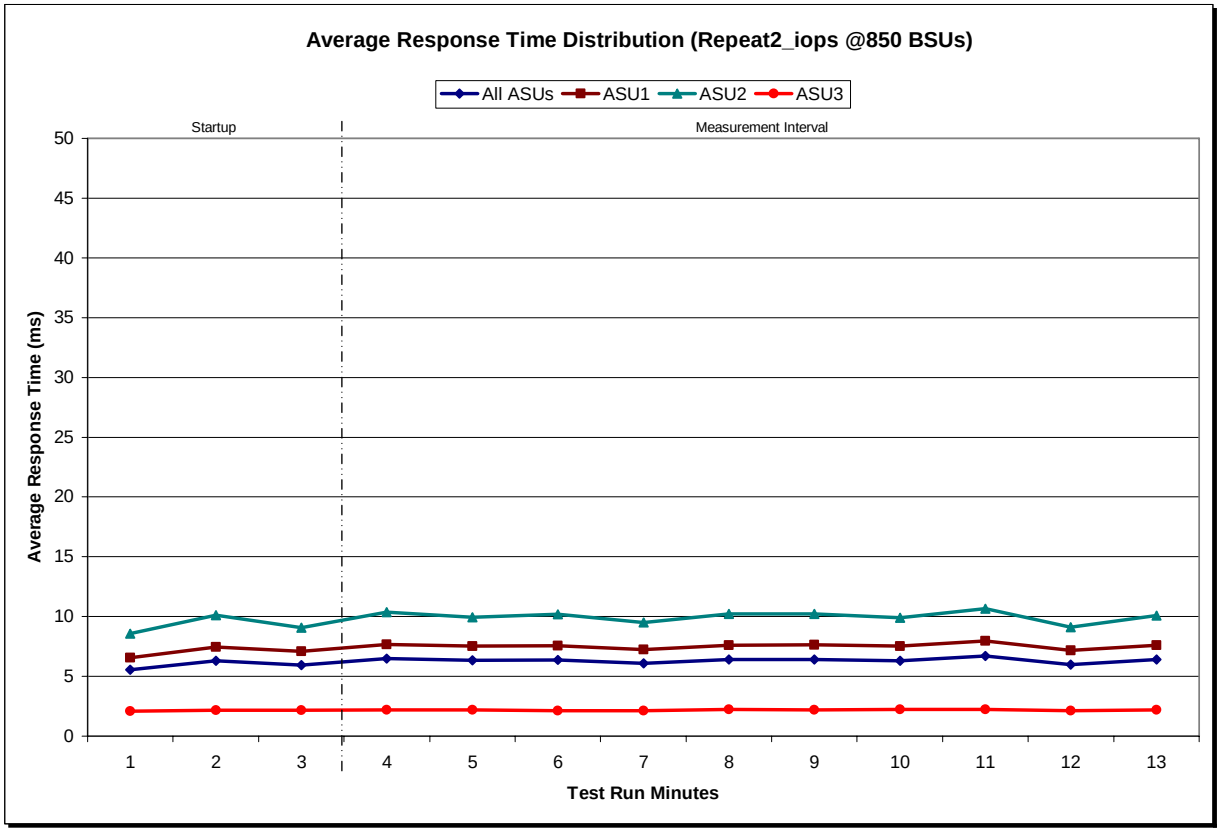


Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

850 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	19:17:31	19:20:32	0-2	0:03:01
Measurement Interval	19:20:32	19:30:32	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5.56	6.56	8.58	2.10
1	6.29	7.44	10.11	2.17
2	5.94	7.08	9.06	2.14
3	6.46	7.67	10.35	2.20
4	6.32	7.53	9.94	2.18
5	6.36	7.56	10.18	2.13
6	6.07	7.22	9.50	2.14
7	6.41	7.61	10.21	2.23
8	6.42	7.62	10.21	2.21
9	6.32	7.51	9.90	2.22
10	6.68	7.96	10.64	2.23
11	5.98	7.15	9.10	2.12
12	6.40	7.61	10.07	2.20
Average	6.34	7.54	10.01	2.19

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	0.0351	0.2813	0.0699	0.2100	0.0178	0.0701	0.0351	0.2808
COV	0.010	0.003	0.008	0.004	0.015	0.008	0.009	0.003

