



**SPC BENCHMARK 1™
FULL DISCLOSURE REPORT**

**LSI LOGIC STORAGE SYSTEMS, INC.
LSI E4600 FIBRE CHANNEL STORAGE SYSTEM**

SPC-1 V1.4

**Submitted for Review
May 20, 2002**

First Edition – May 2002

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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.

Table of Contents

Audit Certification	5
Letter of Good Faith	7
Executive Summary	8
Test Sponsor and Contact Information	8
Revision Information and Key Dates	8
Summary of Results	9
Response Time – Throughput Curve	10
Tested Storage Configuration Pricing	11
Benchmark Configuration/Tested Storage Configuration Diagram	12
Data Repository	13
Definitions	13
Storage Hierarchy Capacity	13
Logical Volume Capacity and ASU Mapping	14
Configuration Information	15
Tuning Parameters and Options	15
Tested Storage Configuration (TSC) Configuration	16
Benchmark Configuration (BC)	16
Host System(s) Configuration	16
SPC-1 Benchmark Execution Results	17
Definitions	17
Sustainability Test Phase	17
SPC-1 Workload Generator Input Parameters	17
Sustainability Test Results File	18
Sustainability – Data Rate Distribution.....	18
Sustainability – I/O Request Throughput Distribution	19
Sustainability – Measured Intensity Multiplier and Coefficient of Variation.....	19
IOPS Test Phase	20
SPC-1 Workload Generator Input Parameters	20
IOPS Test Results File.....	20
IOPS Test Run – I/O Request Throughput Distribution	21
IOPS Test Run – Response Time Frequency Distribution	22
IOPS Test Run – Average Response Time Distribution	23
IOPs Test Run - Measured Intensity Multiplier and Coefficient of Variation	24
Response Time Ramp Test Phase	25

SPC-1 Workload Generator Input Parameters	25
Response Time Ramp Test Results File.....	25
Response Time Distribution (IOPs)	26
SPC-1 LRT™ Average Response Time Distribution	27
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation	27
Repeatability Test	28
SPC-1 Workload Generator Input Parameters	28
Repeatability Test Results Files	29
I/O Request Throughput Distribution.....	30
Average Response Time Distribution.....	34
Repeatability 1 (IOPS) Measured Intensity Multiplier and Coefficient of Variation	37
Repeatability 1 (LRT) Measured Intensity Multiplier and Coefficient of Variation	38
Repeatability 2 (IOPS) Measured Intensity Multiplier and Coefficient of Variation	38
Repeatability 2 (LRT) Measured Intensity Multiplier and Coefficient of Variation	38
Data Persistence Test.....	39
SPC-1 Workload Generator Input Parameters	39
Data Persistence Test Results File	39
Data Persistence Test Results.....	40
Tested Storage Configuration (TSC) Availability Date	41
Pricing Information.....	41
Anomalies or Irregularities	41

AUDIT CERTIFICATION



Test Sponsor: LSI Logic Storage Systems, Inc.
Steve Gardner
3718 North Rock Road
Wichita, KS 67226

May 1, 2002

I verified the SPC Benchmark 1™ measurement for the LSI E4600 Fibre Channel Storage System and the results listed below were produced in compliance with the SPC Benchmark 1™ V1.4 requirements.

SPC-1 Results	
Tested Storage Configuration (TSC) Name: LSI E4600 Fibre Channel Storage System	
Metric	Reported Result
SPC-1 IOPS™	15,708.17
SPC-1 Price-Performance	\$16.01/IOPS™
Total ASU Capacity	400.0 GB
Data Protection Level	Mirroring
SPC-1 LRT™	1.64 ms
Total TSC Price (including three-year maintenance)	\$251,434.15

The following requirements were verified:

- The following Data Repository storage items were verified:
 - ✓ Physical Storage Capacity and requirements.
 - ✓ Configured Storage Capacity and requirements.
 - ✓ Addressable Storage Capacity and requirements.
 - ✓ Capacity of each Logical Volume and requirements.
 - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- The physical presence of all components that comprised the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the BC.
- The type of Host System including the number of processors and main memory.
- The presence and version number of each Workload Generator on each Host System.

Storage Performance Council
1060 El Camino Real, Suite F
Redwood City, CA 94062-1623
AuditService@storageperformance.org
650.556.9384

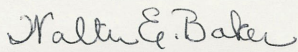
SPC BENCHMARK 1™
AUDIT CERTIFICATION

- The TSC boundary within each Host System.
- Correct execution and successful completion of the following:
 - ✓ Data Persistence Test
 - ✓ Sustainability Test Phase
 - ✓ IOPS Test Phase
 - ✓ Response Time Ramp Test Phase
 - ✓ Repeatability Test

Audit Notes:

There were no additional audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

Storage Performance Council
1060 El Camino Real, Suite F
Redwood City, CA 94062-1623
AuditService@storageperformance.org
650.556.9384

LETTER OF GOOD FAITH



LSI Logic Storage Systems, Inc. | 3718 North Rock Road | Wichita, KS 67226-1397 | 316.636.8000 | www.lsi-logicsystems.com

Date: April 19, 2002 – Results provided to SPC Audit Service
From: LSI Logic Storage Systems, Inc. / Mark Register & Roger Kasten
To: Walter Baker / Gradient Systems
Subject: Letter of Good Faith for the SPC Benchmark-1™ results published on the E4600-1 Configuration.

This Letter of Good Faith between LSI Logic Storage Systems Corporation (“hereafter known as the Test Sponsor”) and the Storage Performance Council (thereafter known as the SPC), documents that:

1. Fidelity and candor has been and will be maintained in reporting any anomalies in the SPC Benchmark-1™ results, even if not explicitly required for disclosure in the SPC Benchmark-1™ specification.
2. No attempt has been or will be made to deceive the SPC Audit Service, SPC, customers, or the public regarding the authenticity or accuracy of SPC Benchmark-1™ results on the E4600-1 Configuration. As such, the SPC-1 Full Disclosure Report that will document SPC Benchmark-1™ results (per Clause 10 of the SPC Benchmark-1™ Specification) on the E4600-1 Configuration is authentic and accurate.
3. The E4600-1 Configuration used for reporting SPC Benchmark-1™ results, as documented in the Full Disclosure Report (per Clause 10 of the SPC Benchmark-1™ Specification), has not been misrepresented to the SPC or SPC Audit Service in any way.
4. SPC Benchmark-1™ results on the E4600-1 Configuration are compliant with the spirit, intent, and letter of the SPC Benchmark-1™.
5. That the SPC Benchmark-1™ results do not represent a “Benchmark Special” as documented in Clause 0.2 of the SPC Benchmark-1™ specification.

Signed:

Ron Engelbrecht Vice President & General Manager LSI Logic Storage Systems, Inc.

April 25, 2002

EXECUTIVE SUMMARY**TEST SPONSOR AND CONTACT INFORMATION**

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	LSI Logic Storage Systems, Inc. www.lsilogicstorage.com Steve Gardner steve.gardner@lsil.com 3718 North Rock Road Wichita, KS 67226 Phone: (316) 636-8000 FAX: (316) 636-8520
Test Sponsor Alternate Contact	LSI Logic Storage Systems, Inc. www.lsilogicstorage.com Mark Regester mark.regester@lsil.com 3718 North Rock Road Wichita, KS 67226 Phone: (316) 636-8000 FAX: (316) 636-8889
Auditor	Storage Performance Council www.storageperformance.org Auditor's Name AuditService@storageperformance.org 1060 El Camino Real, Suite F 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	V1.4
SPC-1 Workload Generator revision number	V1.0
Date Results were first used publicly	May 1, 2002
Date FDR was submitted to the SPC	May 20, 2002
Date the TSC is/was available for shipment to customers	October 1, 2001
Date the TSC completed audit certification	May 1, 2002

SUMMARY OF RESULTS

SPC-1 Results	
Tested Storage Configuration (TSC) Name: LSI E4600 Fibre Channel Storage System	
Metric	Reported Result
SPC-1 IOPS™	15,708.17
SPC-1 Price-Performance	\$16.01 / IOPS™
Total ASU Capacity	400.0 GB
Data Protection Level	Mirroring
SPC-1 LRT™	1.64 ms
Total TSC Price (including three-year maintenance)	\$251,434.15

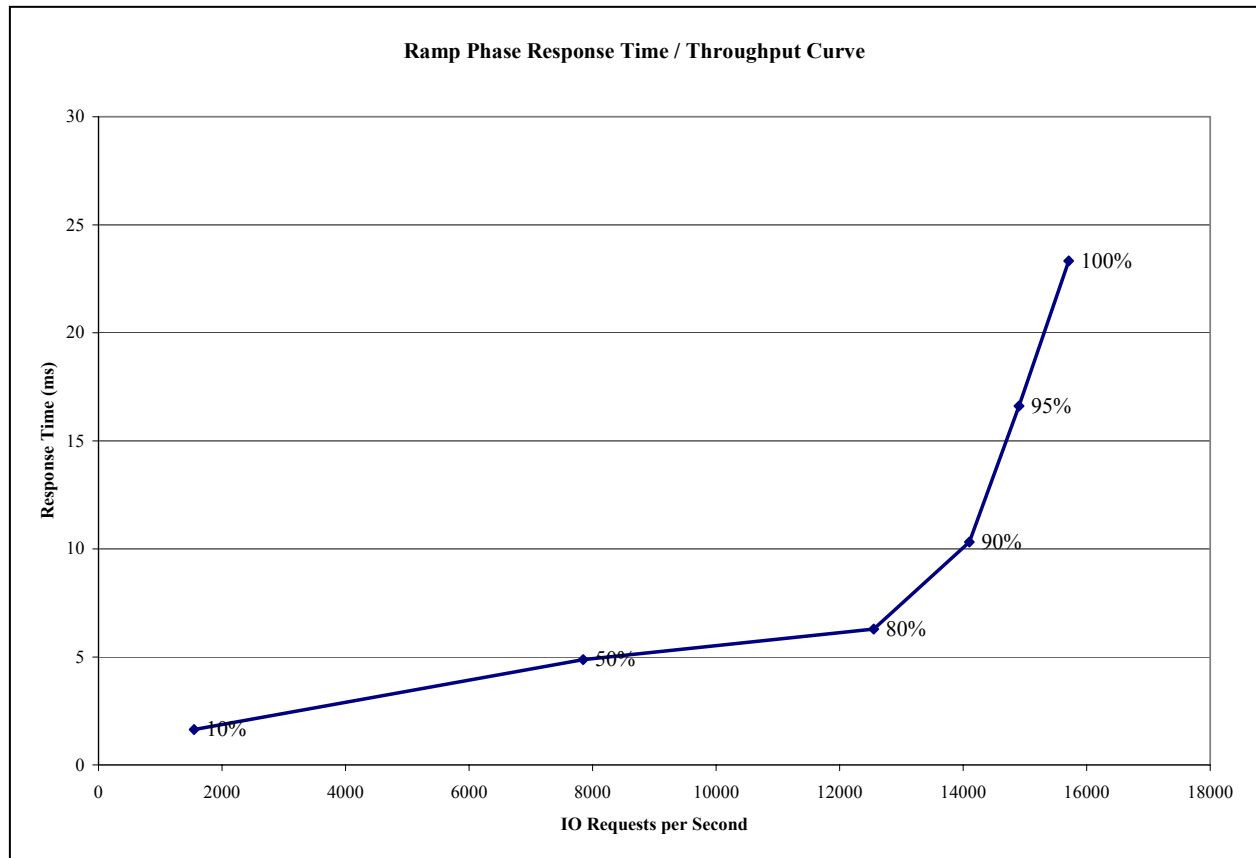
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

