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SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

KAMINARIO, INC.
KAMINARIO K2-D *(1875K-1.1)*

SPC-1 V1.12

Submitted for Review: July 30, 2012
Submission Identifier: A00118

First Edition – July 2012

Trademarks

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AUDIT CERTIFICATION

Eyal David
Kaminario, Inc.
Haotzma 1 Hi-Tech Park
Yoqneam 20692
Israel

July 26, 2012

The SPC Benchmark 1™ Reported Data listed below for the Kaminario K2-D 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: Kaminario K2-D *(1875K-1.1)*	
Metric	**Reported Result**
SPC-1 IOPS™	1,219,973.91
SPC-1 Price-Performance	$0.40/SPC-1 IOPS™
Total ASU Capacity	1,159.830 GB
Data Protection Level	Protected *(Mirroring)*
Total TSC Price (including three-year maintenance)	$490,760.00

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 Kaminario, Inc.:
  - ✓ 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.

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

AUDIT CERTIFICATION *(CONT.)*

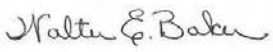
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by physical inspection and information supplied by Kaminario, Inc.:
  - ✓ The type of Host Systems including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each 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 Kaminario, Inc. 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
- The differences between the Tested Storage Configuration and the Priced Storage Configuration, if applied to the Tested Storage Configuration, would not have an impact on the reported SPC-1 performance.
- 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:

At the end of the Sustainability Test Run, one of the SPC-1 Workload Generator slave processes terminated with an error. The measurement and reporting portion of the Test Run had concluded successfully prior to the slave process termination error, so there was no impact on the validity of the data produced by the Sustainability Test Run.

The 'master' execution script was designed to detect this type of non-fatal error and continue execution, which explicitly terminates and restarts all slave processes prior to the each Test Run. That action ensured all slave processes were active at the start of each Test Run.

Respectfully,



Walter E. Baker
SPC Auditor

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

LETTER OF GOOD FAITH

kaminario.
Simply Faster

Kaminario, Inc.
275 Grove Street
Suite 2-400
Newton, MA, USA 02466
Tel: 1-877-98-CALL-K2
(1-877-982-2555)
Email: info@kaminario.com

July 23rd, 2012

From: Shachar Fienblit, VP R&D, Kaminario, Inc.

Subject: SPC-1 Letter of Good Faith for the K2-D

Kaminario 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 1.12 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 specification.

Signed: Date:

Jul, 23, 2012

Shachar Fienblit, VP R&D

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Kaminario, Inc. – www.kaminario.com Eyal David – eyal.david@kaminario.com Haotzma 1 Hi-Tech Park Yoqneam 20692 Israel Phone: +972 72 222 4495 FAX: +972 4 959 0551
Test Sponsor Alternate Contact	Kaminario, Inc. – www.kaminario.com Tamir Segal Haotzma 1 Hi-Tech Park Yoqneam 20692 Israel Phone: +972 72 222 4490 FAX: 972 4 959 -551
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	V2.2.0
Date Results were first used publicly	July 30, 2012
Date the FDR was submitted to the SPC	July 30, 2012
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	July 26, 2012

Tested Storage Product (TSP) Description

Kaminario's K2 all Solid-state SAN storage solution offers extreme performance, high availability, scalability, and simplicity in installation, management, and configuration.

K2 is geared towards latency sensitive and I/O intensive critical business applications that standard storage solutions cannot support. It is based on Kaminario's Scale-out Performance Architecture™ (SPEAR), which is a grid of modular, industry standard blade-based servers, running as Kaminario I/O Directors and Data Nodes and controlled by the Kaminario Storage System Management.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Kaminario K2-D *(1875K-1.1)*	
Metric	**Reported Result**
SPC-1 IOPS™	1,219,973.91
SPC-1 Price-Performance™	$0.40/SPC-1 IOPS™
Total ASU Capacity	1,159.830 GB
Data Protection Level	Protected *(Mirroring)*
Total TSC Price (including three-year maintenance)	$490,760.00

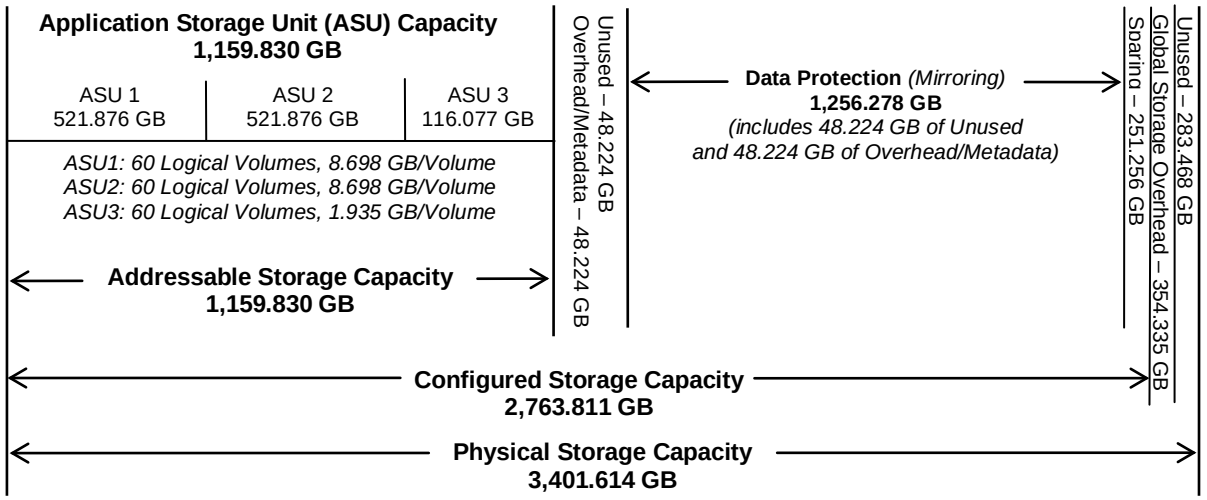
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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 **Protected** using ***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	34.10%
Protected Application Utilization	69.61%
Unused Storage Ratio	11.17%

Application Utilization: Total ASU Capacity *(1,159.830 GB)* divided by Physical Storage Capacity *(3,401.614 GB)*

Protected Application Utilization: Total ASU Capacity *(1,159.830 GB)* plus total Data Protection Capacity *(1,256.278 GB)* minus unused Data Protection Capacity *(48.224 GB)* divided by Physical Storage Capacity *(3,401.614 GB)*

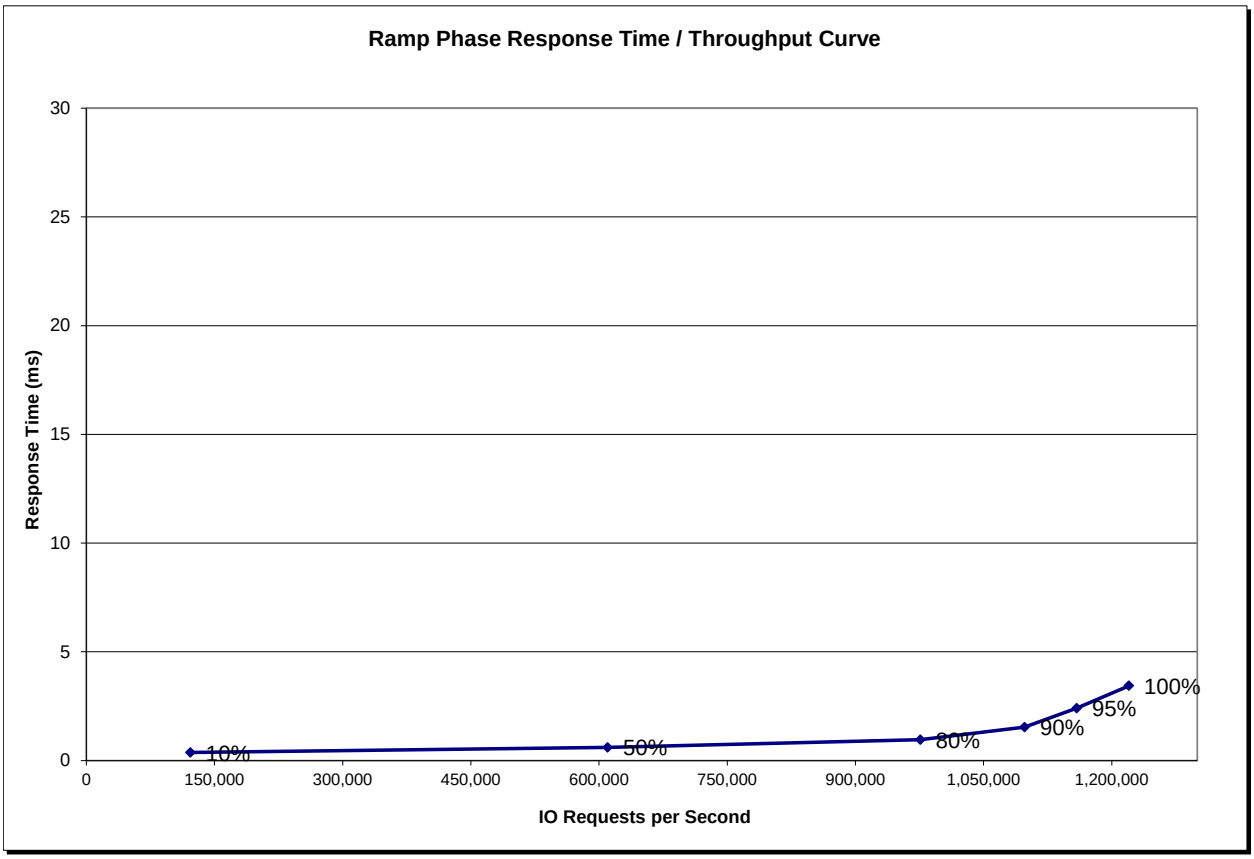
Unused Storage Ratio: Total Unused Capacity *(379.916 GB)* divided by Physical Storage Capacity *(3,401.614 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 22-24.

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	122,005.05	610,008.96	975,990.20	1,097,983.77	1,159,017.29	1,219,973.91
Average Response Time (ms):						
All ASUs	0.37	0.60	0.96	1.53	2.40	3.44
ASU-1	0.34	0.57	0.91	1.46	2.31	3.26
ASU-2	0.36	0.59	0.95	1.58	2.48	3.67
ASU-3	0.42	0.66	1.05	1.67	2.58	3.71
Reads	0.33	0.55	0.89	1.45	2.30	3.29
Writes	0.39	0.63	1.00	1.59	2.47	3.53

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

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

Priced Storage Configuration Pricing

Quantity	Item	Description	Unit Price	Price
1	K2D-1875000-1.1**	1.8M IOPS and 1.1TB	$350,000	$350,000
1	Three years maintenance	4 hours mission ciritcal	$105,000	$105,000
70	T54-M11FF-10	WesternWire FC cable LC-LC 3m	$8	$560
20	QME2572*	QLogic QME2572 8Gbps Fibre Channel I/O Card	$425	$8,500
5	Brocade 300 FC8*	Brocade 300 FC8 (8/16/24 Port)	$5,340	$26,700
	Total System Price:			**$490,760**

**Third-party components with an appropriate quote in Appendix F.*

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 with 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 Price Storage Configuration that can be remedied by the repair or replacement of a Priced Storage Configuration component.

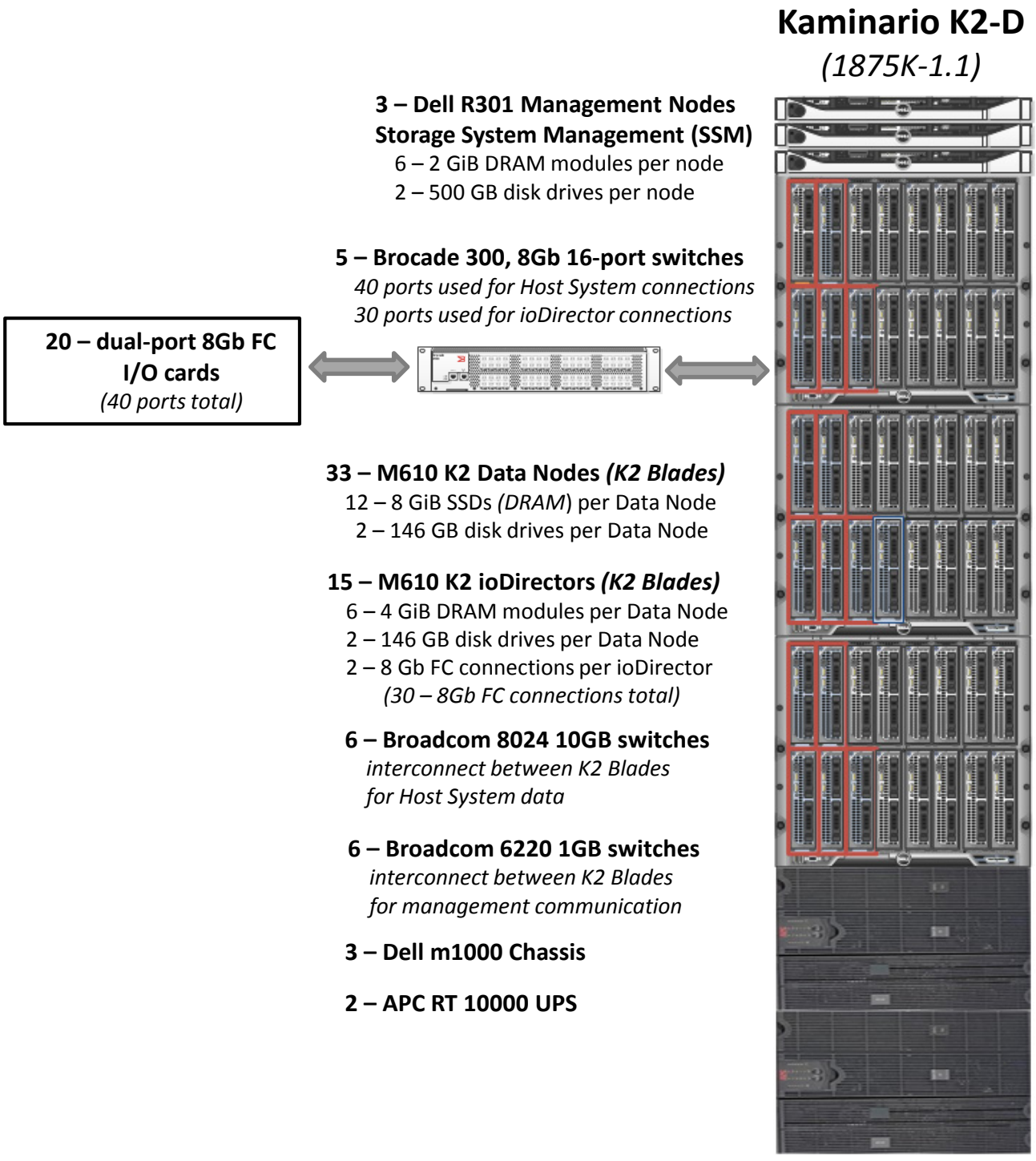
**K2D-1875000-1.1 Line Item Components

The K2D line item in the above pricing includes the following components:

- **K2 Blades:** The K2 blade servers consist of DataNodes and ioDirectors as detailed below.
- **33 – M610 K2 DataNodes:** Each DataNode included twelve 8 GiB solid state storage devices (DRAM), which provided the storage capacity for the mirrored SPC-1 data repository. In addition, each DataNode included two 146 GB disk drives that provided a mirrored, backup copy of the SPC-1 data repository.
- **15 – M610 K2 ioDirectors:** The ioDirectors are responsible for exposing the data volumes to the Host Systems, connected via Fibre Channel. Each ioDirector included six 4 GiB DRAM modules for caching and metadata. Each ioDirector also included two 146 GB disk drives for backup and metadata.

- **6 Broadcom 8024 10GB switches:** Interconnects all blades for the purpose of sending Host System data between the blades.
- **6 Broadcom 6220 1GB switches:** Interconnects all blades for the purpose of supporting management communication between the blades.
- **6 Brocade 8GB FC switches:** Provides FC ports to external Host Systems.
- **3 – Dell m1000 chassis:** Chassis to hold the blades and switches.
- **3 – Dell R310 Management Nodes, Storage System Management (SSM):** The SSM modules provide storage installation, configuration and monitoring functionality. Each SSM module included six 2 GiB DRAM modules and two 500 GB disk drives for metadata.
- **2 – APC RT 10000 UPSs:** A pair of Uninterruptible Power Supplies that can deliver power to the entire K2 configuration, allowing a graceful shutdown without loss of data or data integrity.
- **1 – Rack:** Used to house all of the above components.

Priced Storage Configuration Diagram



Priced Storage Configuration Components

Priced Storage Configuration:
20 – dual port QLogic8 Gb FC I/O Cards *(40 ports total, 40 ports used)*
5 –Brocade 300, 8 Gb switches with SFPs *(16 active ports per switch, 80 total)* *(40 ports for Host System connections, 30 ports for ioDirector connections)*
Kaminario K2-D *(1875K-1.1)* 33 – M610 K2 DataNodes *(K2 Blades)* 12 – 8 GiB solid state storage devices (DRAM) per DataNode 2 – 146 GB disk drives per DataNode 15 – M610 K2 ioDirectors *(K2 Blades)* 6 – 4 GiB DRAM modules per ioDirector 2 – 146 GB disk drives per ioDirector 2 – 8 Gb FC connections per ioDirector *(30 total, 30 used)* 3 – Dell R310 Management Nodes Storage System Management (SSM) 6 – 2 GiB DRAM modules per Management Node 2 – 500 GB disk drives per Management Node 6 – Broadcom 8024 10GB switches *(interconnect between K2 Blades for Host System data)* 6 – Broadcom 6220 1GB switches *(interconnect between K2 Blades for management communication)* 6 – Brocade 8GB FC switches *(provides FC front-end ports)* *(6 ports available per switch, 5 ports used per switch)* 3 – Dell m1000 Chassis *(holds the K2 Blades and switches)* 2 – APC RT 10000 UPS 1 – Rack

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 19 *(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 storage network configuration is illustrated on page 19 *(Benchmark Configuration/Tested Storage Configuration Diagram).*

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 20 *(Host Systems and Tested Storage Configuration Components).*

Benchmark Configuration/Tested Storage Configuration Diagram

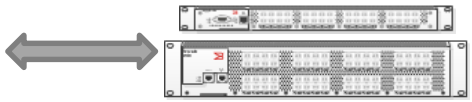
Kaminario K2-D
(1875K-1.1)

10 – Dell M905 Blades

2 – dual-port 8Gb FC I/O cards per Blade
(20 cards, 40 ports)

3 – Dell R301 Management Nodes
Storage System Management (SSM)
6 – 2 GiB DRAM modules per node
2 – 500 GB disk drives per node

1 – Brocade Silkworm 4900 64-port switch
1 – Brocade Silkworm 4100 16-port switch
40 ports used for Host System connections
30 ports used for ioDirector connections



33 – M610 K2 Data Nodes *(K2 Blades)*
12 – 8 GiB SSDs *(DRAM)* per Data Node
2 – 146 GB disk drives per Data Node

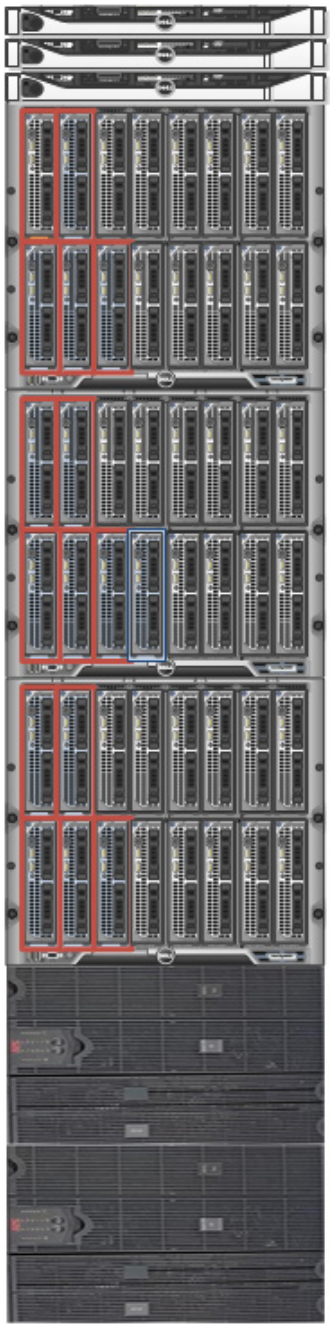
15 – M610 K2 ioDirectors *(K2 Blades)*
6 – 4 GiB DRAM modules per Data Node
2 – 146 GB disk drives per Data Node
2 – 8 Gb FC connections per ioDirector
(30 – 8Gb FC connections total)

6 – Broadcom 8024 10GB switches
interconnect between K2 Blades
for Host System data

6 – Broadcom 6220 1GB switches
interconnect between K2 Blades
for management communication

3 – Dell m1000 Chassis

2 – APC RT 10000 UPS



Host Systems and Tested Storage Configuration Components

Host Systems:

10 – Dell M905 Blades, each with:

- 4 – Quad-Core AMD Opteron™ 8389 Processors
  - 2.9 GHz, 2 MB L2 cache, 2 MB L3 cache
- 96 GB main memory
- Windows 2008 Server R2
- Windows 2008 MPIO

Tested Storage Configuration (TSC):

20 – dual port QLogic 8 Gb FC I/O Cards *(40 ports total, 40 ports used)*

1 – Brocade Silkworm 4900 4 Gb FC 64-port switch
1 – Brocade Silkworm 4100 4 Gb FC 16-port switch
(*40 ports for Host System connections, 30 ports for ioDirector connections)*

Kaminario K2-D *(1875K-1.1)*

- 33 – M610 K2 DataNodes *(K2 Blades)*
  - 12 – 8 GiB solid state storage devices (DRAM) per DataNode
  - 2 – 146 GB disk drives per DataNode
- 15 – M610 K2 ioDirectors *(K2 Blades)*
  - 6 – 4 GiB DRAM modules per ioDirector
  - 2 – 146 GB disk drives per ioDirector
  - 2 – 8 Gb FC connections per ioDirector *(30 total, 30 used)*
- 3 – Dell R310 Management Nodes
  - Storage System Management (SSM)
  - 6 – 2 GiB DRAM modules per Management Node
  - 2 – 500 GB disk drives per Management Node
- 6 – Broadcom 8024 10GB switches
  - *(interconnect between K2 Blades for Host System data)*
- 6 – Broadcom 6220 1GB switches
  - *(interconnect between K2 Blades for management communication)*
- 6 – Brocade 8GB FC switches*(provides FC front-end ports)*
  - *(6 ports available per switch, 5 ports used per switch)*
- 3 – Dell m1000 Chassis *(holds the K2 Blades and switches)*
- 2 – APC RT 10000 UPS
- 1 – Rack

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 61 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 62 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 70.

