SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

ACCELSTOR, INC.
ACCELSTOR NEOSAPPHIRE 3602

SPC-1 V1.14

Submitted for Review: January 13, 2017
Submission Identifier: A00183

First Edition – January 2017

Trademarks

Table of Contents

Note: Each line in the Table of Contents is a hyperlink to the listed item/page

AUDIT CERTIFICATION

Elton Lu
AccelStor, Inc.
10F, No. 465, Sec. 6, Zhongxiao E. Rd., Nangang Dist.
Taipei City 11557, Taiwan

January 12, 2017

The SPC Benchmark 1™ Reported Data listed below for the AccelStor NeoSapphire 3602 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: AccelStor NeoSapphire 3602	
Metric	**Reported Result**
SPC-1 IOPS™	227,970.31
SPC-1 Price-Performance	$0.20/SPC-1 IOPS™
Total ASU Capacity	2,033.256 GB
Data Protection Level	Protected 1 *(FlexiRemap™)*
Total Price (including three-year maintenance)	$44,637.03
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 AccelStor, 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.

Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9380

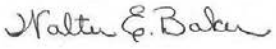
AUDIT CERTIFICATION *(CONT.)*

- An appropriate diagram of both the Priced Storage Configuration and 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 AccelStor, Inc.:
  - ✓ The type and number 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 AccelStor, 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 was no difference between the Tested Storage Configuration (TSC) 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 are no audit notes.

Respectfully,



Walter E. Baker
SPC Auditor

Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9380

LETTER OF GOOD FAITH

AccelStor, Inc.
10F, No. 465, Sec. 6, Zhongxiao E. Rd., Nangang Dist.
Taipei City 11557, Taiwan
T: +886 2 77467616 F: +886 2 77461155
www.accelstor.com

Letter of Good Faith

January 11, 2017

Mr. Walter E. Baker
Auditor, Storage Performance Council
Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94063

Subject: SPC-1 Letter of Good Faith for AccelStor NeoSapphire 3602

AccelStor, Inc. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.14 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.

Sincerely,

Allen Hsu
Chairman
AccelStor, Inc.

1/11/2017
Date of Signature

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	AccelStor, Inc. – http://www.accelstor.com Elton Lu – elton.lu@accelstor.com 10F, No. 465, Sec. 6, Zhongxiao E. Rd., Nangang Dist. Taipei City 11557, Taiwan Phone: +886 2 7746 7616 ext. 2523 FAX: +886 2 7746 1155
Test Sponsor Alternate Contact	AccelStor, Inc. – http://www.accelstor.com Simon Shiau – simon.shiau@accelstor.com 10F, No. 465, Sec. 6, Zhongxiao E. Rd., Nangang Dist. Taipei City 11557, Taiwan Phone: +886 2 7746 7616 ext. 2511 FAX: +886 2 7746 1155
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org Gradient Systems, Inc. 643 Bair Island Road, Suite 211 Redwood City, CA 94063 Phone: (650) 556-9380 FAX: (650) 257-7511

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	January 13, 2017
Date the FDR was submitted to the SPC	January 13, 2017
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	January 12, 2017

Tested Storage Product (TSP) Description

AccelStor's NeoSapphire 3602 all-flash array provides outstanding performance. This 1U model offers 2TB usable capacity, equipped with dual port 16G Fibre Channels *(backward compatible to 8G Fibre Channel).*

The low latency and high reliability of Fibre Channel makes NeoSapphire 3602 ideal for demanding, time-critical applications and integrating with the existing SANs environment, such as banking, finance, and media production application. These applications will usually generate massive I/O bound and further cause the performance bottleneck. With the NeoSapphire 3602' random write high performance, it helps the IT staff increase productivity and makes the storage topology easy to deploy. As for random I/O processing, the sustained performance of the NeoSapphire 3602 helps resolve the storage bottlenecks that often hamstring operations such as server virtualization and database traversal.

With the power of FlexiRemap technology, thin provisioning and zero page deduplication, the NeoSapphire 3602 makes it easy to manage the storage capacity.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: AccelStor NeoSapphire 3602	
Metric	**Reported Result**
SPC-1 IOPS™	227,970.31
SPC-1 Price-Performance™	$0.20/SPC-1 IOPS™
Total ASU Capacity	2,033.256 GB
Data Protection Level	Protected 1 *(FlexiRemap™)*
Total Price	$44,637.03
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 1** using ***FlexiRemap™***, which divides SSD drives into two groups of independent drives. Data is then evenly distributed across the SSDs of the two groups. Fault tolerance protection (parity) is distributed equally across each of the two groups equal to the capacity of a single SSD, resulting the equivalent of two SSDs dedicated to parity, one per group.

> ***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.*

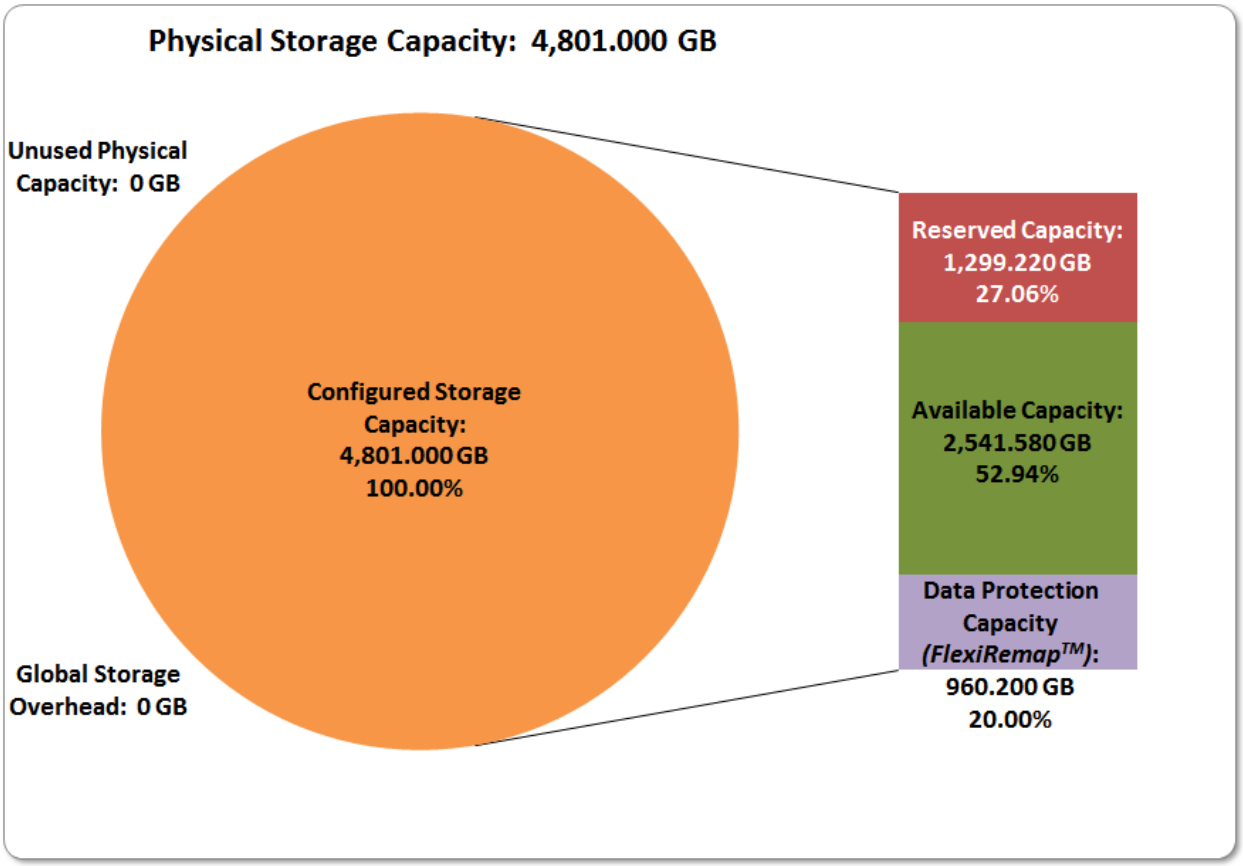
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 17.

