SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

KAMINARIO, INC.
KAMINARIO K2 *(K2F00000700)*

SPC-1 V1.14

Submitted for Review: October 17, 2013
Submission Identifier: A00137

First Edition – October 2013

Trademarks

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AUDIT CERTIFICATION

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

October 17, 2013

The SPC Benchmark 1™ Reported Data listed below for the Kaminario K2 *(K2F00000700)*was produced in compliance with the SPC Benchmark 1™ v1.14 Onsite Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: Kaminario K2 *(K2F00000700)*	
Metric	**Reported Result**
SPC-1 IOPS™	1,239,898.00
SPC-1 Price-Performance	$0.80/SPC-1 IOPS™
Total ASU Capacity	60,129.542 GB
Data Protection Level	Protected 2 *(K-Raid)*
Total Price (including three-year maintenance)	$997,348.00
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

The following SPC Benchmark 1™ Onsite Audit requirements were reviewed and found compliant with 1.14 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.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

Storage Performance Council
643 Bair Island Road, Suite 103
Redwood City, CA 94062
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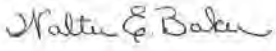
AUDIT CERTIFICATION *(CONT.)*

- 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.
- 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
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

kaminario.
Simply Faster

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Aug 20th, 2013

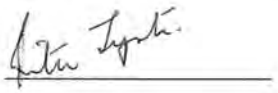
From: Ritu Jyoti, VP Product & Solutions Management, Kaminario, Inc.

Subject: SPC-1 Letter of Good Faith for the K2F000000700

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 1.14 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:



8/21/13

Ritu Jyoti,

VP Product & Solutions Management,

Kaminario, Inc.

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 05511
Test Sponsor Alternate Contact	Kaminario, Inc. – www.kaminario.com Gur Rosenl Haotzma 1 Hi-Tech Park Yoqneam 20692 Israel Phone: +972 72 222 7217 FAX: +972 4 959 -0551
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	V1.14
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	October 17, 2013
Date the FDR was submitted to the SPC	October 17, 2013
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	October 17, 2013

Tested Storage Product (TSP) Description

Kaminario K2 is an enterprise class general purpose MLC Flash array that eliminates I/O and throughput bottlenecks and dramatically reduces latency to accelerate applications. The K2 is consistently fast, highly available, cost effective, and easy to deploy storage. The K2 is a fundamentally better way to store performance sensitive data.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Kaminario K2 *(K2F00000700)*	
Metric	**Reported Result**
SPC-1 IOPS™	1,239,898.00
SPC-1 Price-Performance™	$0.80/SPC-1 IOPS™
Total ASU Capacity	60,129.542 GB
Data Protection Level	Protected 2 *(K-Raid)*
Total Price	$997,348.00
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

SPC-1 Price-Performance™ is the ratio of **Total Price** to **SPC-1 IOPS™**.

Total ASU (Application Storage Unit) **Capacity** represents the total storage capacity available to be read and written in the course of executing the SPC-1 benchmark.

A **Data Protection Level** of **Protected 2** using ***K-RAID,*** which consists of RAID 10 during normal operation, where half of the SSD storage is allocated for data mirroring. During failures, the data is mirrored to the KMS storage capacity (HDDs).

> ***Protected 2:*** *The single point of failure of any* ***component*** *in the configuration will not result in permanent loss of access to or integrity of the SPC-1 Data Repository.*

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 17.

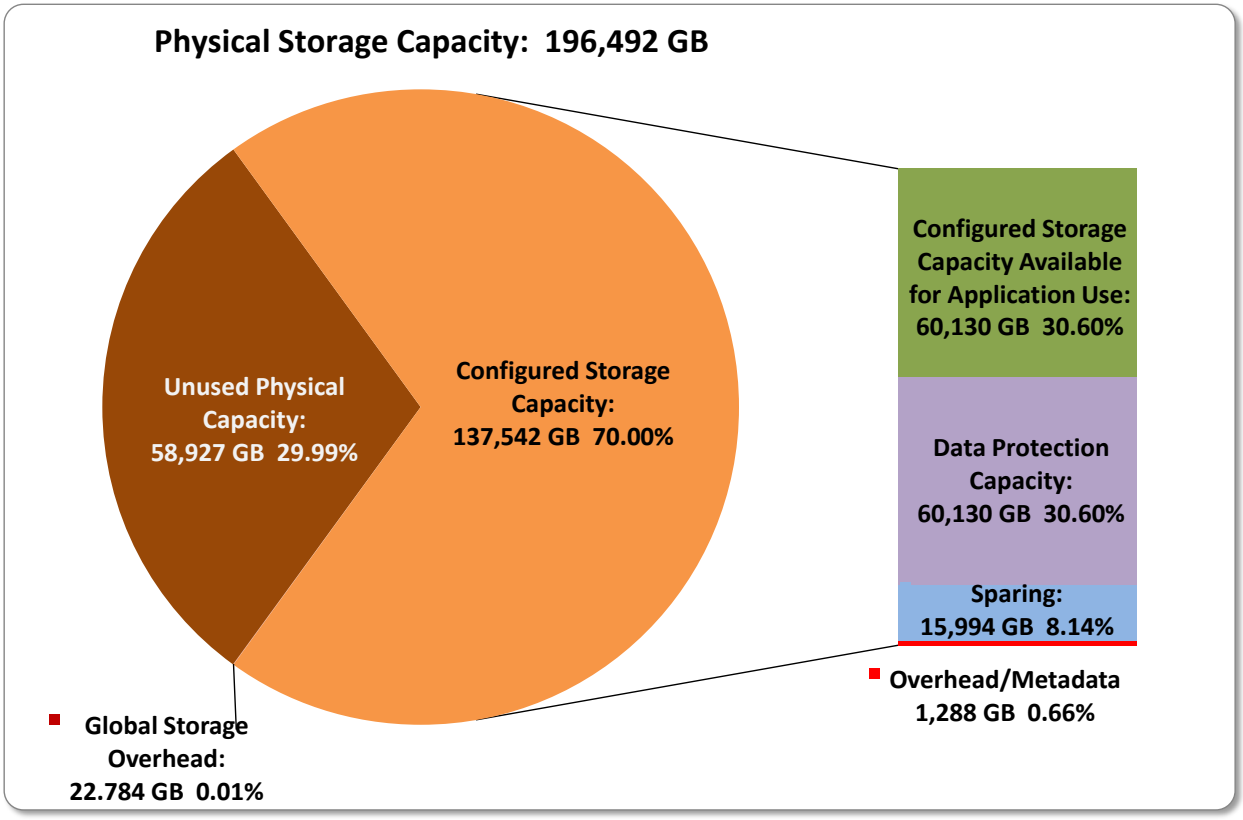
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency).*

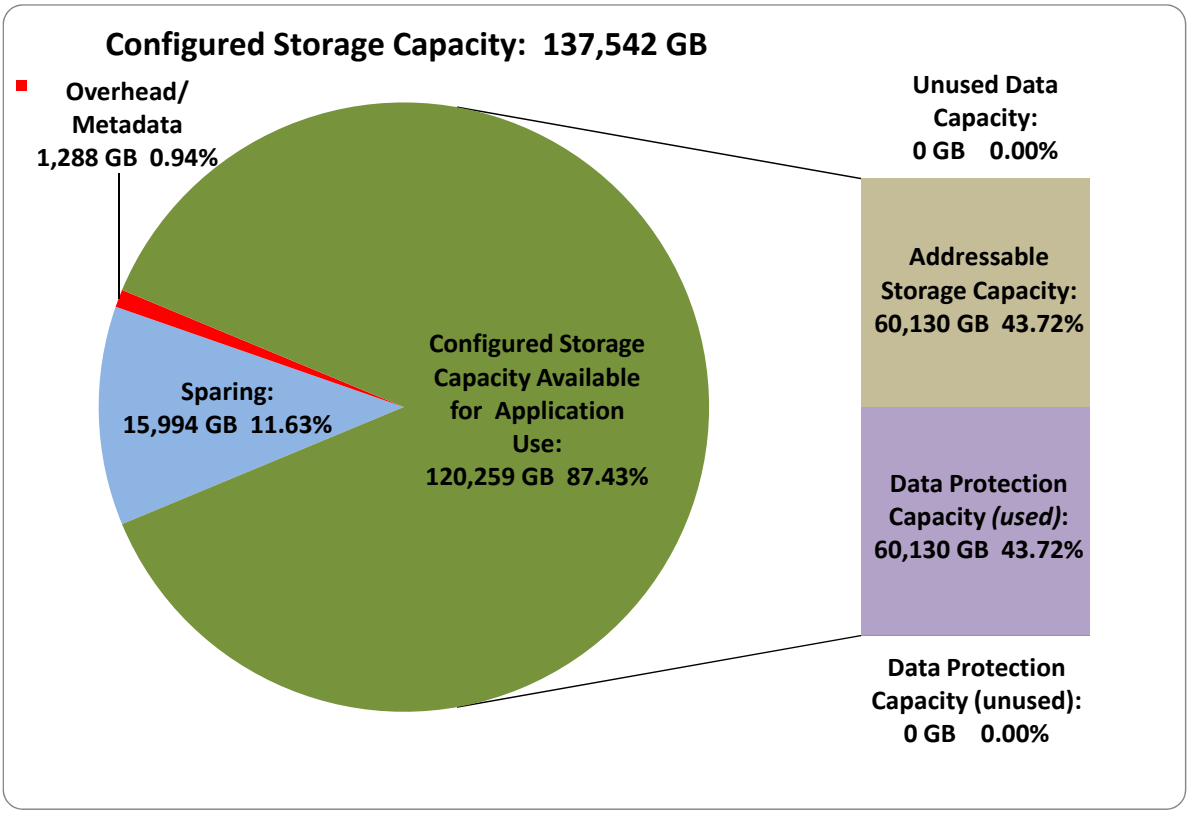
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

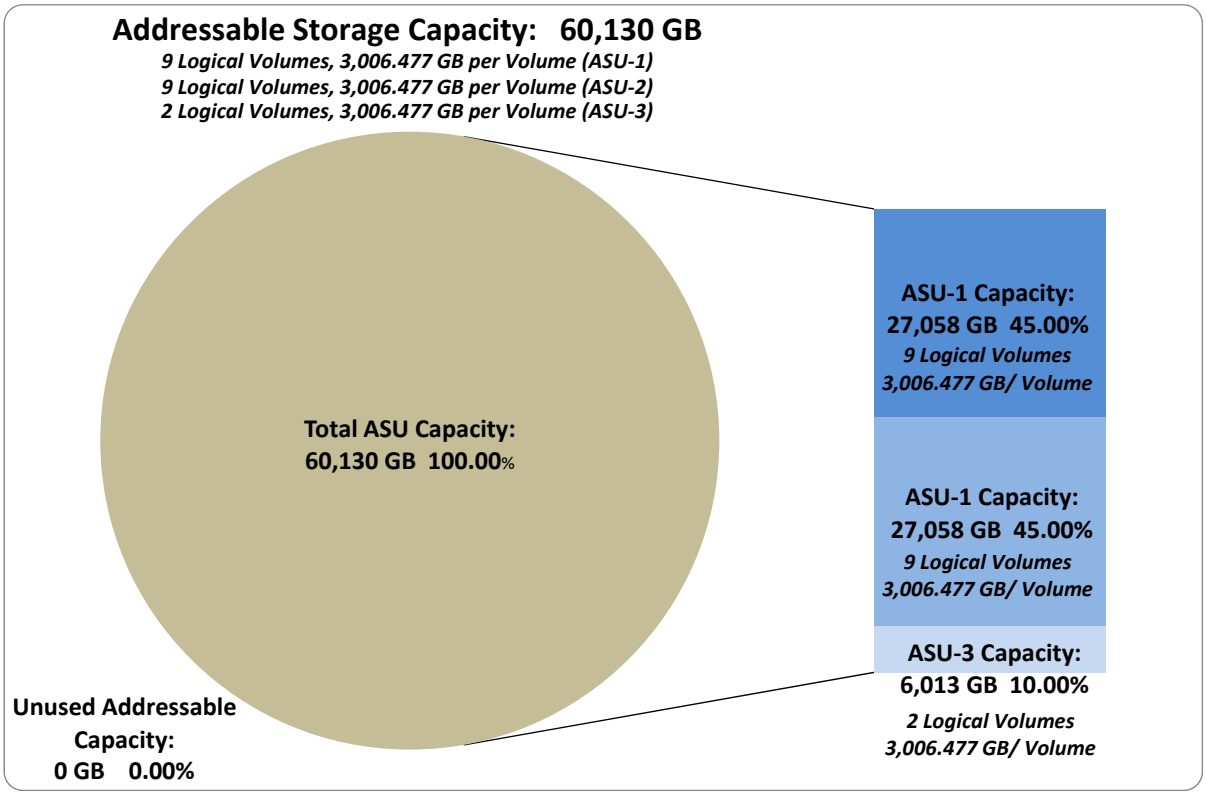
Storage Capacities, Relationships, and Utilization

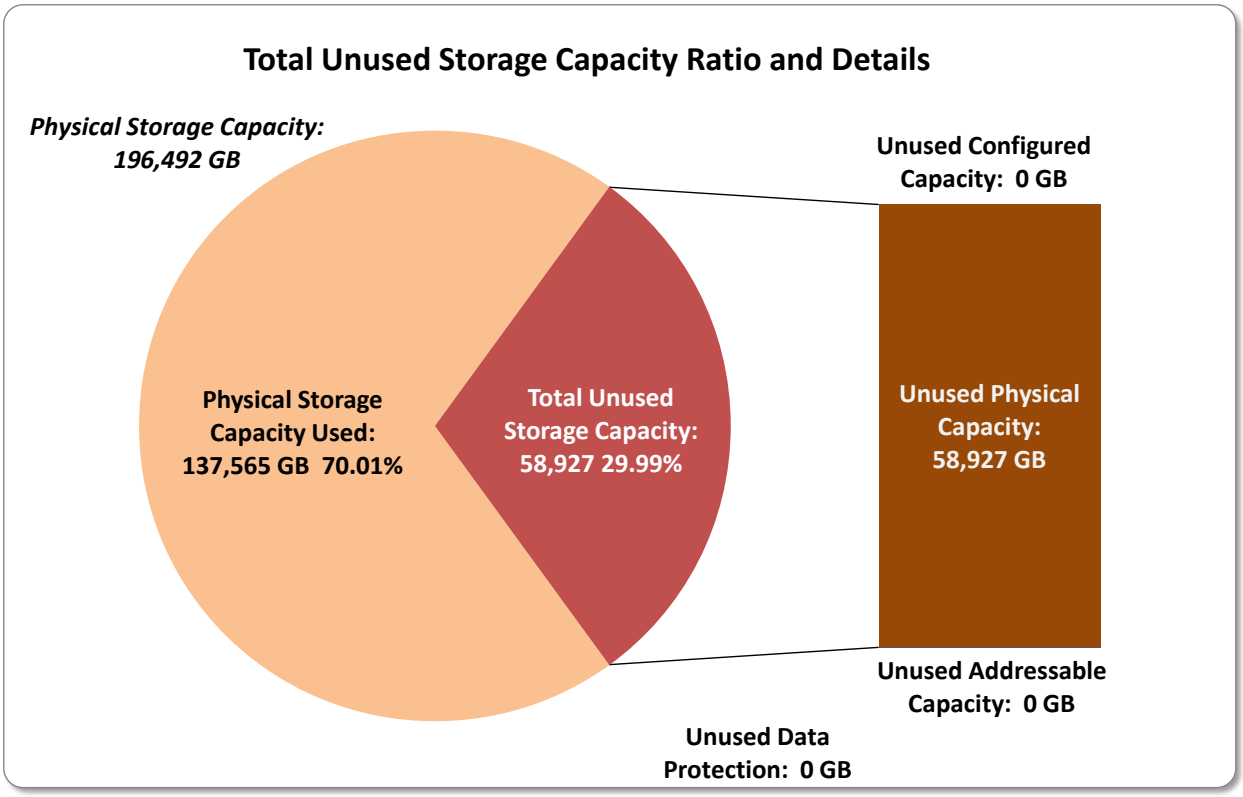
The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts are listed as integer values, for readability, rather than the decimal values listed elsewhere in this document.




Configured Storage Capacity: 137,542 GB
Overhead/ Metadata 1,288 GB 0.94%
Sparing: 15,994 GB 11.63%
Configured Storage Capacity Available for Application Use: 120,259 GB 87.43%
Unused Data Capacity: 0 GB 0.00%
Addressable Storage Capacity: 60,130 GB 43.72%
Data Protection Capacity (used): 60,130 GB 43.72%
Data Protection Capacity (unused): 0 GB 0.00%


Addressable Storage Capacity: 60,130 GB
9 Logical Volumes, 3,006.477 GB per Volume (ASU-1)
9 Logical Volumes, 3,006.477 GB per Volume (ASU-2)
2 Logical Volumes, 3,006.477 GB per Volume (ASU-3)
Total ASU Capacity: 60,130 GB 100.00%
Unused Addressable Capacity: 0 GB 0.00%
ASU-1 Capacity: 27,058 GB 45.00%
9 Logical Volumes
3,006.477 GB/ Volume
ASU-1 Capacity: 27,058 GB 45.00%
9 Logical Volumes
3,006.477 GB/ Volume
ASU-3 Capacity: 6,013 GB 10.00%
2 Logical Volumes
3,006.477 GB/ Volume



SPC-1 Storage Capacity Utilization	
Application Utilization	30.60%
Protected Application Utilization	61.20%
Unused Storage Ratio	29.99%

Application Utilization: Total ASU Capacity *(60,129.542 GB)* divided by Physical Storage Capacity *(196,491.768 GB)*.

Protected Application Utilization: Total ASU Capacity *(60,129.542 GB)* plus total Data Protection Capacity *(60,1129.542 GB)* minus unused Data Protection Capacity *(0.000 GB)* divided by Physical Storage Capacity *(196,491.768 GB)*.

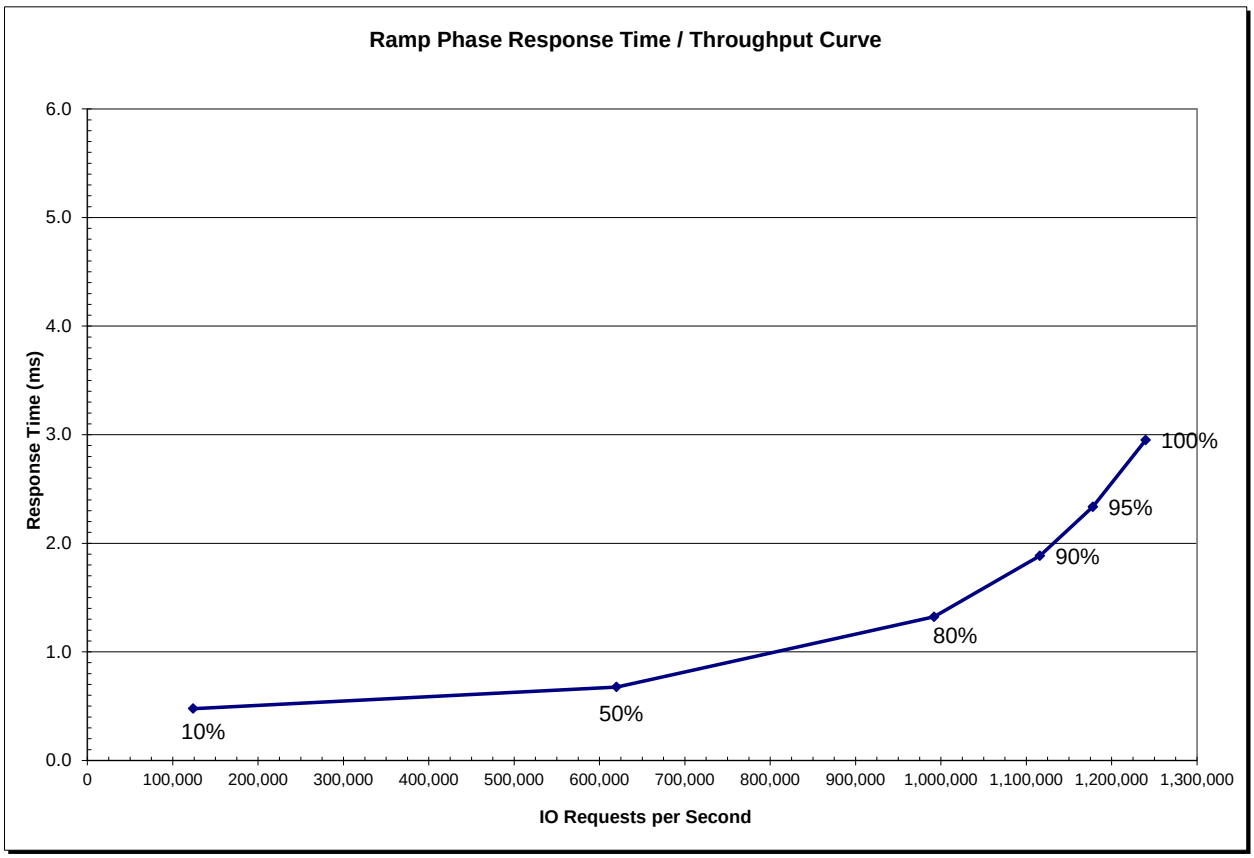
Unused Storage Ratio: Total Unused Capacity *(58,926.951 GB)* divided by Physical Storage Capacity *(196,491.768 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 26-27.

