SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

IBM CORPORATION
IBM TOTALSTORAGE®
SAN VOLUME CONTROLLER 3.1

SPC-1 V1.9

Submitted for Review: October 25, 2005
Submission Identifier: A00043
Revised: October 27, 2005
Accepted: December 24, 2005

First Edition – October 2005

Trademarks

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Notes

The following terms, used in this document, are defined as:

- Kilobyte (KB) is equal to 1,000 (10^3) bytes.
- Megabyte (MB) is equal to 1,000,000 (10^6) bytes.
- Gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.
- 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.

Table of Contents

AUDIT CERTIFICATION

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

October 24, 2005

The SPC Benchmark 1™ results listed below for the IBM TotalStorage® SAN Volume Controller 3.1 were produced in compliance with the SPC Benchmark 1™ V1.9 Remote Audit requirements.

SPC Benchmark 1™ V1.9 Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage® SAN Volume Controller 3.1	
Metric	**Reported Result**
SPC-1 IOPS™	155,519.47
SPC-1 Price-Performance	$12.76/SPC-1 IOPS™
Total ASU Capacity	12,216.796 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$1,938,784

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with V1.9 of the SPC Benchmark 1™ specification:

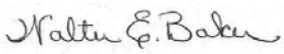
- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified using information supplied by IBM Corporation:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).

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

AUDIT CERTIFICATION *(CONT.)*

- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters.
- Commands and parameters used to configure the SPC-1 Workload Generator.
- The following Host System requirements were reviewed using documentation supplied by IBM Corporation:
  - ✓ The type of Host System including the number of processors and main memory.
  - ✓ The presence and version number of the Workload Generator on the Host System.
  - ✓ The TSC boundary within the Host System.
- The Test Results Files and resultant Summary Results Files received from IBM Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration.
- The final version of the pricing spreadsheet 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.

Respectfully,



Walter E. Baker
SPC Auditor

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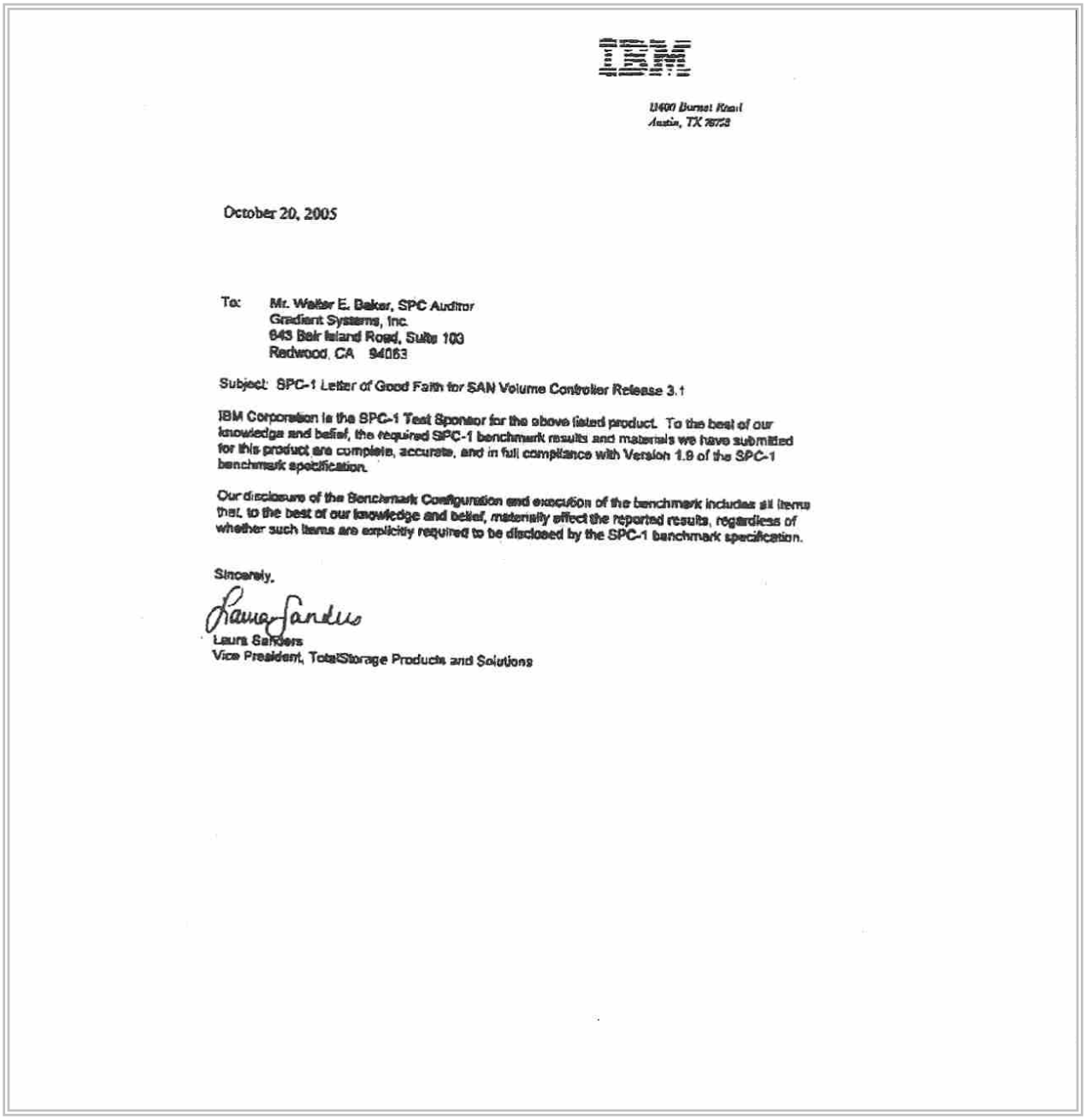
LETTER OF GOOD FAITH



IBM

11400 Burnet Road
Austin, TX 78758

October 20, 2005

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

Subject: SPC-1 Letter of Good Faith for SAN Volume Controller Release 3.1

IBM Corporation is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for this product are complete, accurate, and in full compliance with Version 1.9 of the SPC-1 benchmark specification.

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

Sincerely,

Laura Sanders

Laura Sanders
Vice President, TotalStorage Products and Solutions

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	IBM Corporation – http://www.ibm.com Peter Leung – leungp@us.ibm.com 65S/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-2853 FAX: (520) 799-5530
Test Sponsor Alternate Contact	IBM Corporation – http://www.ibm.com Bruce McNutt – bmcnutt@us.ibm.com KBV/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-2460 FAX: (520) 799-5530
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	V1.9
SPC-1 Workload Generator revision number	V2.00.04a
Date Results were first used publicly	October 25, 2005
Date the FDR was submitted to the SPC	October 25, 2005
Date the revised FDR was submitted to the SPC • Availability Date changed from October 28, 2005 to November 18, 2005 • The Data Protection Overhead value in the "SPC-1 Storage Capacities" table on page 19 of the Full Disclosure Report has been restated correctly in GB rather than GiB as it was in the initial submission.	October 27, 2005
Date the TSC is/was available for shipment to customers	November 18, 2005
Date the TSC completed audit certification	October 24, 2005

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage® SAN Volume Controller 3.1	
Metric	**Reported Result**
SPC-1 IOPS™	155,519.47
SPC-1 Price-Performance	$12.76/SPC-1 IOPS™
Total ASU Capacity	12,216.796 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	$1,983,784.74

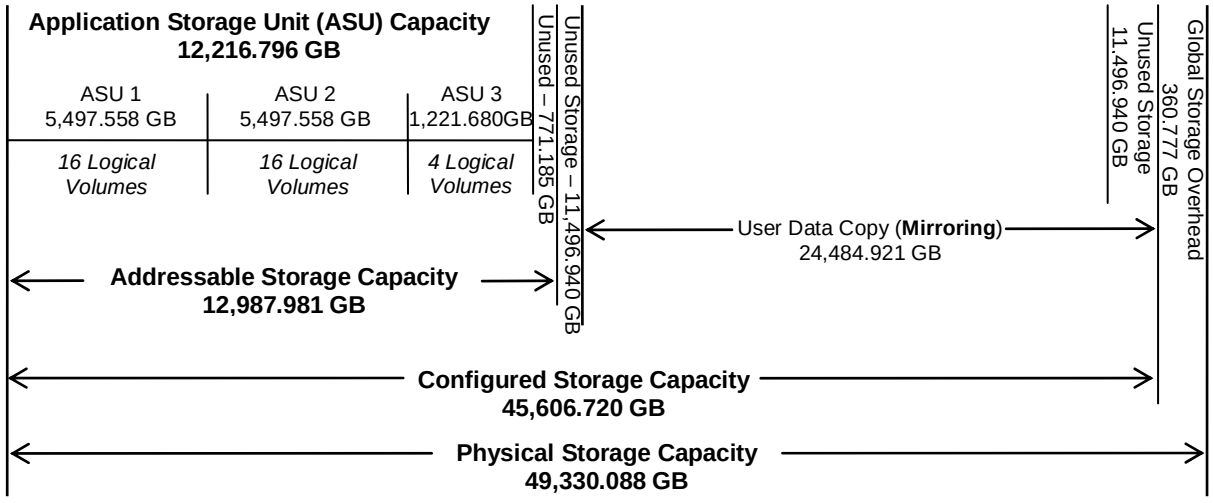
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

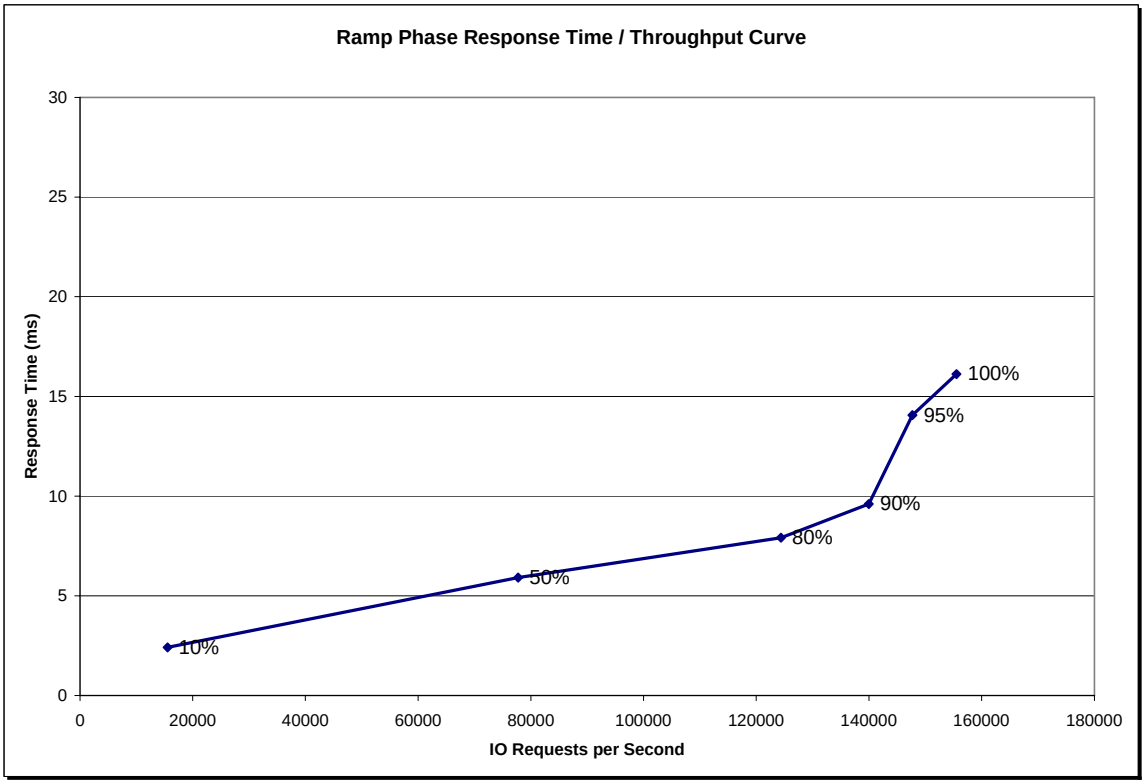
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



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	15,556.55	77,747.99	124,381.62	139,971.90	147,705.17	155,519.47
Average Response Time (ms):						
All ASUs	2.41	5.91	7.92	9.60	14.06	16.12
ASU-1	3.12	7.65	10.26	12.32	17.62	20.57
ASU-2	2.56	7.44	9.55	11.55	16.71	19.35
ASU-3	0.83	1.55	2.23	2.99	5.37	5.26
Reads	4.93	12.80	16.83	19.89	26.88	32.23
Writes	0.77	1.43	2.12	2.91	5.72	5.64

Tested Storage Configuration Pricing *(Priced Storage Configuration)*

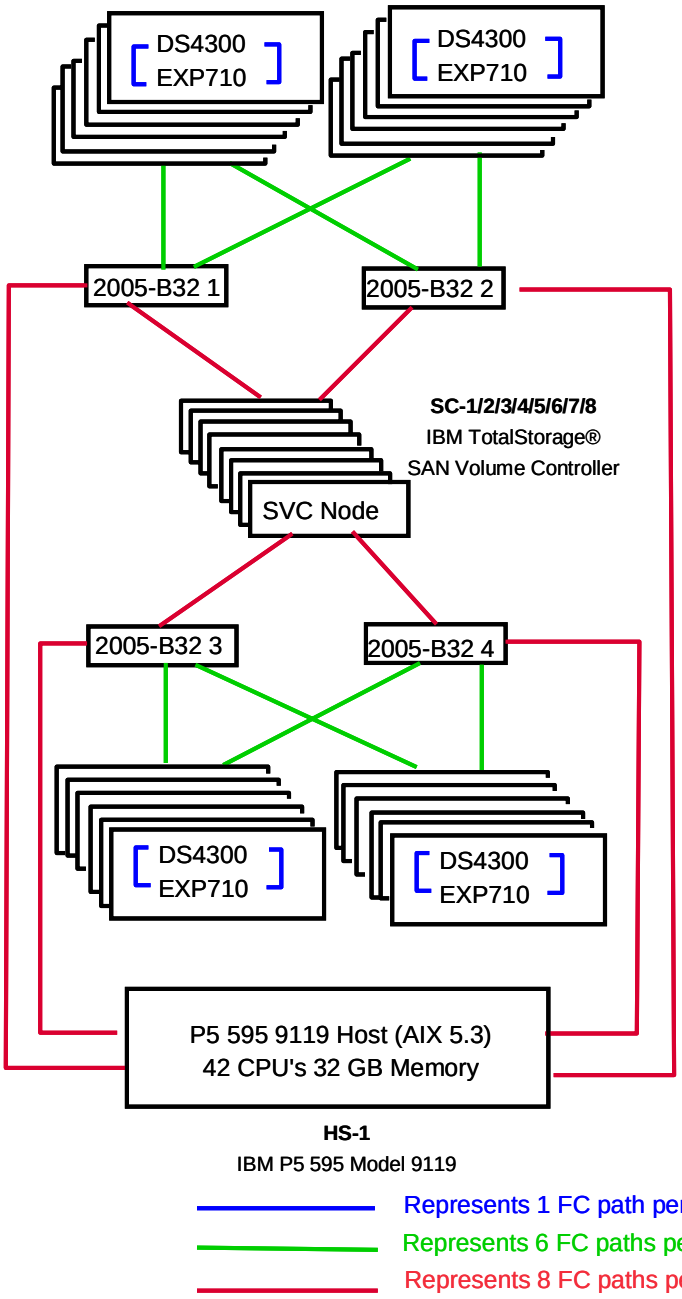
Component	Comments	Quantity	Unit Price	Unit Maint	List w/ Maint	% discount	Total Price
SVC Storage Engine		8	13,750.00	3,564.00	138,512.00	30	96,958.40
UPS		8	1,250.00	2,268.00	28,144.00	30	19,700.80
Master Console		1	7,499.00	3,312.00	10,811.00	30	7,567.70
SVC Software license	up to 48 virtualized TB	1	212,000.00	84,800.00	296,800.00	10	267,120.00
19 inch rack (7014-T42)		5	8,660.00	888.00	47,740.00	50	23,870.00
32 port fibre channel switch (2005-B32)	32 of 32 ports enabled	4	36,475.00	4,200.00	162,700.00	20	130,160.00
Ethernet switch (22P-8743)		3	380.00	100.00	1,440.00	42	835.20
DS4300 with 14 15K RPM drives (73 GB)	w/ 6 SFP, 4 5m cables	24	47,895.00	2,499.00	1,209,456.00	37	761,957.28
EXP710 with 14 15K RPM drives (73 GB)	w/ 4 SFP, 2 1m cables	24	37,640.00	760.00	921,600.00	37	580,608.00
SFP (4 pack)		4	550.00		2,200.00	20	1,760.00
Short wave 2Gbit fibre channel cable (25 m)		32	210.00		6,720.00	20	5,376.00
Ethernet cable (7 feet)		16	6.99		111.84	0	111.84
Ethernet cable (25 feet)		48	14.99		719.52	0	719.52
2 Gbit P5 595 adapter (5716)		32	2,720.00		87,040.00	0	87,040.00
Total Price							**$ 1,983,784.74**

The above pricing provides maintenance/support for 24 hours per day, 7 days per week for three years with four hour acknowledgement and four hour subsequent response (support engineer onsite or customer replaceable part available). The discount applied to the above pricing is the IBM "field delegation" discount.