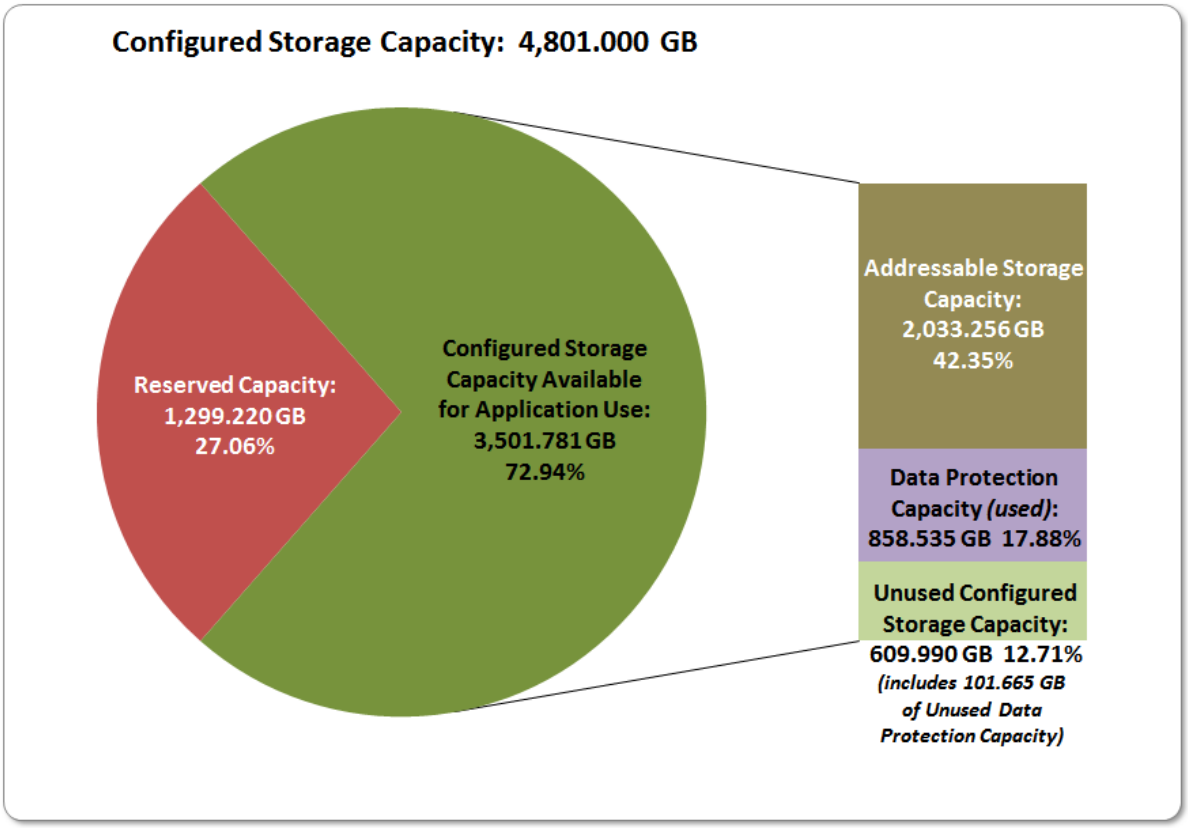
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency)*.

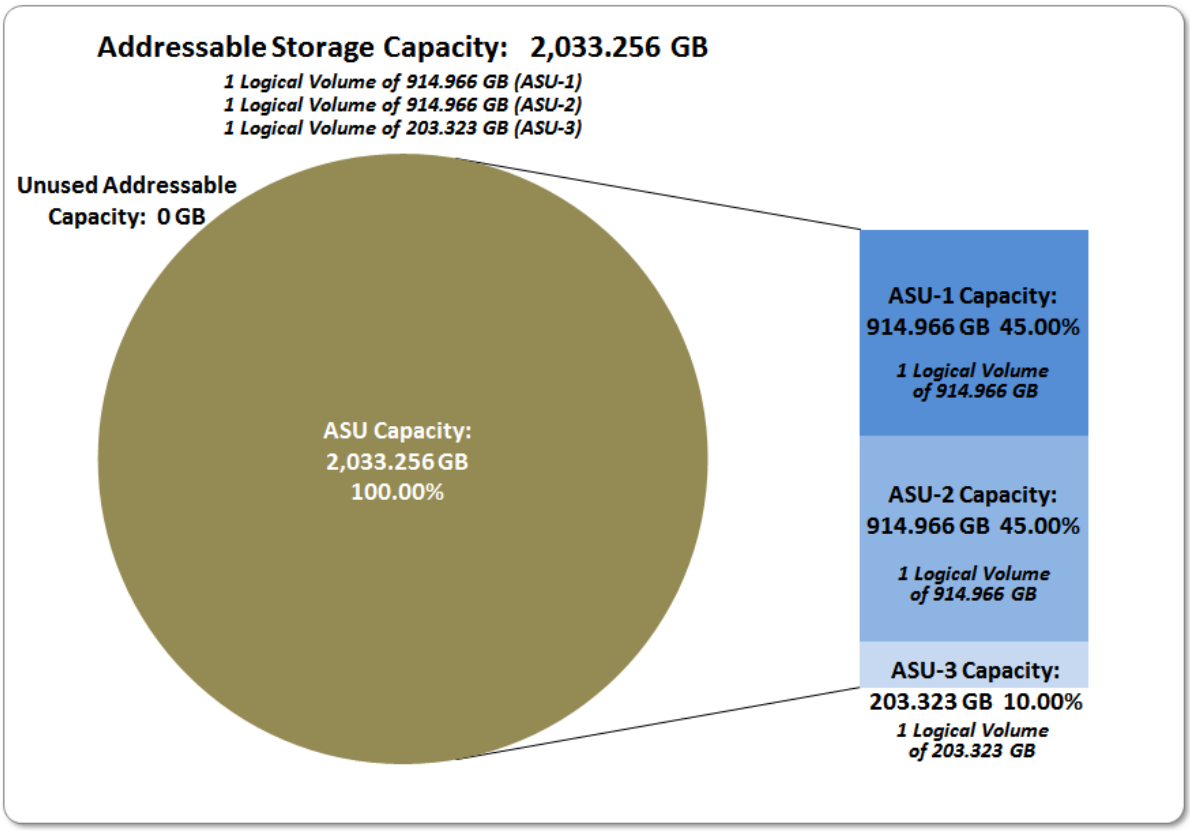
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