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 57 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)	1,159.830
Addressable Storage Capacity	Gigabytes (GB)	1,159.830
Configured Storage Capacity	Gigabytes (GB)	2,763.811
Physical Storage Capacity	Gigabytes (GB)	3,401.614
Data Protection *(Mirroring)*	Gigabytes (GB)	1,256.278
Required Storage *(sparing/overhead/metadata)*	Gigabytes (GB)	347.704
Global Storage Overhead	Gigabytes (GB)	354.335
Total Unused Storage	Gigabytes (GB)	379.916

SPC-1 Storage Hierarchy Ratios

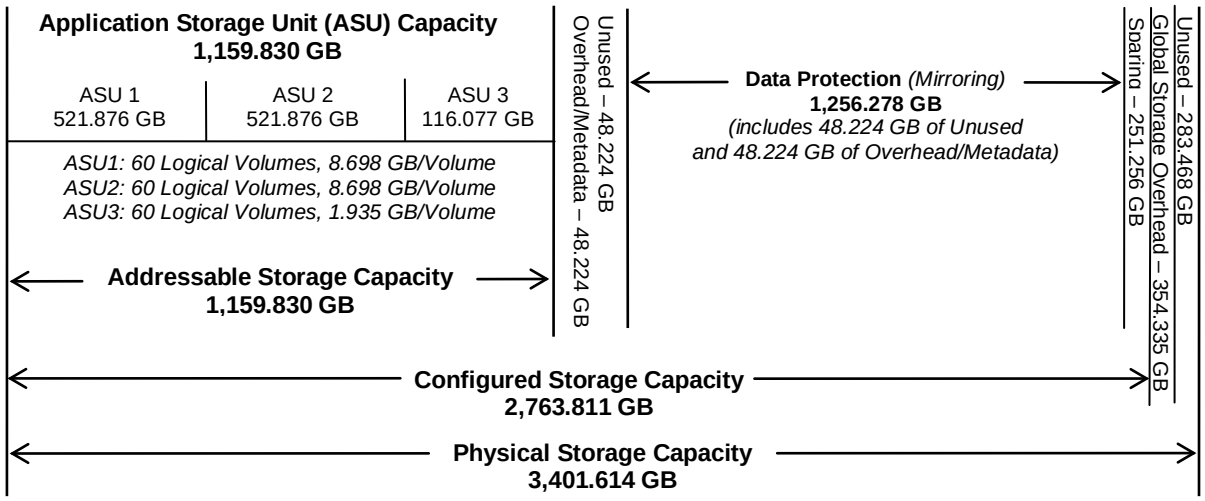
	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	100.00%	41.96%	34.10%
Required for Data Protection *(Mirroring)*		45.45%	36.93%
Addressable Storage Capacity		41.96%	34.10%
Required Storage *(sparing/overhead/metadata)*		12.58%	10.22%
Configured Storage Capacity			81.25%
Global Storage Overhead			10.42%
Unused Storage:			
Addressable	0.00%		
Configured		1.74%	
Physical			8.33%

The Physical Storage Capacity consisted of 3,401.614 GB distributed over 396 solid state storage devices *(DRAM)*, each with a formatted capacity of 8.590 GB. There was 283.468 GB (8.33%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 354.335 GB (10.42%) of the Physical Storage Capacity. There was 48.224 GB (1.74%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 1,256.278 GB of which 1,159.830 GB was utilized. The total Unused Storage capacity was 3.7.916 GB.

In addition, sixty-six (66) 146 GB disk drives were included in the configuration to provide an additional level of data protection. A mirrored, backup copy of the SPC-1 data repository was maintained on those devices.

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 (521.876 GB)	**ASU-2 (521.876 GB)**	**ASU-3 (116.077 GB)**
60 Logical Volumes 8.698 GB per Logical Volume (8.698 GB used per Logical Volume)	60 Logical Volumes 8.698 GB per Logical Volume (8.698 GB used per Logical Volume)	60 Logical Volumes 1.935 GB per Logical Volume (1.935 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was ***Mirrored*** as described on page 11. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

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	34.10%
Protected Application Utilization	69.61%
Unused Storage Ratio	11.17%

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 58 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 78.

Sustainability Test Results File

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

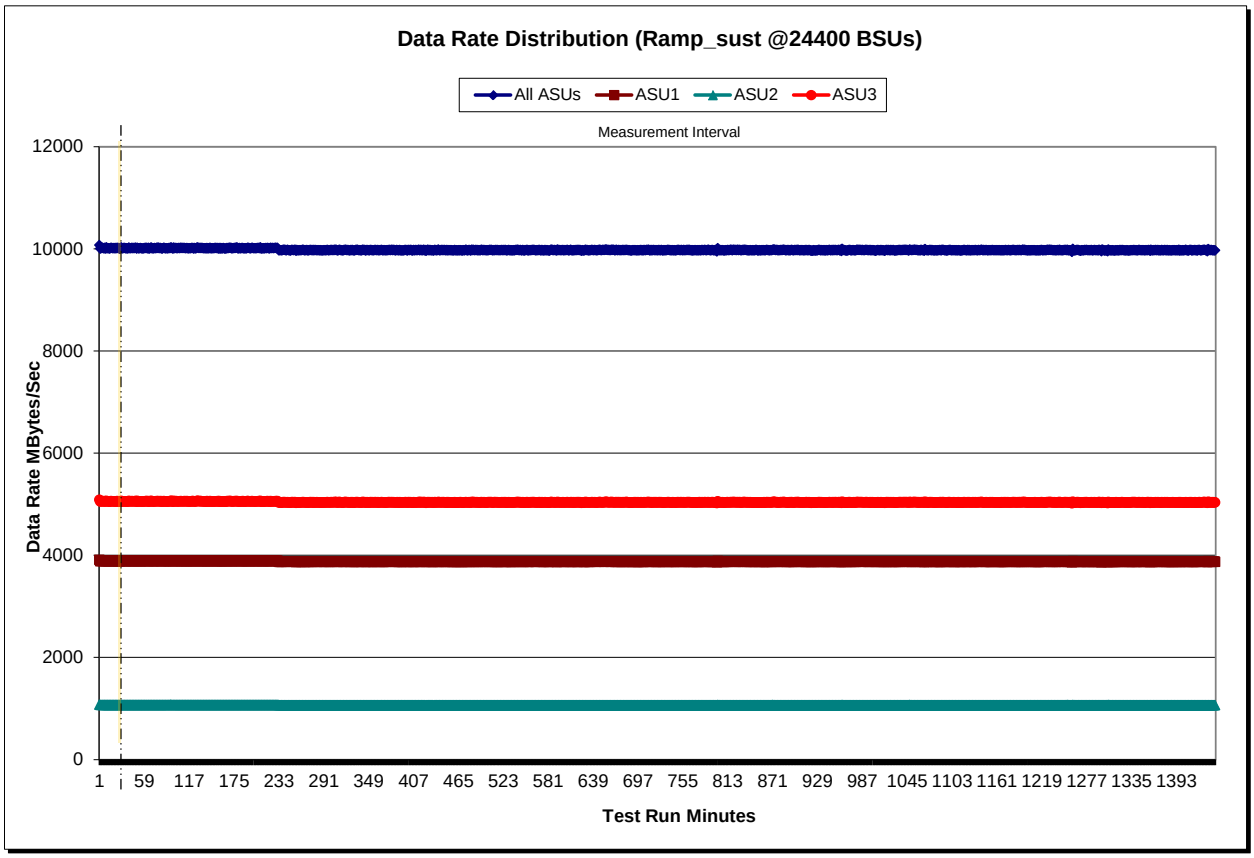
Sustainability Test Results File

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 Rate Table

Sustainability – Data Rate Distribution Graph

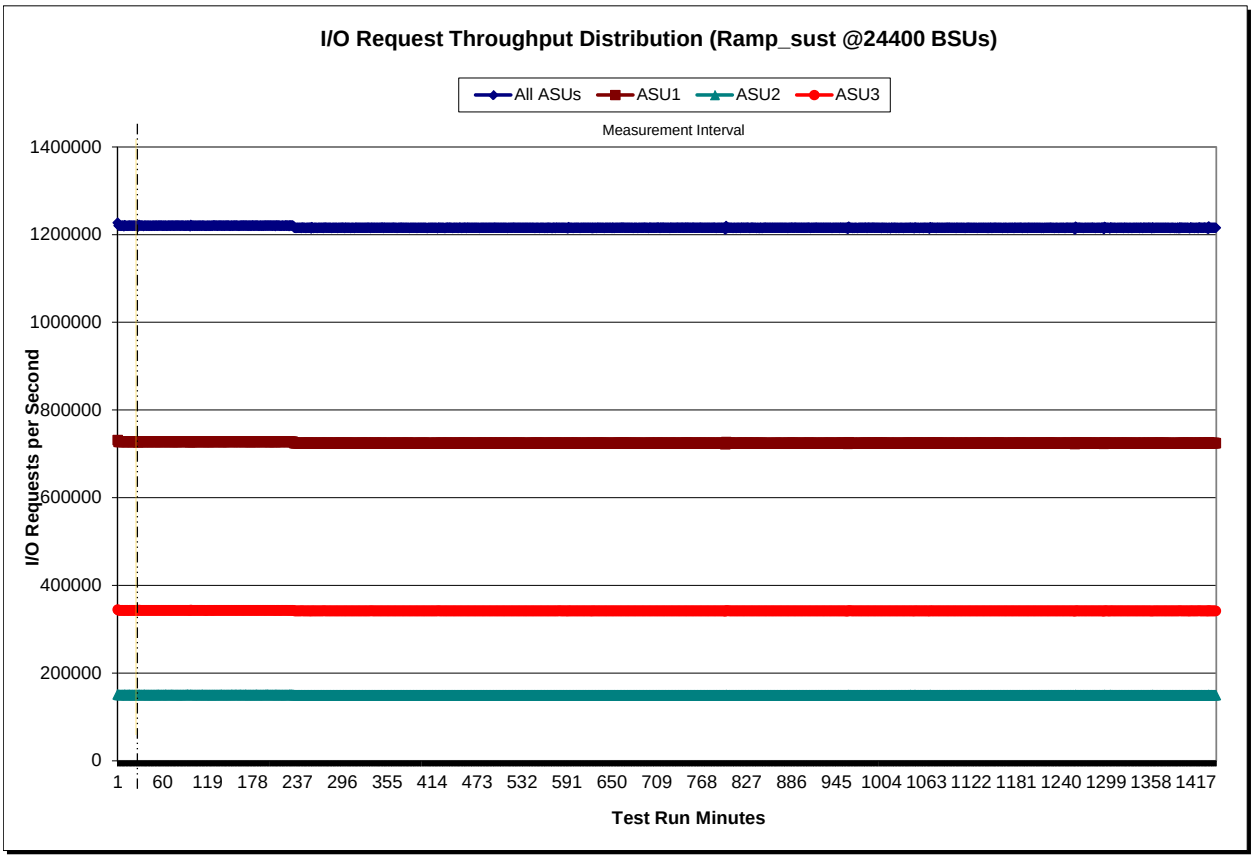


Sustainability – I/O Request Throughput Distribution Data

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 I/O Request Throughput Table

Sustainability – I/O Request Throughput Distribution Graph

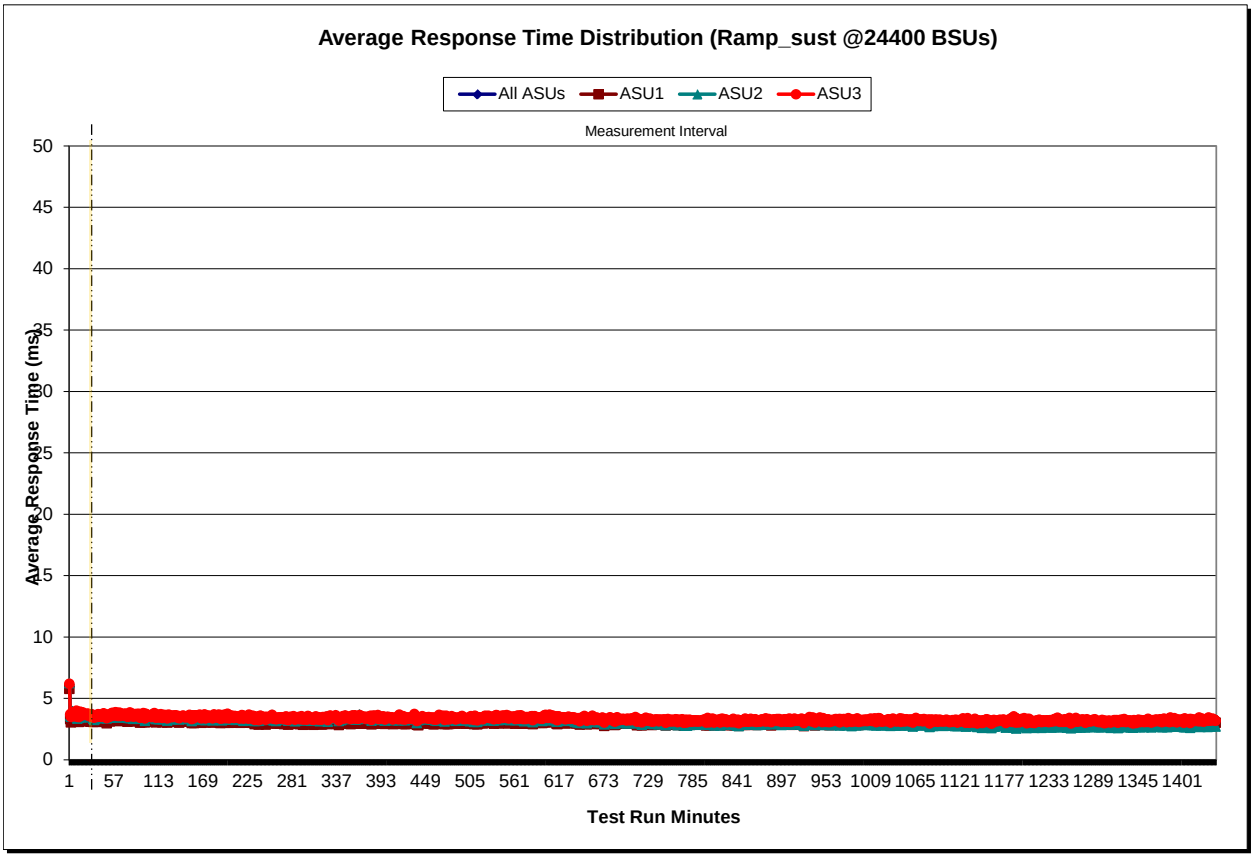


Sustainability – Average Response Time (ms) Distribution Data

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 Average Response Time Table

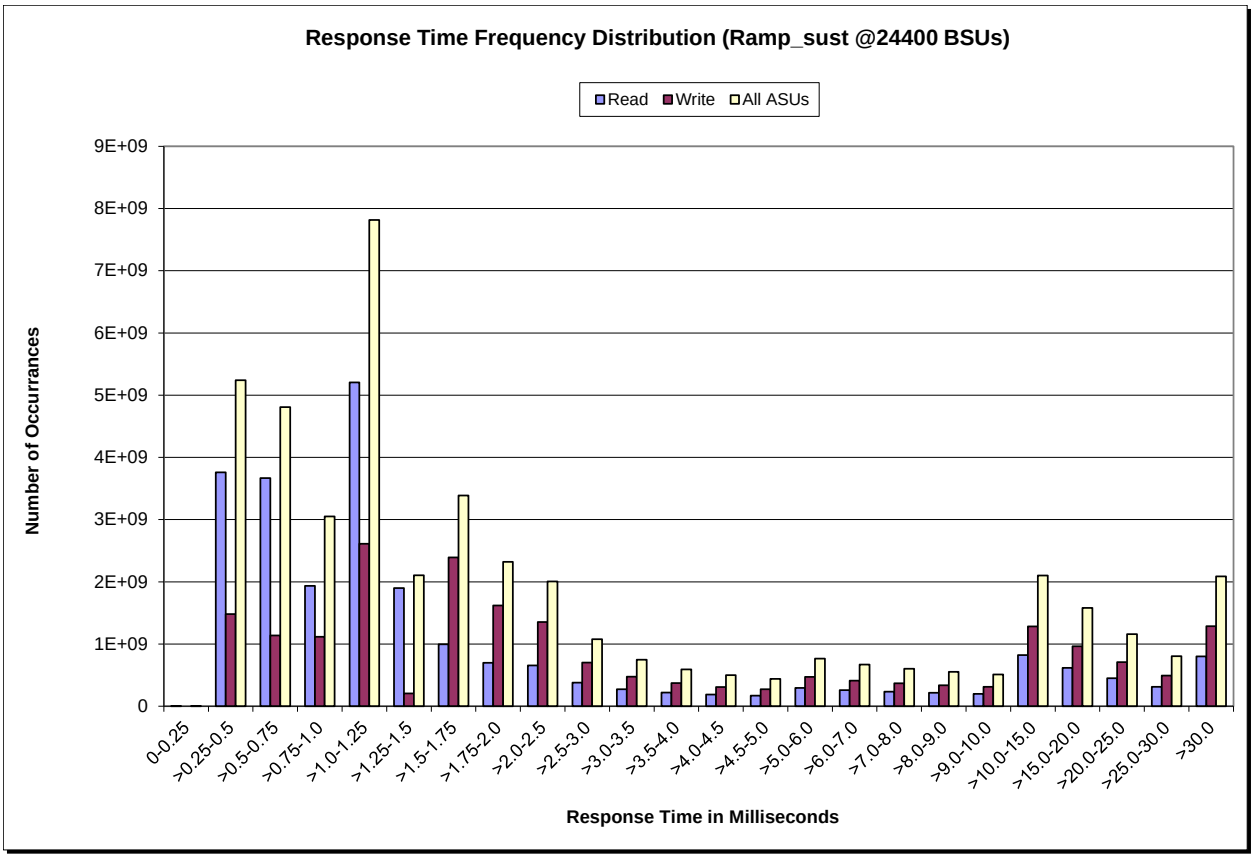
Sustainability – Average Response Time (ms) Distribution Graph



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	62,355	3,759,852,039	3,667,976,667	1,934,390,917	5,203,541,998	1,899,133,410	996,748,324	698,844,751
Write	7	1,481,709,332	1,138,352,356	1,115,561,748	2,611,962,372	204,131,202	2,391,074,982	1,620,596,902
All ASUs	62,362	5,241,561,371	4,806,329,023	3,049,952,665	7,815,504,370	2,103,264,612	3,387,823,306	2,319,441,653
ASU1	54,944	4,038,279,833	89,510,467	(160,764,664)	4,566,852,505	3,236,267,740	1,688,470,911	1,171,241,634
ASU2	7,416	697,251,677	3,413,241,629	3,568,281,473	1,932,377,821	722,230,540	376,760,146	258,802,549
ASU3	2	506,029,861	1,303,576,927	(357,564,144)	1,316,274,044	(1,855,233,668)	1,322,592,249	889,397,470
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	654,097,333	377,513,117	273,838,099	221,272,415	189,152,150	168,485,131	295,402,767	259,756,124
Write	1,351,964,393	700,041,160	474,752,942	371,156,046	309,755,155	272,505,975	470,913,379	409,774,403
All ASUs	2,006,061,726	1,077,554,277	748,591,041	592,428,461	498,907,305	440,991,106	766,316,146	669,530,527
ASU1	1,063,529,916	599,548,000	427,026,510	342,026,516	290,221,498	257,644,094	449,735,432	394,254,513
ASU2	230,675,284	126,741,066	89,044,103	70,769,261	59,807,888	52,964,592	92,318,926	80,862,333
ASU3	711,856,526	351,265,211	232,520,428	179,632,684	148,877,919	130,382,420	224,261,788	194,413,681
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	234,632,426	215,149,580	199,057,583	820,715,144	617,032,511	451,600,591	312,147,075	802,413,502
Write	368,268,081	336,707,570	311,138,110	1,281,182,442	963,865,376	707,870,906	491,488,855	1,286,004,425
All ASUs	602,900,507	551,857,150	510,195,693	2,101,897,586	1,580,897,887	1,159,471,497	803,635,930	2,088,417,927
ASU1	355,525,696	325,655,689	301,074,717	1,239,764,108	931,070,179	680,957,666	470,021,983	1,198,785,102
ASU2	72,909,254	66,813,796	61,843,106	255,540,303	192,971,582	141,875,419	98,581,440	258,863,418
ASU3	174,465,557	159,387,665	147,277,870	606,593,175	456,856,126	336,638,412	235,032,507	630,769,407

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	0.000	0.000	0.001	0.000	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 78.

