



SPC BENCHMARK 1™
FULL DISCLOSURE REPORT
DELL COMPUTER CORPORATION
PERC3/QC SCSI RAID CONTROLLER

SPC-1 V1.4

Submitted for Review
June 19, 2002

First Edition – June 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.

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AUDIT CERTIFICATION



Test Sponsor: Dell Computer Corporation
One Dell Way
Round Rock, TX 78682

June 18, 2002

The SPC Benchmark 1™ measurement for the Dell PERC3/QC SCSI RAID Controller and the results listed below successfully completed the SPC Benchmark 1™ Remote Audit requirements.

SPC-1 Results	
Tested Storage Configuration (TSC) Name: PERC3/QC SCSI RAID Controller	
Metric	Reported Result
SPC-1 IOPS™	7,650.40
SPC-1 Price-Performance	\$4.48/SPC-1 IOPS™
Total ASU Capacity	440.0 GB
Data Protection Level	Mirroring
SPC-1 LRT™	3.10 ms
Total TSC Price (including three-year maintenance)	\$34,241.00

The following Remote Audit requirements were completed:

- A signed Letter of Good Faith was submitted.
- All Test Results and Summary Results files were submitted and verified as authentic.
- The Persistence Test Results files were submitted and verified as authentic.
- The Full Disclosure Report meets all of the requirements for completeness.

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

Audit Notes:

The Measurement Interval parameter value submitted to the Workload Generator for each Test Run was one minute greater than required by the specification. That additional one-minute interval was excluded from the reported Measurement Interval when generating the Summary Results file and treated as part of the Ramp-Down period for each Test Run. That action resulted in a compliant Measurement Interval for each Test Run and had no other impact on the benchmark measurement.

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

FAXSR: A Fax was received on 06/07/02 at 11:07:33 AM Page 1
JUN. 6. 2002 11:13PM

NO.369 P.1/1

Dell Computer Corporation Telephone 512.338.4400
One Dell Way Telefax 512.728.3653
Round Rock, TX 78682 www.dell.com



Date: May 28, 2002

To: Walter E. Baker (SPC Administrator)

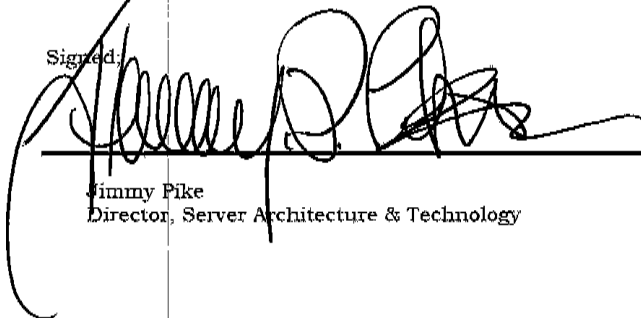
Subject: Letter of Good Faith for the SPC Benchmark-1™ results published on the Perc3/QC Configuration.

This Letter of Good Faith between Dell Computer Corporation ("hereafter known as the Test Sponsor") and the Storage Performance Council (hereafter know 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 Perc3/QC 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 Perc3/QC Configuration is authentic and accurate.
3. The Perc3/QC 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 Perc3/QC 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:

Date


6/8/2002

Jimmy Pike
Director, Server Architecture & Technology

EXECUTIVE SUMMARY**Test Sponsor and Contact Information**

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Dell Computer Corporation – http://www.dell.com/ James Jordan – James_Jordan@dell.com Mailing Address : Enterprise Storage Systems 1 Dell Way Round Rock, TX 78682 Phone: (512) 728-0986 FAX: (512)283-9483
Test Sponsor Alternate Contact	Dell Computer Corporation – http://www.dell.com/ Mike Molloy – Mike_Molloy@dell.com Mailing Address : Enterprise Storage Systems One Dell Way Round Rock, TX 78682 Phone: (512) 723-3525 FAX: (512)283-9483
Test Sponsor Alternate Contact	Dell Computer Corporation – http://www.dell.com/ Serdar Acir– Serdar_Acir@dell.com Mailing Address : RR5 Bldg. One Dell Way Round Rock, TX 78682 Phone: (512) 723-3525 FAX: (512)283-9483
Auditor	Storage Performance Council www.storageperformance.org Walter E. Baker 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	June 19, 2002
Date FDR was submitted to the SPC	June 19, 2002
Date the TSC is/was available for shipment to customers	March 01, 2001
Date the TSC completed audit certification	June 18, 2002

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: PERC3/QC SCSI RAID Controller	
Metric	Reported Result
SPC-1 IOPS ^Ô	7650.40
SPC-1 Price-Performance	4.48 \$/SPC-1 IOPS TM
Total ASU Capacity	440 .0 GB
Data Protection Level	Mirroring
SPC-1 LRT ^Ô	3.10ms
Total TSC Price (including three-year maintenance)	34,241.00\$

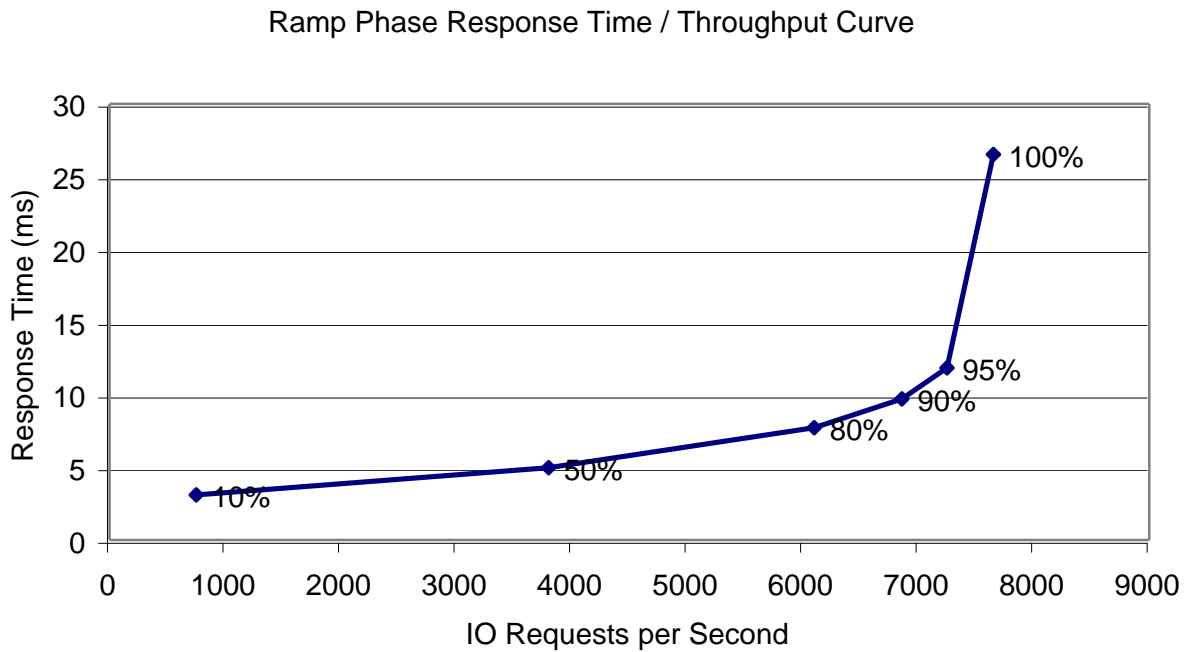
SPC-1 IOPSTM represents the maximum I/O Request Throughput at the 100% load point.