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



Notes:

All storage is managed by each node (single image).

Each DS4300 and EXP710 has 14 disks (total of 672). Disks are 73 GB, 15K RPM.

Each switch has one zone for node-to-host traffic, one zone for node-to-storage traffic

Benchmark Configuration/Tested Storage Configuration Diagram (cont.)

Host Systems:	Tested Storage Configuration (TSC):
UID=HS-1	32 – 2 Gbit P5 595 HBAs
IBM P5 595 Model 9119	***UID=SC-1/2/3/4/5/6/7/8:*** 8 – TotalStorage® SAN Volume Controllers Per controller: xSeries 335 processor which contains: 2 – 3.0 GHz Intel P4 CPUs 8 GB memory/cache 4 – 2 Gbit FC ports
42 – 1.9 GHz CPUs – 2 CPUs/POWER5 chip 32 KB L1 cache, 960 KB L2 cache, and 18 MB L3 cache per CPU	
32 GB main memory	
AIX 5.3	
PCI-X/RIO	4 – 32 port FC switches
WG	3 – Ethernet switch
	24 – DS4300 enclosures 24 – EXP710 enclosures 14 – 73 GB, 15K RPM disk drives per enclosure
	5 – 19 inch racks
	8 – UPS

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 13 *(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 storage network configured as a part of the Tested Storage Configuration is illustrated on page 13 *(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 13 *(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 A: Customer Tunable Parameters and Options" on page 56 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 B: Tested Storage Configuration (TSC) Creation" on page 57 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 C: SPC-1 Workload Generator Storage Commands and Parameters" on page 61.

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 ECC 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.

Storage Capacities and Relationships

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)	12,216.796
Addressable Storage Capacity	Gigabytes (GB)	12,987.981
Configured Storage Capacity	Gigabytes (GB)	48,969.843
Physical Storage Capacity	Gigabytes (GB)	49,330.088
Data Protection Overhead (mirror)	Gigabytes (GB)	24,484.921
Required Storage	Gigabytes (GB)	0.00
Global Storage Overhead	Gigabytes (GB)	360.777
Total Unused Storage	Gigabytes (GB)	22,993.881

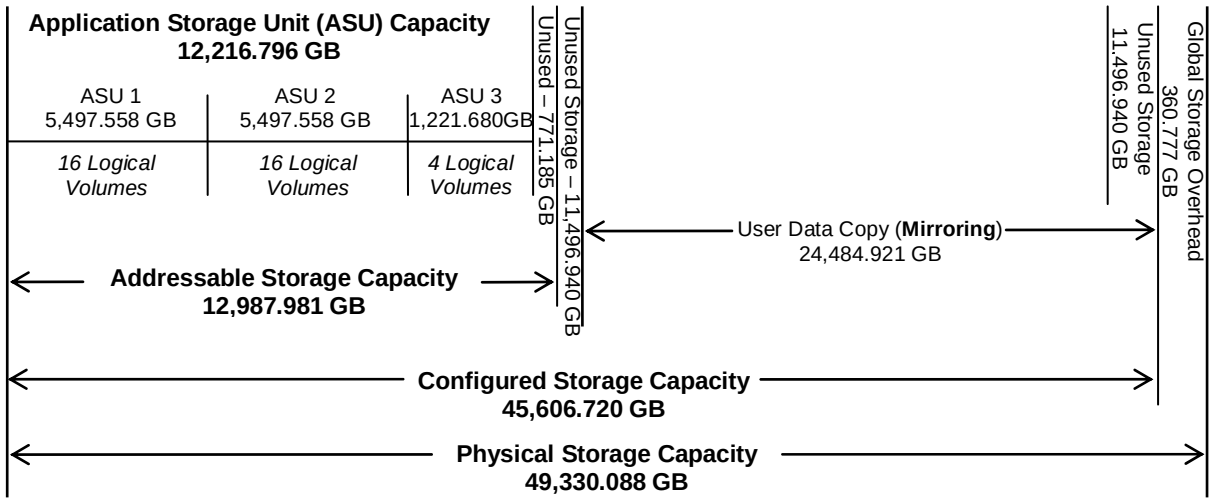
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	94.06%	24.95%	24.77%
Required for Data Protection (Mirroring)		50.00%	49.63%
Addressable Storage Capacity		26.52%	26.33%
Required Storage		0.00%	0.00%
Configured Storage Capacity			99.27%
Global Storage Overhead			0.73%
Unused Storage:			
Addressable	5.94%		
Configured		46.96%	
Physical			0.00%

The Physical Storage Capacity consisted of 49,330.088 GB distributed over 672 disk drives each with a formatted capacity of 73.408 GB. There was 0.00 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 360.77 GB (0.73%) of Physical Storage Capacity. There was 22,993.881 GB (46.96%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 94.06% of the Addressable Storage Capacity resulting in 771.185 GB (5.94%) 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 (5,497.588GB)	**ASU-2 (5,497.558 GB)**	**ASU-3 (1,443.109 GB)**
16 Logical Volumes 360.777 per Logical Volume (343.597GB used per Logical Volume)	16 Logical Volumes 360.777 per Logical Volume (343.597GB used per Logical Volume)	4 Logical Volumes 360.777 per Logical Volume (305.420GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was Mirroring as described on page 10. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

SPC-1 BENCHMARK EXECUTION RESULTS

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.*

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.*

Measurement Interval: *The finite and contiguous time period, after the Tested Storage Configuration (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.*

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. Comment: Steady Stated is achieved only after caches in the TSC have filled and as a result the I/O Request throughput of the TSC has stabilized.*

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

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.*

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 Figure 5-1 below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.*

The SPC-1 benchmark consists of the following Tests, Test Phases, and Test Runs:

- **Data Persistence Test**
  - Data Persistence Test Run 1
  - Data Persistence Test Run 2
- **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

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 5.4.2.1

The Sustainability Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of three (3) hours. The intent is to demonstrate a sustained maximum I/O Request Throughput as well as insuring the Tested Storage Configuration (TSC) has reached steady state prior to measuring the maximum I/O Request Throughput (SPC-1™ IOPS).

The reported I/O Request Throughput of the Sustainability Test Run must be within 5% of the reported SPC-1™ IOPS primary metric. The Average Response Time measured in Sustainability Test Run cannot exceed thirty (30) milliseconds.

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 D: SPC-1 Workload Generator Input Parameters” on Page 62.

Sustainability Test Results File

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

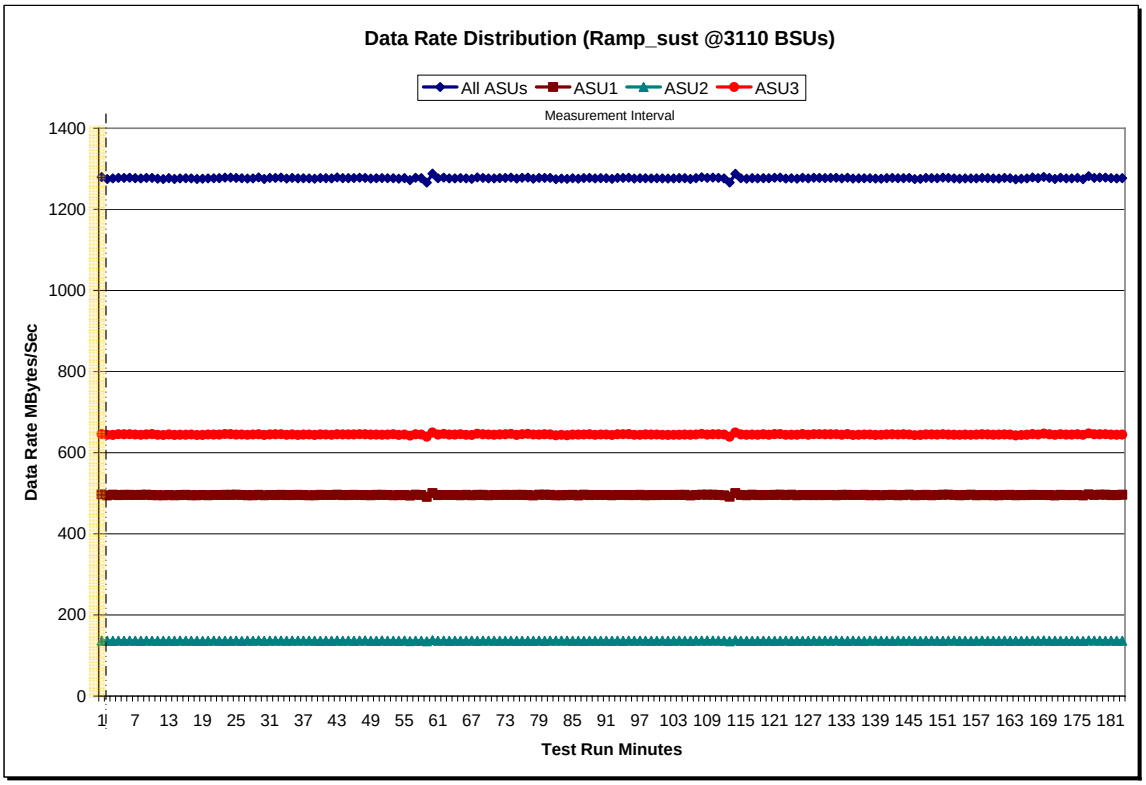
Sustainability Test Results File

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

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	9:03:04	9:06:04	0-2	0:03:00
Measurement Interval	9:06:04	12:06:04	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	1,279.69	497.14	136.78	645.77	63	1,276.50	495.67	136.30	644.53	126	1,276.06	495.51	136.19	644.36
1	1,274.69	494.41	136.19	644.09	64	1,277.11	495.25	136.30	645.55	127	1,277.79	495.59	136.60	645.60
2	1,276.09	496.15	136.17	643.77	65	1,276.47	496.02	136.38	644.07	128	1,277.37	495.41	136.39	645.57
3	1,277.53	495.42	136.64	645.46	66	1,275.16	494.85	136.70	643.61	129	1,277.24	495.35	136.49	645.40
4	1,277.57	495.91	136.39	645.27	67	1,278.68	495.91	135.98	646.79	130	1,277.44	495.82	136.28	645.35
5	1,277.98	496.04	136.50	645.43	68	1,277.71	495.92	136.51	645.27	131	1,277.88	495.28	137.06	645.54
6	1,276.81	495.74	136.32	644.75	69	1,276.24	494.99	136.48	644.76	132	1,276.42	496.05	136.13	644.25
7	1,276.12	495.93	136.03	644.15	70	1,276.40	495.75	136.44	644.20	133	1,277.87	495.96	136.14	645.76
8	1,277.63	496.11	136.50	645.02	71	1,277.07	495.71	136.40	644.96	134	1,275.82	495.71	136.52	643.59
9	1,277.63	495.47	136.47	645.69	72	1,277.46	495.99	136.28	645.19	135	1,276.13	495.63	136.25	644.25
10	1,275.63	495.25	136.30	644.07	73	1,278.37	495.70	136.43	646.24	136	1,276.72	496.02	135.86	644.84
11	1,274.65	494.93	136.05	643.67	74	1,275.95	496.03	136.07	643.85	137	1,276.70	495.32	136.50	644.88
12	1,277.00	495.56	136.36	645.08	75	1,277.93	495.98	136.34	645.61	138	1,275.96	495.49	136.55	643.92
13	1,274.86	495.08	136.04	643.74	76	1,278.31	495.56	136.32	646.43	139	1,275.57	495.05	136.36	644.15
14	1,276.34	495.46	136.54	644.34	77	1,275.31	494.49	136.05	644.77	140	1,276.90	495.68	136.24	644.99
15	1,276.64	496.08	136.25	644.31	78	1,277.56	496.32	136.69	644.55	141	1,277.36	495.97	136.04	645.35
16	1,276.40	495.28	136.38	644.73	79	1,277.69	496.11	136.21	645.37	142	1,276.63	495.23	136.66	644.75
17	1,274.91	495.24	136.13	643.55	80	1,277.68	496.08	136.58	645.03	143	1,276.98	495.45	136.34	645.19
18	1,275.54	495.76	135.95	643.83	81	1,274.45	495.07	136.49	642.89	144	1,277.75	496.54	136.48	644.73
19	1,276.42	495.23	136.42	644.76	82	1,275.82	495.22	136.59	644.01	145	1,274.68	495.09	136.31	643.27
20	1,276.66	495.63	136.58	644.45	83	1,275.01	495.40	136.51	643.10	146	1,275.24	495.53	135.87	643.84
21	1,276.82	495.80	136.45	644.57	84	1,276.75	495.90	136.38	644.48	147	1,277.35	495.99	136.24	645.12
22	1,278.15	495.98	136.14	646.03	85	1,275.51	494.81	136.27	644.44	148	1,277.00	495.30	136.52	645.18
23	1,278.11	495.97	136.43	645.71	86	1,277.21	496.30	136.13	644.79	149	1,276.66	495.75	136.35	644.56
24	1,277.36	496.20	136.58	644.58	87	1,277.26	495.59	136.35	645.32	150	1,278.02	496.31	136.21	645.51
25	1,276.55	495.78	135.94	644.82	88	1,276.04	495.75	136.28	644.01	151	1,277.72	496.52	136.55	644.66
26	1,275.91	495.34	136.55	644.02	89	1,276.81	495.68	136.41	644.73	152	1,276.46	495.66	136.53	644.28
27	1,276.49	495.31	136.29	644.89	90	1,276.75	495.70	136.31	644.74	153	1,275.53	495.33	136.16	644.03
28	1,278.54	496.09	137.12	645.32	91	1,275.15	495.29	136.20	643.66	154	1,276.22	495.43	136.30	644.49
29	1,274.98	494.99	136.14	643.85	92	1,277.50	495.74	136.50	645.26	155	1,276.19	496.37	135.81	644.01
30	1,277.34	495.83	136.53	644.98	93	1,277.38	495.81	136.05	645.51	156	1,276.17	495.27	136.39	644.51
31	1,277.34	495.50	136.53	645.30	94	1,277.81	495.52	136.54	645.75	157	1,277.39	495.44	136.55	645.41
32	1,278.30	496.00	136.70	645.61	95	1,275.80	495.44	136.33	644.04	158	1,276.77	495.44	136.38	644.95
33	1,275.91	495.36	136.45	644.11	96	1,276.57	496.01	136.48	644.08	159	1,276.10	495.32	136.39	644.38
34	1,277.27	495.59	136.51	645.17	97	1,276.65	495.19	136.38	645.08	160	1,275.96	495.23	136.14	644.59
35	1,276.41	495.88	136.65	643.89	98	1,276.35	495.40	136.43	644.53	161	1,277.34	495.72	136.57	645.06
36	1,276.54	495.44	136.48	644.63	99	1,276.65	495.38	136.39	644.87	162	1,276.62	495.88	136.14	644.60
37	1,276.30	495.05	136.53	644.73	100	1,276.44	495.72	136.53	644.18	163	1,274.22	495.21	136.44	642.57
38	1,275.33	495.23	136.27	643.82	101	1,275.78	495.74	136.13	643.91	164	1,275.47	495.58	136.40	643.49
39	1,277.17	495.91	136.16	645.10	102	1,276.07	495.70	136.30	644.07	165	1,276.11	495.47	136.32	644.32
40	1,276.90	495.74	136.27	644.89	103	1,276.92	496.04	136.59	644.29	166	1,278.58	496.05	136.60	645.93
41	1,276.07	495.70	136.20	644.17	104	1,276.90	495.98	136.27	644.64	167	1,276.89	495.61	136.44	644.84
42	1,278.52	496.23	136.89	645.40	105	1,274.91	494.55	136.00	644.36	168	1,279.84	495.73	136.93	647.17
43	1,276.82	495.51	136.25	645.06	106	1,276.99	495.74	136.53	644.71	169	1,277.28	495.55	136.40	645.33
44	1,276.98	495.51	136.50	644.97	107	1,279.24	496.41	136.60	646.23	170	1,274.83	494.83	135.99	644.02
45	1,277.19	495.90	136.11	645.18	108	1,277.55	496.20	136.77	644.58	171	1,277.87	495.98	136.33	645.56
46	1,277.97	495.83	136.48	645.67	109	1,278.22	496.27	136.55	645.40	172	1,276.18	495.40	136.27	644.51
47	1,277.76	495.59	136.75	645.42	110	1,277.59	495.78	136.51	645.31	173	1,276.44	495.44	136.45	644.55
48	1,275.82	495.10	136.14	644.58	111	1,276.28	495.07	136.43	644.79	174	1,277.38	495.60	136.36	645.42
49	1,276.65	495.92	136.15	644.57	112	1,266.13	491.42	135.10	639.62	175	1,274.31	494.40	135.80	644.11
50	1,277.09	495.92	136.81	644.35	113	1,287.66	500.20	137.60	649.85	176	1,281.83	497.24	137.12	647.47
51	1,276.57	495.78	136.32	644.47	114	1,276.70	495.60	136.10	645.00	177	1,277.55	495.61	136.61	645.33
52	1,276.68	494.88	136.27	645.53	115	1,275.71	495.18	136.11	644.42	178	1,278.48	496.45	136.66	645.37
53	1,275.61	495.49	136.19	643.93	116	1,276.88	496.25	136.12	644.51	179	1,278.26	496.18	136.41	645.66
54	1,276.79	495.42	136.58	644.79	117	1,276.22	495.50	136.30	644.42	180	1,276.81	495.56	136.64	644.61
55	1,272.04	494.27	135.68	642.09	118	1,276.94	495.35	136.38	645.21	181	1,276.04	495.46	136.32	644.26
56	1,277.92	496.29	136.36	645.27	119	1,276.54	495.76	136.39	644.40	182	1,277.00	496.10	136.28	644.61
57	1,276.91	495.76	136.38	644.76	120	1,277.78	495.86	136.14	645.79					
58	1,265.95	491.28	135.19	639.47	121	1,278.50	496.17	136.32	646.02					
59	1,288.22	500.53	137.86	649.82	122	1,275.95	495.44	136.55	643.96					
60	1,276.60	495.51	136.44	644.66	123	1,276.61	496.16	136.17	644.28					
61	1,278.44	495.61	136.64	646.19	124	1,275.72	494.95	136.39	644.38					
62	1,276.44	495.82	135.99	644.64	125	1,277.84	495.74	136.41	645.69					