IOPS Test Results File

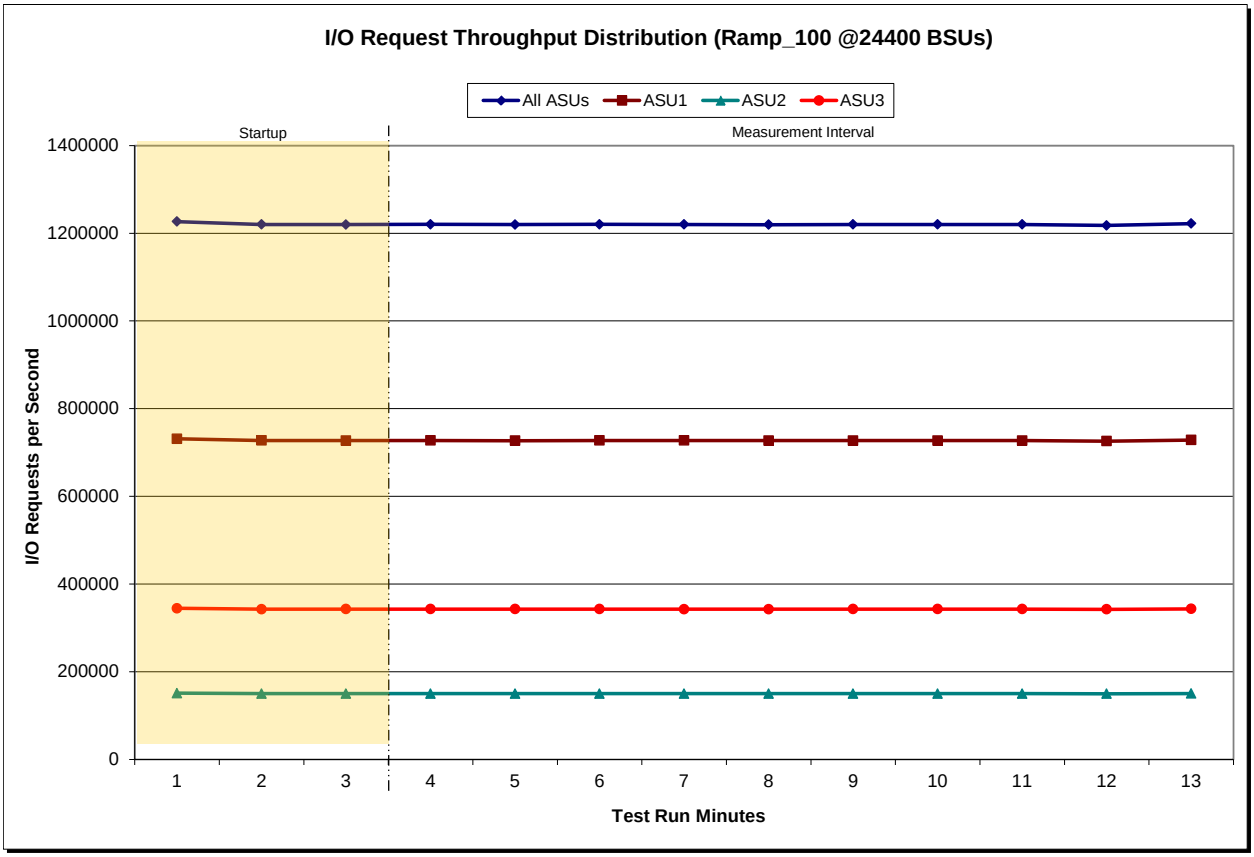
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

24,400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:50:12	9:53:12	0-2	0:03:00
Measurement Interval	9:53:12	10:03:16	3-12	0:10:04
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,226,579.87	731,047.20	150,922.30	344,610.37
1	1,219,963.53	727,250.07	150,086.48	342,626.98
2	1,219,829.82	727,019.95	149,971.67	342,838.20
3	1,220,214.13	727,280.60	150,046.07	342,887.47
4	1,219,700.15	726,925.30	150,009.35	342,765.50
5	1,220,271.88	727,286.08	150,113.38	342,872.42
6	1,220,013.53	727,255.45	150,087.57	342,670.52
7	1,219,650.68	727,033.90	150,043.83	342,572.95
8	1,220,101.93	727,215.10	150,032.35	342,854.48
9	1,219,964.83	727,090.48	150,033.78	342,840.57
10	1,219,964.28	727,112.33	150,023.53	342,828.42
11	1,217,734.87	725,751.52	149,794.40	342,188.95
12	1,222,122.80	728,420.28	150,373.95	343,328.57
Average	***1,219,973.91***	***727,137.11***	***150,055.82***	***342,780.98***

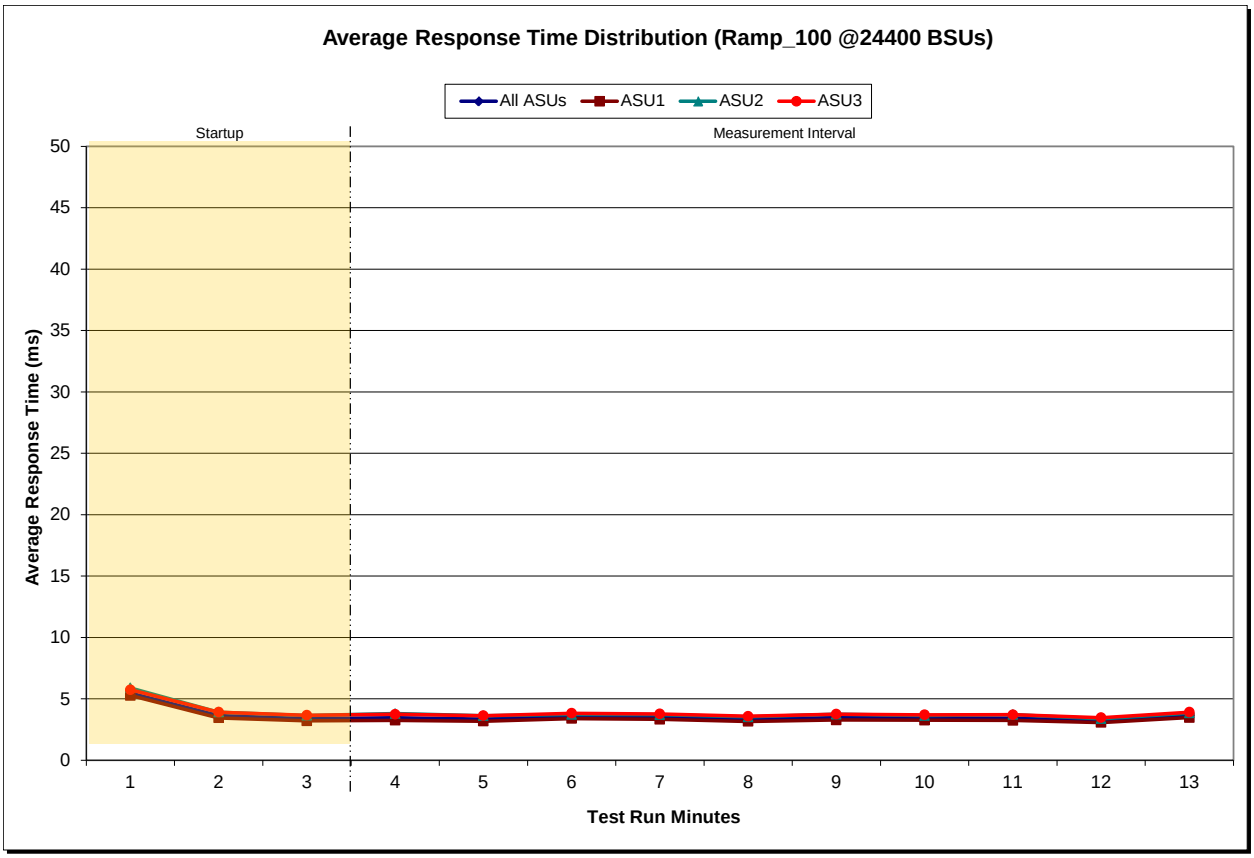
IOPS Test Run – I/O Request Throughput Distribution Graph



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

24,400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:50:12	9:53:12	0-2	0:03:00
Measurement Interval	9:53:12	10:03:16	3-12	0:10:04
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	5.47	5.26	5.89	5.73
1	3.63	3.45	3.91	3.91
2	3.39	3.20	3.64	3.66
3	3.45	3.25	3.80	3.74
4	3.36	3.18	3.62	3.63
5	3.55	3.39	3.72	3.82
6	3.50	3.33	3.71	3.77
7	3.32	3.16	3.53	3.58
8	3.47	3.28	3.74	3.75
9	3.43	3.26	3.63	3.70
10	3.43	3.24	3.71	3.70
11	3.22	3.07	3.37	3.46
12	3.64	3.47	3.84	3.91
Average	***3.44***	***3.26***	***3.67***	***3.71***

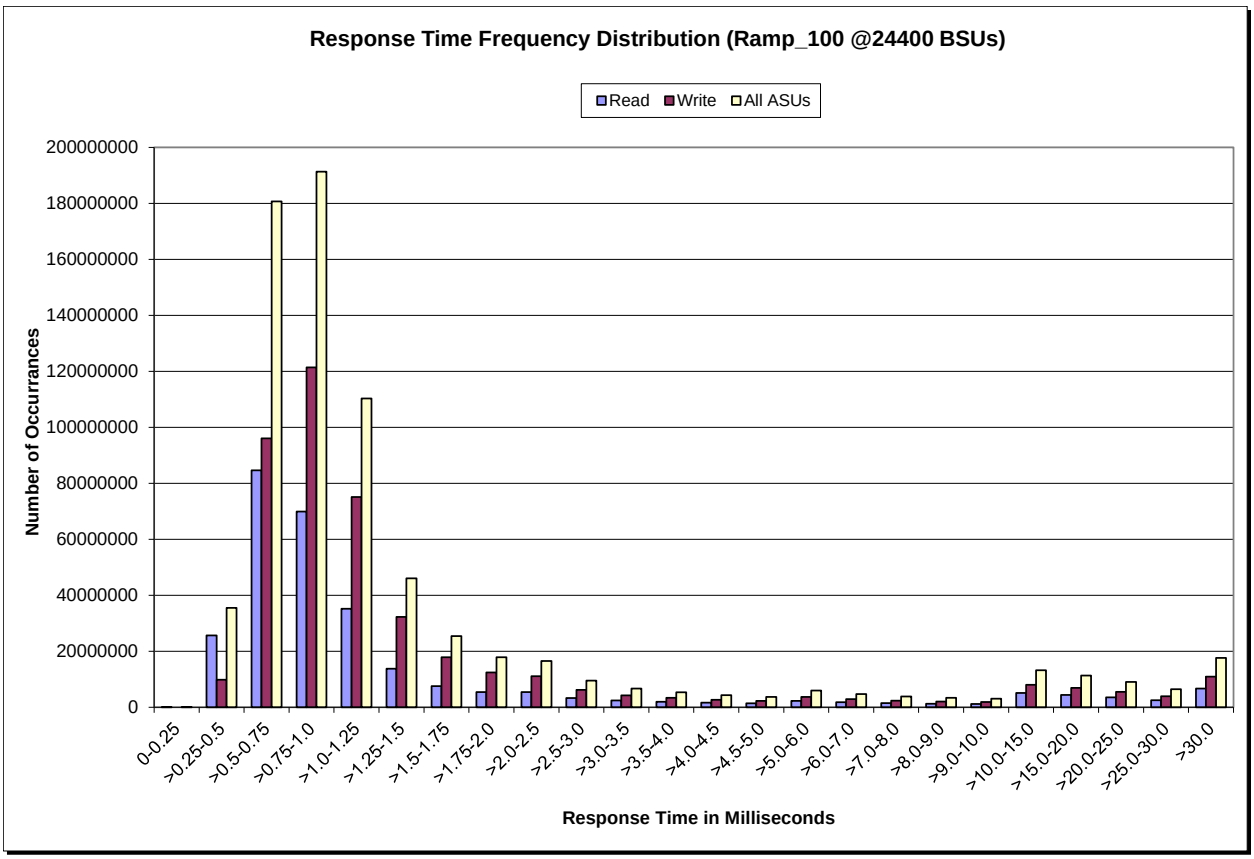
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	466	25,707,130	84,639,497	69,923,217	35,184,348	13,785,695	7,562,636	5,437,199
Write	0	9,841,907	96,016,399	121,370,679	75,084,041	32,269,920	17,901,624	12,417,552
All ASUs	466	35,549,037	180,655,896	191,293,896	110,268,389	46,055,615	25,464,260	17,854,751
ASU1	414	28,012,759	120,790,849	113,533,282	59,250,120	22,994,649	12,473,045	8,848,721
ASU2	52	4,232,570	21,892,569	23,304,534	13,511,118	5,668,299	3,150,767	2,230,613
ASU3	0	3,303,708	37,972,478	54,456,080	37,507,151	17,392,667	9,840,448	6,775,417
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	5,434,041	3,343,986	2,445,013	1,979,245	1,624,912	1,402,933	2,273,347	1,804,718
Write	11,102,509	6,192,465	4,257,512	3,357,853	2,704,016	2,307,226	3,702,108	2,912,199
All ASUs	16,536,550	9,536,451	6,702,525	5,337,098	4,328,928	3,710,159	5,975,455	4,716,917
ASU1	8,591,945	5,201,492	3,755,677	3,028,538	2,475,643	2,132,174	3,450,311	2,730,322
ASU2	2,116,435	1,221,167	854,648	675,970	545,809	466,678	747,487	588,699
ASU3	5,828,170	3,113,792	2,092,200	1,632,590	1,307,476	1,111,307	1,777,657	1,397,896
Response Time (ms)	**>7.0-8.0**	**>8.0-9.0**	**>9.0-10.0**	**>10.0-15.0**	**>15.0-20.0**	**>20.0-25.0**	**>25.0-30.0**	**>30.0**
Read	1,498,258	1,298,874	1,177,765	5,138,033	4,416,529	3,509,234	2,497,970	6,681,702
Write	2,394,848	2,064,649	1,859,476	8,063,545	6,928,088	5,543,419	3,967,448	10,953,976
All ASUs	3,893,106	3,363,523	3,037,241	13,201,578	11,344,617	9,052,653	6,465,418	17,635,678
ASU1	2,259,023	1,956,689	1,769,198	7,704,662	6,612,319	5,249,251	3,717,614	9,741,068
ASU2	486,168	419,203	378,856	1,653,071	1,435,672	1,157,315	840,840	2,454,519
ASU3	1,147,915	987,631	889,187	3,843,845	3,296,626	2,646,087	1,906,964	5,440,091

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
731,980,207	714,344,529	17,635,678

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	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.001	0.000	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 78.

Response Time Ramp Test Results File

A link to each test result file generated from each Response Time Ramp Test Run list listed below.

95% Load Level

90% Load Level

80% Load Level

50% Load Level

10% Load Level

Response Time Ramp Distribution (IOPS) Data

The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data tables and graphs for completeness.

100% Load Level - 24,400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:50:12	9:53:12	0-2	0:03:00
Measurement Interval	9:53:12	10:03:16	3-12	0:10:04

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,226,579.87	731,047.20	150,922.30	344,610.37
1	1,219,963.53	727,250.07	150,086.48	342,626.98
2	1,219,829.82	727,019.95	149,971.67	342,838.20
3	1,220,214.13	727,280.60	150,046.07	342,887.47
4	1,219,700.15	726,925.30	150,009.35	342,765.50
5	1,220,271.88	727,286.08	150,113.38	342,872.42
6	1,220,013.53	727,255.45	150,087.57	342,670.52
7	1,219,650.68	727,033.90	150,043.83	342,572.95
8	1,220,101.93	727,215.10	150,032.35	342,854.48
9	1,219,964.83	727,090.48	150,033.78	342,840.57
10	1,219,964.28	727,112.33	150,023.53	342,828.42
11	1,217,734.87	725,751.52	149,794.40	342,188.95
12	1,222,122.80	728,420.28	150,373.95	343,328.57
Average	***1,219,973.91***	***727,137.11***	***150,055.82***	***342,780.98***

95% Load Level - 23,180 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:20:02	10:23:02	0-2	0:03:00
Measurement Interval	10:23:02	10:33:05	3-12	0:10:03

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,164,799.83	694,228.23	143,229.18	327,342.42
1	1,159,040.73	690,769.93	142,583.60	325,687.20
2	1,159,247.97	690,865.30	142,579.23	325,803.43
3	1,159,117.73	690,799.20	142,575.97	325,742.57
4	1,158,767.83	690,672.13	142,554.28	325,541.42
5	1,159,054.17	690,909.55	142,433.43	325,711.18
6	1,159,204.73	690,960.07	142,614.45	325,630.22
7	1,158,348.55	690,263.18	142,492.32	325,593.05
8	1,159,783.72	691,288.67	142,680.65	325,814.40
9	1,158,860.45	690,677.22	142,594.38	325,588.85
10	1,159,088.38	690,974.67	142,544.80	325,568.92
11	1,158,390.40	690,361.98	142,547.48	325,480.93
12	1,159,556.90	691,101.87	142,639.08	325,815.95
Average	***1,159,017.29***	***690,800.85***	***142,567.69***	***325,648.75***

90% Load Level - 21,960 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:49:03	10:52:03	0-2	0:03:00
Measurement Interval	10:52:03	11:02:07	3-12	0:10:04

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,102,210.43	656,942.40	135,559.72	309,708.32
1	1,098,110.12	654,370.85	135,100.25	308,639.02
2	1,097,936.87	654,292.53	134,925.23	308,719.10
3	1,098,216.52	654,603.43	135,072.60	308,540.48
4	1,097,943.73	654,463.27	135,046.22	308,434.25
5	1,097,956.85	654,338.08	135,069.42	308,549.35
6	1,097,972.33	654,457.63	135,065.78	308,448.92
7	1,097,812.12	654,280.25	135,039.60	308,492.27
8	1,097,984.35	654,362.82	135,073.73	308,547.80
9	1,098,284.12	654,590.08	135,027.48	308,666.55
10	1,097,914.48	654,313.07	135,051.32	308,550.10
11	1,097,752.77	654,299.40	134,998.15	308,455.22
12	1,098,000.47	654,495.30	135,029.30	308,475.87
Average	***1,097,983.77***	***654,420.33***	***135,047.36***	***308,516.08***

80% Load Level - 19,520 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:17:00	11:20:00	0-2	0:03:00
Measurement Interval	11:20:00	11:30:03	3-12	0:10:03

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	979,968.72	584,001.90	120,535.55	275,431.27
1	976,081.80	581,749.17	120,013.23	274,319.40
2	975,851.63	581,643.08	120,060.83	274,147.72
3	976,088.03	581,669.05	120,087.32	274,331.67
4	975,727.42	581,491.35	119,981.38	274,254.68
5	975,865.90	581,560.33	120,031.08	274,274.48
6	976,036.48	581,684.87	119,994.80	274,356.82
7	976,078.78	581,660.55	120,063.73	274,354.50
8	976,178.48	581,762.97	120,107.10	274,308.42
9	975,726.43	581,489.10	120,018.52	274,218.82
10	976,119.32	581,726.67	120,103.90	274,288.75
11	976,111.47	581,713.42	120,129.82	274,268.23
12	975,969.70	581,611.52	120,045.03	274,313.15
Average	***975,990.20***	***581,636.98***	***120,056.27***	***274,296.95***

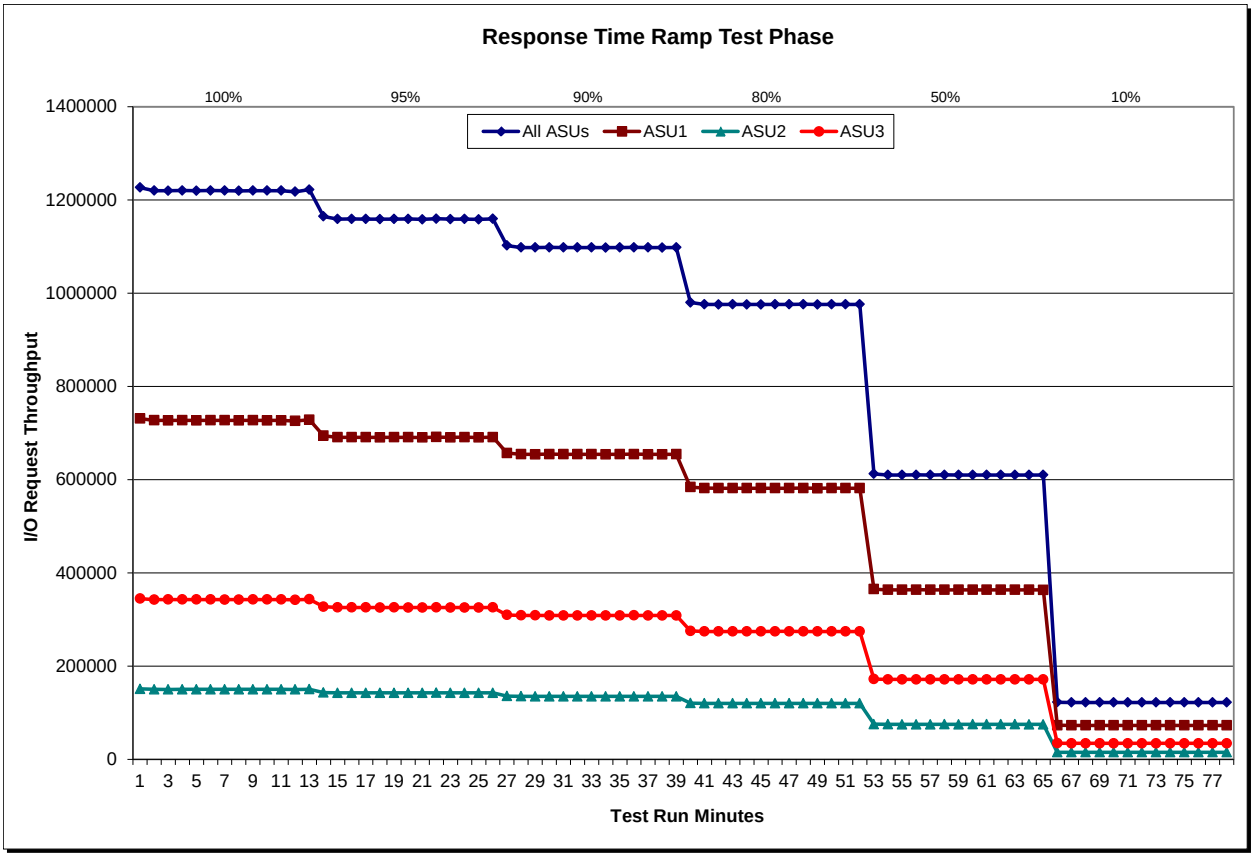
50% Load Level - 12,200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:40:48	11:43:48	0-2	0:03:00
Measurement Interval	11:43:48	11:53:51	3-12	0:10:03

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	612,330.32	364,927.17	75,307.60	172,095.55
1	610,072.53	363,589.75	75,091.82	171,390.97
2	609,950.28	363,585.52	75,009.82	171,354.95
3	610,194.92	363,792.72	75,020.15	171,382.05
4	609,957.22	363,603.55	74,996.20	171,357.47
5	610,147.82	363,630.30	75,061.38	171,456.13
6	610,042.35	363,631.92	74,994.50	171,415.93
7	610,005.23	363,599.13	75,044.80	171,361.30
8	609,879.47	363,516.37	75,036.20	171,326.90
9	610,022.30	363,540.87	75,052.20	171,429.23
10	609,932.30	363,498.95	75,040.03	171,393.32
11	609,991.02	363,598.28	75,008.98	171,383.75
12	609,916.98	363,445.85	74,984.42	171,486.72
Average	***610,008.96***	***363,585.79***	***75,023.89***	***171,399.28***

10% Load Level - 2,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:59:09	12:02:09	0-2	0:03:00
Measurement Interval	12:02:09	12:12:12	3-12	0:10:03

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	122,396.27	72,962.05	15,048.07	34,386.15
1	122,069.00	72,768.00	14,994.82	34,306.18
2	121,961.83	72,717.28	15,005.55	34,239.00
3	121,950.70	72,710.73	15,014.95	34,225.02
4	122,005.12	72,728.52	15,005.82	34,270.78
5	121,942.18	72,684.83	14,988.83	34,268.52
6	121,983.23	72,705.58	14,993.73	34,283.92
7	122,035.62	72,751.58	14,988.82	34,295.22
8	122,029.13	72,720.68	15,017.10	34,291.35
9	122,040.35	72,739.60	15,009.07	34,291.68
10	121,984.62	72,683.75	15,026.38	34,274.48
11	122,049.25	72,725.60	15,023.05	34,300.60
12	122,030.28	72,699.78	14,990.75	34,339.75
Average	***122,005.05***	***72,715.07***	***15,005.85***	***34,284.13***