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* has two or more identical copies of user data maintained on separate disks.

The **SPC-1 LRTTM** metric is the Average Response Time measured at the 10% load point, as illustrated on the next page. SPC-1 LRTTM 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

Performance (IOPS)	Perc3/QC SCSI RAID Controller	Dell Computer Corporation
\$7,649.00		Report Date 5/28/2002
Price / Performance (\$/IOPS)	Price	Availability Date
\$4.48	\$34,241	5/28/2002

Description	Part No.	Vendor	Reference Price	Quantity	Extended Price	3 Yr Maintenance Price
Controller Hardware:						
CONTROLLER: PERC3-QC,128MB,4-CH,PE24/44/6X00.CUS <i>Quad channel 64 bit/ 66 Mhz SCSI RAID controller. Supports 4 PV22xS drive enclosures up to 56 drives. 4 Terabyte storage capacity possible. Uses one PCI slot.</i>	340-4207	1	\$2,049	1	\$2,049	
MAINT: 3Yrs SILVER 4Hr,DL,UNY On-Site initial year	900-6810	1	\$483	1		\$483
MAINT: 3Yrs SILVER 4Hr,DL,UNY On-Site two years	900-6352	1	\$799	1		\$799
					Storage Hardware Subtotal	\$3,331
					Dell Discount (11%)	\$366
Storage Hardware:						
SYSTEM: PowerVault 221S,3U,14HDD,U160 Tower <i>U160 drive enclosure supporting upto 14 drives. Redundant power supply and EMM options.</i>	220-4477	1	\$1,563	4	\$6,252	
CTRL: ZEMM,U160,PV22XS,SINGLE, Not Clusterable	340-3089	1	\$399	4	\$1,596	

EXECUTIVE SUMMARY

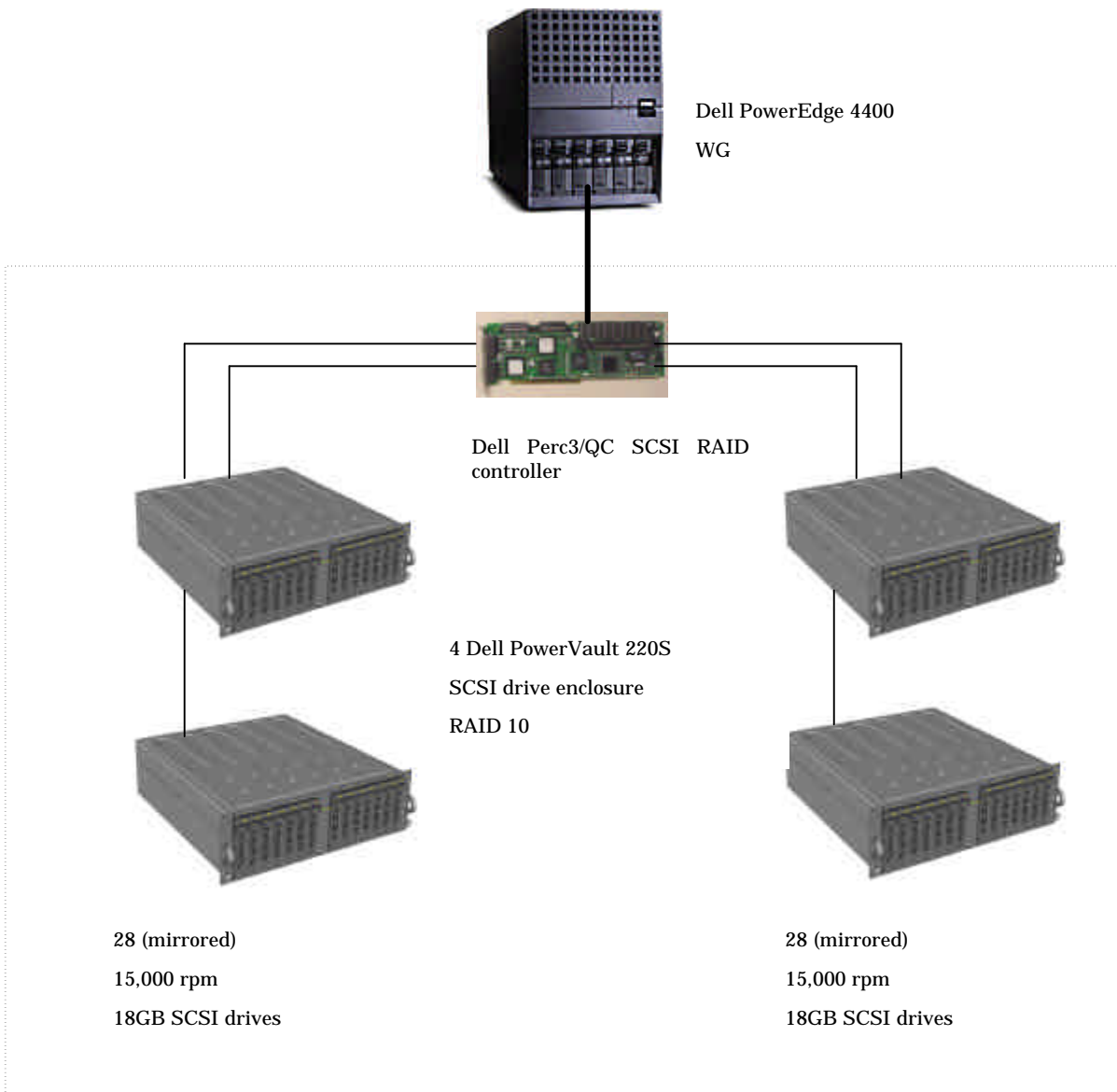
POWER: 600W,PWR SPLY,PV22XS	310-0683	1	\$89	4	\$356	
DISK: 18GB,U160,SCSI,1IN 15K	340-3087	1	\$399	56	\$22,344	
CBL: 2X4M,CBL,PERC/39160,68P	310-0679	1	\$99	2	\$198	
MAINT: 3Yrs SILVER 4Hr,DL,UNY On-Site initial year	900-6790	1	\$480	4		\$1,920
MAINT: 3Yrs SILVER 4Hr,DL,UNY On-Site two years	900-6792	1	\$619	4		\$2,476
					Storage Hardware Subtotal	\$35,142
					Dell Discount (11%)	\$3,866
					TOTAL	\$38,473
					Dell Discounts	\$4,232
Three Year Ownership	Cost	of	\$34,241			

Vendor List

1 - DELL

Benchmark Configuration/Tested Storage Configuration Diagram

Dell PERC3/QC SCSI RAID Controller



Host System	Storage System
Dell Power Edge 4400	Perc3/QC SCSI RAID Controller
UID=HS-PE4400	UID=SC-Perc3/QC
2 x 733MHz Pentium III	128MB
2GB RAM	Ultra3
Windows 2K	4 back-end PowerVault220S SCSI Enclosure
Ultra3	56 x 18GB 15Krpm hard drives
1 64-bit/66MHz PCI slot	

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
Total ASU Capacity	Gigabytes (GB)	440.0
Addressable Storage Capacity	Gigabytes (GB)	515.2
Configured Storage Capacity	Gigabytes (GB)	1030.4
Physical Storage Capacity	Gigabytes (GB)	1030.4

Logical Volume Capacity and ASU Mapping

Logical Volume Capacity and Mapping		
ASU-1 (198GB)	ASU-2 (198GB)	ASU-3 (44GB)
<i>LV_0 = 239.2GB</i>	<i>LV_! = 202.4GB</i>	<i>LV_3 = 73.6GB</i>
<i>ASU1_1 = 198GB</i>	<i>ASU2_1 = 198GB</i>	<i>ASU3_1 = 44GB</i>

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.

