



**SPC BENCHMARK1™
FULL DISCLOSURE REPORT**

**HEWLETT-PACKARD COMPANY
HP P10000 3PAR V800 STORAGE SYSTEM**

SPC-1™ V1.12

**Submitted for Review: October 17, 2011
Submission Identifier: A00109**

First Edition – October 2011

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AUDIT CERTIFICATION



Bill McCormack
Hewlett-Packard Company
4609 Technology Drive
Fremont, CA 94538

October 17, 2011

The SPC Benchmark 1™ Reported Data listed below for the HP P10000 3PAR V800 Storage System were produced in compliance with the SPC Benchmark 1™ v1.12 Onsite Audit requirements.

SPC Benchmark 1™ v1.12 Reported Data	
Tested Storage Product (TSP) Name: HP P10000 3PAR V800 Storage System	
Metric	Reported Result
SPC-1 IOPS™	450,212.66
SPC-1 Price-Performance	\$6.59/SPC-1 IOPS™
Total ASU Capacity	230,400.000 GB
Data Protection Level	Protected (<i>Mirroring</i>)
Total TSC Price (including three-year maintenance)	\$2,965,892

The following SPC Benchmark 1™ Onsite Audit requirements were reviewed and found compliant with 1.12 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and information supplied by Hewlett-Packard Company:
 - ✓ Physical Storage Capacity and requirements.
 - ✓ Configured Storage Capacity and requirements.
 - ✓ Addressable Storage Capacity and requirements.
 - ✓ Capacity of each Logical Volume and requirements.
 - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Physical verification of the components to match the above diagram.
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.

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AuditService@storageperformance.org
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AUDIT CERTIFICATION (CONT.)

HP P10000 3PAR V800 Storage System
SPC-1 Audit Certification

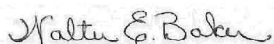
Page 2

- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by physical inspection and information supplied by Hewlett-Packard Company:
 - ✓ The type of Host System including the number of processors and main memory.
 - ✓ The presence and version number of the SPC-1 Workload Generator on the Host System.
 - ✓ The TSC boundary within the Host System.
- The execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from Hewlett-Packard Company 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 and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (*FDR*) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no items requiring audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH



Hewlett-Packard Company
4209 Technology Drive
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LETTER OF GOOD FAITH

Date: September 15, 2011

From: Peter Slocum
Vice President of Engineering
Hewlett Packard Company
4209 Technology Drive
Fremont, CA 94538

To: Walter E. Baker
SPC Administrator and Auditor
Gradient Systems, Inc.
643 Blair Island Road, Suite 103
Redwood City, CA 94063


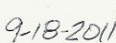

Subject: SPC-1 Letter of Good Faith for the HP P10000 3PAR V800 Storage System

Hewlett Packard Company is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with v1.13 of the SPC-1 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specifications.

Signed:

Date:

  
Peter Slocum
Vice President of Engineering
Hewlett Packard Company
Date of Signature

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Hewlett-Packard Company – http://www.hp.com Bill McCormack – bill.mccormack@hp.com 4609 Technology Drive Fremont, CA 94538 Phone: (510) 897-2784 FAX: (510) 413-5998
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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	V1.12
SPC-1 Workload Generator revision number	V2.1.0
Date Results were first used publicly	October 17, 2011
Date the FDR was submitted to the SPC	October 17, 2011
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	October 17, 2011

Tested Storage Product (TSP) Description

The new Tier 1 storage for cloud computing, the new HP P10000 3PAR Storage Systems are designed to deliver enterprise IT as a utility service simply, efficiently, and flexibly. The arrays feature a tightly coupled clustered architecture, secure multi-tenancy, and mixed workload support to fuel enterprise-class virtual and cloud data centers. Use of unique thin technologies reduces acquisition and operational costs by up to 50% while autonomic management features improve administrative efficiency by up to tenfold. The HP 3PAR Gen4 ASIC in each of the system's controller nodes provides a hyper-efficient, silicon-based engine that drives on-the-fly storage optimization to maximize capacity utilization while delivering high service levels. The arrays are built from the ground up to enable agile and efficient response to the changing business needs present in today's most demanding data centers.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: HP P10000 3PAR V800 Storage System	
Metric	Reported Result
SPC-1 IOPS™	450,212.66
SPC-1 Price-Performance™	\$6.59/SPC-1 IOPS™
Total ASU Capacity	230,400.000 GB
Data Protection Level	Protected (<i>Mirroring</i>)
Total TSC Price (including three-year maintenance)	\$2,965,892

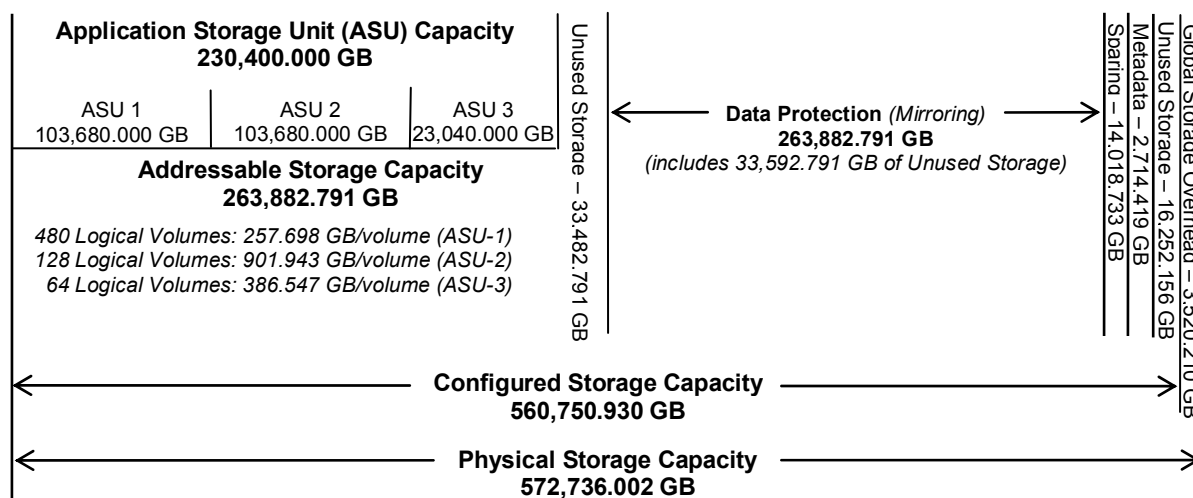
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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, Relationships, and Utilization

The following diagram and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.



SPC-1 Storage Capacity Utilization	
Application Utilization	40.23%
Protected Application Utilization	80.46%
Unused Storage Ratio	14.53%

Application Utilization: Total ASU Capacity (230,400.000 GB) divided by Physical Storage Capacity (572,736.002 GB)

Protected Application Utilization: (Total ASU Capacity (230,400.000 GB) plus total Data Protection Capacity (263,882.791 GB) minus unused Data Protection Capacity (33,482.791 GB) divided by Physical Storage Capacity (572,736.002 GB)

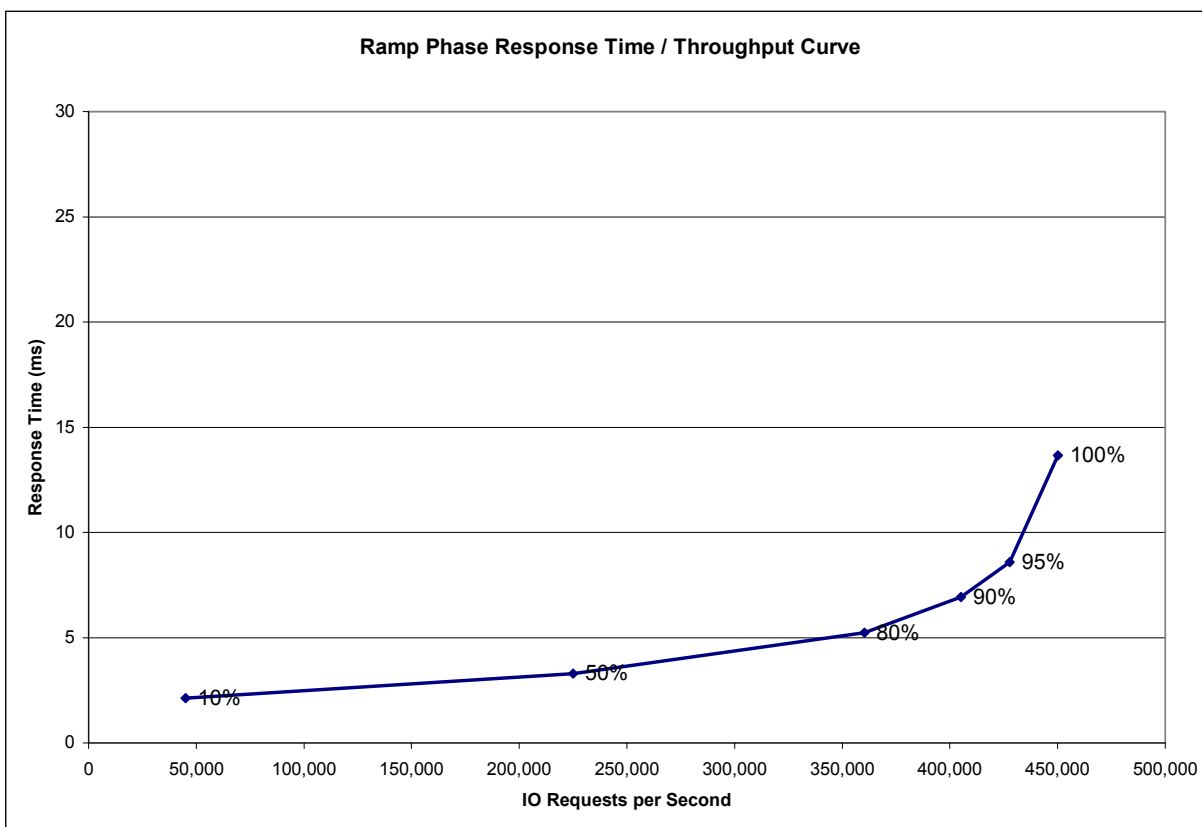
Unused Storage Ratio: Total Unused Capacity (GB) divided by Physical Storage Capacity (572,736.002 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 21-22.

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	45,007.73	225,079.30	360,223.53	405,200.83	427,742.15	450,212.66
Average Response Time (ms):						
All ASUs	2.12	3.29	5.23	6.94	8.60	13.67
ASU-1	2.62	4.13	6.00	7.17	8.17	11.68
ASU-2	2.19	5.10	8.33	10.17	11.23	13.99
ASU-3	1.01	0.71	2.24	5.03	8.36	17.73
Reads	4.23	7.42	10.83	12.57	13.63	16.99
Writes	0.74	0.60	1.58	3.27	5.32	11.50

Priced Storage Configuration Pricing

description	unit price	qty	extended gross		extended net
			price	discount	price
HP P10000 3PAR V800 NEMA Base	\$ 219,037	1	\$ 219,037	50%	\$ 109,519
HP P10000 3PAR V800 Controller Nodes	\$ 66,994	6	\$ 401,964	50%	\$ 200,982
HP P10000 3PAR 2M Expansion NEMA Rack	\$ 11,550	6	\$ 69,300	50%	\$ 34,650
HP P10000 3PAR 4-Port FC Adapter	\$ 9,660	24	\$ 231,840	50%	\$ 115,920
HP P10000 3PAR 4-Port FC Adapter	\$ 9,660	24	\$ 231,840	50%	\$ 115,920
HP P10000 3PAR 40-drive chassis	\$ 9,128	48	\$ 438,144	50%	\$ 219,072
HP P10000 3PAR 4x300GB 15K FC magazine	\$ 4,599	480	\$ 2,207,520	50%	\$ 1,103,760
3PAR 10M 50/125 (LC-LC) Fiber Cable	\$ 214	32	\$ 6,848	50%	\$ 3,424
3PAR 50M 50/125 (LC-LC) Fiber Cable	\$ 352	96	\$ 33,792	50%	\$ 16,896
3PAR MPIO for Microsoft Windows SW	\$ 1	1	\$ 1	50%	\$ 1
HP 3PAR InForm V800/4x300GB 15K Mag LTU	\$ 3,425	480	\$ 1,644,000	50%	\$ 822,000
HP 3y Support Plus 24 SVC					
P10000 3PAR V800 Base Supp	\$ 15,328	1	\$ 15,328	50%	\$ 7,664
P10000 3PAR V800 Controller Nodes Supp	\$ 4,687	6	\$ 28,122	50%	\$ 14,061
For HP 3PAR Internal Entitlement Purpose	\$ -	6	\$ -	50%	\$ -
P10000 3PAR 4-Port FC Adapter Supp	\$ 674	24	\$ 16,176	50%	\$ 8,088
P10000 3PAR 4-Port FC Adapter Supp	\$ 674	24	\$ 16,176	50%	\$ 8,088
P10000 3PAR 40-drive chassis Supp	\$ 641	48	\$ 30,768	50%	\$ 15,384
P10000 3PAR 4x300GB 15K FC mag Supp	\$ 357	480	\$ 171,360	50%	\$ 85,680
3PAR InForm V800/4x300GB Mag LTU Supp	\$ 1,214	41	\$ 49,774	50%	\$ 24,887
HP Technical Installation Startup SVC					
HP Startup 3PAR T/V-Class 8 Node SVC	\$ 19,250	1	\$ 19,250	43%	\$ 10,973
HP B-series 8/24c BladeSystem SAN Switch	\$ 9,285	4	\$ 37,140	8%	\$ 34,169
HP BLc Emulex LPe1205 8Gb FC HBA Opt	\$ 849	16	\$ 13,584	12%	\$ 11,954
HP 8Gb Shortwave B-series FC SFP+ 1 Pack	\$ 199	16	\$ 3,184	12%	\$ 2,802
TOTAL			\$ 5,885,148		\$ 2,965,892

The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- Acknowledgement of new and existing problems within four (4) hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration that can be remedied by the repair or replacement of a Priced Storage Configuration component.

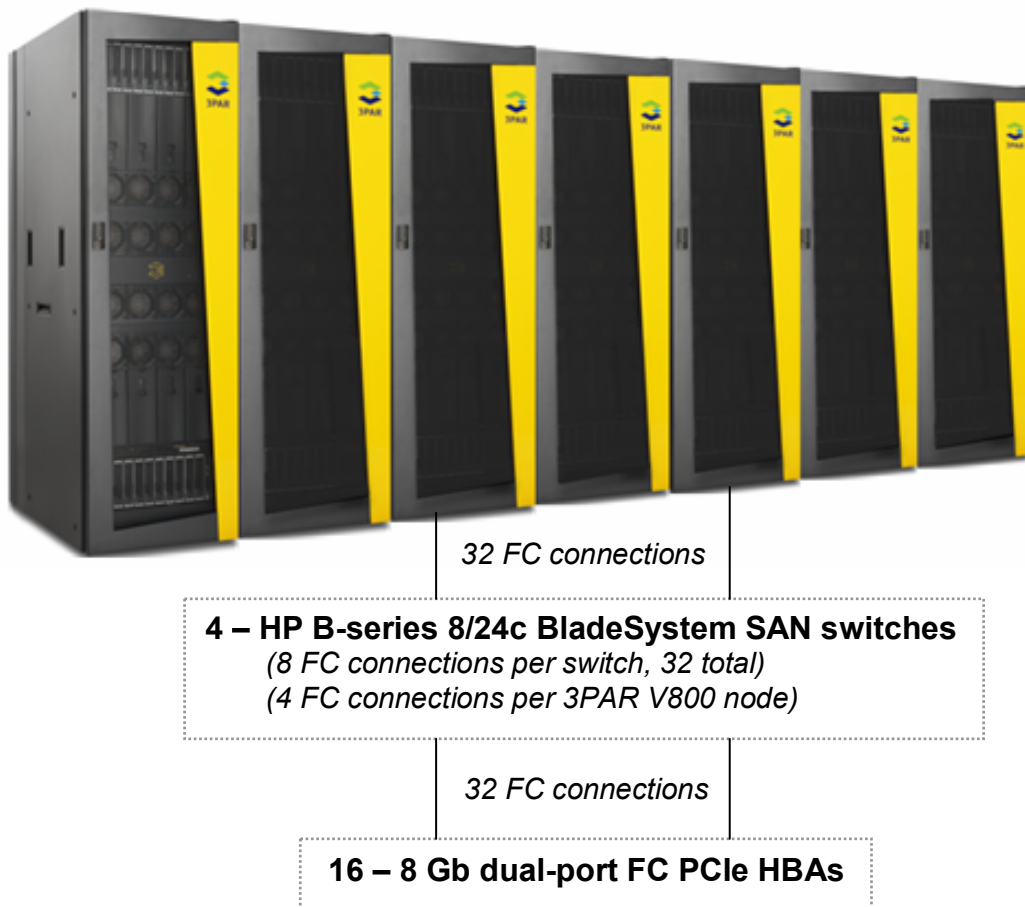
Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

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

Priced Storage Configuration Diagram

HP P10000 3PAR V800 Storage System (8 nodes)

64 GB data cache per node
32 GB control cache per node
3 – 8 Gb quad-port FC front-end adapters per node
3 – 8 Gb quad-port FC backend adapters per node
1,920 – 300 GB, 15K RPM FC disk drives



Priced Storage Configuration Components

Priced Storage Configuration Components:
3PAR MPIO for Microsoft Windows
4 – HP B-series 8/24c BladeSystem SAN switches <i>(includes 4 SFPs per switch, 16 total)</i>
16 – HP 8Gb SFPs
16 – HP 8Gb Shortwave B-series FC SFPs
16 – 8 Gb dual-port FC PCIe HBAs
HP P10000 3PAR V800 Storage System with 8 nodes
64 GB data cache per node <i>(512 GB total)</i>
32 GB control cache per node <i>(256 GB total)</i>
3 – 8 Gb quad-port FC front-end adapters per node <i>(24 adapters total, 96 total front-end connections, 32 used)</i>
3 – 8 Gb quad-port FC backend adapters per node <i>(24 adapters total, 96 total backend connections, 96 used)</i>
48 – HP P10000 3PAR 40-drive chassis
6 – HP P10000 3PAR 2M Expansion NEMA racks
480 – HP P10000 3PAR 4x300GB 15K FC magazines <i>(1,920 – 300 GB 15K RPM FC disk drives)</i>

Note: All front-end and backend FC adapters include the required number of SFPs.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-1 benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

CONFIGURATION INFORMATION

Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram

Clause 9.4.3.4.1

A one page Benchmark Configuration (BC)/Tested Storage Configuration (TSC) diagram shall be included in the FDR...