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	123,983.09	620,025.93	992,030.12	1,116,050.68	1,178,012.70	1,239,898.00
Average Response Time (ms):						
All ASUs	0.48	0.68	1.32	1.88	2.34	2.95
ASU-1	0.49	0.70	1.33	1.78	2.19	2.79
ASU-2	0.50	0.68	1.03	1.42	1.71	2.09
ASU-3	0.44	0.61	1.44	2.31	2.92	3.67
Reads	0.57	0.80	1.35	1.76	2.11	2.64
Writes	0.42	0.60	1.31	1.97	2.48	3.15

Priced Storage Configuration Pricing

Quantity	Item	Description	Unit Price	Price
1	K2F000000700**	Kaminario K2 Flash 7 K-Blocks with 86.49TB total usable capacity		730,000.00
1	Three years maintenance	4 hours mission ciritcal		255,000.00
56	T54-M11FF-10	WesternWire FC cable LC-LC 3m	8.00	448.00
28	QME2572	QLogic QME2572 8Gbps Fibre Channel I/O Card	425.00	11,900.00
	Total System Price:			**997,348.00**

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.

K2F000000700** Line Item Components

The K2F line item in the above pricing includes the following components:

- **28 K-Nodes**: *SuperMicro SYS-1027R-72BRFTP1-EI007*:
  - Each K-Node includes eight 800 GB solid state storage devices (SSD), which provide the storage capacity for the primary and mirror SPC-1 ASUs.
  - Each K-node also runs an IO-director process responsible for exposing the data volumes to the Host Systems, connected via Fibre Channel.
- **2 K-Management Nodes, Storage System Management (SSM)** *SuperMicro SYS-1027R-72BRFTP1-EI007*.

  The SSM modules provide storage installation, configuration and monitoring functionality. Each SSM module included eight 1 TB HDDs that serve as spare backup capacity for the system.
- **2 Dell Force10 S4810 10GB switches** - Interconnects all K-nodes for the purpose of sending Host System data between the K-nodes and for supporting management communication.
- **2 Cisco Catalyst 2960G 1 GB switches** - Interconnects all K-nodes to the K-management node for the purpose IPMI protocol control over the K-nodes.
- **1 Rack:** Used to house all of the above components.

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

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

Priced Storage Configuration Diagram

Kaminario K2
*(*K2F0000700*)*

2 – SuperMicro K-Management Nodes
Storage System Management (SSM)
10 – 4 GiB DRAM modules per node
8 – 1 TB disk drives per node

56 ports used for FC connections

28 – dual-port 8Gb FC I/O cards
(56 ports total)

28 – SuperMicro K-Nodes
10 – 4 GiB DRAM Modules per node
8 – 800 GB Flash SSDs per node

2 – Dell Force10 S4810 10GB switches
interconnect between all K-Nodes and K-Management Nodes for Host System data and management communication

2 – Cisco Catalyst 2960G 1 GB switches
interconnect between all K-Nodes and K-Management nodes for IPMI control

Priced Storage Configuration Components

Priced Storage Configuration
28 – dual port QLogic 8 Gb FC I/O Cards *(56 ports total, 56 ports used)*
Kaminario K2 ***(K2F00000700)***
28 – SuperMicro K-Nodes 8 – 800 GB SSDs per node 10 – 4 GiB DRAM modules per node
2 – SuperMicro K-Management Nodes Storage System Management (SSM) 10 – 4 GiB DRAM modules per node 8 – 1 TB disk drives per node
2 – Dell Force10 S4810 10GB switches *(interconnect between all K-Nodes and K-Management Nodes for Host System data and management communication)*
2 – Cisco Catalyst 2960G 1 GB switches *(interconnect between all K-Nodes and K-Management nodes for IPMI control)*
1 – 42U rack and 4 PDUs

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 22 *(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 Benchmark Configuration (BC)/Tested Storage Configuration (TSC) was configured with local storage and, as such, did not employ a storage network.

Host System(s) 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).

The Host System(s) and TSC table of components may be found on page 23 *(Host Systems and Tested Storage Configuration Components)*.

Benchmark Configuration/Tested Storage Configuration Diagram

Kaminario K2
*(*K2F0000700*)*

14 – Dell M610 Blades

2 – dual-port 8Gb FC I/O cards per Blade
(28 cards, 56 ports)

2 – SuperMicro K-Management Nodes
Storage System Management (SSM)
10 – 4 GiB DRAM modules per node
8 – 1 TB disk drives per node

56 ports used for FC connections

28 – SuperMicro K-Nodes
10 – 4 GiB DRAM Modules per node
8 – 800 GB Flash SSDs per node

2 – Dell Force10 S4810 10GB switches
interconnect between all K-Nodes and K-Management Nodes for Host System data and management communication

2 – Cisco Catalyst 2960G 1 GB switches
interconnect between all K-Nodes and K-Management nodes for IPMI control

Host Systems and Tested Storage Configuration Components

Host Systems

14 – Dell M610 Blades, each with:
- 2 – 6 core Intel® Xeon® Processors @ 2.53 GHz
- 96 GB main memory
- VMware vSphere ESX5.1.0
- Single guest VM: Windows 2008 Server R2 w/SP1
- Windows 2008 MPIO

Tested Storage Configuration (TSC)

28 – dual port QLogic 8 Gb FC I/O Cards *(56 ports total, 56 ports used)*

Kaminario K2 ***(K2F00000700)***

- 28 – SuperMicro K-Nodes
  - 8 – 800 GB SSDs per node
  - 10 – 4 GiB DRAM modules per node
- 2 – SuperMicro K-Management Nodes
  - Storage System Management (SSM)
  - 10 – 4 GiB DRAM modules per node
  - 8 – 1 TB disk drives per node
- 2 – Dell Force10 S4810 10GB switches
  - *(interconnect between all K-Nodes and K-Management Nodes for Host System data and management communication)*
- 2 – Cisco Catalyst 2960G 1 GB switches
  - *(interconnect between all K-Nodes and K-Management nodes for IPMI control)*
- 1 – 42U rack and 4 PDUs

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 67 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 68 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 71.

ASU Pre-Fill

Clause 5.3.3

Each of the three SPC-1 ASUs (ASU-1, ASU-2 and ASU-3) is required to be completely filled with specified content prior to the execution of audited SPC-1 Tests. The content is required to consist of random data pattern such as that produced by an SPC recommended tool.

The configuration file used to complete the required ASU pre-fill appears in Appendix D: SPC-1 Workload Generator Storage Commands and Parameters on page 71.

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 63 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

Two tables and four charts documenting the storage capacities and relationships of the SPC-1 Storage Hierarchy (Clause 2.1) shall be included in the FDR. … The capacity value in each chart may be listed as an integer value, for readability, rather than the decimal value listed in the table below.

SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 196,491.768 GB consisted of the following:

- 224 solid state storage devices *(flash)*, each with a formatted capacity of 800 GB *(179,200.00 GB total)*, which contained primary and mirror copies of the SPC-1 ASUs.
- 300 solid state storage devices *(DRAM)*, each with a formatted capacity of 4.295 GB *(1,288.490 total)*, which is used for caching and runtime metadata.
- 16 disk drives, each with a formatted capacity of 1,000.205 GB *(16,003.278 GB)*, which is used as sparing/backup capacity for mirroring data during a failure.

There was 58,926.951 GB (29.99%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 22.784 GB (0.01%) of the Physical Storage Capacity. There was 0.000 GB (0.00%) 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 60,129.542 GB of which 60,129.542 GB was utilized. The total Unused Storage capacity was 58,926.951 GB.

SPC-1 Storage Capacities

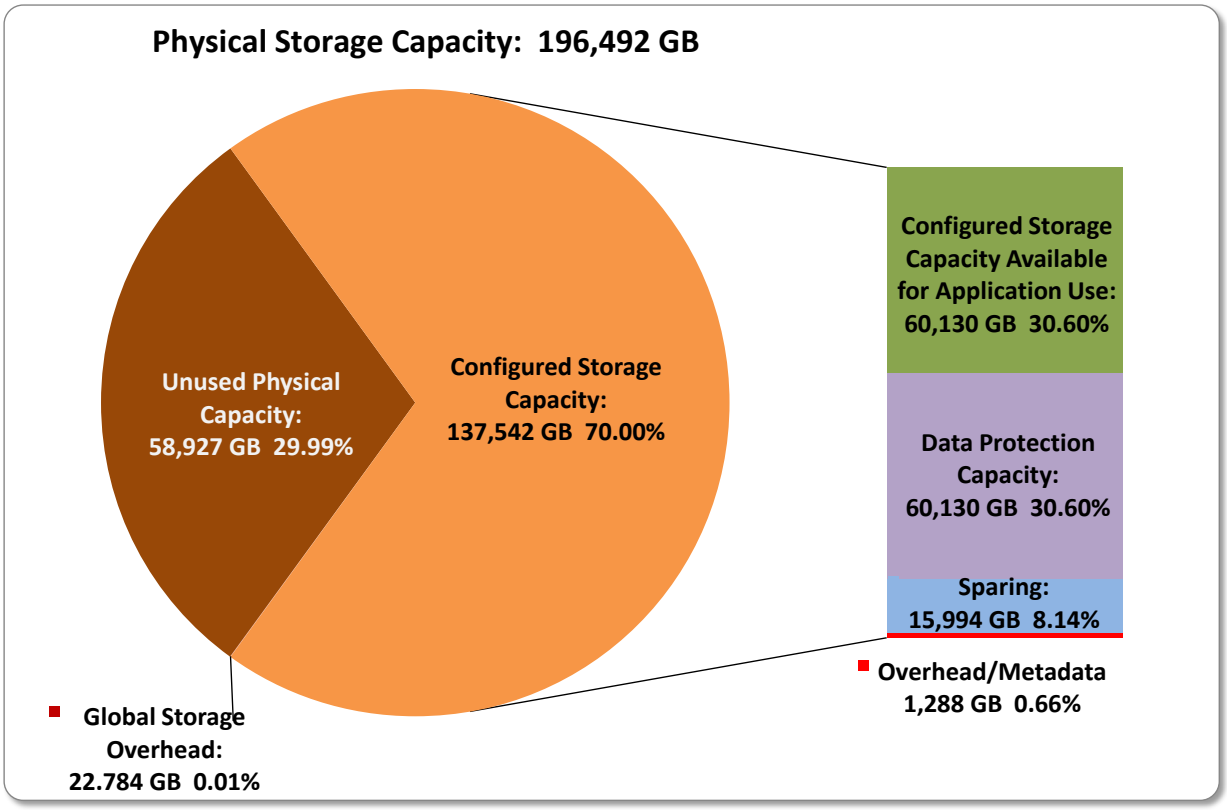
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	60,129.542
Addressable Storage Capacity	Gigabytes (GB)	60,129.542
Configured Storage Capacity	Gigabytes (GB)	137,542.033
Physical Storage Capacity	Gigabytes (GB)	196,491.768
Data Protection *(K-RAID)*	Gigabytes (GB)	60,129.542
Required Storage *(sparing, metadata)*	Gigabytes (GB)	17,282.948
Global Storage Overhead	Gigabytes (GB)	22.784
Total Unused Storage	Gigabytes (GB)	58,926.951

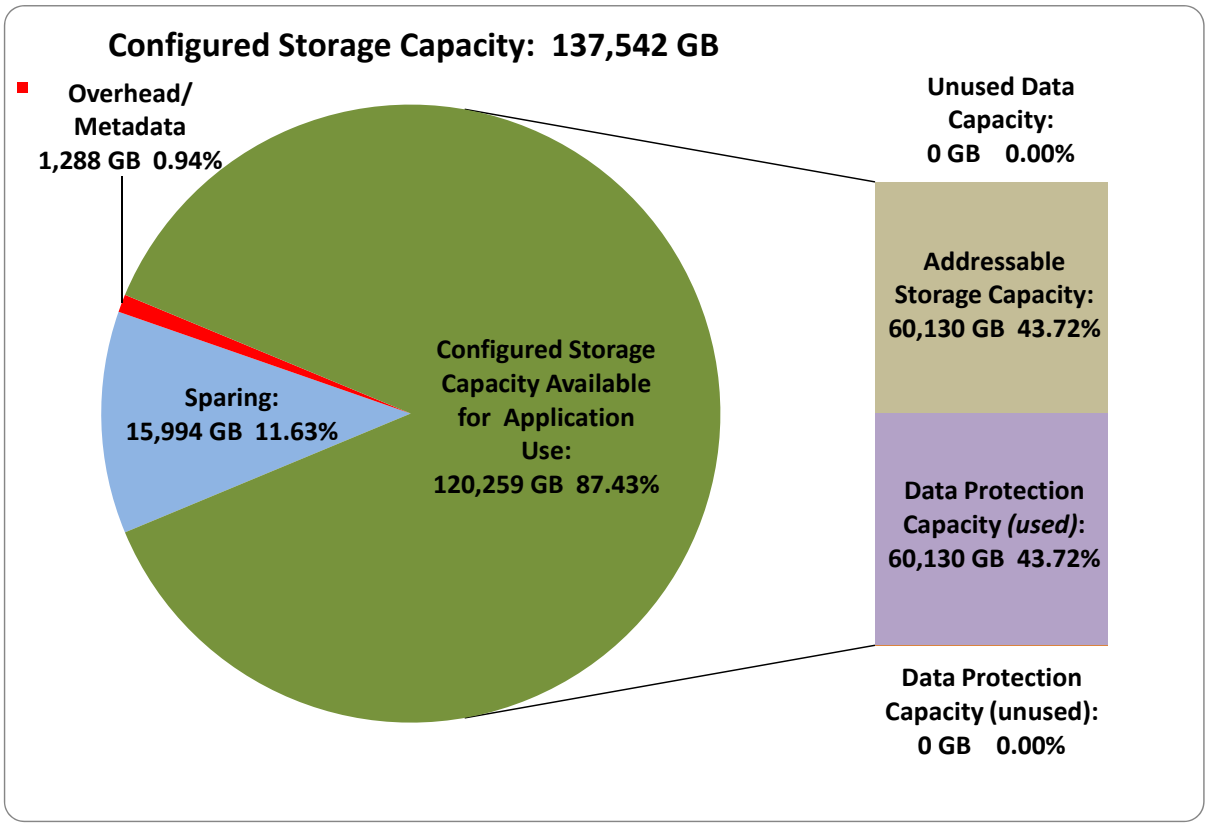
Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.

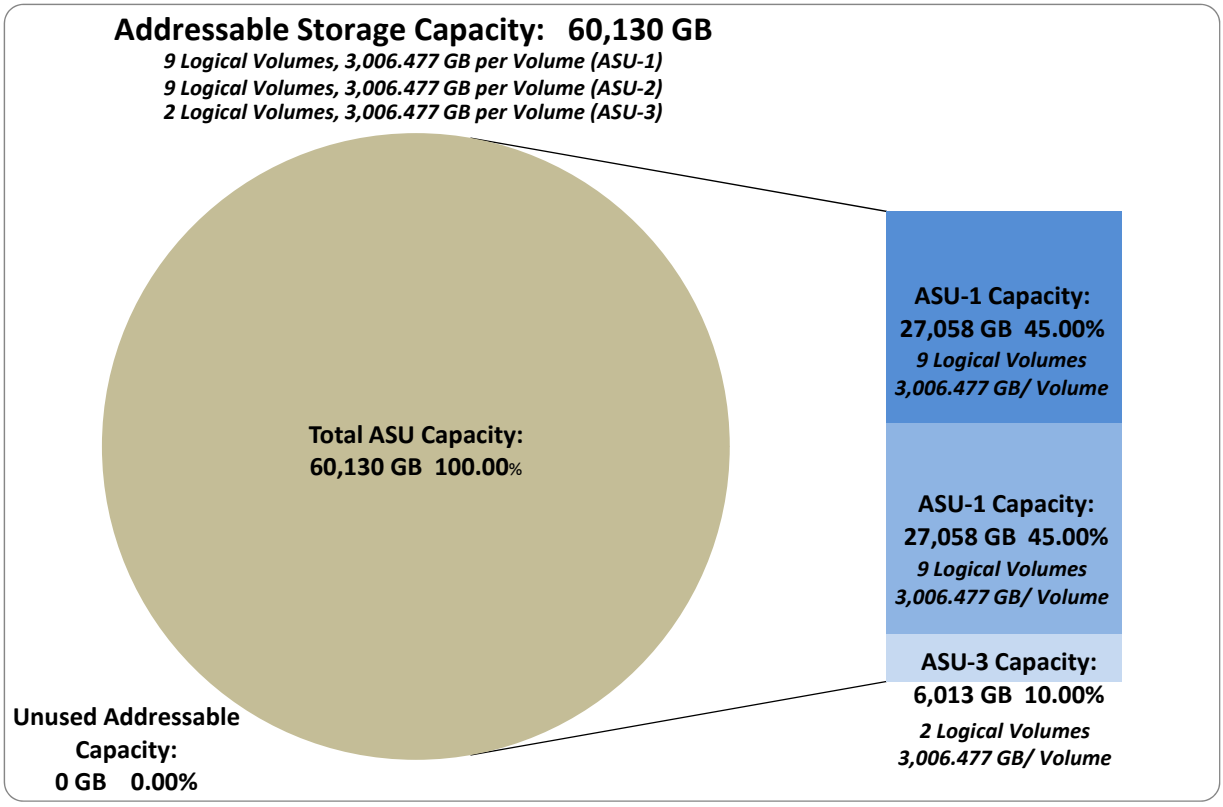
SPC-1 Storage Hierarchy Ratios

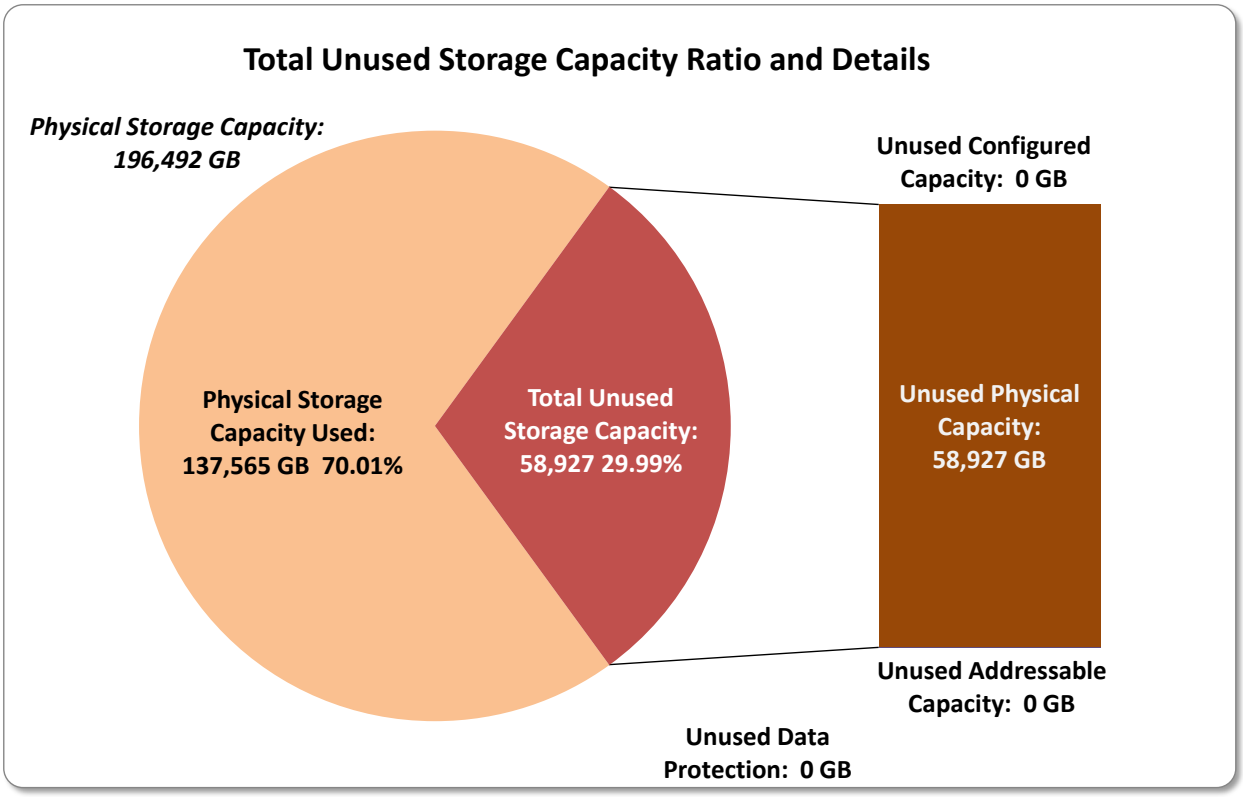
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	43.72%	30.60?%
Required for Data Protection *(K-RAID)*		43.72%	30.60/%
Addressable Storage Capacity		43.72%	30.60
Required Storage *(sparing, metadata)*		12.57%	8.80%
Configured Storage Capacity			70.00%
Global Storage Overhead			0.01%
Unused Storage:			
Addressable	0.00%		
Configured		0.00%	
Physical			29.99%