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0701	0.2101	0.0181	0.0700	0.0350	0.2809
COV	0.002	0.001	0.002	0.002	0.006	0.003	0.005	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	0.0350	0.2809	0.0704	0.2105	0.0180	0.0699	0.0348	0.2806
COV	0.009	0.003	0.005	0.003	0.012	0.009	0.014	0.004

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	0.2811	0.0699	0.2101	0.0180	0.0700	0.0351	0.2809
COV	0.003	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Data Persistence Test

Clause 6

The Data Persistence Test demonstrates the Tested Storage Configuration (TSC):

- *Is capable of maintain data integrity across a power cycle.*
- *Ensures the transfer of data between Logical Volumes and host systems occurs without corruption or loss.*

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

The Benchmark Configuration will be shutdown and restarted using a power off/power on cycle at the end of the above sequence of write operations. In addition, any caches employing battery backup must be flushed/emptied.

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

Clause 9.2.4.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 75.

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	101,787,840
Total Number of Logical Blocks Verified	83,610,864
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 2300 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.

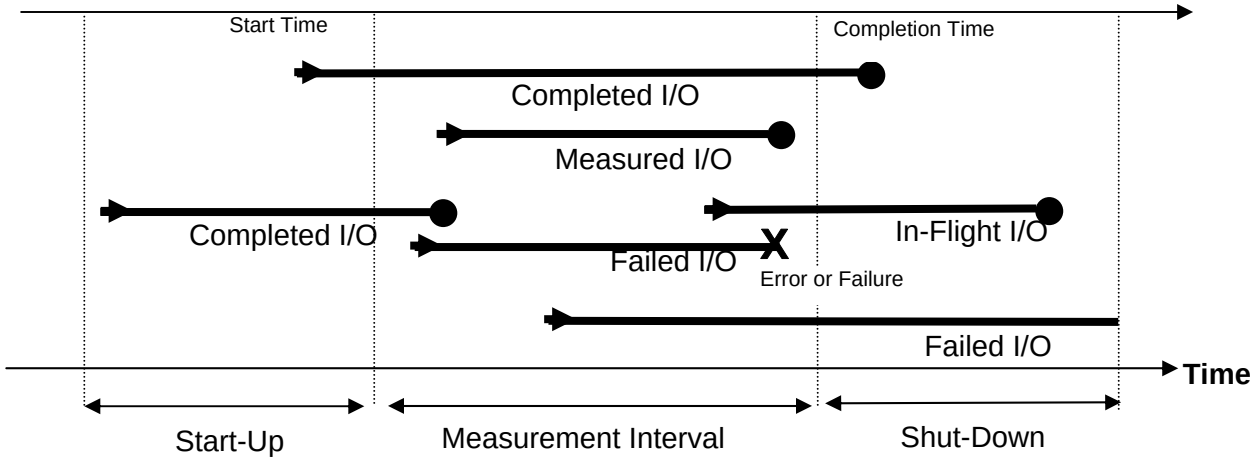
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