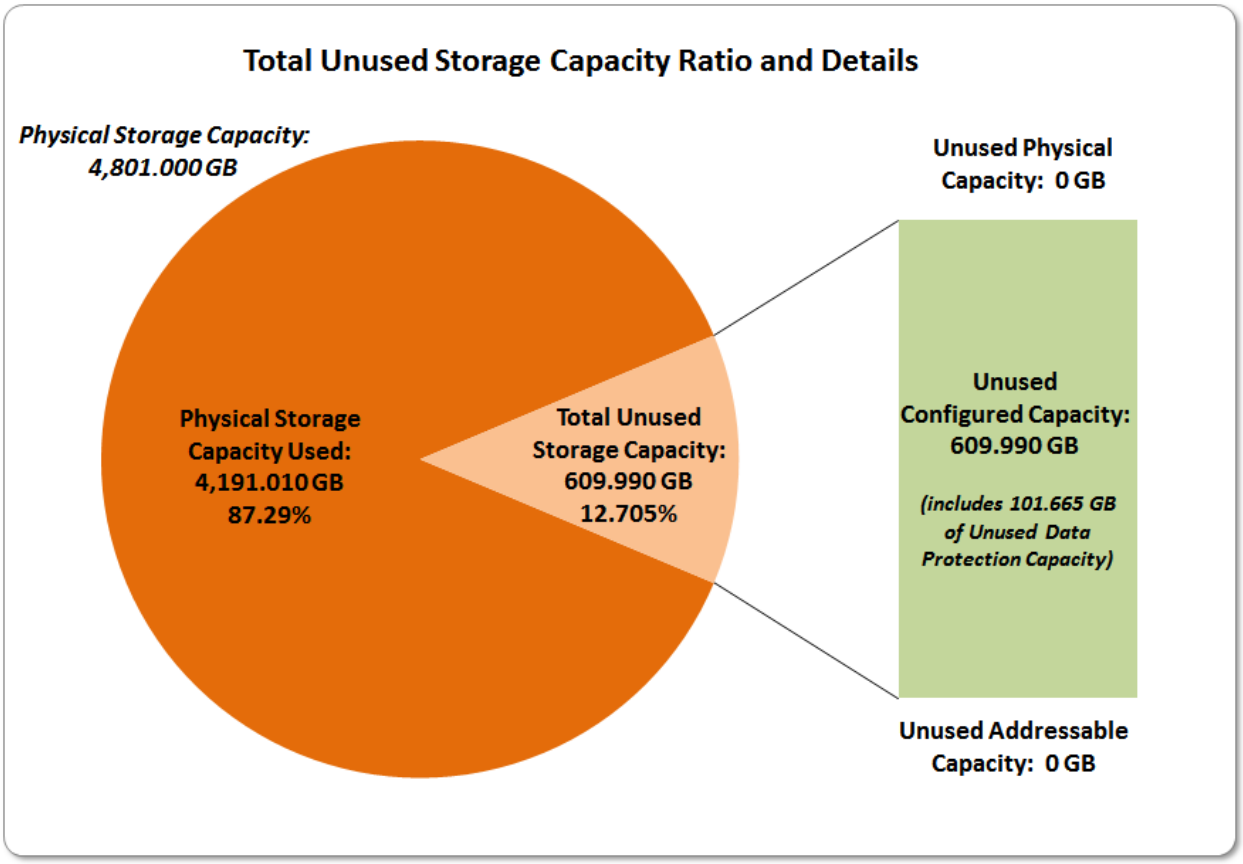
Storage Capacities, Relationships, and Utilization

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.




Configured Storage Capacity: 4,801.000 GB
Reserved Capacity:
1,299.220 GB
27.06%
Configured Storage Capacity Available for Application Use:
3,501.781 GB
72.94%
Addressable Storage Capacity:
2,033.256 GB
42.35%
Data Protection Capacity (used):
858.535 GB 17.88%
Unused Configured Storage Capacity:
609.990 GB 12.71%
(includes 101.665 GB of Unused Data Protection Capacity)


Addressable Storage Capacity: 2,033.256 GB
1 Logical Volume of 914.966 GB (ASU-1)
1 Logical Volume of 914.966 GB (ASU-2)
1 Logical Volume of 203.323 GB (ASU-3)
Unused Addressable Capacity: 0 GB
ASU Capacity:
2,033.256 GB
100.00%
ASU-1 Capacity:
914.966 GB 45.00%
1 Logical Volume of 914.966 GB
ASU-2 Capacity:
914.966 GB 45.00%
1 Logical Volume of 914.966 GB
ASU-3 Capacity:
203.323 GB 10.00%
1 Logical Volume of 203.323 GB



SPC-1 Storage Capacity Utilization	
Application Utilization	42.35%
Protected Application Utilization	60.23%
Unused Storage Ratio	12.71%

Application Utilization: Total ASU Capacity *(2,033.256 GB)* divided by Physical Storage Capacity *(4,801.000 GB)*.

Protected Application Utilization: (Total ASU Capacity *(2,033.256 GB)* plus total Data Protection Capacity *(960.200 GB)* minus unused Data Protection Capacity *(101.665 GB)*) divided by Physical Storage Capacity *(4,801.000 GB)*.

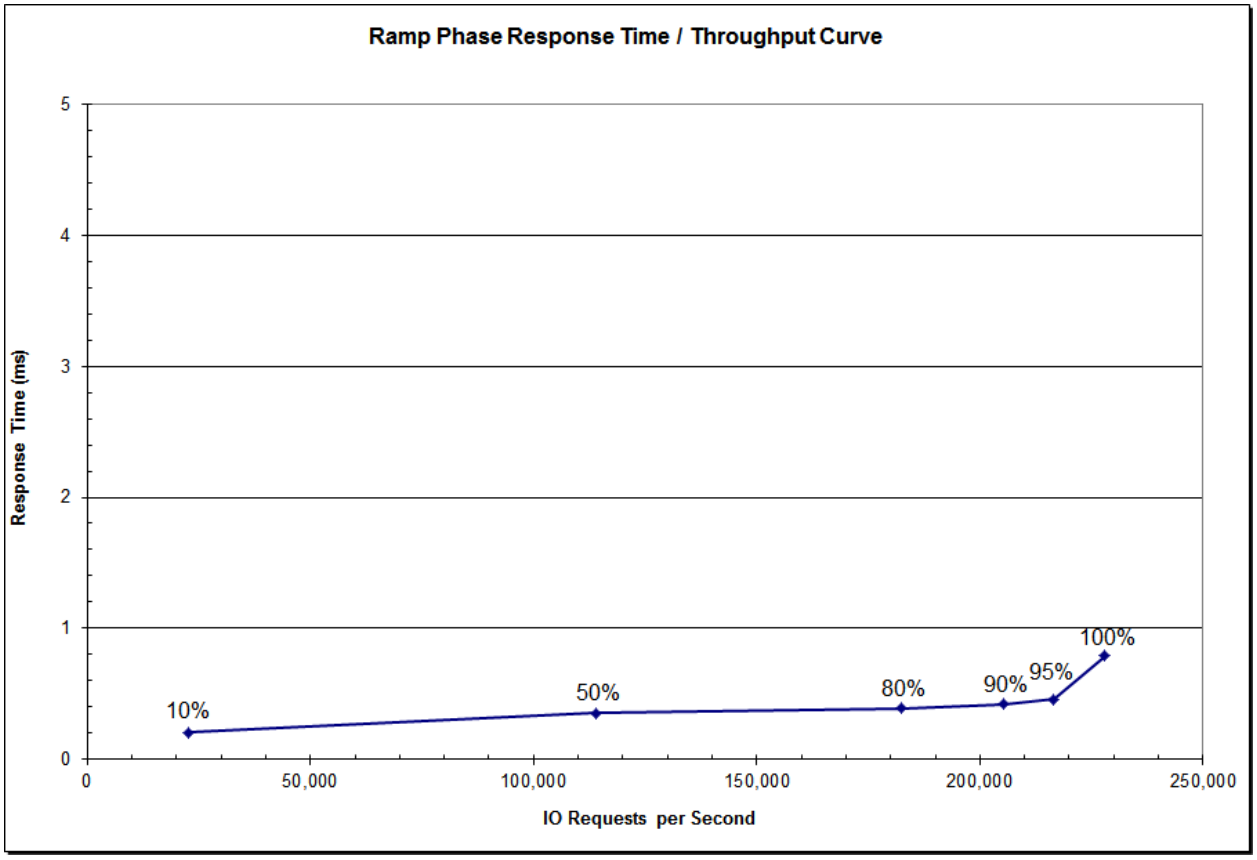
Unused Storage Ratio: Total Unused Capacity *(609.990 GB)* divided by Physical Storage Capacity *(4,801.000 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 23-24.

Response Time – Throughput Curve

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

The Average Response Time measured at any of the above load points cannot exceed 30 milliseconds or the benchmark measurement is invalid.