SPC-1 Storage Capacity Charts




Configured Storage Capacity: 137,542 GB
Overhead/ Metadata
1,288 GB 0.94%
Sparing:
15,994 GB 11.63%
Configured Storage Capacity Available for Application Use:
120,259 GB 87.43%
Unused Data Capacity:
0 GB 0.00%
Addressable Storage Capacity:
60,130 GB 43.72%
Data Protection Capacity (used):
60,130 GB 43.72%
Data Protection Capacity (unused):
0 GB 0.00%


Addressable Storage Capacity: 60,130 GB
9 Logical Volumes, 3,006.477 GB per Volume (ASU-1)
9 Logical Volumes, 3,006.477 GB per Volume (ASU-2)
2 Logical Volumes, 3,006.477 GB per Volume (ASU-3)
Total ASU Capacity:
60,130 GB 100.00%
Unused Addressable Capacity:
0 GB 0.00%
ASU-1 Capacity:
27,058 GB 45.00%
9 Logical Volumes
3,006.477 GB/ Volume
ASU-1 Capacity:
27,058 GB 45.00%
9 Logical Volumes
3,006.477 GB/ Volume
ASU-3 Capacity:
6,013 GB 10.00%
2 Logical Volumes
3,006.477 GB/ Volume



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	30.60%
Protected Application Utilization	61.20%
Unused Storage Ratio	29.99%

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 (27,058.294 GB)	**ASU-2 (27,058.294 GB)**	**ASU-3 (6,012.954 GB)**
9 Logical Volumes 3,006.477 GB per Logical Volume (0.000 GB used per Logical Volume)	9 Logical Volumes 3,006.477 GB per Logical Volume (0.000 GB used per Logical Volume)	2 Logical Volumes 3,006.477 GB per Logical Volume (0.000 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **Protected 2** using ***K-RAID*** as described on page 12. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

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. An SPC-1 glossary on page 63 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.

"Ramp-Up" Test Runs

Clause 5.3.13

In order to warm-up caches or perform the initial ASU data migration in a multi-tier configuration, a Test Sponsor may perform a series of "Ramp-Up" Test Runs as a substitute for an initial, gradual Ramp-Up.

Clause 5.3.13.3

The "Ramp-Up" Test Runs will immediately precede the Primary Metrics Test as part of the uninterrupted SPC-1 measurement sequence.

Clause 9.4.3.7.1

If a series of "Ramp-Up" Test Runs were included in the SPC-1 measurement sequence, the FDR shall report the duration (ramp-up and measurement interval), BSU level, SPC-1 IOPS and average response time for each "Ramp-Up" Test Run in an appropriate table.

There were no "Ramp-Up" Test Runs executed in this set of benchmark measurements.

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 eight (8) 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 9.4.3.7.2

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 77.

Sustainability Test Results File

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

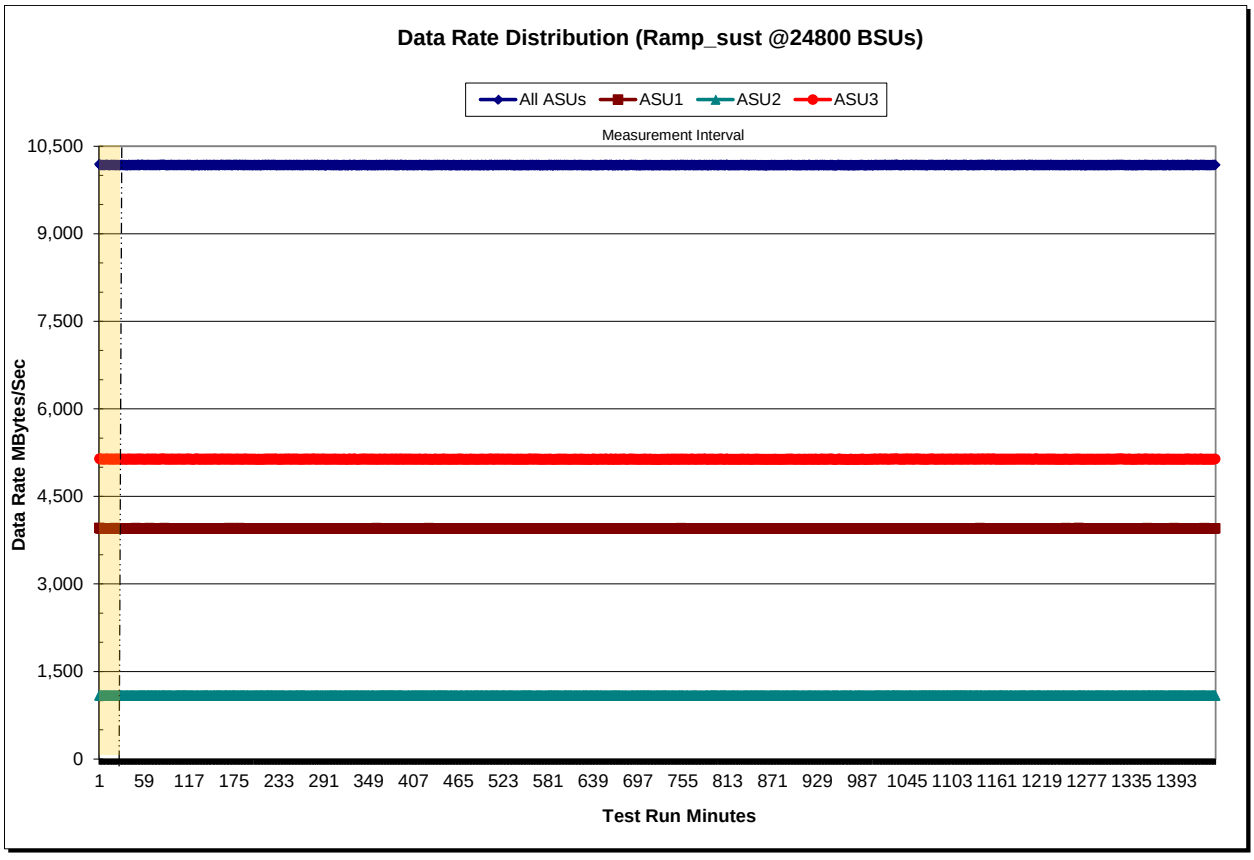
Sustainability Test Results File

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

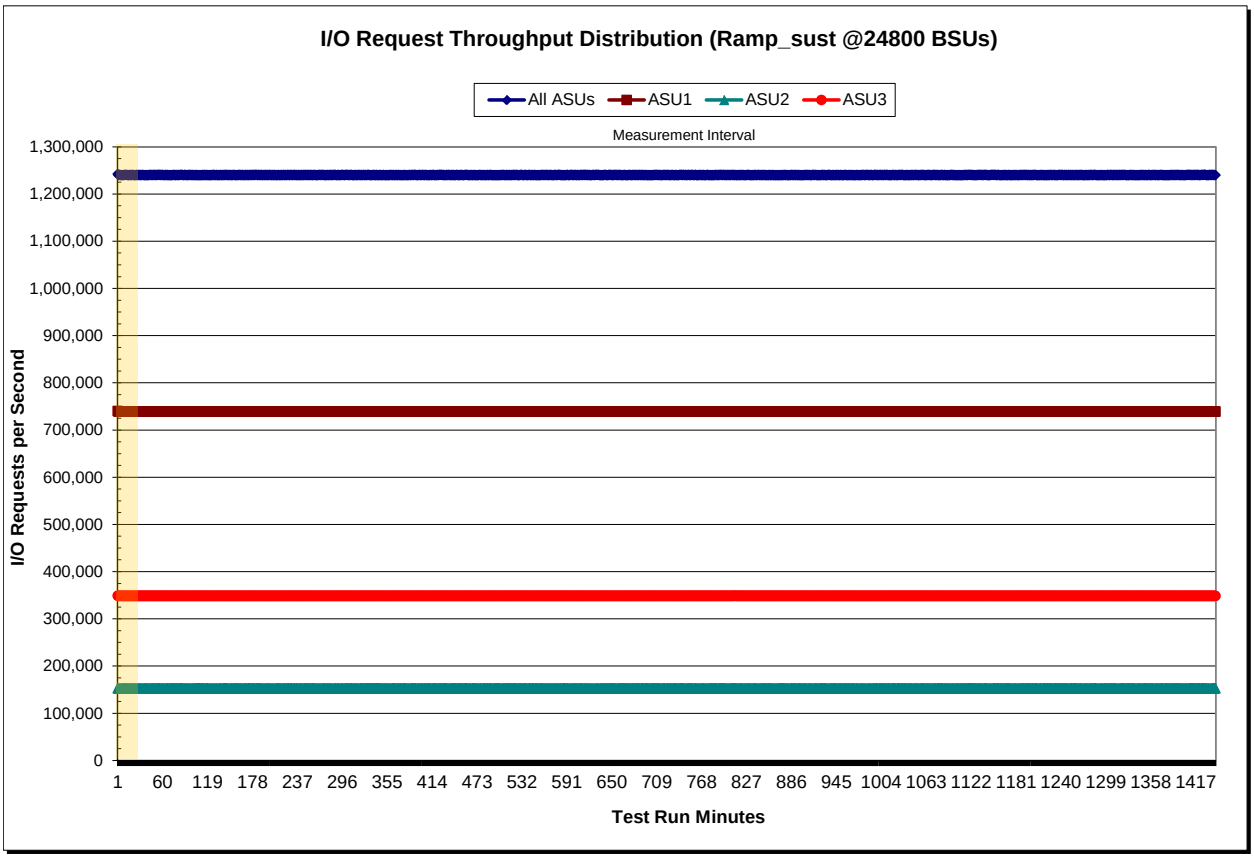


Sustainability – I/O Request Throughput Distribution Data

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

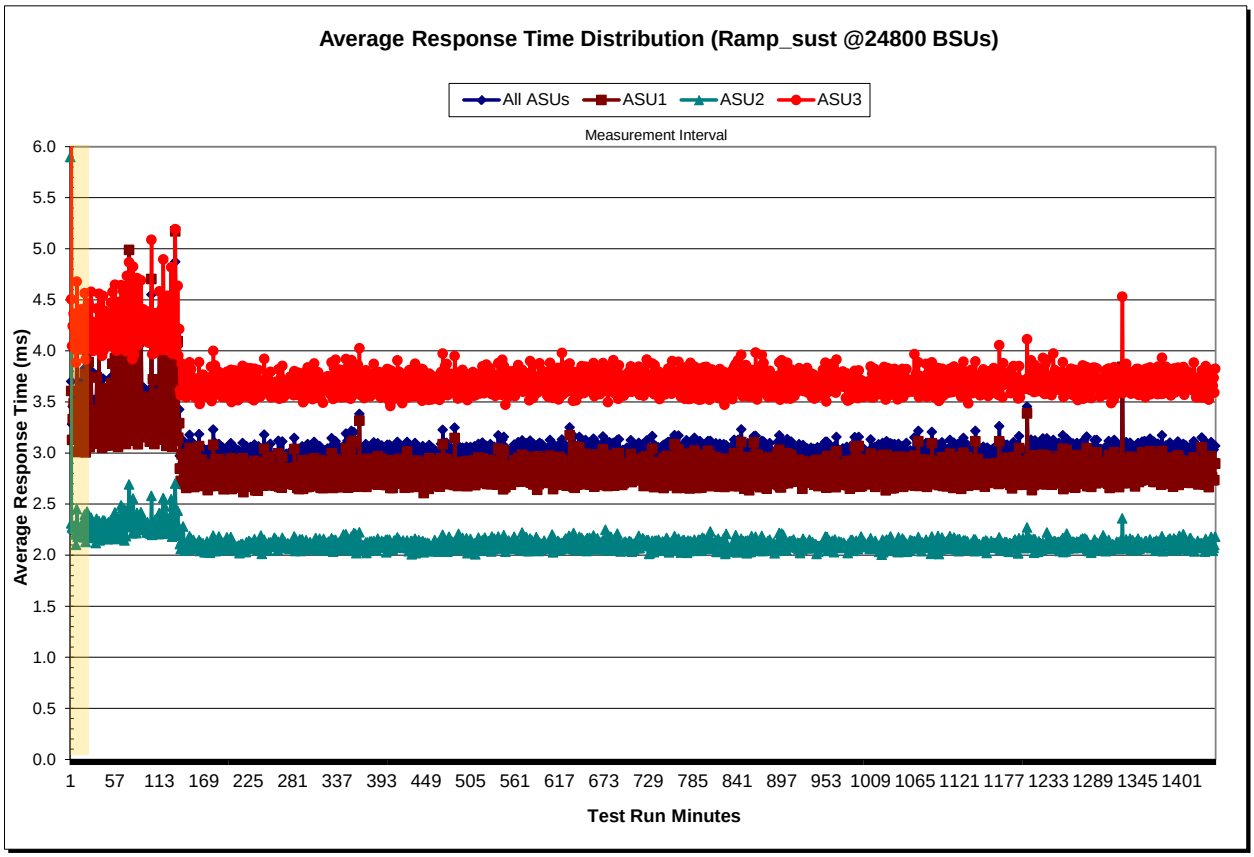


Sustainability – Average Response Time (ms) Distribution Data

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



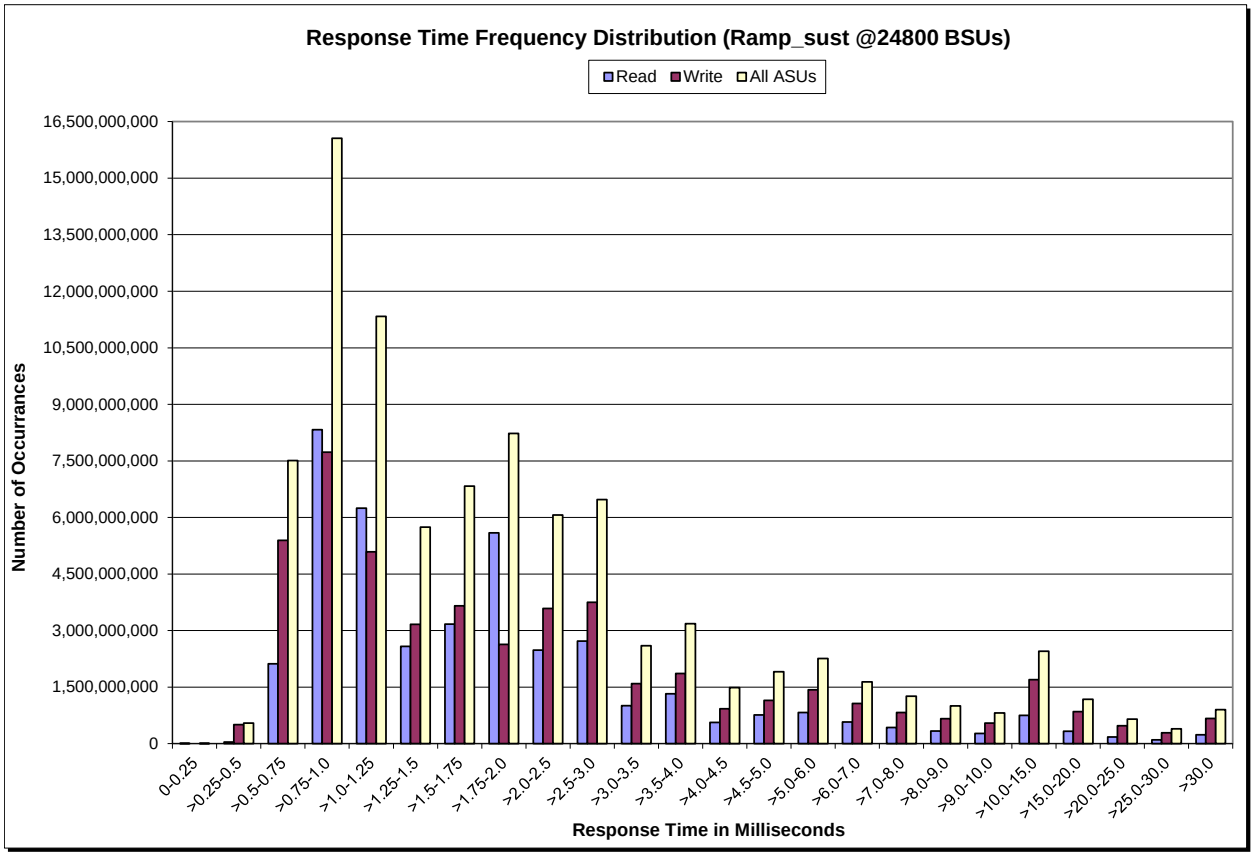
Sustainability – Response Time Frequency Distribution Data

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	5,902	40,940,115	2,117,594,858	8,327,231,036	6,246,483,161	2,577,819,878	3,170,865,074	5,591,720,117
Write	537	501,919,208	5,393,699,208	7,731,224,424	5,086,707,833	3,167,081,849	3,658,039,539	2,634,168,341
All ASUs	6,439	542,859,323	7,511,294,066	16,058,455,460	11,333,190,994	5,744,901,727	6,828,904,613	8,225,888,458
ASU1	5,311	219,460,876	3,782,784,230	9,601,519,667	9,042,692,966	3,624,558,319	4,334,070,230	7,914,345,636
ASU2	956	165,339,896	1,670,250,461	4,334,012,647	1,800,534,302	642,187,393	777,478,998	1,351,356,424
ASU3	172	158,058,551	2,058,259,375	2,122,923,146	489,963,726	1,478,156,015	1,717,355,385	(1,039,813,602)

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	2,479,206,659	2,721,658,336	1,006,333,185	1,322,390,463	563,405,030	759,592,170	826,231,328	574,583,407
Write	3,586,930,660	3,750,334,092	1,593,927,680	1,861,932,680	923,182,944	1,150,778,044	1,429,765,035	1,063,607,225
All ASUs	6,066,137,319	6,471,992,428	2,600,260,865	3,184,323,143	1,486,587,974	1,910,370,214	2,255,996,363	1,638,190,632
ASU1	3,804,991,273	4,092,119,354	1,627,067,456	2,019,473,264	924,981,051	1,198,015,739	1,379,673,560	981,411,210
ASU2	555,688,222	561,800,210	187,905,970	231,342,680	90,110,906	115,924,605	117,620,972	78,978,934
ASU3	1,705,457,824	1,818,072,864	785,287,439	933,507,199	471,496,017	596,429,870	758,701,831	577,800,488

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	429,741,080	336,177,678	268,153,151	750,800,459	330,752,990	176,688,219	103,999,022	236,266,782
Write	827,917,385	664,712,764	545,626,873	1,698,912,275	847,214,728	476,115,295	288,984,945	668,491,408
All ASUs	1,257,658,465	1,000,890,442	813,780,024	2,449,712,734	1,177,967,718	652,803,514	392,983,967	904,758,190
ASU1	740,513,743	580,541,469	464,947,059	1,338,183,352	600,191,089	317,434,658	184,467,514	407,698,969
ASU2	59,314,426	47,601,458	39,294,502	124,369,522	69,982,242	44,881,717	30,184,353	81,478,697
ASU3	457,830,296	372,747,515	309,538,463	987,159,860	507,794,387	290,487,139	178,332,100	415,580,524

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 5.3.15.2

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 5.3.15.3

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 9.4.3.7.3

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 77.