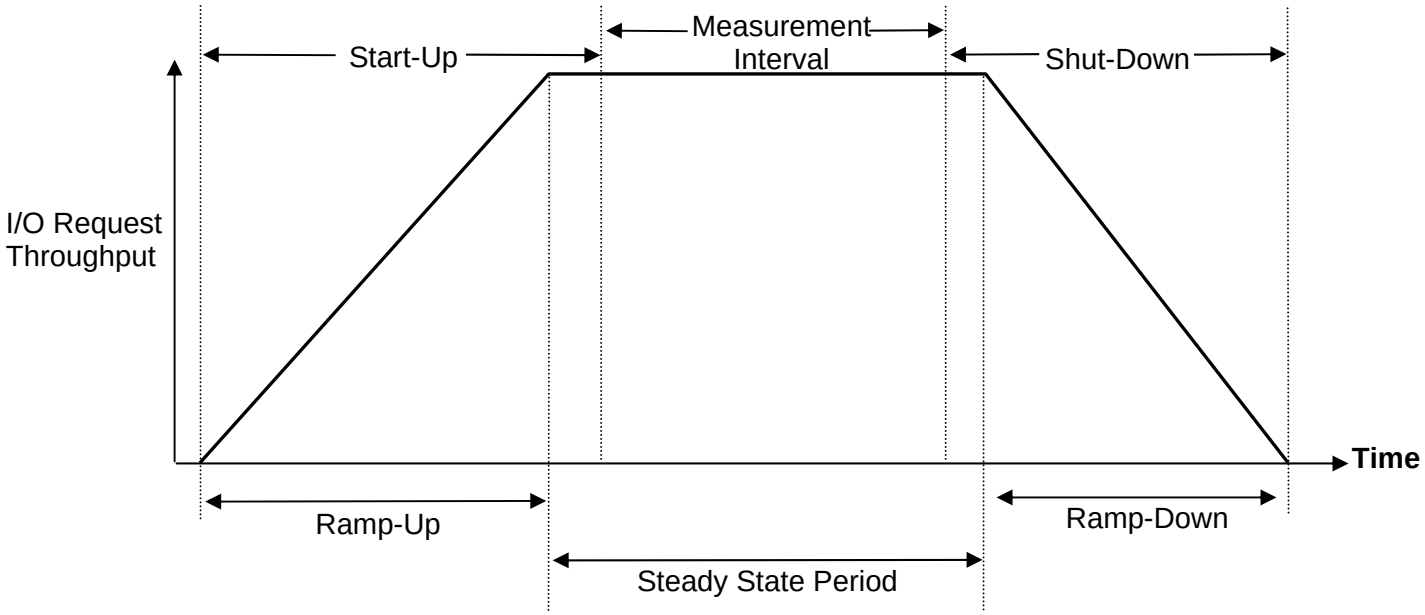
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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	3580	16	2080	16
Partition 1	3580	16	2080	16
Partition 2	-	-	1500	16
Partition 3	-	-	1500	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
LU 0	Read	Enable	Base	256	128	0
LU 1	Read	Disable	Fixed	128	128	1
LU 2	Read	Disable	Fixed	128	128	1
LU 3	Read	Enable	Base	256	128	0
LU 4	Read	Enable	Base	256	128	0
LU 5	Read	Enable	Base	256	128	0
LU 6	Read	Disable	Fixed	128	128	1
LU 7	Read	Enable	Base	256	128	0
LU 8	Read	Enable	Base	256	128	0
LU 9	Read	Enable	Base	256	128	0
LU 10	Read	Enable	Base	256	128	0
LU 11	Read	Disable	Fixed	128	128	1
LU 12	Read	Disable	Fixed	128	128	1
LU 13	Read	Enable	Base	256	128	0
LU 14	Read	Enable	Base	256	128	0
LU 15	Read	Enable	Base	256	128	0
LU 16	Read	Disable	Fixed	128	128	1
LU 17	Read	Enable	Base	256	128	0
LU 18	Read	Enable	Base	256	128	0
LU 19	Read	Enable	Base	256	128	0
LU 20	Read	Enable	Base	256	128	0
LU 21	Read	Disable	Fixed	128	128	1
LU 22	Read	Disable	Fixed	128	128	1
LU 23	Read	Enable	Base	256	128	0
LU 24	Read	Enable	Base	256	128	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
LU 25	Read	Enable	Base	256	128	0
LU 26	Read	Disable	Fixed	128	128	1
LU 27	Read	Enable	Base	256	128	0
LU 28	Read	Enable	Base	256	128	0
LU 29	Read	Enable	Base	256	128	0
LU 30	Read	Enable	Base	256	128	0
LU 31	Read	Disable	Fixed	128	128	1
LU 32	Read	Disable	Fixed	128	128	1
LU 33	Read	Enable	Base	256	128	0
LU 34	Read	Enable	Base	256	128	0
LU 35	Read	Enable	Base	256	128	0
LU 36	Read	Disable	Fixed	128	128	1
LU 37	Read	Enable	Base	256	128	0
LU 38	Read	Enable	Base	256	128	0
LU 39	Read	Enable	Base	256	128	0
LU 40	Read	Enable	Base	256	128	0
LU 41	Read	Disable	Fixed	128	128	1
LU 42	Read	Disable	Fixed	128	128	1
LU 43	Read	Enable	Base	256	128	0
LU 44	Read	Enable	Base	256	128	0
LU 45	Read	Enable	Base	256	128	0
LU 46	Read	Disable	Fixed	128	128	1
LU 47	Read	Enable	Base	256	128	0
LU 48	Read	Enable	Base	256	128	0
LU 49	Read	Enable	Base	256	128	0
LU 50	Read	Enable	Base	256	128	0
LU 51	Read	Disable	Fixed	128	128	1
LU 52	Read	Disable	Fixed	128	128	1
LU 53	Read	Enable	Base	256	128	0
LU 54	Read	Enable	Base	256	128	0
LU 55	Read	Enable	Base	256	128	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
LU 56	Read	Disable	Fixed	128	128	1
LU 57	Read	Enable	Base	256	128	0
LU 58	Read	Enable	Base	256	128	0
LU 59	Read	Enable	Base	256	128	0
LU 60	Read	Enable	Base	256	128	0
LU 61	Read	Disable	Fixed	128	128	1
LU 62	Read	Disable	Fixed	128	128	1
LU 63	Read	Enable	Base	256	128	0
LU 64	Read	Enable	Base	256	128	0
LU 65	Read	Enable	Base	256	128	0
LU 66	Read	Disable	Fixed	128	128	1
LU 67	Read	Enable	Base	256	128	0
LU 68	Read	Enable	Base	256	128	0
LU 69	Read	Enable	Base	256	128	0
LU 70	Read	Enable	Base	256	128	0
LU 71	Read	Disable	Fixed	128	128	1
LU 72	Read	Disable	Fixed	128	128	1
LU 73	Read	Enable	Base	256	128	0
LU 74	Read	Enable	Base	256	128	0
LU 75	Read	Enable	Base	256	128	0
LU 76	Read	Disable	Fixed	128	128	1
LU 77	Read	Enable	Base	256	128	0
LU 78	Read	Enable	Base	256	128	0
LU 79	Read	Enable	Base	256	128	0
LU 80	Read	Enable	Base	256	128	0
LU 81	Read	Disable	Fixed	128	128	1
LU 82	Read	Disable	Fixed	128	128	1
LU 83	Read	Enable	Base	256	128	0
LU 84	Read	Enable	Base	256	128	0
LU 85	Read	Enable	Base	256	128	0
LU 86	Read	Disable	Fixed	128	128	1