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 18 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Storage Network Configuration

Clause 9.4.3.4.1

...

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 9.4.3.4.2.*

Clause 9.4.3.4.2

If a storage network was configured as a part of the Tested Storage Configuration and the Benchmark Configuration diagram described in Clause 9.4.3.4.1 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 Tested Storage Configuration did not include network storage.

Host System and Tested Storage Configuration (TSC) Table of Components

Clause 9.4.3.4.3

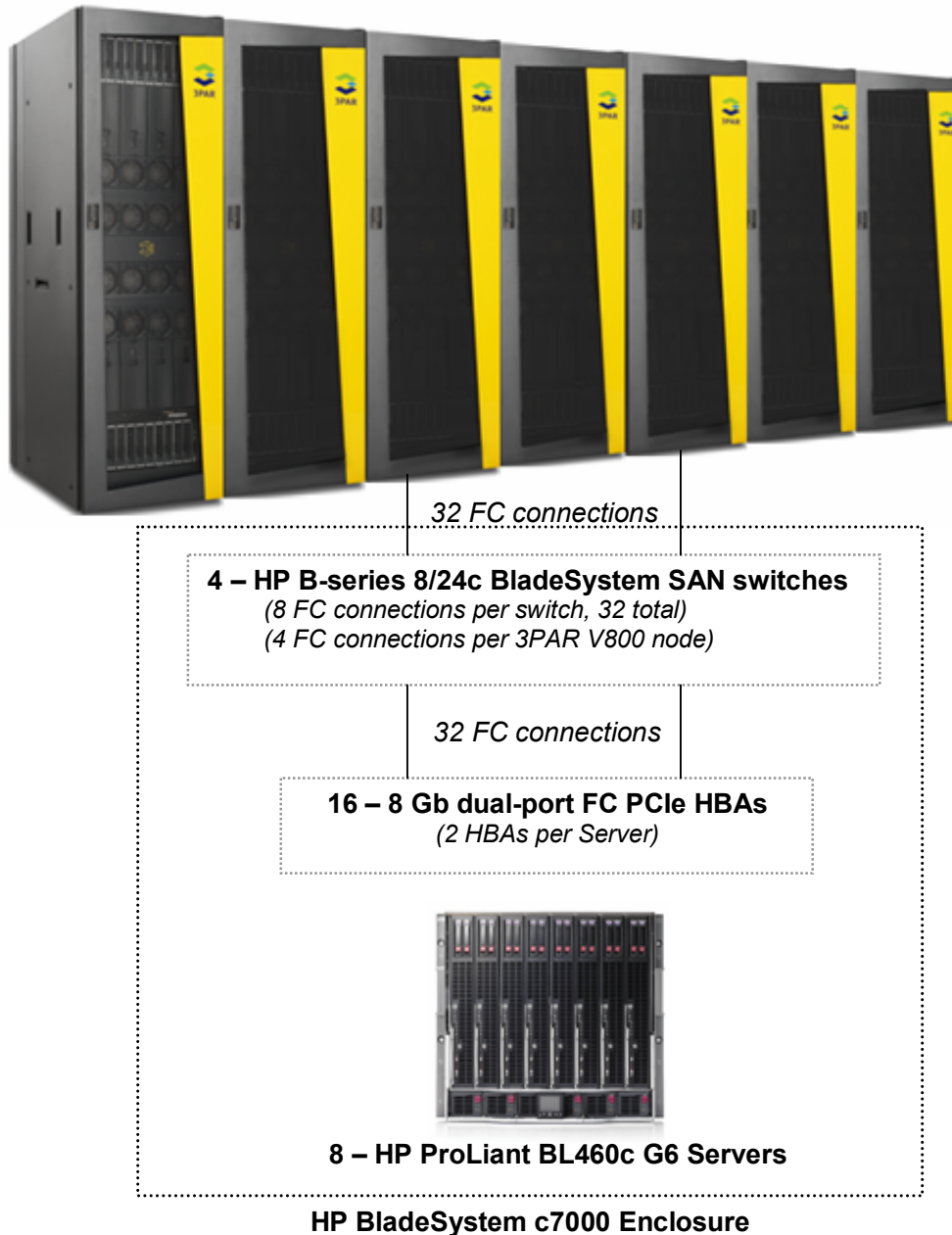
The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC). Table 9-10 specifies the content, format, and appearance of the table.

The Host System and TSC table of components may be found on page 19 (*Host System and Tested Storage Configuration Components*).

Benchmark Configuration/Tested Storage Configuration Diagram

HP P10000 3PAR V800 Storage System (8 nodes)

- 64 GB data cache per node
- 32 GB control cache per node
- 3 – 8 Gb quad-port FC front-end adapters per node
- 3 – 8 Gb quad-port FC backend adapters per node
- 1,920 – 300 GB, 15K RPM FC disk drives



Host System and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
1 – HP BladeSystem c7000 Enclosure	3PAR MPIO for Microsoft Windows
8 – HP ProLiant BL460c G6 Servers each server with: 2 – Intel® Xeon® 5670 six core 2.93 GHz processors with 12 MB Intel Smart Cache per processor 32 GB main memory Microsoft Windows Server 2003 R2 Enterprise 64-bit Emulex One Command Manager (HBA management) PsTools Suite (benchmark execution commands) PCIe	4 – HP B-series 8/24c BladeSystem SAN switches <i>(includes 4 SFPs per switch)</i> 16 – HP 8Gb Shortwave B-series FC SFPs
	16 – 8 Gb dual-port FC PCIe HBAs
	HP P10000 3PAR V800 Storage System with 8 nodes 64 GB data cache per node <i>(512 GB total)</i> 32 GB control cache per node <i>(256 GB total)</i> 3 – 8 Gb quad-port FC front-end adapters per node <i>(24 adapters total, 96 total front-end connections, 32 used)</i> 3 – 8 Gb quad-port FC backend adapters per node <i>(24 adapters total, 96 total backend connections, 96 used)</i>
	48 – HP P10000 3PAR 40-drive chassis
	6 – HP P10000 3PAR 2M Expansion NEMA racks
	480 – HP P10000 3PAR 4x300GB 15K FC magazines <i>(1,920 – 300 GB 15K RPM FC disk drives)</i>

Note: All front-end and backend FC adapters include the required number of SFPs.

Customer Tunable Parameters and Options

Clause 9.4.3.5.1

All Benchmark Configuration (BC) components with customer tunable parameter and options that have been altered from their default values must be listed in the FDR. The FDR entry for each of those components must include both the name of the component and the altered value of the parameter or option. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use must also be included in the FDR entry.

“Appendix B: Customer Tunable Parameters and Options” on page 60 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.4.3.5.2

The FDR must include sufficient information to recreate the logical representation of the TSC. In addition to customer tunable parameters and options (Clause 4.2.4.5.3), that information must include, at a minimum:

- *A diagram and/or description of the following:*
 - *All physical components that comprise the TSC. Those components are also illustrated in the BC Configuration Diagram in Clause 9.2.4.4.1 and/or the Storage Network Configuration Diagram in Clause 9.2.4.4.2.*
 - *The logical representation of the TSC, configured from the above components that will be presented to the Workload Generator.*
- *Listings of scripts used to create the logical representation of the TSC.*
- *If scripts were not used, a description of the process used with sufficient detail to recreate the logical representation of the TSC.*

“Appendix C: Tested Storage Configuration (TSC) Creation” on page 61 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.4.3.5.3

The FDR must include all SPC-1 Workload Generator storage configuration commands and parameters.

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in “Appendix D: SPC-1 Workload Generator Storage Commands and Parameters” on page 63.

SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. “SPC-1 Data Repository Definitions” on page 56 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

Two tables and an illustration documenting the storage capacities and relationships of the SPC-1 Storage Hierarchy (Clause 2.1) shall be included in the FDR.

SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	230,400.000
Addressable Storage Capacity	Gigabytes (GB)	263,882.791
Configured Storage Capacity	Gigabytes (GB)	560,750.930
Physical Storage Capacity	Gigabytes (GB)	572,736.002
Data Protection (<i>Mirroring</i>)	Gigabytes (GB)	263,882.791
Required Storage (<i>sparing</i>)	Gigabytes (GB)	14,018.773
Global Storage Overhead	Gigabytes (GB)	11,985.072
Total Unused Storage	Gigabytes (GB)	83,217.738

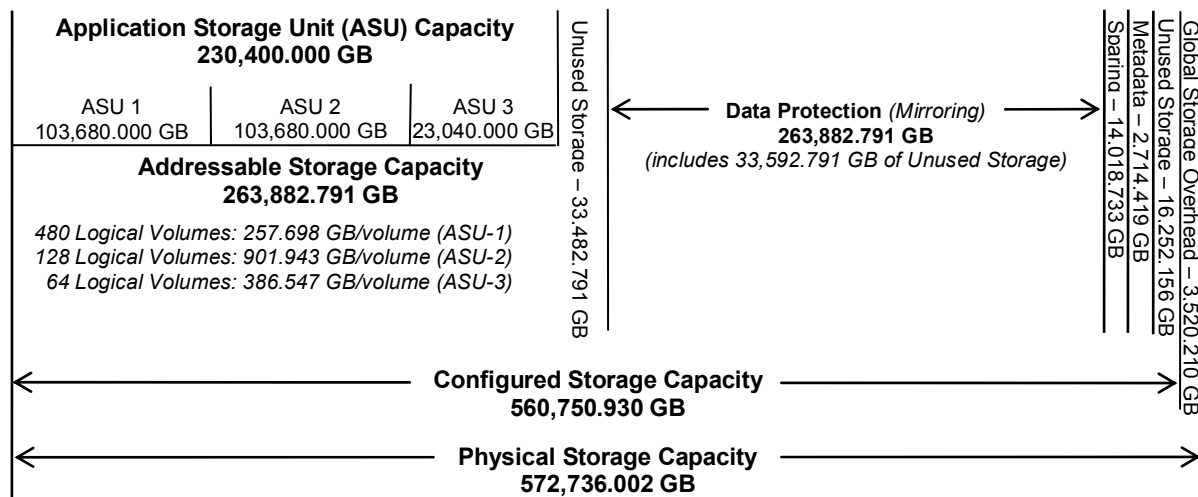
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	87.31%	41.09%	40.23%
Required for Data Protection (<i>Mirrored</i>)		47.06%	46.07%
Addressable Storage Capacity		47.06%	46.07%
Required Storage (<i>sparing</i>)		2.50%	2.45%
Configured Storage Capacity			97.91%
Global Storage Overhead			2.09%
Unused Storage:			
Addressable	12.69%		
Configured		2.90%	
Physical			0.00%

The Physical Storage Capacity consisted of 572,736.002 GB distributed over 1,920 disk drives, each with a formatted capacity of 298.300 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 11.985.072 GB (2.09%) of the Physical Storage Capacity. There was 16,252.156 GB (2.90%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 87.31% of the Addressable Storage Capacity resulting in 33,482.791 GB (12.69%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*mirroring*) capacity was 263,882.791 GB of which 230,400.000 GB was utilized. The total Unused Storage was 83,217.738 GB.

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 9.4.3.6.3

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 (103,680.000 GB)	ASU-2 (103,680.000 GB)	ASU-3 (23,040.000 GB)
480 Logical Volumes 257.698 GB per Logical Volume 216.000 (used per Logical Volume)	128 Logical Volumes 901.943 GB per Logical Volume (810.000 used per Logical Volume)	64 Logical Volumes 386.547 GB per Logical Volume (360.000 used per Logical Volume)

The Data Protection Level used for all Logical Volumes was “Mirrored” as described on page 11. See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

Storage Capacity Utilization

Clause 9.4.3.6.2

The FDR will include a table illustrating the storage capacity utilization values defined for Application Utilization (Clause 2.8.1), Protected Application Utilization (Clause 2.8.2), and Unused Storage Ratio (Clause 2.8.3).

Clause 2.8.1

Application Utilization is defined as Total ASU Capacity divided by Physical Storage Capacity.

Clause 2.8.2

Protected Application Utilization is defined as (Total ASU Capacity plus total Data Protection Capacity minus unused Data Protection Capacity) divided by Physical Storage Capacity.

Clause 2.8.3

Unused Storage Ratio is defined as Total Unused Capacity divided by Physical Storage Capacity and may not exceed 45%.

SPC-1 Storage Capacity Utilization	
Application Utilization	40.23%
Protected Application Utilization	80.46%
Unused Storage Ratio	14.53%

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. “SPC-1 Test Execution Definitions” on page 57 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

The Tests must be executed in the following sequence: Primary Metrics, Repeatability, and Data Persistence. That required sequence must be uninterrupted from the start of Primary Metrics to the completion of Persistence Test Run 1. Uninterrupted means the Benchmark Configuration shall not be power cycled, restarted, disturbed, altered, or adjusted during the above measurement sequence. If the required sequence is interrupted other than for the Host System/TSC power cycle between the two Persistence Test Runs, the measurement is invalid.

SPC-1 Tests, Test Phases, and Test Runs

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

- **Primary Metrics Test**
 - Sustainability Test Phase and Test Run
 - IOPS Test Phase and Test Run
 - Response Time Ramp Test Phase
 - 95% of IOPS Test Run
 - 90% of IOPS Test Run
 - 80% of IOPS Test Run
 - 50% of IOPS Test Run
 - 10% of IOPS Test Run (LRT)
- **Repeatability Test**
 - Repeatability Test Phase 1
 - 10% of IOPS Test Run (LRT)
 - IOPS Test Run
 - Repeatability Test Phase 2
 - 10% of IOPS Test Run (LRT)
 - IOPS Test Run
- **Data Persistence Test**
 - Data Persistence Test Run 1
 - Data Persistence Test Run 2

Each Test is an atomic unit that must be executed from start to finish before any other Test, Test Phase, or Test Run may be executed.

The results from each Test, Test Phase, and Test Run are listed below along with a more detailed explanation of each component.

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous three (3) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).

Clause 5.4.4.1.2

The computed I/O Request Throughput of the Sustainability Test must be within 5% of the reported SPC-1 IOPS™ result.

Clause 5.4.4.1.4

The Average Response Time, as defined in Clause 5.1.1, will be computed and reported for the Sustainability Test Run and cannot exceed 30 milliseconds. If the Average Response time exceeds that 30-milliseconds constraint, the measurement is invalid.

Clause 9.4.3.7.1

For the Sustainability Test Phase the FDR shall contain:

- 1. A Data Rate Distribution graph and data table.*
- 2. I/O Request Throughput Distribution graph and data table.*
- 3. A Response Time Frequency Distribution graph and table.*
- 4. An Average Response Time Distribution graph and table.*
- 5. The human readable Test Run Results File produced by the Workload Generator (may be included in an appendix).*
- 6. A listing or screen image of all input parameters supplied to the Workload Generator (may be included in an appendix).*
- 7. The Measured Intensity Multiplier for each I/O stream.*
- 8. The variability of the Measured Intensity Multiplier, as defined in Clause 5.3.13.3.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1 Workload Generator Input Parameters” on Page 76.

Sustainability Test Results File

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

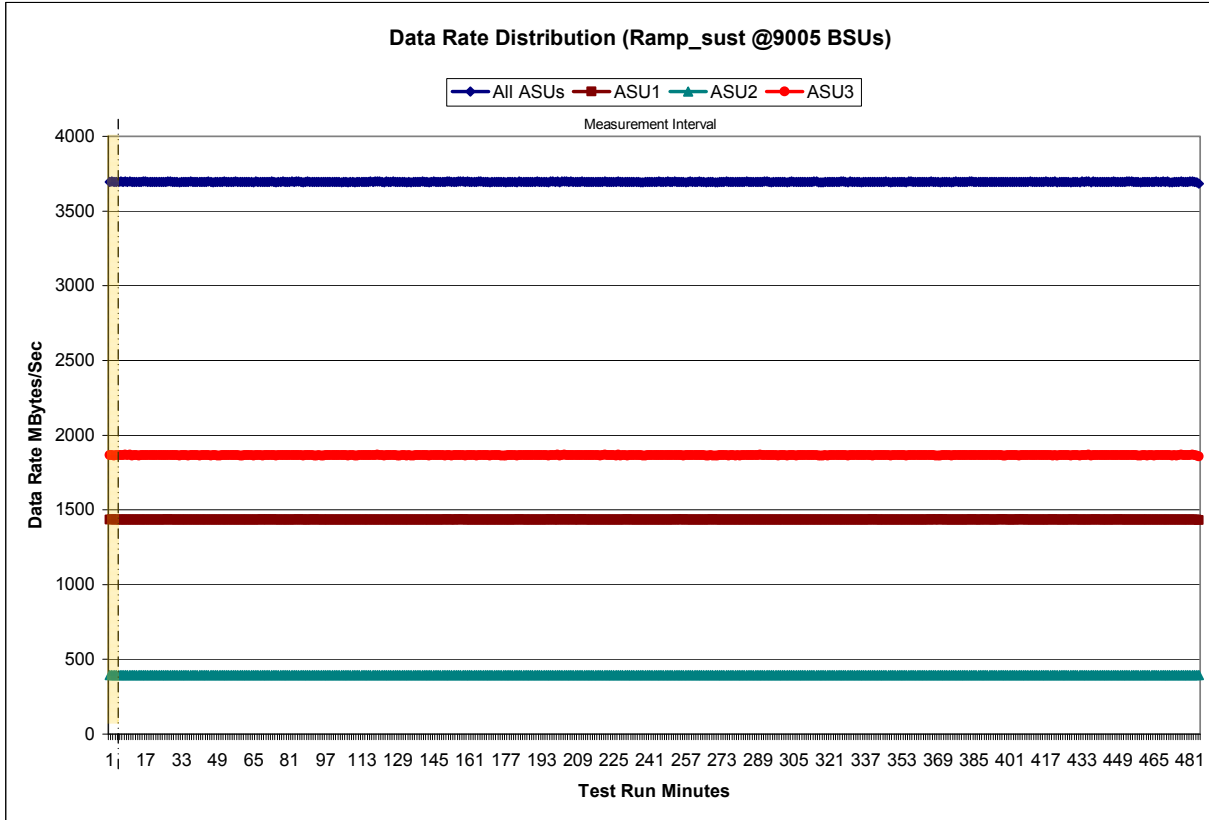
[Sustainability Test Results File](#)