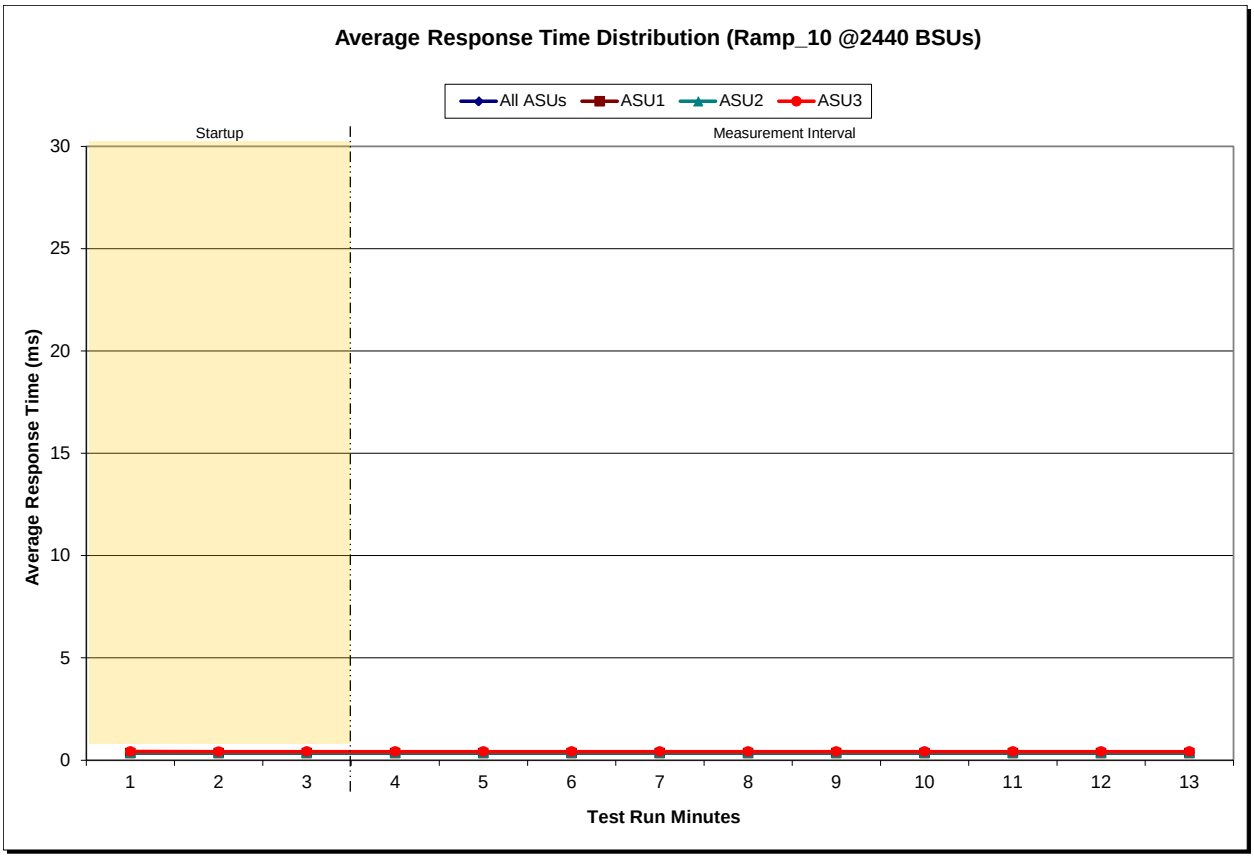
Response Time Ramp Distribution (IOPS) Graph



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

2,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:59:09	12:02:09	0-2	0:03:00
Measurement Interval	12:02:09	12:12:12	3-12	0:10:03
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.37	0.35	0.36	0.42
1	0.36	0.34	0.35	0.42
2	0.37	0.35	0.36	0.42
3	0.37	0.35	0.36	0.42
4	0.37	0.34	0.36	0.42
5	0.37	0.34	0.36	0.42
6	0.37	0.34	0.35	0.42
7	0.37	0.34	0.36	0.42
8	0.37	0.35	0.36	0.42
9	0.37	0.34	0.36	0.42
10	0.37	0.35	0.36	0.42
11	0.37	0.34	0.35	0.42
12	0.37	0.35	0.36	0.42
Average	***0.37***	***0.34***	***0.36***	***0.42***

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	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.000	0.001	0.001	0.002	0.001	0.002	0.001

Repeatability Test

Clause 5.4.5

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ primary metric and the 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 78.

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	***1,219,973.91***
Repeatability Test Phase 1	1,219,936.53
Repeatability Test Phase 2	1,219,784.36

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

	SPC-1 LRT™
Primary Metrics	***0.37 ms***
Repeatability Test Phase 1	0.37 ms
Repeatability Test Phase 2	0.37 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)...

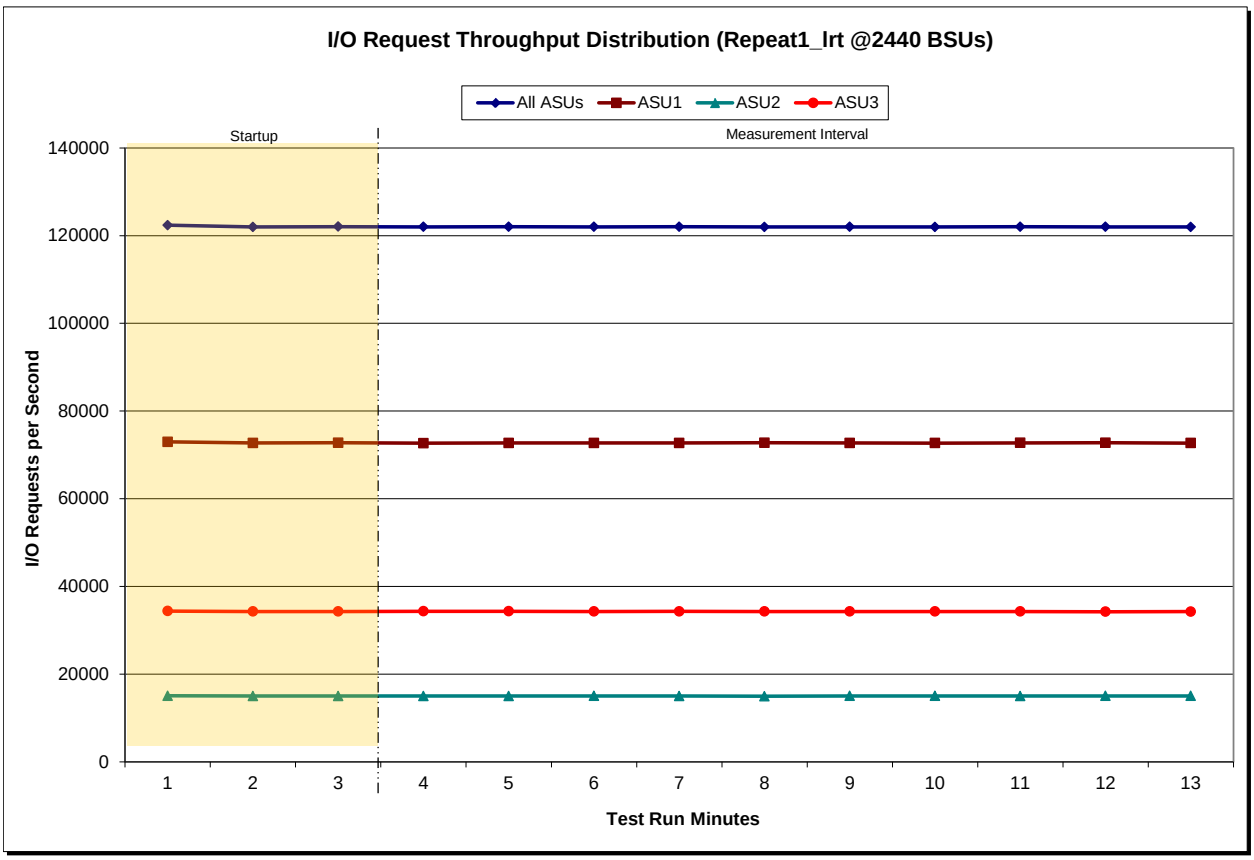
A link to the test result file generated from each Repeatability Test Run is listed below.

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

2,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:17:31	12:20:31	0-2	0:03:00
Measurement Interval	12:20:31	12:30:34	3-12	0:10:03
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	122,388.97	72,956.55	15,042.28	34,390.13
1	121,983.82	72,713.27	14,989.37	34,281.18
2	122,042.83	72,754.70	14,996.30	34,291.83
3	121,999.20	72,670.47	14,994.65	34,334.08
4	122,034.88	72,720.88	14,994.65	34,319.35
5	121,995.40	72,711.53	15,014.65	34,269.22
6	122,035.33	72,723.85	15,009.50	34,301.98
7	121,977.52	72,751.28	14,955.30	34,270.93
8	122,011.70	72,722.75	15,017.93	34,271.02
9	121,979.35	72,684.62	15,015.60	34,279.13
10	122,034.55	72,739.30	15,008.22	34,287.03
11	121,996.67	72,757.97	15,014.43	34,224.27
12	121,972.83	72,679.68	15,032.03	34,261.12
Average	***122,003.74***	***72,716.23***	***15,005.70***	***34,281.81***

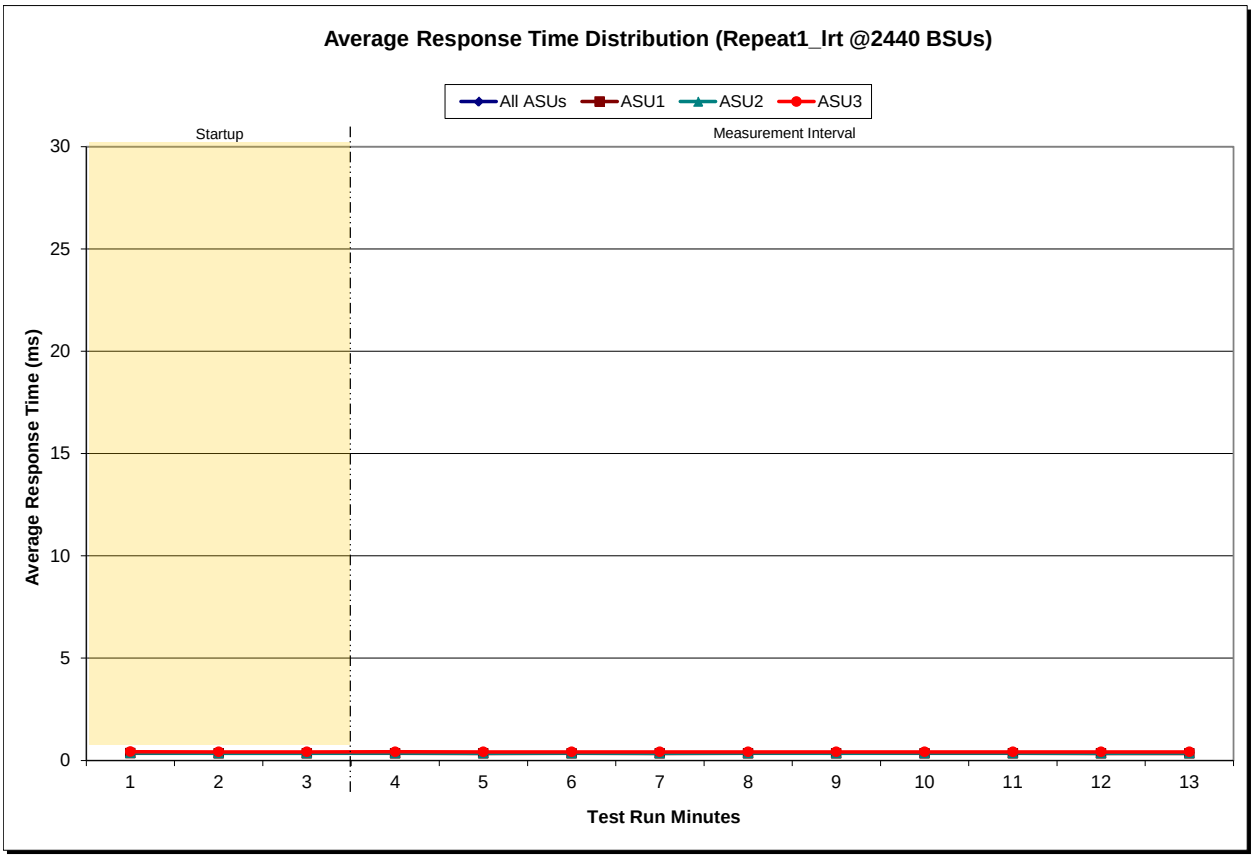
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

2,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:17:31	12:20:31	0-2	0:03:00
Measurement Interval	12:20:31	12:30:34	3-12	0:10:03
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.37	0.35	0.36	0.43
1	0.37	0.35	0.36	0.42
2	0.37	0.35	0.36	0.42
3	0.37	0.35	0.36	0.42
4	0.37	0.35	0.36	0.42
5	0.37	0.35	0.36	0.42
6	0.37	0.35	0.36	0.42
7	0.37	0.35	0.36	0.42
8	0.37	0.35	0.36	0.42
9	0.37	0.35	0.36	0.42
10	0.37	0.35	0.36	0.42
11	0.37	0.35	0.36	0.42
12	0.37	0.35	0.36	0.42
Average	***0.37***	***0.35***	***0.36***	***0.42***

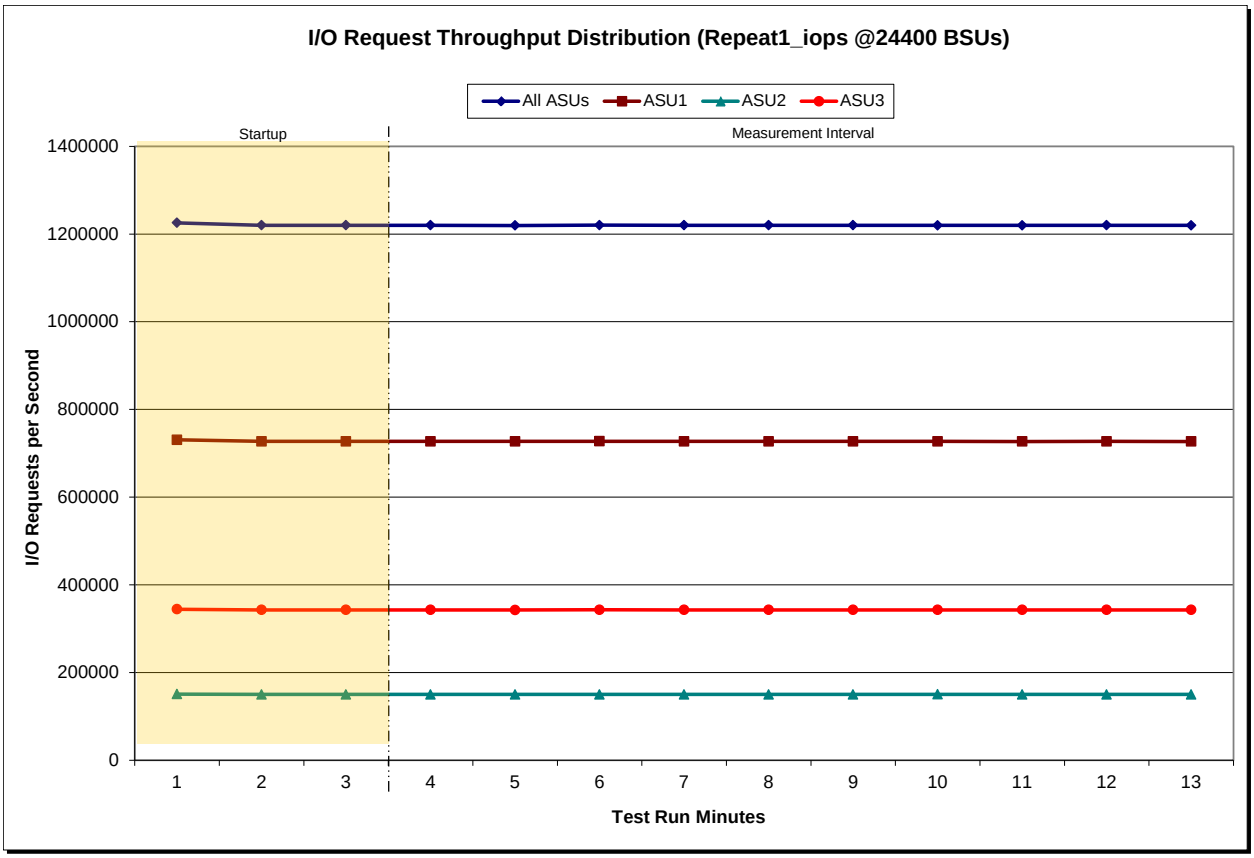
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

24,400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:47:53	12:50:53	0-2	0:03:00
Measurement Interval	12:50:53	13:00:57	3-12	0:10:04
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,225,644.17	730,571.17	150,682.70	344,390.30
1	1,220,099.10	727,157.12	150,065.95	342,876.03
2	1,219,911.83	727,028.95	150,011.02	342,871.87
3	1,220,078.37	727,200.23	150,130.05	342,748.08
4	1,219,603.70	727,062.73	149,995.07	342,545.90
5	1,220,234.87	727,343.53	149,942.85	342,948.48
6	1,220,051.13	727,107.27	150,026.65	342,917.22
7	1,220,034.87	727,240.68	150,009.83	342,784.35
8	1,220,023.43	727,036.13	150,091.25	342,896.05
9	1,219,905.43	727,063.38	150,144.23	342,697.82
10	1,219,707.30	726,936.83	149,991.63	342,778.83
11	1,219,922.15	727,001.73	150,079.22	342,841.20
12	1,219,804.02	726,997.88	149,982.25	342,823.88
Average	***1,219,936.53***	***727,099.04***	***150,039.30***	***342,798.18***

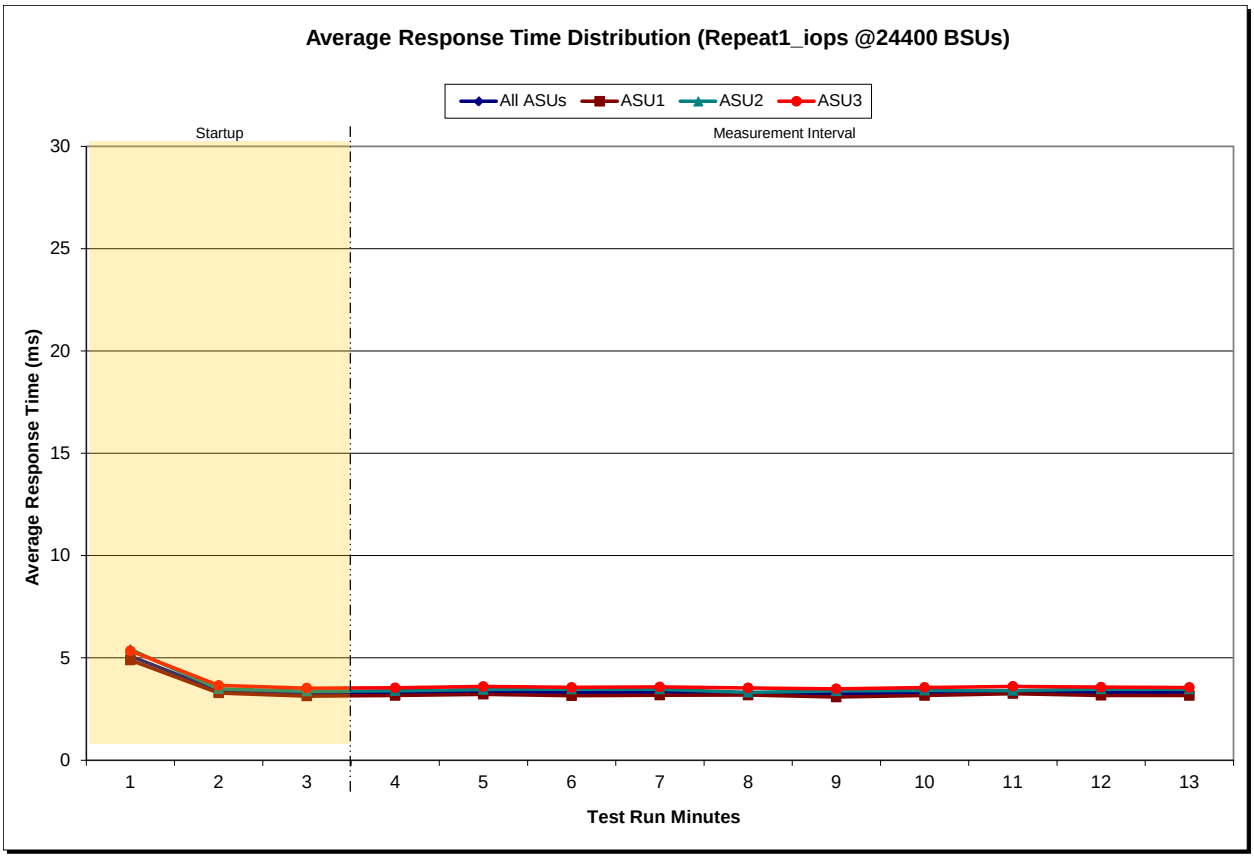
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

24,400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:47:53	12:50:53	0-2	0:03:00
Measurement Interval	12:50:53	13:00:57	3-12	0:10:04
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	5.08	4.89	5.41	5.34
1	3.41	3.28	3.49	3.65
2	3.27	3.13	3.37	3.52
3	3.30	3.16	3.39	3.54
4	3.35	3.22	3.45	3.60
5	3.30	3.15	3.47	3.56
6	3.33	3.18	3.47	3.58
7	3.30	3.18	3.32	3.53
8	3.24	3.09	3.39	3.49
9	3.30	3.16	3.41	3.55
10	3.37	3.25	3.40	3.61
11	3.32	3.17	3.47	3.57
12	3.31	3.16	3.47	3.56
Average	***3.31***	***3.17***	***3.42***	***3.56***