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
LU 87	Read	Enable	Base	256	128	0
LU 88	Read	Enable	Base	256	128	0
LU 89	Read	Enable	Base	256	128	0
LU 90	Read	Enable	Base	256	128	0
LU 91	Read	Disable	Fixed	128	128	1
LU 92	Read	Disable	Fixed	128	128	1
LU 93	Read	Enable	Base	256	128	0
LU 94	Read	Enable	Base	256	128	0
LU 95	Read	Enable	Base	256	128	0
LU 96	Read	Disable	Fixed	128	128	1
LU 97	Read	Enable	Base	256	128	0
LU 98	Read	Enable	Base	256	128	0
LU 99	Read	Enable	Base	256	128	0
LU 100	Read	Enable	Base	256	128	0
LU 101	Read	Disable	Fixed	128	128	1
LU 102	Read	Disable	Fixed	128	128	1
LU 103	Read	Enable	Base	256	128	0
LU 104	Read	Enable	Base	256	128	0
LU 105	Read	Enable	Base	256	128	0
LU 106	Read	Disable	Fixed	128	128	1
LU 107	Read	Enable	Base	256	128	0
LU 108	Read	Enable	Base	256	128	0
LU 109	Read	Enable	Base	256	128	0
LU 110	Read	Enable	Base	256	128	0
LU 111	Read	Disable	Fixed	128	128	1
LU 112	Read	Disable	Fixed	128	128	1
LU 113	Read	Enable	Base	256	128	0
LU 114	Read	Enable	Base	256	128	0
LU 115	Read	Enable	Base	256	128	0
LU 116	Read	Disable	Fixed	128	128	1
LU 117	Read	Enable	Base	256	128	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
LU 118	Read	Enable	Base	256	128	0
LU 119	Read	Enable	Base	256	128	0
LU 120	Read	Enable	Base	256	128	0
LU 121	Read	Disable	Fixed	128	128	1
LU 122	Read	Disable	Fixed	128	128	1
LU 123	Read	Enable	Base	256	128	0
LU 124	Read	Enable	Base	256	128	0
LU 125	Read	Enable	Base	256	128	0
LU 126	Read	Disable	Fixed	128	128	1
LU 127	Read	Enable	Base	256	128	0
LU 128	Read	Enable	Base	256	128	0
LU 129	Read	Enable	Base	256	128	0
LU 130	Read	Enable	Base	256	128	0
LU 131	Read	Disable	Fixed	128	128	1
LU 132	Read	Disable	Fixed	128	128	1
LU 133	Read	Enable	Base	256	128	0
LU 134	Read	Enable	Base	256	128	0
LU 135	Read	Enable	Base	256	128	0
LU 136	Read	Disable	Fixed	128	128	1
LU 137	Read	Enable	Base	256	128	0
LU 138	Read	Enable	Base	256	128	0
LU 139	Read	Enable	Base	256	128	0
LU 140	Read	Enable	Base	256	128	0
LU 141	Read	Disable	Fixed	128	128	1
LU 142	Read	Disable	Fixed	128	128	1
LU 143	Read	Enable	Base	256	128	0
LU 144	Read	Enable	Base	256	128	0
LU 145	Read	Enable	Base	256	128	0
LU 146	Read	Disable	Fixed	128	128	1
LU 147	Read	Enable	Base	256	128	0
LU 148	Read	Enable	Base	256	128	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
LU 149	Read	Enable	Base	256	128	0
LU 150	Read	Enable	Base	256	128	0
LU 151	Read	Disable	Fixed	128	128	1
LU 152	Read	Disable	Fixed	128	128	1
LU 153	Read	Enable	Base	256	128	0
LU 154	Read	Enable	Base	256	128	0
LU 155	Read	Enable	Base	256	128	0
LU 156	Read	Disable	Fixed	128	128	1
LU 157	Read	Enable	Base	256	128	0
LU 158	Read	Enable	Base	256	128	0
LU 159	Read	Enable	Base	256	128	0
LU 160	Read	Enable	Base	256	128	0
LU 161	Read	Disable	Fixed	128	128	1
LU 162	Read	Disable	Fixed	128	128	1
LU 163	Read	Enable	Base	256	128	0
LU 164	Read	Enable	Base	256	128	0
LU 165	Read	Enable	Base	256	128	0
LU 166	Read	Disable	Fixed	128	128	1
LU 167	Read	Enable	Base	256	128	0
LU 168	Read	Enable	Base	256	128	0
LU 169	Read	Enable	Base	256	128	0
LU 170	Read	Enable	Base	256	128	0
LU 171	Read	Disable	Fixed	128	128	1
LU 172	Read	Disable	Fixed	128	128	1
LU 173	Read	Enable	Base	256	128	0
LU 174	Read	Enable	Base	256	128	0
LU 175	Read	Enable	Base	256	128	0
LU 176	Read	Disable	Fixed	128	128	1
LU 177	Read	Enable	Base	256	128	0
LU 178	Read	Enable	Base	256	128	0
LU 179	Read	Enable	Base	256	128	0