IOPS Test Results File

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

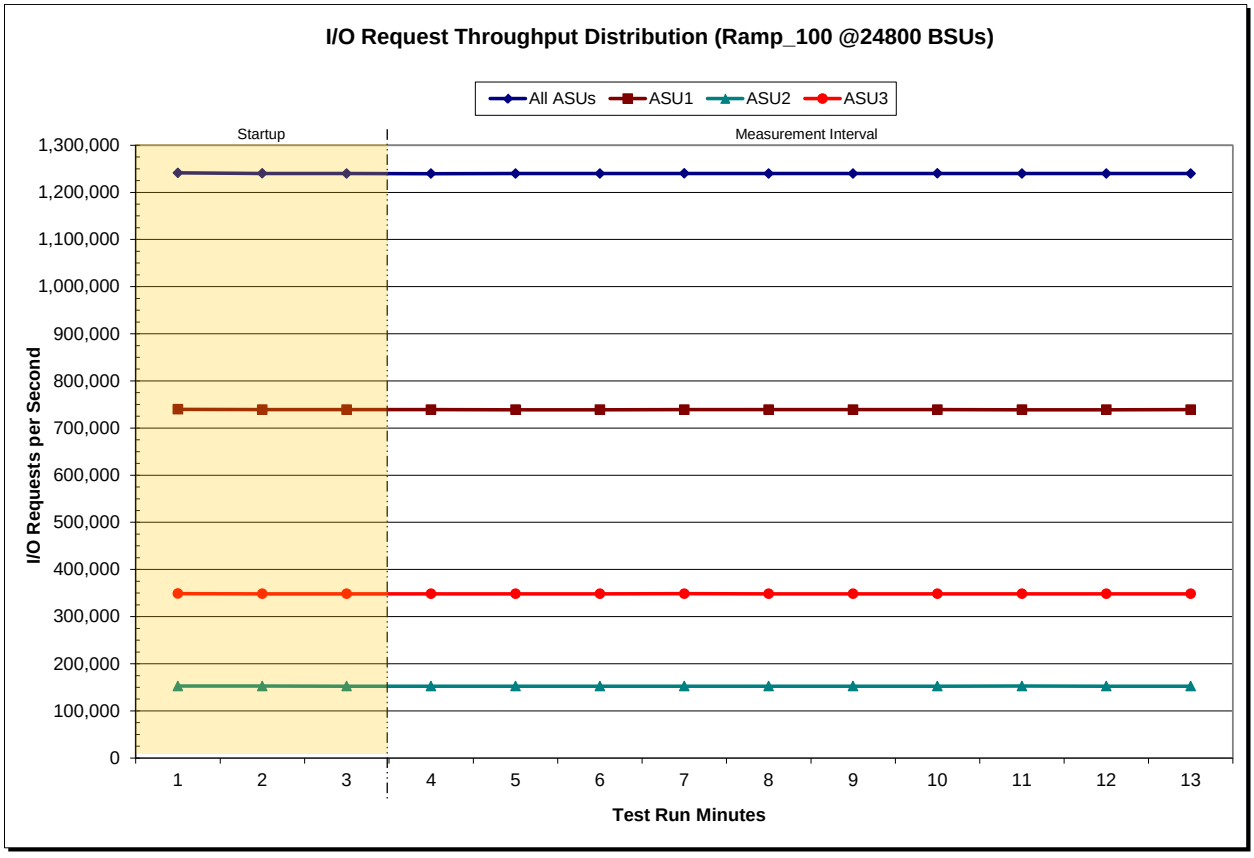
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:31:14	7:34:14	0-2	0:03:00
Measurement Interval	7:34:14	7:44:15	3-12	0:10:01

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1,241,318.47	739,824.13	152,621.20	348,873.13
1	1,240,028.90	739,018.92	152,603.90	348,406.08
2	1,239,901.00	738,986.28	152,543.02	348,371.70
3	1,239,726.27	738,950.58	152,466.73	348,308.95
4	1,239,805.60	738,913.12	152,436.47	348,456.02
5	1,239,791.75	738,852.12	152,512.60	348,427.03
6	1,240,077.62	738,995.75	152,513.52	348,568.35
7	1,239,977.13	739,048.33	152,481.20	348,447.60
8	1,239,928.07	738,964.42	152,505.62	348,458.03
9	1,240,072.55	739,106.97	152,514.08	348,451.50
10	1,239,826.08	738,890.62	152,565.80	348,369.67
11	1,239,864.35	738,940.85	152,526.82	348,396.68
12	1,239,910.62	739,023.88	152,534.42	348,352.32
Average	***1,239,898.00***	***738,968.66***	***152,505.73***	***348,423.62***

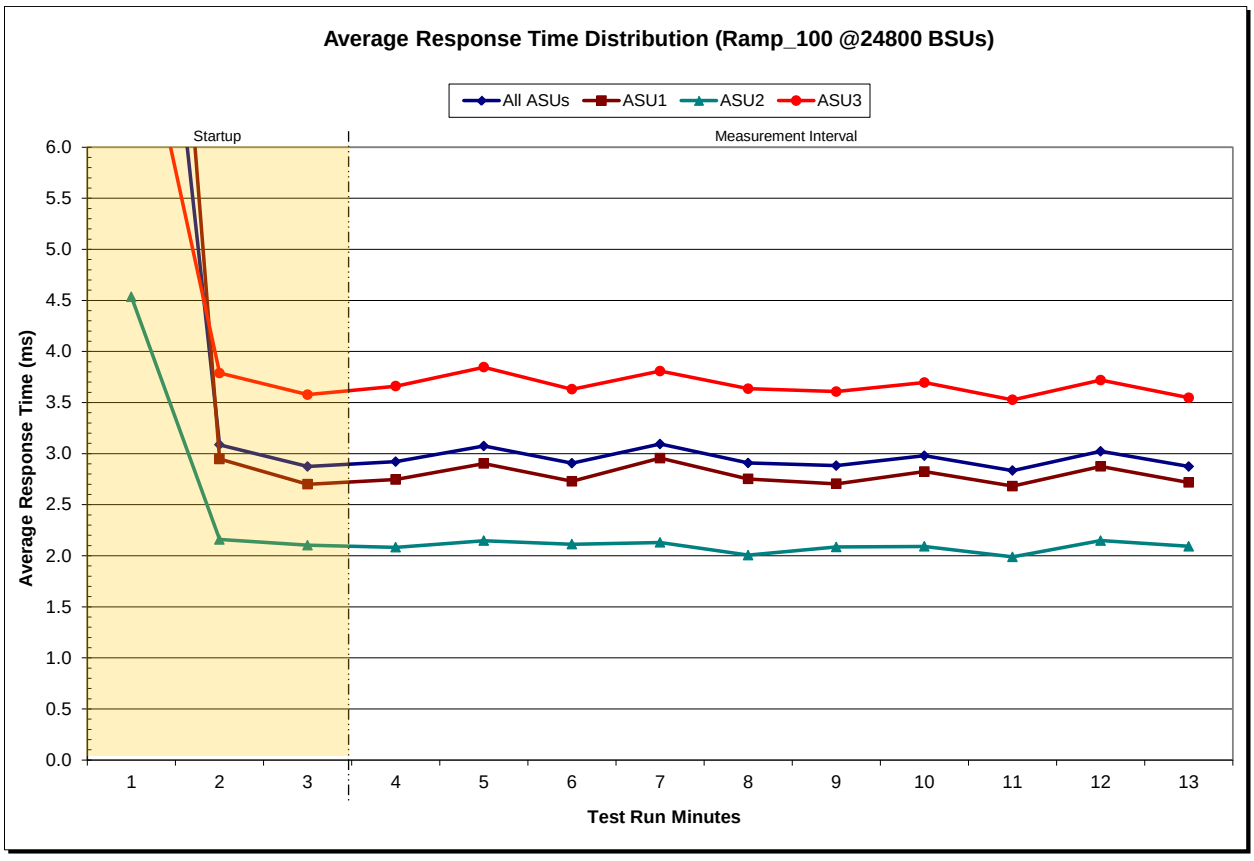
IOPS Test Run – I/O Request Throughput Distribution Graph



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

24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:31:14	7:34:14	0-2	0:03:00
Measurement Interval	7:34:14	7:44:15	3-12	0:10:01
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	11.02	13.90	4.53	7.76
1	3.09	2.95	2.16	3.79
2	2.87	2.70	2.10	3.58
3	2.92	2.75	2.08	3.66
4	3.07	2.90	2.15	3.85
5	2.91	2.73	2.11	3.63
6	3.09	2.96	2.13	3.81
7	2.91	2.75	2.01	3.64
8	2.88	2.70	2.09	3.61
9	2.98	2.82	2.09	3.70
10	2.83	2.68	1.99	3.53
11	3.02	2.87	2.15	3.72
12	2.87	2.72	2.09	3.55
Average	***2.95***	***2.79***	***2.09***	***3.67***

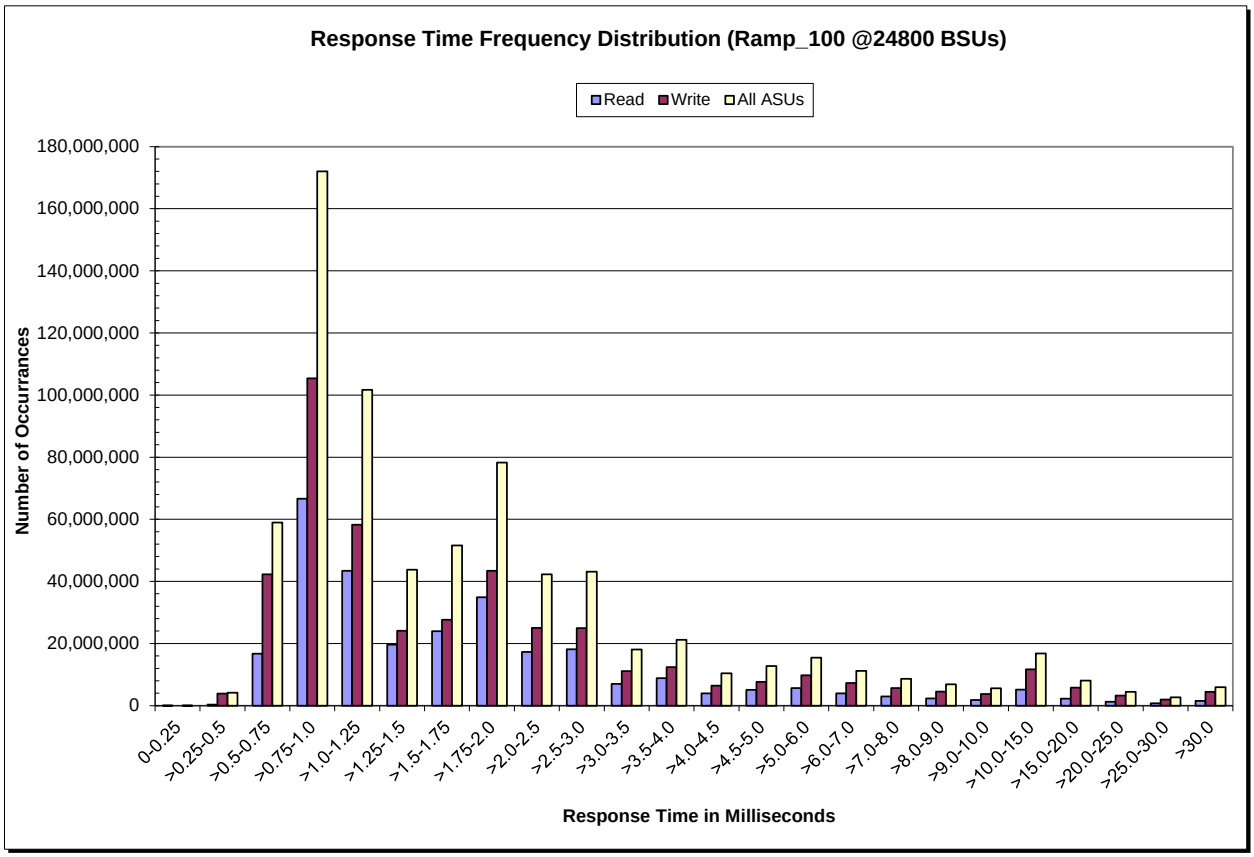
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	39	311,046	16,721,422	66,613,511	43,422,811	19,642,410	23,929,834	34,861,626
Write	1	3,877,946	42,268,135	105,392,258	58,262,584	24,109,753	27,669,064	43,390,624
All ASUs	40	4,188,992	58,989,557	172,005,769	101,685,395	43,752,163	51,598,898	78,252,250
ASU1	38	1,705,370	29,863,443	98,590,676	62,916,406	27,635,988	32,776,028	49,477,683
ASU2	2	1,264,872	13,058,821	29,199,843	12,376,130	4,863,192	5,818,182	8,363,635
ASU3	0	1,218,750	16,067,293	44,215,250	26,392,859	11,252,983	13,004,688	20,410,932
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	17,258,343	18,130,942	7,006,988	8,847,593	3,945,406	5,105,851	5,676,677	3,953,361
Write	25,011,410	24,968,867	11,078,194	12,375,690	6,425,535	7,669,720	9,743,851	7,258,839
All ASUs	42,269,753	43,099,809	18,085,182	21,223,283	10,370,941	12,775,571	15,420,528	11,212,200
ASU1	26,501,550	27,229,307	11,286,572	13,437,349	6,432,268	7,989,266	9,392,458	6,691,071
ASU2	3,825,778	3,706,057	1,295,514	1,533,663	626,342	775,770	804,954	544,956
ASU3	11,942,425	12,164,445	5,503,096	6,252,271	3,312,331	4,010,535	5,223,116	3,976,173
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	2,961,515	2,312,111	1,837,684	5,127,926	2,267,472	1,212,864	718,932	1,533,206
Write	5,653,419	4,545,447	3,731,610	11,650,579	5,801,547	3,245,255	1,976,744	4,428,878
All ASUs	8,614,934	6,857,558	5,569,294	16,778,505	8,069,019	4,458,119	2,695,676	5,962,084
ASU1	5,052,337	3,962,920	3,169,078	9,106,314	4,096,854	2,168,344	1,272,462	2,625,565
ASU2	410,418	330,328	270,795	863,936	488,908	313,711	210,696	556,690
ASU3	3,152,179	2,564,310	2,129,421	6,808,255	3,483,257	1,976,064	1,212,518	2,779,829

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
743,935,520	737,973,436	5,962,084

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 5.3.15.2

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 5.3.15.3

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	0.000	0.000	0.000	0.000	0.001	0.000	0.001	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 16.

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 9.4.3.7.4

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 77.

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 table and graph for completeness.

100% Load Level: 24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:31:14	7:34:14	0-3	0:03:00
Measurement Interval	7:34:14	7:44:15	3-12	0:10:01

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,241,318.47	739,824.13	152,621.20	348,873.13
1	1,240,028.90	739,018.92	152,603.90	348,406.08
2	1,239,901.00	738,986.28	152,543.02	348,371.70
3	1,239,726.27	738,950.58	152,466.73	348,308.95
4	1,239,805.60	738,913.12	152,436.47	348,456.02
5	1,239,791.75	738,852.12	152,512.60	348,427.03
6	1,240,077.62	738,995.75	152,513.52	348,568.35
7	1,239,977.13	739,048.33	152,481.20	348,447.60
8	1,239,928.07	738,964.42	152,505.62	348,458.03
9	1,240,072.55	739,106.97	152,514.08	348,451.50
10	1,239,826.08	738,890.62	152,565.80	348,369.67
11	1,239,864.35	738,940.85	152,526.82	348,396.68
12	1,239,910.62	739,023.88	152,534.42	348,352.32
Average	***1,239,898.00***	***738,968.66***	***152,505.73***	***348,423.62***

95% Load Level: 23,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:15:03	8:18:03	0-3	0:03:00
Measurement Interval	8:18:03	8:28:03	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,179,624.13	703,074.60	145,104.43	331,445.10
1	1,177,976.30	702,000.07	145,027.33	330,948.90
2	1,178,078.82	702,094.72	144,920.17	331,063.93
3	1,177,946.10	702,003.77	144,892.17	331,050.17
4	1,178,004.73	702,160.07	144,841.72	331,002.95
5	1,178,105.97	702,183.05	144,927.90	330,995.02
6	1,178,138.80	702,149.13	144,931.48	331,058.18
7	1,178,104.03	702,098.27	144,844.72	331,161.05
8	1,178,109.05	702,133.00	144,888.63	331,087.42
9	1,177,806.33	701,939.48	144,916.90	330,949.95
10	1,177,927.42	702,057.63	144,832.57	331,037.22
11	1,177,935.90	702,002.75	144,908.63	331,024.52
12	1,178,048.65	702,084.40	144,885.55	331,078.70
Average	***1,178,012.70***	***702,081.16***	***144,887.03***	***331,044.52***

90% Load Level: 22,320 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:58:56	9:01:56	0-3	0:03:00
Measurement Interval	9:01:56	9:11:56	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	1,117,454.63	666,028.40	137,428.28	313,997.95
1	1,116,208.18	665,197.28	137,335.22	313,675.68
2	1,115,920.33	665,099.63	137,247.25	313,573.45
3	1,116,037.42	665,085.27	137,278.55	313,673.60
4	1,116,147.12	665,100.90	137,334.42	313,711.80
5	1,115,909.50	665,026.45	137,277.60	313,605.45
6	1,116,011.28	665,106.85	137,285.25	313,619.18
7	1,116,144.52	665,207.53	137,324.88	313,612.10
8	1,116,035.73	665,178.38	137,276.57	313,580.78
9	1,116,148.50	665,286.13	137,274.40	313,587.97
10	1,116,181.85	665,247.78	137,323.22	313,610.85
11	1,116,046.22	665,154.42	137,283.38	313,608.42
12	1,115,844.70	664,986.43	137,259.93	313,598.33
Average	***1,116,050.68***	***665,138.02***	***137,291.82***	***313,620.85***

80% Load Level: 19,840 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:41:35	9:44:35	0-3	0:03:00
Measurement Interval	9:44:35	9:54:35	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	993,126.25	591,892.75	122,177.42	279,056.08
1	992,185.15	591,335.97	122,079.13	278,770.05
2	991,977.85	591,282.67	122,011.83	278,683.35
3	992,022.13	591,372.50	121,953.28	278,696.35
4	992,106.67	591,285.80	121,936.43	278,884.43
5	992,303.30	591,459.75	121,995.57	278,847.98
6	991,813.70	591,118.43	121,983.20	278,712.07
7	991,808.72	591,115.80	121,956.75	278,736.17
8	991,982.18	591,265.37	122,028.73	278,688.08
9	992,080.03	591,270.08	122,111.95	278,698.00
10	992,152.60	591,285.85	122,011.93	278,854.82
11	992,031.67	591,331.17	122,039.00	278,661.50
12	992,000.17	591,226.23	122,095.17	278,678.77
Average	***992,030.12***	***591,273.10***	***122,011.20***	***278,745.82***