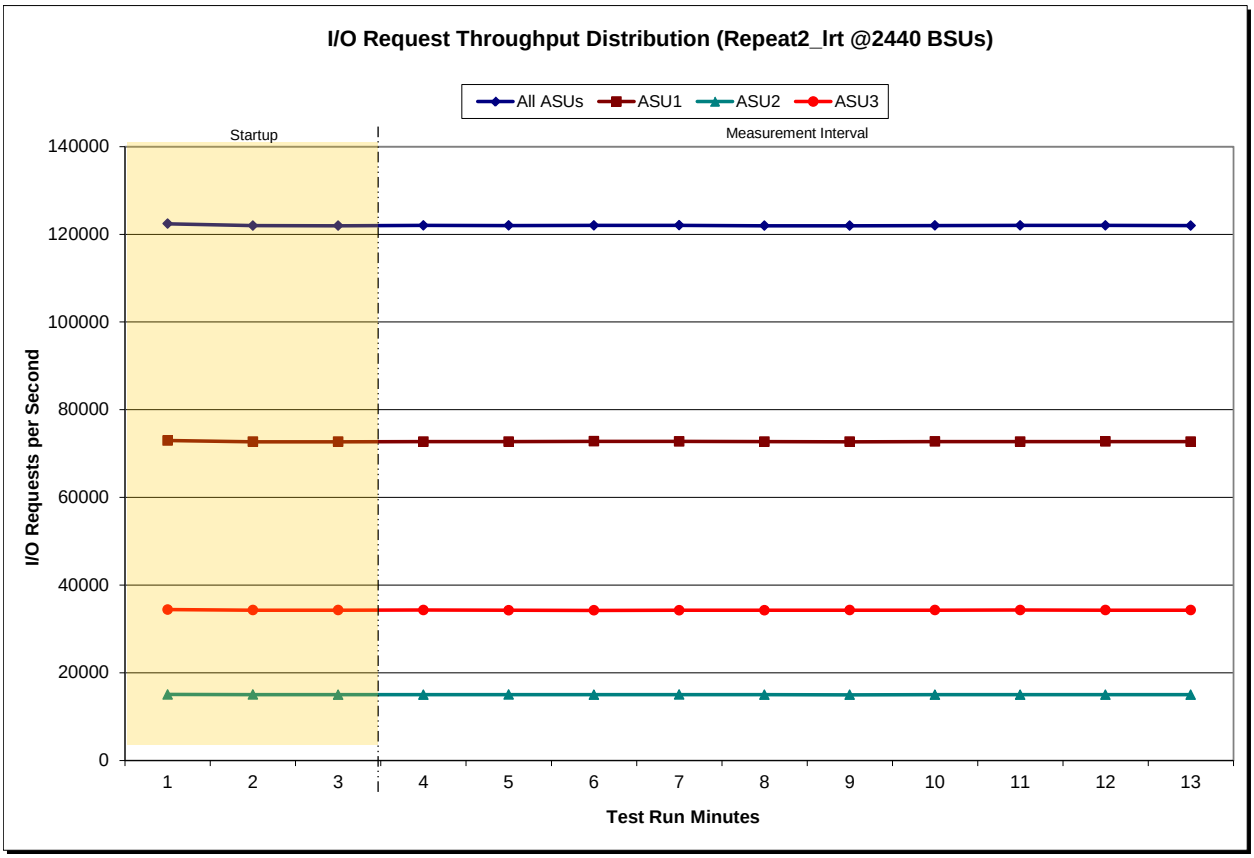
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

2,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:06:15	13:09:15	0-2	0:03:00
Measurement Interval	13:09:15	13:19:18	3-12	0:10:03
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	122,398.72	72,951.23	15,053.47	34,394.02
1	121,968.65	72,686.60	15,014.37	34,267.68
2	121,961.72	72,691.18	14,992.50	34,278.03
3	122,020.78	72,717.83	15,010.63	34,292.32
4	122,015.50	72,720.90	15,029.23	34,265.37
5	122,025.00	72,782.23	15,005.97	34,236.80
6	122,048.90	72,772.37	15,019.10	34,257.43
7	121,959.60	72,710.58	15,004.85	34,244.17
8	121,955.37	72,690.20	14,978.35	34,286.82
9	121,997.95	72,739.82	14,990.22	34,267.92
10	122,023.75	72,712.87	15,004.32	34,306.57
11	122,034.57	72,738.45	15,009.88	34,286.23
12	121,986.52	72,706.68	14,998.77	34,281.07
Average	***122,006.79***	***72,729.19***	***15,005.13***	***34,272.47***

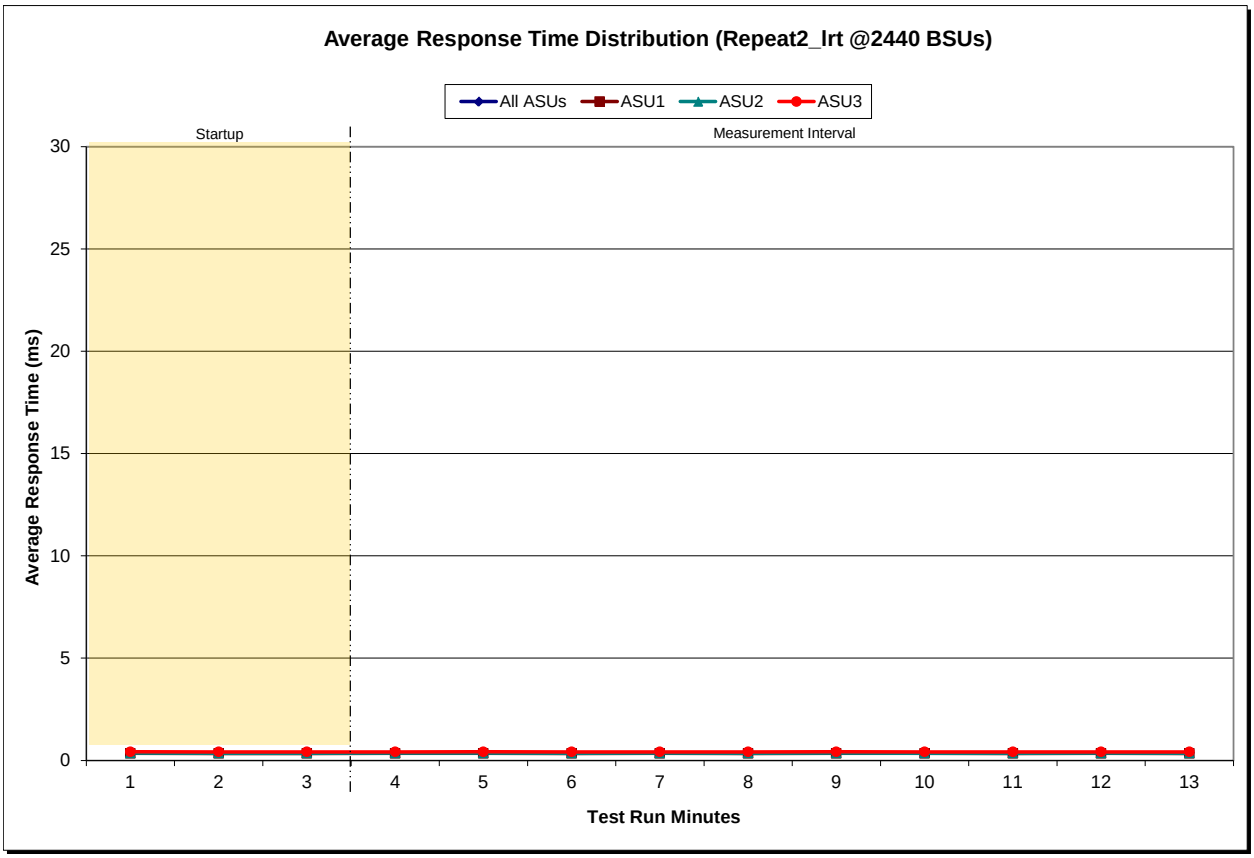
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

2,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:06:15	13:09:15	0-2	0:03:00
Measurement Interval	13:09:15	13:19:18	3-12	0:10:03
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.37	0.35	0.36	0.42
1	0.37	0.34	0.35	0.42
2	0.37	0.35	0.36	0.42
3	0.37	0.35	0.36	0.42
4	0.37	0.35	0.36	0.42
5	0.37	0.35	0.36	0.42
6	0.37	0.35	0.36	0.42
7	0.37	0.35	0.36	0.42
8	0.37	0.35	0.36	0.42
9	0.37	0.35	0.36	0.42
10	0.37	0.35	0.36	0.42
11	0.37	0.35	0.36	0.42
12	0.37	0.35	0.36	0.42
Average	***0.37***	***0.35***	***0.36***	***0.42***

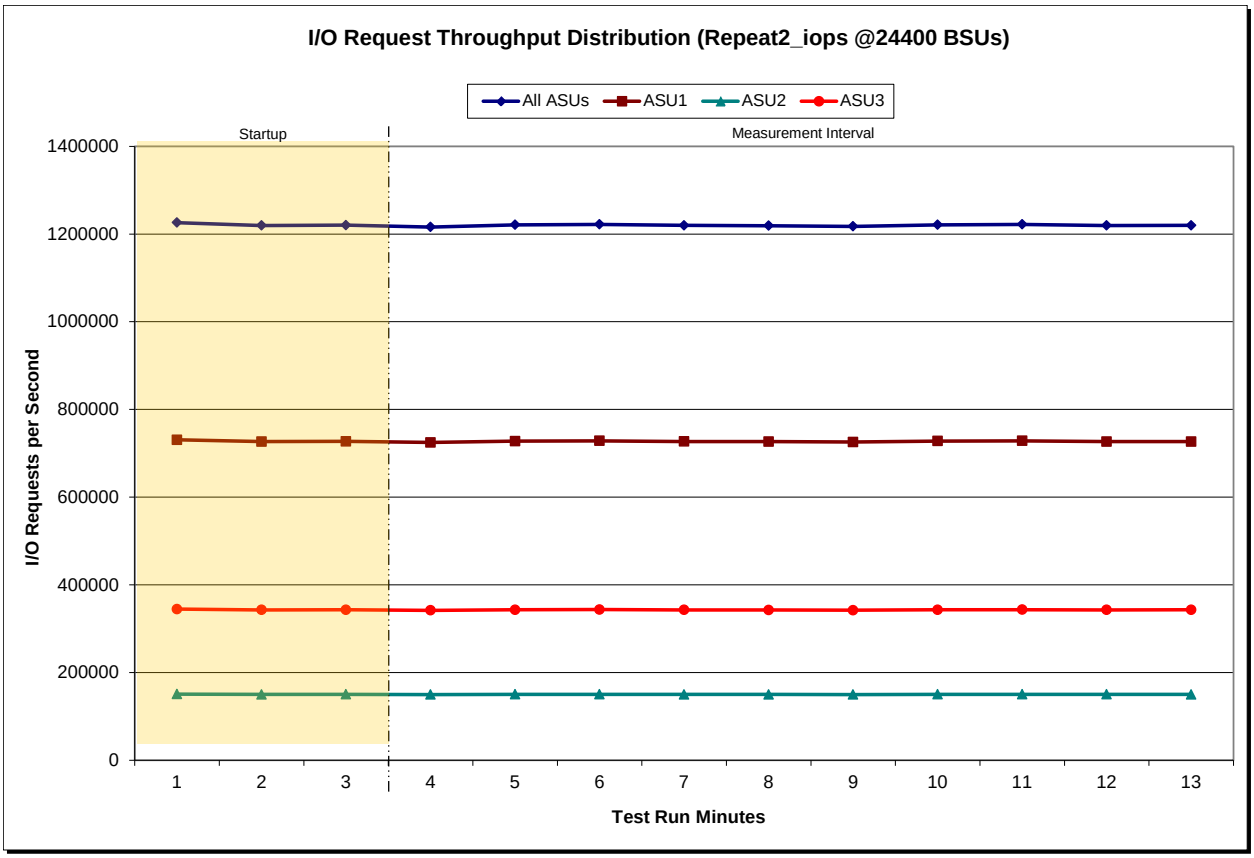
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

24,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:36:45	13:39:45	0-2	0:03:00
Measurement Interval	13:39:45	13:49:49	3-12	0:10:04
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,226,095.57	730,683.88	150,833.00	344,578.68
1	1,219,411.15	726,663.52	150,018.10	342,729.53
2	1,220,213.95	727,099.78	150,170.28	342,943.88
3	1,216,021.88	724,531.68	149,720.45	341,769.75
4	1,221,008.43	727,717.97	150,205.05	343,085.42
5	1,222,112.05	728,257.12	150,365.70	343,489.23
6	1,219,816.02	726,901.83	150,081.48	342,832.70
7	1,218,967.58	726,501.35	149,896.67	342,569.57
8	1,217,422.88	725,572.25	149,735.28	342,115.35
9	1,221,062.63	727,794.68	150,220.18	343,047.77
10	1,221,968.85	728,304.47	150,335.47	343,328.92
11	1,219,623.87	726,695.63	150,169.98	342,758.25
12	1,219,839.35	726,709.90	150,115.27	343,014.18
Average	***1,219,784.36***	***726,898.69***	***150,084.55***	***342,801.11***

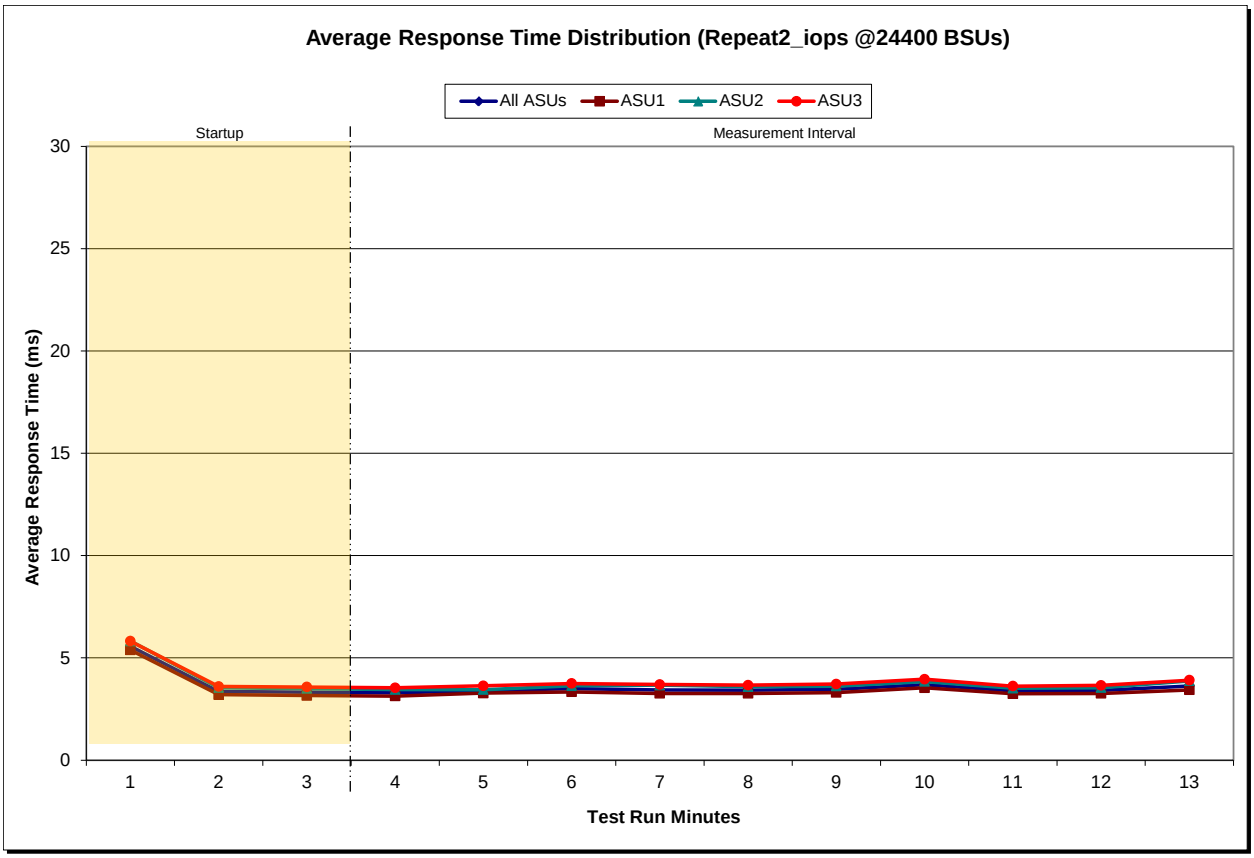
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

24,440 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:36:45	13:39:45	0-2	0:03:00
Measurement Interval	13:39:45	13:49:49	3-12	0:10:04
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	5.56	5.39	5.82	5.81
1	3.36	3.21	3.55	3.60
2	3.32	3.16	3.50	3.57
3	3.29	3.13	3.45	3.54
4	3.40	3.28	3.45	3.63
5	3.49	3.34	3.64	3.75
6	3.44	3.26	3.67	3.70
7	3.42	3.26	3.59	3.67
8	3.46	3.31	3.62	3.72
9	3.69	3.53	3.84	3.96
10	3.39	3.25	3.52	3.62
11	3.41	3.26	3.54	3.65
12	3.62	3.43	3.88	3.91
Average	***3.46***	***3.31***	***3.62***	***3.71***

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	0.28100	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.002	0.001	0.002	0.002	0.002	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	0.000	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	0.2811	0.0700	0.2100	0.0180	0.0699	0.0350	0.02809
COV	0.001	0.001	0.001	0.001	0.002	0.002	0.002	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
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0349	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

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 78.

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	673,498
Total Number of Logical Blocks Verified	502,160
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	5 minutes
Size in KB 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 Kaminario K2-D 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 differences 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.

At the end of the Sustainability Test Run, one of the SPC-1 Workload Generator slave processes terminated with an error. The measurement and reporting portion of the Test Run had concluded successfully prior to the slave process termination error, so there was no impact on the validity of the data produced by the Sustainability Test Run.

The 'master' execution script was designed to detect this type of non-fatal error and continue execution, which explicitly terminates and restarts all slave processes prior to the each Test Run. That action ensured all slave processes were active at the start of each Test Run.

APPENDIX A: SPC-1 GLOSSARY

"Decimal" *(powers of ten)* Measurement Units

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

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

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

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

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

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

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

"Binary" *(powers of two)* Measurement Units

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

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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.

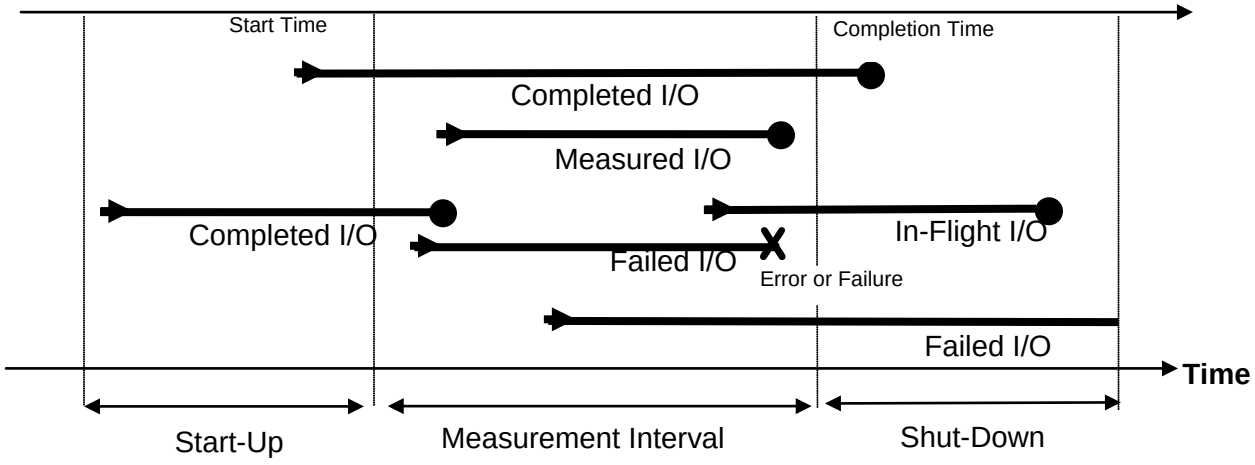
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

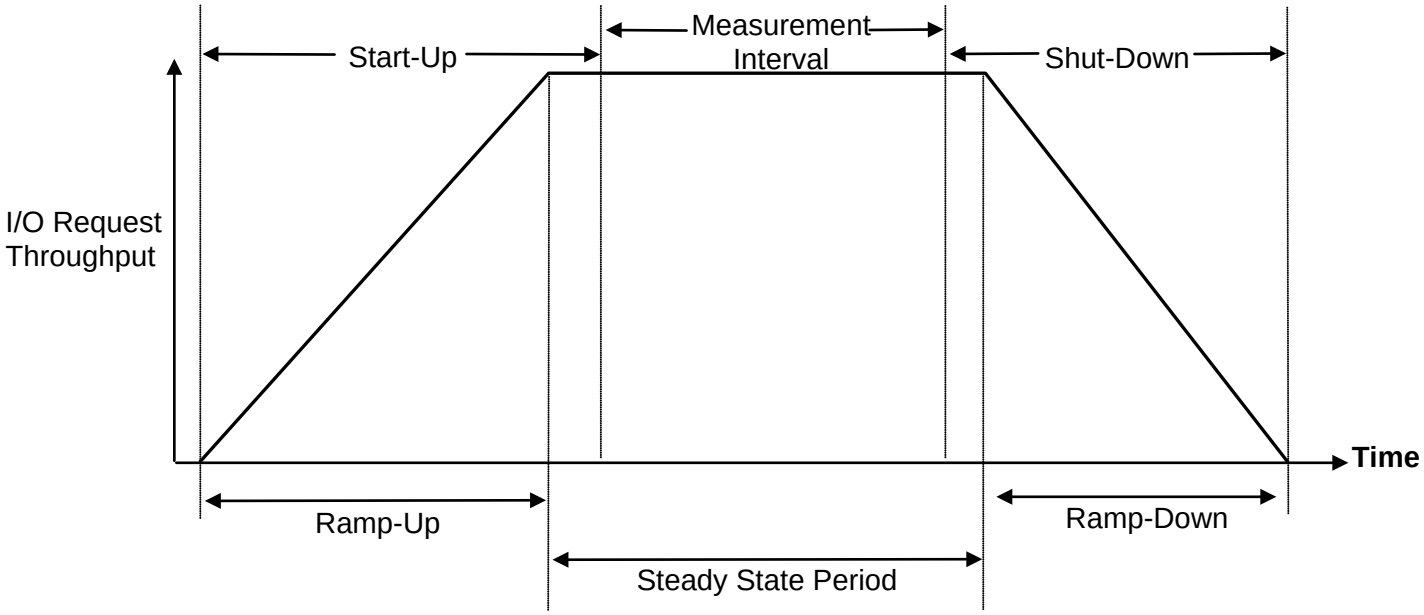
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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 Windows 2008 MPIO load balancing policy was explicitly set to be "least queue depth" on each Host System with the **LB_policy_tool.vbs** script, which is invoked by the **update_disks** script. The details of those scripts and functionality are documented in Appendix C.