LU #	Default					
	Mode	Prefetch Next	Prefetch Criteria	Fixed	Base	Count of Judgment Sequential
LU 180	Read	Enable	Base	256	128	0
LU 181	Read	Disable	Fixed	128	128	1
LU 182	Read	Disable	Fixed	128	128	1
LU 183	Read	Enable	Base	256	128	0
LU 184	Read	Enable	Base	256	128	0
LU 185	Read	Enable	Base	256	128	0
LU 186	Read	Disable	Fixed	128	128	1
LU 187	Read	Enable	Base	256	128	0
LU 188	Read	Enable	Base	256	128	0
LU 189	Read	Enable	Base	256	128	0
LU 190	Read	Enable	Base	256	128	0
LU 191	Read	Disable	Fixed	128	128	1
LU 192	Read	Disable	Fixed	128	128	1
LU 193	Read	Enable	Base	256	128	0
LU 194	Read	Enable	Base	256	128	0
LU 195	Read	Enable	Base	256	128	0
LU 196	Read	Disable	Fixed	128	128	1
LU 197	Read	Enable	Base	256	128	0
LU 198	Read	Enable	Base	256	128	0
LU 199	Read	Enable	Base	256	128	0
LU 200	Read/Write	Enable	Base	256	128	1
LU 201	Read/Write	Enable	Base	256	128	1
LU 202	Read/Write	Enable	Base	256	128	1
LU 203	Read/Write	Enable	Base	256	128	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 AMS2300 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)
```

2. Cache Partition Configuration

The AMS2300 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 AMS2500, but a reboot is only needed after the last command to enable the newly configured cache partitioning.