Sustainability – Data Rate Distribution Graph

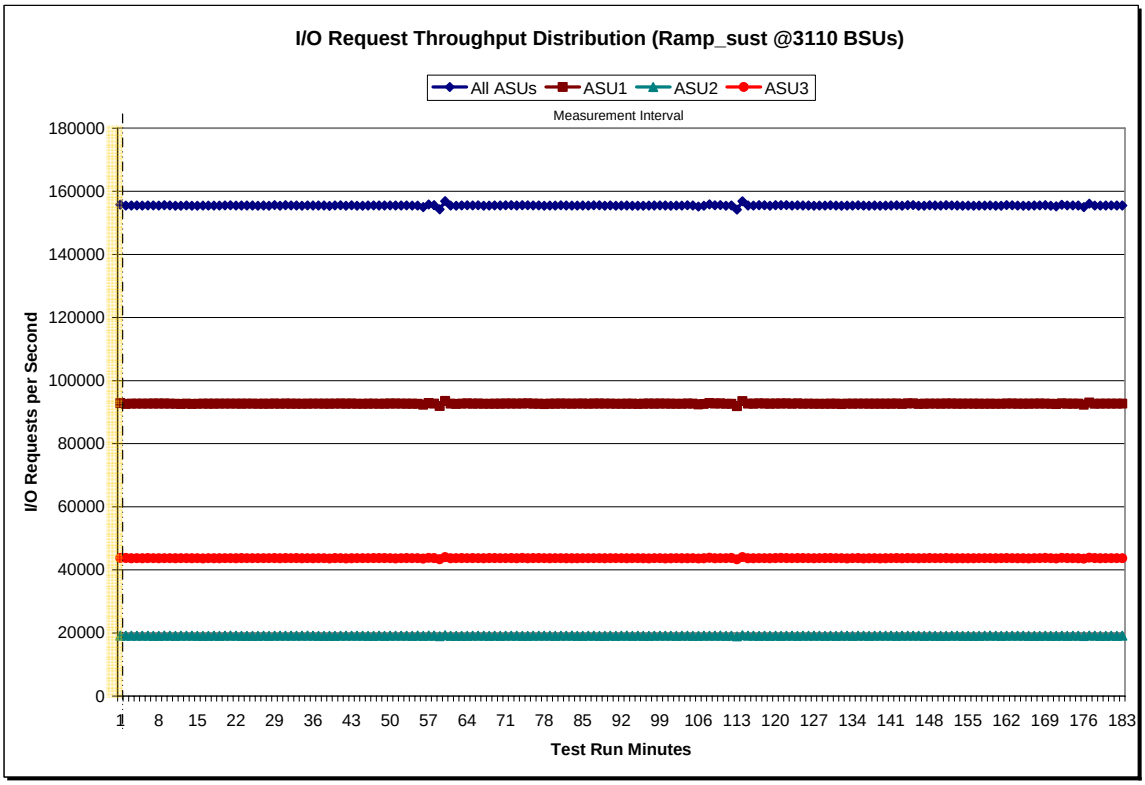


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	9:03:04	9:06:04	0-2	0:03:00
Measurement Interval	9:06:04	12:06:04	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	155,782.37	92,871.83	19,146.88	43,763.65	63	155,553.35	92,748.97	19,118.37	43,686.02	126	155,449.00	92,642.63	19,123.70	43,682.67
1	155,478.10	92,602.37	19,126.97	43,748.77	64	155,533.67	92,662.68	19,130.40	43,740.58	127	155,455.82	92,633.27	19,134.00	43,688.55
2	155,509.68	92,704.73	19,129.62	43,675.33	65	155,553.40	92,716.45	19,130.23	43,706.72	128	155,476.68	92,626.25	19,108.12	43,742.32
3	155,530.83	92,685.05	19,150.85	43,694.93	66	155,429.07	92,617.27	19,149.17	43,662.63	129	155,552.88	92,679.35	19,137.53	43,736.00
4	155,476.52	92,691.47	19,126.85	43,658.20	67	155,468.82	92,644.67	19,089.75	43,734.40	130	155,467.37	92,655.70	19,099.12	43,712.55
5	155,538.40	92,687.32	19,121.65	43,729.43	68	155,525.07	92,670.40	19,129.47	43,725.20	131	155,442.43	92,576.08	19,162.98	43,703.37
6	155,539.37	92,722.25	19,104.63	43,712.48	69	155,497.30	92,677.92	19,117.85	43,701.53	132	155,470.90	92,710.35	19,122.07	43,638.48
7	155,475.58	92,718.17	19,105.92	43,651.50	70	155,550.93	92,714.17	19,144.68	43,692.08	133	155,475.78	92,666.68	19,093.87	43,715.23
8	155,588.22	92,733.60	19,158.57	43,696.05	71	155,587.77	92,716.87	19,130.80	43,740.10	134	155,553.98	92,708.62	19,127.62	43,717.75
9	155,526.50	92,698.62	19,131.15	43,696.73	72	155,514.65	92,709.53	19,123.70	43,681.42	135	155,481.32	92,702.97	19,128.83	43,649.52
10	155,432.73	92,642.17	19,115.88	43,674.68	73	155,589.40	92,723.90	19,107.72	43,757.78	136	155,442.58	92,654.18	19,110.33	43,678.07
11	155,420.82	92,609.57	19,121.07	43,690.18	74	155,576.63	92,787.07	19,114.73	43,674.83	137	155,492.97	92,650.45	19,137.50	43,705.02
12	155,544.50	92,689.05	19,148.30	43,707.15	75	155,526.83	92,665.02	19,132.85	43,728.97	138	155,430.22	92,666.18	19,125.17	43,638.87
13	155,411.35	92,613.73	19,136.28	43,661.33	76	155,544.32	92,662.25	19,141.40	43,740.67	139	155,462.47	92,653.07	19,128.18	43,681.22
14	155,444.83	92,637.22	19,112.42	43,695.20	77	155,413.93	92,576.88	19,129.45	43,707.60	140	155,490.38	92,658.37	19,121.48	43,710.53
15	155,456.25	92,692.32	19,116.05	43,647.88	78	155,469.85	92,657.25	19,150.28	43,662.32	141	155,554.53	92,734.93	19,088.87	43,730.73
16	155,470.15	92,659.30	19,115.68	43,695.17	79	155,461.52	92,669.27	19,088.38	43,703.87	142	155,413.08	92,610.13	19,140.75	43,662.20
17	155,461.00	92,661.07	19,138.20	43,661.73	80	155,560.65	92,737.60	19,126.83	43,696.22	143	155,613.52	92,747.75	19,133.43	43,732.33
18	155,476.32	92,709.42	19,103.45	43,663.45	81	155,515.28	92,709.02	19,148.37	43,657.90	144	155,622.48	92,786.30	19,143.95	43,692.23
19	155,540.68	92,695.35	19,132.82	43,712.52	82	155,470.48	92,660.62	19,157.70	43,652.17	145	155,393.10	92,616.68	19,124.28	43,652.13
20	155,569.82	92,692.68	19,169.72	43,707.42	83	155,473.10	92,687.52	19,119.35	43,666.23	146	155,452.13	92,659.25	19,097.60	43,695.28
21	155,465.78	92,684.42	19,128.62	43,652.75	84	155,507.58	92,714.33	19,107.85	43,685.40	147	155,557.22	92,693.45	19,136.52	43,727.25
22	155,515.88	92,668.90	19,108.05	43,738.93	85	155,484.25	92,646.10	19,142.35	43,695.80	148	155,509.07	92,685.00	19,114.25	43,709.82
23	155,512.93	92,707.45	19,116.28	43,689.20	86	155,557.28	92,723.70	19,124.45	43,709.13	149	155,466.30	92,674.28	19,107.43	43,684.58
24	155,517.20	92,693.60	19,109.12	43,714.48	87	155,549.77	92,740.93	19,094.15	43,714.68	150	155,596.43	92,742.77	19,117.83	43,735.83
25	155,399.47	92,625.62	19,086.58	43,687.27	88	155,448.15	92,688.45	19,107.38	43,652.32	151	155,529.07	92,735.65	19,133.90	43,659.52
26	155,505.52	92,664.18	19,136.92	43,704.42	89	155,528.20	92,682.50	19,141.53	43,704.17	152	155,487.95	92,680.32	19,137.90	43,669.73
27	155,417.22	92,619.35	19,087.68	43,710.18	90	155,414.35	92,644.18	19,084.40	43,685.77	153	155,437.07	92,663.87	19,099.52	43,673.68
28	155,618.13	92,732.70	19,148.32	43,737.12	91	155,462.92	92,639.58	19,127.78	43,695.55	154	155,463.33	92,687.28	19,114.50	43,661.55
29	155,433.55	92,636.28	19,131.52	43,665.75	92	155,493.53	92,652.08	19,160.30	43,681.15	155	155,427.67	92,658.65	19,098.02	43,671.00
30	155,582.13	92,724.93	19,134.37	43,722.83	93	155,441.10	92,656.13	19,085.33	43,699.63	156	155,483.47	92,664.02	19,111.20	43,708.25
31	155,522.62	92,676.70	19,138.93	43,706.98	94	155,439.97	92,609.55	19,127.22	43,703.20	157	155,474.25	92,630.33	19,140.25	43,703.67
32	155,517.25	92,662.23	19,130.40	43,724.62	95	155,450.87	92,665.07	19,103.45	43,682.35	158	155,520.83	92,662.98	19,154.67	43,703.18
33	155,431.92	92,626.85	19,149.73	43,655.33	96	155,458.75	92,717.20	19,102.95	43,638.60	159	155,450.20	92,647.68	19,122.05	43,680.47
34	155,535.32	92,679.67	19,154.30	43,701.35	97	155,496.52	92,673.70	19,136.00	43,686.82	160	155,424.35	92,621.17	19,098.40	43,704.78
35	155,496.58	92,701.45	19,143.10	43,652.03	98	155,537.80	92,722.65	19,122.82	43,692.33	161	155,613.70	92,728.07	19,144.13	43,741.50
36	155,516.73	92,708.58	19,096.28	43,711.87	99	155,487.20	92,692.37	19,150.87	43,643.97	162	155,570.03	92,727.55	19,144.22	43,698.27
37	155,505.07	92,676.82	19,119.27	43,708.98	100	155,431.95	92,650.68	19,129.18	43,652.08	163	155,472.73	92,662.22	19,137.17	43,673.35
38	155,382.38	92,665.57	19,107.07	43,609.75	101	155,455.12	92,636.35	19,117.73	43,701.03	164	155,448.45	92,651.78	19,127.63	43,669.03
39	155,534.90	92,700.47	19,109.58	43,724.85	102	155,460.57	92,643.13	19,142.68	43,674.75	165	155,429.70	92,672.90	19,115.17	43,641.63
40	155,556.78	92,718.07	19,129.05	43,709.67	103	155,557.88	92,744.25	19,144.47	43,669.17	166	155,499.13	92,695.02	19,108.40	43,695.72
41	155,425.87	92,661.00	19,122.80	43,642.07	104	155,486.52	92,693.22	19,103.17	43,690.13	167	155,529.00	92,716.65	19,104.57	43,707.78
42	155,566.22	92,740.63	19,147.23	43,678.35	105	155,168.75	92,474.17	19,080.13	43,614.45	168	155,601.88	92,695.27	19,148.80	43,757.82
43	155,442.93	92,620.90	19,128.08	43,693.95	106	155,395.80	92,598.97	19,137.05	43,659.78	169	155,443.27	92,644.20	19,108.83	43,690.23
44	155,442.30	92,619.32	19,136.92	43,686.07	107	155,845.27	92,879.73	19,143.93	43,821.60	170	155,234.65	92,555.58	19,075.25	43,603.82
45	155,492.22	92,680.18	19,115.17	43,696.87	108	155,562.62	92,740.15	19,147.42	43,675.05	171	155,732.68	92,793.27	19,150.13	43,789.28
46	155,546.30	92,710.27	19,116.62	43,719.42	109	155,630.22	92,761.10	19,161.30	43,707.82	172	155,525.55	92,669.15	19,110.47	43,745.93
47	155,510.13	92,641.27	19,152.57	43,716.30	110	155,444.80	92,630.40	19,113.53	43,700.87	173	155,536.75	92,676.43	19,148.88	43,711.43
48	155,501.03	92,652.65	19,105.93	43,742.45	111	155,526.67	92,628.73	19,142.57	43,755.37	174	155,489.80	92,688.55	19,122.42	43,678.83
49	155,544.95	92,720.97	19,139.48	43,684.50	112	154,198.77	91,893.00	18,950.05	43,355.72	175	154,979.88	92,389.40	19,045.32	43,545.17
50	155,497.87	92,715.53	19,135.93	43,646.40	113	156,844.20	93,511.70	19,291.68	44,040.82	176	156,065.12	93,002.90	19,202.83	43,859.38
51	155,512.58	92,689.22	19,121.18	43,702.18	114	155,517.07	92,712.23	19,123.87	43,680.97	177	155,479.07	92,623.33	19,137.15	43,718.58
52	155,526.32	92,662.62	19,133.55	43,730.15	115	155,468.63	92,679.30	19,129.28	43,660.05	178	155,474.42	92,690.30	19,117.35	43,666.77
53	155,476.68	92,671.15	19,114.63	43,690.90	116	155,600.60	92,777.93	19,108.32	43,714.35	179	155,498.82	92,686.30	19,108.18	43,704.33
54	155,483.67	92,623.80	19,165.00	43,694.87	117	155,554.78	92,736.68	19,133.72	43,684.38	180	155,538.80	92,706.72	19,131.95	43,700.13
55	154,988.18	92,367.40	19,061.65	43,559.13	118	155,449.32	92,664.95	19,111.43	43,672.93	181	155,501.50	92,698.62	19,109.92	43,692.97
56	155,813.50	92,858.85	19,159.12	43,795.53	119	155,598.72	92,744.70	19,128.62	43,725.40	182	155,511.15	92,692.23	19,131.58	43,687.33
57	155,594.27	92,707.82	19,164.82	43,721.63	120	155,589.58	92,730.27	19,110.93	43,748.38	Average	155,500.52	92,680.50	19,125.13	43,694.89
58	154,290.17	91,926.98	18,998.85	43,364.33	121	155,614.32	92,757.33	19,128.20	43,728.78					
59	156,867.67	93,527.88	19,308.15	44,031.63	122	155,478.62	92,648.18	19,134.92	43,695.52					
60	155,477.12	92,705.17	19,112.15	43,659.80	123	155,581.20	92,747.97	19,113.18	43,720.05					
61	155,433.98	92,615.42	19,106.25	43,712.32	124	155,513.28	92,645.22	19,134.42	43,733.65					
62	155,526.30	92,708.13	19,102.13	43,716.03	125	155,516.08	92,683.68	19,132.20	43,700.20					