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	22,808.63	113,983.94	182,376.87	205,184.34	216,593.19	227,970.31
Average Response Time (ms):						
All ASUs	0.21	0.35	0.39	0.42	0.46	0.79
ASU-1	0.22	0.38	0.44	0.48	0.54	1.05
ASU-2	0.23	0.39	0.45	0.47	0.50	0.65
ASU-3	0.16	0.27	0.27	0.25	0.26	0.29
Reads	0.29	0.50	0.60	0.67	0.75	1.30
Writes	0.15	0.26	0.25	0.25	0.27	0.46

Priced Storage Configuration Pricing

Part Number	Name/Description	Quantity	Unit List Price	Extended List Price	Discount	Discounted Price
AF3602-110NS2US-1XX	All-Flash Array, NeoSapphire 3602 1U Rack Mount, 10 Drives, 3-Year Warranty (24/7 Help Desk & Onsite Parts within 4 Hours) Spare Kit (1 x Optics, 1 x SSD, 1 x PSU)	1	$ 84,000.00	$84,000.00	50%	$42,000.00
Third Party Components						
LPe16002B-M6	2 Ports 16GFC Short Wave Optical - LC SFP+	1	$ 2,608.23	$ 2,608.23	0%	$ 2,608.23
Fibre Channel Cables	10-Gigabit Optical Fiber Patch Cords (OM3 Fibers)	2	$ 14.40	$ 28.80	0%	$ 28.80
				Total		**$44,637.03**

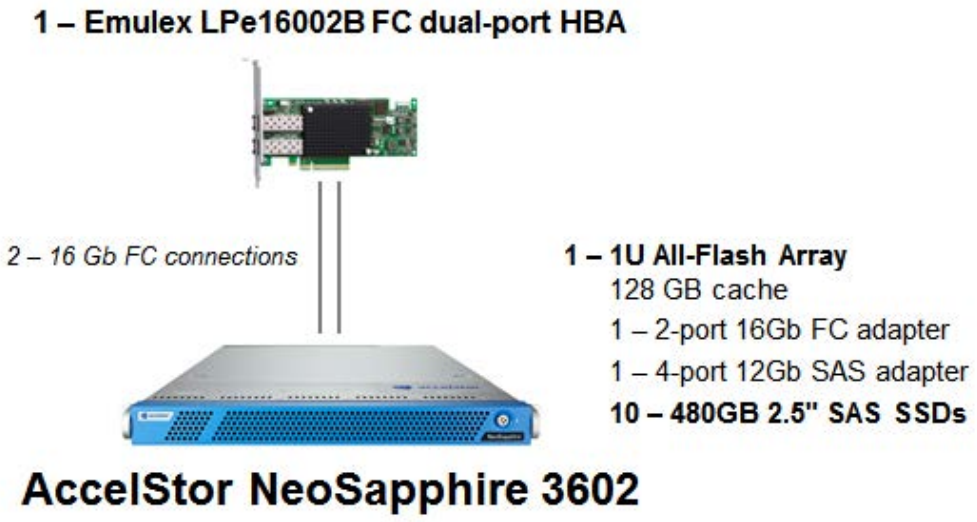
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

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

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

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

Priced Storage Configuration Diagram



Priced Storage Configuration Components

Priced Storage Configuration
AccelStor FlexiRemap™
1 – Emulex LPe16002B FC dual-port, 16 Gbps, FC HBA
AccelStor NeoSapphire 3602 1 – 1U All Flash Array 128 GB cache 1 – 2-port 16 Gb FC adapter 1 – 4-port 12 Gb SAS adapter 10 – 480 GB, 2.5” SAS SSDs

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 20 *(Benchmark Configuration/Tested Storage Configuration Diagram)*.

Storage Network Configuration

Clause 9.4.3.4.1

…

5. *If the TSC contains network storage, the diagram will include the network configuration. If a single diagram is not sufficient to illustrate both the Benchmark Configuration and network configuration in sufficient detail, the Benchmark Configuration diagram will include a high-level network illustration as shown in Figure 9-8. In that case, a separate, detailed network configuration diagram will also be included as described in Clause 9.4.3.4.2.*

Clause 9.4.3.4.2

If a storage network was configured as a part of the Tested Storage Configuration and the Benchmark Configuration diagram described in Clause 9.4.3.4.1 contains a high-level illustration of the network configuration, the Executive Summary will contain a one page topology diagram of the storage network as illustrated in Figure 9-9.

The Tested Storage Configuration only utilized direct-attached storage and, as such, did not utilize a storage network.

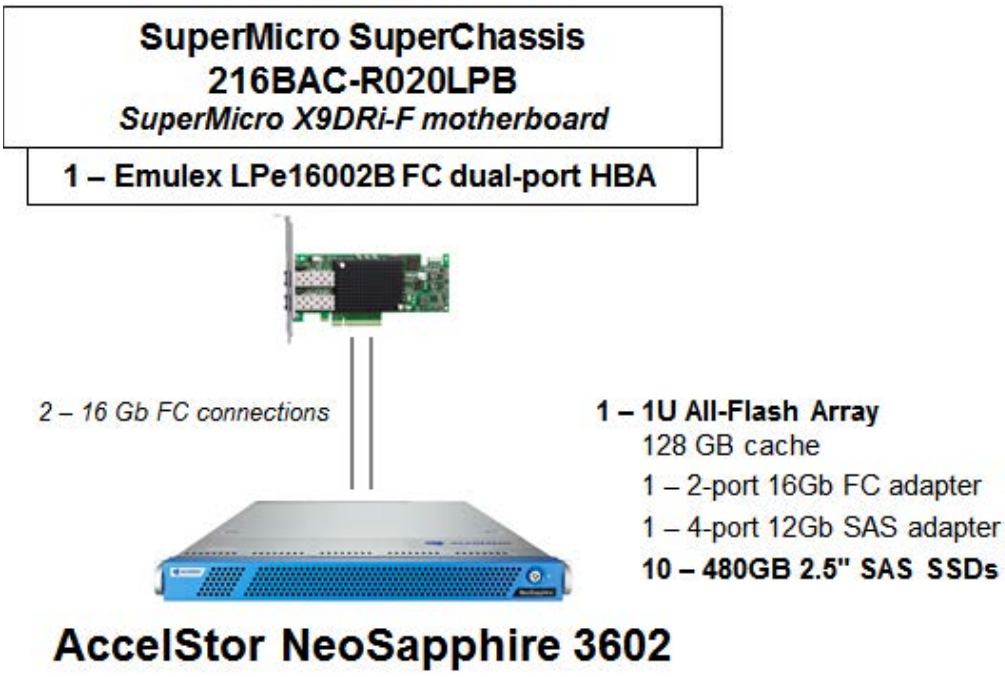
Host System(s) and Tested Storage Configuration (TSC) Table of Components

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

Benchmark Configuration/Tested Storage Configuration Diagram



Host System and Tested Storage Configuration Components

Host System
1 – Supermicro SuperChassis 216BAC-R920LPB, with: Supermicro X9DRi-F motherboard 1 – Intel® Xeon® 3.00 GHz processor E5-2690 V2 with 10 cores, 25 MB SmartCache 128 GB main memory Red Hat Enterprise Linux Server release 6.4 x86_64 PCIe
Tested Storage Configuration
AccelStor FlexiRemap™
1 – Emulex LPe16002B FC dual-port, 16 Gbps, FC HBA
AccelStor NeoSapphire 3602 1 – 1U All Flash Array 128 GB cache 1 – 2-port 16 Gb FC adapter 1 – 4-port 12 Gb SAS adapter 10 – 480 GB, 2.5” SAS SSDs

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 77 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 78 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 84.

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 84.

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 73 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 4,801.000 GB distributed over 10 solid state drives (SSDs) each with a formatted capacity of 480.100 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0,000 GB (0.00%) of the Physical Storage Capacity. There was 609.990 GB (12.71%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100.00% 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 960.200 GB of which 858.535 GB was utilized. The total Unused Storage capacity was 609.90 GB.

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.