Sustainability – Data Rate Distribution Data (MB/second)

The Sustainability Data Rate table of data is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability Data Tables](#)

Sustainability – Data Rate Distribution Graph

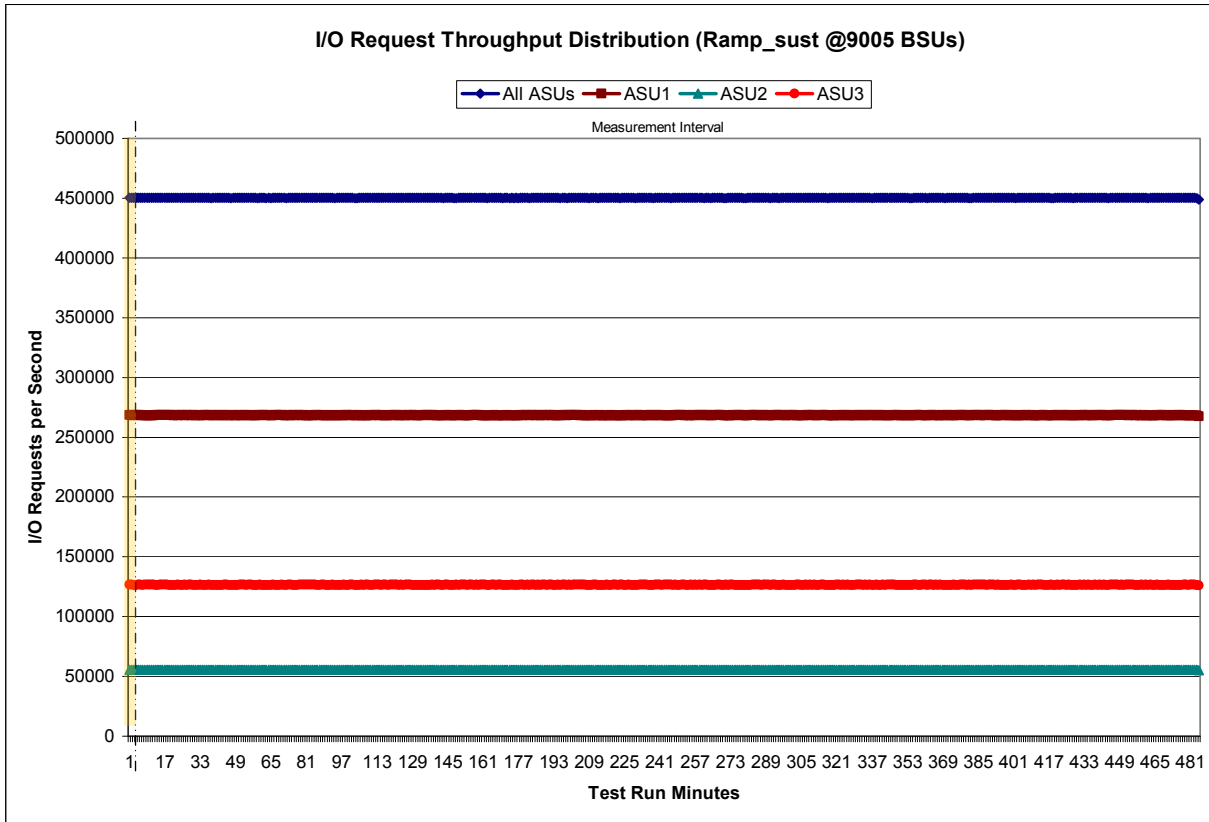


Sustainability – I/O Request Throughput Distribution Data

The Sustainability I/O Request Throughput table of data is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability Data Tables](#)

Sustainability – I/O Request Throughput Distribution Graph

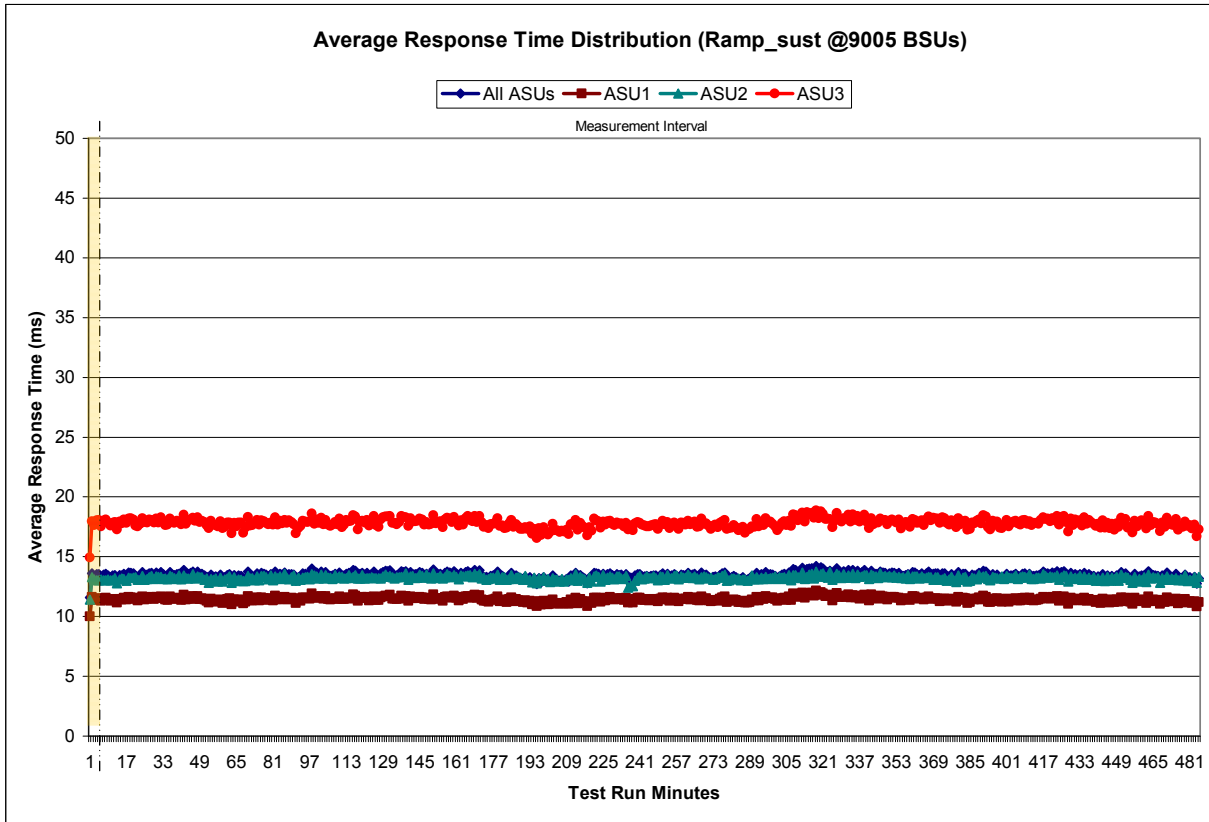


Sustainability – Average Response Time (ms) Distribution Data

The Sustainability Average Response Time table of data is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability Data Tables](#)

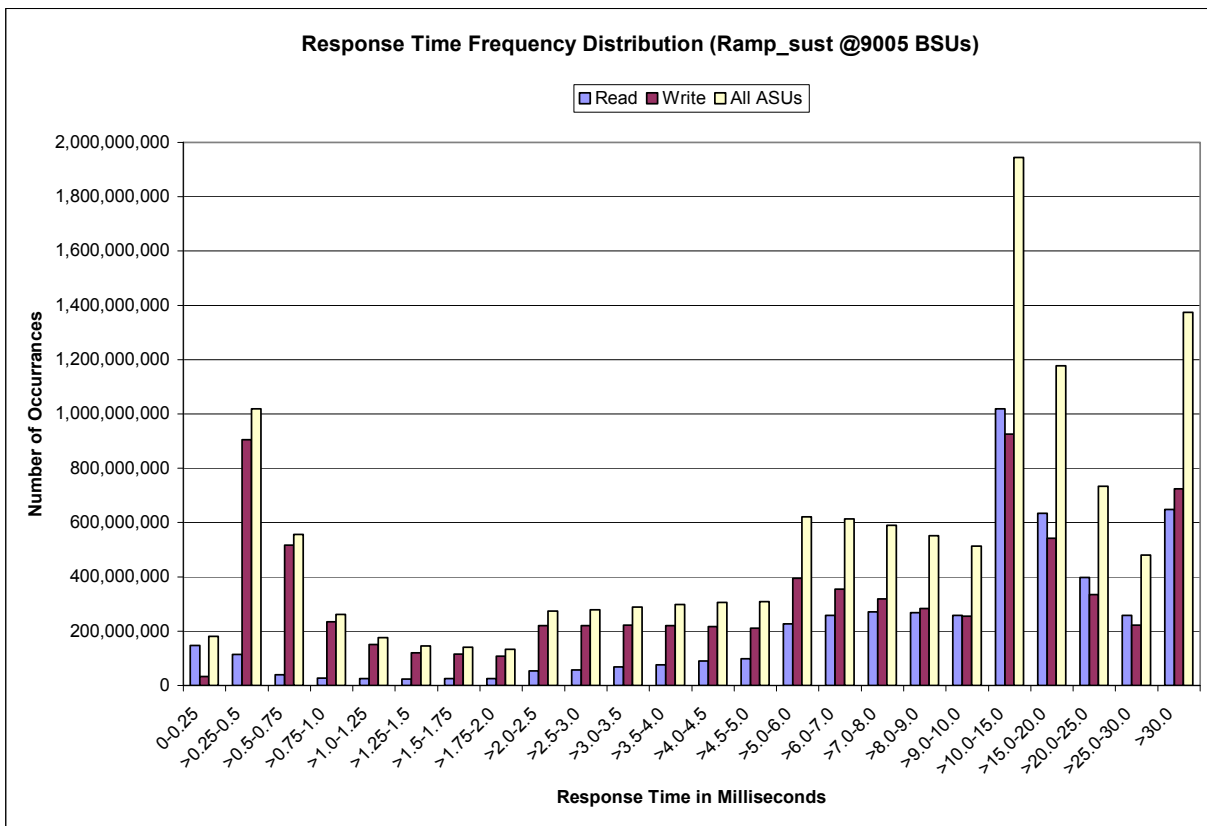
Sustainability – Average Response Time (ms) Distribution Graph



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	147,205,085	113,741,199	40,338,197	27,379,775	25,418,985	24,512,601	25,243,757	24,785,059
Write	33,583,112	904,830,767	516,546,602	233,845,811	150,812,846	121,208,058	115,640,637	107,908,760
All ASUs	180,788,197	1,018,571,966	556,884,799	261,225,586	176,231,831	145,720,659	140,884,394	132,693,819
ASU1	135,887,556	600,651,212	291,212,452	128,678,434	90,157,932	78,792,480	77,717,531	74,280,137
ASU2	41,300,315	230,978,016	97,127,138	38,651,943	27,205,092	24,169,198	23,662,062	22,224,910
ASU3	3,600,326	186,942,738	168,545,209	93,895,209	58,868,807	42,758,981	39,504,801	36,188,772
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	54,393,396	57,259,265	67,363,606	76,616,806	89,725,479	98,349,937	226,304,989	258,435,997
Write	219,804,933	220,962,515	221,158,218	220,817,579	216,593,009	211,377,749	395,138,650	354,829,921
All ASUs	274,198,329	278,221,780	288,521,824	297,434,385	306,318,488	309,727,686	621,443,639	613,265,918
ASU1	158,426,543	162,714,083	174,418,124	183,024,693	193,759,363	197,655,595	405,918,727	410,645,765
ASU2	45,756,269	43,754,293	42,452,550	40,515,824	39,161,212	37,135,547	69,946,414	65,441,376
ASU3	70,015,517	71,753,404	71,651,150	73,893,868	73,397,913	74,936,544	145,578,498	137,178,777
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	271,343,341	267,894,868	258,542,527	1,019,764,790	634,699,244	398,507,430	257,731,848	648,772,813
Write	318,771,096	284,362,774	255,188,857	925,396,278	542,215,212	335,131,146	221,944,018	724,882,187
All ASUs	590,114,437	552,257,642	513,731,384	1,945,161,068	1,176,914,456	733,638,576	479,675,866	1,373,655,000
ASU1	397,821,414	372,008,249	345,216,061	1,288,449,494	744,674,037	431,673,078	258,948,993	525,664,880
ASU2	61,965,159	57,927,203	52,859,897	180,237,939	90,938,569	54,763,017	37,359,179	169,458,940
ASU3	130,327,864	122,322,190	115,655,426	476,473,635	341,301,850	247,202,481	183,367,694	678,531,180

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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 9.4.3.7.2

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 to the Workload Generator.*
- 6. The total number of I/O Requests completed in the Measurement Interval as well as the number of I/O Requests with a Response Time less than or equal to 30 milliseconds and the number of I/O Requests with a Response Time greater than 30 milliseconds.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1 Workload Generator Input Parameters” on Page 76.

IOPS Test Results File

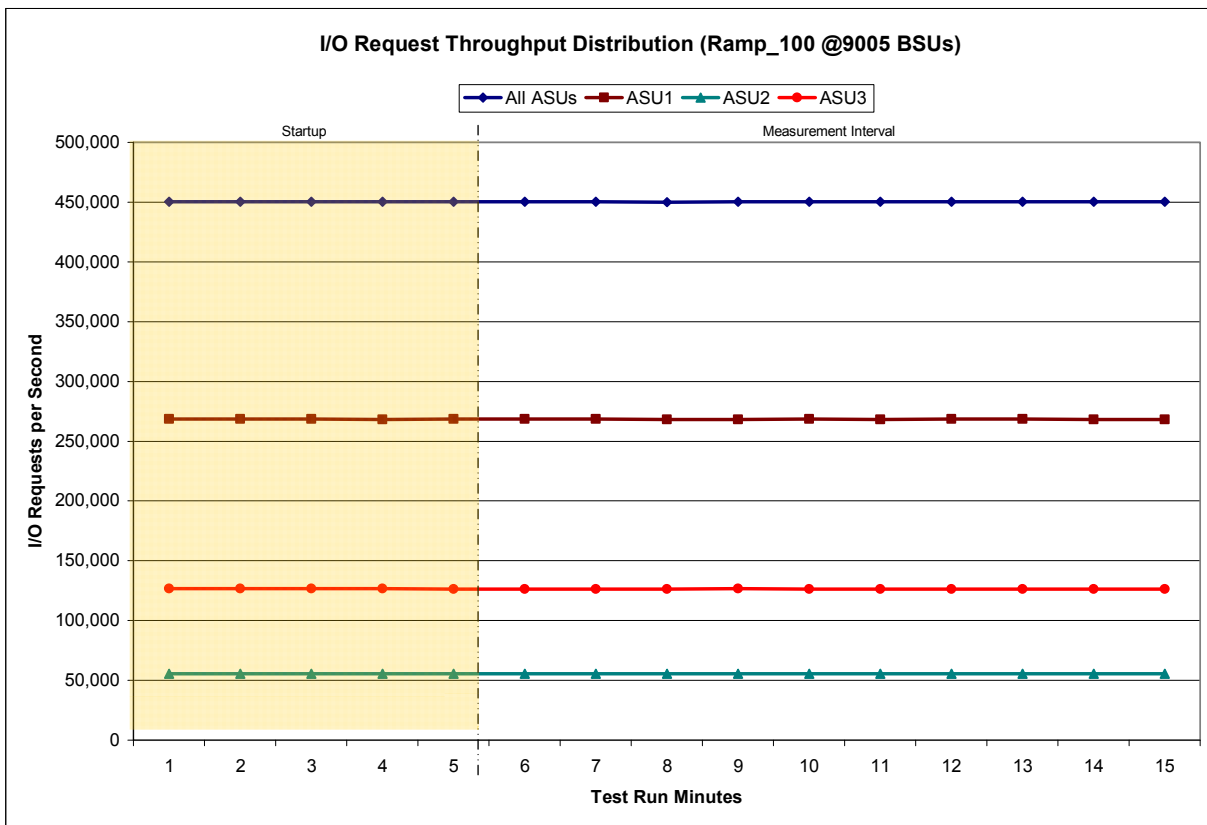
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

9005 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	18:03:12	18:08:12	0-4	0:05:00
	18:08:12	18:18:15	5-14	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	450,442.25	268,435.88	55,446.75	126,559.62
1	450,282.20	268,398.77	55,328.47	126,554.97
2	450,318.23	268,381.68	55,373.03	126,563.52
3	450,276.45	268,345.18	55,369.02	126,562.25
4	450,217.52	268,375.45	55,371.75	126,470.32
5	450,243.97	268,360.77	55,396.03	126,487.17
6	450,276.88	268,414.30	55,358.28	126,504.30
7	450,142.92	268,262.72	55,373.90	126,506.30
8	450,230.78	268,307.83	55,367.40	126,555.55
9	450,256.00	268,377.52	55,390.28	126,488.20
10	450,153.33	268,320.65	55,378.35	126,454.33
11	450,285.15	268,406.78	55,391.10	126,487.27
12	450,180.25	268,360.47	55,363.37	126,456.42
13	450,197.27	268,293.88	55,381.07	126,522.32
14	450,160.08	268,301.35	55,358.75	126,499.98
Average	450,212.66	268,340.63	55,375.85	126,496.18