Sustainability – I/O Request Throughput Distribution Graph

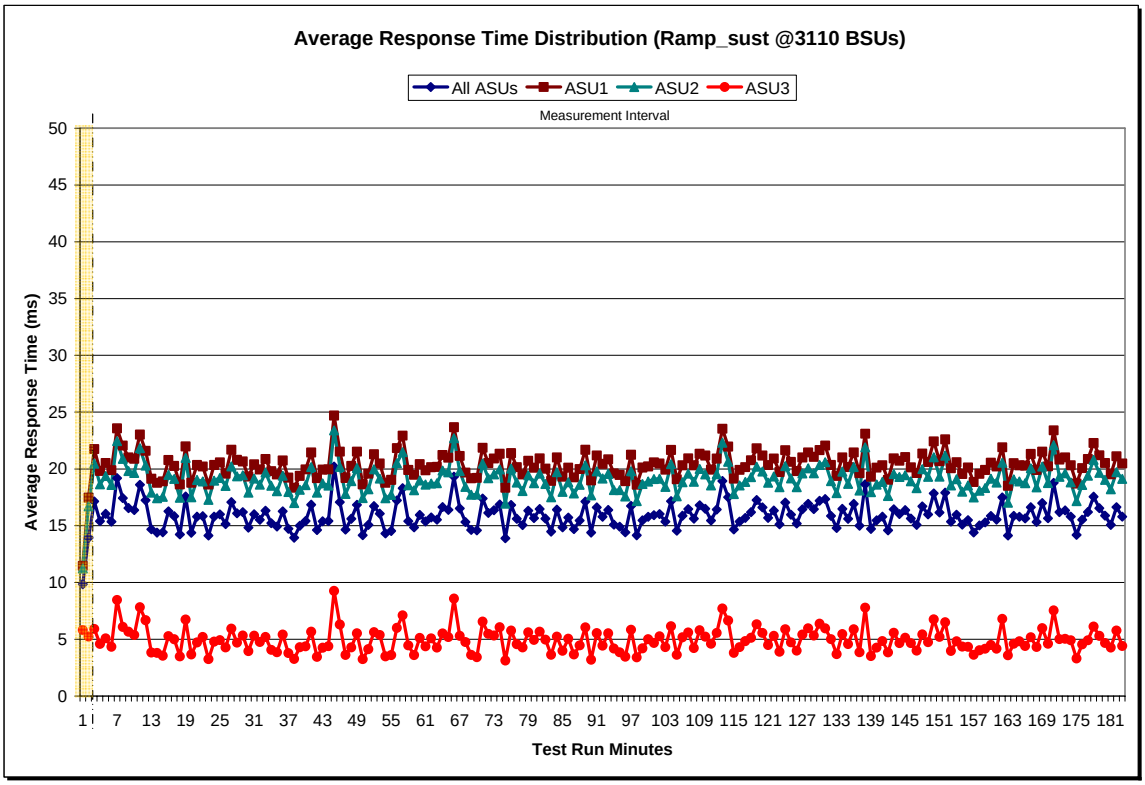


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	9:03:04	9:06:04	0-2	0:03:00
Measurement Interval	9:06:04	12:06:04	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	9.85	11.46	11.23	5.82	63	16.65	21.23	19.86	5.52	126	16.45	21.00	19.60	5.42
1	13.93	17.47	16.70	5.24	64	16.39	20.99	19.70	5.19	127	16.93	21.45	20.06	5.96
2	17.14	21.75	20.47	5.91	65	19.31	23.67	22.71	8.58	128	16.46	21.06	19.62	5.33
3	15.40	19.83	18.64	4.60	66	16.52	21.13	19.80	5.30	129	17.20	21.66	20.34	6.36
4	16.05	20.52	19.37	5.08	67	15.32	19.67	18.42	4.75	130	17.35	22.06	20.58	5.96
5	15.36	19.89	18.59	4.34	68	14.63	19.18	17.73	3.62	131	15.86	20.34	18.93	5.01
6	19.19	23.58	22.45	8.47	69	14.59	19.21	17.74	3.42	132	14.80	19.39	17.87	3.69
7	17.43	22.06	20.88	6.09	70	17.39	21.86	20.47	6.55	133	16.48	21.00	19.76	5.46
8	16.55	21.00	19.82	5.66	71	16.12	20.52	19.18	5.47	134	15.60	20.17	18.69	4.57
9	16.38	20.88	19.64	5.38	72	16.37	20.91	19.52	5.33	135	16.92	21.45	20.17	5.88
10	18.61	23.02	21.83	7.82	73	16.87	21.34	19.96	6.05	136	15.00	19.62	18.10	3.86
11	17.24	21.60	20.30	6.68	74	13.89	18.33	16.94	3.13	137	18.65	23.10	21.90	7.79
12	14.68	19.13	17.90	3.83	75	16.83	21.39	20.02	5.76	138	14.72	19.32	17.96	3.52
13	14.40	18.77	17.42	3.80	76	15.61	20.16	18.80	4.57	139	15.48	20.11	18.62	4.27
14	14.42	18.90	17.55	3.55	77	15.05	19.51	18.06	4.28	140	15.79	20.33	18.87	4.84
15	16.27	20.78	19.48	5.28	78	16.32	20.72	19.43	5.61	141	14.59	19.04	17.61	3.84
16	15.84	20.27	19.12	5.01	79	15.67	20.11	18.75	4.94	142	16.44	20.93	19.55	5.58
17	14.24	18.64	17.47	3.49	80	16.48	20.92	19.60	5.67	143	16.03	20.72	19.29	4.66
18	17.57	21.98	20.97	6.74	81	15.63	20.02	18.67	4.97	144	16.38	21.04	19.44	5.14
19	14.38	18.78	17.51	3.66	82	14.47	18.95	17.51	3.64	145	15.63	20.13	18.92	4.66
20	15.79	20.35	19.03	4.71	83	16.41	21.00	19.71	5.23	146	15.08	19.63	18.30	4.01
21	15.84	20.21	18.90	5.20	84	14.85	19.32	17.99	3.99	147	16.71	21.35	19.99	5.42
22	14.13	18.62	17.27	3.25	85	15.71	20.10	18.83	5.05	148	15.99	20.61	19.31	4.74
23	15.81	20.34	18.97	4.79	86	14.70	19.25	17.84	3.66	149	17.85	22.42	21.03	6.75
24	16.00	20.56	19.21	4.92	87	15.45	19.98	18.61	4.46	150	16.16	20.67	19.32	5.21
25	15.15	19.58	18.51	4.28	88	17.12	21.68	20.33	6.05	151	17.90	22.60	21.17	6.50
26	17.08	21.69	20.22	5.94	89	14.39	18.99	17.67	3.20	152	15.36	20.06	18.56	3.98
27	16.09	20.80	19.35	4.70	90	16.61	21.18	19.78	5.54	153	15.97	20.58	19.10	4.82
28	16.20	20.66	19.43	5.32	91	15.79	20.44	19.16	4.44	154	15.09	19.56	18.00	4.36
29	14.83	19.32	17.91	3.95	92	16.38	20.84	19.57	5.52	155	15.50	20.12	18.55	4.34
30	16.01	20.40	19.15	5.32	93	15.09	19.61	18.13	4.18	156	14.40	18.84	17.49	3.63
31	15.52	19.95	18.61	4.76	94	14.92	19.47	18.13	3.85	157	15.02	19.57	18.08	4.03
32	16.32	20.87	19.69	5.20	95	14.41	18.92	17.58	3.47	158	15.29	19.91	18.32	4.17
33	15.22	19.80	18.51	4.06	96	16.74	21.25	19.80	5.84	159	15.86	20.54	19.14	4.49
34	14.93	19.50	18.04	3.86	97	14.16	18.61	17.16	3.41	160	15.53	20.22	18.80	4.18
35	16.27	20.73	19.41	5.41	98	15.47	20.12	18.68	4.20	161	17.49	21.91	20.55	6.80
36	14.74	19.23	17.98	3.79	99	15.79	20.22	18.89	5.01	162	14.14	18.52	17.03	3.59
37	13.94	18.34	17.00	3.27	100	15.93	20.57	19.11	4.68	163	15.86	20.51	19.08	4.60
38	15.00	19.39	18.17	4.30	101	16.03	20.47	19.14	5.26	164	15.79	20.32	18.90	4.81
39	15.41	19.96	18.57	4.38	102	15.36	19.93	18.42	4.31	165	15.64	20.29	18.74	4.41
40	16.85	21.44	20.17	5.66	103	17.16	21.67	20.42	6.14	166	16.63	21.32	20.05	5.19
41	14.62	19.20	17.91	3.45	104	14.56	19.08	17.59	3.63	167	15.33	19.89	18.38	4.31
42	15.38	19.93	18.73	4.26	105	15.88	20.32	18.83	5.17	168	16.99	21.53	20.21	5.98
43	15.41	19.96	18.54	4.38	106	16.46	20.93	19.58	5.60	169	15.66	20.23	18.76	4.61
44	20.20	24.70	23.39	9.26	107	15.62	20.32	18.87	4.22	170	18.78	23.39	22.08	7.54
45	17.08	21.53	20.18	6.30	108	16.81	21.34	20.00	5.79	171	16.19	20.83	19.31	5.01
46	14.65	19.21	17.80	3.62	109	16.49	21.18	19.51	5.22	172	16.35	21.01	19.62	5.04
47	15.61	20.26	18.93	4.28	110	15.46	19.94	18.55	4.60	173	15.80	20.32	18.81	4.92
48	16.84	21.52	20.07	5.52	111	16.42	20.91	19.53	5.55	174	14.19	18.71	17.17	3.31
49	14.16	18.63	17.43	3.25	112	18.94	23.54	22.31	7.71	175	15.53	20.07	18.58	4.55
50	15.07	19.58	18.21	4.13	113	17.50	21.97	20.63	6.66	176	16.21	20.87	19.41	4.91
51	16.73	21.29	19.97	5.63	114	14.68	19.15	17.79	3.81	177	17.55	22.28	20.80	6.12
52	16.07	20.47	19.15	5.38	115	15.36	19.91	18.55	4.31	178	16.54	21.20	19.65	5.30
53	14.31	18.77	17.42	3.49	116	15.69	20.15	18.85	4.83	179	15.89	20.52	19.04	4.68
54	14.54	19.03	17.72	3.61	117	16.19	20.77	19.28	5.13	180	15.07	19.52	18.20	4.27
55	17.22	21.83	20.51	6.01	118	17.26	21.80	20.19	6.32	181	16.63	21.11	19.72	5.77
56	18.30	22.93	21.48	7.11	119	16.61	21.18	19.78	5.56	182	15.80	20.48	19.12	4.42
57	15.40	19.91	18.56	4.46	120	15.69	20.33	18.80	4.49	Average	15.94	20.47	19.10	4.93
58	14.85	19.48	18.12	3.61	121	16.33	20.92	19.34	5.30					
59	15.95	20.42	18.98	5.12	122	15.12	19.73	18.39	3.90					
60	15.37	19.88	18.63	4.38	123	17.04	21.65	20.25	5.88					
61	15.74	20.15	18.72	5.09	124	15.97	20.62	19.17	4.73					
62	15.53	20.17	18.74	4.27	125	15.19	19.81	18.39	3.99					

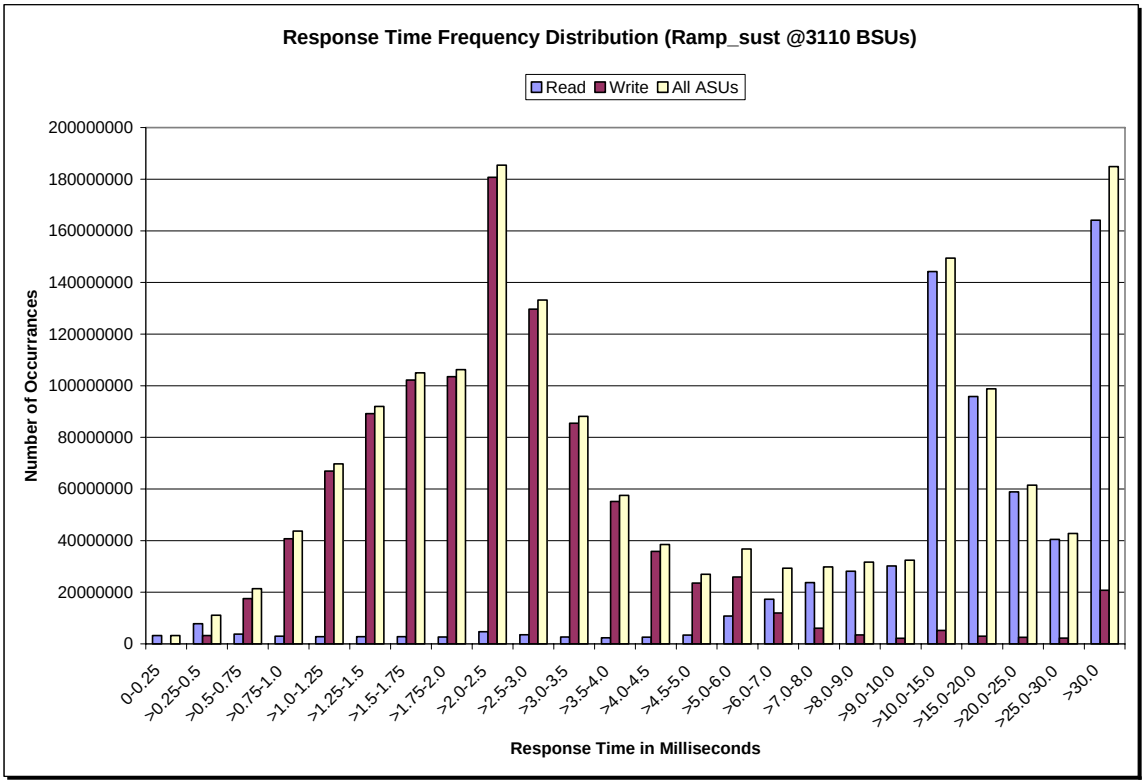
Sustainability – Average Response Time (ms) Distribution Graph



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	3,200,812	7,840,443	3,812,934	2,991,525	2,799,226	2,797,323	2,799,628	2,697,758
Write	889	3,261,832	17,557,117	40,715,840	66,965,951	89,191,214	102,188,644	103,531,468
All ASUs	3,201,701	11,102,275	21,370,051	43,707,365	69,765,177	91,988,537	104,988,272	106,229,226
ASU1	3,011,600	9,188,618	12,650,863	23,001,621	34,866,599	44,520,139	49,472,460	48,819,910
ASU2	189,849	904,841	2,487,743	5,186,501	8,139,629	10,487,580	11,684,539	11,522,067
ASU3	252	1,008,816	6,231,445	15,519,243	26,758,949	36,980,818	43,831,273	45,887,249
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	4,696,074	3,537,440	2,670,002	2,345,677	2,616,661	3,426,557	10,793,068	17,328,993
Write	180,715,279	129,646,371	85,463,612	55,161,601	35,849,960	23,519,259	25,950,107	11,988,974
All ASUs	185,411,353	133,183,811	88,133,614	57,507,278	38,466,621	26,945,816	36,743,175	29,317,967
ASU1	82,350,194	56,676,385	36,156,965	23,059,701	15,487,672	11,359,205	18,137,332	18,706,845
ASU2	19,405,759	13,297,818	8,429,062	5,323,699	3,501,953	2,476,607	3,677,676	3,503,961
ASU3	83,655,400	63,209,608	43,547,587	29,123,878	19,476,996	13,110,004	14,928,167	7,107,161
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	23,749,467	28,183,763	30,218,747	144,195,739	95,833,384	58,872,625	40,495,769	164,098,635
Write	6,117,657	3,484,758	2,213,059	5,219,258	3,005,990	2,584,282	2,258,678	20,807,411
All ASUs	29,867,124	31,668,521	32,431,806	149,414,997	98,839,374	61,456,907	42,754,447	184,906,046
ASU1	22,199,269	25,096,951	26,395,153	123,861,288	82,067,524	50,729,109	35,092,311	148,038,630
ASU2	4,036,795	4,546,023	4,789,305	22,868,698	15,407,669	9,592,794	6,678,199	28,412,013
ASU3	3,631,060	2,025,547	1,247,348	2,685,011	1,364,181	1,135,004	983,937	8,455,403

Sustainability – Response Time Frequency Distribution Graph



Sustainability – 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	0.1406	0.2810	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.003	0.001	0.002	0.001

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.*

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 D: SPC-1 Workload Generator Input Parameters" on Page 62.