The **SPC-1 LRT™** metric is the Average Response Time measured at the 10% load point, as illustrated on the next page. SPC-1 LRT™ represents the Average Response Time measured on a lightly loaded Tested Storage Configuration (TSC).

RESPONSE TIME – THROUGHPUT CURVE



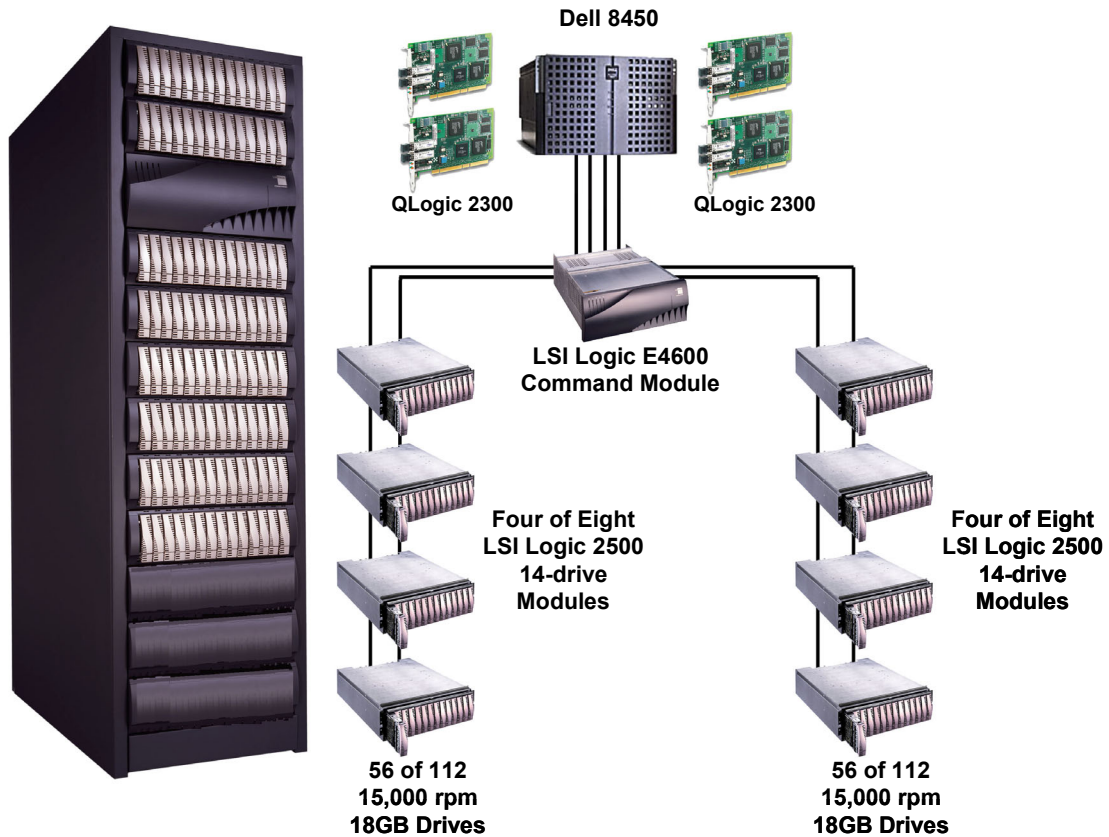
The Response Time-Throughput Curve illustrates the Average Response Time (milliseconds) and I/O Request Throughput at 100%, 95%, 90%, 80%, 50%, and 10% of the workload level used to generate the SPC-1 IOPS™ metric.

The Average Response Time measured at the 100% load point cannot exceed 30 milliseconds or the benchmark measurement is invalid.

TESTED STORAGE CONFIGURATION PRICING

Item	Description / Notes	Qty	List	Sell	Total
M100040	E4600 Command Module, Rack Mount, Dual Controller (One per system, supports 8 FC hosts, 16 drive modules max (14 slot module) or 22 drives modules max (10 slot module). Must order SANtricity, at least one drive module and 5 drives min. Requires SANtricity 7.11 or higher)	1	62,595.00 HWUNIT	43,816.50 30%	\$43,816.50
M100020	System Color - Warm Gray (Default)	1	0.00 HWOPT	0.00 0%	\$0.00
M100011	E2400/4400/4600 Expansion Drive Module, 14 Slot, Rack Mount, Dual ESM (Requires dual controller command module, includes FC interconnect cable.)	8	9,995.00 HWUNIT	6,996.50 30%	\$55,972.00
M100348	SANtricity 7.11 for Windows 2000 Software Feature (Must pick one SANtricity per system)	1	9,995.00 SW	6,996.50 30%	\$6,996.50
M100116	SANtricity 7.11 for Windows 2000 Software Maintenance Subscription (Per annum)	3	1,499.00 SVC	1,274.15 15%	\$3,822.45
2500-F327M	18GB FC 15K Drive Canister, 1.0" FF (For 14 slot Module. Order with system.)	112	1,195.00 DSK	836.50 30%	\$93,688.00
QL-2300	Qlogic 2300 HBA	4	1,225.00	896.00	\$3,584.00
006-1086726	FC Optical Cable - 1GB/2Gb, 10.0m	4	144.00 ACC	100.80 30%	\$403.20
M100017	LSI 19" Equipment Rack Feature, 72"H x 22"W x 36"D w/ 220 Volt Power Dist. Unit, N. America	1	4,595.00 HWUNIT	3,216.50 30%	\$3,216.50
M100019	LSI Rack Mount Rails (Req'd with rack, 1 set per command/drive module, order with rack only)	9	200.00 HWOPT	140.00 30%	\$1,260.00
M100246	Onsite Service w/ Part Delivery, 4 Hour Response - E4400/E4600 Command Module - 3 Year Contract (Requires signed Service Agreement)	1	11,000.00 SVC	9,350.00 15%	\$9,350.00
M100247	Onsite Service w/ Part Delivery, 4 Hour Response - E4400/E4600 Drive Module - 3 Year Contract (Requires signed Service Agreement)	8	3,750.00 SVC	3,187.50 15%	\$25,500.00
M100055	On-site Installation Service, E4600 Command Module	1	3,500.00 SVC	2,975.00 15%	\$2,975.00
M100057	On-site Installation Service, 4 to 9 Drive Modules	1	1,000.00 SVC	850.00 15%	\$850.00
Total End User Selling Price					\$251,434.15
Total \$US list price of this configuration					\$348,258.00

BENCHMARK CONFIGURATION/TESTED STORAGE CONFIGURATION DIAGRAM



Host System:	Storage System:
Dell 8450	LSI Logic E4600 Command Module
UID=HS-BM8450C	UID=SC-E4600-1
8 x 900MHz Pentium III Xeon with 2MB L2 Cache	2 x 4884 Disk Array Controllers 128MB/1GB RAM Each
4GB RAM	4 x Fibre Channel Host Connect
Microsoft Win2K, Service Pack 2	4 x Fibre Channel Drive Connect
4 QLogic 2300 Host Adapters	8 x LSI Logic 2500 Drive Modules
4 64-bit/66MHz PCI Slots Used	112 x 18GB 15,000 RPM Drives

DATA REPOSITORY

DEFINITIONS

Physical Storage Capacity: The formatted capacity of all storage devices physically present in the Tested Storage Configuration (TSC), excluding any storage that cannot be configured for use by the benchmark.

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.

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.

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.

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.

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

STORAGE HIERARCHY CAPACITY

Storage Hierarchy Capacity		
Storage Hierarchy Component	Units	Capacity
ASU Capacity	Gigabytes (GB)	400.0
Addressable Storage Capacity	Gigabytes (GB)	482.8
Configured Storage Capacity	Gigabytes (GB)	965.6
Physical Storage Capacity	Gigabytes (GB)	2,039.5

LOGICAL VOLUME CAPACITY AND ASU MAPPING

Logical Volume Capacity and Mapping					
ASU-1 (180 GB)		ASU-2 (180 GB)		ASU-3 (40 GB)	
LV_0 LUN 0	107.3 GB	LV_2 LUN 2	107.3 GB	LV_4 LUN 4	53.6 GB
ASU_1_1	90 GB	ASU_2_1	90 GB	ASU_3_1	40 GB
LV_1 LUN 1	107.3 GB	LV_3 LUN 3	107.3 GB		
ASU_1_2	90 GB	ASU_2_2	90 GB		

All storage is configured as Mirroring.

See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed information.

CONFIGURATION INFORMATION

TUNING PARAMETERS AND OPTIONS

This section describes the customer-tunable parameters that have been altered from their default value for all components of the Benchmark Configuration (BC).