```
set ASU1_2size=208
set ASU3size=150
set segsize=16

aucachept -unit %UNAME% -chg -pt 0 -ptsize %ASU1_2size%
aucachept -unit %UNAME% -chg -pt 1 -ptsize %ASU1_2size%
aucachept -unit %UNAME% -add -ptsize %ASU3size% -segsize %segsize% -ctl0
aucachept -unit %UNAME% -add -ptsize %ASU3size% -segsize %segsize% -ctl1
```

3. RAID Group (RG) Creation

Twenty (20) RAID Groups *(0-19, 4D+4D, RAID1+0)* were created and used for ASU-1 and ASU-2. Four (4) RAID Groups *(20-23, 2D+2D, RAID1+0)* were created and used for ASU-3. The RAID Groups were created using the following commands:

```
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 4.9-4.14 8.0 8.1 -pnum 1
aurgadd -unit %UNAME% -rg 13 -RAID10 -drive 5.9-5.14 9.0 9.1 -pnum 1
aurgadd -unit %UNAME% -rg 14 -RAID10 -drive 6.9-6.14 10.0 10.1 -pnum 1
aurgadd -unit %UNAME% -rg 15 -RAID10 -drive 7.9-7.14 11.0 11.1 -pnum 1
aurgadd -unit %UNAME% -rg 16 -RAID10 -drive 8.2-8.9 -pnum 1
aurgadd -unit %UNAME% -rg 17 -RAID10 -drive 9.2-9.9 -pnum 1
aurgadd -unit %UNAME% -rg 18 -RAID10 -drive 10.2-10.9 -pnum 1
aurgadd -unit %UNAME% -rg 19 -RAID10 -drive 11.2-11.9 -pnum 1
aurgadd -unit %UNAME% -rg 20 -RAID10 -drive 8.10-8.13 -pnum 1
```

```
aurgadd -unit %UNAME% -rg 21 -RAID10 -drive 9.10-9.13 -pnum 1
aurgadd -unit %UNAME% -rg 22 -RAID10 -drive 10.10-10.13 -pnum 1
aurgadd -unit %UNAME% -rg 23 -RAID10 -drive 11.10-11.13 -pnum 1
```

4. Logical Unit (LU) Creation

There were 100 logical devices (Logical Unit, LU) created on RAID Groups 0-9 for ASU-1. A second set of 100 LUs were also created on RAID Groups 10-19 for ASU-2. Four (4) LUs were created on RAID Groups 20-23 for ASU-3.

The following commands were used to create the LUs:

```
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 0 -noluformat
for /L %%I IN (70, 1,79) DO auluadd -unit %UNAME% -lu %%I -rg 7 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (80, 1,89) DO auluadd -unit %UNAME% -lu %%I -rg 8 -size 75497472 -
cachept 0 -noluformat
for /L %%I IN (90, 1,99) DO auluadd -unit %UNAME% -lu %%I -rg 9 -size 75497472 -
cachept 0 -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
for /L %%I IN (120, 1,129) DO auluadd -unit %UNAME% -lu %%I -rg 12 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (130, 1,139) DO auluadd -unit %UNAME% -lu %%I -rg 13 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (140, 1,149) DO auluadd -unit %UNAME% -lu %%I -rg 14 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (150, 1,159) DO auluadd -unit %UNAME% -lu %%I -rg 15 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (160, 1,169) DO auluadd -unit %UNAME% -lu %%I -rg 16 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (170, 1,179) DO auluadd -unit %UNAME% -lu %%I -rg 17 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (180, 1,189) DO auluadd -unit %UNAME% -lu %%I -rg 18 -size 75497472
-cachept 1 -noluformat
for /L %%I IN (190, 1,199) DO auluadd -unit %UNAME% -lu %%I -rg 19 -size 75497472
-cachept 1 -noluformat
auluadd -unit %UNAME% -lu 200 -rg 20 -size 417595392 -stripesize 512 -cachept 2 -
noluformat
auluadd -unit %UNAME% -lu 201 -rg 21 -size 417595392 -stripesize 512 -cachept 2 -
noluformat
auluadd -unit %UNAME% -lu 202 -rg 22 -size 417595392 -stripesize 512 -cachept 3 -
noluformat
auluadd -unit %UNAME% -lu 203 -rg 23 -size 417595392 -stripesize 512 -cachept 3 –
noluformat
```