CONFIGURATION INFORMATION

Tuning Parameters and Options

The value for each customer-tunable parameter that has been altered from its default value for all components of the Benchmark Configuration (BC). Those customer-tunable parameters include but are not limited to:

- *Operating system and application configuration parameters.*

Default values used.

- *Array controller options.*

No readahead and write-back cache.

- *HBA options*

Default values used.

- *Options for each component in a network used to connect storage to the Host System(s).*

Default values used.

Tested Storage Configuration (TSC)

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.

All other components of the TSC used their default values.

Benchmark Configuration (BC)

All scripts and/or commands used to configure the BC to support the TSC and SPC-1 Workload Generator.

No configuration change.

Host System(s) Configuration

A description of the configuration and features of each Host System in the BC that executes the SPC-1 Workload Generator.

The Host System configuration is description in the **Benchmark Configuration/Tested Storage Configuration Diagram** section (*page 14*) of this document.

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 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.

SPC-1 Workload Generator Input Parameters

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

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

Sustainability Test Results File

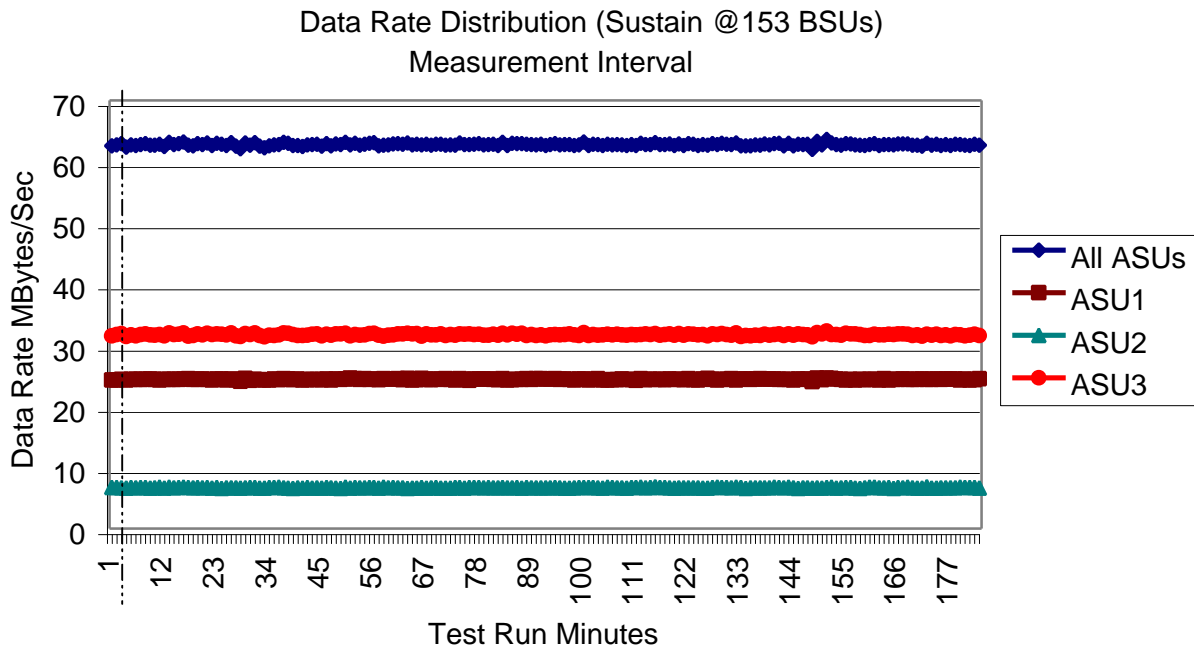
A link to the test results file generated from the Sustainability Test Run is listed below.

[Sustainability Test Results File](#)

Sustainability - Data Rate Distribution

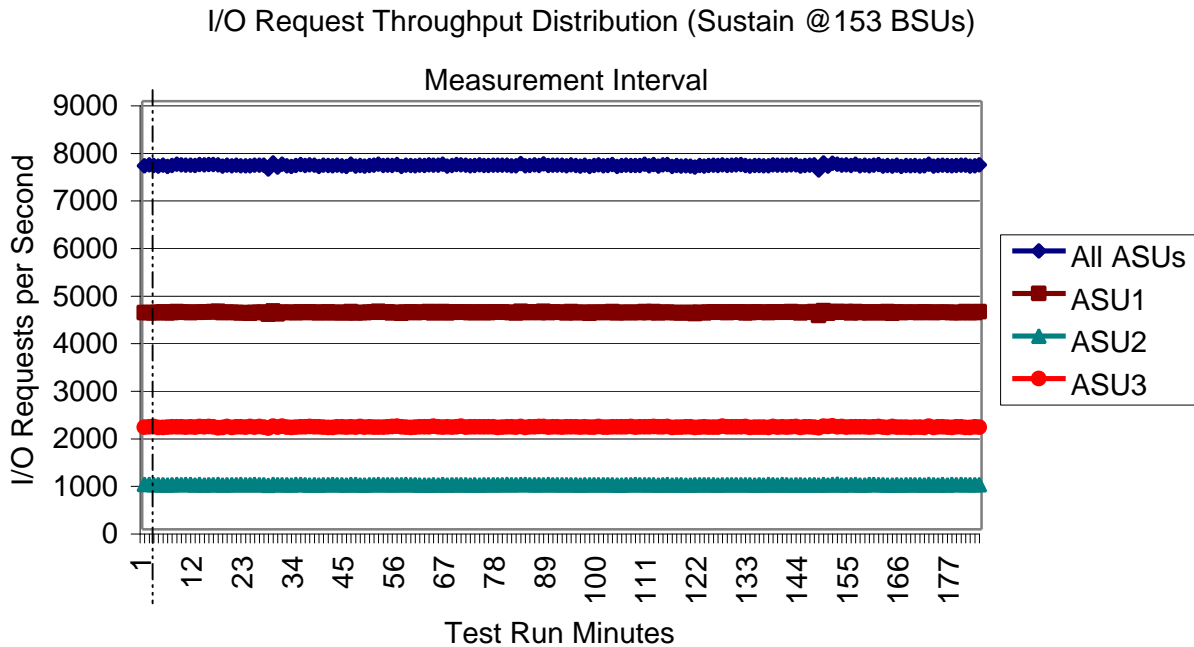
The Measurement Interval duration for the Sustainability Test Run was 181 minutes. The actual analysis period was 180 minutes. (Test Run Minutes 3-182).

Data Rate Distribution – Sustainability Test Run



Sustainability - I/O Request Throughput Distribution

The Measurement Interval duration for the Sustainability Test Run was 181 minutes. The actual analysis period was 180 minutes. (Test Run Minutes 3 – 182).