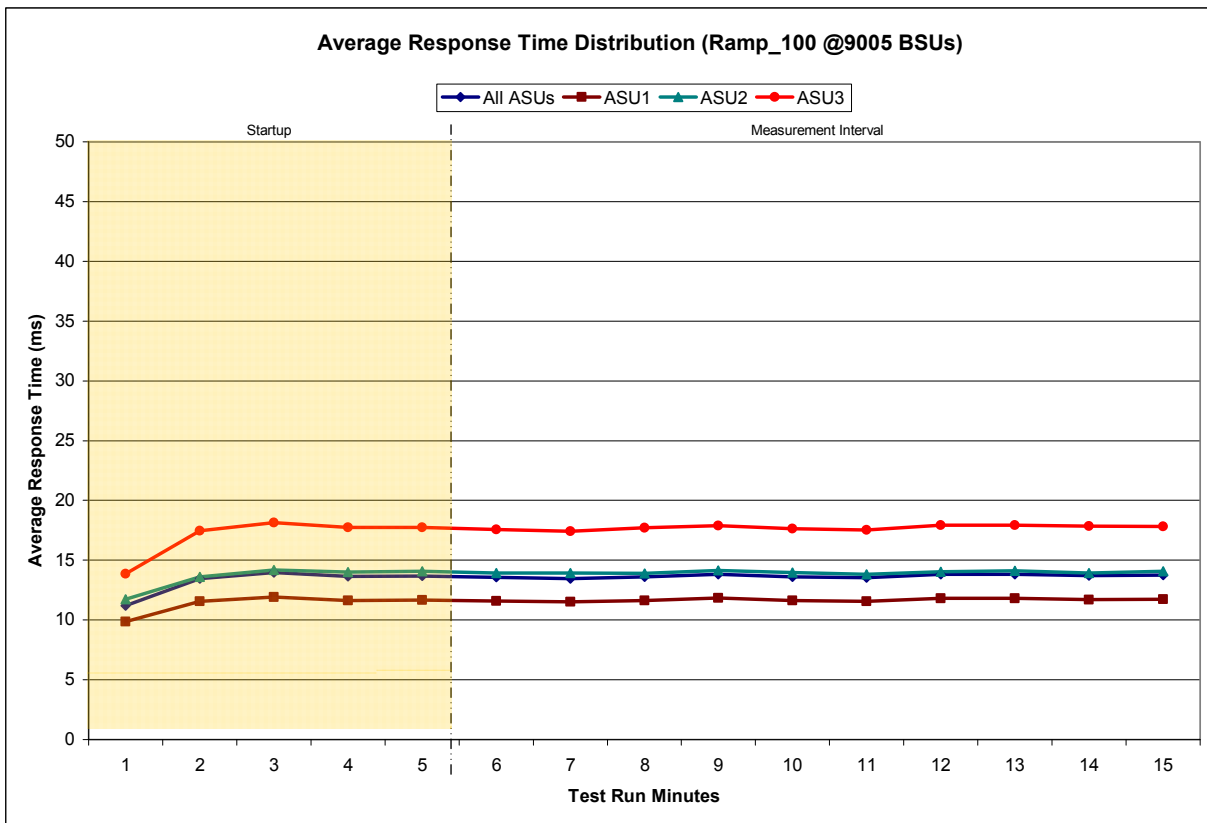
IOPS Test Run – I/O Request Throughput Distribution Graph



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

9005 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:03:12	18:08:12	0-4	0:05:00
Measurement Interval	18:08:12	18:18:15	5-14	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	11.21	9.85	11.74	13.84
1	13.47	11.56	13.61	17.47
2	13.96	11.93	14.19	18.15
3	13.63	11.61	13.99	17.75
4	13.67	11.67	14.07	17.74
5	13.56	11.60	13.93	17.56
6	13.48	11.52	13.94	17.42
7	13.62	11.63	13.90	17.70
8	13.82	11.83	14.14	17.89
9	13.61	11.63	13.98	17.65
10	13.52	11.57	13.82	17.53
11	13.81	11.81	14.05	17.94
12	13.81	11.80	14.11	17.94
13	13.72	11.72	13.95	17.87
14	13.73	11.74	14.06	17.82
Average	13.67	11.68	13.99	17.73

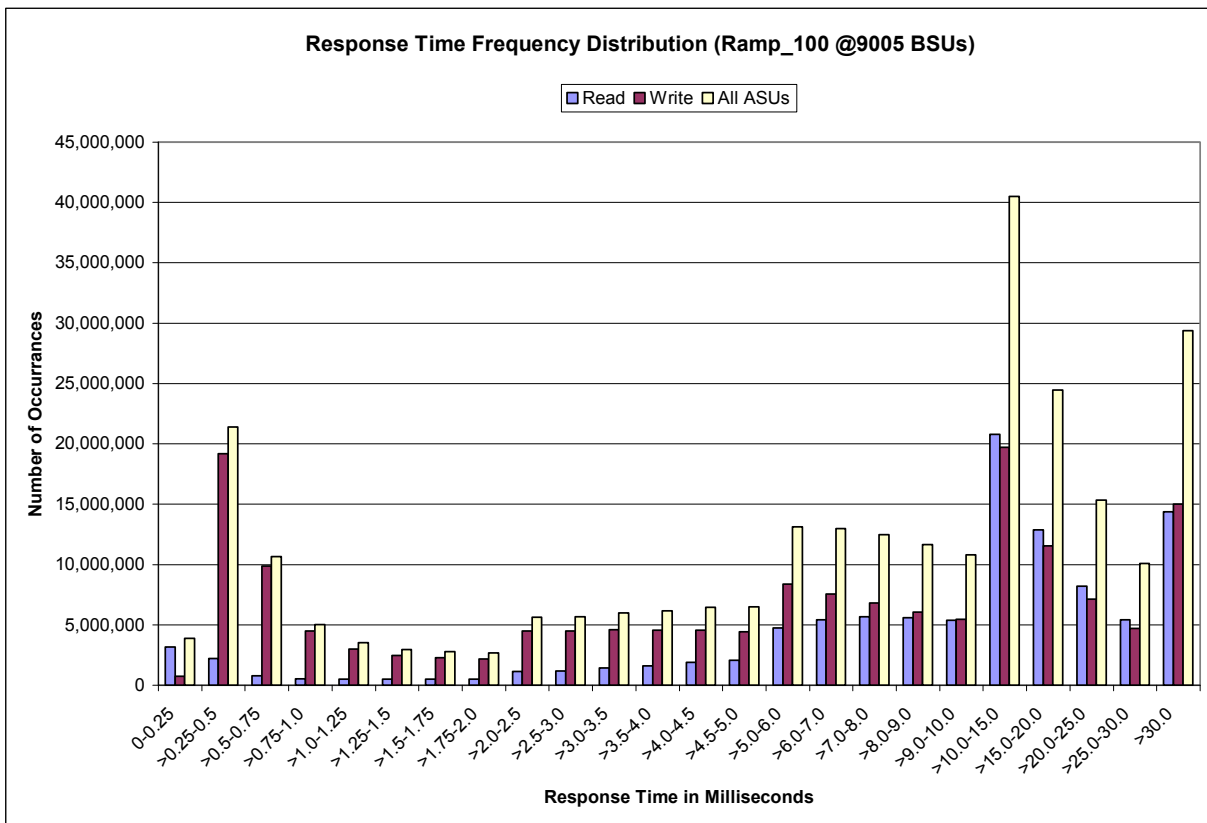
IOPS Test Run – Average Response Time (ms) Distribution Graph



IOPS Test Run – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	3,160,563	2,223,786	778,009	549,795	515,700	500,334	510,977	507,666
Write	742,512	19,173,049	9,887,353	4,491,297	3,007,150	2,442,609	2,282,631	2,160,535
All ASUs	3,903,075	21,396,835	10,665,362	5,041,092	3,522,850	2,942,943	2,793,608	2,668,201
ASU1	2,962,244	12,954,673	5,547,109	2,490,359	1,807,453	1,593,384	1,552,049	1,505,547
ASU2	857,155	4,228,104	1,656,784	716,453	531,333	477,511	461,431	445,210
ASU3	83,676	4,214,058	3,461,469	1,834,280	1,184,064	872,048	780,128	717,444
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	1,127,079	1,186,188	1,415,900	1,607,525	1,888,385	2,063,844	4,756,218	5,431,913
Write	4,492,577	4,475,829	4,586,055	4,555,154	4,554,250	4,423,635	8,364,249	7,548,731
All ASUs	5,619,656	5,662,017	6,001,955	6,162,679	6,442,635	6,487,479	13,120,467	12,980,644
ASU1	3,246,177	3,304,688	3,600,073	3,765,481	4,029,711	4,105,379	8,494,952	8,634,452
ASU2	937,420	914,675	924,540	900,072	892,003	851,225	1,616,931	1,493,326
ASU3	1,436,059	1,442,654	1,477,342	1,497,126	1,520,921	1,530,875	3,008,584	2,852,866
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	5,685,605	5,587,685	5,367,980	20,800,163	12,884,865	8,201,936	5,406,367	14,383,082
Write	6,797,786	6,063,117	5,439,828	19,705,905	11,568,703	7,126,460	4,691,493	14,999,615
All ASUs	12,483,391	11,650,802	10,807,808	40,506,068	24,453,568	15,328,396	10,097,860	29,382,697
ASU1	8,367,306	7,803,073	7,228,011	26,619,815	15,298,116	8,921,095	5,426,066	11,744,314
ASU2	1,396,672	1,294,073	1,171,470	3,906,074	1,913,092	1,147,113	784,095	3,708,092
ASU3	2,719,413	2,553,656	2,408,327	9,980,179	7,242,360	5,260,188	3,887,699	13,930,291

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
270,112,088	240,739,391	23,382,697

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.000	0.000	0.001	0.001	0.000	0.000

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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 13.

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 9.4.3.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1 Workload Generator Input Parameters” on Page 76.

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](#)

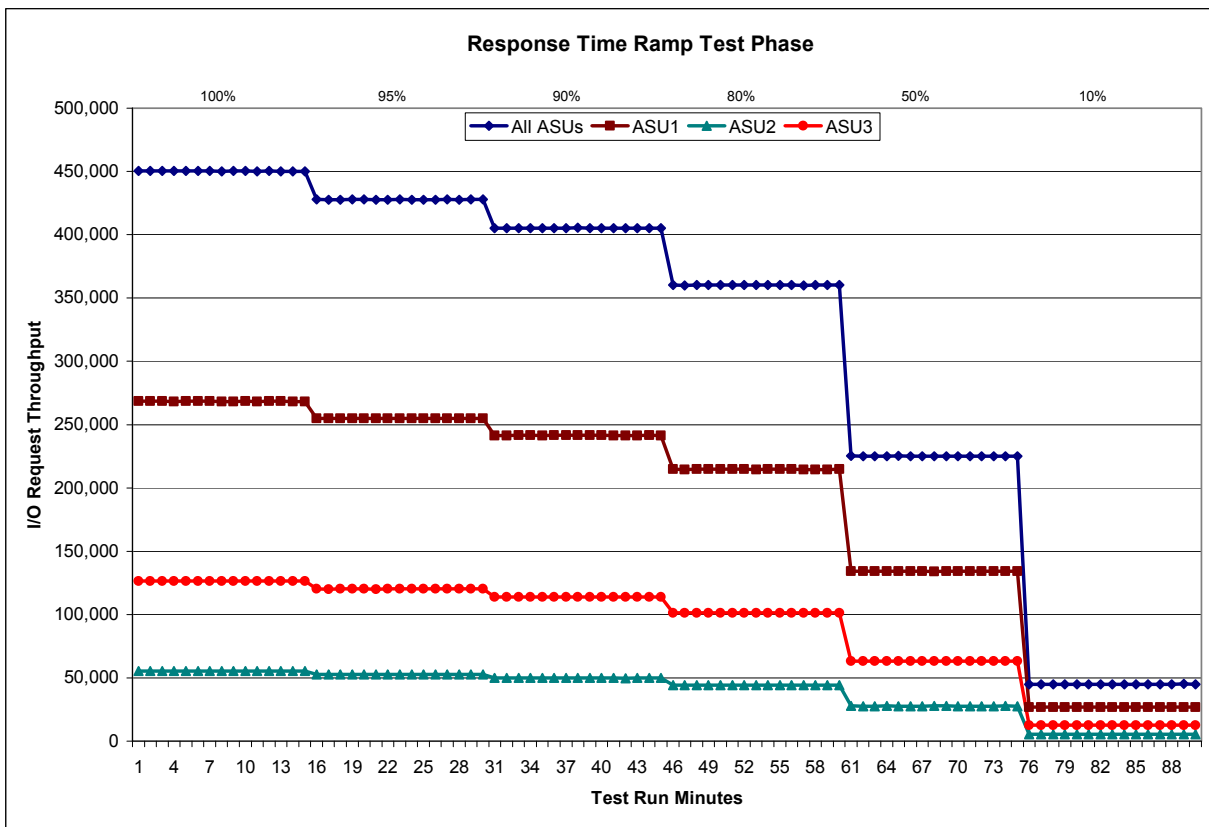
[90% Load Level](#)

[80% Load Level](#)

[50% Load Level](#)

[10% Load Level](#)

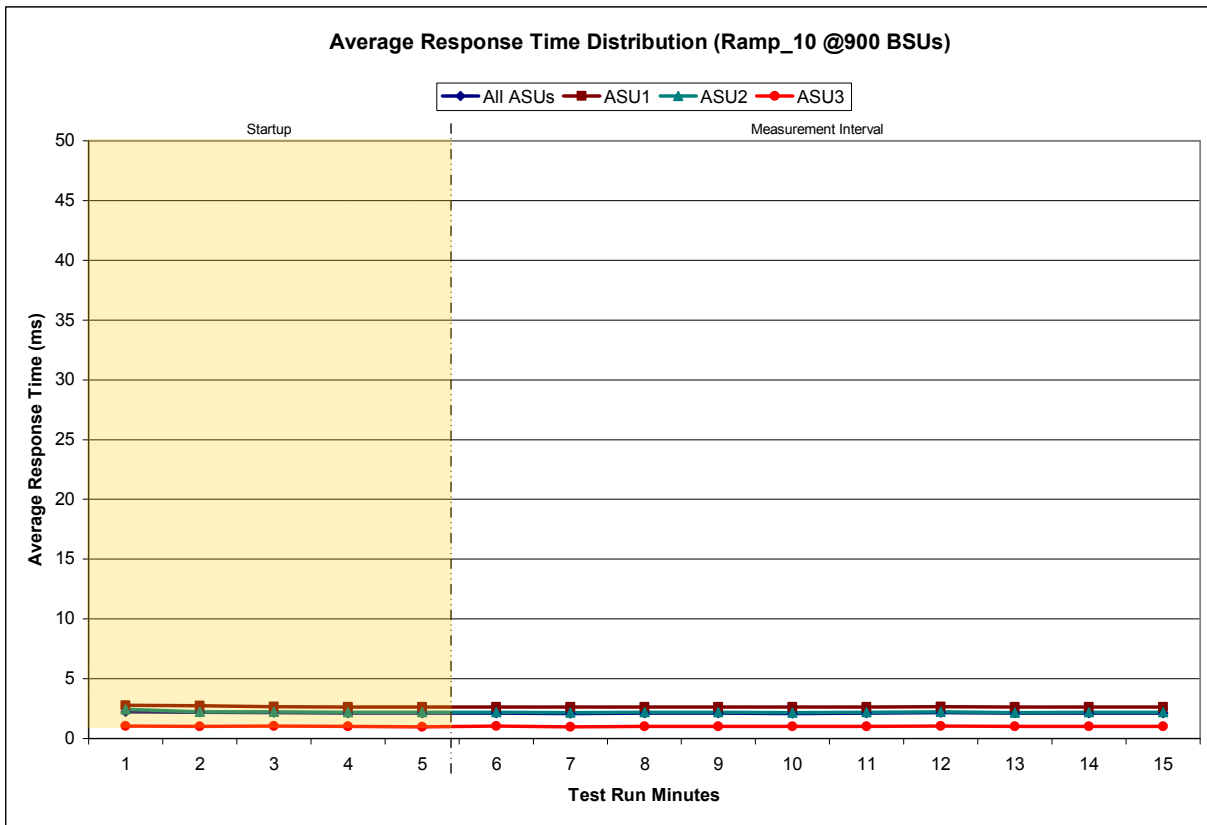
Response Time Ramp Distribution (IOPS) Graph



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

900 BSUs Start-Up/Ramp-Up Measurement Interval	Start 20:39:43	Stop 20:44:43	Interval 0-4	Duration 0:05:00
	20:44:43	20:54:45	5-14	0:10:02
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.24	2.77	2.46	1.03
1	2.18	2.72	2.23	1.02
2	2.16	2.67	2.23	1.03
3	2.12	2.63	2.18	1.01
4	2.11	2.62	2.18	0.99
5	2.12	2.62	2.20	1.03
6	2.10	2.61	2.17	0.99
7	2.11	2.61	2.18	1.01
8	2.12	2.62	2.19	1.01
9	2.11	2.62	2.17	0.99
10	2.13	2.65	2.20	1.02
11	2.15	2.65	2.22	1.04
12	2.11	2.62	2.15	1.00
13	2.11	2.61	2.18	1.01
14	2.11	2.61	2.19	1.01
Average	2.12	2.62	2.19	1.01

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2811
COV	0.004	0.001	0.002	0.001	0.004	0.002	0.003	0.001

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% or less than the SPC-1 LRT™ metric plus one (1) millisecond (ms).

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 9.4.3.7.4

The following content shall appear in the FDR for each Test Run in the two Repeatability Test Phases:

- 1. A table containing the results of the Repeatability Test.*
- 2. An I/O Request Throughput Distribution graph and table.*
- 3. An Average Response Time Distribution graph and table.*
- 4. The human readable Test Run Results File produced by the Workload Generator.*
- 5. A listing or screen image of all input parameters supplied to the Workload Generator.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1 Workload Generator Input Parameters” on Page 76.

Repeatability Test Results File

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

	SPC-1 IOPS™
Primary Metrics	450,212.66
Repeatability Test Phase 1	450,190.65
Repeatability Test Phase 2	450,247.65

The SPC-1 IOPS™ values in the above table were generated using 100% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 IOPS™ must be greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
Primary Metrics	2.12 ms
Repeatability Test Phase 1	2.12 ms
Repeatability Test Phase 2	2.11 ms

The average response time values in the SPC-1 LRT™ column were generated using 10% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 LRT™ must be less than 105% of the reported SPC-1 LRT™ Primary Metric or less than the reported SPC-1 LRT™ Primary Metric minus one (1) millisecond (ms)..