- Operating system and application configuration parameters:
 - Windows 2000 registry setting change:
 - HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\ql2300\Device\MaximumSGList=0xff
- Array controller options:
 - All array controller configuration options are set by the configuration script described in the “Tested Storage Configuration (TSC) Configuration” section below.
- HBA options:
 - The table below identifies the Host Bus Adapter options that were changed from their default values:

Host Bus Adapter Settings		
Item	Default	New Value
Host Adapter Settings		
Loop Reset Delay	5	8
Adapter Hard Loop ID	Disabled	Enabled
Hard Loop ID (unique for each)	0	Eg. 22
Advanced Adapter Settings		
Execution Throttle	16	255
Fast Command Posting	Disabled	Enabled
LUNs per Target	8	0
Enable Target Reset	No	Yes
Login Retry Count	8	30
Port Down Retry Count	8	70
Extended Firmware Settings		
Data Rate	0	2

TESTED STORAGE CONFIGURATION (TSC) CONFIGURATION

All scripts and/or commands used to configure all components of the TSC. Each script or list of commands should clearly reference its associated component as identified in the Benchmark Configuration/Tested Storage Configuration Diagram on page 12.

The configuration of the TSC was performed using the script engine of SANtricity 7.11 for Windows 2000. A link to the actual script used to create and configure the volumes is listed below. These volumes represent the Logical Volumes visible by the host and benchmark program. The Addressable Storage Capacity is taken from these Logical Volumes.

[SANtricity TSC configuration script](#)

Additionally, the “Default Array Host Type” was set to “Windows 2000 Non-Clustered” using the SANtricity GUI configuration utility.

BENCHMARK CONFIGURATION (BC)

No additional steps were required to make the storage useable for the benchmark.

HOST SYSTEM(S) CONFIGURATION

The major components of the Host System configuration are described in the **Benchmark Configuration/Tested Storage Configuration Diagram** section of this document.

SANtricity 7.11, Redundant Disk Array Controller (RDAC) package, was installed to support controller failover in the event of a host to disk array IO path failure. Other than installation, no additional configuration of this software was required.

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.*

SUSTAINABILITY TEST PHASE

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 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.

SPC-1 Workload Generator Input Parameters

The Sustainability, IOPs, and Response Time Ramp Test runs were run from a single host command file (script) and a single workload generator parameter file. The following host command was used to start these test phases:

```
java -Xmx64m -Xms64m spc1 -fprimarymetrics.parm  
-nk -oaudit(alpha_2002_04_18)\output.primary
```

SPC-1 BENCHMARK EXECUTION RESULTS
SUSTAINABILITY TEST PHASE

A link to the SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp, test runs is listed below.

[Input Parameters \(Sustainability, IOPS, and Response Time Ramp\)](#)

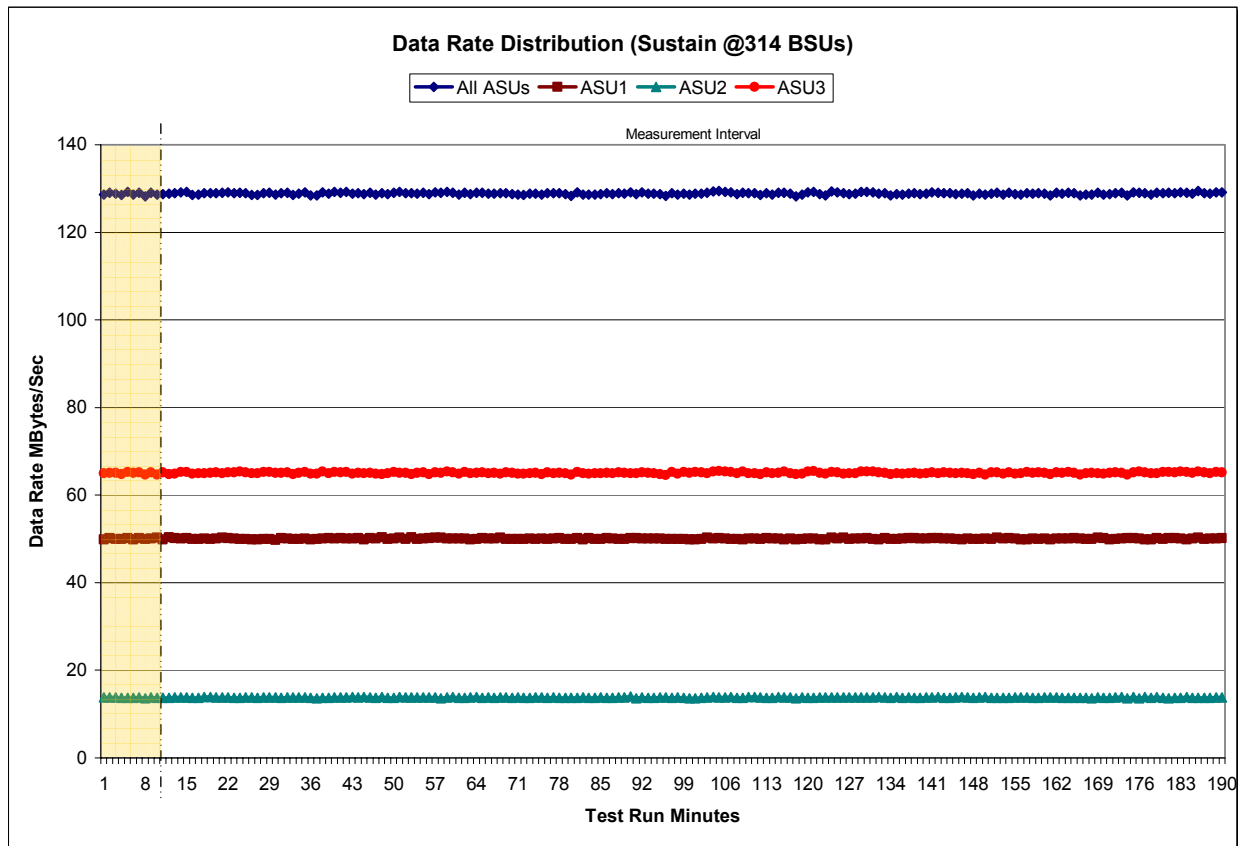
Sustainability Test Results File

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

[Sustainability Test Results File](#)

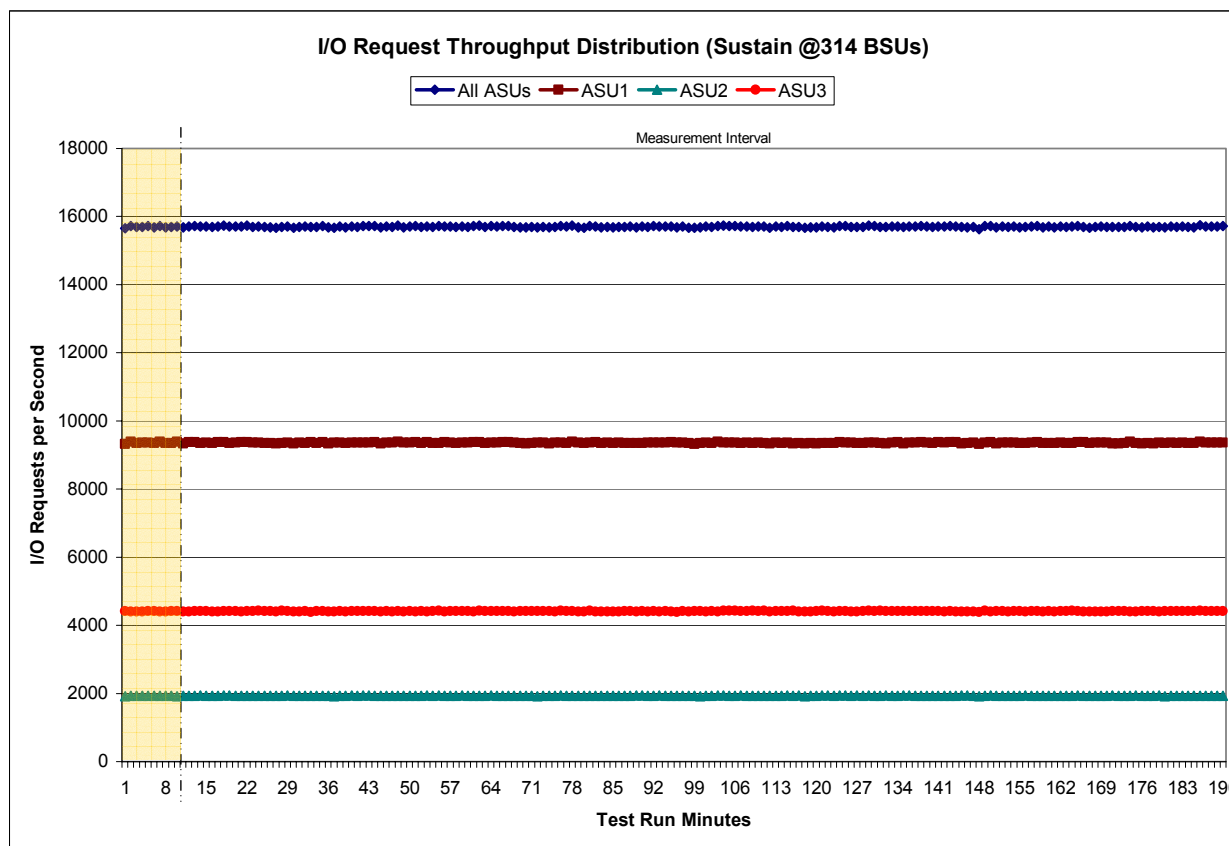
Sustainability – Data Rate Distribution

The Measurement Interval duration for the Sustainability Test Run was 180 minutes.



Sustainability – I/O Request Throughput Distribution

The Measurement Interval duration for the Sustainability Test Run was 180 minutes.



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	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
MIM	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
COV	0.006	0.002	0.004	0.002	0.007	0.004	0.005	0.002

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.

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%.

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

IOPS TEST PHASE

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.

SPC-1 Workload Generator Input Parameters

The Sustainability, IOPs, and Response Time Ramp Test runs were run from a single host command file (script) and a single workload generator parameter file. The following host command was used to start these test phases:

```
java -Xmx64m -Xms64m spc1 -fprimarymetrics.parm  
-nk -oaudit(alpha_2002_04_18)\output.primary
```

A link to the SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp, test runs is listed below.