I/O Request Throughput Distribution – Sustainability Test Run

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	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00

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: This 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

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

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

IOPS Test Results File

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

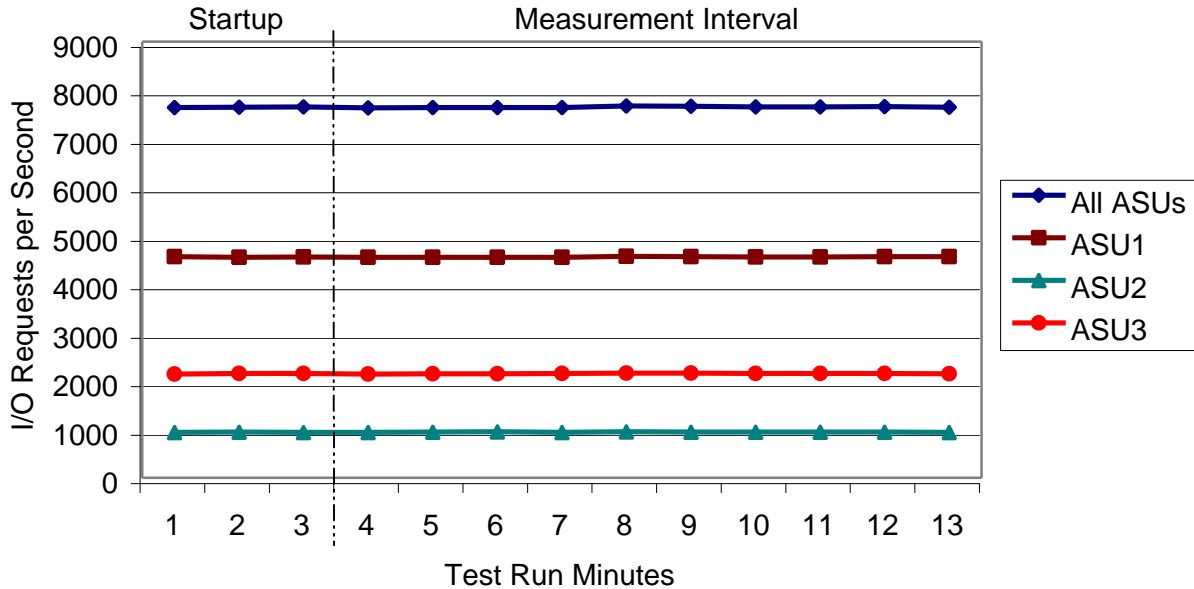
[IOPS Test Results File](#)

IOPS Test Run - I/O Request Throughput Distribution

The Measurement Interval duration for the IOPS Test Run was 11 minutes. The actual analysis period was 10 minutes. (Test Run Minutes 3-12).

I/O Request Throughput Distribution – 100% Load Level

I/O Request Throughput Distribution (Ramp_100 @153 BSUs)

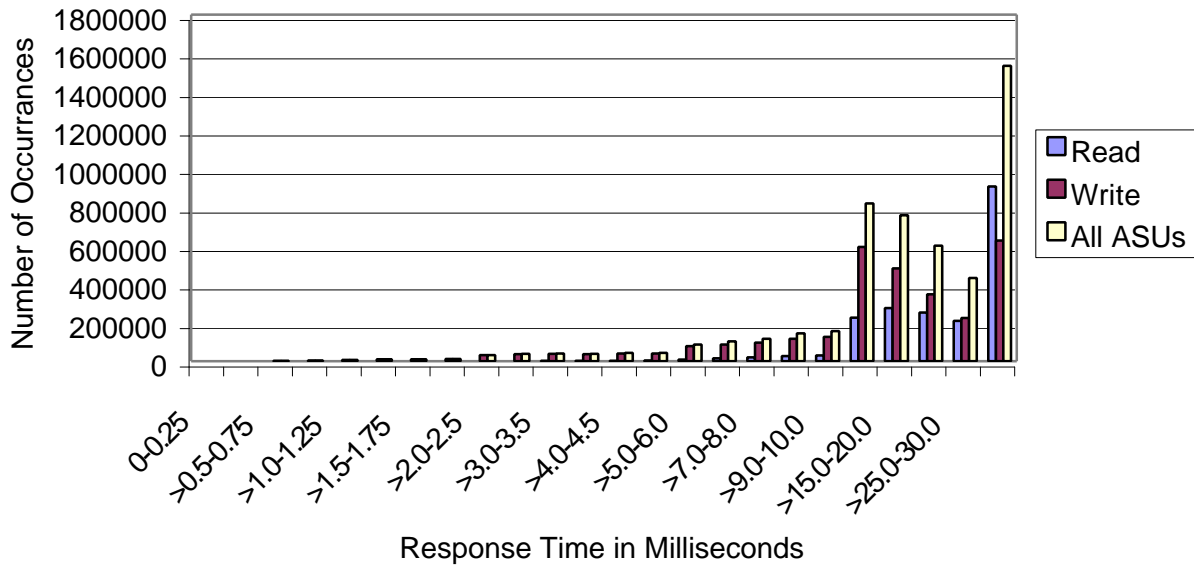


IOPS Test Run –Response Time Frequency Distribution

The Measurement Interval duration for the IOPS Test Run was 11 minutes. The actual analysis period was 10 minutes. (Test Run Minutes 3 – 12).

Response Time Frequency Distribution – 100% Load Level Test Run

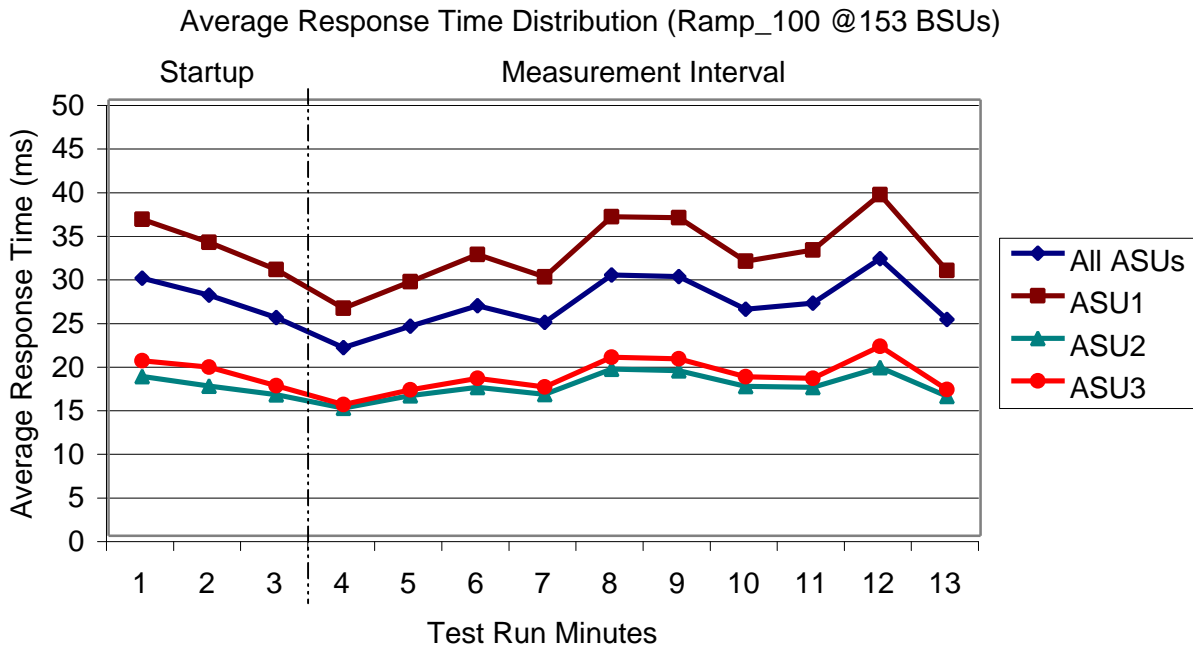
Response Time Frequency Distribution (Ramp_100 @153 BSUs)



IOPS Test Run – Average Response Time Distribution

The Measurement Interval duration for the IOPS Test Run was 11 minutes. The actual analysis period was 10 minutes. (Test Run Minutes 3 – 12).