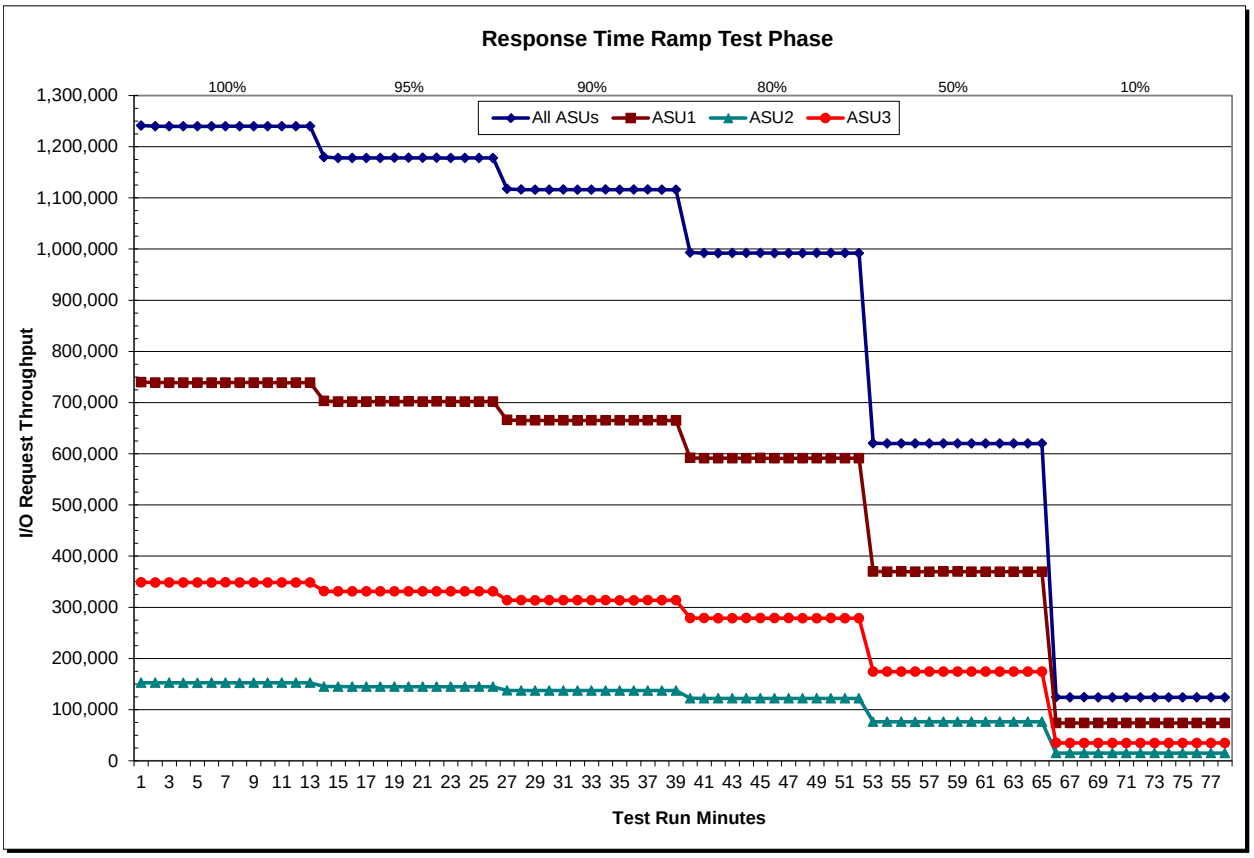
50% Load Level: 12,400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:21:41	10:24:41	0-3	0:03:00
Measurement Interval	10:24:41	10:34:41	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	620,681.22	369,969.43	76,363.63	174,348.15
1	619,959.02	369,465.28	76,298.97	174,194.77
2	620,140.77	369,727.77	76,289.40	174,123.60
3	620,066.60	369,582.82	76,246.58	174,237.20
4	620,057.85	369,531.62	76,278.22	174,248.02
5	620,135.78	369,595.67	76,329.95	174,210.17
6	620,236.58	369,627.57	76,288.72	174,320.30
7	620,021.63	369,459.28	76,298.33	174,264.02
8	619,880.47	369,415.78	76,254.40	174,210.28
9	619,896.07	369,434.22	76,269.30	174,192.55
10	620,058.47	369,569.60	76,267.77	174,221.10
11	619,889.13	369,438.03	76,259.25	174,191.85
12	620,016.67	369,547.33	76,283.73	174,185.60
Average	***620,025.93***	***369,520.19***	***76,277.63***	***174,228.11***

10% Load Level: 2,480 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:57:38	11:00:38	0-3	0:03:00
Measurement Interval	11:00:38	11:10:38	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	124,190.82	74,018.63	15,271.12	34,901.07
1	123,915.92	73,855.83	15,235.38	34,824.70
2	124,092.35	73,951.55	15,242.98	34,897.82
3	124,040.20	73,953.43	15,261.72	34,825.05
4	123,909.18	73,821.12	15,256.33	34,831.73
5	123,971.80	73,885.85	15,227.15	34,858.80
6	123,970.02	73,928.48	15,224.52	34,817.02
7	123,982.70	73,913.70	15,253.42	34,815.58
8	123,984.35	73,858.73	15,262.38	34,863.23
9	124,034.43	73,931.17	15,272.13	34,831.13
10	124,033.57	73,901.75	15,277.93	34,853.88
11	123,950.52	73,881.83	15,228.02	34,840.67
12	123,954.12	73,829.25	15,258.10	34,866.77
Average	***123,983.09***	***73,890.53***	***15,252.17***	***34,840.39***

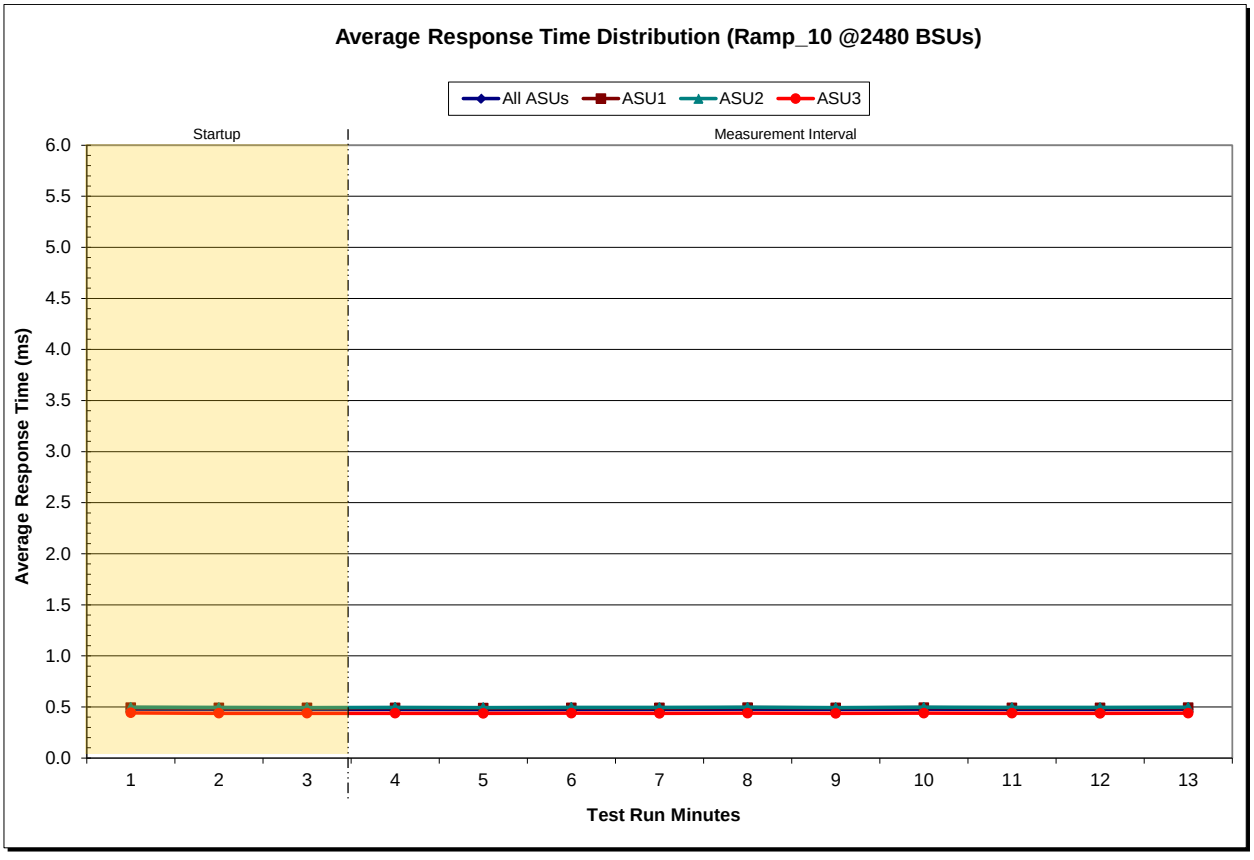
Response Time Ramp Distribution (IOPS) Graph



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

2,480 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:57:38	11:00:38	0-2	0:03:00
Measurement Interval	11:00:38	11:10:38	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.48	0.49	0.50	0.44
1	0.48	0.49	0.50	0.44
2	0.48	0.49	0.49	0.44
3	0.48	0.49	0.50	0.44
4	0.48	0.49	0.49	0.44
5	0.48	0.49	0.50	0.44
6	0.48	0.49	0.50	0.44
7	0.48	0.49	0.50	0.44
8	0.48	0.49	0.49	0.44
9	0.48	0.49	0.50	0.44
10	0.48	0.49	0.49	0.44
11	0.48	0.49	0.50	0.44
12	0.48	0.49	0.50	0.44
Average	***0.48***	***0.49***	***0.50***	***0.44***

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 5.3.15.2

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 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0700	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.0o01	0.001	0.003	0.002	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 9.4.3.7.5

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 77.

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	***1,239,898.00***
Repeatability Test Phase 1	1,239,960.35
Repeatability Test Phase 2	1,240,068.80

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	***0.48 ms***
Repeatability Test Phase 1	0.48 ms
Repeatability Test Phase 2	0.47 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).

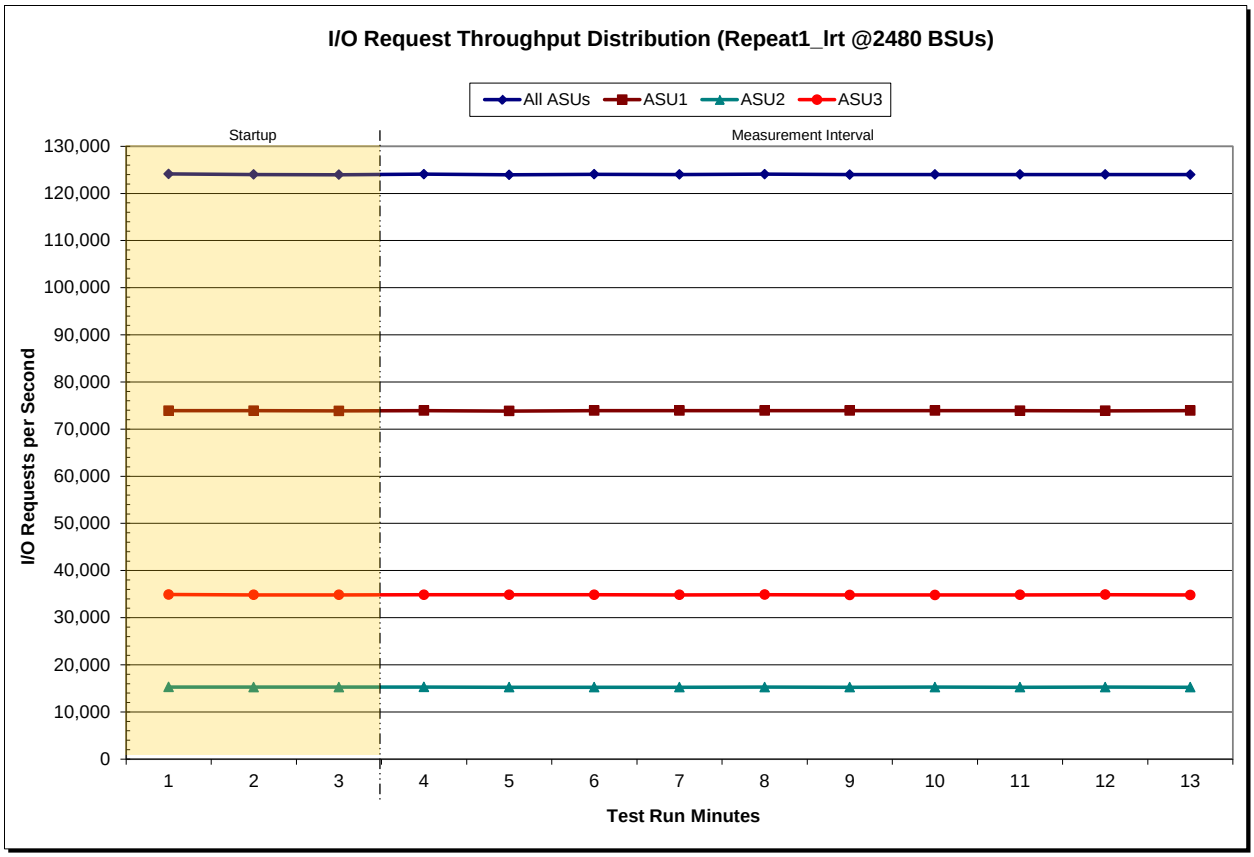
A link to the test result file generated from each Repeatability Test Run is listed below.

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

2,480 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:34:10	11:37:10	0-2	0:03:00
Measurement Interval	11:37:10	11:47:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	124,123.73	73,911.55	15,295.30	34,916.88
1	124,015.60	73,909.15	15,275.05	34,831.40
2	123,957.10	73,864.23	15,264.43	34,828.43
3	124,070.85	73,929.23	15,282.33	34,859.28
4	123,940.50	73,827.18	15,250.63	34,862.68
5	124,046.48	73,938.65	15,253.50	34,854.33
6	124,016.48	73,929.32	15,254.43	34,832.73
7	124,073.95	73,932.93	15,267.72	34,873.30
8	123,990.43	73,929.65	15,249.50	34,811.28
9	124,015.43	73,925.70	15,274.38	34,815.35
10	124,004.93	73,911.43	15,248.93	34,844.57
11	124,015.22	73,881.02	15,260.63	34,873.57
12	123,986.78	73,919.55	15,253.47	34,813.77
Average	***124,016.11***	***73,912.47***	***15,259.55***	***34,844.09***

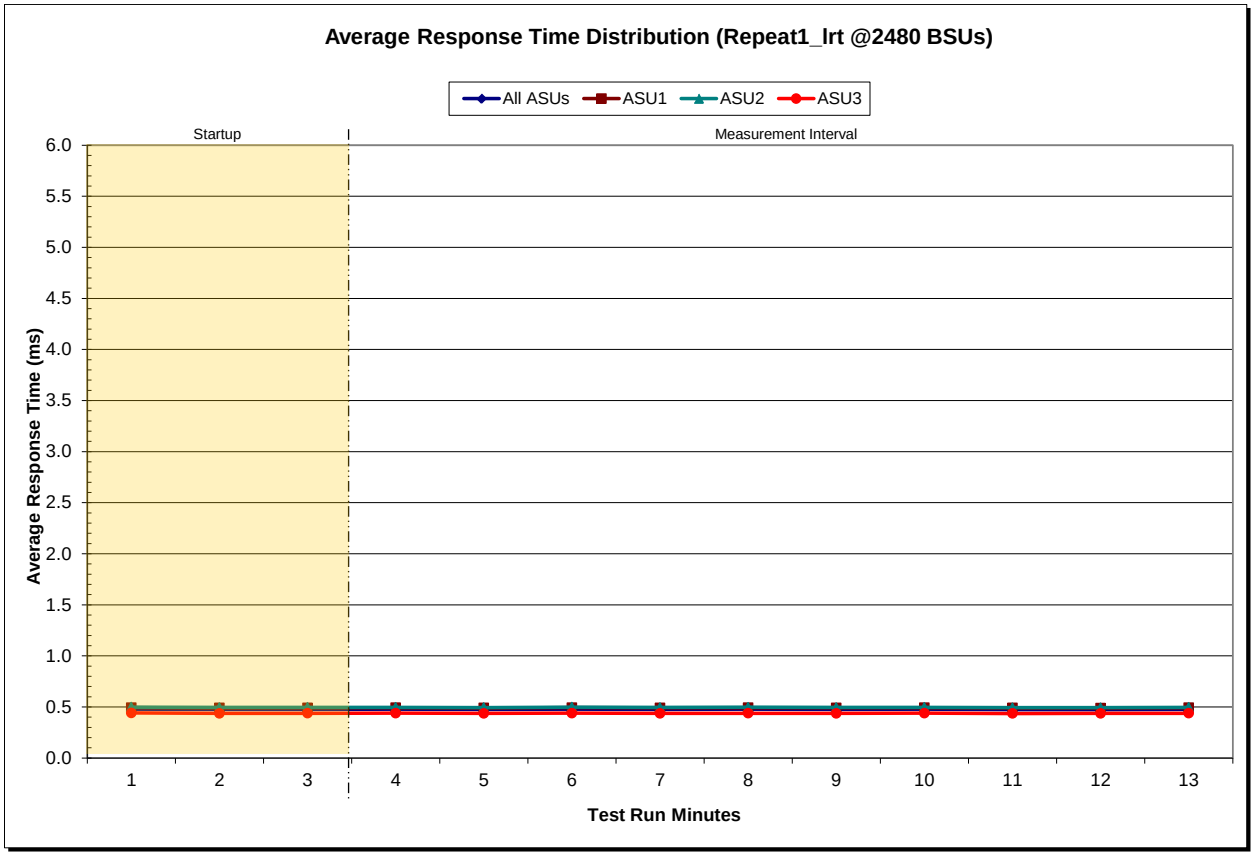
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

2,480 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:34:10	11:37:10	0-2	0:03:00
Measurement Interval	11:37:10	11:47:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.48	0.49	0.50	0.44
1	0.48	0.49	0.49	0.44
2	0.48	0.49	0.50	0.44
3	0.48	0.49	0.50	0.44
4	0.48	0.49	0.49	0.44
5	0.48	0.49	0.50	0.44
6	0.48	0.49	0.50	0.44
7	0.48	0.49	0.50	0.44
8	0.48	0.49	0.50	0.44
9	0.48	0.49	0.50	0.44
10	0.48	0.49	0.49	0.44
11	0.48	0.49	0.49	0.44
12	0.48	0.49	0.50	0.44
Average	***0.48***	***0.49***	***0.50***	***0.44***