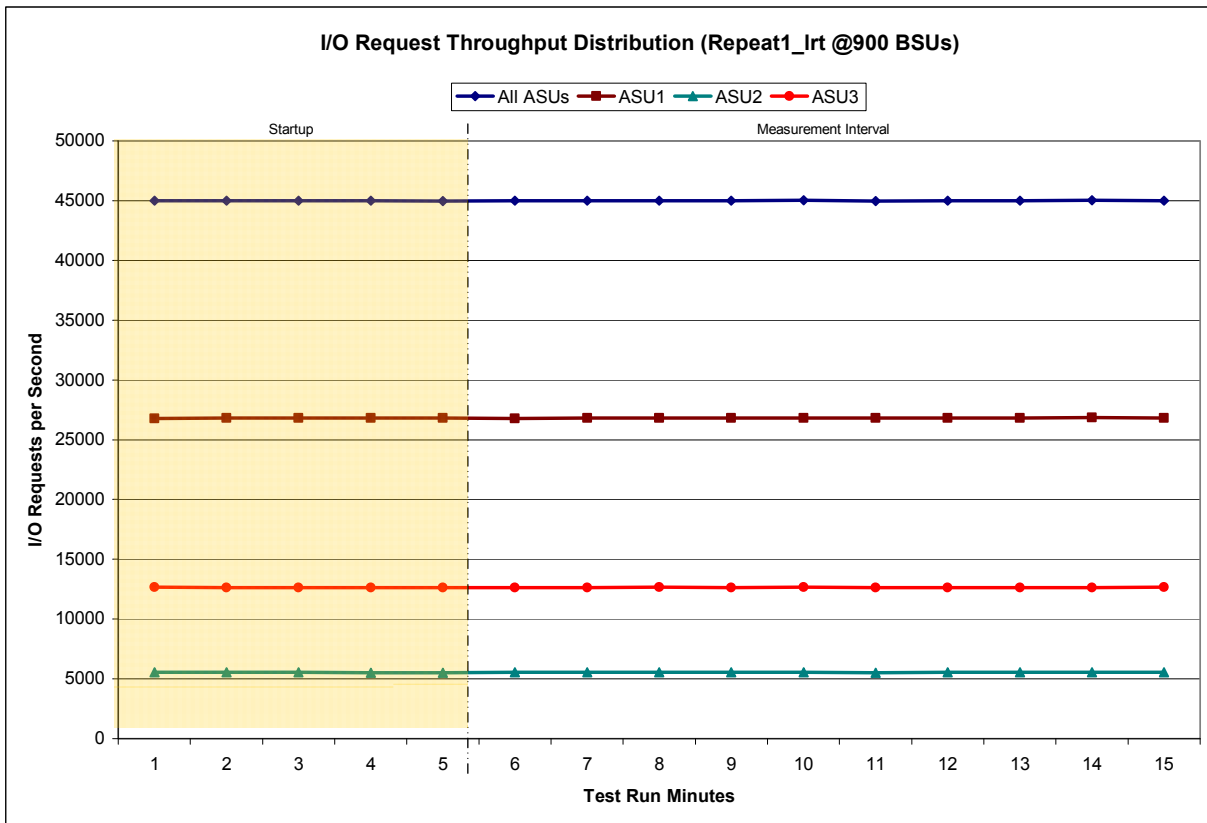
A link to the test result file generated from each Repeatability Test Run is listed below.

- [Repeatability Test Phase 1, Test Run 1 \(LRT\)](#)
- [Repeatability Test Phase 1, Test Run 2 \(IOPS\)](#)
- [Repeatability Test Phase 2, Test Run 1 \(LRT\)](#)
- [Repeatability Test Phase 2, Test Run 2 \(IOPS\)](#)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

900 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	21:09:59	21:14:59	0-4	0:05:00
	21:14:59	21:25:01	5-14	0:10:02
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	45,004.27	26,799.07	5,537.68	12,667.52
1	44,990.60	26,812.97	5,542.70	12,634.93
2	44,986.98	26,825.10	5,534.08	12,627.80
3	44,982.57	26,819.43	5,522.22	12,640.92
4	44,953.25	26,807.98	5,506.48	12,638.78
5	44,985.27	26,779.47	5,554.58	12,651.22
6	44,990.88	26,812.15	5,528.68	12,650.05
7	45,001.65	26,802.38	5,537.15	12,662.12
8	45,006.50	26,828.95	5,534.05	12,643.50
9	45,043.00	26,832.58	5,551.32	12,659.10
10	44,974.57	26,812.05	5,524.87	12,637.65
11	44,995.00	26,828.87	5,533.10	12,633.03
12	45,004.50	26,821.87	5,531.55	12,651.08
13	45,029.18	26,835.97	5,548.77	12,644.45
14	44,999.12	26,810.25	5,533.10	12,655.77
Average	45,002.97	26,816.45	5,537.72	12,648.80

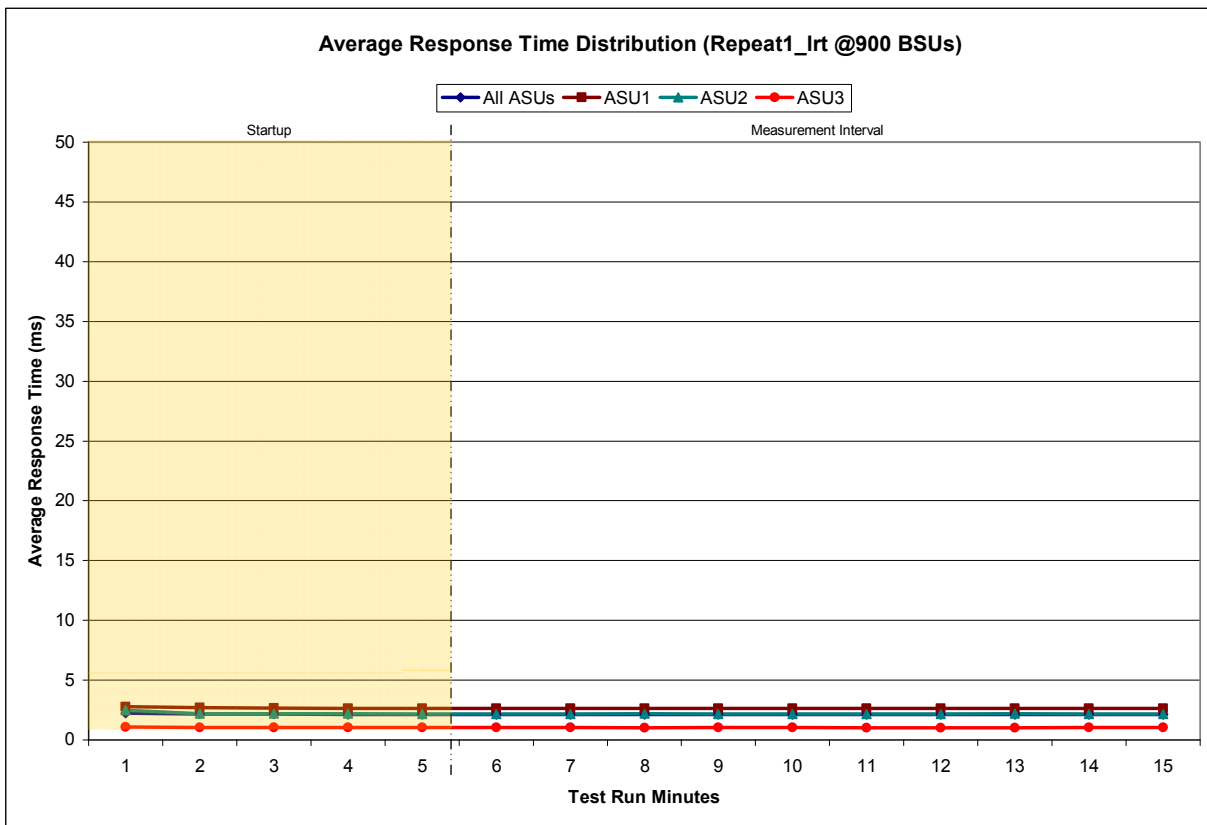
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

900 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	21:09:59	21:14:59	0-4	0:05:00
	21:14:59	21:25:01	5-14	0:10:02
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.25	2.75	2.48	1.07
1	2.17	2.70	2.20	1.04
2	2.14	2.65	2.20	1.04
3	2.14	2.64	2.19	1.04
4	2.13	2.63	2.17	1.03
5	2.13	2.63	2.18	1.04
6	2.13	2.63	2.17	1.04
7	2.12	2.62	2.18	1.01
8	2.12	2.61	2.16	1.05
9	2.12	2.63	2.18	1.04
10	2.12	2.63	2.16	1.02
11	2.12	2.64	2.17	1.01
12	2.12	2.62	2.20	1.03
13	2.12	2.62	2.16	1.03
14	2.12	2.61	2.18	1.04
Average	2.12	2.62	2.17	1.03

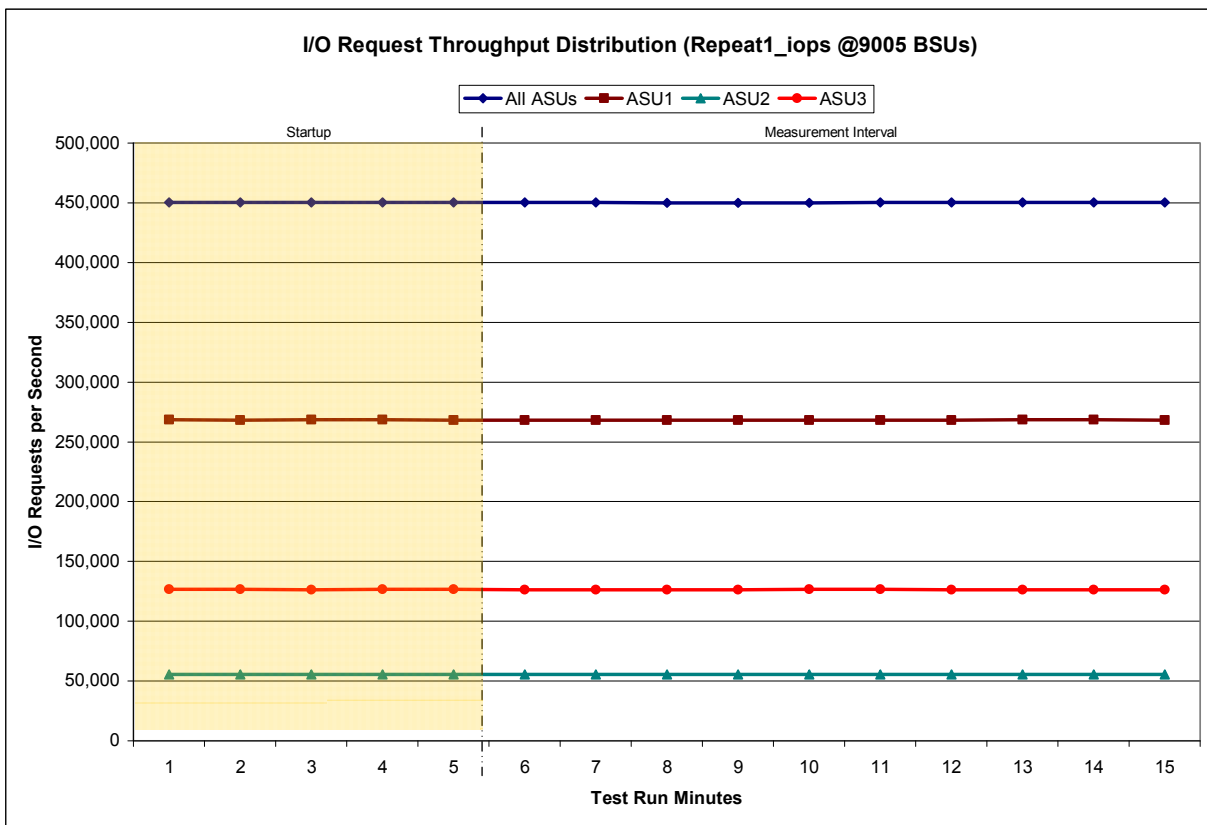
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

9005 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	21:41:05	21:46:05	0-4	0:05:00
<i>Measurement Interval</i>	21:46:05	21:56:08	5-14	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	450,497.38	268,527.00	55,381.18	126,589.20
1	450,245.02	268,298.28	55,369.48	126,577.25
2	450,238.18	268,406.43	55,396.00	126,435.75
3	450,377.80	268,396.42	55,427.53	126,553.85
4	450,192.38	268,273.80	55,382.17	126,536.42
5	450,247.42	268,348.18	55,380.75	126,518.48
6	450,199.98	268,350.48	55,358.15	126,491.35
7	450,082.50	268,265.73	55,350.33	126,466.43
8	450,080.13	268,270.98	55,360.85	126,448.30
9	450,133.17	268,229.80	55,354.43	126,548.93
10	450,249.70	268,265.03	55,394.68	126,589.98
11	450,185.82	268,342.13	55,329.98	126,513.70
12	450,237.20	268,396.40	55,353.02	126,487.78
13	450,226.78	268,388.88	55,405.68	126,432.22
14	450,263.83	268,300.35	55,440.03	126,523.45
Average	450,190.65	268,315.80	55,372.79	126,502.06

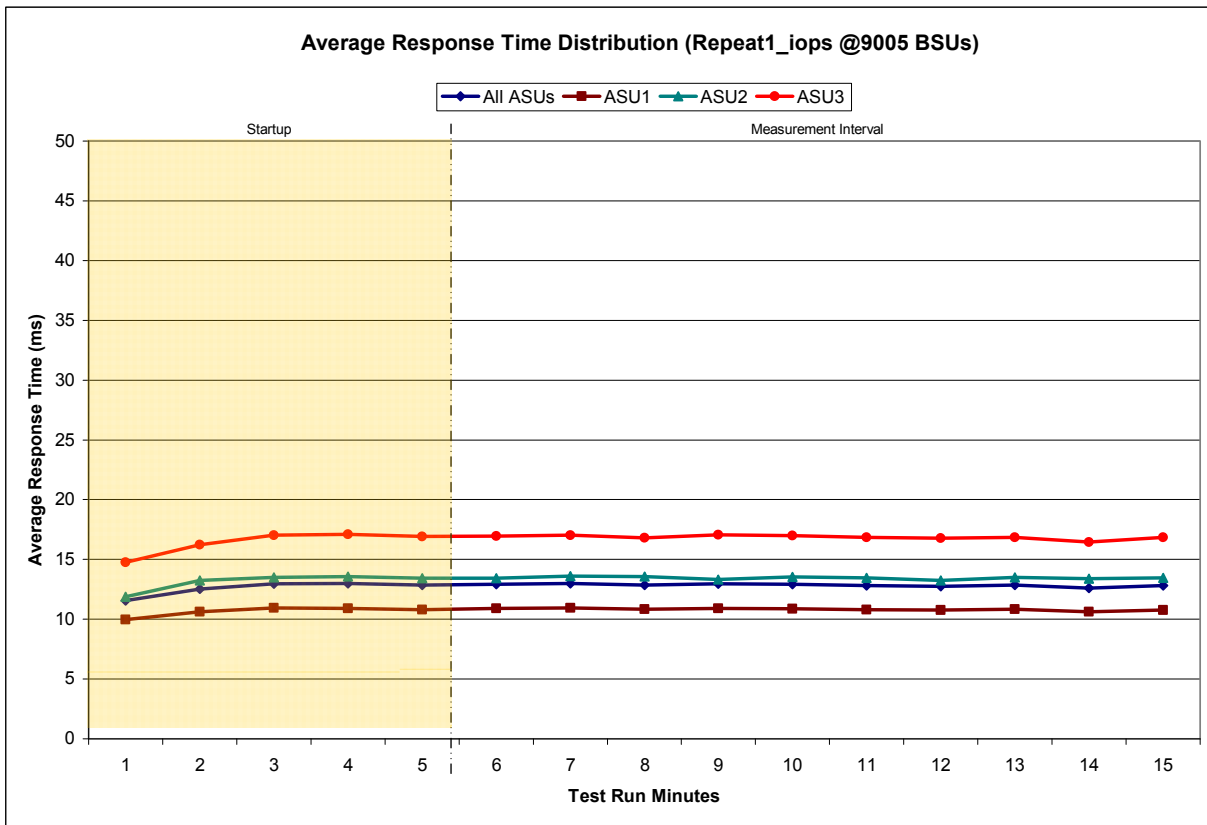
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

9005 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	21:41:05	21:46:05	0-4	0:05:00
<i>Measurement Interval</i>	21:46:05	21:56:08	5-14	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	11.56	9.99	11.86	14.76
1	12.52	10.61	13.25	16.23
2	12.97	10.95	13.50	17.02
3	12.98	10.92	13.55	17.08
4	12.83	10.79	13.41	16.91
5	12.92	10.92	13.41	16.96
6	12.98	10.95	13.59	17.03
7	12.86	10.85	13.58	16.80
8	12.94	10.92	13.32	17.07
9	12.93	10.88	13.53	17.00
10	12.83	10.79	13.45	16.86
11	12.75	10.76	13.26	16.76
12	12.85	10.83	13.51	16.85
13	12.60	10.63	13.39	16.44
14	12.81	10.77	13.45	16.86
Average	12.85	10.83	13.45	16.86

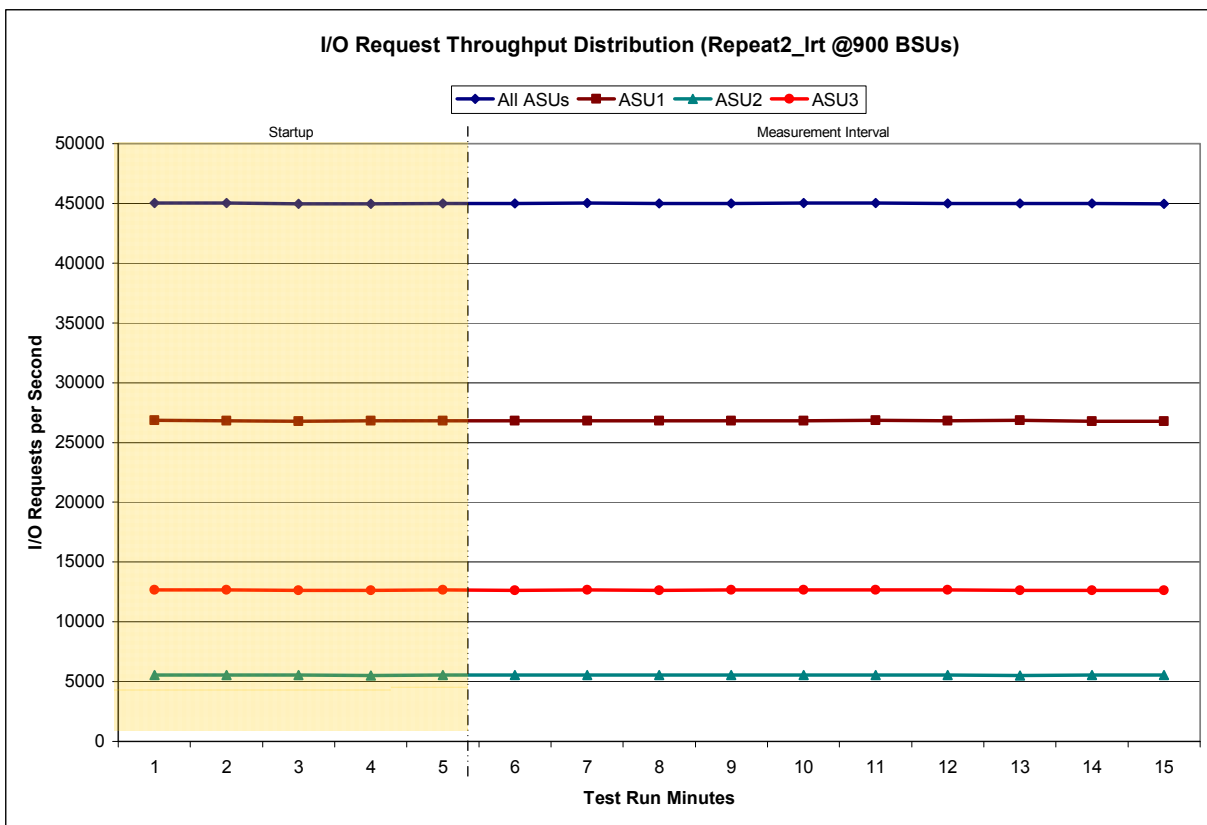
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