Average Response Time Distribution – 100% Load Level Test Run



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval (10 min)	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
5025627	3490986	1534641

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	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00

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: This 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 11.

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

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

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

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](#)

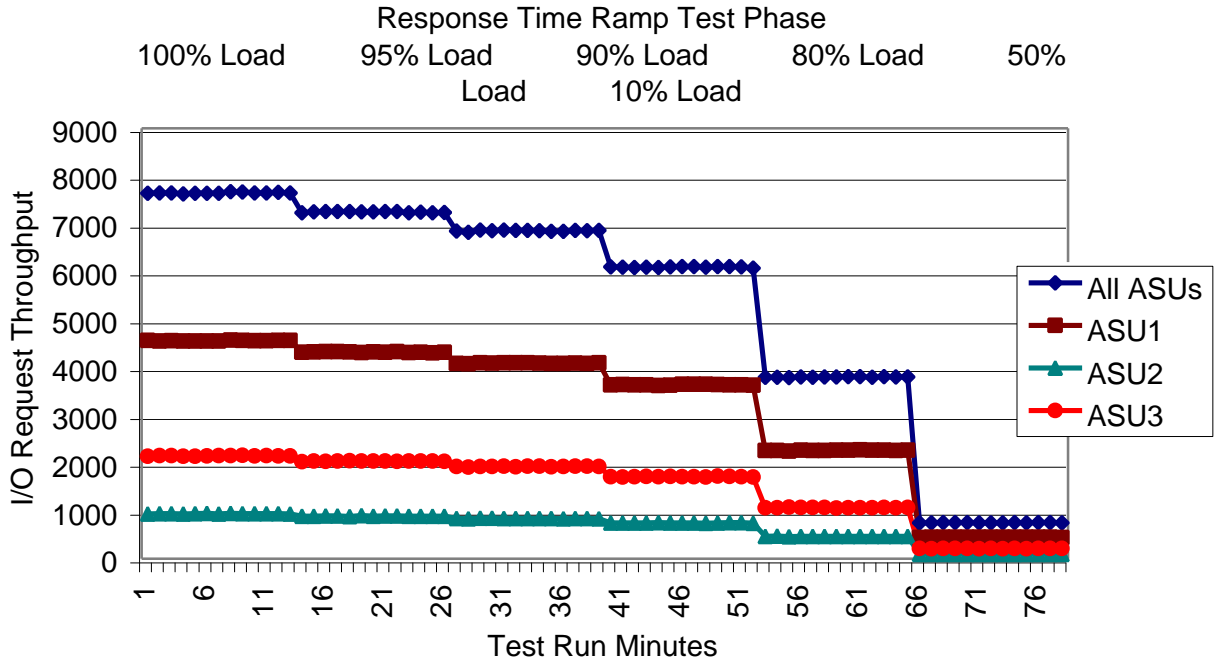
[80% Load Level](#)

[50% Load Level](#)

[10% Load Level](#)

Response Time Ramp Distribution (IOPS)

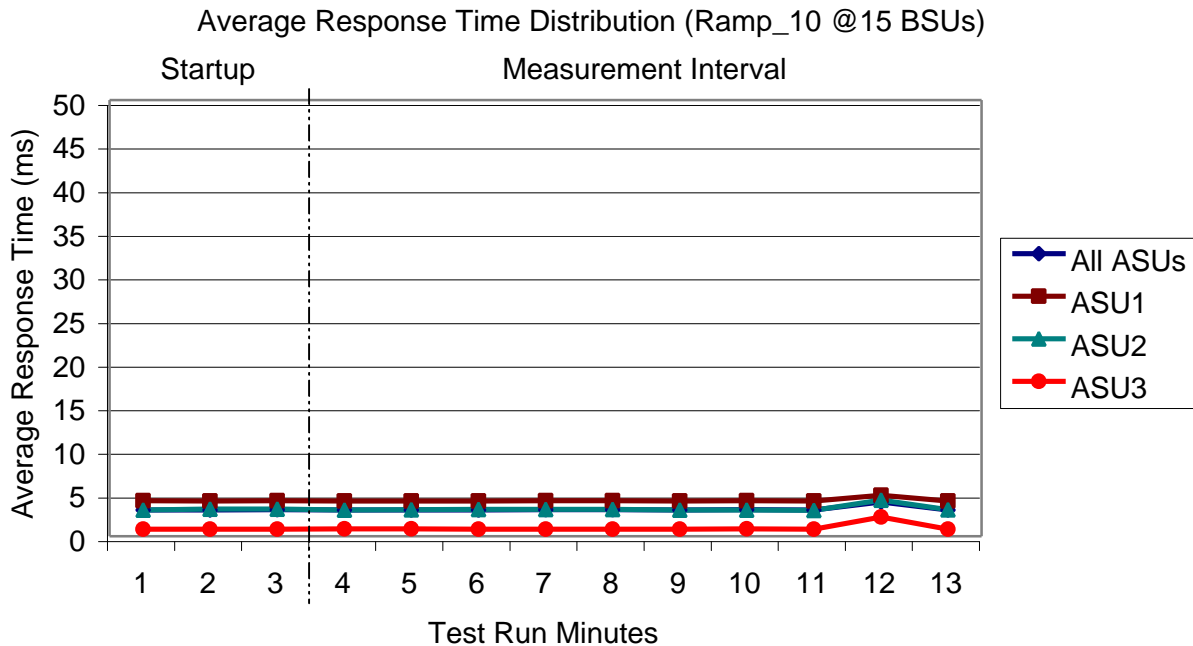
100%, 95% 90%, 80%, 50% and 10% IOPS Results



SPC-1 LRT™ Average Response Time Distribution

The Measurement Interval duration for the LRT (10%) Response Time Ramp Test Run was 10 minutes. The actual analysis period was 10 minutes. (Test Run Minutes 3 – 12).

Average Response Time Distribution – SPC-1 LRT™ (10% Load Level)



SPC-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	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
MIM	0.036	0.282	0.070	0.211	0.018	0.070	0.035	0.280
COV	0.03	0.01	0.02	0.01	0.04	0.01	0.02	0.01

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: This 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

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

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

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	7650.40	3.1
Repeatability Test Phase 1	7646.70	3.0
Repeatability Test Phase 2	7645.70	3.0

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

[Repeatability Test Phase 1, Test Run 1, 10% Load Level \(LRT\)](#)

[Repeatability Test Phase 1, Test Run 2, 100% Load Level \(IOPS\)](#)