[*Input Parameters \(Sustainability, IOPS, and Response Time Ramp\)*](#)

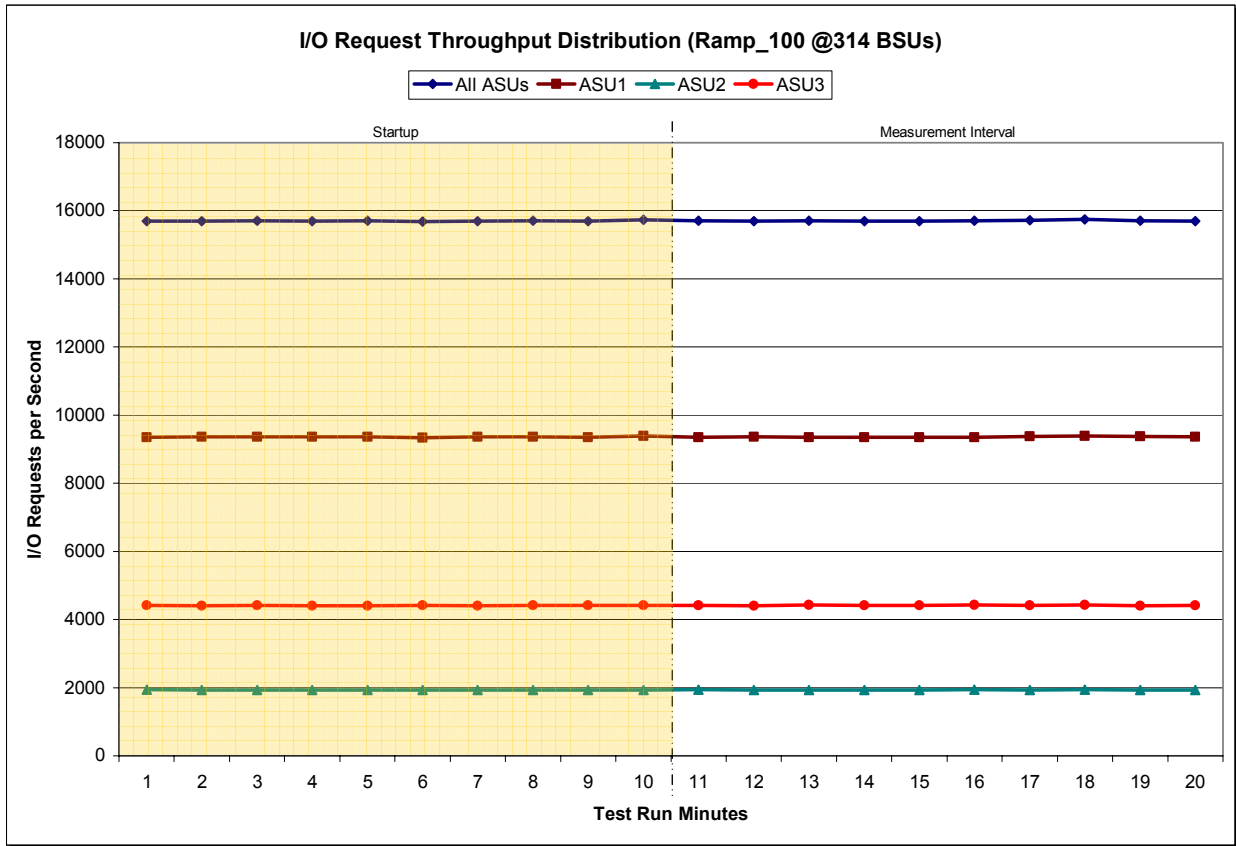
IOPS Test Results File

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

[IOPS Test Results File](#)

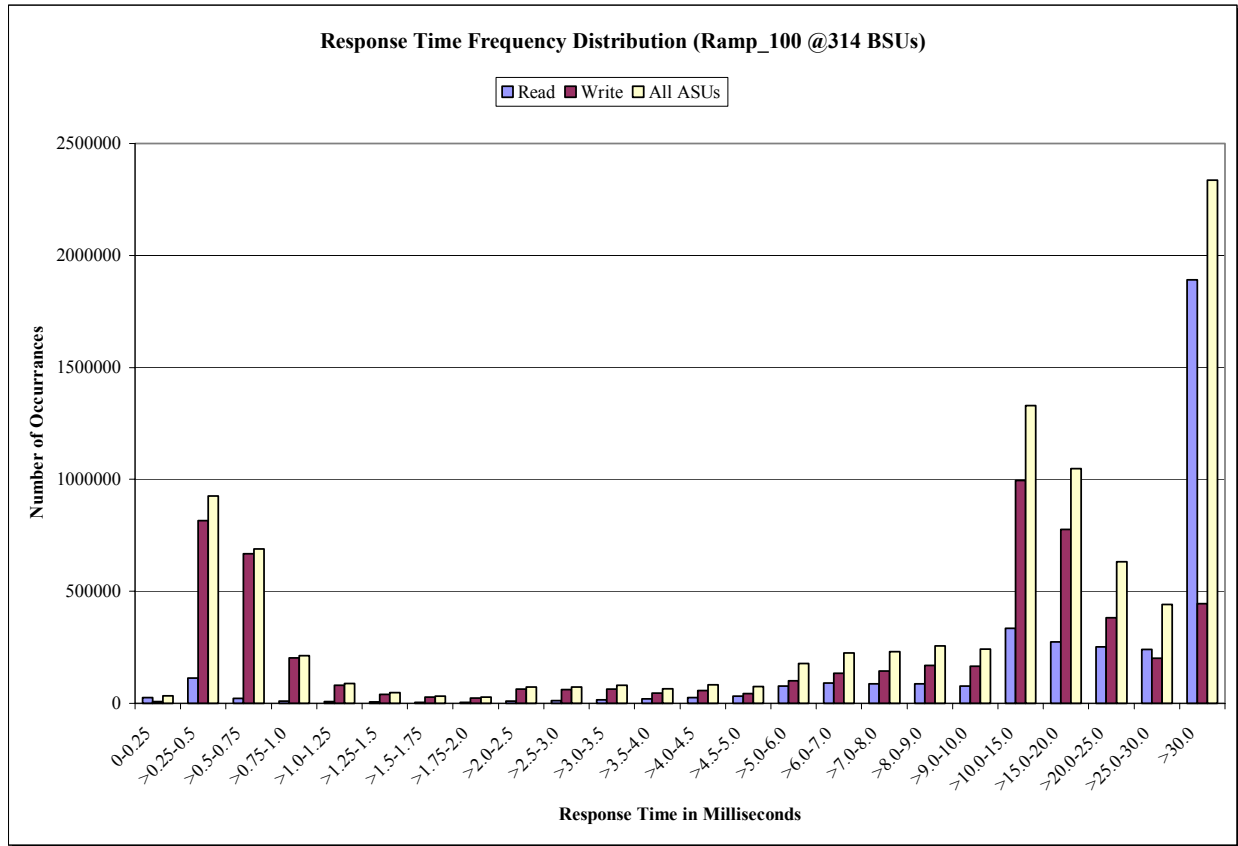
IOPS Test Run – I/O Request Throughput Distribution

The Measurement Interval duration for the IOPS Test Run was 10 minutes.



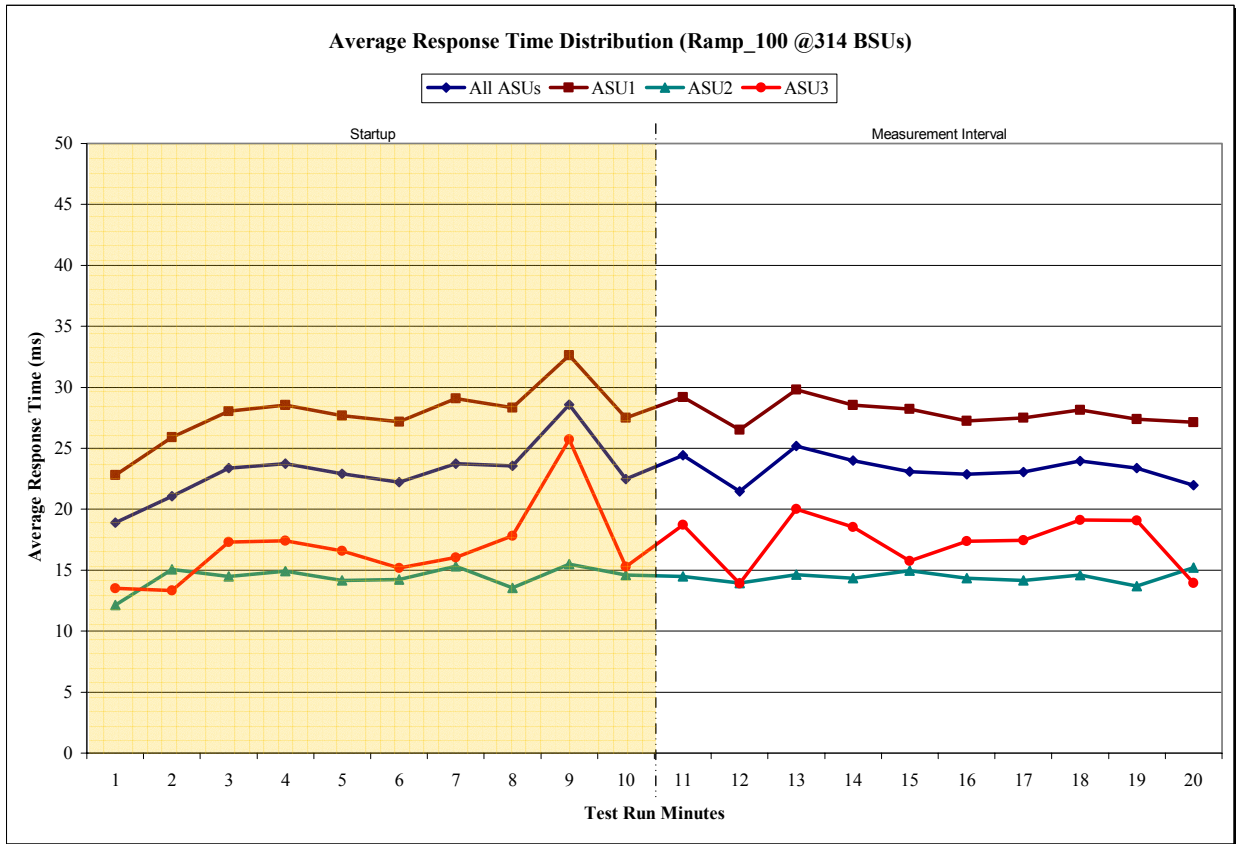
IOPS Test Run – Response Time Frequency Distribution

The Measurement Interval duration for the IOPS Test Run was 10 minutes.