900 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	22:11:41	22:16:41	0-4	0:05:00
	22:16:41	22:26:43	5-14	0:10:02
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	45,034.50	26,838.37	5,532.90	12,663.23
1	45,019.82	26,825.72	5,535.52	12,658.58
2	44,968.57	26,790.80	5,526.83	12,650.93
3	44,975.22	26,821.05	5,524.27	12,629.90
4	45,007.80	26,813.47	5,534.43	12,659.90
5	44,993.20	26,815.18	5,529.57	12,648.45
6	45,020.88	26,811.33	5,555.25	12,654.30
7	45,008.90	26,824.62	5,539.25	12,645.03
8	45,011.47	26,816.82	5,540.97	12,653.68
9	45,021.38	26,808.97	5,533.67	12,678.75
10	45,042.18	26,840.48	5,534.80	12,666.90
11	44,984.10	26,800.42	5,530.28	12,653.40
12	45,004.80	26,843.70	5,518.25	12,642.85
13	44,980.63	26,798.05	5,534.20	12,648.38
14	44,961.42	26,782.10	5,536.97	12,642.35
Average	45,002.90	26,814.17	5,535.32	12,653.41

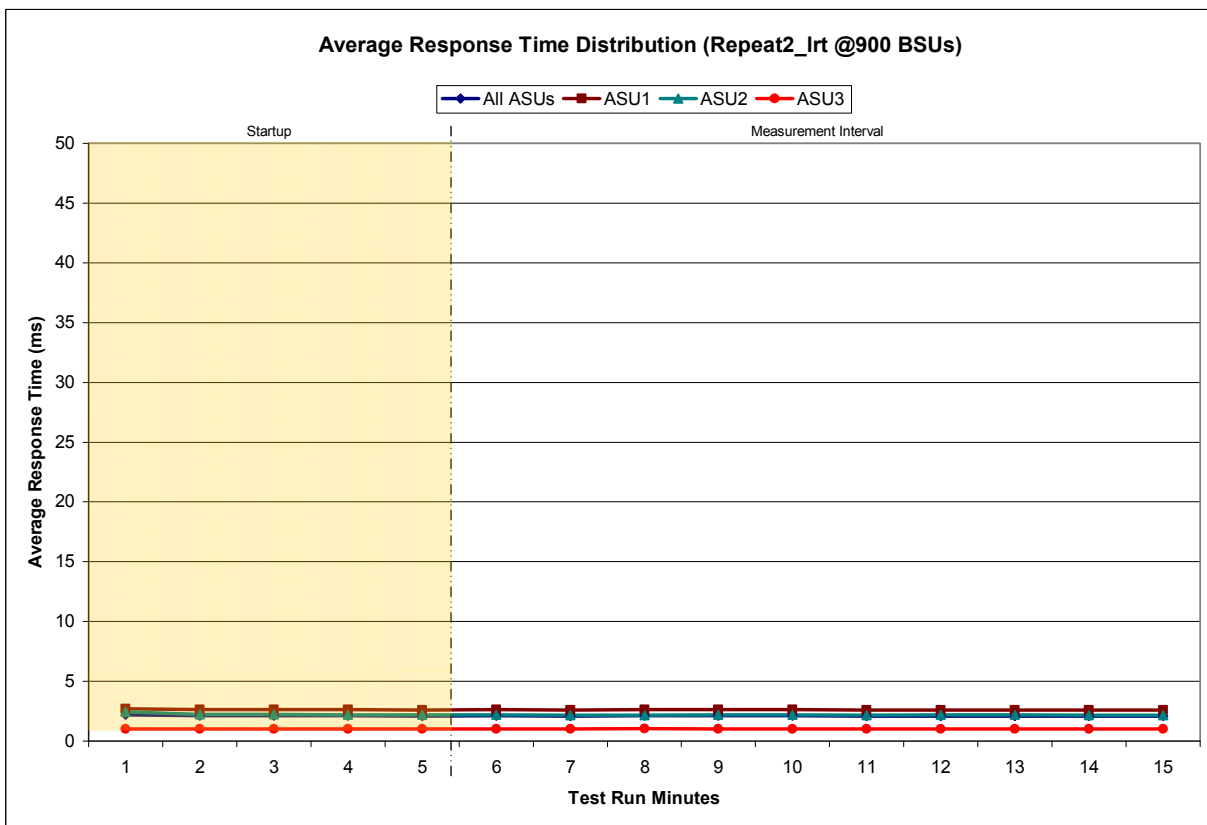
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

900 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	22:11:41	22:16:41	0-4	0:05:00
	22:16:41	22:26:43	5-14	0:10:02
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.21	2.72	2.46	1.01
1	2.14	2.64	2.22	1.02
2	2.13	2.63	2.22	1.02
3	2.12	2.62	2.20	1.02
4	2.10	2.61	2.19	1.00
5	2.12	2.62	2.20	1.02
6	2.10	2.61	2.17	1.00
7	2.11	2.61	2.17	1.03
8	2.11	2.62	2.18	1.02
9	2.12	2.63	2.20	1.02
10	2.10	2.60	2.17	1.02
11	2.10	2.59	2.18	1.01
12	2.10	2.60	2.20	1.00
13	2.10	2.59	2.17	1.01
14	2.10	2.59	2.16	1.02
Average	2.11	2.61	2.18	1.01

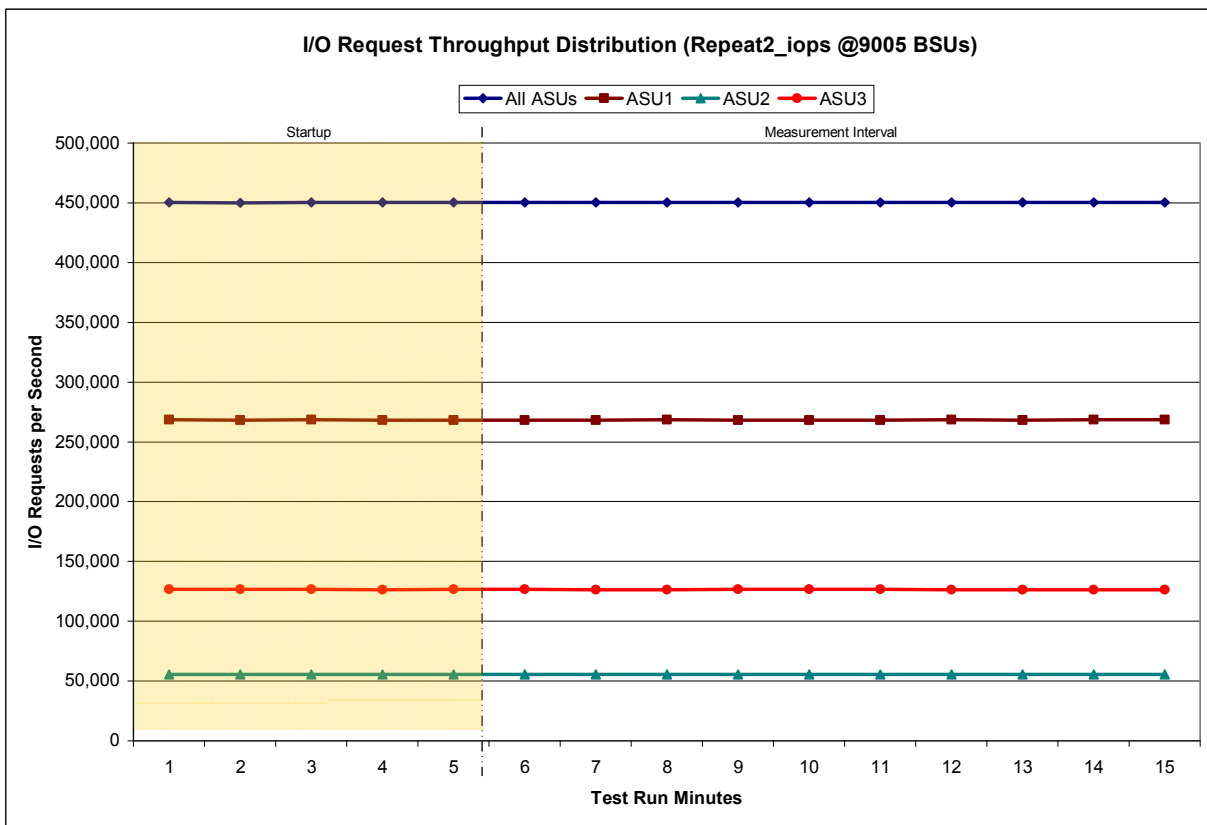
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

9005 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	22:42:50	22:47:50	0-4	0:05:00
	22:47:50	22:57:53	5-14	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	450,485.05	268,467.83	55,420.27	126,596.95
1	450,116.22	268,209.55	55,372.68	126,533.98
2	450,384.38	268,422.70	55,384.17	126,577.52
3	450,252.40	268,349.78	55,409.38	126,493.23
4	450,247.08	268,282.48	55,358.80	126,605.80
5	450,231.05	268,328.12	55,372.92	126,530.02
6	450,167.00	268,235.08	55,409.08	126,522.83
7	450,247.82	268,374.87	55,363.35	126,509.60
8	450,253.33	268,304.20	55,387.50	126,561.63
9	450,367.25	268,309.02	55,447.03	126,611.20
10	450,242.27	268,249.37	55,436.53	126,556.37
11	450,226.58	268,373.82	55,347.83	126,504.93
12	450,171.23	268,346.17	55,351.68	126,473.38
13	450,364.77	268,412.13	55,447.65	126,504.98
14	450,205.20	268,364.78	55,328.00	126,512.42
Average	450,247.65	268,329.76	55,389.16	126,528.74

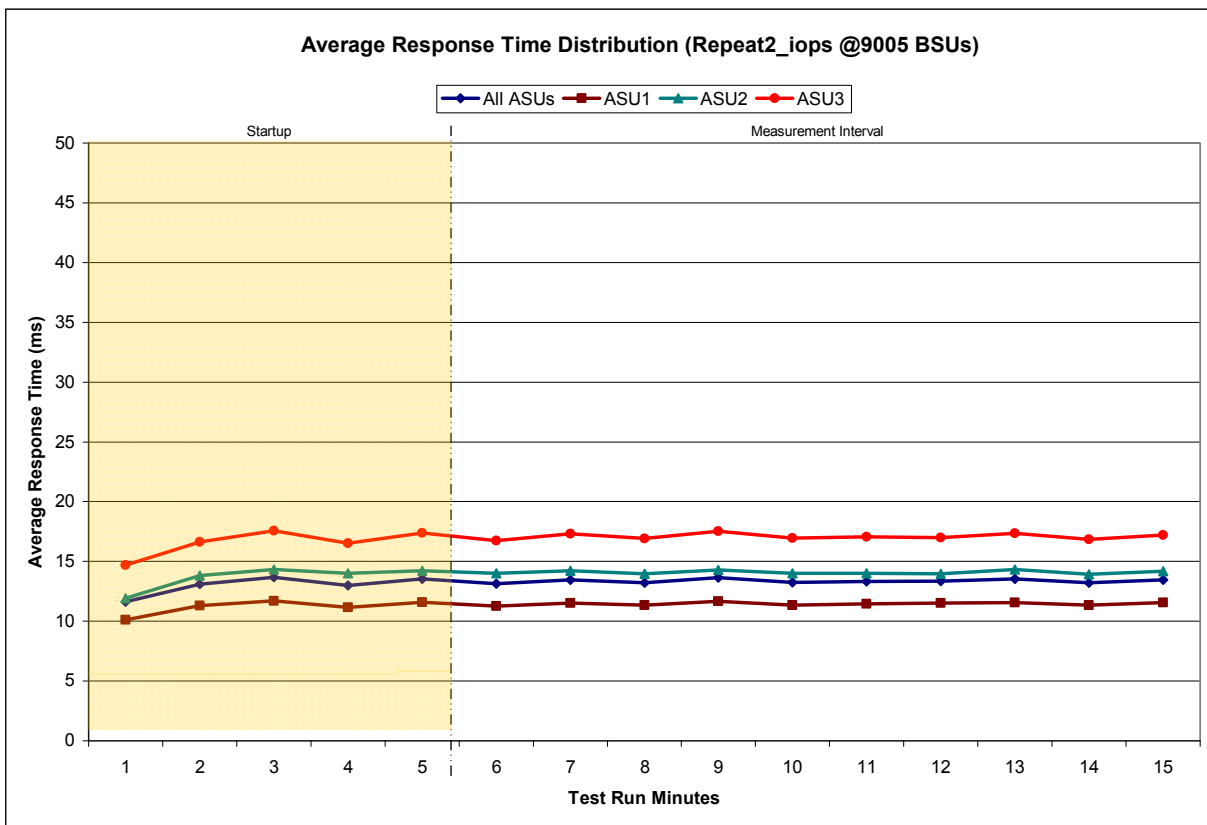
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

9005 BSUs Start-Up/Ramp-Up Measurement Interval	Start 22:42:50	Stop 22:47:50	Interval 0-4	Duration 0:05:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	11.63	10.12	11.93	14.70
1	13.11	11.29	13.82	16.64
2	13.66	11.69	14.32	17.57
3	13.00	11.14	14.00	16.52
4	13.54	11.58	14.23	17.38
5	13.15	11.28	13.99	16.73
6	13.47	11.51	14.23	17.31
7	13.23	11.34	13.96	16.91
8	13.63	11.66	14.28	17.52
9	13.26	11.35	13.99	16.97
10	13.33	11.44	14.02	17.05
11	13.35	11.50	13.95	16.99
12	13.53	11.57	14.34	17.34
13	13.21	11.34	13.92	16.85
14	13.47	11.55	14.19	17.22
Average	13.36	11.46	14.09	17.09

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2809	0.0700	0.2100	0.0180	0.0701	0.0350	0.2811
COV	0.003	0.001	0.002	0.001	0.006	0.002	0.003	0.001

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	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.000

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2812
COV	0.004	0.001	0.002	0.002	0.004	0.002	0.003	0.001

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>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.001	0.001	0.001	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 IOPS™ 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 Tested Storage Configuration (TSC) 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 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1 Workload Generator Input Parameters” on Page 76.

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	4,313,314
Total Number of Logical Blocks Verified	4,273,674
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	1024
Number of Failed I/O Requests in the process of the Test	0

If approved by the SPC Auditor, the SPC-2 Persistence Test may be used to meet the SPC-1 persistence requirements. Both the SPC-1 and SPC-2 Persistence Tests provide the same level of functionality and verification of data integrity. The SPC-2 Persistence Test may be easily configured to address an SPC-1 storage configuration. The SPC-2 Persistence Test extends the size of storage configurations that may be tested and significantly reduces the test duration of such configurations.

The SPC-2 Persistence Test was approved for use in this set of audited measurements.

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 for the Priced Storage Configuration must be the date at which all components are committed to be available.

The HP P10000 3PAR V800 Storage System as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

The Executive Summary shall contain a pricing spreadsheet as documented in Clause 8.3.1.

Pricing information may be found in the Priced Storage Configuration Pricing section on page 14.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.7

The Executive Summary shall contain a pricing a list of all differenced between the Tested Storage Configuration (TSC) and the Priced Storage Configuration.

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 14.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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 Onsite Audit of the HP P10000 3PAR V800 Storage System .

APPENDIX A: SPC-1 GLOSSARY

“Decimal” (*powers of ten*) Measurement Units

In the storage industry, the terms “kilo”, “mega”, “giga”, “tera”, “peta”, and “exa” are commonly used prefixes for computing performance and capacity. For the purposes of the SPC workload definitions, all of the following terms are defined in “powers of ten” measurement units.

A kilobyte (KB) is equal to 1,000 (10^3) bytes.

A megabyte (MB) is equal to 1,000,000 (10^6) bytes.

A gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.

A terabyte (TB) is equal to 1,000,000,000,000 (10^{12}) bytes.

A petabyte (PB) is equal to 1,000,000,000,000,000 (10^{15}) bytes

An exabyte (EB) is equal to 1,000,000,000,000,000,000 (10^{18}) bytes

“Binary” (*powers of two*) Measurement Units

The sizes reported by many operating system components use “powers of two” measurement units rather than “power of ten” units. The following standardized definitions and terms are also valid and may be used in this document.

A kibibyte (KiB) is equal to 1,024 (2^{10}) bytes.

A mebibyte (MiB) is equal to 1,048,576 (2^{20}) bytes.

A gibibyte (GiB) is equal to 1,073,741,824 (2^{30}) bytes.

A tebibyte (TiB) is equal to 1,099,511,627,776 (2^{40}) bytes.

A pebibyte (PiB) is equal to 1,125,899,906,842,624 (2^{50}) bytes.

An exbibyte (EiB) is equal to 1,152,921,504,606,846,967 (2^{60}) bytes.

SPC-1 Data Repository Definitions

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

Application Storage Unit (ASU): The logical interface between the storage and SPC-1 Workload Generator. The three ASUs (Data, User, and Log) are typically implemented on one or more Logical Volume.

Logical Volume: The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-1 benchmark. Each Logical Volume is implemented as a single, contiguous address space.