The "least queue depth" policy routes I/O to the available path with the least number of outstanding requests.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Log into the K2 CLI, using an SSH client, from any Host System. Enter the referenced commands listed at the end of this section to create and configure the TSC.

Create the Hosts

- Create a Host group
- Create Host System entries and associate them with the Host group
- Configure the WWPNs of the FC HBAs on the Hosts for later mapping

Configure the Volumes

- Create a volume group
- Create the volumes for the SPC-1 ASUs and associate them with the group.

Map the Volume Group

Map the volume group to the Host group with the following command:

```
volume volume-map-create volume_group=spc host_group=spc_hosts
```

Create the Hosts Commands

```
volume host-group-create name=spc_hosts
volume host-create os_type=Windows name=bo19 host_group=spc_hosts
volume host-create os_type=Windows name=bo20 host_group=spc_hosts
volume host-create os_type=Windows name=bo13 host_group=spc_hosts
volume host-create os_type=Windows name=bo8 host_group=spc_hosts
volume host-create os_type=Windows name=bo15 host_group=spc_hosts
volume host-create os_type=Windows name=bo17 host_group=spc_hosts
volume host-create os_type=Windows name=bo4 host_group=spc_hosts
volume host-create os_type=Windows name=bo7 host_group=spc_hosts
volume host-create os_type=Windows name=bo21 host_group=spc_hosts
volume host-create os_type=Windows name=bo24 host_group=spc_hosts

volume host-change name=bo19 silent=true  add_fc_port=21-00-00-1B-32-85-63-09
volume host-change name=bo19 silent=true  add_fc_port=21-01-00-1B-32-A5-63-09
volume host-change name=bo19 silent=true  add_fc_port=21-00-00-1B-32-90-E3-A9
volume host-change name=bo19 silent=true  add_fc_port=21-01-00-1B-32-B0-E3-A9
volume host-change name=bo20 silent=true  add_fc_port=21-00-00-1B-32-8A-51-3F
volume host-change name=bo20 silent=true  add_fc_port=21-01-00-1B-32-AA-51-3F
volume host-change name=bo20 silent=true  add_fc_port=21-00-00-1B-32-90-CC-A9
volume host-change name=bo20 silent=true  add_fc_port=21-01-00-1B-32-B0-CC-A9
volume host-change name=bo13 silent=true  add_fc_port=21-00-00-1B-32-86-D0-86
volume host-change name=bo13 silent=true  add_fc_port=21-01-00-1B-32-A6-D0-86
volume host-change name=bo13 silent=true  add_fc_port=21-00-00-1B-32-86-74-87
volume host-change name=bo13 silent=true  add_fc_port=21-01-00-1B-32-A6-74-87
volume host-change name=bo8 silent=true  add_fc_port=21-00-00-1B-32-86-97-87
volume host-change name=bo8 silent=true  add_fc_port=21-01-00-1B-32-A6-97-87
volume host-change name=bo8 silent=true  add_fc_port=21-00-00-1B-32-90-B8-AD
volume host-change name=bo8 silent=true  add_fc_port=21-01-00-1B-32-B0-B8-AD
volume host-change name=bo15 silent=true  add_fc_port=21-00-00-1B-32-90-C6-A9
volume host-change name=bo15 silent=true  add_fc_port=21-01-00-1B-32-B0-C6-A9
volume host-change name=bo15 silent=true  add_fc_port=21-00-00-1B-32-90-5F-B1
```

```
volume host-change name=bo15 silent=true  add_fc_port=21-01-00-1B-32-B0-5F-B1
volume host-change name=bo17 silent=true  add_fc_port=21-00-00-1B-32-85-DC-A7
volume host-change name=bo17 silent=true  add_fc_port=21-01-00-1B-32-A5-DC-A7
volume host-change name=bo17 silent=true  add_fc_port=21-00-00-1B-32-8A-F1-40
volume host-change name=bo17 silent=true  add_fc_port=21-01-00-1B-32-AA-F1-40
volume host-change name=bo4 silent=true  add_fc_port=50-02-4F-40-C0-41-01-00
volume host-change name=bo4 silent=true  add_fc_port=50-02-4F-40-C0-41-01-01
volume host-change name=bo4 silent=true  add_fc_port=21-00-00-24-FF-35-65-EC
volume host-change name=bo4 silent=true  add_fc_port=21-00-00-24-FF-35-65-ED
volume host-change name=bo7 silent=true  add_fc_port=21-00-00-1B-32-9C-9B-53
volume host-change name=bo7 silent=true  add_fc_port=21-01-00-1B-32-BC-9B-53
volume host-change name=bo7 silent=true  add_fc_port=21-00-00-24-FF-2E-A9-9C
volume host-change name=bo7 silent=true  add_fc_port=21-00-00-24-FF-2E-A9-9D
volume host-change name=bo21 silent=true  add_fc_port=21-00-00-1B-32-86-4E-87
volume host-change name=bo21 silent=true  add_fc_port=21-01-00-1B-32-A6-4E-87
volume host-change name=bo21 silent=true  add_fc_port=21-00-00-1B-32-90-95-AA
volume host-change name=bo21 silent=true  add_fc_port=21-01-00-1B-32-B0-95-AA
volume host-change name=bo24 silent=true  add_fc_port=21-00-00-1B-32-9D-AB-A4
volume host-change name=bo24 silent=true  add_fc_port=21-01-00-1B-32-BD-AB-A4
volume host-change name=bo24 silent=true  add_fc_port=21-00-00-1B-32-88-46-8E
volume host-change name=bo24 silent=true  add_fc_port=21-01-00-1B-32-A8-46-8E
```

Configure the Volumes Commands

```
volume volume-group-create name=spc

volume volume-create media_type=DRAM volume_group=spc name=asu1_01 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_02 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_03 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_04 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_05 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_06 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_07 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_08 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_09 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_10 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_11 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_12 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_13 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_14 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_15 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_16 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_17 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_18 size=8294MB
logical_subsystem=3
```

```
volume volume-create media_type=DRAM volume_group=spc name=asu1_19 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_20 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_21 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_22 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_23 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_24 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_25 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_26 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_27 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_28 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_29 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_30 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_31 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_32 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_33 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_34 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_35 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_36 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_37 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_38 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_39 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_40 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_41 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_42 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_43 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_44 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_45 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_46 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_47 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_48 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_49 size=8294MB
logical_subsystem=1
```

```
volume volume-create media_type=DRAM volume_group=spc name=asu1_50 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_51 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_52 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_53 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_54 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_55 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_56 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_57 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu1_58 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu1_59 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu1_60 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_01 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_02 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_03 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_04 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_05 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_06 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_07 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_08 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_09 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_10 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_11 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_12 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_13 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_14 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_15 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_16 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_17 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_18 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_19 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_20 size=8294MB
logical_subsystem=2
```

```
volume volume-create media_type=DRAM volume_group=spc name=asu2_21 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_22 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_23 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_24 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_25 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_26 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_27 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_28 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_29 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_30 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_31 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_32 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_33 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_34 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_35 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_36 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_37 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_38 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_39 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_40 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_41 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_42 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_43 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_44 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_45 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_46 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_47 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_48 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_49 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_50 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_51 size=8294MB
logical_subsystem=3
```

```
volume volume-create media_type=DRAM volume_group=spc name=asu2_52 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_53 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_54 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_55 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_56 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_57 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu2_58 size=8294MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu2_59 size=8294MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu2_60 size=8294MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_01 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_02 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_03 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_04 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_05 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_06 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_07 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_08 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_09 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_10 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_11 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_12 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_13 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_14 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_15 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_16 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_17 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_18 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_19 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_20 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_21 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_22 size=1843MB
logical_subsystem=1
```

```
volume volume-create media_type=DRAM volume_group=spc name=asu3_23 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_24 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_25 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_26 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_27 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_28 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_29 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_30 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_31 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_32 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_33 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_34 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_35 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_36 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_37 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_38 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_39 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_40 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_41 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_42 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_43 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_44 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_45 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_46 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_47 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_48 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_49 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_50 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_51 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_52 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_53 size=1843MB
logical_subsystem=2
```

```
volume volume-create media_type=DRAM volume_group=spc name=asu3_54 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_55 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_56 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_57 size=1843MB
logical_subsystem=3
volume volume-create media_type=DRAM volume_group=spc name=asu3_58 size=1843MB
logical_subsystem=1
volume volume-create media_type=DRAM volume_group=spc name=asu3_59 size=1843MB
logical_subsystem=2
volume volume-create media_type=DRAM volume_group=spc name=asu3_60 size=1843MB
logical_subsystem=3
```

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, is listed below.

The content of the SPC-2 Workload Generator command and parameter files, used for the SPC-2 Persistence Test, is also listed below.

Common Command Lines – Primary Metrics and Repeatability Tests

The following command lines appear at the beginning of each command and parameter file for the Primary Metrics and Repeatability Test. The command lines are only listed below to eliminate redundancy.

```
host=master
slaves=(bo19_100,bo19_101,bo19_102,bo19_103,bo19_104,bo19_105,bo19_106,bo19_107,bo19
_108,bo19_109,bo19_110,bo19_111,bo19_112,bo19_113,bo19_114,bo19_115,bo19_116,bo19_11
7,bo19_118,bo19_119,bo19_120,bo19_121,bo19_122,bo19_123,bo19_124,bo20_100,bo20_101,b
o20_102,bo20_103,bo20_104,bo20_105,bo20_106,bo20_107,bo20_108,bo20_109,bo20_110,bo20
_111,bo20_112,bo20_113,bo20_114,bo20_115,bo20_116,bo20_117,bo20_118,bo20_119,bo20_12
0,bo20_121,bo20_122,bo20_123,bo20_124,bo8_100,bo8_101,bo8_102,bo8_103,bo8_104,bo8_10
5,bo8_106,bo8_107,bo8_108,bo8_109,bo8_110,bo8_111,bo8_112,bo8_113,bo8_114,bo8_115,bo
8_116,bo8_117,bo8_118,bo8_119,bo8_120,bo8_121,bo8_122,bo8_123,bo8_124,bo4_100,bo4_10
1,bo4_102,bo4_103,bo4_104,bo4_105,bo4_106,bo4_107,bo4_108,bo4_109,bo4_110,bo4_111,bo
4_112,bo4_113,bo4_114,bo4_115,bo4_116,bo4_117,bo4_118,bo4_119,bo4_120,bo4_121,bo4_12
2,bo4_123,bo4_124,bo7_100,bo7_101,bo7_102,bo7_103,bo7_104,bo7_105,bo7_106,bo7_107,bo
7_108,bo7_109,bo7_110,bo7_111,bo7_112,bo7_113,bo7_114,bo7_115,bo7_116,bo7_117,bo7_11
8,bo7_119,bo7_120,bo7_121,bo7_122,bo7_123,bo7_124,bo23_100,bo23_101,bo23_102,bo23_10
3,bo23_104,bo23_105,bo23_106,bo23_107,bo23_108,bo23_109,bo23_110,bo23_111,bo23_112,b
o23_113,bo23_114,bo23_115,bo23_116,bo23_117,bo23_118,bo23_119,bo23_120,bo23_121,bo23
_122,bo23_123,bo23_124,bo15_100,bo15_101,bo15_102,bo15_103,bo15_104,bo15_105,bo15_10
6,bo15_107,bo15_108,bo15_109,bo15_110,bo15_111,bo15_112,bo15_113,bo15_114,bo15_115,b
o15_116,bo15_117,bo15_118,bo15_119,bo15_120,bo15_121,bo15_122,bo15_123,bo15_124,bo17
_100,bo17_101,bo17_102,bo17_103,bo17_104,bo17_105,bo17_106,bo17_107,bo17_108,bo17_10
9,bo17_110,bo17_111,bo17_112,bo17_113,bo17_114,bo17_115,bo17_116,bo17_117,bo17_118,b
o17_119,bo17_120,bo17_121,bo17_122,bo17_123,bo17_124,bo21_100,bo21_101,bo21_102,bo21
_103,bo21_104,bo21_105,bo21_106,bo21_107,bo21_108,bo21_109,bo21_110,bo21_111,bo21_11
2,bo21_113,bo21_114,bo21_115,bo21_116,bo21_117,bo21_118,bo21_119,bo21_120,bo21_121,b
o21_122,bo21_123,bo21_124,bo24_100,bo24_101,bo24_102,bo24_103,bo24_104,bo24_105,bo24
_106,bo24_107,bo24_108,bo24_109,bo24_110,bo24_111,bo24_112,bo24_113,bo24_114,bo24_11
5,bo24_116,bo24_117,bo24_118,bo24_119,bo24_120,bo24_121,bo24_122,bo24_123,bo24_124)
sd=asu1_01,lun=\\.\PHYSICALDRIVE2
sd=asu1_02,lun=\\.\PHYSICALDRIVE124
sd=asu1_03,lun=\\.\PHYSICALDRIVE138
sd=asu1_04,lun=\\.\PHYSICALDRIVE3
sd=asu1_05,lun=\\.\PHYSICALDRIVE125
sd=asu1_06,lun=\\.\PHYSICALDRIVE64
sd=asu1_07,lun=\\.\PHYSICALDRIVE4
sd=asu1_08,lun=\\.\PHYSICALDRIVE126
sd=asu1_09,lun=\\.\PHYSICALDRIVE65
sd=asu1_10,lun=\\.\PHYSICALDRIVE63
sd=asu1_11,lun=\\.\PHYSICALDRIVE5
sd=asu1_12,lun=\\.\PHYSICALDRIVE66
sd=asu1_13,lun=\\.\PHYSICALDRIVE6
sd=asu1_14,lun=\\.\PHYSICALDRIVE128
sd=asu1_15,lun=\\.\PHYSICALDRIVE67
sd=asu1_16,lun=\\.\PHYSICALDRIVE7
sd=asu1_17,lun=\\.\PHYSICALDRIVE129
```

```
sd=asu1_18,lun=\\.\PHYSICALDRIVE68
sd=asu1_19,lun=\\.\PHYSICALDRIVE8
sd=asu1_20,lun=\\.\PHYSICALDRIVE130
sd=asu1_21,lun=\\.\PHYSICALDRIVE69
sd=asu1_22,lun=\\.\PHYSICALDRIVE9
sd=asu1_23,lun=\\.\PHYSICALDRIVE131
sd=asu1_24,lun=\\.\PHYSICALDRIVE70
sd=asu1_25,lun=\\.\PHYSICALDRIVE10
sd=asu1_26,lun=\\.\PHYSICALDRIVE132
sd=asu1_27,lun=\\.\PHYSICALDRIVE71
sd=asu1_28,lun=\\.\PHYSICALDRIVE11
sd=asu1_29,lun=\\.\PHYSICALDRIVE133
sd=asu1_30,lun=\\.\PHYSICALDRIVE72
sd=asu1_31,lun=\\.\PHYSICALDRIVE12
sd=asu1_32,lun=\\.\PHYSICALDRIVE134
sd=asu1_33,lun=\\.\PHYSICALDRIVE73
sd=asu1_34,lun=\\.\PHYSICALDRIVE136
sd=asu1_35,lun=\\.\PHYSICALDRIVE135
sd=asu1_36,lun=\\.\PHYSICALDRIVE74
sd=asu1_37,lun=\\.\PHYSICALDRIVE14
sd=asu1_38,lun=\\.\PHYSICALDRIVE13
sd=asu1_39,lun=\\.\PHYSICALDRIVE75
sd=asu1_40,lun=\\.\PHYSICALDRIVE15
sd=asu1_41,lun=\\.\PHYSICALDRIVE137
sd=asu1_42,lun=\\.\PHYSICALDRIVE76
sd=asu1_43,lun=\\.\PHYSICALDRIVE16
sd=asu1_44,lun=\\.\PHYSICALDRIVE127
sd=asu1_45,lun=\\.\PHYSICALDRIVE77
sd=asu1_46,lun=\\.\PHYSICALDRIVE17
sd=asu1_47,lun=\\.\PHYSICALDRIVE139
sd=asu1_48,lun=\\.\PHYSICALDRIVE78
sd=asu1_49,lun=\\.\PHYSICALDRIVE18
sd=asu1_50,lun=\\.\PHYSICALDRIVE140
sd=asu1_51,lun=\\.\PHYSICALDRIVE79
sd=asu1_52,lun=\\.\PHYSICALDRIVE19
sd=asu1_53,lun=\\.\PHYSICALDRIVE141
sd=asu1_54,lun=\\.\PHYSICALDRIVE80
sd=asu1_55,lun=\\.\PHYSICALDRIVE20
sd=asu1_56,lun=\\.\PHYSICALDRIVE142
sd=asu1_57,lun=\\.\PHYSICALDRIVE81
sd=asu1_58,lun=\\.\PHYSICALDRIVE21
sd=asu1_59,lun=\\.\PHYSICALDRIVE143
sd=asu1_60,lun=\\.\PHYSICALDRIVE82
sd=asu2_01,lun=\\.\PHYSICALDRIVE22
sd=asu2_02,lun=\\.\PHYSICALDRIVE144
sd=asu2_03,lun=\\.\PHYSICALDRIVE83
sd=asu2_04,lun=\\.\PHYSICALDRIVE23
sd=asu2_05,lun=\\.\PHYSICALDRIVE145
sd=asu2_06,lun=\\.\PHYSICALDRIVE84
sd=asu2_07,lun=\\.\PHYSICALDRIVE24
sd=asu2_08,lun=\\.\PHYSICALDRIVE146
sd=asu2_09,lun=\\.\PHYSICALDRIVE85
sd=asu2_10,lun=\\.\PHYSICALDRIVE25
sd=asu2_11,lun=\\.\PHYSICALDRIVE147
sd=asu2_12,lun=\\.\PHYSICALDRIVE86
sd=asu2_13,lun=\\.\PHYSICALDRIVE26
sd=asu2_14,lun=\\.\PHYSICALDRIVE148
sd=asu2_15,lun=\\.\PHYSICALDRIVE87
sd=asu2_16,lun=\\.\PHYSICALDRIVE27
sd=asu2_17,lun=\\.\PHYSICALDRIVE149
sd=asu2_18,lun=\\.\PHYSICALDRIVE88
sd=asu2_19,lun=\\.\PHYSICALDRIVE28
sd=asu2_20,lun=\\.\PHYSICALDRIVE150
```

```
sd=asu2_21,lun=\\.\PHYSICALDRIVE89
sd=asu2_22,lun=\\.\PHYSICALDRIVE29
sd=asu2_23,lun=\\.\PHYSICALDRIVE151
sd=asu2_24,lun=\\.\PHYSICALDRIVE90
sd=asu2_25,lun=\\.\PHYSICALDRIVE30
sd=asu2_26,lun=\\.\PHYSICALDRIVE152
sd=asu2_27,lun=\\.\PHYSICALDRIVE91
sd=asu2_28,lun=\\.\PHYSICALDRIVE31
sd=asu2_30,lun=\\.\PHYSICALDRIVE92
sd=asu2_29,lun=\\.\PHYSICALDRIVE153
sd=asu2_31,lun=\\.\PHYSICALDRIVE154
sd=asu2_32,lun=\\.\PHYSICALDRIVE32
sd=asu2_33,lun=\\.\PHYSICALDRIVE93
sd=asu2_34,lun=\\.\PHYSICALDRIVE33
sd=asu2_35,lun=\\.\PHYSICALDRIVE155
sd=asu2_36,lun=\\.\PHYSICALDRIVE94
sd=asu2_37,lun=\\.\PHYSICALDRIVE34
sd=asu2_38,lun=\\.\PHYSICALDRIVE156
sd=asu2_39,lun=\\.\PHYSICALDRIVE95
sd=asu2_40,lun=\\.\PHYSICALDRIVE35
sd=asu2_41,lun=\\.\PHYSICALDRIVE157
sd=asu2_42,lun=\\.\PHYSICALDRIVE96
sd=asu2_43,lun=\\.\PHYSICALDRIVE36
sd=asu2_44,lun=\\.\PHYSICALDRIVE158
sd=asu2_45,lun=\\.\PHYSICALDRIVE97
sd=asu2_46,lun=\\.\PHYSICALDRIVE37
sd=asu2_47,lun=\\.\PHYSICALDRIVE159
sd=asu2_48,lun=\\.\PHYSICALDRIVE98
sd=asu2_49,lun=\\.\PHYSICALDRIVE38
sd=asu2_50,lun=\\.\PHYSICALDRIVE160
sd=asu2_51,lun=\\.\PHYSICALDRIVE99
sd=asu2_52,lun=\\.\PHYSICALDRIVE39
sd=asu2_53,lun=\\.\PHYSICALDRIVE161
sd=asu2_54,lun=\\.\PHYSICALDRIVE100
sd=asu2_55,lun=\\.\PHYSICALDRIVE40
sd=asu2_56,lun=\\.\PHYSICALDRIVE162
sd=asu2_57,lun=\\.\PHYSICALDRIVE101
sd=asu2_58,lun=\\.\PHYSICALDRIVE41
sd=asu2_59,lun=\\.\PHYSICALDRIVE163
sd=asu2_60,lun=\\.\PHYSICALDRIVE102
sd=asu3_01,lun=\\.\PHYSICALDRIVE42
sd=asu3_02,lun=\\.\PHYSICALDRIVE164
sd=asu3_03,lun=\\.\PHYSICALDRIVE103
sd=asu3_04,lun=\\.\PHYSICALDRIVE43
sd=asu3_05,lun=\\.\PHYSICALDRIVE165
sd=asu3_06,lun=\\.\PHYSICALDRIVE104
sd=asu3_07,lun=\\.\PHYSICALDRIVE44
sd=asu3_08,lun=\\.\PHYSICALDRIVE166
sd=asu3_09,lun=\\.\PHYSICALDRIVE105
sd=asu3_10,lun=\\.\PHYSICALDRIVE45
sd=asu3_11,lun=\\.\PHYSICALDRIVE167
sd=asu3_12,lun=\\.\PHYSICALDRIVE106
sd=asu3_13,lun=\\.\PHYSICALDRIVE46
sd=asu3_14,lun=\\.\PHYSICALDRIVE168
sd=asu3_15,lun=\\.\PHYSICALDRIVE107
sd=asu3_16,lun=\\.\PHYSICALDRIVE47
sd=asu3_17,lun=\\.\PHYSICALDRIVE169
sd=asu3_18,lun=\\.\PHYSICALDRIVE108
sd=asu3_19,lun=\\.\PHYSICALDRIVE48
sd=asu3_20,lun=\\.\PHYSICALDRIVE170
sd=asu3_21,lun=\\.\PHYSICALDRIVE109
sd=asu3_22,lun=\\.\PHYSICALDRIVE49
sd=asu3_23,lun=\\.\PHYSICALDRIVE171
```

```
sd=asu3_24,lun=\\.\PHYSICALDRIVE110
sd=asu3_25,lun=\\.\PHYSICALDRIVE50
sd=asu3_26,lun=\\.\PHYSICALDRIVE172
sd=asu3_27,lun=\\.\PHYSICALDRIVE111
sd=asu3_28,lun=\\.\PHYSICALDRIVE51
sd=asu3_29,lun=\\.\PHYSICALDRIVE173
sd=asu3_30,lun=\\.\PHYSICALDRIVE112
sd=asu3_31,lun=\\.\PHYSICALDRIVE52
sd=asu3_32,lun=\\.\PHYSICALDRIVE174
sd=asu3_33,lun=\\.\PHYSICALDRIVE113
sd=asu3_34,lun=\\.\PHYSICALDRIVE53
sd=asu3_35,lun=\\.\PHYSICALDRIVE175
sd=asu3_36,lun=\\.\PHYSICALDRIVE114
sd=asu3_37,lun=\\.\PHYSICALDRIVE179
sd=asu3_38,lun=\\.\PHYSICALDRIVE176
sd=asu3_39,lun=\\.\PHYSICALDRIVE115
sd=asu3_40,lun=\\.\PHYSICALDRIVE180
sd=asu3_41,lun=\\.\PHYSICALDRIVE177
sd=asu3_42,lun=\\.\PHYSICALDRIVE116
sd=asu3_43,lun=\\.\PHYSICALDRIVE56
sd=asu3_44,lun=\\.\PHYSICALDRIVE178
sd=asu3_45,lun=\\.\PHYSICALDRIVE117
sd=asu3_46,lun=\\.\PHYSICALDRIVE57
sd=asu3_47,lun=\\.\PHYSICALDRIVE54
sd=asu3_48,lun=\\.\PHYSICALDRIVE118
sd=asu3_49,lun=\\.\PHYSICALDRIVE58
sd=asu3_50,lun=\\.\PHYSICALDRIVE55
sd=asu3_51,lun=\\.\PHYSICALDRIVE119
sd=asu3_52,lun=\\.\PHYSICALDRIVE59
sd=asu3_53,lun=\\.\PHYSICALDRIVE181
sd=asu3_54,lun=\\.\PHYSICALDRIVE120
sd=asu3_55,lun=\\.\PHYSICALDRIVE60
sd=asu3_56,lun=\\.\PHYSICALDRIVE182
sd=asu3_57,lun=\\.\PHYSICALDRIVE121
sd=asu3_58,lun=\\.\PHYSICALDRIVE61
sd=asu3_59,lun=\\.\PHYSICALDRIVE183
sd=asu3_60,lun=\\.\PHYSICALDRIVE122
```