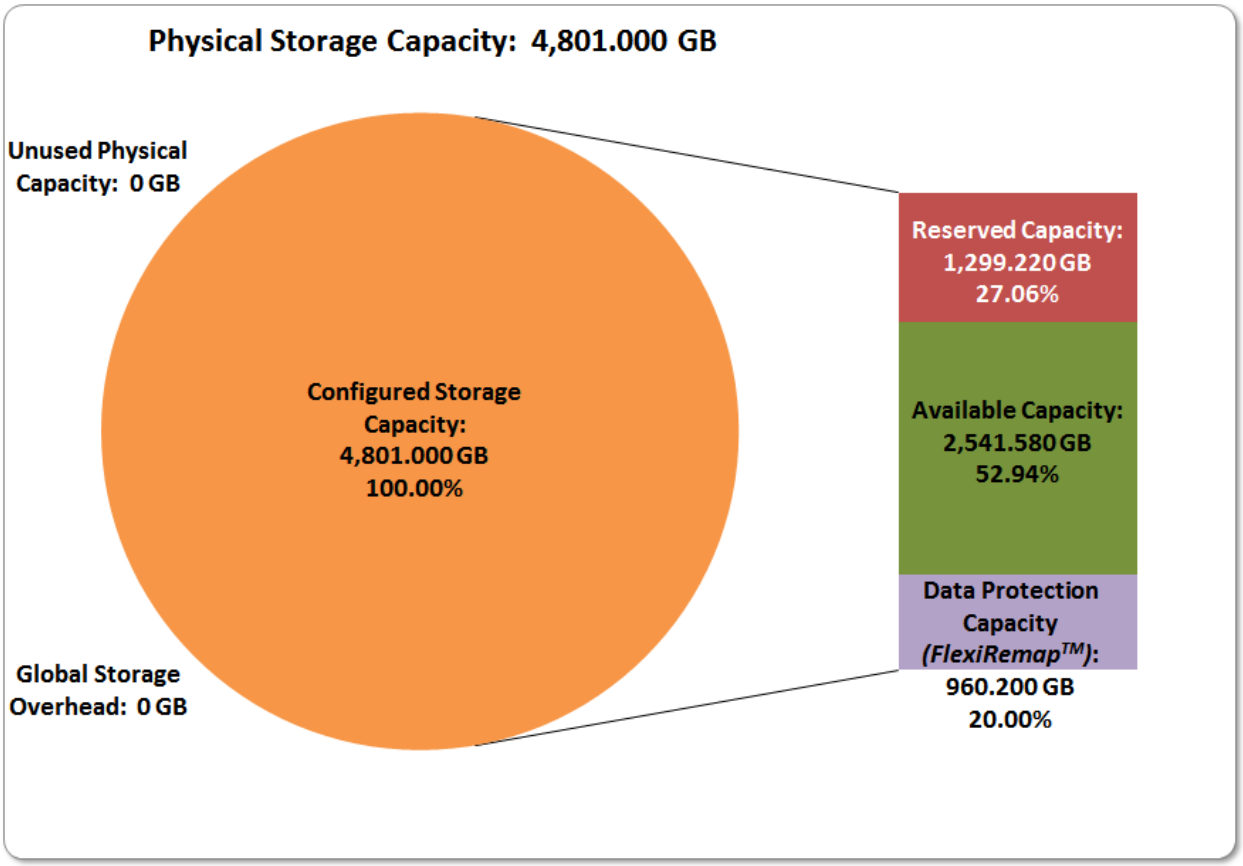
SPC-1 Storage Capacities

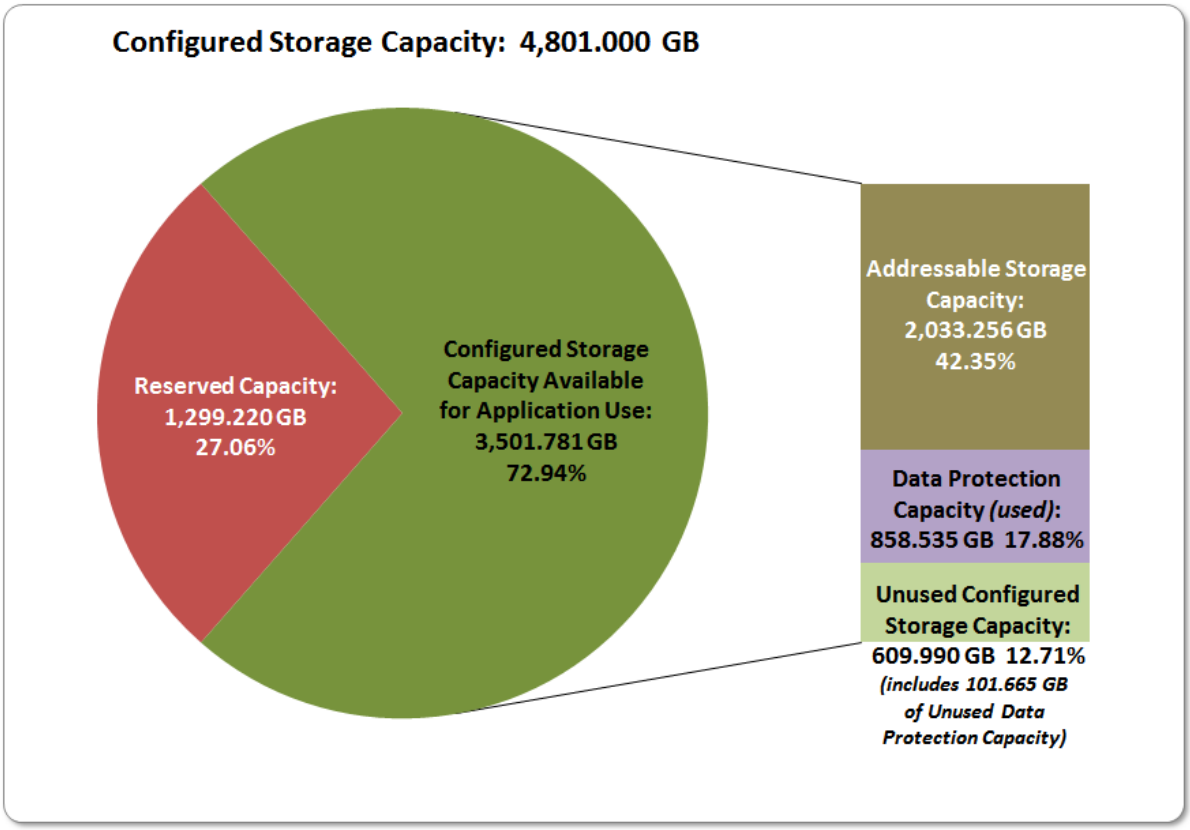
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	2,033.256
Addressable Storage Capacity	Gigabytes (GB)	2,033.256
Configured Storage Capacity	Gigabytes (GB)	4,801.000
Physical Storage Capacity	Gigabytes (GB)	4,801.000
Data Protection (*FlexiRemap™*)	Gigabytes (GB)	960.200
Required Storage	Gigabytes (GB)	1,229.220
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	609.990