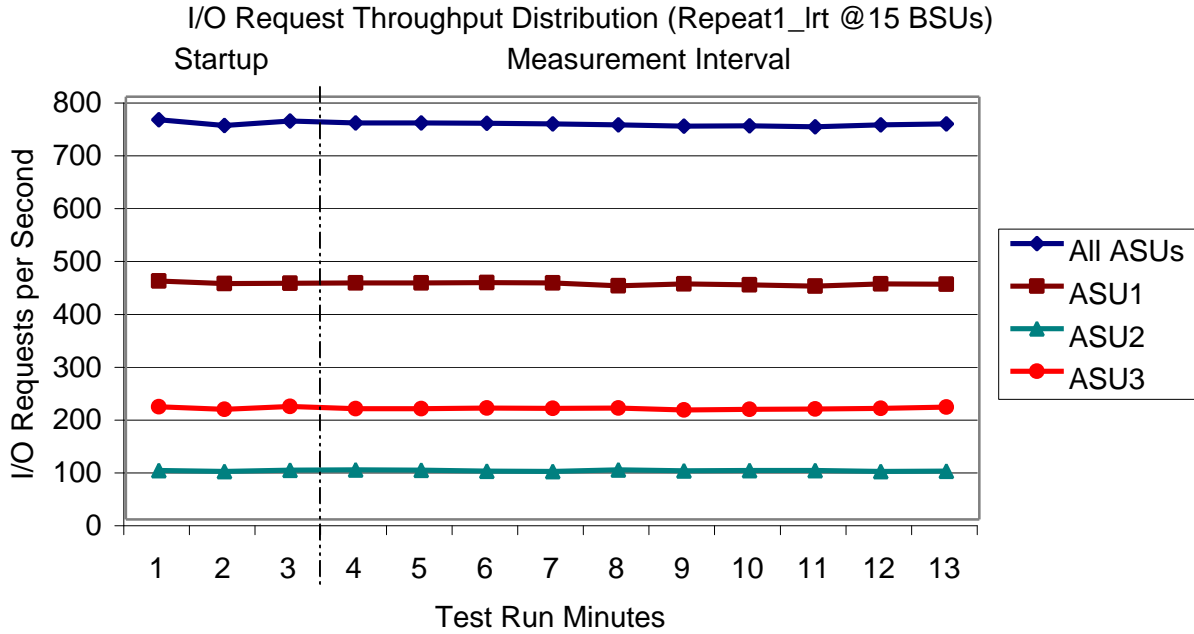
[Repeatability Test Phase 2, Test Run 1, 10% Load Level \(LRT\)](#)

[Repeatability Test Phase 2, Test Run 2, 100% Load Level \(IOPS\)](#)

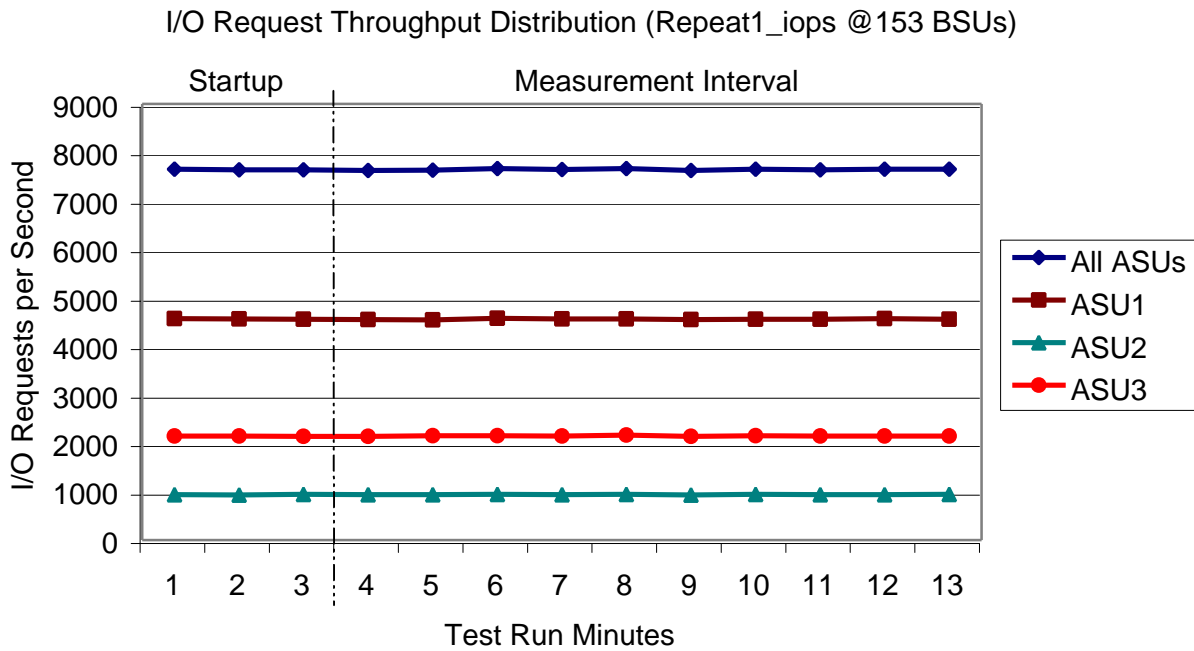
I/O Request Throughput Distribution

The Measurement Interval duration for each Repeatability Test Run was 11 minutes. The actual analysis period was 10 minutes. (Test Run Minutes 3– 12).

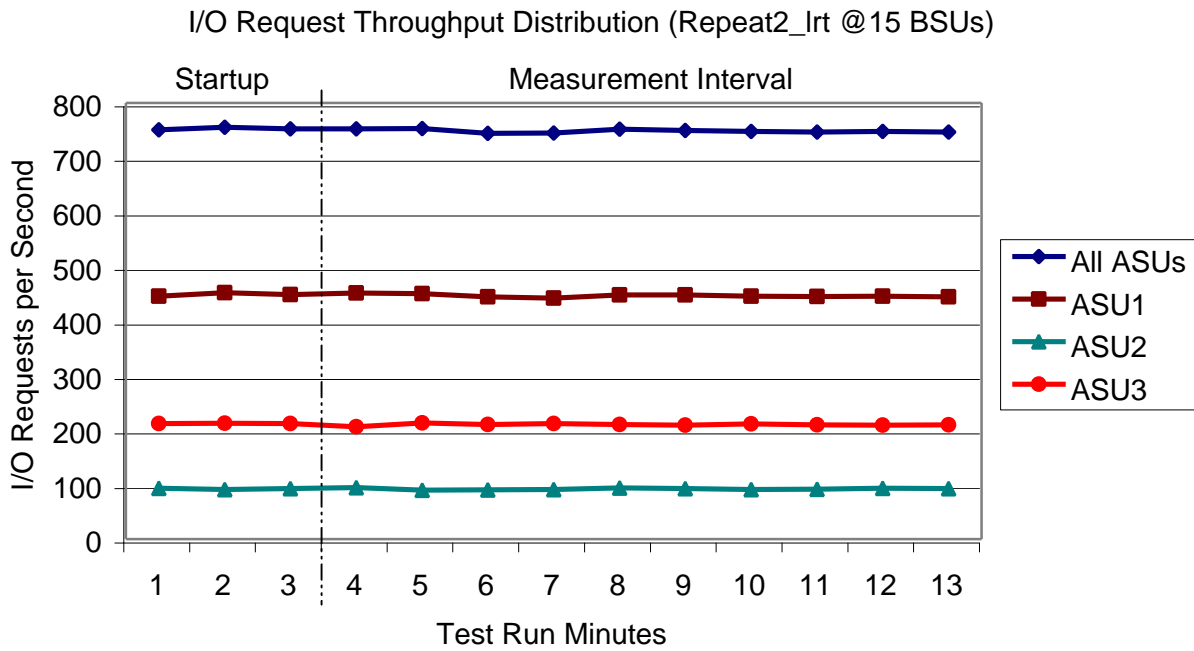
I/O Request Throughput Distribution – Repeatability Test Run 1, 10% Load Level