IOPS Test Run – Average Response Time Distribution

The Measurement Interval duration for the IOPS Test Run was 10 minutes.



IOPs Test Run - I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
9,424,851	7,087,689	2,337,152

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	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
MIM	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
COV	0.007	0.003	0.002	0.002	0.008	0.004	0.005	0.002

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.

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%.

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

RESPONSE TIME RAMP TEST PHASE

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 10.

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

SPC-1 Workload Generator Input Parameters

The Sustainability, IOPs, and Response Time Ramp Test runs were run from a single host command file (script) and a single workload generator parameter file. The following host command was used to start these test phases:

```
java -Xmx64m -Xms64m spc1 -fprimarymetrics.parm  
-nk -oaudit(alpha_2002_04_18)\output.primary
```

A link to the SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp, test runs is listed below.

[Input Parameters \(Sustainability, IOPS, and Response Time Ramp\)](#)

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](#)

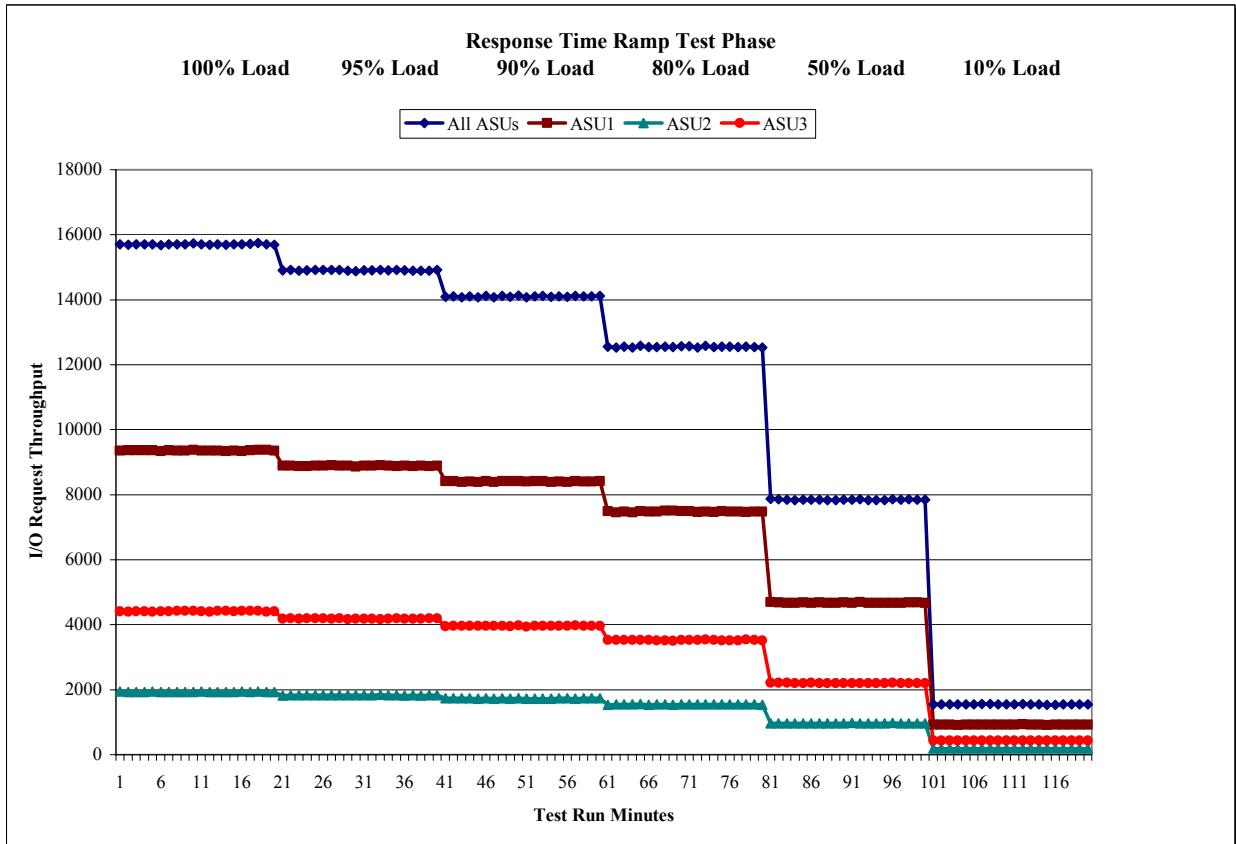
[90% Load Level](#)

[80% Load Level](#)

[50% Load Level](#)

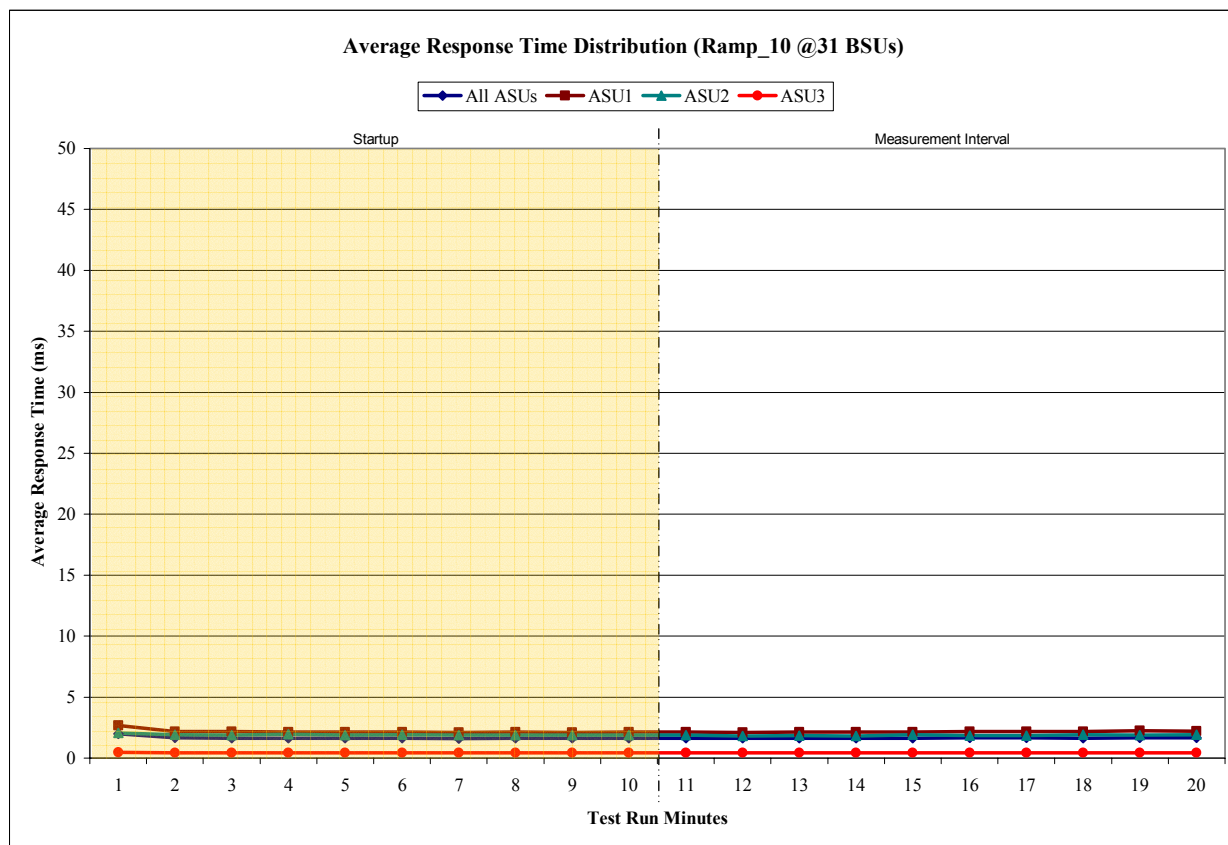
[10% Load Level](#)

Response Time Distribution (IOPs)



SPC-1 LRT™ Average Response Time Distribution

The Measurement Interval duration for the LRT (10%) Response Time Ramp Test Run was 10 minutes.



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
<i>IM</i>	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
<i>MIM</i>	0.035	0.282	0.070	0.210	0.018	0.070	0.035	0.280
<i>COV</i>	0.020	0.008	0.014	0.007	0.014	0.011	0.016	0.004

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.

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%.

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

REPEATABILITY TEST

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ and SPC-1 LRT™ primary metrics 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™ primary metric. Each Average Response Time value must be less than the SPC-1 LRT™ primary 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.

SPC-1 Workload Generator Input Parameters

Repeatability test run #1 was run from a single host command file. The following host command was used to start this test phase:

```
java -Xmx64m -Xms64m spc1 -frepeat1.parm  
-nk -oaudit(alpha_2002_04_18)\output.repeat1
```

A link to the SPC-1 Workload Generator input parameters for the Repeatability Test Run #1 is listed below.

[Input Parameters \(Repeatability Test #1\)](#)

Repeatability test run #2 was run from a single host command file. The following host command was used to start this test phase:

```
java -Xmx64m -Xms64m spc1 -frepeat2.parm  
-nk -oaudit(alpha_2002_04_18)\output.repeat2
```

A link to the SPC-1 Workload Generator input parameters for the Repeatability Test Run #2 is listed below.