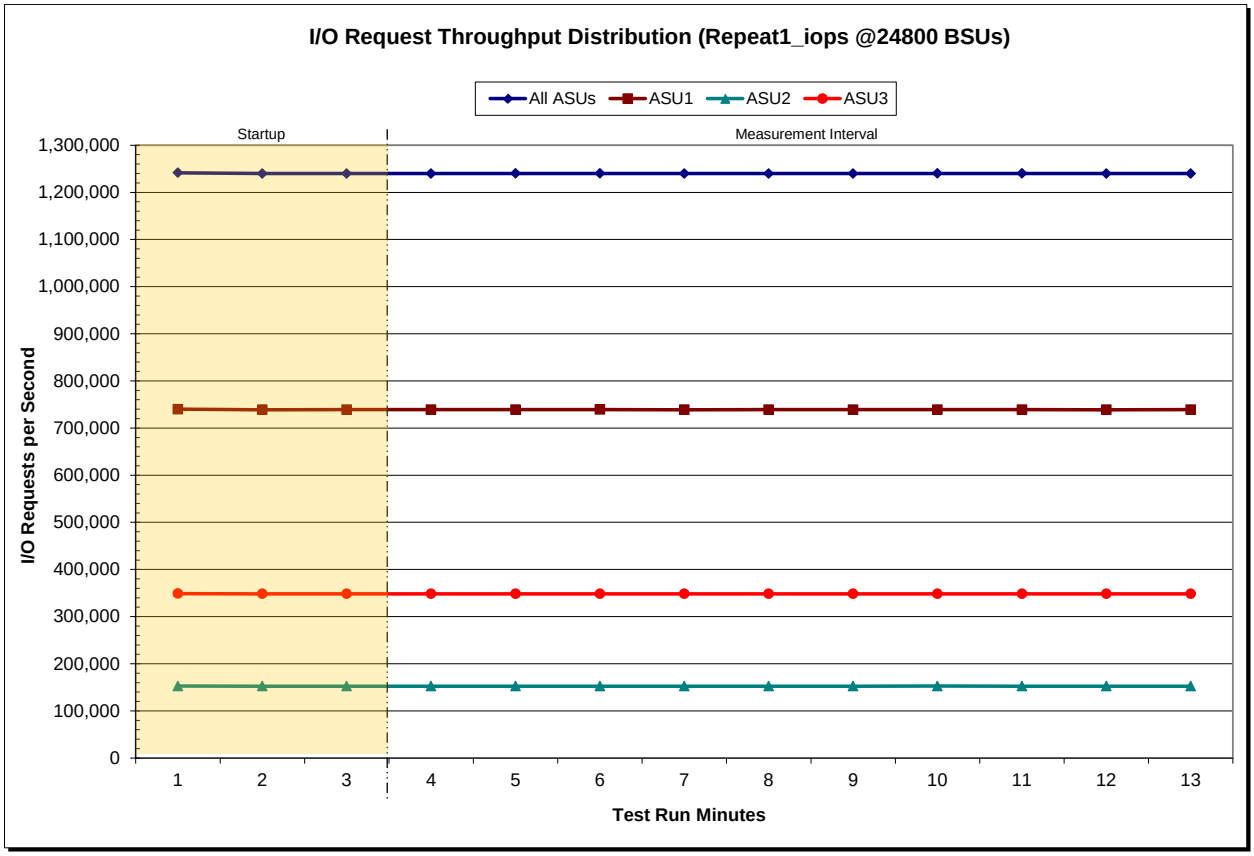
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:19:15	12:22:15	0-2	0:03:00
Measurement Interval	12:22:15	12:32:15	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,241,486.67	739,912.28	152,707.93	348,866.45
1	1,239,837.32	738,877.80	152,548.77	348,410.75
2	1,239,936.83	739,079.35	152,441.70	348,415.78
3	1,239,900.52	738,981.18	152,502.05	348,417.28
4	1,239,999.98	739,054.90	152,503.42	348,441.67
5	1,240,090.88	739,202.17	152,528.48	348,360.23
6	1,239,844.25	738,941.50	152,493.45	348,409.30
7	1,239,877.82	739,046.43	152,396.25	348,435.13
8	1,239,980.03	739,087.92	152,505.32	348,386.80
9	1,240,072.27	739,061.28	152,598.32	348,412.67
10	1,240,006.23	739,120.48	152,472.43	348,413.32
11	1,239,907.25	738,915.65	152,512.65	348,478.95
12	1,239,924.30	738,969.15	152,561.22	348,393.93
Average	***1,239,960.35***	***739,038.07***	***152,507.36***	***348,414.93***

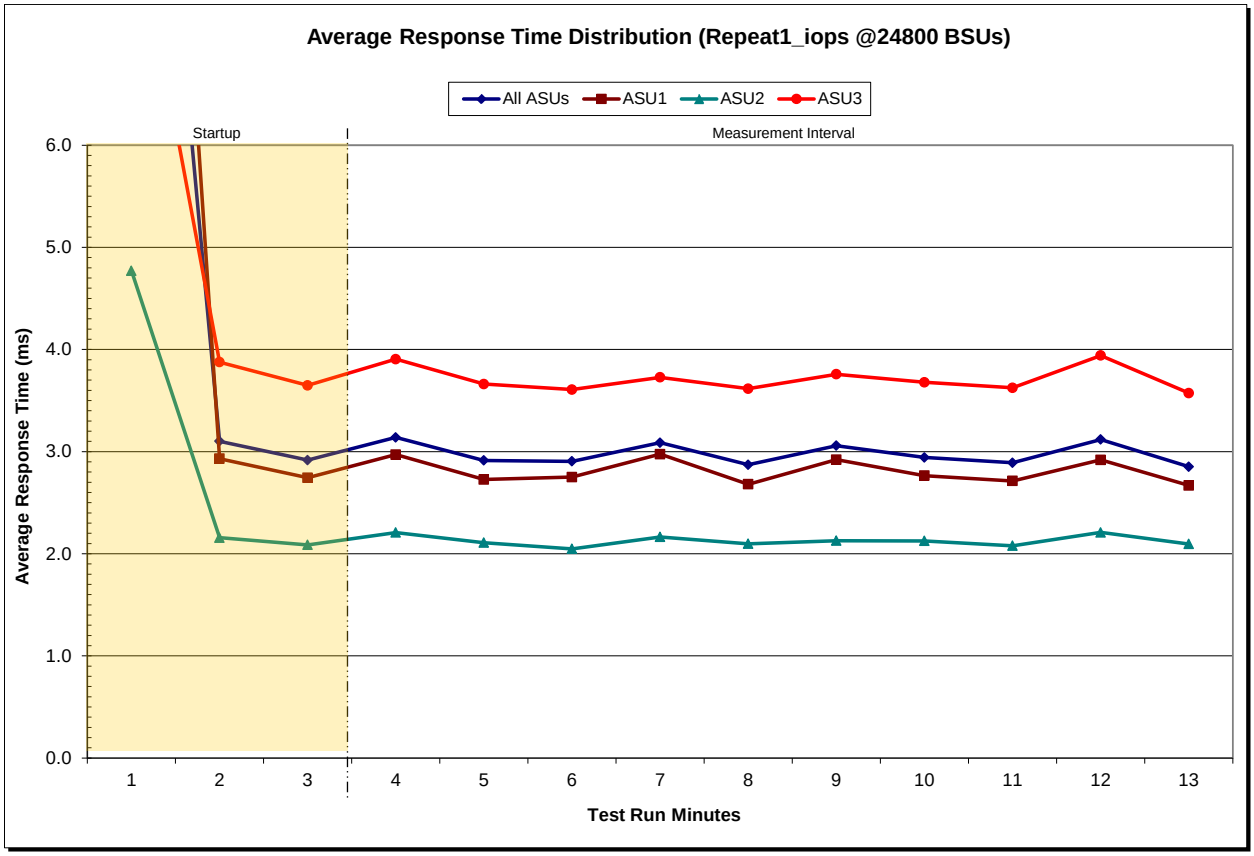
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:19:15	12:22:15	0-2	0:03:00
Measurement Interval	12:22:15	12:32:15	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	12.39	15.80	4.77	8.51
1	3.10	2.93	2.16	3.88
2	2.92	2.74	2.09	3.65
3	3.14	2.97	2.21	3.90
4	2.91	2.73	2.11	3.66
5	2.91	2.75	2.05	3.61
6	3.09	2.98	2.16	3.73
7	2.87	2.68	2.10	3.62
8	3.06	2.92	2.13	3.76
9	2.94	2.76	2.13	3.68
10	2.89	2.71	2.08	3.63
11	3.12	2.92	2.21	3.94
12	2.85	2.67	2.10	3.57
Average	***2.98***	***2.81***	***2.13***	***3.71***

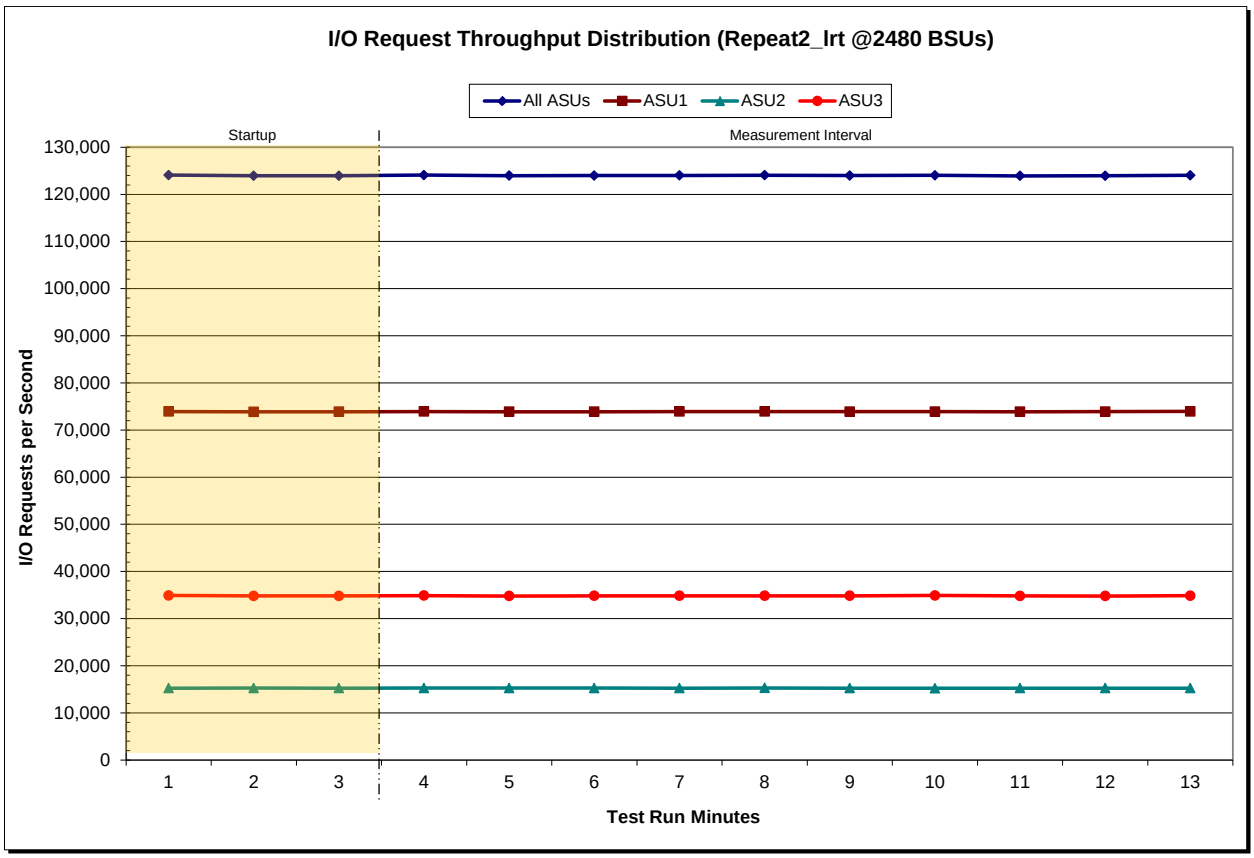
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

2,480 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:55:50	12:58:50	0-2	0:03:00
Measurement Interval	12:58:50	13:08:50	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	124,076.48	73,928.27	15,238.52	34,909.70
1	123,943.47	73,854.45	15,265.35	34,823.67
2	123,942.28	73,877.10	15,244.47	34,820.72
3	124,084.42	73,939.07	15,266.80	34,878.55
4	123,963.02	73,891.72	15,271.25	34,800.05
5	123,989.38	73,886.83	15,272.92	34,829.63
6	124,011.62	73,920.77	15,243.07	34,847.78
7	124,053.28	73,932.27	15,285.92	34,835.10
8	123,990.55	73,908.22	15,252.43	34,829.90
9	124,037.53	73,906.37	15,227.88	34,903.28
10	123,926.28	73,880.73	15,233.28	34,812.27
11	123,950.47	73,912.02	15,241.63	34,796.82
12	124,040.70	73,951.58	15,237.17	34,851.95
Average	***124,004.73***	***73,912.96***	***15,253.24***	***34,838.53***

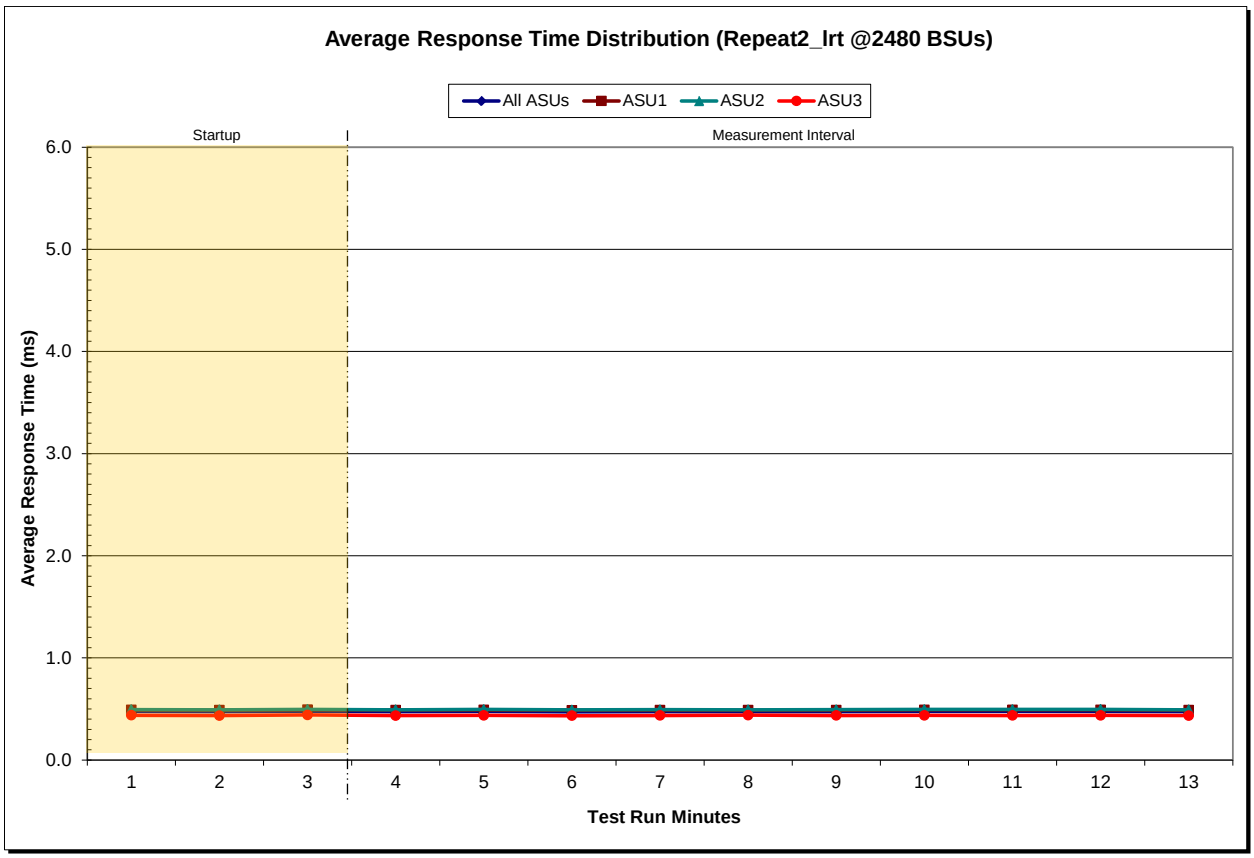
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

2,480 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:55:50	12:58:50	0-2	0:03:00
Measurement Interval	12:58:50	13:08:50	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.48	0.49	0.49	0.44
1	0.47	0.49	0.49	0.43
2	0.48	0.49	0.50	0.44
3	0.47	0.49	0.49	0.43
4	0.48	0.49	0.50	0.44
5	0.47	0.49	0.49	0.43
6	0.47	0.49	0.49	0.44
7	0.47	0.49	0.49	0.44
8	0.47	0.49	0.49	0.44
9	0.48	0.49	0.50	0.44
10	0.48	0.49	0.50	0.44
11	0.48	0.49	0.50	0.44
12	0.47	0.49	0.49	0.43
Average	***0.47***	***0.49***	***0.49***	***0.44***

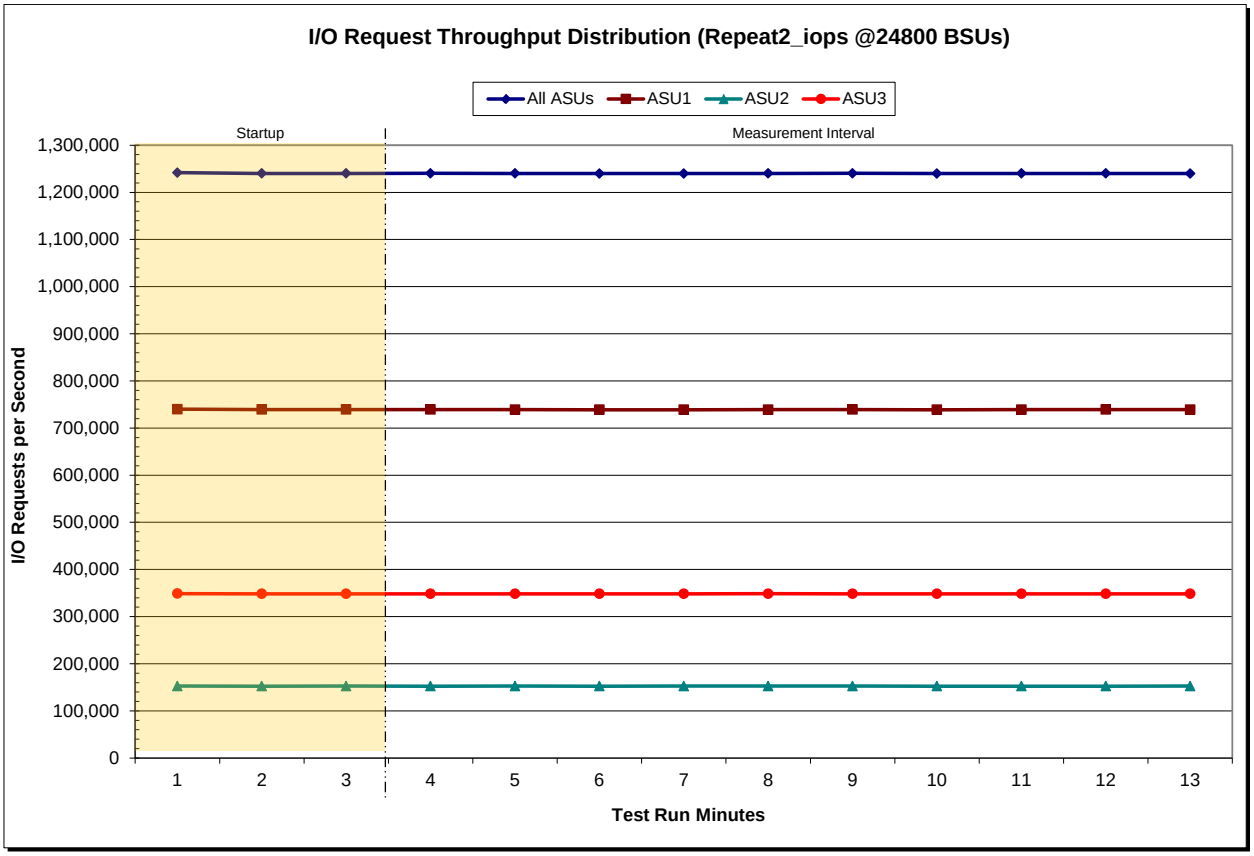
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:40:00	13:43:00	0-2	0:03:00
Measurement Interval	13:43:00	13:53:00	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1,241,763.45	740,052.17	152,754.98	348,956.30
1	1,240,172.77	739,190.38	152,498.05	348,484.33
2	1,240,204.65	739,199.28	152,588.60	348,416.77
3	1,240,272.88	739,266.17	152,547.43	348,459.28
4	1,240,156.88	739,127.72	152,607.15	348,422.02
5	1,239,892.18	738,946.48	152,486.27	348,459.43
6	1,239,917.40	738,905.20	152,578.05	348,434.15
7	1,240,215.57	739,132.05	152,584.17	348,499.35
8	1,240,317.28	739,198.62	152,631.92	348,486.75
9	1,239,772.27	738,941.85	152,545.68	348,284.73
10	1,239,994.23	739,064.05	152,521.67	348,408.52
11	1,240,192.32	739,271.70	152,492.42	348,428.20
12	1,239,956.93	738,982.43	152,572.45	348,402.05
Average	***1,240,068.80***	***739,083.63***	***152,556.72***	***348,428.45***