Primary Metrics Test: Sustainability Test Phase/Test Run

```
rd=sustain,bsus=24400,startup=180,elapsed=86400,interval=60
```

Primary Metrics Test: IOPS Test Phase *(100% Test Run)*

```
rd=ramp_100,bsus=24400,startup=180,elapsed=600,interval=60
```

Primary Metrics Test: Response Time Ramp Test Phase *(95% Test Run)*

```
rd=ramp_95,bsus=23180,startup=180,elapsed=600,interval=60
```

Primary Metrics Test: Response Time Ramp Test Phase *(90% Test Run)*

```
rd=ramp_90,bsus=21960,startup=180,elapsed=600,interval=60
```

Primary Metrics Test: Response Time Ramp Test Phase *(80% Test Run)*

```
rd=ramp_80,bsus=19520,startup=180,elapsed=600,interval=60
```

Primary Metrics Test: Response Time Ramp Test Phase *(50% Test Run)*

```
rd=ramp_50,bsus=12200,startup=180,elapsed=600,interval=60
```

Primary Metrics Test: Response Time Ramp Test Phase *(10% Test Run)*

```
rd=ramp_10,bsus=2440,startup=180,elapsed=600,interval=60
```

Repeatability Test: Repeatability Test Phase 1 *(10% Test Run)*

```
rd=repeat1_lrt,bsus=2440,startup=180,elapsed=600,interval=60
```

Repeatability Test: Repeatability Test Phase 1 *(100% Test Run)*

```
rd=repeat1_iops,bsus=24400,startup=180,elapsed=600,interval=60
```

Repeatability Test: Repeatability Test Phase 2 *(10% Test Run)*

```
rd=repeat2_lrt,bsus=2440,startup=180,elapsed=600,interval=60
```

Repeatability Test: Repeatability Test Phase 2 *(100% Test Run)*

```
rd=repeat2_iops,bsus=24400,startup=180,elapsed=600,interval=60
```

SPC-2 Persistence Test

Common Command Lines – SPC-2 Persistence Test

The following command lines appear at the beginning of each command and parameter file for the two SPC-2 Persistence Test Runs. The command lines are only listed below to eliminate redundancy.

```
host=localhost,jvms=8,maxstreams=880
sd=asu1_01,lun=\\.\PHYSICALDRIVE2,size=8697937920
sd=asu1_02,lun=\\.\PHYSICALDRIVE63,size=8697937920
sd=asu1_03,lun=\\.\PHYSICALDRIVE77,size=8697937920
sd=asu1_04,lun=\\.\PHYSICALDRIVE3,size=8697937920
sd=asu1_05,lun=\\.\PHYSICALDRIVE64,size=8697937920
sd=asu1_06,lun=\\.\PHYSICALDRIVE125,size=8697937920
sd=asu1_07,lun=\\.\PHYSICALDRIVE4,size=8697937920
sd=asu1_08,lun=\\.\PHYSICALDRIVE65,size=8697937920
sd=asu1_09,lun=\\.\PHYSICALDRIVE126,size=8697937920
sd=asu1_10,lun=\\.\PHYSICALDRIVE124,size=8697937920
sd=asu1_11,lun=\\.\PHYSICALDRIVE5,size=8697937920
sd=asu1_12,lun=\\.\PHYSICALDRIVE127,size=8697937920
sd=asu1_13,lun=\\.\PHYSICALDRIVE6,size=8697937920
sd=asu1_14,lun=\\.\PHYSICALDRIVE67,size=8697937920
sd=asu1_15,lun=\\.\PHYSICALDRIVE128,size=8697937920
sd=asu1_16,lun=\\.\PHYSICALDRIVE7,size=8697937920
sd=asu1_17,lun=\\.\PHYSICALDRIVE68,size=8697937920
sd=asu1_18,lun=\\.\PHYSICALDRIVE129,size=8697937920
sd=asu1_19,lun=\\.\PHYSICALDRIVE8,size=8697937920
sd=asu1_20,lun=\\.\PHYSICALDRIVE69,size=8697937920
sd=asu1_21,lun=\\.\PHYSICALDRIVE130,size=8697937920
sd=asu1_22,lun=\\.\PHYSICALDRIVE9,size=8697937920
sd=asu1_23,lun=\\.\PHYSICALDRIVE70,size=8697937920
sd=asu1_24,lun=\\.\PHYSICALDRIVE131,size=8697937920
sd=asu1_25,lun=\\.\PHYSICALDRIVE10,size=8697937920
sd=asu1_26,lun=\\.\PHYSICALDRIVE71,size=8697937920
sd=asu1_27,lun=\\.\PHYSICALDRIVE132,size=8697937920
sd=asu1_28,lun=\\.\PHYSICALDRIVE11,size=8697937920
sd=asu1_29,lun=\\.\PHYSICALDRIVE72,size=8697937920
sd=asu1_30,lun=\\.\PHYSICALDRIVE133,size=8697937920
sd=asu1_31,lun=\\.\PHYSICALDRIVE12,size=8697937920
sd=asu1_32,lun=\\.\PHYSICALDRIVE73,size=8697937920
```

```
sd=asu1_33,lun=\\.\PHYSICALDRIVE134,size=8697937920
sd=asu1_34,lun=\\.\PHYSICALDRIVE75,size=8697937920
sd=asu1_35,lun=\\.\PHYSICALDRIVE74,size=8697937920
sd=asu1_36,lun=\\.\PHYSICALDRIVE135,size=8697937920
sd=asu1_37,lun=\\.\PHYSICALDRIVE14,size=8697937920
sd=asu1_38,lun=\\.\PHYSICALDRIVE13,size=8697937920
sd=asu1_39,lun=\\.\PHYSICALDRIVE136,size=8697937920
sd=asu1_40,lun=\\.\PHYSICALDRIVE15,size=8697937920
sd=asu1_41,lun=\\.\PHYSICALDRIVE76,size=8697937920
sd=asu1_42,lun=\\.\PHYSICALDRIVE137,size=8697937920
sd=asu1_43,lun=\\.\PHYSICALDRIVE16,size=8697937920
sd=asu1_44,lun=\\.\PHYSICALDRIVE66,size=8697937920
sd=asu1_45,lun=\\.\PHYSICALDRIVE138,size=8697937920
sd=asu1_46,lun=\\.\PHYSICALDRIVE17,size=8697937920
sd=asu1_47,lun=\\.\PHYSICALDRIVE78,size=8697937920
sd=asu1_48,lun=\\.\PHYSICALDRIVE139,size=8697937920
sd=asu1_49,lun=\\.\PHYSICALDRIVE18,size=8697937920
sd=asu1_50,lun=\\.\PHYSICALDRIVE79,size=8697937920
sd=asu1_51,lun=\\.\PHYSICALDRIVE140,size=8697937920
sd=asu1_52,lun=\\.\PHYSICALDRIVE19,size=8697937920
sd=asu1_53,lun=\\.\PHYSICALDRIVE80,size=8697937920
sd=asu1_54,lun=\\.\PHYSICALDRIVE141,size=8697937920
sd=asu1_55,lun=\\.\PHYSICALDRIVE20,size=8697937920
sd=asu1_56,lun=\\.\PHYSICALDRIVE81,size=8697937920
sd=asu1_57,lun=\\.\PHYSICALDRIVE142,size=8697937920
sd=asu1_58,lun=\\.\PHYSICALDRIVE21,size=8697937920
sd=asu1_59,lun=\\.\PHYSICALDRIVE82,size=8697937920
sd=asu1_60,lun=\\.\PHYSICALDRIVE143,size=8697937920
sd=asu2_01,lun=\\.\PHYSICALDRIVE22,size=8697937920
sd=asu2_02,lun=\\.\PHYSICALDRIVE83,size=8697937920
sd=asu2_03,lun=\\.\PHYSICALDRIVE144,size=8697937920
sd=asu2_04,lun=\\.\PHYSICALDRIVE23,size=8697937920
sd=asu2_05,lun=\\.\PHYSICALDRIVE84,size=8697937920
sd=asu2_06,lun=\\.\PHYSICALDRIVE145,size=8697937920
sd=asu2_07,lun=\\.\PHYSICALDRIVE24,size=8697937920
sd=asu2_08,lun=\\.\PHYSICALDRIVE85,size=8697937920
sd=asu2_09,lun=\\.\PHYSICALDRIVE146,size=8697937920
sd=asu2_10,lun=\\.\PHYSICALDRIVE25,size=8697937920
sd=asu2_11,lun=\\.\PHYSICALDRIVE86,size=8697937920
sd=asu2_12,lun=\\.\PHYSICALDRIVE147,size=8697937920
sd=asu2_13,lun=\\.\PHYSICALDRIVE26,size=8697937920
sd=asu2_14,lun=\\.\PHYSICALDRIVE87,size=8697937920
sd=asu2_15,lun=\\.\PHYSICALDRIVE148,size=8697937920
sd=asu2_16,lun=\\.\PHYSICALDRIVE27,size=8697937920
sd=asu2_17,lun=\\.\PHYSICALDRIVE88,size=8697937920
sd=asu2_18,lun=\\.\PHYSICALDRIVE149,size=8697937920
sd=asu2_19,lun=\\.\PHYSICALDRIVE28,size=8697937920
sd=asu2_20,lun=\\.\PHYSICALDRIVE89,size=8697937920
sd=asu2_21,lun=\\.\PHYSICALDRIVE150,size=8697937920
sd=asu2_22,lun=\\.\PHYSICALDRIVE29,size=8697937920
sd=asu2_23,lun=\\.\PHYSICALDRIVE90,size=8697937920
sd=asu2_24,lun=\\.\PHYSICALDRIVE151,size=8697937920
sd=asu2_25,lun=\\.\PHYSICALDRIVE30,size=8697937920
sd=asu2_26,lun=\\.\PHYSICALDRIVE91,size=8697937920
sd=asu2_27,lun=\\.\PHYSICALDRIVE152,size=8697937920
sd=asu2_28,lun=\\.\PHYSICALDRIVE31,size=8697937920
sd=asu2_29,lun=\\.\PHYSICALDRIVE92,size=8697937920
sd=asu2_30,lun=\\.\PHYSICALDRIVE153,size=8697937920
sd=asu2_31,lun=\\.\PHYSICALDRIVE93,size=8697937920
sd=asu2_32,lun=\\.\PHYSICALDRIVE32,size=8697937920
sd=asu2_33,lun=\\.\PHYSICALDRIVE154,size=8697937920
sd=asu2_34,lun=\\.\PHYSICALDRIVE33,size=8697937920
sd=asu2_35,lun=\\.\PHYSICALDRIVE94,size=8697937920
```

```
sd=asu2_36,lun=\\.\PHYSICALDRIVE155,size=8697937920
sd=asu2_37,lun=\\.\PHYSICALDRIVE34,size=8697937920
sd=asu2_38,lun=\\.\PHYSICALDRIVE95,size=8697937920
sd=asu2_39,lun=\\.\PHYSICALDRIVE156,size=8697937920
sd=asu2_40,lun=\\.\PHYSICALDRIVE35,size=8697937920
sd=asu2_41,lun=\\.\PHYSICALDRIVE96,size=8697937920
sd=asu2_42,lun=\\.\PHYSICALDRIVE157,size=8697937920
sd=asu2_43,lun=\\.\PHYSICALDRIVE36,size=8697937920
sd=asu2_44,lun=\\.\PHYSICALDRIVE97,size=8697937920
sd=asu2_45,lun=\\.\PHYSICALDRIVE158,size=8697937920
sd=asu2_46,lun=\\.\PHYSICALDRIVE37,size=8697937920
sd=asu2_47,lun=\\.\PHYSICALDRIVE98,size=8697937920
sd=asu2_48,lun=\\.\PHYSICALDRIVE159,size=8697937920
sd=asu2_49,lun=\\.\PHYSICALDRIVE38,size=8697937920
sd=asu2_50,lun=\\.\PHYSICALDRIVE99,size=8697937920
sd=asu2_51,lun=\\.\PHYSICALDRIVE160,size=8697937920
sd=asu2_52,lun=\\.\PHYSICALDRIVE39,size=8697937920
sd=asu2_53,lun=\\.\PHYSICALDRIVE100,size=8697937920
sd=asu2_54,lun=\\.\PHYSICALDRIVE161,size=8697937920
sd=asu2_55,lun=\\.\PHYSICALDRIVE40,size=8697937920
sd=asu2_56,lun=\\.\PHYSICALDRIVE101,size=8697937920
sd=asu2_57,lun=\\.\PHYSICALDRIVE162,size=8697937920
sd=asu2_58,lun=\\.\PHYSICALDRIVE41,size=8697937920
sd=asu2_59,lun=\\.\PHYSICALDRIVE102,size=8697937920
sd=asu2_60,lun=\\.\PHYSICALDRIVE163,size=8697937920
sd=asu3_01,lun=\\.\PHYSICALDRIVE42,size=1934622720
sd=asu3_02,lun=\\.\PHYSICALDRIVE103,size=1934622720
sd=asu3_03,lun=\\.\PHYSICALDRIVE164,size=1934622720
sd=asu3_04,lun=\\.\PHYSICALDRIVE43,size=1934622720
sd=asu3_05,lun=\\.\PHYSICALDRIVE104,size=1934622720
sd=asu3_06,lun=\\.\PHYSICALDRIVE165,size=1934622720
sd=asu3_07,lun=\\.\PHYSICALDRIVE44,size=1934622720
sd=asu3_08,lun=\\.\PHYSICALDRIVE105,size=1934622720
sd=asu3_09,lun=\\.\PHYSICALDRIVE166,size=1934622720
sd=asu3_10,lun=\\.\PHYSICALDRIVE45,size=1934622720
sd=asu3_11,lun=\\.\PHYSICALDRIVE106,size=1934622720
sd=asu3_12,lun=\\.\PHYSICALDRIVE167,size=1934622720
sd=asu3_13,lun=\\.\PHYSICALDRIVE46,size=1934622720
sd=asu3_14,lun=\\.\PHYSICALDRIVE107,size=1934622720
sd=asu3_15,lun=\\.\PHYSICALDRIVE168,size=1934622720
sd=asu3_16,lun=\\.\PHYSICALDRIVE47,size=1934622720
sd=asu3_17,lun=\\.\PHYSICALDRIVE108,size=1934622720
sd=asu3_18,lun=\\.\PHYSICALDRIVE169,size=1934622720
sd=asu3_19,lun=\\.\PHYSICALDRIVE48,size=1934622720
sd=asu3_20,lun=\\.\PHYSICALDRIVE109,size=1934622720
sd=asu3_21,lun=\\.\PHYSICALDRIVE170,size=1934622720
sd=asu3_22,lun=\\.\PHYSICALDRIVE49,size=1934622720
sd=asu3_23,lun=\\.\PHYSICALDRIVE110,size=1934622720
sd=asu3_24,lun=\\.\PHYSICALDRIVE171,size=1934622720
sd=asu3_25,lun=\\.\PHYSICALDRIVE50,size=1934622720
sd=asu3_26,lun=\\.\PHYSICALDRIVE111,size=1934622720
sd=asu3_27,lun=\\.\PHYSICALDRIVE172,size=1934622720
sd=asu3_28,lun=\\.\PHYSICALDRIVE51,size=1934622720
sd=asu3_29,lun=\\.\PHYSICALDRIVE112,size=1934622720
sd=asu3_30,lun=\\.\PHYSICALDRIVE173,size=1934622720
sd=asu3_31,lun=\\.\PHYSICALDRIVE52,size=1934622720
sd=asu3_32,lun=\\.\PHYSICALDRIVE113,size=1934622720
sd=asu3_33,lun=\\.\PHYSICALDRIVE174,size=1934622720
sd=asu3_34,lun=\\.\PHYSICALDRIVE53,size=1934622720
sd=asu3_35,lun=\\.\PHYSICALDRIVE114,size=1934622720
sd=asu3_36,lun=\\.\PHYSICALDRIVE175,size=1934622720
sd=asu3_37,lun=\\.\PHYSICALDRIVE118,size=1934622720
sd=asu3_38,lun=\\.\PHYSICALDRIVE115,size=1934622720
```

```
sd=asu3_39,lun=\\.\PHYSICALDRIVE176,size=1934622720
sd=asu3_40,lun=\\.\PHYSICALDRIVE119,size=1934622720
sd=asu3_41,lun=\\.\PHYSICALDRIVE116,size=1934622720
sd=asu3_42,lun=\\.\PHYSICALDRIVE177,size=1934622720
sd=asu3_43,lun=\\.\PHYSICALDRIVE56,size=1934622720
sd=asu3_44,lun=\\.\PHYSICALDRIVE117,size=1934622720
sd=asu3_45,lun=\\.\PHYSICALDRIVE178,size=1934622720
sd=asu3_46,lun=\\.\PHYSICALDRIVE57,size=1934622720
sd=asu3_47,lun=\\.\PHYSICALDRIVE54,size=1934622720
sd=asu3_48,lun=\\.\PHYSICALDRIVE179,size=1934622720
sd=asu3_49,lun=\\.\PHYSICALDRIVE58,size=1934622720
sd=asu3_50,lun=\\.\PHYSICALDRIVE55,size=1934622720
sd=asu3_51,lun=\\.\PHYSICALDRIVE180,size=1934622720
sd=asu3_52,lun=\\.\PHYSICALDRIVE59,size=1934622720
sd=asu3_53,lun=\\.\PHYSICALDRIVE120,size=1934622720
sd=asu3_54,lun=\\.\PHYSICALDRIVE181,size=1934622720
sd=asu3_55,lun=\\.\PHYSICALDRIVE60,size=1934622720
sd=asu3_56,lun=\\.\PHYSICALDRIVE121,size=1934622720
sd=asu3_57,lun=\\.\PHYSICALDRIVE182,size=1934622720
sd=asu3_58,lun=\\.\PHYSICALDRIVE61,size=1934622720
sd=asu3_59,lun=\\.\PHYSICALDRIVE122,size=1934622720
sd=asu3_60,lun=\\.\PHYSICALDRIVE183,size=1934622720
maxlatestart=1
reportinginterval=5
segmentlength=512m
```

SPC-2 Persistence Test Run 1 *(write phase)*

```
rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1
rd=default,rdpct=0,xfersize=1024k
rd=TR1_SPC-2-persist-w,streams=880
```

SPC-2 Persistence Test Run 1 *(read phase)*

```
maxpersistenceerrors=10
rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1_SPC-2-persist-r
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

'Master' Execution Script for the required ASU "pre-fill", Primary Metrics Test, Repeatability and Persistence Test *(SPC-1 or SPC-2)*

This script is invoked from a "start-up" script, **tests_sequence**, which is listed below.