IOPS Test Results File

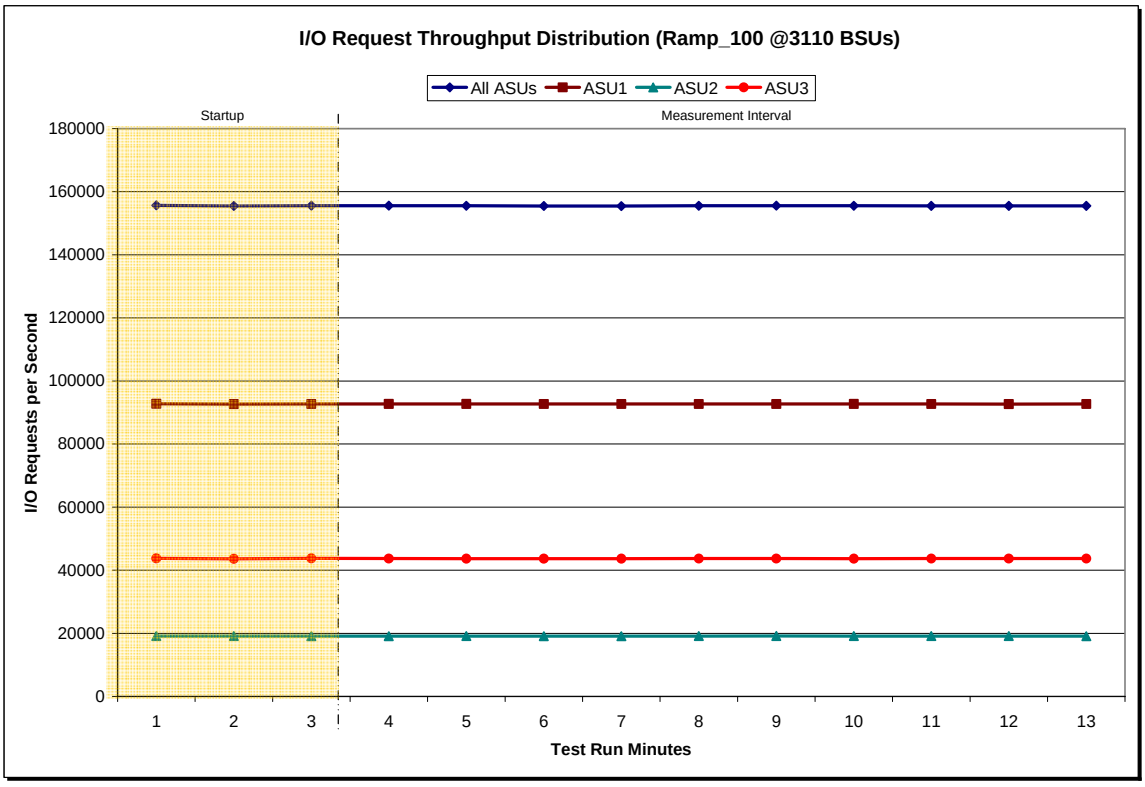
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:07:05	12:10:06	0-2	0:03:01
Measurement Interval	12:10:06	12:20:06	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	155,654.63	92,754.70	19,134.93	43,765.00
1	155,455.22	92,658.57	19,147.70	43,648.95
2	155,551.00	92,689.65	19,107.52	43,753.83
3	155,555.77	92,727.15	19,116.93	43,711.68
4	155,534.13	92,723.30	19,143.52	43,667.32
5	155,477.23	92,695.67	19,100.85	43,680.72
6	155,447.83	92,685.12	19,108.37	43,654.35
7	155,547.42	92,712.18	19,138.48	43,696.75
8	155,576.32	92,695.93	19,170.50	43,709.88
9	155,546.67	92,727.10	19,149.68	43,669.88
10	155,512.52	92,703.18	19,124.05	43,685.28
11	155,498.95	92,663.03	19,140.25	43,695.67
12	155,497.83	92,688.10	19,115.17	43,694.57
Average	155,519.47	92,702.08	19,130.78	43,686.61

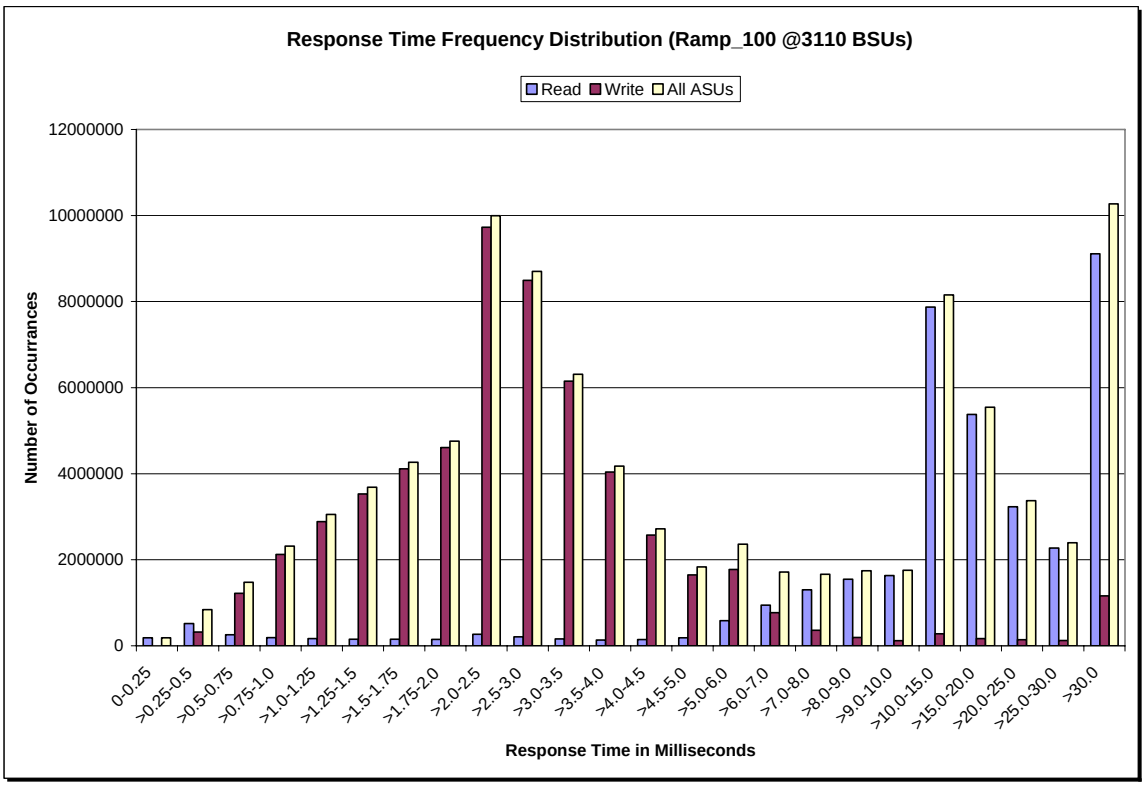
IOPS Test Run – I/O Request Throughput Distribution Graph



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	185122	518,975	256,655	191,835	166,061	156,474	153,186	149,496
Write	53	320,911	1,222,677	2,123,407	2,886,847	3,528,632	4,113,549	4,606,772
All ASUs	185175	839,886	1,479,332	2,315,242	3,052,908	3,685,106	4,266,735	4,756,268
ASU1	175664	671,006	868,190	1,216,479	1,521,207	1,784,990	2,031,459	2,235,262
ASU2	9503	69,500	166,261	265,518	348,495	417,415	478,819	528,688
ASU3	8	99,380	444,881	833,245	1,183,206	1,482,701	1,756,457	1,992,318
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	269,105	210,291	160,474	137,325	146,048	186,420	585,565	946,176
Write	9,728,479	8,492,370	6,150,320	4,040,286	2,573,652	1,650,145	1,775,090	769,708
All ASUs	9,997,584	8,702,661	6,310,794	4,177,611	2,719,700	1,836,565	2,360,655	1,715,884
ASU1	4,589,892	3,836,944	2,662,876	1,695,698	1,086,493	751,175	1,101,921	1,050,811
ASU2	1,082,823	903,226	622,657	392,782	247,397	166,392	227,614	197,732
ASU3	4,324,869	3,962,491	3,025,261	2,089,131	1,385,810	918,998	1,031,120	467,341
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	1,302,937	1,548,900	1,634,697	7,873,810	5,376,078	3,232,578	2,274,072	9,109,394
Write	362,050	196,261	120,691	279,752	169,940	141,711	122,632	1,162,206
All ASUs	1,664,987	1,745,161	1,755,388	8,153,562	5,546,018	3,374,289	2,396,704	10,271,600
ASU1	1,223,653	1,380,671	1,427,670	6,754,633	4,598,484	2,780,011	1,965,617	8,208,965
ASU2	223,790	250,943	260,453	1,254,451	870,001	531,525	376,818	1,585,385
ASU3	217,544	113,547	67,265	144,478	77,533	62,753	54,269	477,250

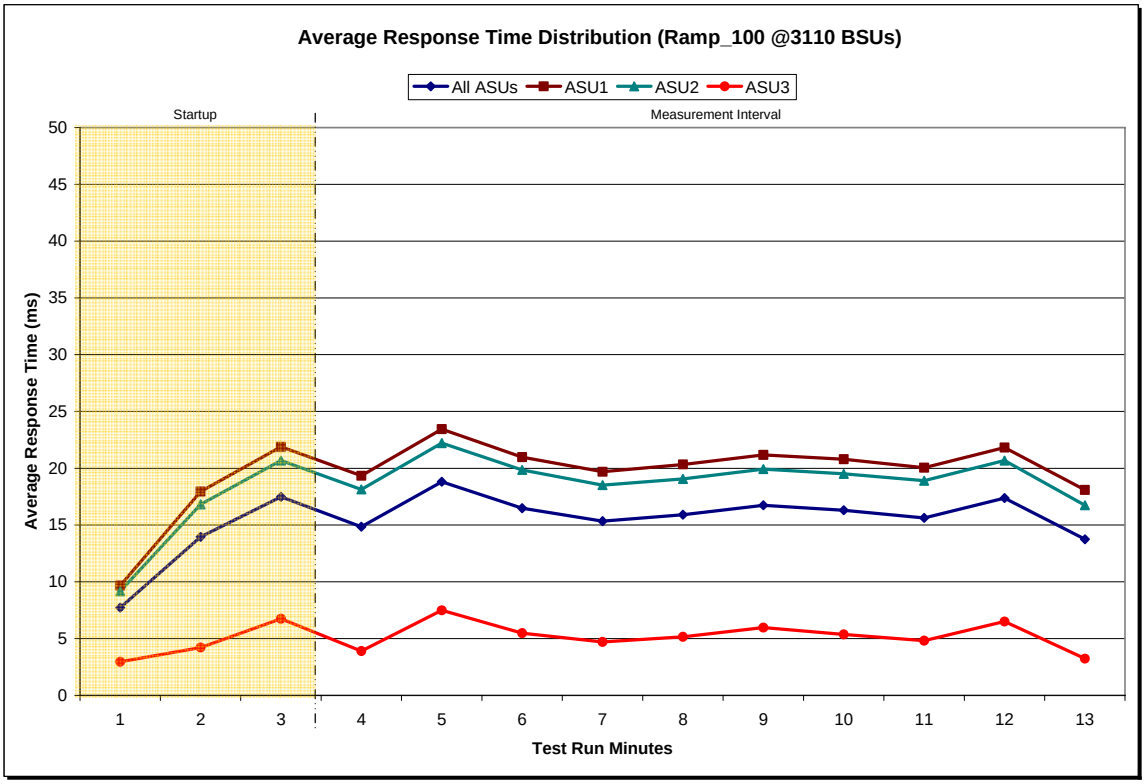
IOPS Test Run –Response Time Frequency Distribution Graph



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

3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:07:05	12:10:06	0-2	0:03:01
Measurement Interval	12:10:06	12:20:06	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	7.72	9.67	9.17	2.96
1	13.96	17.95	16.82	4.22
2	17.48	21.89	20.67	6.75
3	14.85	19.34	18.14	3.90
4	18.81	23.44	22.22	7.49
5	16.49	20.98	19.86	5.48
6	15.34	19.69	18.51	4.71
7	15.92	20.34	19.06	5.15
8	16.75	21.17	19.92	5.96
9	16.31	20.80	19.51	5.37
10	15.63	20.05	18.90	4.81
11	17.38	21.83	20.68	6.50
12	13.75	18.09	16.74	3.23
Average	16.12	20.57	19.35	5.26

IOPS Test Run – Average Response Time (ms) 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
93,309,815	83,038,215	10,271,600

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2811	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.002	0.001	0.001	0.001	0.003	0.001	0.002	0.000

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.*

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 11.

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 D: SPC-1 Workload Generator Input Parameters" on Page 62.

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 - 3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:07:05	12:10:06	0-2	0:03:01
Measurement Interval	12:10:06	12:20:06	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	155,654.63	92,754.70	19,134.93	43,765.00
1	155,455.22	92,658.57	19,147.70	43,648.95
2	155,551.00	92,689.65	19,107.52	43,753.83
3	155,555.77	92,727.15	19,116.93	43,711.68
4	155,534.13	92,723.30	19,143.52	43,667.32
5	155,477.23	92,695.67	19,100.85	43,680.72
6	155,447.83	92,685.12	19,108.37	43,654.35
7	155,547.42	92,712.18	19,138.48	43,696.75
8	155,576.32	92,695.93	19,170.50	43,709.88
9	155,546.67	92,727.10	19,149.68	43,669.88
10	155,512.52	92,703.18	19,124.05	43,685.28
11	155,498.95	92,663.03	19,140.25	43,695.67
12	155,497.83	92,688.10	19,115.17	43,694.57
Average	155,519.47	92,702.08	19,130.78	43,686.61

95% Load Level - 2954 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:20:43	12:23:44	0-2	0:03:01
Measurement Interval	12:23:44	12:33:44	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	147,794.47	88,067.57	18,192.78	41,534.12
1	147,755.12	88,053.58	18,189.73	41,511.80
2	147,673.30	88,021.55	18,171.63	41,480.12
3	147,635.65	87,975.03	18,155.42	41,505.20
4	147,739.13	88,022.68	18,166.88	41,549.57
5	147,751.33	88,078.25	18,198.30	41,474.78
6	147,738.58	88,063.20	18,165.83	41,509.55
7	147,580.50	87,970.18	18,159.13	41,451.18
8	147,757.00	88,061.15	18,160.07	41,535.78
9	147,746.92	88,053.18	18,168.63	41,525.10
10	147,656.32	87,982.12	18,167.45	41,506.75
11	135,944.98	81,022.63	16,730.23	38,192.12
12	159,501.25	94,984.63	19,636.63	44,879.98
Average	147,705.17	88,021.31	18,170.86	41,513.00

90% Load Level - 2799 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:34:21	12:37:22	0-2	0:03:01
Measurement Interval	12:37:22	12:47:22	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	140,044.90	83,454.55	17,244.77	39,345.58
1	139,981.50	83,457.95	17,209.03	39,314.52
2	139,914.63	83,406.05	17,211.50	39,297.08
3	139,852.47	83,375.25	17,181.32	39,295.90
4	139,957.17	83,415.80	17,218.73	39,322.63
5	140,005.78	83,481.63	17,221.58	39,302.57
6	140,039.72	83,477.95	17,219.18	39,342.58
7	140,001.10	83,441.07	17,222.22	39,337.82
8	139,878.43	83,338.62	17,185.68	39,354.13
9	140,035.10	83,454.55	17,210.75	39,369.80
10	139,959.33	83,427.20	17,212.17	39,319.97
11	139,973.53	83,431.47	17,217.02	39,325.05
12	140,016.32	83,454.18	17,224.37	39,337.77
Average	139,971.90	83,429.77	17,211.30	39,330.82

80% Load Level - 2488 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:47:57	12:50:58	0-2	0:03:01
Measurement Interval	12:50:58	13:00:58	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	124,616.35	74,254.58	15,328.27	35,033.50
1	124,421.68	74,159.85	15,307.73	34,954.10
2	124,331.05	74,072.62	15,314.22	34,944.22
3	124,355.33	74,137.22	15,276.78	34,941.33
4	124,379.02	74,146.82	15,296.28	34,935.92
5	124,342.60	74,126.48	15,291.10	34,925.02
6	124,501.52	74,207.48	15,310.03	34,984.00
7	124,298.23	74,084.52	15,276.63	34,937.08
8	124,461.00	74,172.73	15,305.07	34,983.20
9	124,364.32	74,114.92	15,297.87	34,951.53
10	124,324.55	74,129.03	15,272.93	34,922.58
11	124,420.23	74,130.37	15,317.12	34,972.75
12	124,369.37	74,122.82	15,290.43	34,956.12
Average	124,381.62	74,137.24	15,293.43	34,950.95