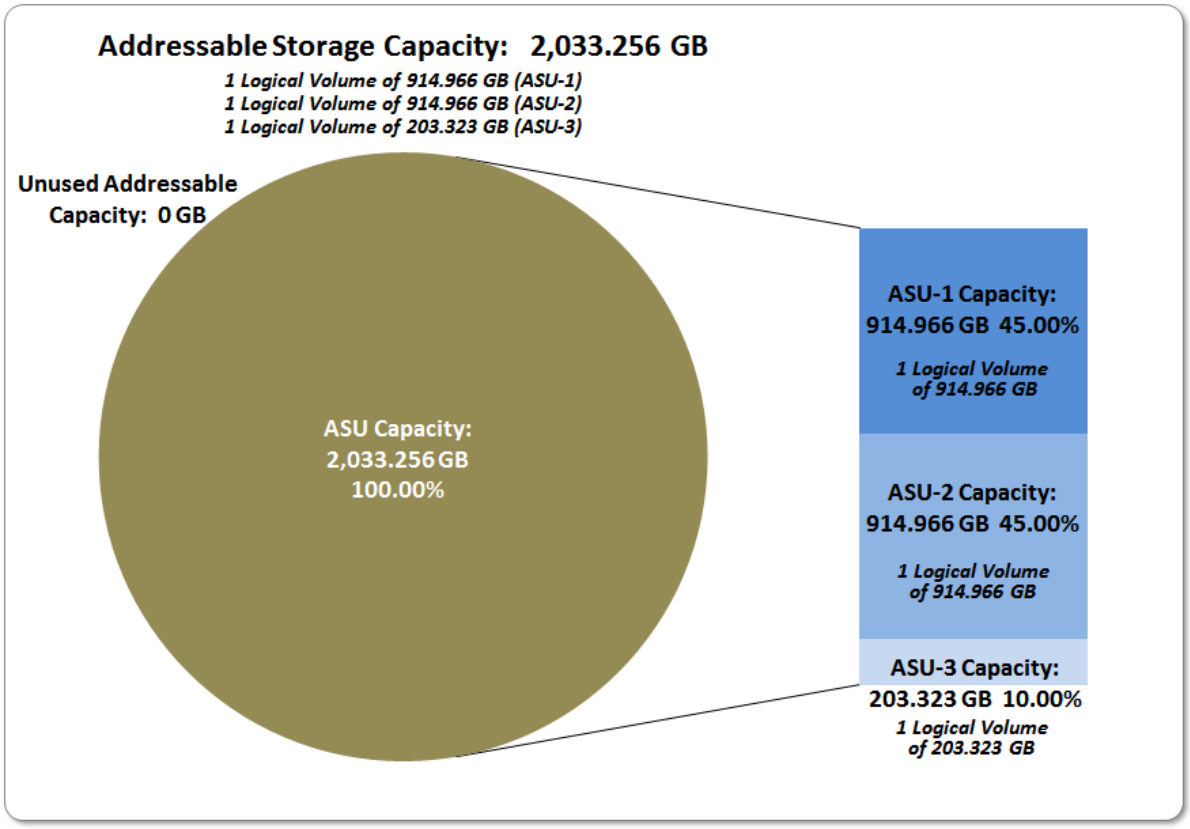
SPC-1 Storage Hierarchy Ratios

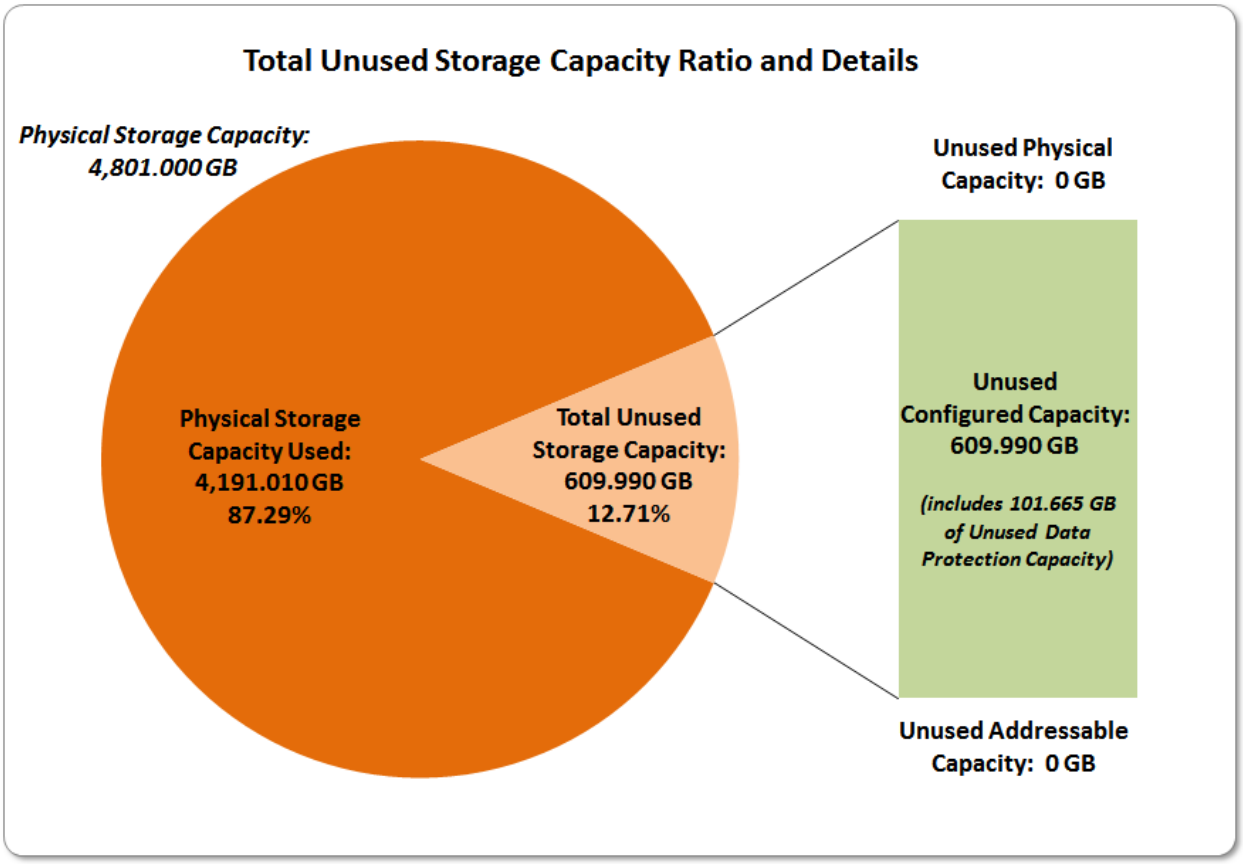
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	42.35%	42.35%
Required for Data Protection (*FlexiRemap™*)		20.00%	20.00%
Addressable Storage Capacity		42.35%	42.35%
Required Storage		27.06%	27.06%
Configured Storage Capacity			100.00%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	0.00%		
Configured		12.71%	
Physical			0.00%

SPC-1 Storage Capacity Charts




Configured Storage Capacity: 4,801.000 GB
Reserved Capacity:
1,299.220 GB
27.06%
Configured Storage Capacity Available for Application Use:
3,501.781 GB
72.94%
Addressable Storage Capacity:
2,033.256 GB
42.35%
Data Protection Capacity (used):
858.535 GB 17.88%
Unused Configured Storage Capacity:
609.990 GB 12.71%
(includes 101.665 GB of Unused Data Protection Capacity)


Addressable Storage Capacity: 2,033.256 GB
1 Logical Volume of 914.966 GB (ASU-1)
1 Logical Volume of 914.966 GB (ASU-2)
1 Logical Volume of 203.323 GB (ASU-3)
Unused Addressable Capacity: 0 GB
ASU Capacity:
2,033.256 GB
100.00%
ASU-1 Capacity:
914.966 GB 45.00%
1 Logical Volume of 914.966 GB
ASU-2 Capacity:
914.966 GB 45.00%
1 Logical Volume of 914.966 GB
ASU-3 Capacity:
203.323 GB 10.00%
1 Logical Volume of 203.323 GB



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	42.35%
Protected Application Utilization	60.23%
Unused Storage Ratio	12.71%

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 (914.966 GB)
1 Logical Volume 914.966 GB per Logical Volume (914.966 GB used per Logical Volume)
ASU-2 (914.966 GB)
1 Logical Volume 914.966 GB per Logical Volume (914.966 GB used per Logical Volume)
ASU-3 (203.323 GB)
1 Logical Volume 203.323 GB per Logical Volume (203.323 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **Protected 1** using ***FlexiRemap™*** 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 73 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.

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 86.