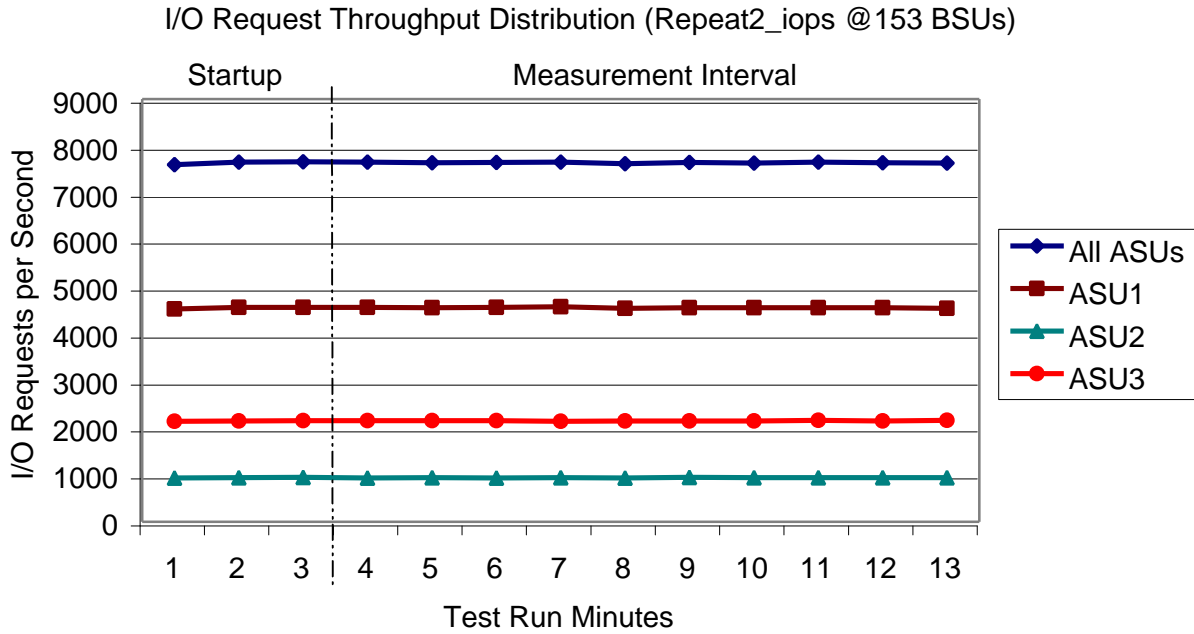
I/O Request Throughput Distribution – Repeatability Test Run 1, 100% Load Level



I/O Request Throughput Distribution – Repeatability Test Run 2, 10% Load Level



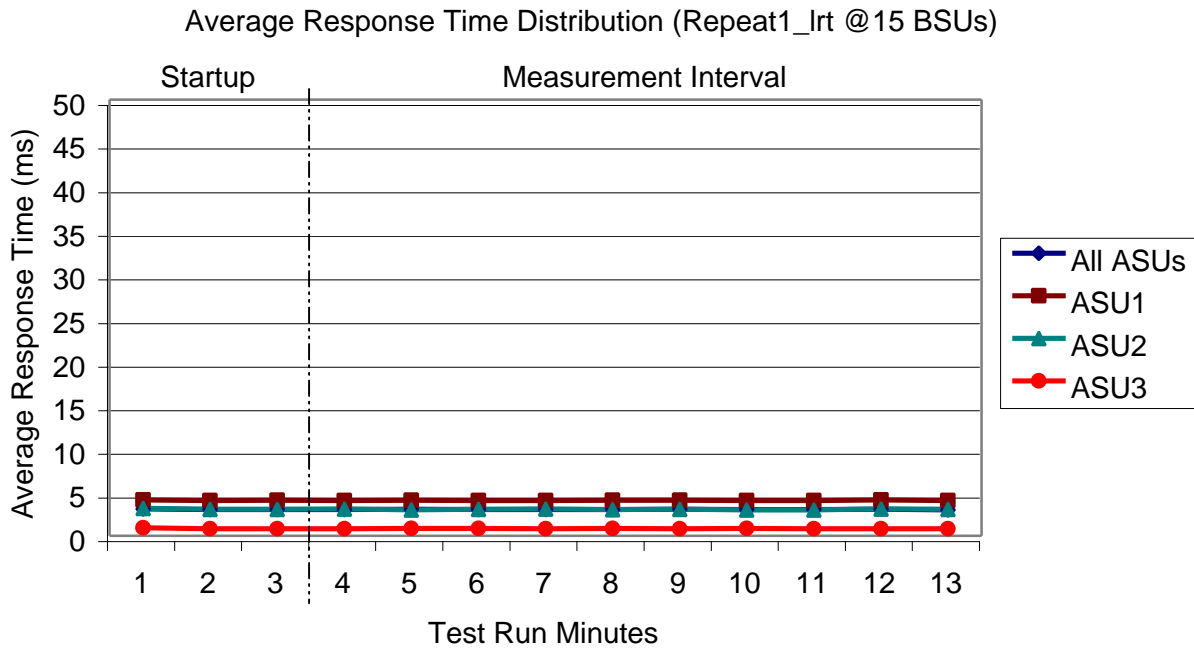
I/O Request Throughput Distribution – Repeatability Test Run 2, 100% Load Level



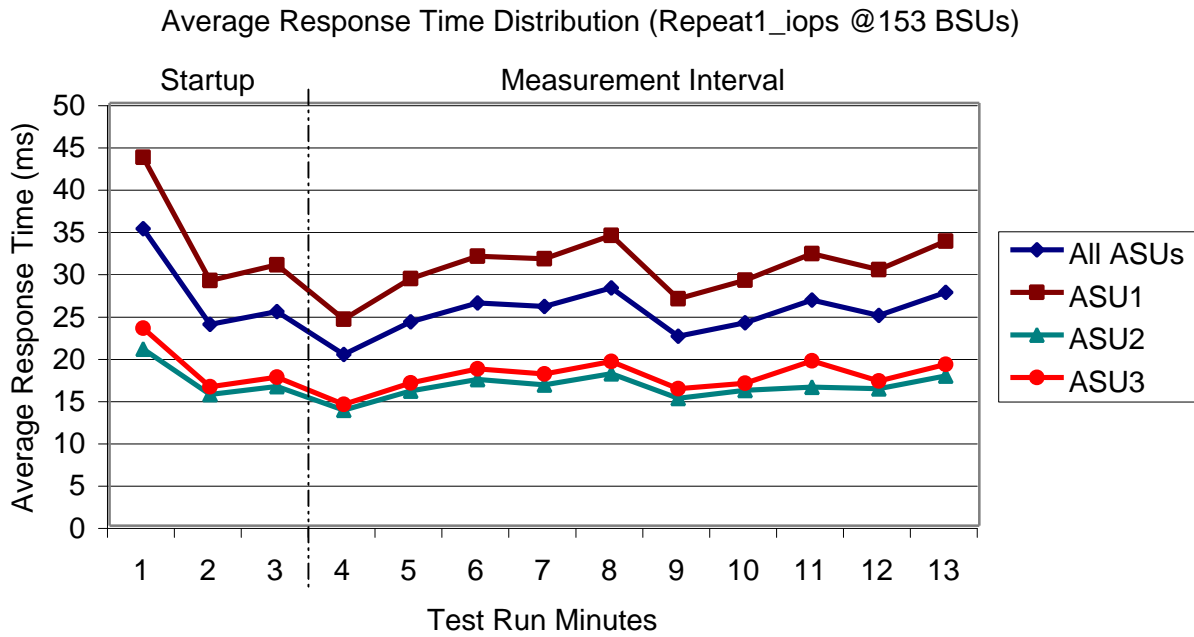
Average Response Time Distribution

The Measurement Interval duration for each Repeatability Test Run was 11 minutes. The actual analysis period was 10 minutes. (Test Run Minutes 3 – 12).