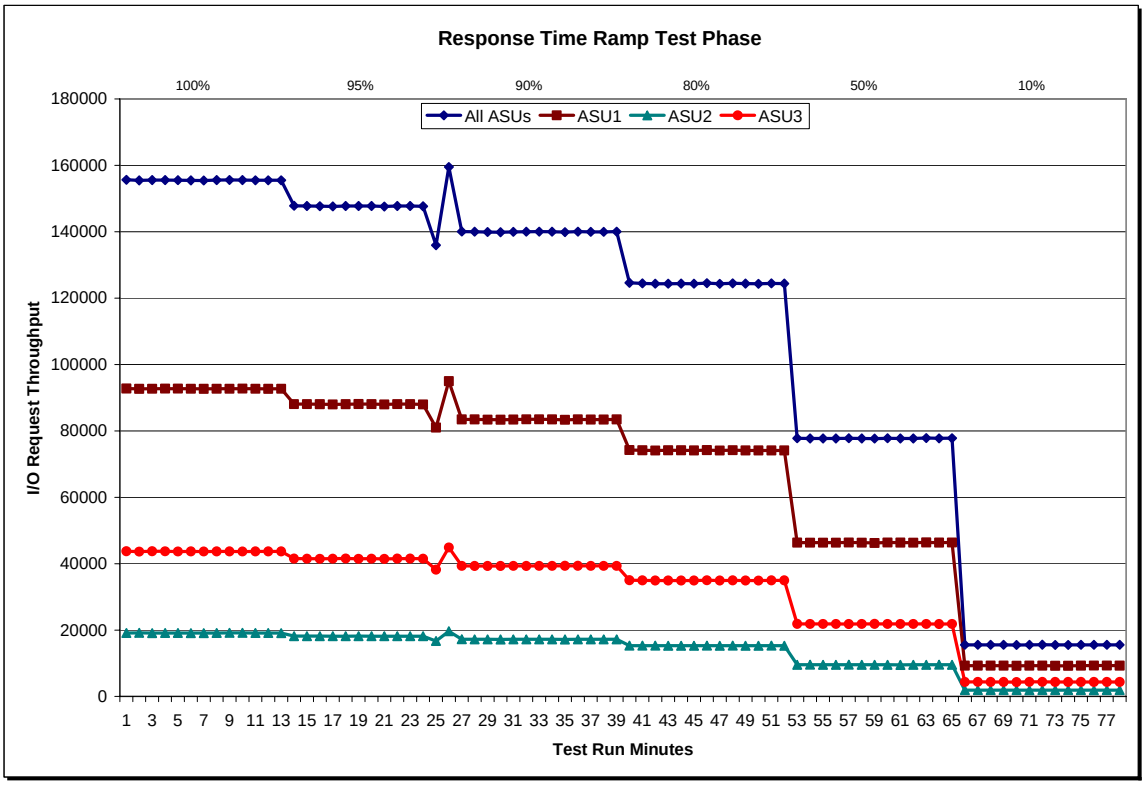
50% Load Level - 1555 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:01:27	13:04:28	0-2	0:03:01
Measurement Interval	13:04:28	13:14:28	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	77,790.95	46,347.53	9,562.93	21,880.48
1	77,729.52	46,325.55	9,567.47	21,836.50
2	77,711.53	46,324.75	9,553.75	21,833.03
3	77,705.27	46,307.30	9,553.72	21,844.25
4	77,767.23	46,367.55	9,567.65	21,832.03
5	77,730.95	46,331.05	9,548.50	21,851.40
6	77,675.93	46,240.50	9,565.52	21,869.92
7	77,776.93	46,381.82	9,540.25	21,854.87
8	77,715.87	46,351.50	9,519.17	21,845.20
9	77,721.75	46,308.50	9,558.37	21,854.88
10	77,835.80	46,425.12	9,564.52	21,846.17
11	77,753.92	46,355.47	9,576.43	21,822.02
12	77,796.23	46,395.35	9,559.98	21,840.90
Average	77,747.99	46,346.42	9,555.41	21,846.16

10% Load Level - 311 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:14:49	13:17:50	0-2	0:03:01
Measurement Interval	13:17:50	13:27:50	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	15,568.15	9,278.18	1,920.23	4,369.73
1	15,566.92	9,277.60	1,910.07	4,379.25
2	15,552.67	9,269.50	1,918.62	4,364.55
3	15,564.58	9,280.80	1,918.58	4,365.20
4	15,511.28	9,252.45	1,912.07	4,346.77
5	15,569.45	9,280.88	1,907.00	4,381.57
6	15,588.62	9,283.55	1,922.67	4,382.40
7	15,532.70	9,250.67	1,914.15	4,367.88
8	15,530.20	9,256.52	1,907.22	4,366.47
9	15,566.23	9,266.43	1,924.05	4,375.75
10	15,574.55	9,296.75	1,906.37	4,371.43
11	15,575.32	9,293.35	1,910.23	4,371.73
12	15,552.52	9,268.93	1,914.10	4,369.48
Average	15,556.55	9,273.03	1,913.64	4,369.87

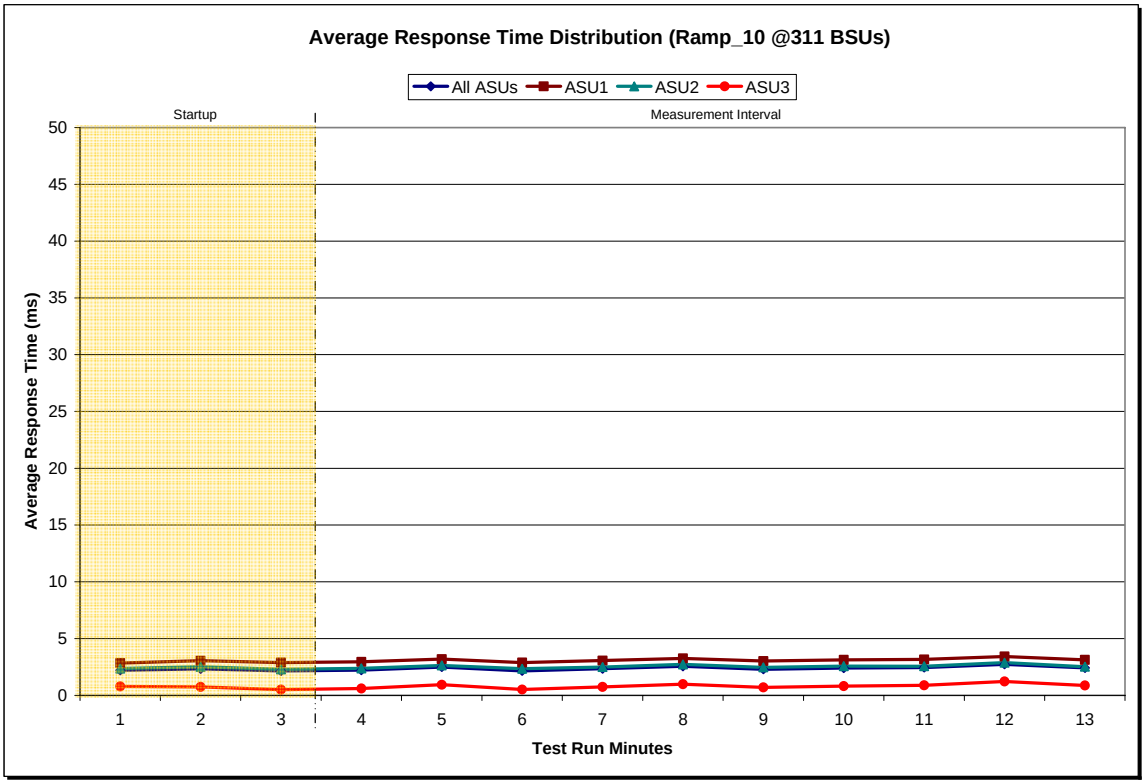
Response Time Ramp Distribution (IOPS) Graph



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

311 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:14:49	13:17:50	0-2	0:03:01
Measurement Interval	13:17:50	13:27:50	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.21	2.85	2.37	0.79
1	2.34	3.05	2.52	0.75
2	2.15	2.89	2.30	0.50
3	2.23	2.96	2.38	0.60
4	2.49	3.19	2.64	0.94
5	2.16	2.89	2.35	0.52
6	2.35	3.07	2.50	0.75
7	2.56	3.26	2.73	0.99
8	2.30	3.02	2.47	0.70
9	2.41	3.13	2.58	0.82
10	2.45	3.16	2.57	0.89
11	2.74	3.42	2.88	1.23
12	2.42	3.13	2.53	0.87
Average	2.41	3.12	2.56	0.83

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



SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2810	0.0701	0.2100	0.0179	0.0701	0.0350	0.2809
COV	0.005	0.002	0.003	0.003	0.006	0.004	0.004	0.001

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.*

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 D: SPC-1 Workload Generator Input Parameters" on Page 62.

Repeatability Test Results File

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

	SPC-1 IOPS™	SPC-1 LRT™
Primary Metrics	*155,519.46*	*2.41*
Repeatability Test Phase 1	155,472.12	2.34
Repeatability Test Phase 2	155,475.86	2.48

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

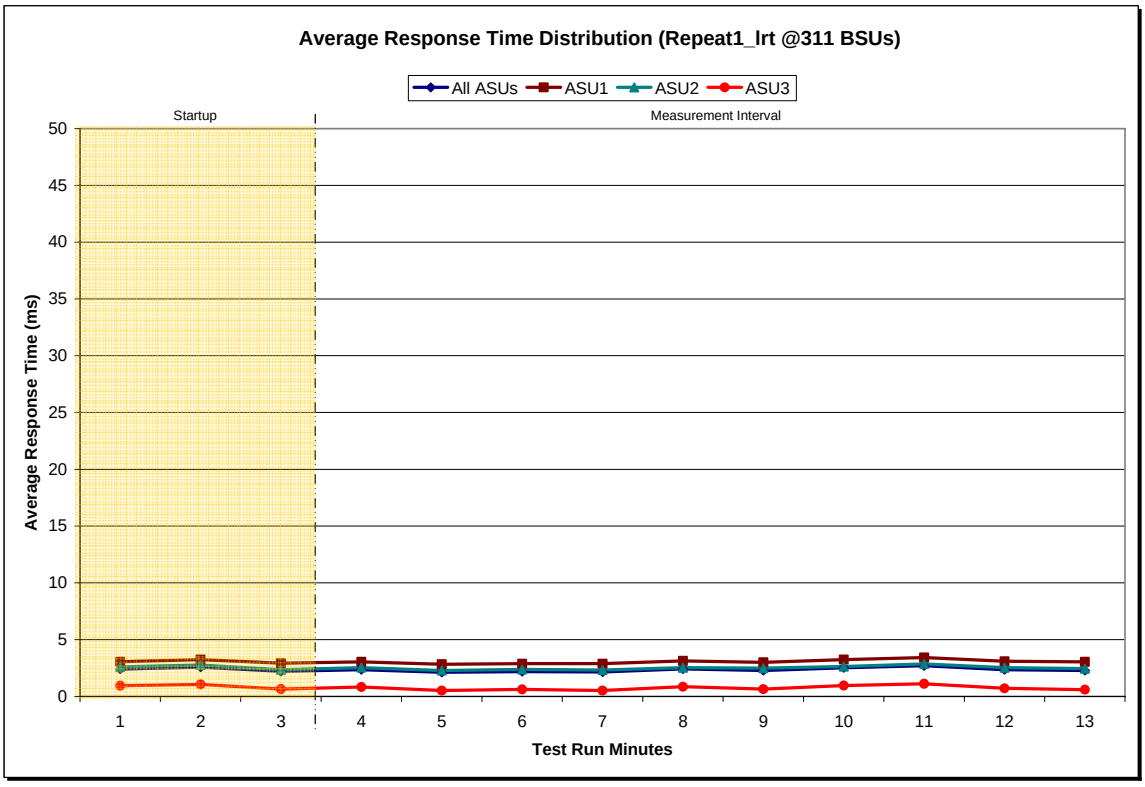
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

311 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:30:30	13:33:30	0-2	0:03:00
Measurement Interval	13:33:30	13:43:30	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	15,572.68	9,269.03	1,923.97	4,379.68
1	15,536.75	9,262.35	1,915.03	4,359.37
2	15,523.58	9,249.43	1,911.88	4,362.27
3	15,547.98	9,267.88	1,912.57	4,367.53
4	15,572.93	9,287.15	1,915.53	4,370.25
5	15,545.92	9,266.78	1,907.45	4,371.68
6	15,579.18	9,301.22	1,907.90	4,370.07
7	15,534.92	9,256.93	1,910.37	4,367.62
8	15,560.05	9,276.35	1,909.93	4,373.77
9	15,531.85	9,263.17	1,902.45	4,366.23
10	15,543.13	9,264.72	1,910.12	4,368.30
11	15,565.52	9,259.03	1,914.20	4,392.28
12	15,550.22	9,264.48	1,915.48	4,370.25
Average	15,553.17	9,270.77	1,910.60	4,371.80

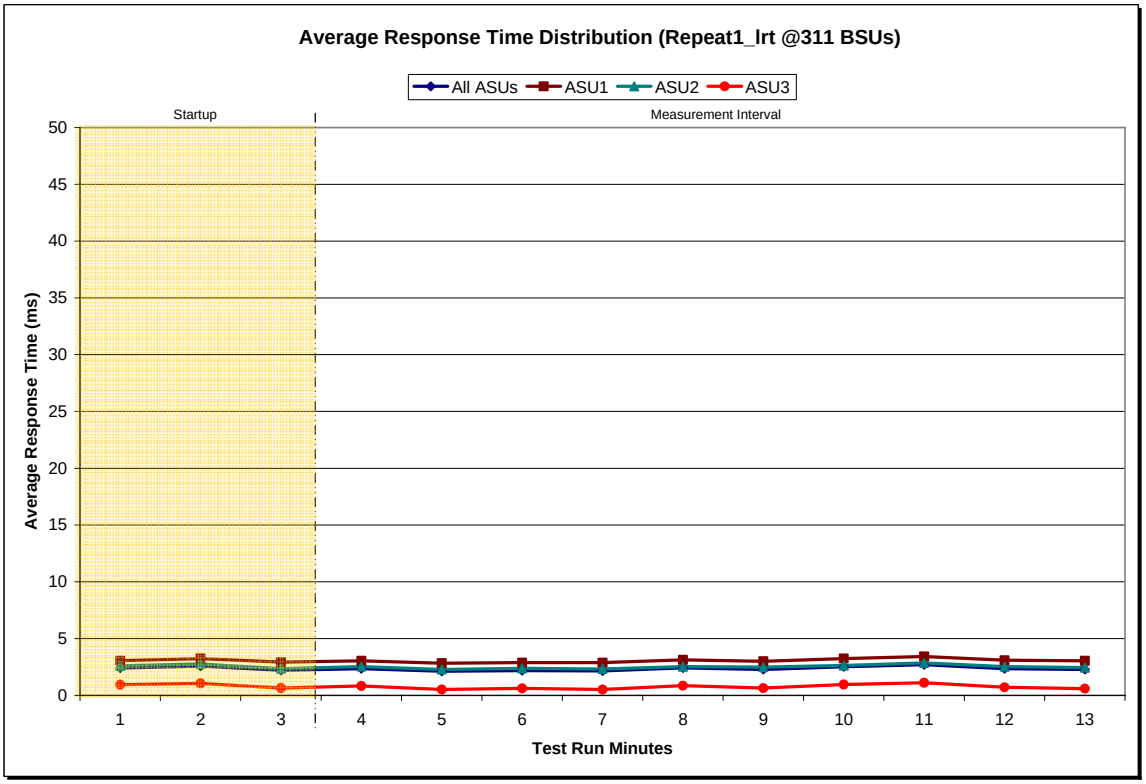
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

311 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:30:30	13:33:30	0-2	0:03:00
Measurement Interval	13:33:30	13:43:30	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.40	3.05	2.61	0.94
1	2.57	3.24	2.77	1.07
2	2.22	2.92	2.36	0.65
3	2.36	3.04	2.55	0.83
4	2.12	2.84	2.28	0.52
5	2.18	2.88	2.38	0.63
6	2.15	2.88	2.32	0.52
7	2.42	3.13	2.53	0.86
8	2.28	3.01	2.49	0.65
9	2.53	3.24	2.63	0.97
10	2.70	3.42	2.86	1.11
11	2.35	3.09	2.54	0.71
12	2.28	3.04	2.44	0.60
Average	2.34	3.06	2.50	0.74