```
auformat -unit %UNAME% -lu 0-203
```

5. Map LUs to Front-End Ports

Each front-end port is assigned fifty-one (51) LUs as follows: twenty-five (25) LUs for ASU-1, twenty-five (25) 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:

```
auhgmap -unit %UNAME% -MappingMode off
auhgmap -unit %UNAME% -MappingMode on

for /L %%I IN (  0, 1,  49) DO auhgmap -unit %UNAME% -add 0 B 0 %%I %%I
for /L %%I IN (  50, 1, 99) DO auhgmap -unit %UNAME% -add 0 C 0 %%I %%I
for /L %%I IN (  100, 1,  149) DO auhgmap -unit %UNAME% -add 1 B 0 %%I %%I
for /L %%I IN (150, 1, 199) DO auhgmap -unit %UNAME% -add 1 C 0 %%I %%I

auhgmap -unit %UNAME% -add 0 B 0 200 200
auhgmap -unit %UNAME% -add 0 C 0 201 201
auhgmap -unit %UNAME% -add 1 B 0 202 202
auhgmap -unit %UNAME% -add 1 C 0 203 203
```

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

7. Turn Off Trace and Monitoring Information – AMS2300 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 – AMS2300 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 0-203 -seqcount 0
for /L %%I IN ( 1, 10, 199) DO autuningmultistream -unit %UNAME% -set -scope lu -
lu %%I -seqcount 1 -next disable -criteria fixed
for /L %%I IN ( 2, 10, 199) DO autuningmultistream -unit %UNAME% -set -scope lu -
lu %%I -seqcount 1 -next disable -criteria fixed
for /L %%I IN ( 6, 10, 199) DO autuningmultistream -unit %UNAME% -set -scope lu -
lu %%I -seqcount 1 -next disable -criteria fixed
autuningmultistream -unit %UNAME% -set -scope lu -lu 200 -readwrite enable -
seqcount 1 -criteria base
autuningmultistream -unit %UNAME% -set -scope lu -lu 201 -readwrite enable -
seqcount 1 -criteria base
autuningmultistream -unit %UNAME% -set -scope lu -lu 202 -readwrite enable -
seqcount 1 -criteria base
autuningmultistream -unit %UNAME% -set -scope lu -lu 203 -readwrite enable -
seqcount 1 -criteria base

set PREF_SIZE=128
set PREB_SIZE=128
for /L %%I IN ( 1, 10, 199) DO autuningmultistream -unit %UNAME% -set -scope lu -
lu %%I -fixedsize %PREF_SIZE% -basesize %PREF_SIZE%
for /L %%I IN ( 2, 10, 199) DO autuningmultistream -unit %UNAME% -set -scope lu -
lu %%I -fixedsize %PREF_SIZE% -basesize %PREF_SIZE%
for /L %%I IN ( 6, 10, 199) 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 and 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 204 "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 and Logical Volumes are created using the native AIX Logical Volume Manager. First, create an environment file such as **env.cfg.pe82.11vg** that identifies all logical volume settings needed by the LVM scripts. Then run **mkvg.ksh** script to create the volume groups, and **mklv.ksh** to create the logical volumes:

The content of **env.cfg.pe82.11vg**, **mkvg.ksh**, and **mklv.ksh** are listed below.

env.cfg.pe82.11vg

```
# 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="hdisk1 hdisk11 hdisk21 hdisk31 hdisk41 hdisk52 hdisk62 hdisk72
hdisk82 hdisk92 hdisk103 hdisk113 hdisk123 hdisk133 hdisk143 hdisk154 hdisk164
hdisk174 hdisk184 hdisk194"

ASU12DISK="hdisk2 hdisk12 hdisk22 hdisk32 hdisk42 hdisk53 hdisk63 hdisk73
hdisk83 hdisk93 hdisk104 hdisk114 hdisk124 hdisk134 hdisk144 hdisk155 hdisk165
hdisk175 hdisk185 hdisk195"