Sustainability Test Results File

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

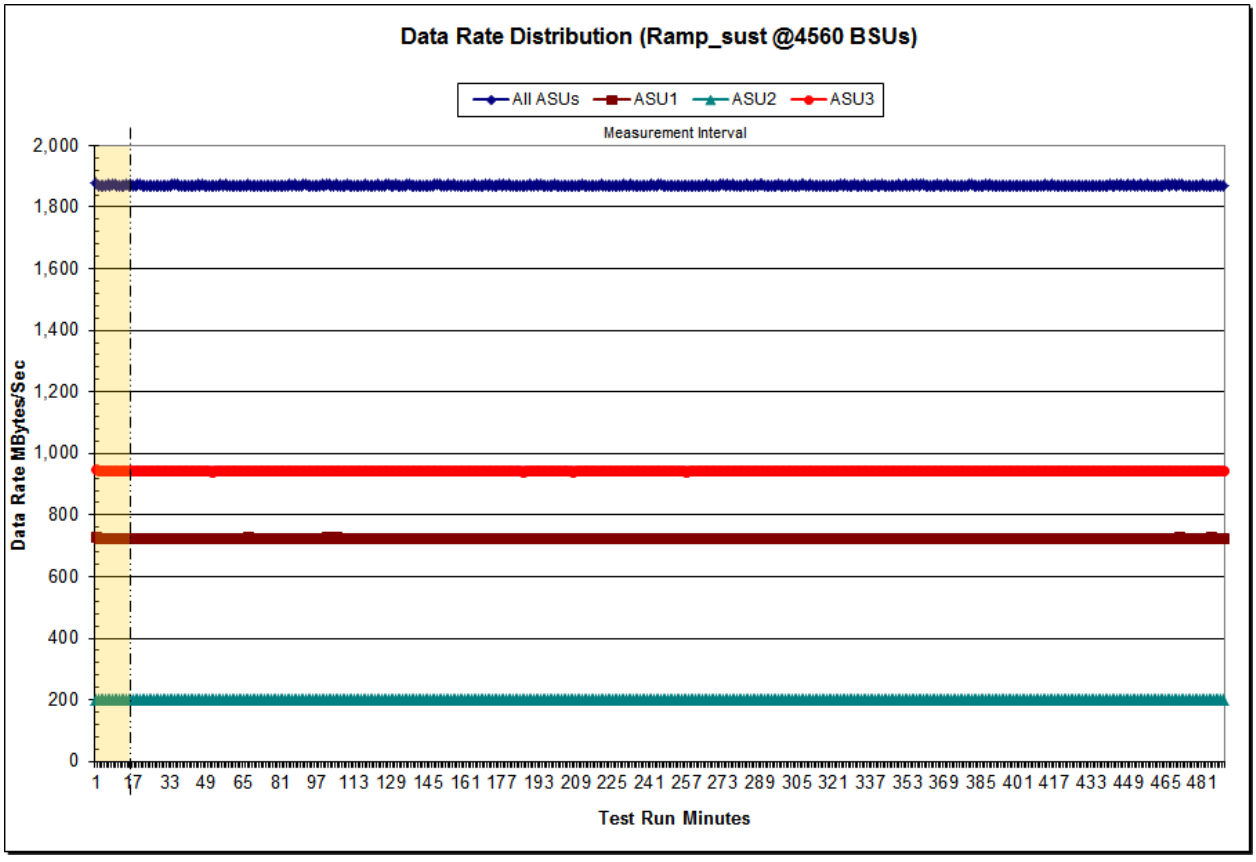
Sustainability Test Results File

Sustainability – Data Rate Distribution Data (MB/second)

The *"Sustainability – Data Rate Distribution Data"* table is not embedded in this document due to its size. The table is available via the following URL:

Sustainability Data Rate Distribution Data Table

Sustainability – Data Rate Distribution Graph

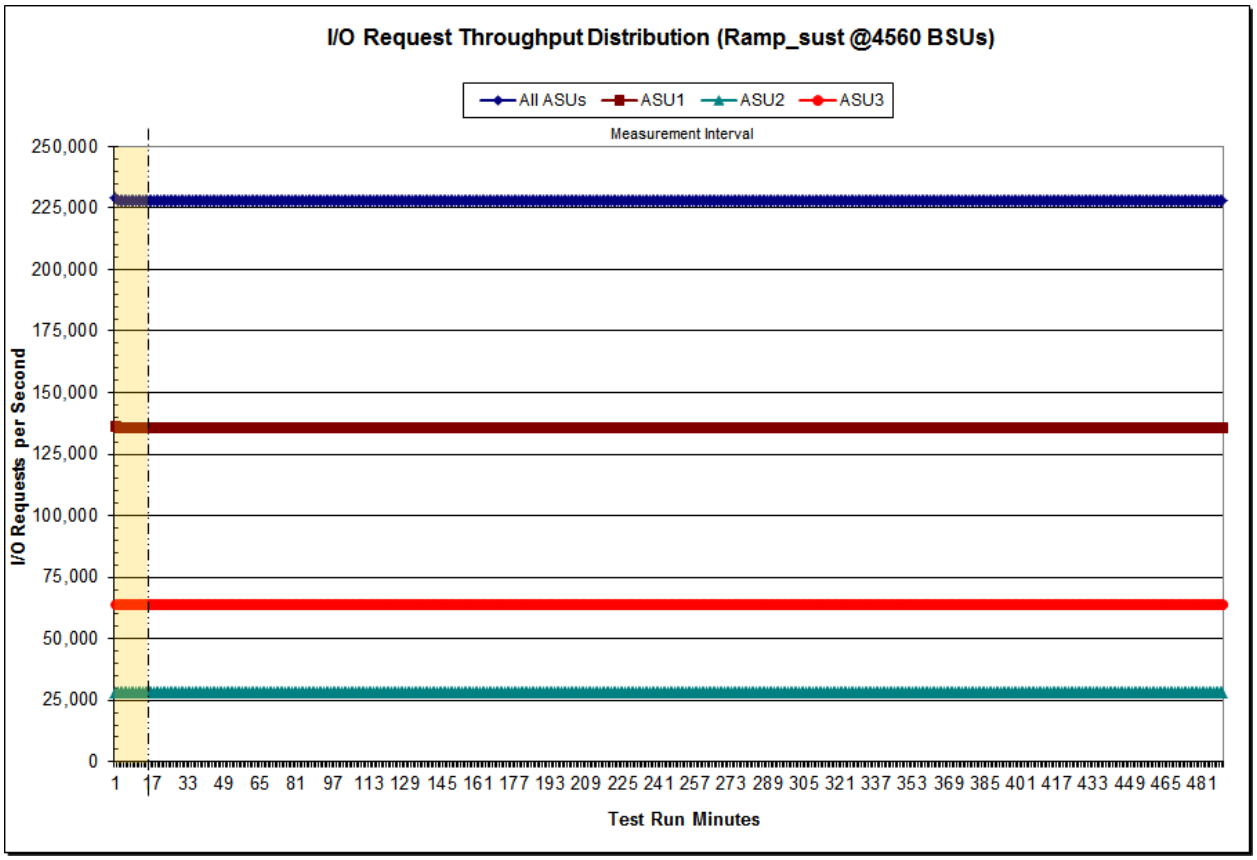


Sustainability – I/O Request Throughput Distribution Data

The *"Sustainability – I/O Request Throughput Data"* table 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