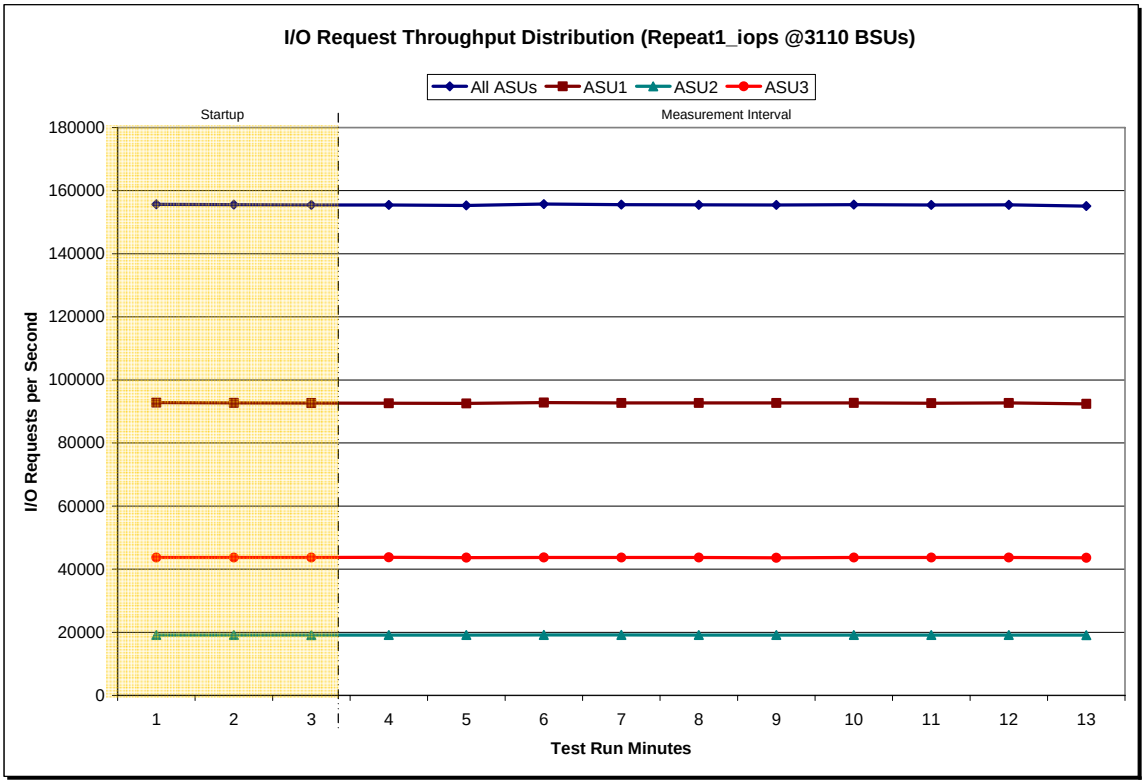
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:44:11	13:47:12	0-2	0:03:01
Measurement Interval	13:47:12	13:57:12	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	155,653.63	92,803.90	19,144.78	43,704.95
1	155,565.57	92,718.07	19,134.08	43,713.42
2	155,476.18	92,652.33	19,117.40	43,706.45
3	155,474.13	92,604.07	19,121.72	43,748.35
4	155,311.87	92,531.65	19,127.80	43,652.42
5	155,731.15	92,838.17	19,157.05	43,735.93
6	155,556.83	92,709.70	19,158.67	43,688.47
7	155,505.50	92,693.18	19,124.83	43,687.48
8	155,474.83	92,682.70	19,141.08	43,651.05
9	155,568.73	92,719.68	19,135.93	43,713.12
10	155,464.22	92,632.50	19,136.83	43,694.88
11	155,504.98	92,683.13	19,137.27	43,684.58
12	155,128.97	92,410.82	19,093.60	43,624.55
Average	155,472.12	92,650.56	19,133.48	43,688.08

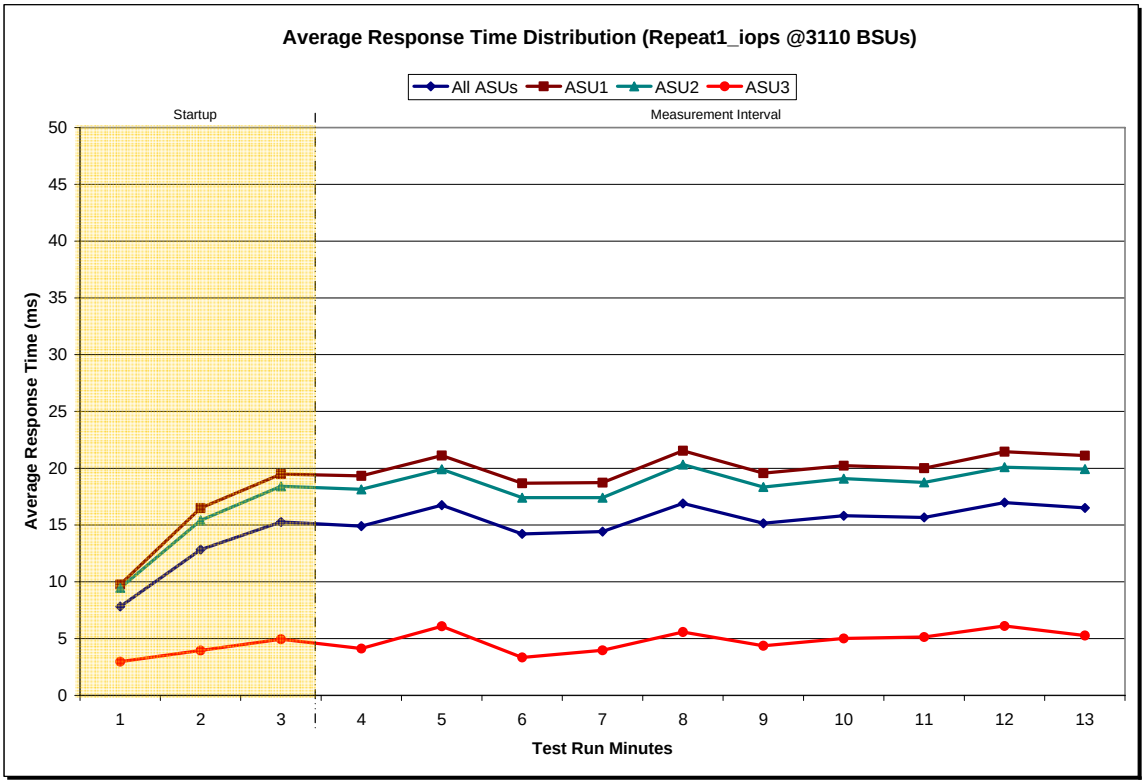
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:44:11	13:47:12	0-2	0:03:01
Measurement Interval	13:47:12	13:57:12	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	7.82	9.76	9.46	2.97
1	12.84	16.50	15.42	3.95
2	15.27	19.49	18.41	4.95
3	14.90	19.32	18.14	4.12
4	16.75	21.12	19.91	6.09
5	14.22	18.68	17.41	3.35
6	14.42	18.73	17.41	3.97
7	16.90	21.54	20.33	5.58
8	15.15	19.57	18.34	4.37
9	15.81	20.23	19.08	5.02
10	15.67	20.01	18.76	5.14
11	16.98	21.46	20.09	6.11
12	16.51	21.11	19.92	5.27
Average	15.73	20.18	18.94	4.90

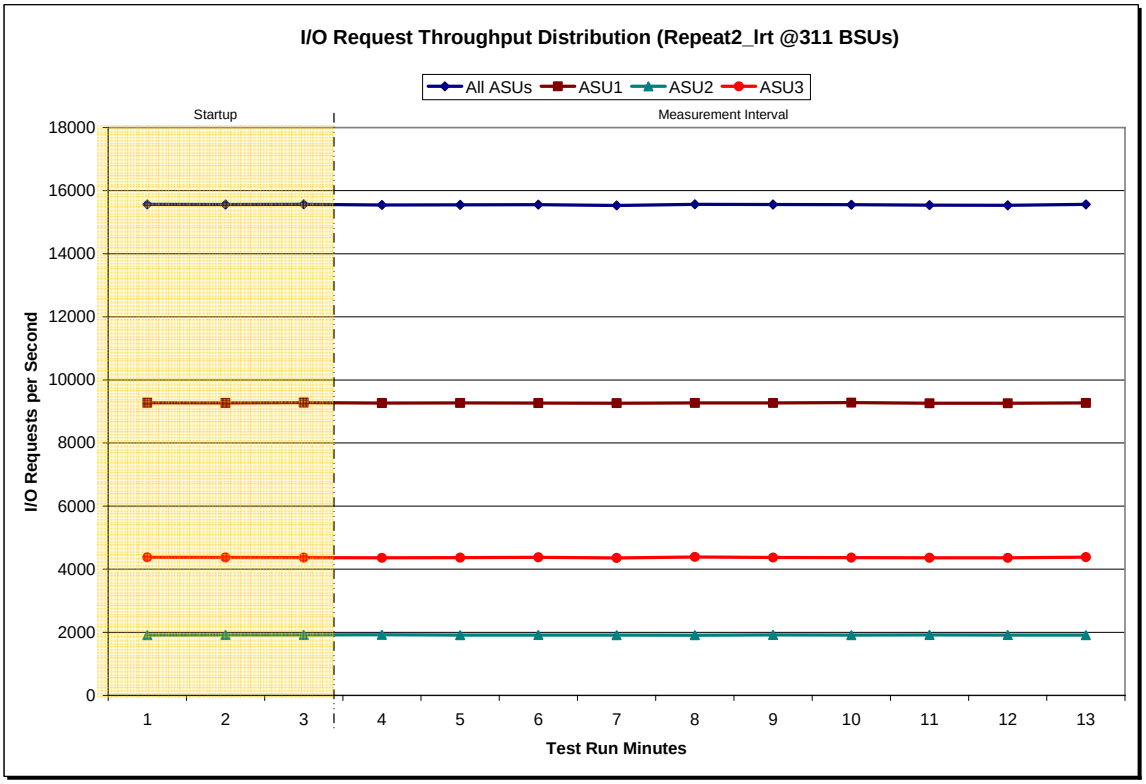
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

311 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:59:36	14:02:36	0-2	0:03:00
Measurement Interval	14:02:36	14:12:36	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	15,563.27	9,275.82	1,910.02	4,377.43
1	15,560.10	9,268.83	1,917.98	4,373.28
2	15,567.05	9,283.33	1,916.13	4,367.58
3	15,548.33	9,267.35	1,920.78	4,360.20
4	15,548.58	9,270.72	1,911.63	4,366.23
5	15,555.00	9,265.75	1,912.93	4,376.32
6	15,531.22	9,262.40	1,910.63	4,358.18
7	15,566.20	9,269.58	1,908.12	4,388.50
8	15,559.45	9,270.85	1,918.17	4,370.43
9	15,553.60	9,277.87	1,909.38	4,366.35
10	15,540.97	9,260.32	1,916.37	4,364.28
11	15,534.10	9,259.53	1,913.30	4,361.27
12	15,562.30	9,269.07	1,910.42	4,382.82
Average	15,549.98	9,267.34	1,913.17	4,369.46

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

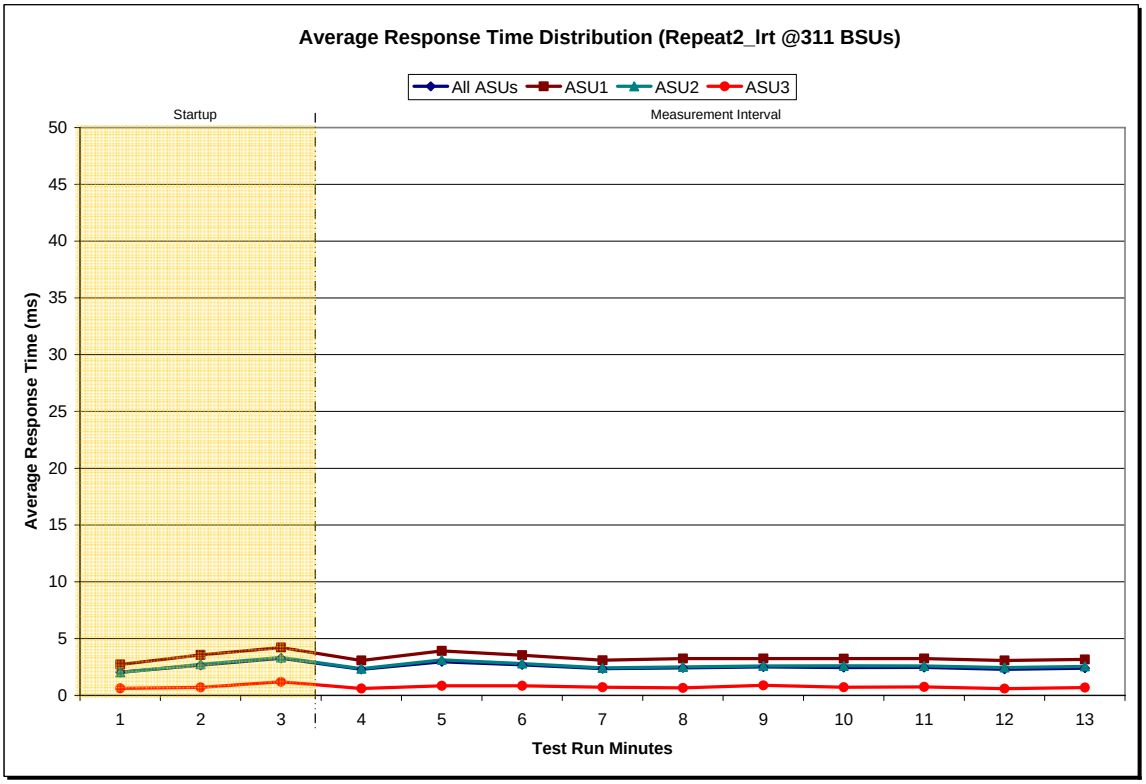


Repeatability 2 LRT –Average Response Time (ms) Distribution Data

311 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:59:36	14:02:36	0-2	0:03:00
Measurement Interval	14:02:36	14:12:36	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.04	2.72	2.01	0.62
1	2.66	3.57	2.74	0.70
2	3.26	4.22	3.34	1.19
3	2.30	3.08	2.34	0.61
4	2.96	3.92	3.13	0.85
5	2.69	3.54	2.81	0.85
6	2.35	3.10	2.42	0.72
7	2.43	3.25	2.50	0.66
8	2.50	3.25	2.59	0.88
9	2.45	3.23	2.61	0.72
10	2.46	3.25	2.58	0.75
11	2.30	3.07	2.45	0.60
12	2.40	3.17	2.55	0.70
Average	2.48	3.29	2.60	0.73

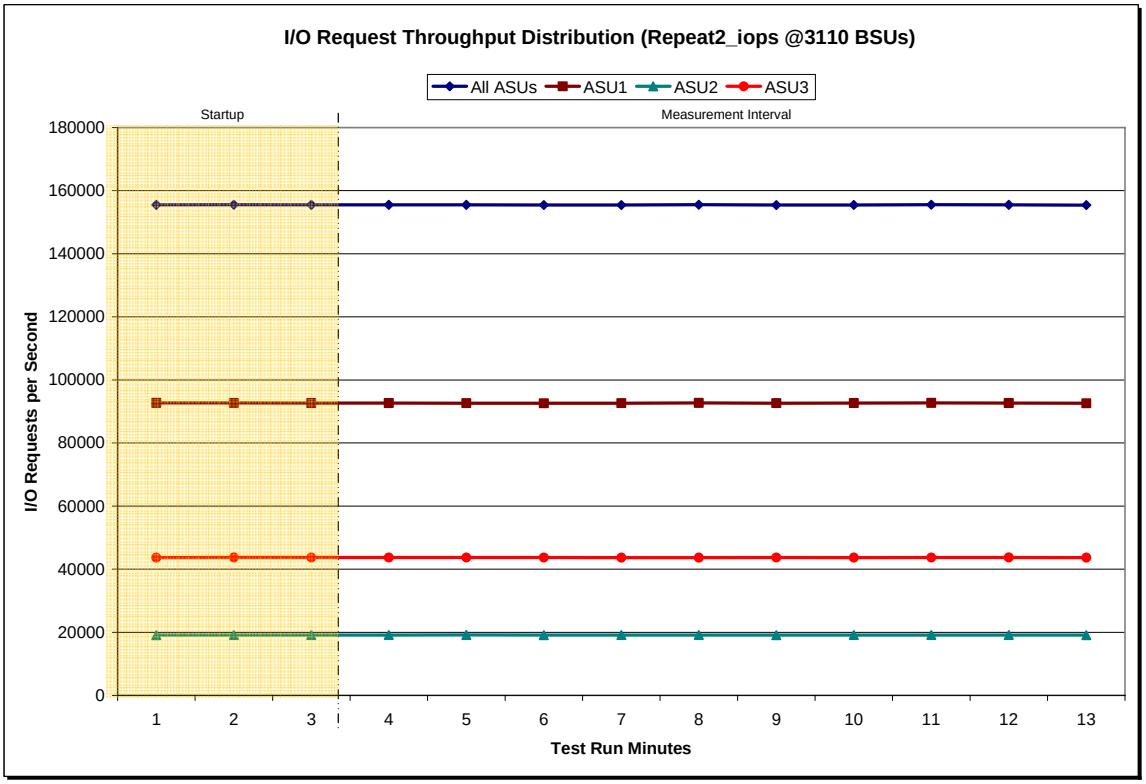
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:13:17	14:16:18	0-2	0:03:01
Measurement Interval	14:16:18	14:26:18	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	155,491.50	92,713.40	19,105.10	43,673.00
1	155,546.37	92,689.80	19,136.28	43,720.28
2	155,487.12	92,660.58	19,127.88	43,698.65
3	155,514.80	92,671.62	19,139.93	43,703.25
4	155,490.30	92,625.50	19,174.35	43,690.45
5	155,421.05	92,610.72	19,106.98	43,703.35
6	155,444.75	92,643.82	19,124.65	43,676.28
7	155,538.90	92,719.03	19,138.82	43,681.05
8	155,448.42	92,622.60	19,118.72	43,707.10
9	155,475.50	92,670.83	19,137.58	43,667.08
10	155,535.97	92,717.93	19,122.67	43,695.37
11	155,499.58	92,652.53	19,121.65	43,725.40
12	155,389.30	92,611.83	19,117.72	43,659.75
Average	155,475.86	92,654.64	19,130.31	43,690.91