[Input Parameters \(Repeatability Test #2\)](#)

Repeatability Test Results Files

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	15,708.85	1.64
Repeatability Test Phase 1	15,708.17	1.62
Repeatability Test Phase 2	15,702.00	1.60

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

[Repeatability Test Run 1 \(LRT\)](#)

[Repeatability Test Run 1 \(IOPS\)](#)

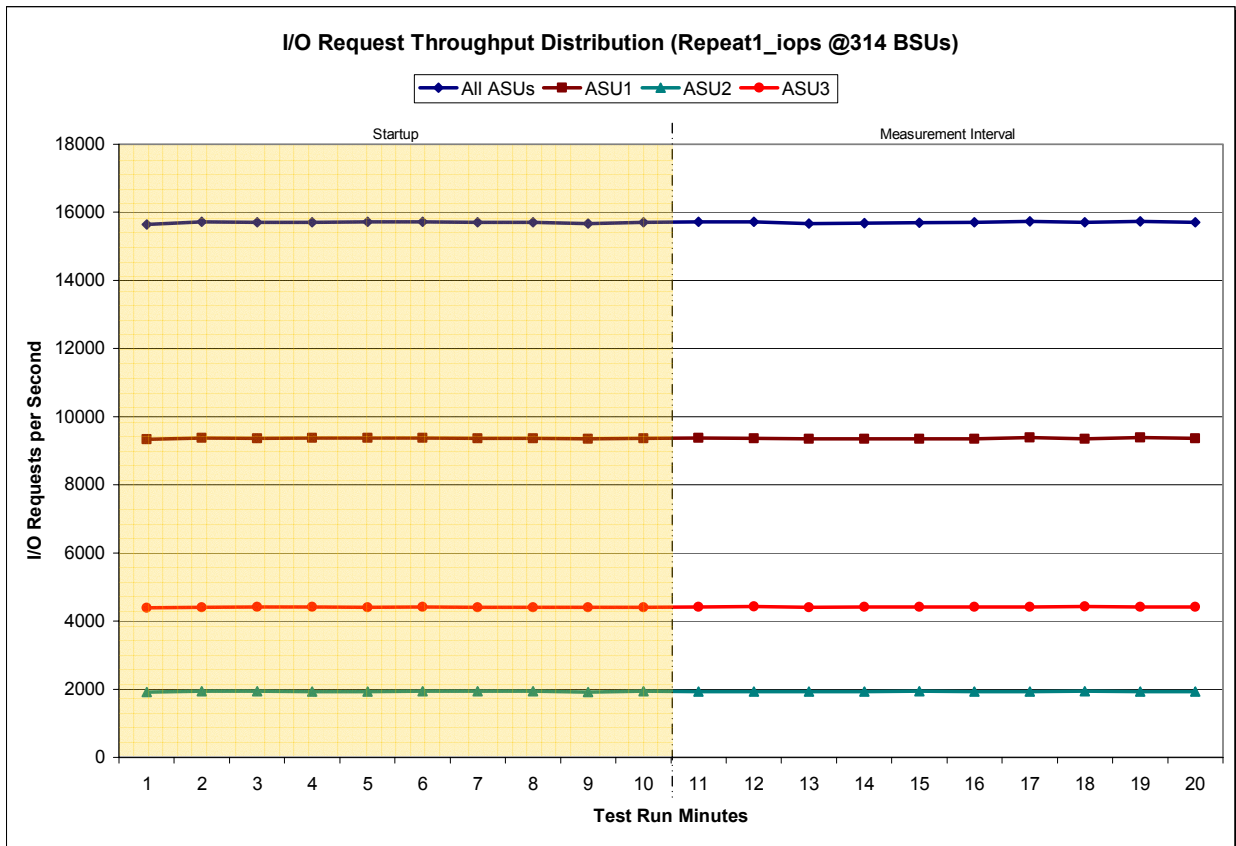
[Repeatability Test Run 2 \(LRT\)](#)

[Repeatability Test Run 2 \(IOPS\)](#)

I/O Request Throughput Distribution

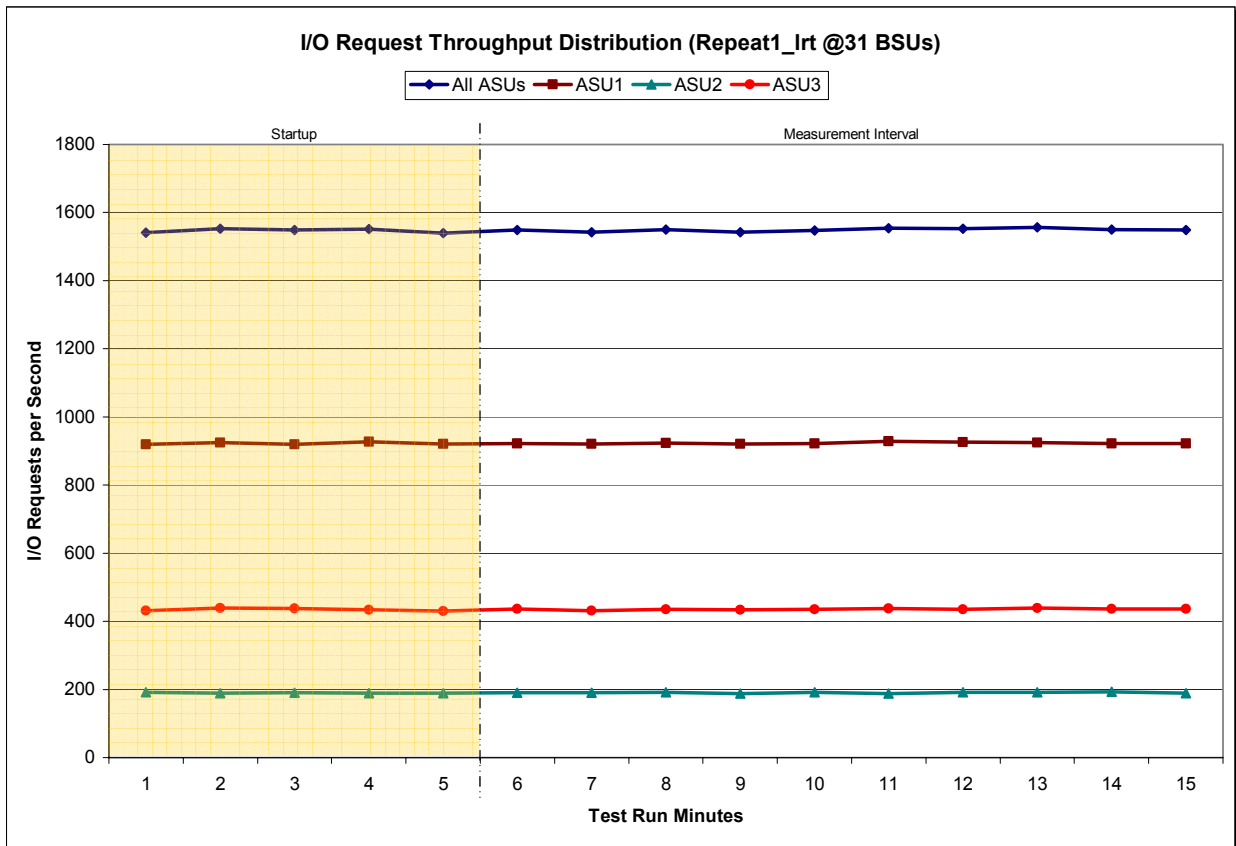
The Measurement Interval duration for each Repeatability Test Run was 10 minutes.

Repeatability IOPs Test Phase #1, IOPs chart:



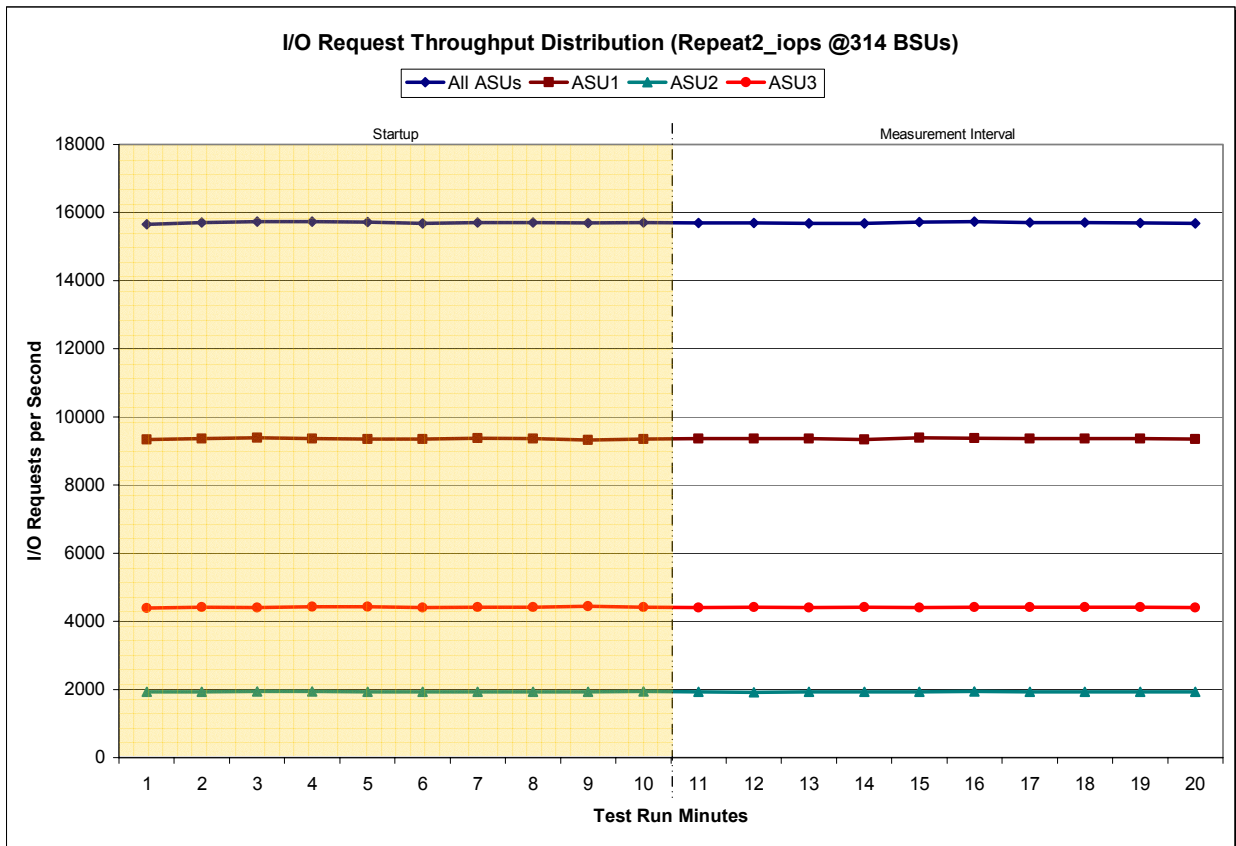
SPC-1 BENCHMARK EXECUTION RESULTS
REPEATABILITY TEST