```
#!/bin/bash


ROOTDIR='/cygdrive/c/spc/run/'
JAVA=$ROOTDIR"java7 -Xmx12000m -Xms12000m"
SPC2="/cygdrive/c/spc/spc2/spc2.bat"
BSU=24400
PERSIST1_FACTOR=10
SUSTAIN_TIME=86400
TIME=600
STARTUP=180
INTERVAL=60
STREAMS=880
DISKS=$ROOTDIR"disks"
DISKS_SIZES=$ROOTDIR"disks_sizes"
PERSISTDIR=$ROOTDOIR"persist/"
PERSIST_W='persist_write'
PERSIST_R='persist_read'
PHASES='sustain:100 ramp_100:100 ramp_95:95 ramp_90:90 ramp_80:80 ramp_50:50
ramp_10:10 repeat1_lrt:10 repeat1_iops:100 repeat2_lrt:10 repeat2_iops:100'

mkdir -p $PERSISTDIR
cd $ROOTDIR

echo "Updating disk mapping"
./all_update_disks
sleep 120

echo "Preparing files"
# creating main tests files
for phase in $PHASES; do
     NAME=${phase%:*}
     FACTOR=${phase#*:}
     if [ $NAME = "sustain" ];
     then
            ACTUAL_TIME=$SUSTAIN_TIME
     else
            ACTUAL_TIME=$TIME
     fi
     cat $ROOTDIR"spc1.cfg" > $NAME".txt"
     echo "rd=$NAME,bsus=$[$BSU * $FACTOR /
100],startup=$STARTUP,elapsed=$ACTUAL_TIME,interval=$INTERVAL" >> $NAME".txt"
done
# creating persistence test files
cd $PERSISTDIR
echo "host=localhost,jvms=8,maxstreams=$STREAMS" > $PERSIST_W".txt"
cat $DISKS_SIZES >> $PERSIST_W".txt"
echo "maxlatestart=1" >> $PERSIST_W".txt"
echo "reportinginterval=5" >> $PERSIST_W".txt"
echo "segmentlength=512m" >> $PERSIST_W".txt"
```

```
echo
"rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1" >>
$PERSIST_W".txt"
echo "rd=default,rdpct=0,xfersize=1024k" >> $PERSIST_W".txt"
echo "rd=TR1_SPC-2-persist-w,streams=$STREAMS" >> $PERSIST_W".txt"

echo "host=localhost,jvms=8,maxstreams=$STREAMS" > $PERSIST_R".txt"
cat $DISKS_SIZES >> $PERSIST_R".txt"
echo "maxlatestart=1" >> $PERSIST_R".txt"
echo "reportinginterval=5" >> $PERSIST_R".txt"
echo "segmentlength=512m" >> $PERSIST_R".txt"
echo "maxpersistenceerrors=10" >> $PERSIST_R".txt"
echo "rd=default,buffers=1,rdpct=100,xfersize=1024k" >> $PERSIST_R".txt"
echo "rd=TR1_SPC-2-persist-r" >> $PERSIST_R".txt"
cd $ROOTDIR

case "$1"  in
     main)

            #echo "Running vdbench pre-fill"
            /cygdrive/c/Users/Administrator/Desktop/vdbench503rc11/vdbench.bat -f
prepssd.txt -o ssdprep

            echo "Running test with low level commands"
            for phase in $PHASES; do
                  if [ $phase == 'restart' ]
                  then
                        echo "Restarting slaves"
                        #Calling all_runslaves will kill and then run the slaves on
each host"
                        ./all_runslaves
                        sleep 10
                  else
                        ./all_runslaves
                        sleep 10
                        NAME=${phase%:*}
                        CMD="$JAVA spc1 -w SPC1 -f $NAME.txt -o $NAME SPCOut"
                        echo $CMD
                        $CMD
                        if [ `tail $ROOTDIR$NAME/logfile.html | grep Error | wc -l`
-gt 0  ]
                        then
                              echo "Found an error - waiting"
                              sleep 300
                              if [ `grep "Task IO_task stopped after 3 minutes"
/tmp/slaves.bo* | wc -l` -gt 0 ]
                              then
                                    echo "There was a stuck slave. we can
continue"
                              else
                                    echo "An error detected in phase $NAME"
                                    exit 1
                              fi
                        fi
                  fi
            done
            ;;
     spc2_persist_w)
            echo "Running persist_w"
            ./all_killslaves
            cd $PERSISTDIR
            $SPC2 -f $PERSIST_W".txt" -o init -init
            $SPC2 -f $PERSIST_W".txt" -o $PERSIST_W
```

```
        ;;
    spc2_persist_r)
        echo "Running persist_r"
        ./all_killslaves
        cd $PERSISTDIR
        $SPC2 -f $PERSIST_R".txt" -o $PERSIST_R
        ;;
    spc1_persist1)
        echo "Running persist1"
        ./all_killslaves
        cp disks $PERSISTDIR"spc1.cfg"
        cd $PERSISTDIR
        $JAVA persist1 -b $[$BSU * $PERSIST1_FACTOR / 100];
        ;;
    spc1_persist2)
        echo "Running persist2"
        ./all_killslaves
        cp disks $PERSISTDIR"spc1.cfg"
        cd $PERSISTDIR
        $JAVA persist2;
        ;;
    *)
        echo "no stage supplied -
main|spc2_persist_w|spc2_persist_r|spc1_persist1|spc1_persist2"
        ;;
esac
```

Referenced Scripts

tests_sequence

This script invokes the above 'master' script. The various parameters in this script will determine what portion of the 'master' script is executed.

```
ROOTDIR='/cygdrive/c/spc/run/'
cd $ROOTDIR
./tests main
#./tests spc1_persist1
#./tests spc1_persist2
./tests spc2_persist_w
#./tests spc2_persist_r
```

hosts

Contains the current Host Systems and the mapping from the K2 volumes to the SPC-1 ASUs.

```
#!/bin/bash

hosts_slaves='bo19:25 bo20:25 bo8:25 bo4:25 bo7:25 bo23:25 bo15:25 bo17:25 bo21:25
bo24:25';

disk_map='"asu1_01:b15a0001   asu1_02:b21b0001   asu1_03:b21b000f   asu1_04:b15a0002
asu1_05:b21b0002 asu1_06:b20c0002 asu1_07:b15a0003 asu1_08:b21b0003 asu1_09:b20c0003
asu1_10:b20c0001 asu1_11:b15a0004 asu1_12:b20c0004 asu1_13:b15a0005 asu1_14:b21b0005
asu1_15:b20c0005 asu1_16:b15a0006 asu1_17:b21b0006 asu1_18:b20c0006 asu1_19:b15a0007
asu1_20:b21b0007 asu1_21:b20c0007 asu1_22:b15a0008 asu1_23:b21b0008 asu1_24:b20c0008
asu1_25:b15a0009 asu1_26:b21b0009 asu1_27:b20c0009 asu1_28:b15a000a asu1_29:b21b000a
asu1_30:b20c000a asu1_31:b15a000b asu1_32:b21b000b asu1_33:b20c000b asu1_34:b21b000d
asu1_35:b21b000c asu1_36:b20c000c asu1_37:b15a000d asu1_38:b15a000c asu1_39:b20c000d
```

```
asu1_40:b15a000e asu1_41:b21b000e asu1_42:b20c000e asu1_43:b15a000f asu1_44:b21b0004
asu1_45:b20c000f asu1_46:b15a0010 asu1_47:b21b0010 asu1_48:b20c0010 asu1_49:b15a0011
asu1_50:b21b0011 asu1_51:b20c0011 asu1_52:b15a0012 asu1_53:b21b0012 asu1_54:b20c0012
asu1_55:b15a0013 asu1_56:b21b0013 asu1_57:b20c0013 asu1_58:b15a0014 asu1_59:b21b0014
asu1_60:b20c0014 asu2_01:b15a0015 asu2_02:b21b0015 asu2_03:b20c0015 asu2_04:b15a0016
asu2_05:b21b0016 asu2_06:b20c0016 asu2_07:b15a0017 asu2_08:b21b0017 asu2_09:b20c0017
asu2_10:b15a0018 asu2_11:b21b0018 asu2_12:b20c0018 asu2_13:b15a0019 asu2_14:b21b0019
asu2_15:b20c0019 asu2_16:b15a001a asu2_17:b21b001a asu2_18:b20c001a asu2_19:b15a001b
asu2_20:b21b001b asu2_21:b20c001b asu2_22:b15a001c asu2_23:b21b001c asu2_24:b20c001c
asu2_25:b15a001d asu2_26:b21b001d asu2_27:b20c001d asu2_28:b15a001e asu2_30:b20c001e
asu2_29:b21b001e asu2_31:b21b001f asu2_32:b15a001f asu2_33:b20c001f asu2_34:b15a0020
asu2_35:b21b0020 asu2_36:b20c0020 asu2_37:b15a0021 asu2_38:b21b0021 asu2_39:b20c0021
asu2_40:b15a0022 asu2_41:b21b0022 asu2_42:b20c0022 asu2_43:b15a0023 asu2_44:b21b0023
asu2_45:b20c0023 asu2_46:b15a0024 asu2_47:b21b0024 asu2_48:b20c0024 asu2_49:b15a0025
asu2_50:b21b0025 asu2_51:b20c0025 asu2_52:b15a0026 asu2_53:b21b0026 asu2_54:b20c0026
asu2_55:b15a0027 asu2_56:b21b0027 asu2_57:b20c0027 asu2_58:b15a0028 asu2_59:b21b0028
asu2_60:b20c0028 asu3_01:b15a0029 asu3_02:b21b0029 asu3_03:b20c0029 asu3_04:b15a002a
asu3_05:b21b002a asu3_06:b20c002a asu3_07:b15a002b asu3_08:b21b002b asu3_09:b20c002b
asu3_10:b15a002c asu3_11:b21b002c asu3_12:b20c002c asu3_13:b15a002d asu3_14:b21b002d
asu3_15:b20c002d asu3_16:b15a002e asu3_17:b21b002e asu3_18:b20c002e asu3_19:b15a002f
asu3_20:b21b002f asu3_21:b20c002f asu3_22:b15a0030 asu3_23:b21b0030 asu3_24:b20c0030
asu3_25:b15a0031 asu3_26:b21b0031 asu3_27:b20c0031 asu3_28:b15a0032 asu3_29:b21b0032
asu3_30:b20c0032 asu3_31:b15a0033 asu3_32:b21b0033 asu3_33:b20c0033 asu3_34:b15a0034
asu3_35:b21b0034 asu3_36:b20c0034 asu3_37:b21b0038 asu3_38:b21b0035 asu3_39:b20c0035
asu3_40:b21b0039 asu3_41:b21b0036 asu3_42:b20c0036 asu3_43:b15a0037 asu3_44:b21b0037
asu3_45:b20c0037 asu3_46:b15a0038 asu3_47:b15a0035 asu3_48:b20c0038 asu3_49:b15a0039
asu3_50:b15a0036 asu3_51:b20c0039 asu3_52:b15a003a asu3_53:b21b003a asu3_54:b20c003a
asu3_55:b15a003b asu3_56:b21b003b asu3_57:b20c003b asu3_58:b15a003c asu3_59:b21b003c
asu3_60:b20c003c"'
```

all_update_disks

Invokes the **update_disks** script for each Host System.

```
#!/bin/bash

source hosts
for host_slave in $hosts_slaves; do
     NAME=${host_slave%:*}
     SLAVES=${host_slave#*:}
     if [ $SLAVES -gt 0 ]; then
            ssh -n -f $NAME "/cygdrive/c/spc/run/update_disks $disk_map $1
2>/tmp/update_disks.err" > /tmp/update_disks.$NAME &
     fi
done
wait
echo "Disk count , LB policy and path count:"
grep -A 1000 New  /tmp/update_disks.* | grep count | sort | uniq -c
echo "Done updating disks"
```

update_disks

This script:

- Rescans the LUNs
- Creates the mapping between the K2 volumes and LUN using the **get_disks** script
- Ensures the LUNs are all online
- Ensures the load balancing policy is LDQ using the **LB_policy_tool.vbs** script

- Creates the directories for Slave JVM output and recreates the **spc.cfg** files using the **mktree** script

```
#!/bin/bash

FILENAME=diskpart_script
ROOTDIR='/cygdrive/c/spc/run/'
BASHSCRIPT=$ROOTDIR$FILENAME

# rescan for disks
echo 'rescan' > $BASHSCRIPT
schtasks.exe /Run /TN run_diskpart_script

# get the kaminario disks
/cygdrive/c/spc/run/get_disks "$1"

if [ $2 ]; then
     # make all disks online
     rm -f $BASHSCRIPT
     for disk in `cat $ROOTDIR"disks"`; do
            echo "SELECT DISK="`echo $disk |  grep -o  'PHYSICALDRIVE[0-9]*' | cut  -
-complement -c 1-13` >> $BASHSCRIPT
            echo "ATTRIBUTES DISK CLEAR READONLY NOERR" >> $BASHSCRIPT
            echo "ONLINE DISK NOERR" >> $BASHSCRIPT
            echo "CONVERT MBR NOERR" >> $BASHSCRIPT
     done

     schtasks.exe /Run /TN run_diskpart_script
fi

# Set the LB policy to LQD
 cscript.exe "C:\spc\run\LB_policy_tool.vbs" 3

# Remake the slave tree
$ROOTDIR"mktree"

# Create the spc config file
$ROOTDIR"createspc1cfg"
```

get_disks

```
#!/bin/bash

if [ $# == 0 ]; then
     echo "Missing disk map (e.g:  \"asu1_1:c0210001 asu2_1:c0210002
asu3_1:c0200002\")"
     exit
fi
ROOTDIR='/cygdrive/c/spc/run/'
DISKS=$ROOTDIR"disks"
DISKS_SIZES=$ROOTDIR"disks_sizes"
PREPSSD=$ROOTDIR"prepssd.txt"
WDTMP=$ROOTDIR"wd.tmp"
rm -f $DISKS
rm -f $WDTMP
rm -f $DISKS_SIZES
echo "compratio=1" > $PREPSSD

wmic_disks="`wmic diskdrive get name,serialnumber,model,size | tr -s ' ' ':' | grep
KMNRIO | cut -d ':' -f 6-8`"
for map in $1 ; do
     ASU=${map%:*}
```

```
      ID=${map#*:}
      for l in $wmic_disks; do
            DISK=${l%:*:*}
            SERIAL_SIZE=${l#*:}
            SERIAL=${SERIAL_SIZE%:*}
            SIZE=${SERIAL_SIZE#*:}
            if [ "$SERIAL" = "$ID" ]
            then
                  echo sd=$ASU,lun=$DISK >> $DISKS
                  echo sd=$ASU,lun=$DISK,size=$SIZE >> $DISKS_SIZES
                  echo sd=$ASU,lun=$DISK,threads=32 >> $PREPSSD
                  echo wd=wd_$ASU,sd=$ASU,rdpct=0,seek=-1,xfersize=4K >> $WDTMP
            fi
      done
done

cat $WDTMP >> $PREPSSD
echo rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10 >> $PREPSSD
```

LB_policy_tool.vbs

```
Option Explicit



const LB_POLICY_DONT_CHANGE           = -1
const LB_POLICY_ROUND_ROBIN           = 2
const LB_POLICY_LEAST_QUEUE_DEPTH     = 4

'''Get the user selection
'''======================
Dim args
Dim strMsg
Dim strInput
dim intNewValue
Dim myFSO, WriteStuff

strMsg = "Load blanace control tool for MPIO" & vbCr & vbCr & _
      " {1} Query the current load balance policy" & vbcr & vbCr & _
      " {2} Set load balance policy to ROUND ROBIN" & vbCr & vbCr & _
      " {3} Change load blance policy ro LEAST QUEUE DEPTH"

args = WScript.Arguments.Count
If args < 1 then
'''  Wscript.Echo(strMsg)
  WScript.Quit
end If


select Case WScript.Arguments.Item(0)
     Case "1"
           intNewValue = LB_POLICY_DONT_CHANGE
     Case "2"
           intNewValue = LB_POLICY_ROUND_ROBIN
     Case "3"
           intNewValue = LB_POLICY_LEAST_QUEUE_DEPTH
     Case Else
           if (strInput <> "") Then
                 wScript.echo  "unsupprted command  (" & strInput & ")"
           end if
           wScript.Quit
End Select
```

```
'''Query the current LB policy
'''============================

Dim objWMIService, objProcess, colProcess, objProcess2, colProcess2, Policy(1000)
Dim strComputer, strList
Dim strRes, strPolicy
Dim i

strComputer = "."


Set objWMIService = GetObject("winmgmts:" _
& "{impersonationLevel=impersonate}!\\" _
& strComputer & "\root\wmi")

Set colProcess = objWMIService.ExecQuery _
("Select * from DSM_QueryLBPolicy")

strRes="LB policies before update" & vbCr & vbCr
WScript.Echo strRes
i=0
For Each objProcess in colProcess
     Set Policy(i) = objProcess.LoadBalancePolicy
     strPolicy = Policy(i).LoadBalancePolicy
     select case strPolicy
            case LB_POLICY_ROUND_ROBIN
                   strPolicy = strPolicy & " (ROUND ROBIN)"
            case LB_POLICY_LEAST_QUEUE_DEPTH
                   strPolicy = strPolicy & " (LEAST QUEUE DEPTH)"
     end select
     strRes = "LoadBalancePolicy= "& strPolicy & " Path count=" &
Policy(i).DSMPathCount & vbCr
     WScript.Echo strRes
     i=i+1
Next

'''Set the new policy
'''==================

'''If no change is required quit
If (intNewValue = LB_POLICY_DONT_CHANGE      ) Then wScript.Quit


Set colProcess = objWMIService.ExecQuery _
("Select * from DSM_LB_Operations")

WScript.Echo ""
WScript.Echo "New LB policies" & vbCr & vbCr
i=0
For Each objProcess in colProcess
     Policy(i).LoadBalancePolicy = intNewValue
     strPolicy = Policy(i).LoadBalancePolicy
     select case strPolicy
            case LB_POLICY_ROUND_ROBIN
                   strPolicy = strPolicy & " (ROUND ROBIN)"
            case LB_POLICY_LEAST_QUEUE_DEPTH
                   strPolicy = strPolicy & " (LEAST QUEUE DEPTH)"
     end select

     objProcess.DsmSetLoadBalancePolicy(Policy(i))
```

```
      WScript.Echo "Disk Name: " & objProcess.InstanceName
      strRes = "LoadBalancePolicy= "& strPolicy & " Path count=" &
Policy(i).DSMPathCount
      WScript.Echo strRes
      WScript.Echo ""

      i=i+1
Next


WScript.Quit
```

mktree

```
#!/bin/bash

NUMOFSLAVES=30
HOST=`hostname |  tr '[A-Z]' '[a-z]' | tr -d '\n' | tr -d '\r'`
ROOTDIR='/cygdrive/c/spc/run/slaves/'

rm -rf $ROOTDIR
mkdir $ROOTDIR

MASTER='bo19'

FILENAME=$HOST"_"
STARTDIR=100

ENDDIR=$[$STARTDIR + $NUMOFSLAVES]
for NDIR in `seq $STARTDIR $ENDDIR`; do

        DIR=$ROOTDIR$FILENAME$NDIR
        CFGFILE=$DIR/$FILENAME$NDIR.txt
        HOSTNAME=$FILENAME$NDIR
        /bin/mkdir -p $DIR
        /bin/echo "master=$MASTER" > $CFGFILE
        /bin/echo "host=$HOSTNAME" >> $CFGFILE
            cat $ROOTDIR"../disks" >> $CFGFILE
done
```

createspc1cfg

```
Creates the ‘master’ SPC-1 configuration file.
#!/bin/bash

ROOTDIR='/cygdrive/c/spc/run/'
source $ROOTDIR"hosts"

CFGFILE=$ROOTDIR"spc1.cfg"
SLAVELIST=""

for host_slave in $hosts_slaves; do
     NAME=${host_slave%:*}
     SLAVES=${host_slave#*:}
     FIRSTSLAVE=100

     LASTSLAVE=$[$FIRSTSLAVE    + $SLAVES - 1]
     for SLAVENUM in `seq $FIRSTSLAVE $LASTSLAVE`; do
            SLAVENAME=$NAME"_"$SLAVENUM
            SLAVELIST="$SLAVELIST,$SLAVENAME"
     done
done
```

```
SLAVELIST=${SLAVELIST:1}

/bin/echo "host=master" > $CFGFILE
/bin/echo "slaves=($SLAVELIST)" >> $CFGFILE
cat $ROOTDIR"disks" >> $CFGFILE
```

all_killslaves

Invokes the **killslaves** script to terminate all Slave JVMs.

```
#!/bin/bash

source hosts
for host_slave in $hosts_slaves; do
     NAME=${host_slave%:*}
     ssh -n -f $NAME "CLASSPATH='c:\spc\spc1' /cygdrive/c/spc/run/killslaves >
/dev/null 2>/dev/null" &
done
wait
echo "Done killing all slaves"
```

killslaves

```
ps -efW | grep java | awk '{print "/bin/kill -f " $2}' | bash
```

all_runslaves

Invokes the **runslaves** script to start all the Slave JVMs

```
#!/bin/bash

source hosts
for host_slave in $hosts_slaves; do
     NAME=${host_slave%:*}
     SLAVES=${host_slave#*:}
     if [ $SLAVES -gt 0 ]; then
           ssh -n -f $NAME "/cygdrive/c/spc/run/killslaves; CLASSPATH='c:\spc\spc1'
/cygdrive/c/spc/run/runslaves $SLAVES 2> /tmp/slaves.err " >/tmp/slaves.$NAME &
     fi
done
wait
echo "Done running all slaves"
```

runslaves

```
#!/bin/bash

if [ $# -gt 0 ]; then
     NUMOFSLAVES=$1
else
     echo "Missing number of slaves to run"
     exit
fi
FILENAME=`hostname|  tr '[A-Z]' '[a-z]' | tr -d '\n' | tr -d '\r'`"_"
ROOTDIR='/cygdrive/c/spc/run/slaves/'

SCRIPT_PATH=`pwd`
CNTR=0

slaves_list=`ls -l $ROOTDIR |  grep -o $FILENAME[0-9]*`

for SLAVE in ${slaves_list}; do
```

```
        if [ $CNTR -ge $NUMOFSLAVES ]; then
                exit 0
        fi

        cd $ROOTDIR$SLAVE > /dev/null
        /cygdrive/c/Program\ Files/Java/jre7/bin/java.exe spc1 -f$SLAVE.txt && echo
"$SLAVE finished with success. Time:`date`" || echo "$SLAVE finished with rc $?.
Time: `date`"&
        cd $SCRIPT_PATH > /dev/null
        CNTR=$[$CNTR + 1]
Done
```

APPENDIX F: THIRD-PARTY QUOTATION

MediateK computers MediateK networking MediateK college

THE STANDARDS INSTITUTION OF ISRAEL

July 16, 2012

Quote # 160712-04

Attn: Kaminario Ltd

Subject: Price Quotation

Line	Qty	Description	Unit Price
1	20	QLogic QME2572 8Gbps Fibre Channel I/O Card - Kit	425$
1	5	**Dell-Brocade 300 FC8 (8/16/24 Port) 8 SFP FC8, EUC** Brocade 300 8 Port Upgrade FC8, License Key + SFPs Dell Build Worldwide PDU Power Cord (2) No Hardware Installation Brocade 4900/5300 Rack Rail 3Yr Pro Support and 4hr Mission Critical	5,340$

* Price in US $ not included VAT
* Valid for the 60 days

Regard,

Etay Aharon

20, Halutzei Hataasiya Haifa Bay, 26294, ISRAEL
Tel: 972-4-8813300 Fax: 972-4-8813301