ASU13DISK="hdisk3 hdisk13 hdisk23 hdisk33 hdisk43 hdisk54 hdisk64 hdisk74
hdisk84 hdisk94 hdisk105 hdisk115 hdisk125 hdisk135 hdisk145 hdisk156 hdisk166
hdisk176 hdisk186 hdisk196"

ASU14DISK="hdisk4 hdisk14 hdisk24 hdisk34 hdisk44 hdisk55 hdisk65 hdisk75
hdisk85 hdisk95 hdisk106 hdisk116 hdisk126 hdisk136 hdisk146 hdisk157 hdisk167
hdisk177 hdisk187 hdisk197"

ASU15DISK="hdisk5 hdisk15 hdisk25 hdisk35 hdisk45 hdisk56 hdisk66 hdisk76
hdisk86 hdisk96 hdisk107 hdisk117 hdisk127 hdisk137 hdisk147 hdisk158 hdisk168
hdisk178 hdisk188 hdisk198"

ASU21DISK="hdisk6 hdisk16 hdisk26 hdisk36 hdisk46 hdisk57 hdisk67 hdisk77
hdisk87 hdisk97 hdisk108 hdisk118 hdisk128 hdisk138 hdisk148 hdisk159 hdisk169
hdisk179 hdisk189 hdisk199"

ASU22DISK="hdisk7 hdisk17 hdisk27 hdisk37 hdisk47 hdisk58 hdisk68 hdisk78
hdisk88 hdisk98 hdisk109 hdisk119 hdisk129 hdisk139 hdisk149 hdisk160 hdisk170
hdisk180 hdisk190 hdisk200"

ASU23DISK="hdisk8 hdisk18 hdisk28 hdisk38 hdisk48 hdisk59 hdisk69 hdisk79
hdisk89 hdisk99 hdisk110 hdisk120 hdisk130 hdisk140 hdisk150 hdisk161 hdisk171
hdisk181 hdisk191 hdisk201"

ASU24DISK="hdisk9 hdisk19 hdisk29 hdisk39 hdisk49 hdisk60 hdisk70 hdisk80
hdisk90 hdisk100 hdisk111 hdisk121 hdisk131 hdisk141 hdisk151 hdisk162 hdisk172
hdisk182 hdisk192 hdisk202"

ASU25DISK="hdisk10 hdisk20 hdisk30 hdisk40 hdisk50 hdisk61 hdisk71 hdisk81
hdisk91 hdisk101 hdisk112 hdisk122 hdisk132 hdisk142 hdisk152 hdisk163 hdisk173
hdisk183 hdisk193 hdisk203"

ASU31DISK="hdisk51 hdisk102 hdisk153 hdisk204"

# 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=11448
ASU12LVSIZE=11448
ASU13LVSIZE=11448
ASU14LVSIZE=11448
ASU15LVSIZE=11448
ASU21LVSIZE=11448
ASU22LVSIZE=11448
ASU23LVSIZE=11448
ASU24LVSIZE=11448
ASU25LVSIZE=11448
ASU31LVSIZE=12720

# Maximum Number of Logical Partition
ASU11LP=20
ASU12LP=20
ASU13LP=20
ASU14LP=20
ASU15LP=20
ASU21LP=20
ASU22LP=20
ASU23LP=20
ASU24LP=20
ASU25LP=20
ASU31LP=4
```

mkvg.ksh

```
#!/bin/ksh


. /home/perf/spc1/env.cfg.pe82.11vg

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.ksh

```
#!/bin/ksh

. /home/perf/spc1/env.cfg.pe82.11vg

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=716g
sd=asu1_2,lun=/dev/rlvasu12,size=716g
sd=asu1_3,lun=/dev/rlvasu13,size=716g
sd=asu1_4,lun=/dev/rlvasu14,size=716g
sd=asu1_5,lun=/dev/rlvasu15,size=716g
sd=asu2_1,lun=/dev/rlvasu21,size=716g
sd=asu2_2,lun=/dev/rlvasu22,size=716g
sd=asu2_3,lun=/dev/rlvasu23,size=716g
sd=asu2_4,lun=/dev/rlvasu24,size=716g
sd=asu2_5,lun=/dev/rlvasu25,size=716g
sd=asu3_1,lun=/dev/rlvasu31,size=795g
```

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

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