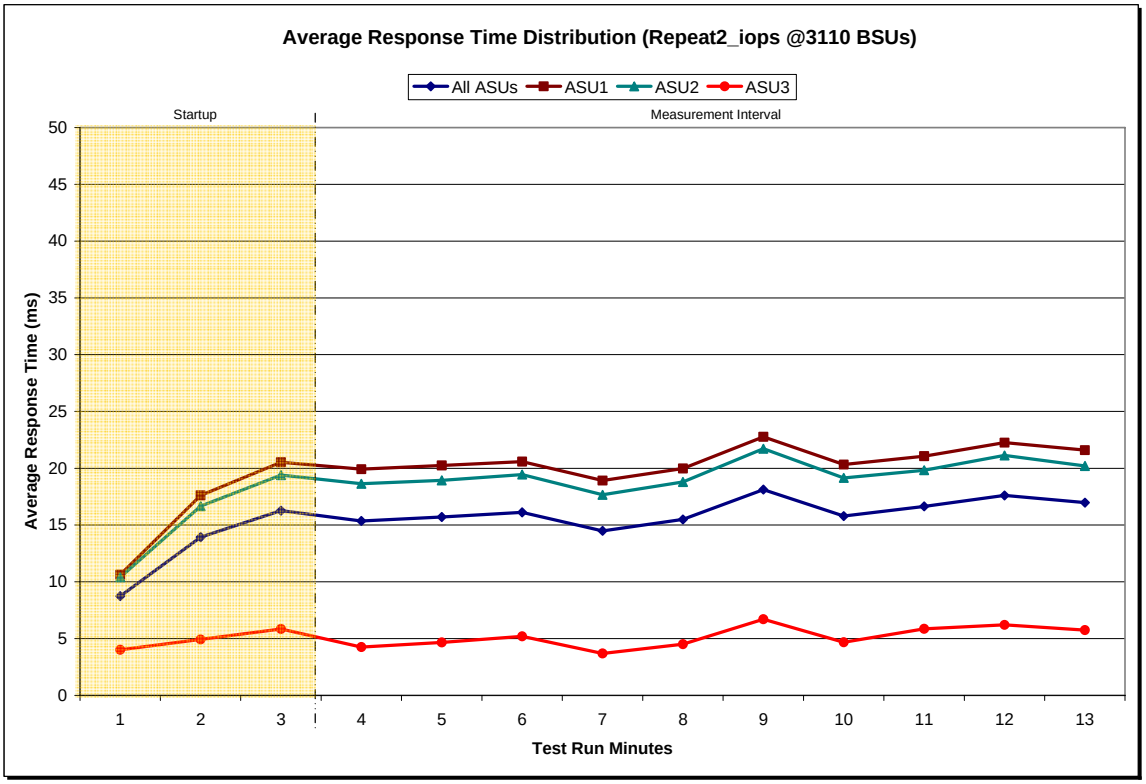
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

3110 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:13:17	14:16:18	0-2	0:03:01
Measurement Interval	14:16:18	14:26:18	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	8.74	10.62	10.40	4.02
1	13.93	17.62	16.66	4.92
2	16.27	20.53	19.40	5.85
3	15.35	19.91	18.63	4.25
4	15.71	20.25	18.93	4.67
5	16.12	20.58	19.44	5.20
6	14.48	18.91	17.66	3.70
7	15.49	19.98	18.79	4.51
8	18.12	22.77	21.72	6.71
9	15.79	20.32	19.15	4.68
10	16.64	21.07	19.83	5.86
11	17.61	22.26	21.13	6.21
12	16.97	21.59	20.20	5.76
Average	16.23	20.76	19.55	5.15

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



Repeatability 1 (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	0.2810	0.0700	0.2100	0.0180	0.0699	0.0349	0.2811
COV	0.005	0.002	0.004	0.002	0.006	0.002	0.005	0.002

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.*

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	0.0700	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.000	0.003	0.001	0.002	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0351	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.005	0.002	0.004	0.002	0.004	0.004	0.003	0.002

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2809	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.002	0.001	0.002	0.000

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 D: SPC-1 Workload Generator Input Parameters" on Page 62.

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	159,666,592
Total Number of Logical Blocks Verified	115,720,864
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 IBM TotalStorage® SAN Volume Controller 3.1, as documented in this Full Disclosure Report will become available for customer purchase and shipment on November 18, 2005.

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 12. 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 12.

ANOMALIES OR IRREGULARITIES

Clause 9.2.4.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the IBM TotalStorage® SAN Volume Controller 3.1.

APPENDIX A: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The AIX queue depth was set to 128 via the **chqdepth.sh** script:

The SVC extent size was set to 512 MiB (536.87 MB) via the **mkgroup.sh** script.

The contents of both scripts are contained in "Appendix B: Tested Storage Configuration (TSC) Creation" on page 57.

APPENDIX B: TESTED STORAGE CONFIGURATION (TSC) CREATION

Create RAID-10 Arrays (mDisks)

The following script creates two RAID-10 (mirrored+striped) arrays. The script is run against each of the 24 DS4300 storage systems to produce a total of 48 arrays. The resulting arrays appear to the SAN Volume Controller (SVC) as mDisks.

defineRAID10.script

```
set storageSubsystem defaultHostType=12;

create logicalDrive drives[0,1 0,2 0,3 0,4 0,5 0,6 0,7 1,1 1,2 1,3 1,4 1,5 1,6 1,7]
RAIDLevel=1
segmentSize=256
userLabel="1"
capacity=498136576kb
owner=a;
create logicalDrive drives[0,8 0,9 0,10 0,11 0,12 0,13 0,14 1,8 1,9 1,10 1,11 1,12
1,13 1,14]
RAIDLevel=1
segmentSize=256
userLabel="2"
capacity=498136576kb
owner=b;
set allLogicalDrives mirrorEnabled=TRUE writeCacheEnabled=TRUE
cacheWithoutBatteryEnabled=FALSE readAheadMultiplier=1;
```

Define the mDisk Group

The next script defines a pool of mDisk storage within the SVC, which is referred to as a mDisk group. It should be noted the $VCreq in the script gets substituted with a ssh call... basically $VCreq means "please tell the SVC to do the following".

mkgroup.sh

```
#makes an mdisk group, extent size 512 MiB
$VCreq svctask mkmdiskgrp -name thebiggroup -ext 512 -mdisk \
md0:md1:md2:md3:md4:md5:md6:md7:md8:md9:md10:md11:\
md12:md13:md14:md15:md16:md17:md18:md19:md20:md21:md22:md23:\
md24:md25:md26:md27:md28:md29:md30:md31:md32:md33:md34:md35:\
md36:md37:md38:md39:md40:md41:md42:md43:md44:md45:md46:md47
```

Define the vDisks (LUNs)

The following script will define 96 vDisks (LUNs) that will be presented to the Host System.

mk96vd_8node.sh

```
#Creates 96 vDisks and assigns them to 8 nodes.
#The specified size corresponds to 253 extents of 512 MiB each.
i=0
iogrp=0
lode=1
while [ $i -le 95 ]
do
echo $i $iogrp $lode
```

```
$VCreq svctask mkvdisk -size 129500 -unit mb -mdiskgrp thebiggroup -iogrp
io_grp$iogrp -name vd$i -node lode$lode
if [ $((i%24)) -eq 23 ]
then iogrp=$((iogrp+1))
fi
if [ $((i%12)) -eq 11 ]
then lode=$((lode+1))
fi
i=$((i+1))
done
```

Define vDisk Paths

The first script defines nicknames for the various Host System HBAs and their associated WWNs. The second script defines two paths for each vDisk, by which the vDisk can be accessed by the Host System. **mapfcsgroups** is the main routine, which makes calls to **map4x4**. The specific mapping used was chosen in order to balance the use of the available SVC ports (each port is assigned an equal number of vDisks). This step completes the configuration process on the SVC.

mkhosts.sh

```
$VCreq svctask mkhost -force -name D0 -hbawwpn 10000000C944431B
$VCreq svctask mkhost -force -name D1 -hbawwpn 10000000C9424FD5
$VCreq svctask mkhost -force -name D2 -hbawwpn 10000000C94259CC
$VCreq svctask mkhost -force -name D3 -hbawwpn 10000000C942518A
$VCreq svctask mkhost -force -name D4 -hbawwpn 10000000C94030FD
$VCreq svctask mkhost -force -name D5 -hbawwpn 10000000C942498B
$VCreq svctask mkhost -force -name D6 -hbawwpn 10000000C94256F7
$VCreq svctask mkhost -force -name D7 -hbawwpn 10000000C9427F7E
$VCreq svctask mkhost -force -name D8 -hbawwpn 10000000C9444479
$VCreq svctask mkhost -force -name D9 -hbawwpn 10000000C944446C
$VCreq svctask mkhost -force -name D10 -hbawwpn 10000000C94443C8
$VCreq svctask mkhost -force -name D11 -hbawwpn 10000000C9444524
$VCreq svctask mkhost -force -name D12 -hbawwpn 10000000C94440F4
$VCreq svctask mkhost -force -name D13 -hbawwpn 10000000C9403183
$VCreq svctask mkhost -force -name D14 -hbawwpn 10000000C9427A39
$VCreq svctask mkhost -force -name D15 -hbawwpn 10000000C942E674
$VCreq svctask mkhost -force -name D16 -hbawwpn 10000000C944454D
$VCreq svctask mkhost -force -name D17 -hbawwpn 10000000C94079D7
$VCreq svctask mkhost -force -name D18 -hbawwpn 10000000C94443C9
$VCreq svctask mkhost -force -name D19 -hbawwpn 10000000C9427DB5
$VCreq svctask mkhost -force -name D20 -hbawwpn 10000000C94443C0
$VCreq svctask mkhost -force -name D21 -hbawwpn 10000000C9444199
$VCreq svctask mkhost -force -name D22 -hbawwpn 10000000C944425F
$VCreq svctask mkhost -force -name D23 -hbawwpn 10000000C94443DA
$VCreq svctask mkhost -force -name D24 -hbawwpn 10000000C94441ED
$VCreq svctask mkhost -force -name D25 -hbawwpn 10000000C9444428
$VCreq svctask mkhost -force -name D26 -hbawwpn 10000000C9427F7F
$VCreq svctask mkhost -force -name D27 -hbawwpn 10000000C944428C
$VCreq svctask mkhost -force -name D28 -hbawwpn 10000000C9444204
$VCreq svctask mkhost -force -name D29 -hbawwpn 10000000C9402F88
$VCreq svctask mkhost -force -name D30 -hbawwpn 10000000C9444156
$VCreq svctask mkhost -force -name D31 -hbawwpn 10000000C9444311
```

mapfcsgroups.sh

```
# uses map4x4 to map each vdisk to two fcs's.  The fcs's are organized
# into groups of four, with two groups in each switch.
set -A fcsarray C9   C11  C13  C15    C2   C4   C6   C0   \
```

```
                C3   C5   C7   C1     C24  C26  C28  C30  \
                C25  C27  C29  C31    C16  C18  C20  C22  \
                C17  C19  C21  C23    C8   C10  C12  C14
for s in 0 1 2 3
  do
  for nodegroup in 1 2
    do
    let i="8*s + 4*(nodegroup-1)"
    fcsgroup="${fcsarray[$i]}"
    for member in 2nd 3rd 4th
      do
      let i="i+1"
      fcsgroup="$fcsgroup ${fcsarray[$i]}"
      done
    map4x4.sh "$fcsgroup" $nodegroup $s
    let as="(s/2)*2 + (1-s%2)"
    let i="8*as + 4*(2-nodegroup)"
    fcsgroup="${fcsarray[$i]}"
    for member in 2nd 3rd 4th
      do
      let i="i+1"
      fcsgroup="$fcsgroup ${fcsarray[$i]}"
      done
    map4x4.sh "$fcsgroup" $nodegroup $s
    done
  done
```

map4x4.sh

```
# maps set of four host path names ($1) to four nodes ($2 = 1 or 2 chooses
# odd or even nodes).  Uses 12 vdisk-to-path assignments chosen in
# a rotating pattern.  The paths belong to switch $3=0, 1, 2, or 3.
fcslist=""
for pluck in $1
  do
  fcslist="$fcslist $pluck $pluck $pluck"
  done
n=1
for fcs in $fcslist
  do
  let i="(7*n)%12"
  let j="12*($2-1) + 3*$3 + 24*(i/3) + i%3"
  $VCreq svctask mkvdiskhostmap -force -host $fcs vd$j
  let n="(n+1)%12"
  done
```

Discover each vDisk

This next script discovers the vDisks available to the Host System. Each available vDisk will appear to the operating system as a MPIO-enabled hdisk.

cfg32.sh

```
#discovers 32 host paths numbered fcs0 through fcs31
i=0
while [[ $i -le 31 ]]
do
echo "configuring fcs$i"
cfgmgr -vl fcs$i > fcs$i.cfg
i=$((i+1))
done
```

Increase hdisk queue depth

The following script increases the queue depth of each hdisk to 128.

chqdepth.sh

```
#changes the queue depth of each hdisk in hlist
h=4
while [[ $h -le 99 ]]
do
chdev -l hdisk$h -a queue_depth=128
let h="h+1"
done
```

Create a striped volume group

This last script uses the Logical Volume Manager to present the available storage as a striped volume group containing 36 logical volumes, each with 672 extents of 512 MiB per extent. This step completes the configuration process and the resulting volumes are used to comprise the ASU storage for the SPC-1 measurements.

mkthinstripe.sh

```
# Creates 36 logical volumes in a volume group with fine striping.
# Assumes that the "physical" storage is hdisks 4-99 each 253
# partitions of 512 MiB.

hfield=""
next=4
while [ $next -le 99  ]
do
hfield="$hfield hdisk$next"
let next="$next + 1"
done

mkvg -fy thinstripevg -B -s 512 $hfield

l=1
while [[ $l -le 36 ]]
do
mklv -b n -y thin$l -x 1016 -u 96 -S 128K thinstripevg 672
l=$((l+1))
done
```

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

The contents of the SPC-1 Workload Generator command and parameter file, **SPC1.cfg**, is listed below.

```
javaparms="-Xms384m -Xmx768m -Xss128k -Xgcpolicy:optavgpause"
sd=asu1_1,size=343597383680,lun=/dev/rthin1
sd=asu1_2,size=343597383680,lun=/dev/rthin2
sd=asu1_3,size=343597383680,lun=/dev/rthin3
sd=asu1_4,size=343597383680,lun=/dev/rthin4
sd=asu1_5,size=343597383680,lun=/dev/rthin5
sd=asu1_6,size=343597383680,lun=/dev/rthin6
sd=asu1_7,size=343597383680,lun=/dev/rthin7
sd=asu1_8,size=343597383680,lun=/dev/rthin8
sd=asu1_9,size=343597383680,lun=/dev/rthin9
sd=asu1_10,size=343597383680,lun=/dev/rthin10
sd=asu1_11,size=343597383680,lun=/dev/rthin11
sd=asu1_12,size=343597383680,lun=/dev/rthin12
sd=asu1_13,size=343597383680,lun=/dev/rthin13
sd=asu1_14,size=343597383680,lun=/dev/rthin14
sd=asu1_15,size=343597383680,lun=/dev/rthin15
sd=asu1_16,size=343597383680,lun=/dev/rthin16
sd=asu2_1,size=343597383680,lun=/dev/rthin17
sd=asu2_2,size=343597383680,lun=/dev/rthin18
sd=asu2_3,size=343597383680,lun=/dev/rthin19
sd=asu2_4,size=343597383680,lun=/dev/rthin20
sd=asu2_5,size=343597383680,lun=/dev/rthin21
sd=asu2_6,size=343597383680,lun=/dev/rthin22
sd=asu2_7,size=343597383680,lun=/dev/rthin23
sd=asu2_8,size=343597383680,lun=/dev/rthin24
sd=asu2_9,size=343597383680,lun=/dev/rthin25
sd=asu2_10,size=343597383680,lun=/dev/rthin26
sd=asu2_11,size=343597383680,lun=/dev/rthin27
sd=asu2_12,size=343597383680,lun=/dev/rthin28
sd=asu2_13,size=343597383680,lun=/dev/rthin29
sd=asu2_14,size=343597383680,lun=/dev/rthin30
sd=asu2_15,size=343597383680,lun=/dev/rthin31
sd=asu2_16,size=343597383680,lun=/dev/rthin32
sd=asu3_1,size=305419894784,lun=/dev/rthin33
sd=asu3_2,size=305419894784,lun=/dev/rthin34
sd=asu3_3,size=305419894784,lun=/dev/rthin35
sd=asu3_4,size=305419894784,lun=/dev/rthin36
```

APPENDIX D: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

The following script was used to execute the required SPC-1 Test Runs with the exception of the Persistence Test Run 2, which was executed manually at the console.

```
export CLASSPATH=../spc1
export LIBPATH=../spc1/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaopts.cfg metrics -b 3110
java -Xoptionsfile=javaopts.cfg repeat1 -b 3110
java -Xoptionsfile=javaopts.cfg repeat2 -b 3110
java -Xoptionsfile=javaoptsp.cfg persist1 -b 3110
```