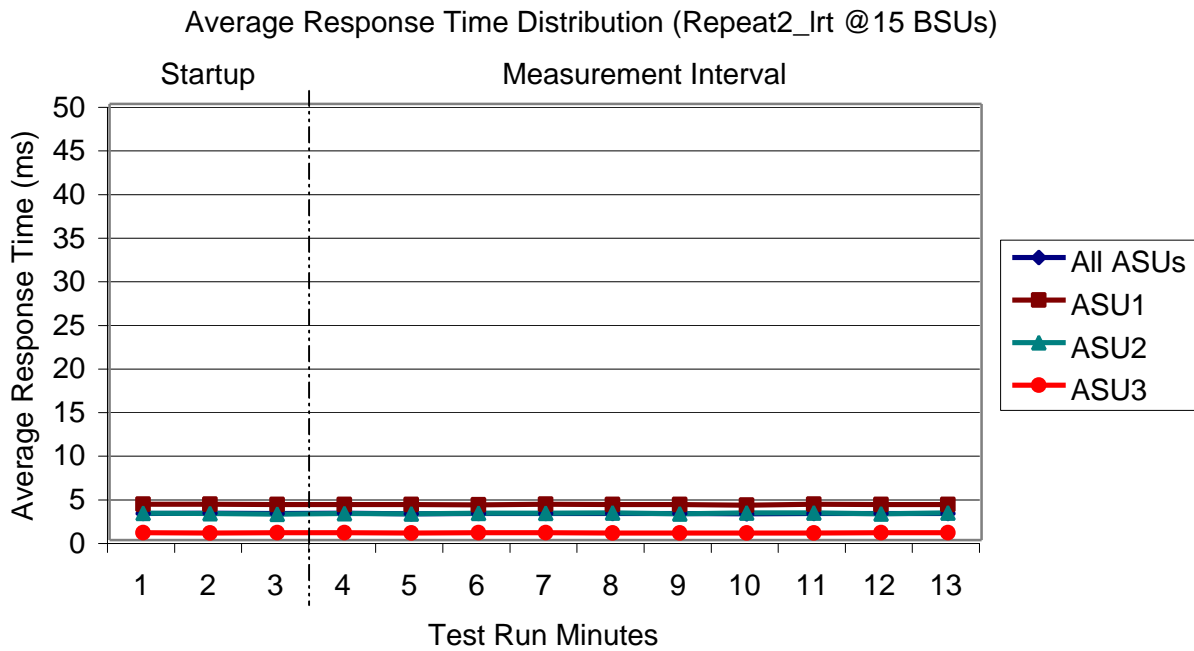
Average Response Time Distribution – Repeatability Test Run 1, 10% Load Level



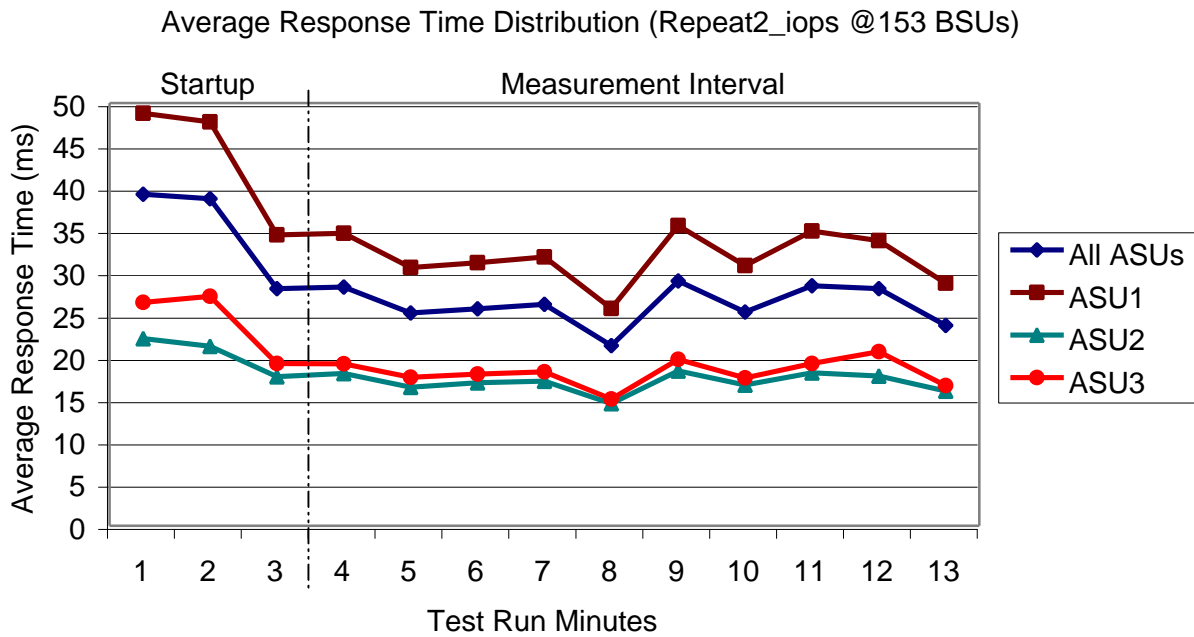
Average Response Time Distribution – Repeatability Test Run 1, 100% Load Level



Average Response Time Distribution – Repeatability Test Run 2, 10% Load Level



Average Response Time Distribution – Repeatability Test Run 2, 100% Load Level



**Repeatability Test Run 1, 10% Load Level
 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	0.069	0.211	0.018	0.071	0.035	0.281
COV	0.03	0.01	0.01	0.01	0.03	0.03	0.02	0.01

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: This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.

**Repeatability Test Run 1, 100% Load Level
 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	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00

**Repeatability Test Run 2, 10% Load Level
 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	0.209	0.018	0.070	0.035	0.281
COV	0.02	0.01	0.02	0.01	0.03	0.02	0.03	0.01

**Repeatability Test Run 2, 100% Load Level
 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	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00

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

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

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

[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	3857642
Total Number of Logical Blocks Verified	3024317
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

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.

TESTED STORAGE CONFIGURATION (TSC) AVAILABILITY DATE

The PERC3/QC RAID Controller as documented in this Full Disclosure Report is available for shipment to customers since *March 01, 2001*.

PRICING INFORMATION

Pricing information may found in the Tested Storage Configuration Pricing section on page 12.

ANOMALIES OR IRREGULARITIES

The Measurement Interval parameter value submitted to the Workload Generator for each Test Run was one minute greater than required by the specification. That additional one-minute interval was excluded from the reported Measurement Interval when generating the Summary Results file and treated as part of the Ramp-Down period for each Test Run. That action resulted in a compliant Measurement Interval for each Test Run and had no other impact on the benchmark measurement.