Repeatability LRT Test Phase #1, IOPs chart:



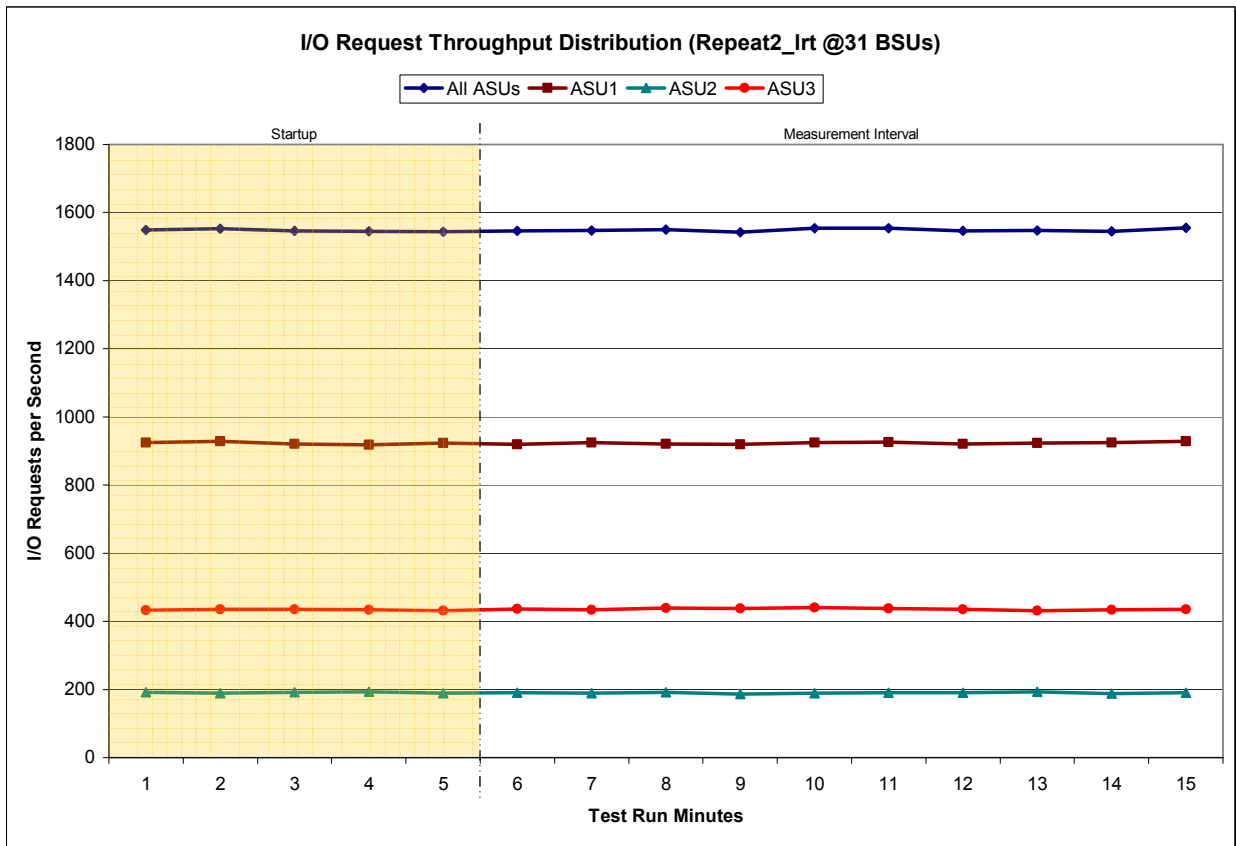
SPC-1 BENCHMARK EXECUTION RESULTS
REPEATABILITY TEST

Repeatability IOPs Test Phase #2, IOPs chart:



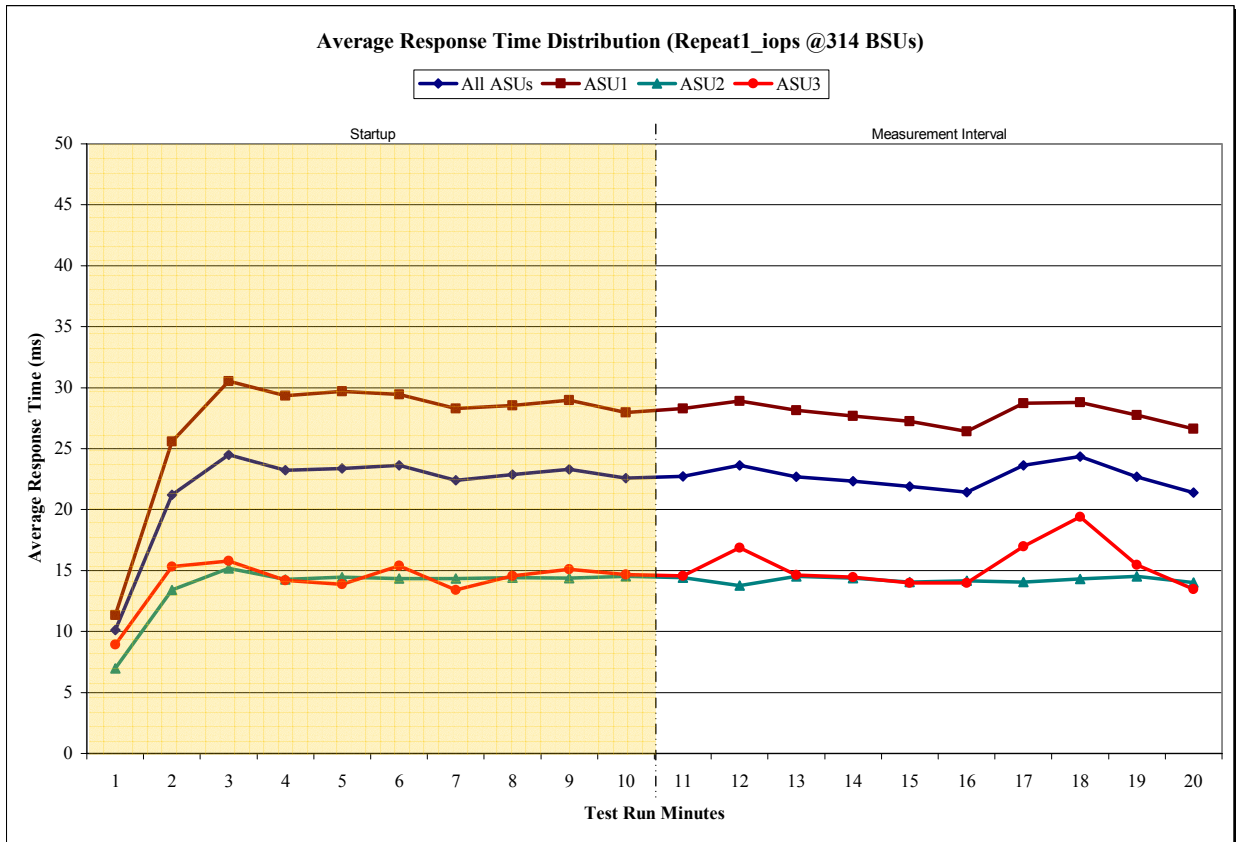
SPC-1 BENCHMARK EXECUTION RESULTS
REPEATABILITY TEST

Repeatability LRT Test Phase #2, IOPs chart:



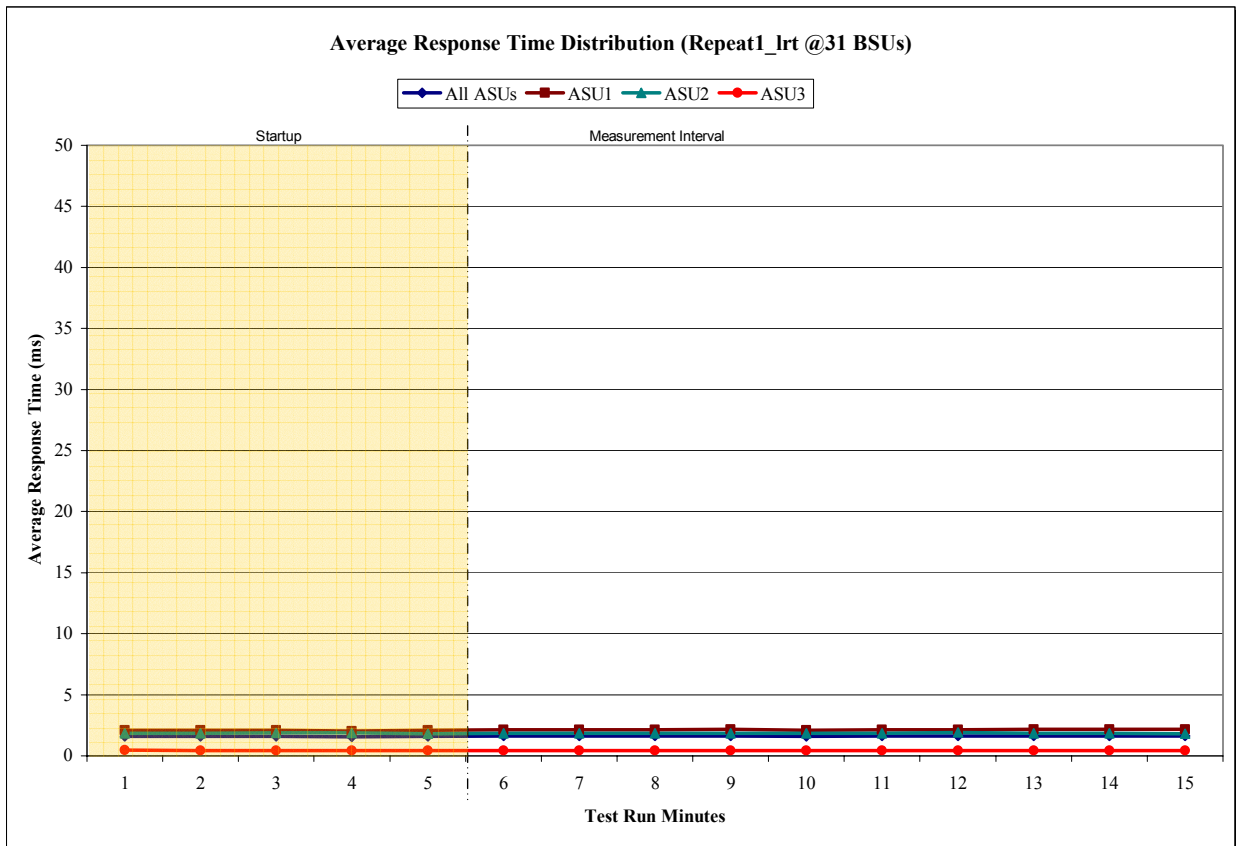
Average Response Time Distribution

The Measurement Interval duration for each Repeatability Test Run was 10 minutes.
Repeatability IOPs Test Phase #1, Average Response Time chart:



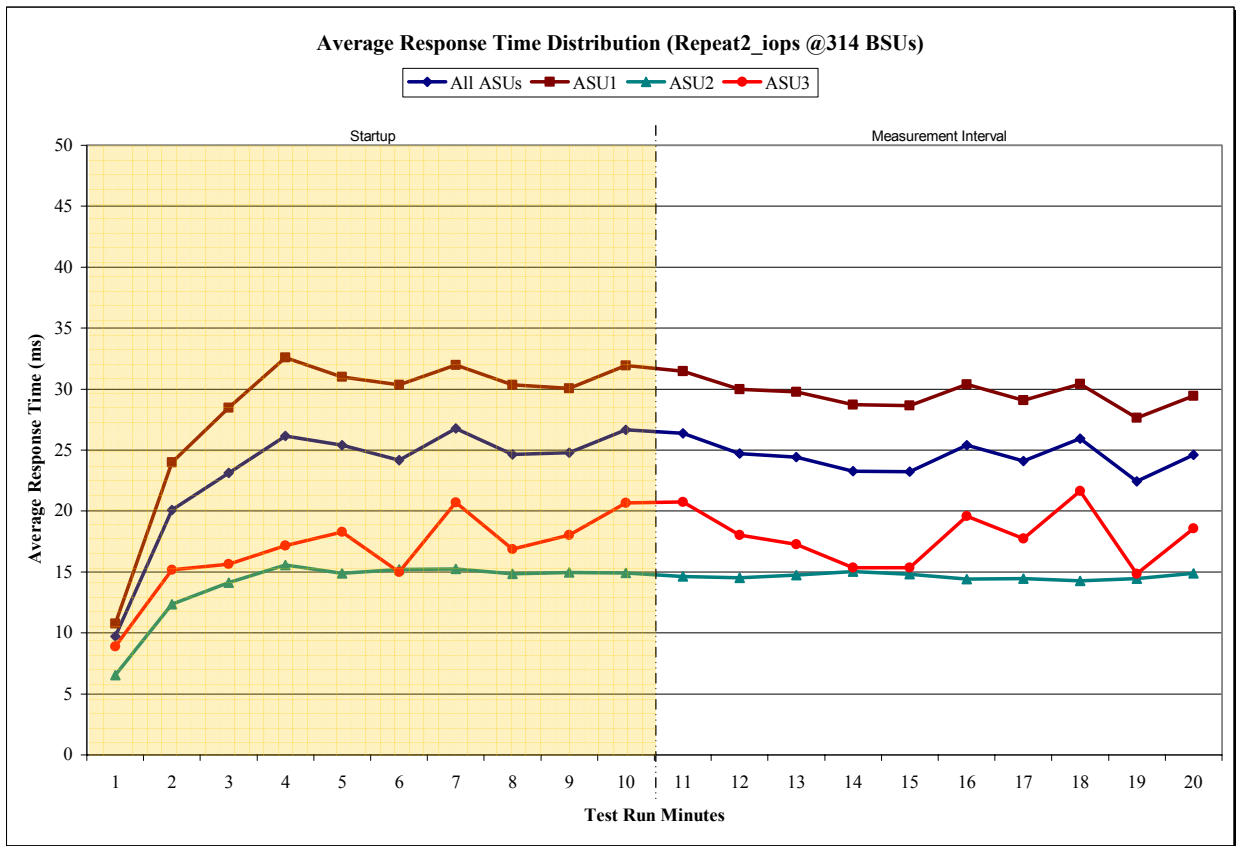
SPC-1 BENCHMARK EXECUTION RESULTS
REPEATABILITY TEST

Repeatability LRT Test Phase #1, Average Response Time chart:

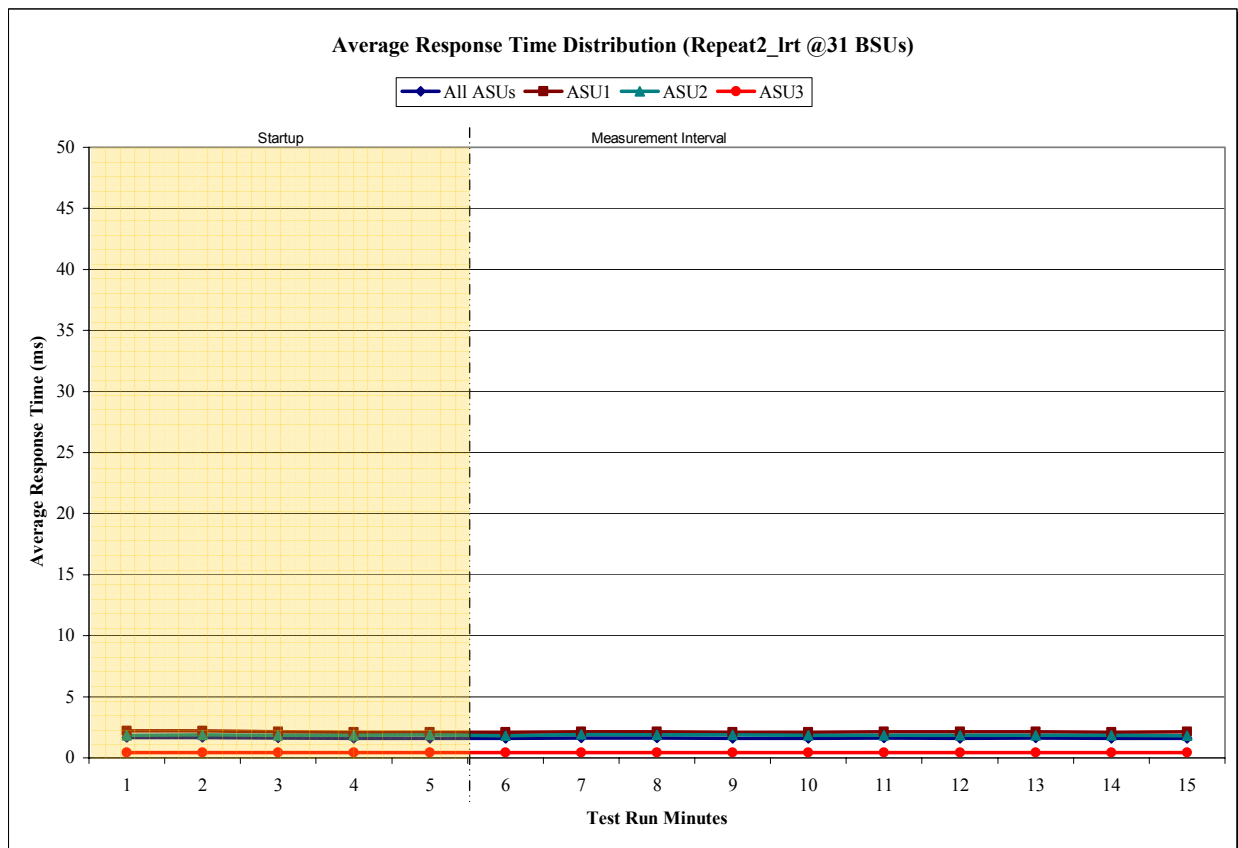


SPC-1 BENCHMARK EXECUTION RESULTS
REPEATABILITY TEST

Repeatability IOPs Test Phase #2, Average Response Time chart:



Repeatability LRT Test Phase #2, Average Response Time chart:



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
<i>IM</i>	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
<i>MIM</i>	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
<i>COV</i>	0.008	0.003	0.003	0.002	0.006	0.004	0.005	0.002

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.

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%.

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

SPC-1 BENCHMARK EXECUTION RESULTS
 REPEATABILITY TEST

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
<i>IM</i>	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
MIM	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
COV	0.012	0.006	0.012	0.007	0.027	0.008	0.017	0.005

Repeatability 2 (IOPS)

Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
MIM	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
COV	0.004	0.002	0.003	0.002	0.007	0.004	0.006	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
<i>IM</i>	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
MIM	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
COV	0.018	0.007	0.015	0.006	0.015	0.015	0.015	0.006

DATA PERSISTENCE TEST

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.

SPC-1 Workload Generator Input Parameters

The Data Persistence test, phase #1, was run from a single host command file. The following host command was used to start this test phase:

```
java -Xmx64m spc1 -fpersist1.parm -nk -oaudit\persist\output.persist1
```

A link to the SPC-1 Workload Generator input parameters for the Data Persistence Test phase #1 is listed below.

[Input Parameters \(Persistence 1\)](#)

The Data Persistence test, phase #2, was run from a single host command file. The following host command was used to start this test phase:

```
java -Xmx64m spc1 -fpersist2.parm -nk -oaudit\persist\output.persist2
```

A link to the SPC-1 Workload Generator input parameters for the Data Persistence Test phase #2 is listed below.

[Input Parameters \(Persistence 2\)](#)

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	37,440,000
Total Number of Logical Blocks Verified	26,110,624
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10:00
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

TESTED STORAGE CONFIGURATION (TSC) AVAILABILITY DATE

The LSI E4600 Fibre Channel Storage System, as documented in this Full Disclosure Report has been available for shipment to customers since October 1, 2001.

PRICING INFORMATION

Pricing information may found in the Tested Storage Configuration Pricing section on page 11.

ANOMALIES OR IRREGULARITIES

There were no anomalies or irregularities observed during the course of the benchmark measurement.