Addressable Storage Capacity: The total storage (sum of Logical Volumes) that can be read and written by application programs such as the SPC-1 Workload Generator.

Configured Storage Capacity: This capacity includes the Addressable Storage Capacity and any other storage (parity disks, hot spares, etc.) necessary to implement the Addressable Storage Capacity.

Physical Storage Capacity: The formatted capacity of all storage devices physically present in the Tested Storage Configuration (TSC).

Data Protection Overhead: The storage capacity required to implement the selected level of data protection.

Required Storage: The amount of Configured Storage Capacity required to implement the Addressable Storage Configuration, excluding the storage required for the three ASUs.

Global Storage Overhead: The amount of Physical Storage Capacity that is required for storage subsystem use and unavailable for use by application programs.

Total Unused Storage: The amount of storage capacity available for use by application programs but not included in the Total ASU Capacity.

SPC-1 Data Protection Levels

Protected: This level will ensure data protection in the event of a single point of failure of any configured storage device. A brief description of the data protection utilized is included in the Executive Summary.

Unprotected: No claim of data protection is asserted in the event of a single point of failure.

SPC-1 Test Execution Definitions

Average Response Time: The sum of the Response Times for all Measured I/O Requests divided by the total number of Measured I/O Requests.

Completed I/O Request: An I/O Request with a Start Time and a Completion Time (see “I/O Completion Types” below).

Completion Time: The time recorded by the Workload Generator when an I/O Request is satisfied by the TSC as signaled by System Software.

Data Rate: The data transferred in all Measured I/O Requests in an SPC-1 Test Run divided by the length of the Test Run in seconds.

Expected I/O Count: For any given I/O Stream and Test Phase, the product of 50 times the BSU level, the duration of the Test Phase in seconds, and the Intensity Multiplier for that I/O Stream.

Failed I/O Request: Any I/O Request issued by the Workload Generator that could not be completed or was signaled as failed by System Software. A Failed I/O Request has no Completion Time (see “I/O Completion Types” below).

I/O Request Throughput: The total number of Measured I/O requests in an SPC-1 Test Run divided by the duration of the Measurement Interval in seconds.

In-Flight I/O Request: An I/O Request issued by the I/O Command Generator to the TSC that has a recorded Start Time, but does not complete within the Measurement Interval (see “I/O Completion Types” below).

Measured I/O Request: A Completed I/O Request with a Completion Time occurring within the Measurement Interval (see “I/O Completion Types” below).

Measured Intensity Multiplier: The percentage of all Measured I/O Requests that were issued by a given I/O Stream.

Measurement Interval: The finite and contiguous time period, after the TSC has reached Steady State, when data is collected by a Test Sponsor to generate an SPC-1 test result or support an SPC-1 test result.

Ramp-Up: The time required for the Benchmark Configuration (BC) to produce Steady State throughput after the Workload Generator begins submitting I/O Requests to the TSC for execution.

Ramp-Down: The time required for the BC to complete all I/O Requests issued by the Workload Generator. The Ramp-Down period begins when the Workload Generator ceases to issue new I/O Requests to the TSC.

Response Time: The Response Time of a Measured I/O Request is its Completion Time minus its Start Time.

Start Time: The time recorded by the Workload Generator when an I/O Request is submitted, by the Workload Generator, to the System Software for execution on the Tested Storage Configuration (TSC).

Start-Up: The period that begins after the Workload Generator starts to submit I/O requests to the TSC and ends at the beginning of the Measurement Interval.

Shut-Down: The period between the end of the Measurement Interval and the time when all I/O Requests issued by the Workload Generator have completed or failed.

Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

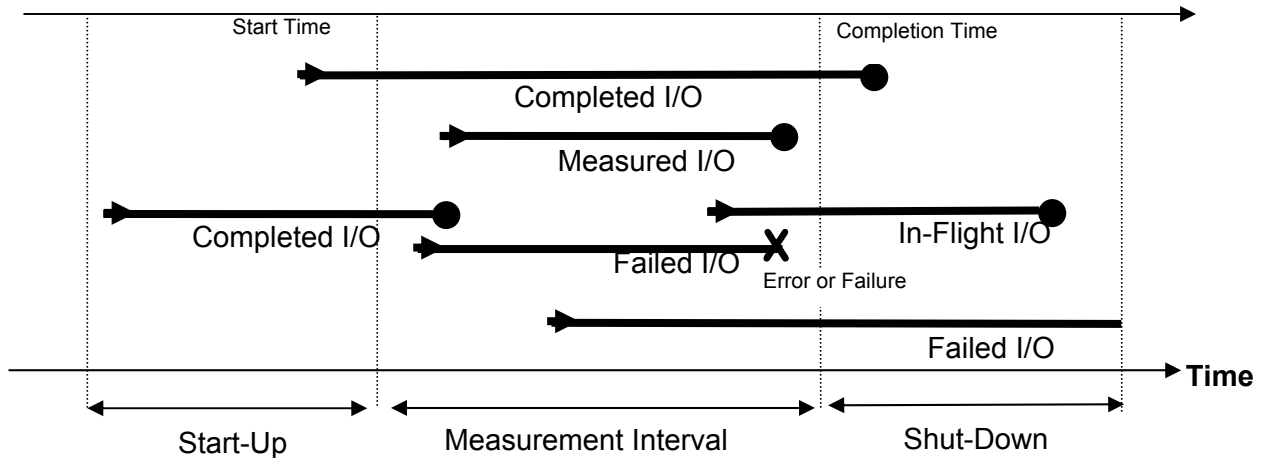
Test: A collection of Test Phases and or Test Runs sharing a common objective.

Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up

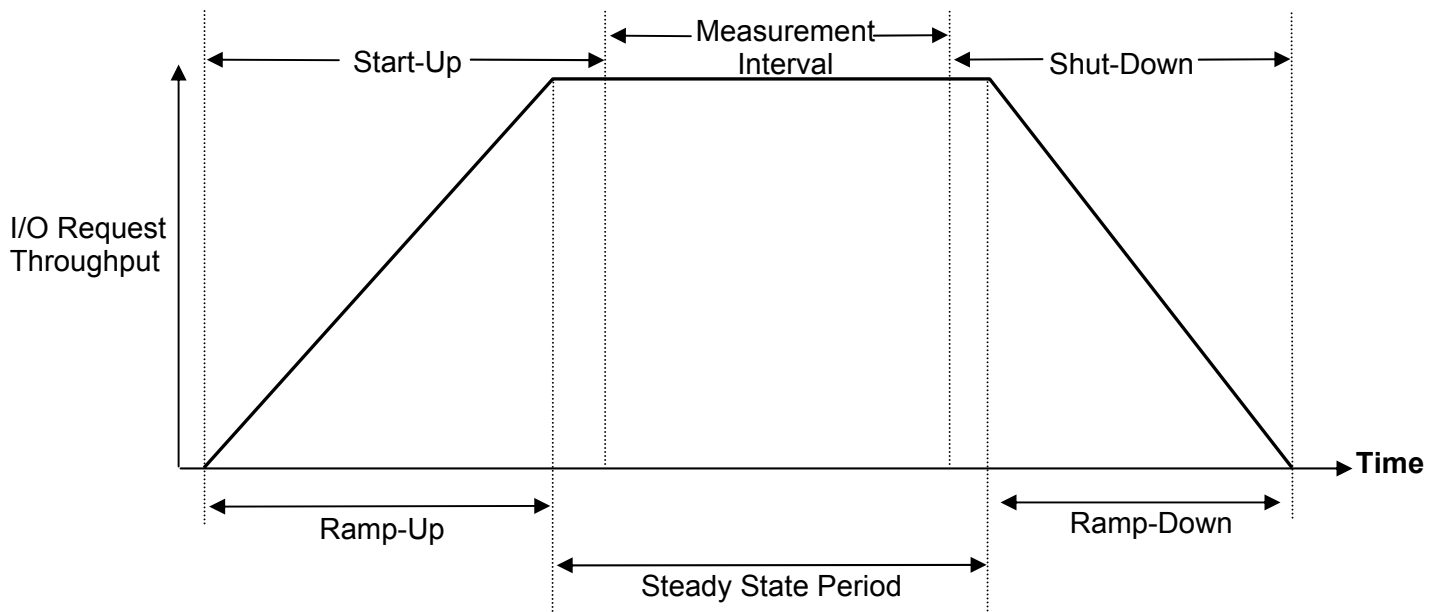
period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

Test Phase: A collection of one or more SPC-1 Test Runs sharing a common objective and intended to be run in a specific sequence.

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The **QueueDepth** parameter for each HBA was changed from a default of 32 to 254. The **QueueTarget** parameter was set from a default of 0 to 1, which means the **QueueDepth** parameter value applies on a per target (HBA) basis, not a LUN basis.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Customer-Ready Configuration

As part of the customer installation process, an HP Field Engineer will execute a series of default commands that will result in the storage system self-configuring and self-provisioning the appropriate available, spare and metadata capacities based upon the number and capacity of storage devices in the HP P10000 3PAR V800 Storage System configuration.

Front-End Port Configuration

As described in the *HP 3PAR Windows 2003 Implementation Guide*, the InServ front-end ports are configured to the correct Host System. The SPC-1 configuration was connected via the blade fabric, so all ports were changed to “point”. The following script did this for all of the Host System port used (32 ports, 4 per Host System).

```
for n in {0..7}
do
  for s in 1 4 7
  do
    if (($s==1))
    then
      for p in 4
      do
        controlport offline -f $n:$s:$p
        controlport config host -ct point -f $n:$s:$p
        controlport rst -f $n:$s:$p
      done
    fi

    for p in 2
    do
      controlport offline -f $n:$s:$p
      controlport config host -ct point -f $n:$s:$p
      controlport rst -f $n:$s:$p
    done
  done
done
```

Create the SPC-1 Logical Volumes

The following script does the following

- Creates 672 SPC-1 Logical Volumes
(480 for ASU-1, 128 for ASU-2 and 64 for ASU-3)
- Exports the volumes to the Host System ports.

The volumes are visible to the Host Systems after a reboot of each Host System.

```
PORTS[0]=":7:2"  
PORTS[1]=":1:2"  
PORTS[2]=":1:4"  
PORTS[3]=":4:2"
```

```
for nd in {0..7}
do
  createcpg -t rl -rs 120 -sdgs 120g -p -nd $nd  cpgfc$nd

  for hba in {0..3}
  do
    for i in {0..14} ; do
      id=$((1+60*nd+15*hba+i))
      createvv -i $id cpgfc${nd} asu1.${id} 240g;
      createvlun -f asu1.${id} $((15*nd+i+1)) ${nd}${PORTS[$hba]}
    done

    for i in {0..1} ; do
      id=$((681+8*nd+2*hba+i))
      j=$((id-680))
      createvv -i $id cpgfc${nd} asu3.${j} 360g;
      createvlun -f asu3.${j} $((2*nd+i+181)) ${nd}${PORTS[$hba]}
    done

    for i in {0..3} ; do
      id=$((481+16*nd+4*hba+i))
      j=$((id-480))
      createvv -i $id cpgfc${nd} asu2.${j} 840g;
      createvlun -f asu2.${j} $((4*nd+i+121)) ${nd}${PORTS[$hba]}
    done
  done
done
done
```

Host System Configuration

The following steps were done on each Host System:

- Installed the “Windows Null Driver” software. This simply prevents a popup appearing for each installed storage device thinking it has found new hardware.
- Installed HP 3PAR MPIO.
- Installed Emulex OneCommand™ Manager to configure the HBAs. The changes made to HBA default settings are documented in Appendix B.
- Installed the PsTools Suite (from <http://technet.microsoft.com/en-us/sysinternals/bb896649>) to be able to start Slave JVMs from the master Host System.

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

The content of SPC-1 Workload Generator command and parameter files, used in this benchmark to execute the Primary Metrics and Repeatability Tests, are listed below.

Common Entries

The command lines listed below appear at the beginning of each of the command and parameter files for the Primary Metrics and Repeatability Tests.

```
host=master
```

```
slaves=(slave32a,slave32b,slave32c,slave32d,slave32e,slave32f,slave32g,slave32h,slave32i,slave32j,slave32k,slave32l,slave32m,slave32n,slave32o,slave32p,slave33a,slave33b,slave33c,slave33d,slave33e,slave33f,slave33g,slave33h,slave33i,slave33j,slave33k,slave33l,slave33m,slave33n,slave33o,slave33p,slave34a,slave34b,slave34c,slave34d,slave34e,slave34f,slave34g,slave34h,slave34i,slave34j,slave34k,slave34l,slave34m,slave34n,slave34o,slave34p,slave35a,slave35b,slave35c,slave35d,slave35e,slave35f,slave35g,slave35h,slave35i,slave35j,slave35k,slave35l,slave35m,slave35n,slave35o,slave35p,slave36a,slave36b,slave36c,slave36d,slave36e,slave36f,slave36g,slave36h,slave36i,slave36j,slave36k,slave36l,slave36m,slave36n,slave36o,slave36p,slave37a,slave37b,slave37c,slave37d,slave37e,slave37f,slave37g,slave37h,slave37i,slave37j,slave37k,slave37l,slave37m,slave37n,slave37o,slave37p,slave38a,slave38b,slave38c,slave38d,slave38e,slave38f,slave38g,slave38h,slave38i,slave38j,slave38k,slave38l,slave38m,slave38n,slave38o,slave38p,slave39a,slave39b,slave39c,slave39d,slave39e,slave39f,slave39g,slave39h,slave39i,slave39j,slave39k,slave39l,slave39m,slave39n,slave39o,slave39p)
```

```
sd=asul_1,lun=\\.PhysicalDrive169,size=216g  
sd=asul_2,lun=\\.PhysicalDrive505,size=216g  
sd=asul_3,lun=\\.PhysicalDrive190,size=216g  
sd=asul_4,lun=\\.PhysicalDrive589,size=216g  
sd=asul_5,lun=\\.PhysicalDrive652,size=216g  
sd=asul_6,lun=\\.PhysicalDrive148,size=216g  
sd=asul_7,lun=\\.PhysicalDrive149,size=216g  
sd=asul_8,lun=\\.PhysicalDrive484,size=216g  
sd=asul_9,lun=\\.PhysicalDrive485,size=216g  
sd=asul_10,lun=\\.PhysicalDrive170,size=216g  
sd=asul_11,lun=\\.PhysicalDrive171,size=216g  
sd=asul_12,lun=\\.PhysicalDrive172,size=216g  
sd=asul_13,lun=\\.PhysicalDrive173,size=216g  
sd=asul_14,lun=\\.PhysicalDrive174,size=216g  
sd=asul_15,lun=\\.PhysicalDrive175,size=216g  
sd=asul_16,lun=\\.PhysicalDrive506,size=216g  
sd=asul_17,lun=\\.PhysicalDrive507,size=216g  
sd=asul_18,lun=\\.PhysicalDrive508,size=216g  
sd=asul_19,lun=\\.PhysicalDrive509,size=216g  
sd=asul_20,lun=\\.PhysicalDrive510,size=216g  
sd=asul_21,lun=\\.PhysicalDrive511,size=216g  
sd=asul_22,lun=\\.PhysicalDrive211,size=216g  
sd=asul_23,lun=\\.PhysicalDrive212,size=216g  
sd=asul_24,lun=\\.PhysicalDrive213,size=216g  
sd=asul_25,lun=\\.PhysicalDrive214,size=216g  
sd=asul_26,lun=\\.PhysicalDrive215,size=216g  
sd=asul_27,lun=\\.PhysicalDrive216,size=216g  
sd=asul_28,lun=\\.PhysicalDrive217,size=216g  
sd=asul_29,lun=\\.PhysicalDrive337,size=216g  
sd=asul_30,lun=\\.PhysicalDrive191,size=216g  
sd=asul_31,lun=\\.PhysicalDrive295,size=216g  
sd=asul_32,lun=\\.PhysicalDrive85,size=216g
```

sd=asul_33,lun=\\.\PhysicalDrive547,size=216g
sd=asul_34,lun=\\.\PhysicalDrive64,size=216g
sd=asul_35,lun=\\.\PhysicalDrive65,size=216g
sd=asul_36,lun=\\.\PhysicalDrive253,size=216g
sd=asul_37,lun=\\.\PhysicalDrive232,size=216g
sd=asul_38,lun=\\.\PhysicalDrive43,size=216g
sd=asul_39,lun=\\.\PhysicalDrive379,size=216g
sd=asul_40,lun=\\.\PhysicalDrive590,size=216g
sd=asul_41,lun=\\.\PhysicalDrive421,size=216g
sd=asul_42,lun=\\.\PhysicalDrive274,size=216g
sd=asul_43,lun=\\.\PhysicalDrive568,size=216g
sd=asul_44,lun=\\.\PhysicalDrive442,size=216g
sd=asul_45,lun=\\.\PhysicalDrive22,size=216g
sd=asul_46,lun=\\.\PhysicalDrive631,size=216g
sd=asul_47,lun=\\.\PhysicalDrive463,size=216g
sd=asul_48,lun=\\.\PhysicalDrive653,size=216g
sd=asul_49,lun=\\.\PhysicalDrive654,size=216g
sd=asul_50,lun=\\.\PhysicalDrive655,size=216g
sd=asul_51,lun=\\.\PhysicalDrive656,size=216g
sd=asul_52,lun=\\.\PhysicalDrive657,size=216g
sd=asul_53,lun=\\.\PhysicalDrive658,size=216g
sd=asul_54,lun=\\.\PhysicalDrive659,size=216g
sd=asul_55,lun=\\.\PhysicalDrive660,size=216g
sd=asul_56,lun=\\.\PhysicalDrive661,size=216g
sd=asul_57,lun=\\.\PhysicalDrive662,size=216g
sd=asul_58,lun=\\.\PhysicalDrive663,size=216g
sd=asul_59,lun=\\.\PhysicalDrive664,size=216g
sd=asul_60,lun=\\.\PhysicalDrive150,size=216g
sd=asul_61,lun=\\.\PhysicalDrive151,size=216g
sd=asul_62,lun=\\.\PhysicalDrive152,size=216g
sd=asul_63,lun=\\.\PhysicalDrive153,size=216g
sd=asul_64,lun=\\.\PhysicalDrive154,size=216g
sd=asul_65,lun=\\.\PhysicalDrive155,size=216g
sd=asul_66,lun=\\.\PhysicalDrive156,size=216g
sd=asul_67,lun=\\.\PhysicalDrive157,size=216g
sd=asul_68,lun=\\.\PhysicalDrive158,size=216g
sd=asul_69,lun=\\.\PhysicalDrive159,size=216g
sd=asul_70,lun=\\.\PhysicalDrive160,size=216g
sd=asul_71,lun=\\.\PhysicalDrive161,size=216g
sd=asul_72,lun=\\.\PhysicalDrive486,size=216g
sd=asul_73,lun=\\.\PhysicalDrive233,size=216g
sd=asul_74,lun=\\.\PhysicalDrive380,size=216g
sd=asul_75,lun=\\.\PhysicalDrive665,size=216g
sd=asul_76,lun=\\.\PhysicalDrive275,size=216g
sd=asul_77,lun=\\.\PhysicalDrive66,size=216g
sd=asul_78,lun=\\.\PhysicalDrive548,size=216g
sd=asul_79,lun=\\.\PhysicalDrive192,size=216g
sd=asul_80,lun=\\.\PhysicalDrive106,size=216g
sd=asul_81,lun=\\.\PhysicalDrive358,size=216g
sd=asul_82,lun=\\.\PhysicalDrive234,size=216g
sd=asul_83,lun=\\.\PhysicalDrive400,size=216g
sd=asul_84,lun=\\.\PhysicalDrive338,size=216g
sd=asul_85,lun=\\.\PhysicalDrive296,size=216g
sd=asul_86,lun=\\.\PhysicalDrive526,size=216g
sd=asul_87,lun=\\.\PhysicalDrive86,size=216g
sd=asul_88,lun=\\.\PhysicalDrive254,size=216g
sd=asul_89,lun=\\.\PhysicalDrive23,size=216g
sd=asul_90,lun=\\.\PhysicalDrive512,size=216g
sd=asul_91,lun=\\.\PhysicalDrive591,size=216g
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sd=asul_95,lun=\\.\PhysicalDrive45,size=216g