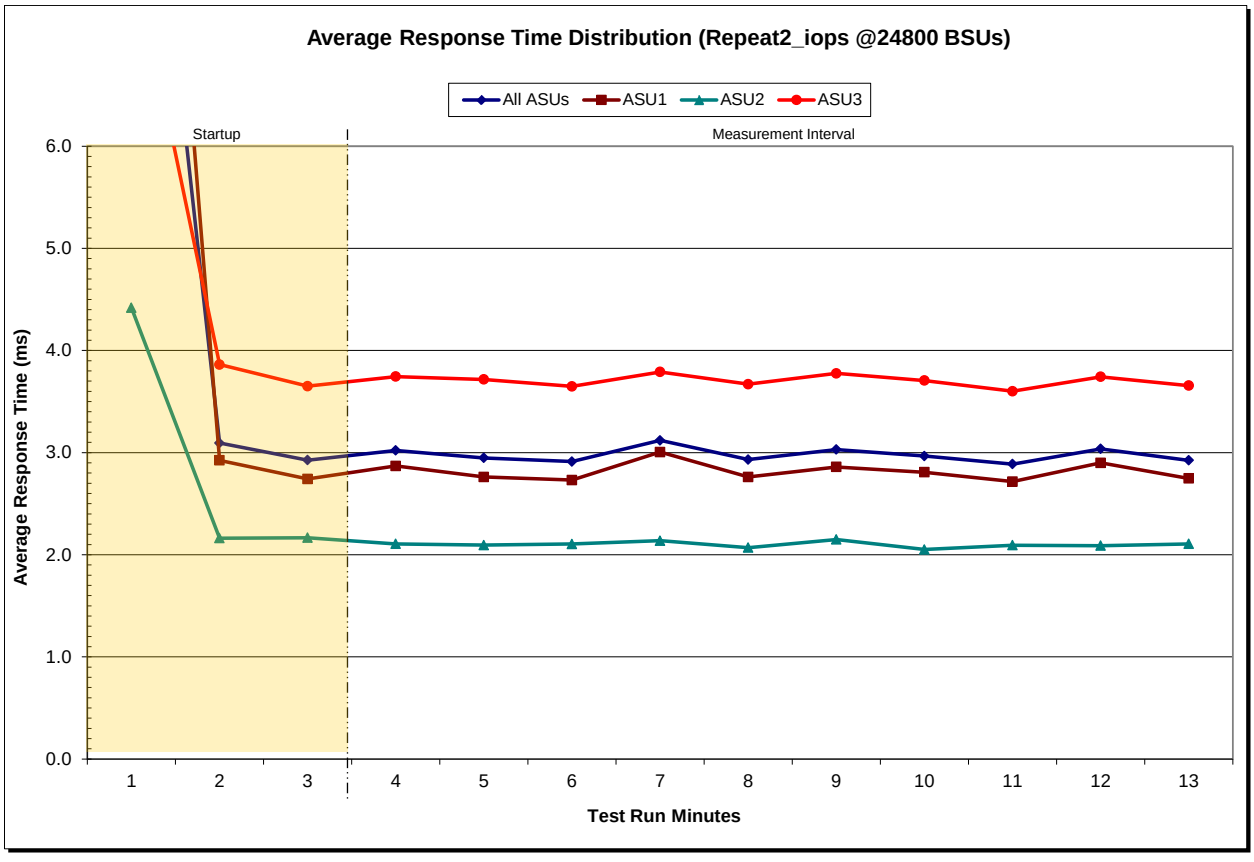
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

24,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:40:00	13:43:00	0-2	0:03:00
Measurement Interval	13:43:00	13:53:00	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	10.90	13.60	4.42	7.99
1	3.09	2.92	2.16	3.86
2	2.93	2.74	2.17	3.65
3	3.02	2.87	2.11	3.74
4	2.95	2.76	2.10	3.72
5	2.91	2.73	2.11	3.65
6	3.12	3.01	2.14	3.79
7	2.93	2.76	2.07	3.67
8	3.03	2.86	2.15	3.78
9	2.97	2.81	2.05	3.71
10	2.89	2.72	2.09	3.60
11	3.04	2.90	2.09	3.74
12	2.92	2.75	2.11	3.66
Average	***2.98***	***2.82***	***2.10***	***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.*

Clauses5.1.10 and 5.3.15.2

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 5.3.15.3

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	0.2811	0.0700	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.003	0.001	0.001	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	0.000	0.000	0.000	0.000	0.001	0.000	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	0.0700	0.0350	0.2809
COV	0.002	0.001	0.002	0.001	0.003	0.001	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	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.000	0.000	0.000	0.000	0.0o01	0.000	0.000	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 (may be contained in an appendix).*

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 77.

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	1,362,499
Total Number of Logical Blocks Verified	1,345,856
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	5 minutes
Size in bytes of each Logical Block	1024
Number of Failed I/O Requests in the process of the Test	0

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

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

In some cases the same address was the target of multiple writes, which resulted in more Logical Blocks Written than Logical Blocks Verified. In the case of multiple writes to the same address, the pattern written and verified must be associated with the last write to that address.

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.4.3.9

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 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 17.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

The Executive Summary shall contain 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 17.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the Kaminario K2.

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 1: The single point of failure of any ***storage device*** in the configuration will not result in permanent loss of access to or integrity of the SPC-1 Data Repository.

Protected 2: The single point of failure of any ***component*** in the configuration will not result in permanent loss of access to or integrity of the SPC-1 Data Repository.

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.

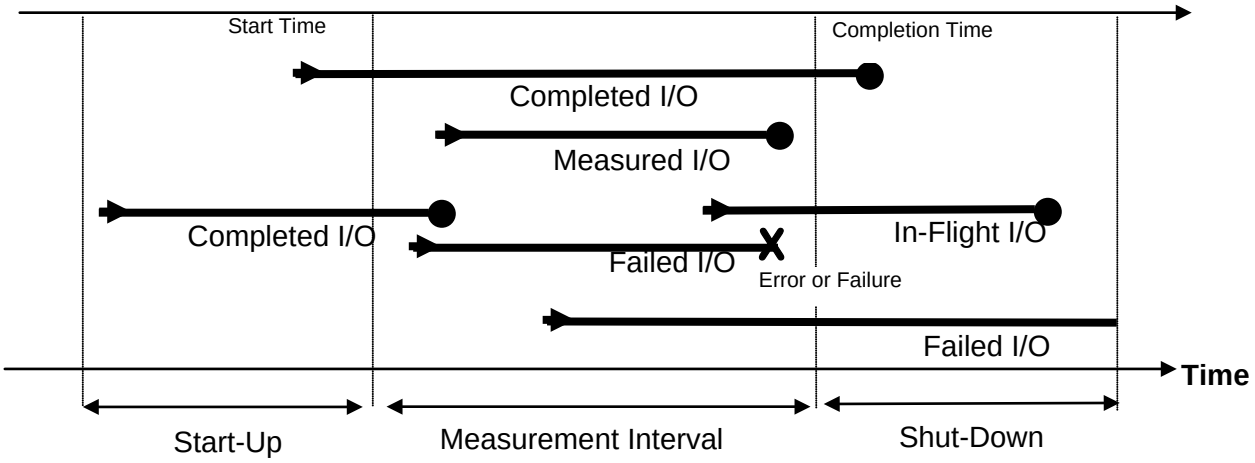
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

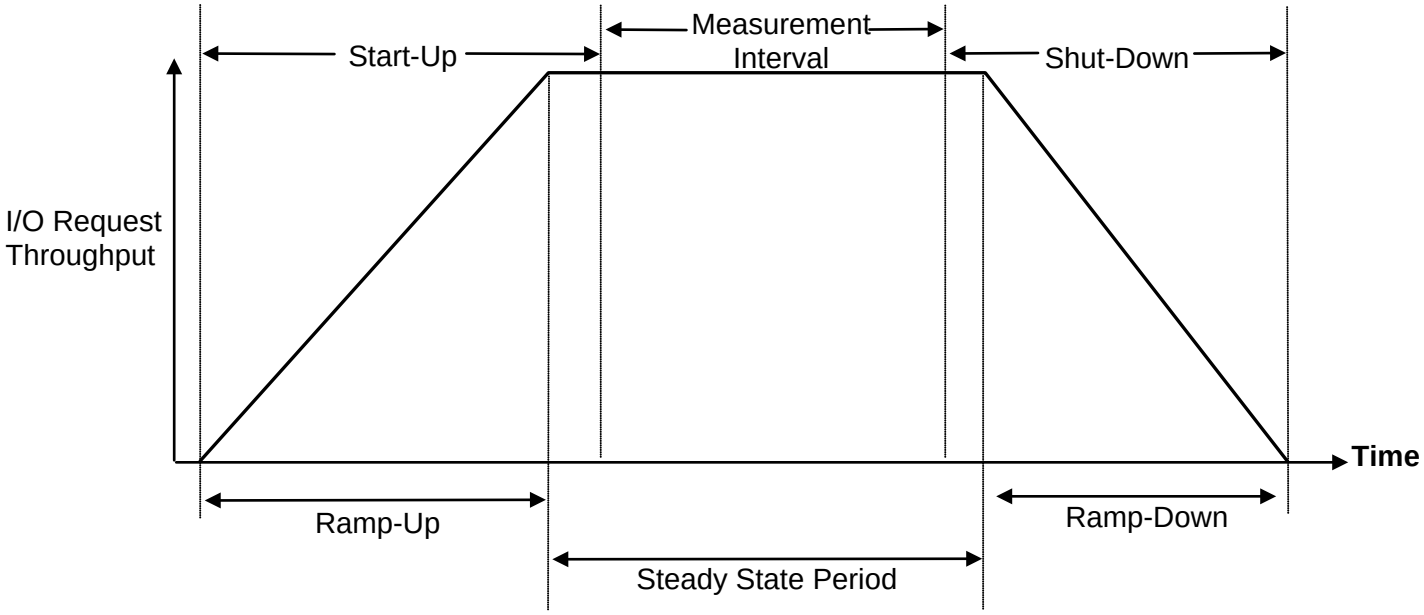
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have 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

There were no customer tunable parameters or options changed from their default values for the SPC-1 measurements.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

All referenced scripts will appear at the end of this appendix in the **TSC Creation/Configuration Scripts** section.

Log into the K2 CLI with an SSH client from any Host System and execute the following two scripts and single command to create and configure the SPC-1 ASUs:

- **tsc_creation-hosts.txt**
  - Creates a host group,
  - Creates a list of Host Systems and associates them to the newly created host group.
  - Configures the WWPNs of the FC HBA on each Host System to be mapped to the volumes created by the next script,
- **tsc_creation-volumes.txt**
  Create the volumes (SPC-1 Logical Volumes) that comprise the SPC-1 ASUs.
- Map the newly created volumes to the host group with the following command:
  volume mapping create host_group=spc volumes="asu1_01, asu1_02, asu1_03, asu1_04, asu1_05, asu1_06, asu1_07, asu1_08, asu1_09,asu2_01, asu2_02, asu2_03, asu2_04, asu2_05, asu2_06, asu2_07, asu2_08, asu2_09, asu3_01, asu3_02"

TSC Creation/Configuration Scripts

tsc_creation-hosts.txt

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

volume host-create host_group=spc os_type=ESX name=winperf01
volume host-create host_group=spc os_type=ESX name=winperf05
volume host-create host_group=spc os_type=ESX name=winperf06
volume host-create host_group=spc os_type=ESX name=winperf07
volume host-create host_group=spc os_type=ESX name=winperf08
volume host-create host_group=spc os_type=ESX name=winperf09
volume host-create host_group=spc os_type=ESX name=winperf10
volume host-create host_group=spc os_type=ESX name=winperf11
volume host-create host_group=spc os_type=ESX name=winperf12
volume host-create host_group=spc os_type=ESX name=winperf13
volume host-create host_group=spc os_type=ESX name=winperf14
volume host-create host_group=spc os_type=ESX name=winperf15
volume host-create host_group=spc os_type=ESX name=winperf16
volume host-create host_group=spc os_type=ESX name=winperfAli1



volume host-change silent=true add_fc_port=50024f40c0370300 name=winperf01
volume host-change silent=true add_fc_port=50024f40c0370301 name=winperf01
volume host-change silent=true add_fc_port=50024f40b20c2b00 name=winperf01
volume host-change silent=true add_fc_port=50024f40b20c2b01 name=winperf01
volume host-change silent=true add_fc_port=50024f40b15a0200 name=winperf05
volume host-change silent=true add_fc_port=50024f40b15a0201 name=winperf05
volume host-change silent=true add_fc_port=21000024ff45a618 name=winperf05
```

```
volume host-change silent=true add_fc_port=21000024ff45a619 name=winperf05
volume host-change silent=true add_fc_port=2100001b329d14ab name=winperf06
volume host-change silent=true add_fc_port=2101001b32bd14ab name=winperf06
volume host-change silent=true add_fc_port=21000024ff45a4d8 name=winperf06
volume host-change silent=true add_fc_port=21000024ff45a4d9 name=winperf06
volume host-change silent=true add_fc_port=50024f40dddd0200 name=winperf07
volume host-change silent=true add_fc_port=50024f40dddd0201 name=winperf07
volume host-change silent=true add_fc_port=21000024ff2efad4 name=winperf07
volume host-change silent=true add_fc_port=21000024ff2efad5 name=winperf07
volume host-change silent=true add_fc_port=50024f40b15a0900 name=winperf08
volume host-change silent=true add_fc_port=50024f40b15a0901 name=winperf08
volume host-change silent=true add_fc_port=21000024ff34add2 name=winperf08
volume host-change silent=true add_fc_port=21000024ff34add3 name=winperf08
volume host-change silent=true add_fc_port=21000024ff3565ec name=winperf09
volume host-change silent=true add_fc_port=21000024ff3565ed name=winperf09
volume host-change silent=true add_fc_port=2100001b32885a8e name=winperf09
volume host-change silent=true add_fc_port=2101001b32a85a8e name=winperf09
volume host-change silent=true add_fc_port=21000024ff356602 name=winperf10
volume host-change silent=true add_fc_port=21000024ff356603 name=winperf10
volume host-change silent=true add_fc_port=50024f40b21b1100 name=winperf10
volume host-change silent=true add_fc_port=50024f40b21b1101 name=winperf10
volume host-change silent=true add_fc_port=50024f40b21b1b00 name=winperf11
volume host-change silent=true add_fc_port=50024f40b21b1b01 name=winperf11
volume host-change silent=true add_fc_port=50024f40dddd0100 name=winperf11
volume host-change silent=true add_fc_port=50024f40dddd0101 name=winperf11
volume host-change silent=true add_fc_port=2100001b3297b756 name=winperf12
volume host-change silent=true add_fc_port=2101001b32b7b756 name=winperf12
volume host-change silent=true add_fc_port=2100001b329c9b53 name=winperf12
volume host-change silent=true add_fc_port=2101001b32bc9b53 name=winperf12
volume host-change silent=true add_fc_port=2100001b329d85a3 name=winperf13
volume host-change silent=true add_fc_port=2101001b32bd85a3 name=winperf13
volume host-change silent=true add_fc_port=2100001b3288468e name=winperf13
volume host-change silent=true add_fc_port=2101001b32a8468e name=winperf13
volume host-change silent=true add_fc_port=21000024ff45a65c name=winperf14
volume host-change silent=true add_fc_port=21000024ff45a65d name=winperf14
volume host-change silent=true add_fc_port=21000024ff34ae80 name=winperf14
volume host-change silent=true add_fc_port=21000024ff34ae81 name=winperf14
volume host-change silent=true add_fc_port=21000024ff45a400 name=winperf15
volume host-change silent=true add_fc_port=21000024ff45a401 name=winperf15
volume host-change silent=true add_fc_port=50024f40b15a0b00 name=winperf15
volume host-change silent=true add_fc_port=50024f40b15a0b01 name=winperf15
volume host-change silent=true add_fc_port=21000024ff45a3e6 name=winperf16
volume host-change silent=true add_fc_port=21000024ff45a3e7 name=winperf16
volume host-change silent=true add_fc_port=50024f40dddd0a00 name=winperf16
volume host-change silent=true add_fc_port=50024f40dddd0a01 name=winperf16
volume host-change name=winperfAli1 silent=true  add_fc_port=21-00-00-24-FF-36-60-A4
volume host-change name=winperfAli1 silent=true  add_fc_port=21-00-00-24-FF-36-60-A5
volume host-change name=winperfAli1 silent=true  add_fc_port=21-00-00-24-FF-36-5E-58
volume host-change name=winperfAli1 silent=true  add_fc_port=21-00-00-24-FF-36-5E-59
```

tsc_creation-volumes.txt

```
volume volume-create name=asu1_01 size=3000GB
volume volume-create name=asu1_02 size=3000GB
volume volume-create name=asu1_03 size=3000GB
volume volume-create name=asu1_04 size=3000GB
volume volume-create name=asu1_05 size=3000GB
volume volume-create name=asu1_06 size=3000GB
volume volume-create name=asu1_07 size=3000GB
volume volume-create name=asu1_08 size=3000GB
volume volume-create name=asu1_09 size=3000GB
volume volume-create name=asu2_01 size=3000GB
volume volume-create name=asu2_02 size=3000GB
volume volume-create name=asu2_03 size=3000GB
volume volume-create name=asu2_04 size=3000GB
volume volume-create name=asu2_05 size=3000GB
volume volume-create name=asu2_06 size=3000GB
volume volume-create name=asu2_07 size=3000GB
volume volume-create name=asu2_08 size=3000GB
volume volume-create name=asu2_09 size=3000GB
volume volume-create name=asu3_01 size=3000GB
volume volume-create name=asu3_02 size=3000GB
```

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

ASU Pre-Fill

Each Host System was assigned one or more LUNs *(SPC-1 Logical Volumes)* to pre-fill as a distinct execution sequence. This approach partitioned the pre-fill work, by LUN, across the Host Systems, allowing pre-fill sequences to execute simultaneously with each Host System responsible for its assigned LUN(s) rather than all LUNs. The result is a significant reduction in the time required to complete the entire ASU pre-fill operation.

The content of each command and parameter file used by each Host System is listed below.

Host System: win01, LUN: PHYSICALDRIVE11

```
compratio=1
sd=asu1_09,lun=\\.\PHYSICALDRIVE11,threads=32
wd=wd_asu1_09,sd=asu1_09,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win05, LUNs: PHYSICALDRIVE3, PHYSICALDRIVE12

```
compratio=1
sd=asu1_01,lun=\\.\PHYSICALDRIVE3,threads=32
sd=asu2_01,lun=\\.\PHYSICALDRIVE12,threads=32
wd=wd_asu1_01,sd=asu1_01,rdpct=0,seek=-1,xfersize=128K
wd=wd_asu2_01,sd=asu2_01,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win06, LUNs: PHYSICALDRIVE18, PHYSICALDRIVE13

```
compratio=1
sd=asu2_07,lun=\\.\PHYSICALDRIVE18,threads=32
sd=asu2_02,lun=\\.\PHYSICALDRIVE13,threads=32
wd=wd_asu2_07,sd=asu2_07,rdpct=0,seek=-1,xfersize=128K
wd=wd_asu2_02,sd=asu2_02,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win07, LUNs: PHYSICALDRIVE19, PHYSICALDRIVE14

```
compratio=1
sd=asu2_08,lun=\\.\PHYSICALDRIVE19,threads=32
sd=asu2_03,lun=\\.\PHYSICALDRIVE14,threads=32
wd=wd_asu2_08,sd=asu2_08,rdpct=0,seek=-1,xfersize=128K
wd=wd_asu2_03,sd=asu2_03,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win08, LUNs: PHYSICALDRIVE20, PHYSICALDRIVE15

```
compratio=1
sd=asu2_09,lun=\\.\PHYSICALDRIVE20,threads=32
sd=asu2_04,lun=\\.\PHYSICALDRIVE15,threads=32
wd=wd_asu2_09,sd=asu2_09,rdpct=0,seek=-1,xfersize=128K
wd=wd_asu2_04,sd=asu2_04,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win09, LUNs: PHYSICALDRIVE21, PHYSICALDRIVE16

```
compratio=1
sd=asu3_01,lun=\\.\PHYSICALDRIVE21,threads=32
sd=asu2_05,lun=\\.\PHYSICALDRIVE16,threads=32
wd=wd_asu3_01,sd=asu3_01,rdpct=0,seek=-1,xfersize=128K
wd=wd_asu2_05,sd=asu2_05,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win10, LUNs: PHYSICALDRIVE22, PHYSICALDRIVE17

```
compratio=1
sd=asu3_02,lun=\\.\PHYSICALDRIVE22,threads=32
sd=asu2_06,lun=\\.\PHYSICALDRIVE17,threads=32
wd=wd_asu3_02,sd=asu3_02,rdpct=0,seek=-1,xfersize=128K
wd=wd_asu2_06,sd=asu2_06,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win11, LUN: PHYSICALDRIVE4

```
compratio=1
sd=asu1_02,lun=\\.\PHYSICALDRIVE4,threads=32
wd=wd_asu1_02,sd=asu1_02,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win12, LUN: PHYSICALDRIVE5

```
compratio=1
sd=asu1_03,lun=\\.\PHYSICALDRIVE5,threads=32
wd=wd_asu1_03,sd=asu1_03,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win13, LUN: PHYSICALDRIVE6

```
compratio=1
sd=asu1_04,lun=\\.\PHYSICALDRIVE6,threads=32
wd=wd_asu1_04,sd=asu1_04,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win14, LUN: PHYSICALDRIVE7

```
compratio=1
sd=asu1_05,lun=\\.\PHYSICALDRIVE7,threads=32
wd=wd_asu1_05,sd=asu1_05,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win15, LUN: PHYSICALDRIVE8

```
compratio=1
sd=asu1_06,lun=\\.\PHYSICALDRIVE8,threads=32
wd=wd_asu1_06,sd=asu1_06,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: win16, LUN: PHYSICALDRIVE9

```
compratio=1
sd=asu1_07,lun=\\.\PHYSICALDRIVE9,threads=32
wd=wd_asu1_07,sd=asu1_07,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Host System: winperfali1, LUN: PHYSICALDRIVE10

```
compratio=1
sd=asu1_08,lun=\\.\PHYSICALDRIVE10,threads=32
wd=wd_asu1_08,sd=asu1_08,rdpct=0,seek=-1,xfersize=128K
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

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=(win01_100,win01_101,win01_102,win01_103,win01_104,win01_105,win01_106,win01_
107,win01_108,win01_109,win01_110,win01_111,win01_112,win01_113,win01_114,win01_115,
win01_116,win01_117,win05_100,win05_101,win05_102,win05_103,win05_104,win05_105,win0
5_106,win05_107,win05_108,win05_109,win05_110,win05_111,win05_112,win05_113,win05_11
4,win05_115,win05_116,win05_117,win06_100,win06_101,win06_102,win06_103,win06_104,wi
n06_105,win06_106,win06_107,win06_108,win06_109,win06_110,win06_111,win06_112,win06_
113,win06_114,win06_115,win06_116,win06_117,win07_100,win07_101,win07_102,win07_103,
win07_104,win07_105,win07_106,win07_107,win07_108,win07_109,win07_110,win07_111,win0
7_112,win07_113,win07_114,win07_115,win07_116,win07_117,win08_100,win08_101,win08_10
2,win08_103,win08_104,win08_105,win08_106,win08_107,win08_108,win08_109,win08_110,wi
n08_111,win08_112,win08_113,win08_114,win08_115,win08_116,win08_117,win09_100,win09_
101,win09_102,win09_103,win09_104,win09_105,win09_106,win09_107,win09_108,win09_109,
win09_110,win09_111,win09_112,win09_113,win09_114,win09_115,win09_116,win09_117,win1
0_100,win10_101,win10_102,win10_103,win10_104,win10_105,win10_106,win10_107,win10_10
8,win10_109,win10_110,win10_111,win10_112,win10_113,win10_114,win10_115,win10_116,wi
n10_117,win11_100,win11_101,win11_102,win11_103,win11_104,win11_105,win11_106,win11_
107,win11_108,win11_109,win11_110,win11_111,win11_112,win11_113,win11_114,win11_115,
win11_116,win11_117,win12_100,win12_101,win12_102,win12_103,win12_104,win12_105,win1
2_106,win12_107,win12_108,win12_109,win12_110,win12_111,win12_112,win12_113,win12_11
4,win12_115,win12_116,win12_117,win13_100,win13_101,win13_102,win13_103,win13_104,wi
n13_105,win13_106,win13_107,win13_108,win13_109,win13_110,win13_111,win13_112,win13_
113,win13_114,win13_115,win13_116,win13_117,win14_100,win14_101,win14_102,win14_103,
win14_104,win14_105,win14_106,win14_107,win14_108,win14_109,win14_110,win14_111,win1
4_112,win14_113,win14_114,win14_115,win14_116,win14_117,win15_100,win15_101,win15_10
2,win15_103,win15_104,win15_105,win15_106,win15_107,win15_108,win15_109,win15_110,wi
n15_111,win15_112,win15_113,win15_114,win15_115,win15_116,win15_117,win16_100,win16_
101,win16_102,win16_103,win16_104,win16_105,win16_106,win16_107,win16_108,win16_109,
win16_110,win16_111,win16_112,win16_113,win16_114,win16_115,win16_116,win16_117,winp
erfali1_100,winperfali1_101,winperfali1_102,winperfali1_103,winperfali1_104,winperfa
li1_105,winperfali1_106,winperfali1_107,winperfali1_108,winperfali1_109,winperfali1_
110,winperfali1_111,winperfali1_112,winperfali1_113,winperfali1_114,winperfali1_115,
winperfali1_116,winperfali1_117)
sd=asu1_01,lun=\\.\PHYSICALDRIVE3
sd=asu1_02,lun=\\.\PHYSICALDRIVE4
sd=asu1_03,lun=\\.\PHYSICALDRIVE5
sd=asu1_04,lun=\\.\PHYSICALDRIVE6
sd=asu1_05,lun=\\.\PHYSICALDRIVE7
sd=asu1_06,lun=\\.\PHYSICALDRIVE8
sd=asu1_07,lun=\\.\PHYSICALDRIVE9
sd=asu1_08,lun=\\.\PHYSICALDRIVE10
sd=asu1_09,lun=\\.\PHYSICALDRIVE11
sd=asu2_01,lun=\\.\PHYSICALDRIVE12
sd=asu2_02,lun=\\.\PHYSICALDRIVE13
sd=asu2_03,lun=\\.\PHYSICALDRIVE14
sd=asu2_04,lun=\\.\PHYSICALDRIVE15
```

```
sd=asu2_05,lun=\\.\PHYSICALDRIVE16
sd=asu2_06,lun=\\.\PHYSICALDRIVE17
sd=asu2_07,lun=\\.\PHYSICALDRIVE18
sd=asu2_08,lun=\\.\PHYSICALDRIVE19
sd=asu2_09,lun=\\.\PHYSICALDRIVE20
sd=asu3_01,lun=\\.\PHYSICALDRIVE21
sd=asu3_02,lun=\\.\PHYSICALDRIVE22
```

Primary Metrics Test: Sustainability Test Phase/Test Run

command commands 1

```
rd=sustain,bsus=24800,startup=180,elapsed=86400,interval=60
```

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

command commands 1

```
rd=ramp_100,bsus=24800,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=ramp_95,bsus=23560,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=ramp_90,bsus=22320,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=ramp_80,bsus=19840,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=ramp_50,bsus=12400,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=ramp_10,bsus=2480,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=repeat1_lrt,bsus=2480,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=repeat1_iops,bsus=24800,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=repeat2_lrt,bsus=2480,startup=180,elapsed=600,interval=60
```

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

command commands 1

```
rd=repeat2_iops,bsus=24800,startup=180,elapsed=600,interval=60
```

SPC-1 Persistence Test Run 1

The content of SPC-1 Workload Generator command and parameter file, used in this benchmark to execute a reduced level SPC-1 Persistence Test Run 1, is listed below.

```
sd=asu1_01,lun=\\.\PHYSICALDRIVE3
sd=asu1_02,lun=\\.\PHYSICALDRIVE4
sd=asu1_03,lun=\\.\PHYSICALDRIVE5
sd=asu1_04,lun=\\.\PHYSICALDRIVE6
sd=asu1_05,lun=\\.\PHYSICALDRIVE7
sd=asu1_06,lun=\\.\PHYSICALDRIVE8
sd=asu1_07,lun=\\.\PHYSICALDRIVE9
sd=asu1_08,lun=\\.\PHYSICALDRIVE10
sd=asu1_09,lun=\\.\PHYSICALDRIVE11
sd=asu2_01,lun=\\.\PHYSICALDRIVE12
sd=asu2_02,lun=\\.\PHYSICALDRIVE13
sd=asu2_03,lun=\\.\PHYSICALDRIVE14
sd=asu2_04,lun=\\.\PHYSICALDRIVE15
sd=asu2_05,lun=\\.\PHYSICALDRIVE16
sd=asu2_06,lun=\\.\PHYSICALDRIVE17
sd=asu2_07,lun=\\.\PHYSICALDRIVE18
sd=asu2_08,lun=\\.\PHYSICALDRIVE19
sd=asu2_09,lun=\\.\PHYSICALDRIVE20
sd=asu3_01,lun=\\.\PHYSICALDRIVE21
sd=asu3_02,lun=\\.\PHYSICALDRIVE22
```

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=850
sd=asu1_01,lun=\\.\PHYSICALDRIVE3,size=3006477107200
sd=asu1_02,lun=\\.\PHYSICALDRIVE4,size=3006477107200
sd=asu1_03,lun=\\.\PHYSICALDRIVE5,size=3006477107200
sd=asu1_04,lun=\\.\PHYSICALDRIVE6,size=3006477107200
sd=asu1_05,lun=\\.\PHYSICALDRIVE7,size=3006477107200
sd=asu1_06,lun=\\.\PHYSICALDRIVE8,size=3006477107200
sd=asu1_07,lun=\\.\PHYSICALDRIVE9,size=3006477107200
sd=asu1_08,lun=\\.\PHYSICALDRIVE10,size=3006477107200
sd=asu1_09,lun=\\.\PHYSICALDRIVE11,size=3006477107200
sd=asu2_01,lun=\\.\PHYSICALDRIVE12,size=3006477107200
sd=asu2_02,lun=\\.\PHYSICALDRIVE13,size=3006477107200
```

```
sd=asu2_03,lun=\\.\PHYSICALDRIVE14,size=3006477107200
sd=asu2_04,lun=\\.\PHYSICALDRIVE15,size=3006477107200
sd=asu2_05,lun=\\.\PHYSICALDRIVE16,size=3006477107200
sd=asu2_06,lun=\\.\PHYSICALDRIVE17,size=3006477107200
sd=asu2_07,lun=\\.\PHYSICALDRIVE18,size=3006477107200
sd=asu2_08,lun=\\.\PHYSICALDRIVE19,size=3006477107200
sd=asu2_09,lun=\\.\PHYSICALDRIVE20,size=3006477107200
sd=asu3_01,lun=\\.\PHYSICALDRIVE21,size=3006477107200
sd=asu3_02,lun=\\.\PHYSICALDRIVE22,size=3006477107200
maxlatestart=1
reportinginterval=5
segmentlength=512m
```

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

command commands 2

```
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=850
```

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

command commands 2

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

Slave JVMs

Each Slave JVM was invoked with a command and parameter file similar to the example listed below. The only difference in each file was **host** parameter value, which was unique to each Slave JVM, e.g. **win01_100**…**win01_150**…

```
master=win01
host=win01_100
sd=asu1_01,lun=\\.\PHYSICALDRIVE3
sd=asu1_02,lun=\\.\PHYSICALDRIVE4
sd=asu1_03,lun=\\.\PHYSICALDRIVE5
sd=asu1_04,lun=\\.\PHYSICALDRIVE6
sd=asu1_05,lun=\\.\PHYSICALDRIVE7
sd=asu1_06,lun=\\.\PHYSICALDRIVE8
sd=asu1_07,lun=\\.\PHYSICALDRIVE9
sd=asu1_08,lun=\\.\PHYSICALDRIVE10
sd=asu1_09,lun=\\.\PHYSICALDRIVE11
sd=asu2_01,lun=\\.\PHYSICALDRIVE12
sd=asu2_02,lun=\\.\PHYSICALDRIVE13
sd=asu2_03,lun=\\.\PHYSICALDRIVE14
sd=asu2_04,lun=\\.\PHYSICALDRIVE15
sd=asu2_05,lun=\\.\PHYSICALDRIVE16
sd=asu2_06,lun=\\.\PHYSICALDRIVE17
sd=asu2_07,lun=\\.\PHYSICALDRIVE18
sd=asu2_08,lun=\\.\PHYSICALDRIVE19
sd=asu2_09,lun=\\.\PHYSICALDRIVE20
sd=asu3_01,lun=\\.\PHYSICALDRIVE21
sd=asu3_02,lun=\\.\PHYSICALDRIVE22
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

'Master' Execution Script

This 'master' script is invoked from a "start-up" script, **tests_sequence**, which is listed below. This script is responsible for the execution of the required ASU Pre-Fill, Primary Metrics Test, Repeatability Test, a reduced level SPC-1 Persistence Test Run 1 and the SPC-2 Persistence Test.

```
#!/bin/bash


ROOTDIR='/cygdrive/c/spc/run/'
JAVA=$ROOTDIR"java7 -Xmx12000m -Xms12000m"
SPC2="/cygdrive/c/spc/spc2/spc2.bat"
BSU=24800
PERSIST1_FACTOR=10
SUSTAIN_TIME=86400
TIME=600
STARTUP=180
INTERVAL=60
STREAMS=850
DISKS=$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 3

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

#creating SPC-2 files
#source createspc2_files

case "$1"  in

     prepssd)
            echo "Running vdbench pre-fill from multiple hosts"
            ./all_prepssd
            ;;
     main)
            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
                        $CMD
                        RC=$?

                        # move the slave directories aside
                        ./all_killslaves
                        ./all_run_cmd "rm -rf "$ROOTDIR"slaves_$NAME/"
                        ./all_run_cmd "mv "$ROOTDIR"slaves "$ROOTDIR"slaves_$NAME/"

                        # Check the run return code
                        if [ $RC -gt 0 ]
                        then
                              echo "Test ended with error code $RC. Stopping run."
                              exit $RC
                        fi
                        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.winperf* | wc -l` -gt 0 ]
                              then
```

```
                                        echo "There was a stuck slave. we can
 continue"
                                fi
                                        echo "An error detected in phase $NAME"
                                        exit 1
                                fi
                        fi

                        # Remake the slave tree
                        ./all_run_cmd ""$ROOTDIR"mktree"
                        sleep 10

                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;
        ;;
    spc2_main)
        echo "Running spc-2 main"
        ./all_startremote
        $SPC2 -f lfp.txt -o init -init
        $SPC2 -f lfp.txt -o LFP
        #$SPC2 -f ldq.txt -o LDQ
        #$SPC2 -f vod.txt -o VOD
        ;;
    *)
        echo "no stage supplied -
 prepssd|main|spc2_persist_w|spc2_persist_r|spc1_persist1|spc1_persist2|spc2_main"
        ;;
 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.

The first invocation of the script, listed below, will execute the required ASU Pre-Fill, Primary Metrics Test, Repeatability Test, a reduced level SPC-1 Persistence Test Run 1 and SPC-2 Persistence Test Run 1.

```
#!/bin/bash
ROOTDIR='/cygdrive/c/spc/run/'
cd $ROOTDIR
echo "Inventory start: `date`" > inventory.pre
ssh root@kcs499 "echo system server-show table=inventory | /opt/km/cli/km-cli" >>
inventory.pre
echo "Inventory end: `date`" >> inventory.pre
sleep 300
./tests prepssd
sleep 3600
./tests main
./tests spc1_persist1
./tests spc2_persist_w
#./tests spc2_persist_r
#sleep 300
#echo "Inventory start: `date`" > inventory.post
#ssh root@kcs499 "echo system server-show table=inventory | /opt/km/cli/km-cli" >>
inventory.post
#echo "Inventory end: `date`" >> inventory.post
```

The second invocation of the script, listed below, will execute SPC-2 Persistence Test Run 2 after the required TSC power off/power on cycle.

```
#!/bin/bash
ROOTDIR='/cygdrive/c/spc/run/'
cd $ROOTDIR
#echo "Inventory start: `date`" > inventory.pre
#ssh root@kcs499 "echo system server-show table=inventory | /opt/km/cli/km-cli" >>
inventory.pre
#echo "Inventory end: `date`" >> inventory.pre
#sleep 300
#./tests prepssd
#sleep 3600
#./tests main
#./tests spc1_persist1
#./tests spc2_persist_w
./tests spc2_persist_r
sleep 300
echo "Inventory start: `date`" > inventory.post
ssh root@kcs499 "echo system server-show table=inventory | /opt/km/cli/km-cli" >>
inventory.post
echo "Inventory end: `date`" >> inventory.post
```

hosts

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

```
#!/bin/bash
```

```
SLAVES=18

hosts_slaves="win01:$SLAVES win02:0 win03:0 win04:0 win05:$SLAVES win06:$SLAVES
win07:$SLAVES win08:$SLAVES win09:$SLAVES win10:$SLAVES win11:$SLAVES win12:$SLAVES
win13:$SLAVES win14:$SLAVES win15:$SLAVES win16:$SLAVES winperfali1:$SLAVES
winperfali2:0"

#hosts_slaves="win01:$SLAVES win05:$SLAVES  win11:$SLAVES"

hosts_slaves="`echo $hosts_slaves | tr ' ' '\n' | grep -v :0 | xargs`"


disk_map='"asu1_01:bcac0001 asu1_02:bcac0002 asu1_03:bcac0003 asu1_04:bcac0004
asu1_05:bcac0005 asu1_06:bcac0006 asu1_07:bcac0007 asu1_08:bcac0008 asu1_09:bcac0009
asu2_01:bcac000a asu2_02:bcac000b asu2_03:bcac000c asu2_04:bcac000d asu2_05:bcac000e
asu2_06:bcac000f asu2_07:bcac0010 asu2_08:bcac0011 asu2_09:bcac0012 asu3_01:bcac0013
asu3_02:bcac0014 asu3_03:bcac0015 asu3_04:bcac0016"'
```

all_update_disks

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

```
source hosts
I=0
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 $I `echo
$hosts_slaves | wc -w` $1 2>/tmp/update_disks.err" > /tmp/update_disks.$NAME &
     fi
     I=$[ $I + 1 ]
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 and initialized
- Ensures the load balancing policy is LDQ using the **LB_policy_tool.vbs** script
- Creates the directories for Slave JVM output and recreates the Slave JVM configuration files using the **mktree** script
- Creates the 'master' SPC-1 configuration file ("spc1.cfg") using the **createspc1cfg** 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" $2 $3

if [ $4 ]; 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 $DISKS
rm -f "$DISKS"_tmp
rm -f $WDTMP
rm -f $DISKS_SIZES
rm -f "$DISKS_SIZES"_tmp
echo "compratio=1" > $PREPSSD

wmic_disks="`wmic diskdrive get name,serialnumber,model,size | tr -s ' ' ':' | grep
KMNRIO | cut -d ':' -f 6-8`"
ind=0
for l in $wmic_disks; do
     DISK=${l%:*:*}
     SERIAL_SIZE=${l#*:}
     SERIAL=${SERIAL_SIZE%:*}
     SIZE=${SERIAL_SIZE#*:}
     SIZE=`/cygdrive/c/sg_utils/sg_readcap.exe  $DISK | grep size | cut -d " " -f 6`
     echo "A: " $ind $3 $2
     for map in $1 ; do
            ASU=${map%:*}
```

```
            ID=${map#*:}
            if [ "$SERIAL" = "$ID" ]
            then
                  ind=$[ $ind + 1 ]
                  echo sd=$ASU,lun=$DISK >> "$DISKS"_tmp
                  echo sd=$ASU,lun=$DISK,size=$SIZE >> "$DISKS_SIZES"_tmp
                  if [ "`expr $ind % $3`" = "$2" ]
                  then
                        echo "B: " $ind $3 $2
                        echo sd=$ASU,lun=$DISK,threads=32 >> $PREPSSD
                        echo wd=wd_$ASU,sd=$ASU,rdpct=0,seek=-1,xfersize=128K >>
$WDTMP
                  fi
            fi
      done
done

cat "$DISKS"_tmp | sort > $DISKS
cat "$DISKS_SIZES"_tmp | sort > $DISKS_SIZES

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=50
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='win01'

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

```
#!/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

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
```

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/'
JAVA='/cygdrive/c/spc/run/java7 -Xmx8000m -Xms3000m'

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`"&
            $JAVA spc1 -f$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 QUOTATIONS

QLogic QME2572 8Gbps FC I/O Card

MediateK

MediateK COMPUTER MediateK MICROSYSTEMS MediateK OFFICE

September 10, 2013

Quote # 100913-01

Attn: Kaminario Ltd

Subject: Price Quotation

Line	Qty	Description	Unit Price
1	28	QLogic QME2572 8Gbps Fibre Channel I/O Card – Kit	425$

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

Regard,

Etay Aharon

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