sd=asul_96,lun=\\.\PhysicalDrive107,size=216g
sd=asul_97,lun=\\.\PhysicalDrive1,size=216g
sd=asul_98,lun=\\.\PhysicalDrive401,size=216g
sd=asul_99,lun=\\.\PhysicalDrive569,size=216g
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sd=asul_103,lun=\\.\PhysicalDrive316,size=216g
sd=asul_104,lun=\\.\PhysicalDrive3,size=216g
sd=asul_105,lun=\\.\PhysicalDrive4,size=216g
sd=asul_106,lun=\\.\PhysicalDrive5,size=216g
sd=asul_107,lun=\\.\PhysicalDrive297,size=216g
sd=asul_108,lun=\\.\PhysicalDrive465,size=216g
sd=asul_109,lun=\\.\PhysicalDrive317,size=216g
sd=asul_110,lun=\\.\PhysicalDrive443,size=216g
sd=asul_111,lun=\\.\PhysicalDrive46,size=216g
sd=asul_112,lun=\\.\PhysicalDrive402,size=216g
sd=asul_113,lun=\\.\PhysicalDrive235,size=216g
sd=asul_114,lun=\\.\PhysicalDrive193,size=216g
sd=asul_115,lun=\\.\PhysicalDrive381,size=216g
sd=asul_116,lun=\\.\PhysicalDrive108,size=216g
sd=asul_117,lun=\\.\PhysicalDrive487,size=216g
sd=asul_118,lun=\\.\PhysicalDrive570,size=216g
sd=asul_119,lun=\\.\PhysicalDrive592,size=216g
sd=asul_120,lun=\\.\PhysicalDrive466,size=216g
sd=asul_121,lun=\\.\PhysicalDrive513,size=216g
sd=asul_122,lun=\\.\PhysicalDrive444,size=216g
sd=asul_123,lun=\\.\PhysicalDrive318,size=216g
sd=asul_124,lun=\\.\PhysicalDrive488,size=216g
sd=asul_125,lun=\\.\PhysicalDrive25,size=216g
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sd=asul_128,lun=\\.\PhysicalDrive527,size=216g
sd=asul_129,lun=\\.\PhysicalDrive26,size=216g
sd=asul_130,lun=\\.\PhysicalDrive514,size=216g
sd=asul_131,lun=\\.\PhysicalDrive489,size=216g
sd=asul_132,lun=\\.\PhysicalDrive298,size=216g
sd=asul_133,lun=\\.\PhysicalDrive219,size=216g
sd=asul_134,lun=\\.\PhysicalDrive127,size=216g
sd=asul_135,lun=\\.\PhysicalDrive359,size=216g
sd=asul_136,lun=\\.\PhysicalDrive6,size=216g
sd=asul_137,lun=\\.\PhysicalDrive177,size=216g
sd=asul_138,lun=\\.\PhysicalDrive220,size=216g
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sd=asul_140,lun=\\.\PhysicalDrive87,size=216g
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sd=asul_142,lun=\\.\PhysicalDrive339,size=216g
sd=asul_143,lun=\\.\PhysicalDrive222,size=216g
sd=asul_144,lun=\\.\PhysicalDrive490,size=216g
sd=asul_145,lun=\\.\PhysicalDrive340,size=216g
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sd=asu2_36,lun=\\.\PhysicalDrive206,size=810g
sd=asu2_37,lun=\\.\PhysicalDrive60,size=810g
sd=asu2_38,lun=\\.\PhysicalDrive79,size=810g
sd=asu2_39,lun=\\.\PhysicalDrive416,size=810g
sd=asu2_40,lun=\\.\PhysicalDrive16,size=810g
sd=asu2_41,lun=\\.\PhysicalDrive395,size=810g
sd=asu2_42,lun=\\.\PhysicalDrive439,size=810g
sd=asu2_43,lun=\\.\PhysicalDrive584,size=810g
sd=asu2_44,lun=\\.\PhysicalDrive627,size=810g
sd=asu2_45,lun=\\.\PhysicalDrive541,size=810g
sd=asu2_46,lun=\\.\PhysicalDrive417,size=810g
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sd=asu2_51,lun=\\.\PhysicalDrive292,size=810g
sd=asu2_52,lun=\\.\PhysicalDrive628,size=810g
sd=asu2_53,lun=\\.\PhysicalDrive374,size=810g
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sd=asu2_56,lun=\\.\PhysicalDrive606,size=810g

```
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sd=asu2_60,lun=\\.\PhysicalDrive124,size=810g
sd=asu2_61,lun=\\.\PhysicalDrive17,size=810g
sd=asu2_62,lun=\\.\PhysicalDrive332,size=810g
sd=asu2_63,lun=\\.\PhysicalDrive499,size=810g
sd=asu2_64,lun=\\.\PhysicalDrive667,size=810g
sd=asu2_65,lun=\\.\PhysicalDrive478,size=810g
sd=asu2_66,lun=\\.\PhysicalDrive163,size=810g
sd=asu2_67,lun=\\.\PhysicalDrive646,size=810g
sd=asu2_68,lun=\\.\PhysicalDrive647,size=810g
sd=asu2_69,lun=\\.\PhysicalDrive397,size=810g
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sd=asu2_71,lun=\\.\PhysicalDrive459,size=810g
sd=asu2_72,lun=\\.\PhysicalDrive585,size=810g
sd=asu2_73,lun=\\.\PhysicalDrive520,size=810g
sd=asu2_74,lun=\\.\PhysicalDrive38,size=810g
sd=asu2_75,lun=\\.\PhysicalDrive250,size=810g
sd=asu2_76,lun=\\.\PhysicalDrive61,size=810g
sd=asu2_77,lun=\\.\PhysicalDrive418,size=810g
sd=asu2_78,lun=\\.\PhysicalDrive586,size=810g
sd=asu2_79,lun=\\.\PhysicalDrive460,size=810g
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sd=asu2_86,lun=\\.\PhysicalDrive479,size=810g
sd=asu2_87,lun=\\.\PhysicalDrive480,size=810g
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sd=asu2_90,lun=\\.\PhysicalDrive334,size=810g
sd=asu2_91,lun=\\.\PhysicalDrive668,size=810g
sd=asu2_92,lun=\\.\PhysicalDrive669,size=810g
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sd=asu2_94,lun=\\.\PhysicalDrive164,size=810g
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sd=asu2_119,lun=\\.\PhysicalDrive376,size=810g
```



```
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sd=asu2_121,lun=\\.\PhysicalDrive102,size=810g
sd=asu2_122,lun=\\.\PhysicalDrive103,size=810g
sd=asu2_123,lun=\\.\PhysicalDrive563,size=810g
sd=asu2_124,lun=\\.\PhysicalDrive564,size=810g
sd=asu2_125,lun=\\.\PhysicalDrive565,size=810g
sd=asu2_126,lun=\\.\PhysicalDrive80,size=810g
sd=asu2_127,lun=\\.\PhysicalDrive81,size=810g
sd=asu2_128,lun=\\.\PhysicalDrive82,size=810g
sd=asu3_1,lun=\\.\PhysicalDrive377,size=360g
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sd=asu3_3,lun=\\.\PhysicalDrive650,size=360g
sd=asu3_4,lun=\\.\PhysicalDrive104,size=360g
sd=asu3_5,lun=\\.\PhysicalDrive188,size=360g
sd=asu3_6,lun=\\.\PhysicalDrive608,size=360g
sd=asu3_7,lun=\\.\PhysicalDrive482,size=360g
sd=asu3_8,lun=\\.\PhysicalDrive251,size=360g
sd=asu3_9,lun=\\.\PhysicalDrive20,size=360g
sd=asu3_10,lun=\\.\PhysicalDrive209,size=360g
sd=asu3_11,lun=\\.\PhysicalDrive629,size=360g
sd=asu3_12,lun=\\.\PhysicalDrive293,size=360g
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sd=asu3_31,lun=\\.\PhysicalDrive167,size=360g
sd=asu3_32,lun=\\.\PhysicalDrive525,size=360g
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sd=asu3_36,lun=\\.\PhysicalDrive419,size=360g
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sd=asu3_41,lun=\\.\PhysicalDrive356,size=360g
sd=asu3_42,lun=\\.\PhysicalDrive273,size=360g
sd=asu3_43,lun=\\.\PhysicalDrive378,size=360g
sd=asu3_44,lun=\\.\PhysicalDrive357,size=360g
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sd=asu3_46,lun=\\.\PhysicalDrive189,size=360g
sd=asu3_47,lun=\\.\PhysicalDrive63,size=360g
sd=asu3_48,lun=\\.\PhysicalDrive420,size=360g
sd=asu3_49,lun=\\.\PhysicalDrive399,size=360g
sd=asu3_50,lun=\\.\PhysicalDrive609,size=360g
sd=asu3_51,lun=\\.\PhysicalDrive147,size=360g
sd=asu3_52,lun=\\.\PhysicalDrive441,size=360g
sd=asu3_53,lun=\\.\PhysicalDrive294,size=360g
sd=asu3_54,lun=\\.\PhysicalDrive630,size=360g
```

```
sd=asu3_55,lun=\\.\PhysicalDrive588,size=360g
sd=asu3_56,lun=\\.\PhysicalDrive462,size=360g
sd=asu3_57,lun=\\.\PhysicalDrive42,size=360g
sd=asu3_58,lun=\\.\PhysicalDrive651,size=360g
sd=asu3_59,lun=\\.\PhysicalDrive21,size=360g
sd=asu3_60,lun=\\.\PhysicalDrive483,size=360g
sd=asu3_61,lun=\\.\PhysicalDrive336,size=360g
sd=asu3_62,lun=\\.\PhysicalDrive672,size=360g
sd=asu3_63,lun=\\.\PhysicalDrive168,size=360g
sd=asu3_64,lun=\\.\PhysicalDrive504,size=360g
```

sustain.txt

```
rd=sustain,bsus=9005,startup=300,elapsed=28800,interval=60
```

ramp100.txt

```
rd=ramp_100,bsus=9005,startup=300,elapsed=600,interval=60
```

ramp095.txt

```
rd=ramp_95,bsus=8554,startup=300,elapsed=600,interval=60
```

ramp090.txt

```
rd=ramp_90,bsus=8104,startup=300,elapsed=600,interval=60
```

ramp080.txt

```
rd=ramp_80,bsus=7204,startup=300,elapsed=600,interval=60
```

ramp050.txt

```
rd=ramp_50,bsus=4502,startup=300,elapsed=600,interval=60
```

ramp010.txt

```
rd=ramp_10,bsus=900,startup=300,elapsed=600,interval=60
```

repeat1a.txt

```
rd=repeat1_lrt,bsus=900,startup=300,elapsed=600,interval=60
```

repeat1b.txt

```
rd=repeat1_iops,bsus=9005,startup=300,elapsed=600,interval=60
```

repeat2a.txt

```
rd=repeat2_lrt,bsus=900,startup=300,elapsed=600,interval=60
```

repeat2b.txt

```
rd=repeat2_iops,bsus=9005,startup=300,elapsed=600,interval=60
```

Persistence Test

The content of SPC-2 Workload Generator command and parameter files, used in this benchmark to execute the Persistence Test, is listed below.

Common Entries

The command lines that appear at the beginning of each of the command and parameter files for the two SPC-2 Persistence Test Runs are available at the following URL due to the number of entries:

[spc-2_persist_common_entries](#)

spc2persw.txt (write phase)

```
maxlatestart=1
reportinginterval=5
segmentlength=512m
rd=default,rampup=360,periods=90,measurement=300,runout=0,rampdown=0,buffers=1

* "write" Test Phase
rd=default,rdpct=0,xfersize=1024k
rd=TR1_SPC-2-persist-w,streams=320
```

spc2persr.txt (read phase)

```
maxlatestart=1
reportinginterval=5
segmentlength=512m

maxpersistenceerrors=10

* "read" Test Phase
rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1_SPC-2-persist-r
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

Primary Metrics Test, Repeatability Test, and Persistence Test Run 1

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

```
echo off
setlocal

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f sustain.txt -o sustain SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f ramp100.txt -o ramp100 SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f ramp095.txt -o ramp095 SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f ramp090.txt -o ramp090 SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f ramp080.txt -o ramp080 SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f ramp050.txt -o ramp050 SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f ramp010.txt -o ramp010 SPCOut
call C:\spc\spc1\rmslaves.bat

rem break repeat steps into two pieces as well

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f repeat1a.txt -o repeat1_lrt SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f repeat1b.txt -o repeat1_iops SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f repeat2a.txt -o repeat2_lrt SPCOut
call C:\spc\spc1\rmslaves.bat

call C:\spc\spc1\runslaves.bat
java -Xmx1400m -Xms1400m -Xss4k spc1 -w SPC1 -f repeat2b.txt -o repeat2_iops SPCOut
call C:\spc\spc1\rmslaves.bat

rem need to do persistrunw for spc2
cd c:\spc\spc2
```

```
call spc2.bat -f spc2persw.txt -o persist.init -init

call c:\spc\spc2\startallspc2.bat
call c:\spc\spc2\startallspc2.bat

call spc2.bat -f spc2persw.txt -o persist.write

REM    when done reboot system
```

The following scripts were invoked to start and stop the SPC-1 Slave JVMs, respectively.

runslaves.bat

```
C:\PSTools\psexec \\10.112.135.33 -u spcuser -p spcrun c:\spc\spc1\start33.bat
C:\PSTools\psexec \\10.112.135.34 -u spcuser -p spcrun c:\spc\spc1\start34.bat
C:\PSTools\psexec \\10.112.135.35 -u spcuser -p spcrun c:\spc\spc1\start35.bat
C:\PSTools\psexec \\10.112.135.36 -u spcuser -p spcrun c:\spc\spc1\start36.bat
C:\PSTools\psexec \\10.112.135.37 -u spcuser -p spcrun c:\spc\spc1\start37.bat
C:\PSTools\psexec \\10.112.135.38 -u spcuser -p spcrun c:\spc\spc1\start38.bat
C:\PSTools\psexec \\10.112.135.39 -u spcuser -p spcrun c:\spc\spc1\start39.bat
c:\spc\spc1\start32.bat
```

start32.bat

The files **start32.bat** – **start39.bat** are identical with the exception of the Slave JVM identifier (*slave32a...slave32p, slave33a...slave33p, slave34a...slave34p...*).

```
cd C:\SPC\SPC1
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32a.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32b.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32c.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32d.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32e.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32f.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32g.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32h.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32i.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32j.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32k.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32l.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32m.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32n.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32o.txt
start java -Xmx1400m -Xss4k spc1 -f C:\SPC\SPC1\slave32p.txt
```

rmslaves.bat

```
TASKKILL /IM java.exe
taskkill /S hpc7000-06-b2 /U spcuser /P spcrun /IM java.exe
taskkill /S hpc7000-06-b3 /U spcuser /P spcrun /IM java.exe
taskkill /S hpc7000-06-b4 /U spcuser /P spcrun /IM java.exe
taskkill /S hpc7000-06-b5 /U spcuser /P spcrun /IM java.exe
taskkill /S hpc7000-06-b6 /U spcuser /P spcrun /IM java.exe
taskkill /S hpc7000-06-b7 /U spcuser /P spcrun /IM java.exe
taskkill /S hpc7000-06-b8 /U spcuser /P spcrun /IM java.exe
```

The following script was invoked to start and SPC-2 Slave JVMs.

startallspc2.bat

```
C:\PSTools\psexec \\10.112.135.33 -u spcuser -p spcrun c:\spc\spc2\start1.bat
C:\PSTools\psexec \\10.112.135.34 -u spcuser -p spcrun c:\spc\spc2\start1.bat
C:\PSTools\psexec \\10.112.135.35 -u spcuser -p spcrun c:\spc\spc2\start1.bat
C:\PSTools\psexec \\10.112.135.36 -u spcuser -p spcrun c:\spc\spc2\start1.bat
C:\PSTools\psexec \\10.112.135.37 -u spcuser -p spcrun c:\spc\spc2\start1.bat
C:\PSTools\psexec \\10.112.135.38 -u spcuser -p spcrun c:\spc\spc2\start1.bat
C:\PSTools\psexec \\10.112.135.39 -u spcuser -p spcrun c:\spc\spc2\start1.bat
start java -cp c:\spc\spc2 RemoteStart
```

start1.bat

```
start java -cp c:\spc\spc2 RemoteStart
```

SPC-2 Persistence Test Run 2

The following script was used to execute SPC-2 Persistence Test Run 2.

```
cd c:\spc\spc2
call c:\spc\spc2\startallspc2.bat
call c:\spc\spc2\startallspc2.bat

call spc2.bat -f spc2persr.txt -o persist.read
```