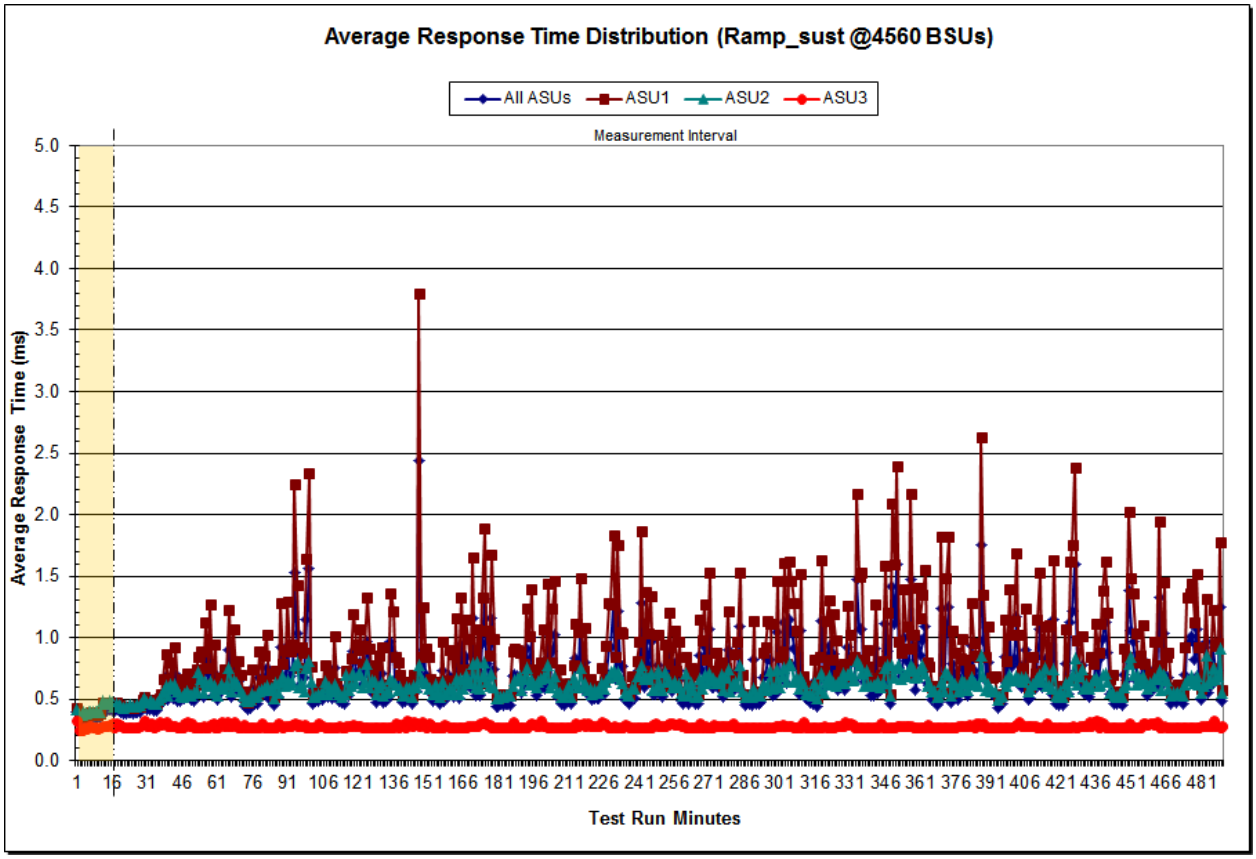


Sustainability – Average Response Time (ms) Distribution Data

The *"Sustainability – Average Response Time Distribution Data"* table is not embedded in this document due to its size. The table is available via the following URL:

Sustainability Average Response Time Distribution Data Table

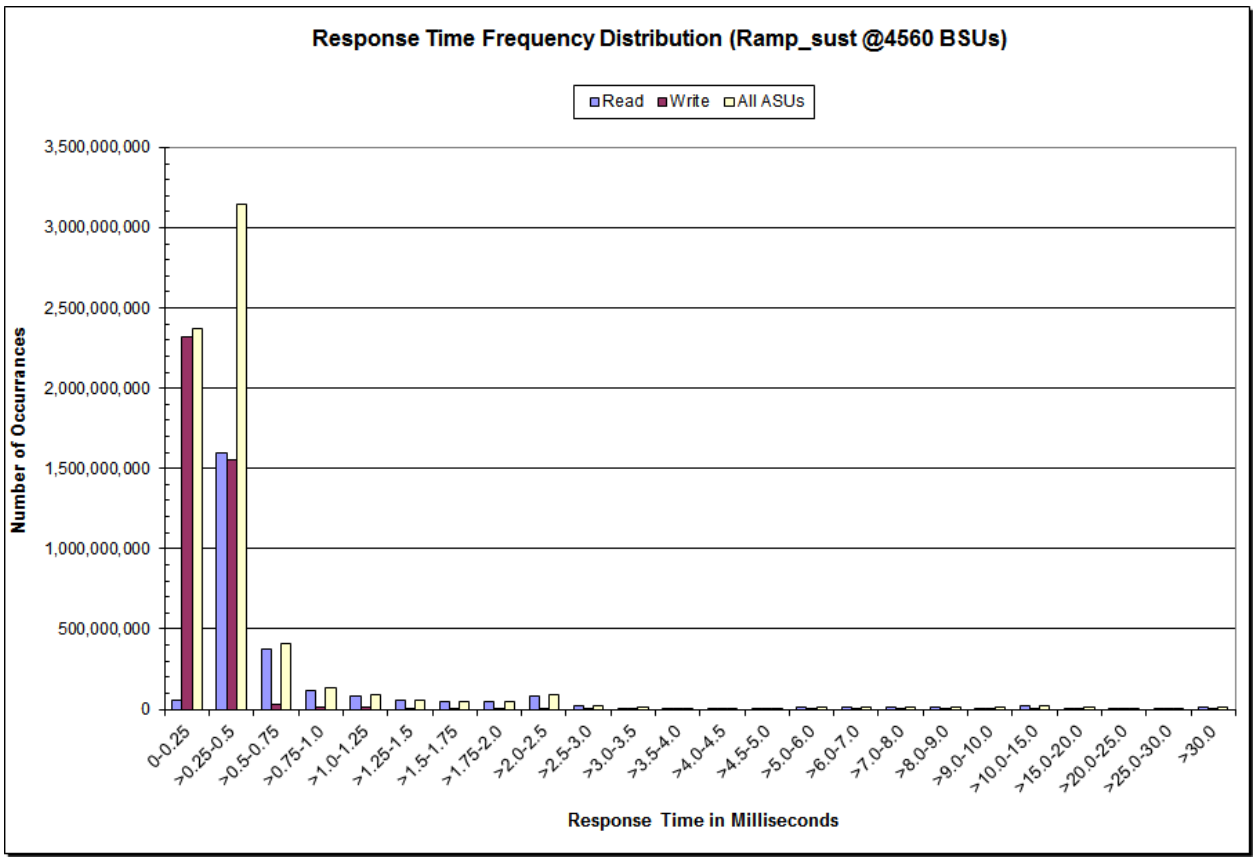
Sustainability – Average Response Time (ms) Distribution Graph



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	57,813,520	1,598,289,072	378,693,689	116,964,526	79,016,595	52,186,566	44,428,153	43,234,957
Write	2,317,474,258	1,549,943,820	33,804,038	13,845,529	11,467,723	5,874,321	3,272,988	2,715,296
All ASUs	2,375,287,778	3,148,232,892	412,497,727	130,810,055	90,484,318	58,060,887	47,701,141	45,950,253
ASU1	1,196,220,865	1,888,619,948	325,453,556	101,658,809	69,067,484	44,898,072	37,604,159	36,301,965
ASU2	287,614,561	347,639,700	65,372,643	22,629,289	16,222,847	10,582,890	8,989,718	8,874,743
ASU3	891,452,352	911,973,244	21,671,528	6,521,957	5,193,987	2,579,925	1,107,264	773,545
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	82,853,675	21,602,724	7,188,658	6,206,480	5,779,951	5,533,541	10,710,605	10,257,695
Write	4,382,733	3,488,132	2,800,890	2,127,490	1,563,614	1,213,876	1,905,256	1,530,085
All ASUs	87,236,408	25,090,856	9,989,548	8,333,970	7,343,565	6,747,417	12,615,861	11,787,780
ASU1	68,725,859	19,898,457	8,286,089	6,874,733	5,992,829	5,482,282	10,346,001	9,873,897
ASU2	17,544,093	4,668,835	1,371,090	1,220,350	1,163,887	1,106,031	2,002,863	1,680,728
ASU3	966,456	523,564	332,369	238,887	186,849	159,104	266,997	233,155
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	9,584,807	8,855,543	7,615,120	19,220,376	6,876,225	3,264,658	2,647,888	10,911,343
Write	1,334,936	1,218,992	1,111,380	3,435,889	2,254,388	1,957,603	1,618,741	6,211,366
All ASUs	10,919,743	10,074,535	8,726,500	22,656,265	9,130,613	5,222,261	4,266,629	17,122,709
ASU1	9,287,118	8,595,818	7,404,074	18,683,658	7,958,722	5,061,389	4,171,628	17,030,594
ASU2	1,416,125	1,271,803	1,126,890	3,653,184	1,167,172	158,869	93,738	86,382
ASU3	216,500	206,914	195,536	319,423	4,719	2,003	1,263	5,733

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	0.001	0.001	0.002	0.001	0.001	0.000

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

The IOPS Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of ten (10) minutes. The IOPS Test Phase immediately follows the Sustainability Test Phase without any interruption or manual intervention.

The IOPS Test Run generates the SPC-1 IOPS™ primary metric, which is computed as the I/O Request Throughput for the Measurement Interval of the IOPS Test Run.

The Average Response Time is computed for the IOPS Test Run and cannot exceed 30 milliseconds. If the Average Response Time exceeds the 30 millisecond constraint, the measurement is invalid.

Clause 9.4.3.7.3

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 86.

IOPS Test Results File

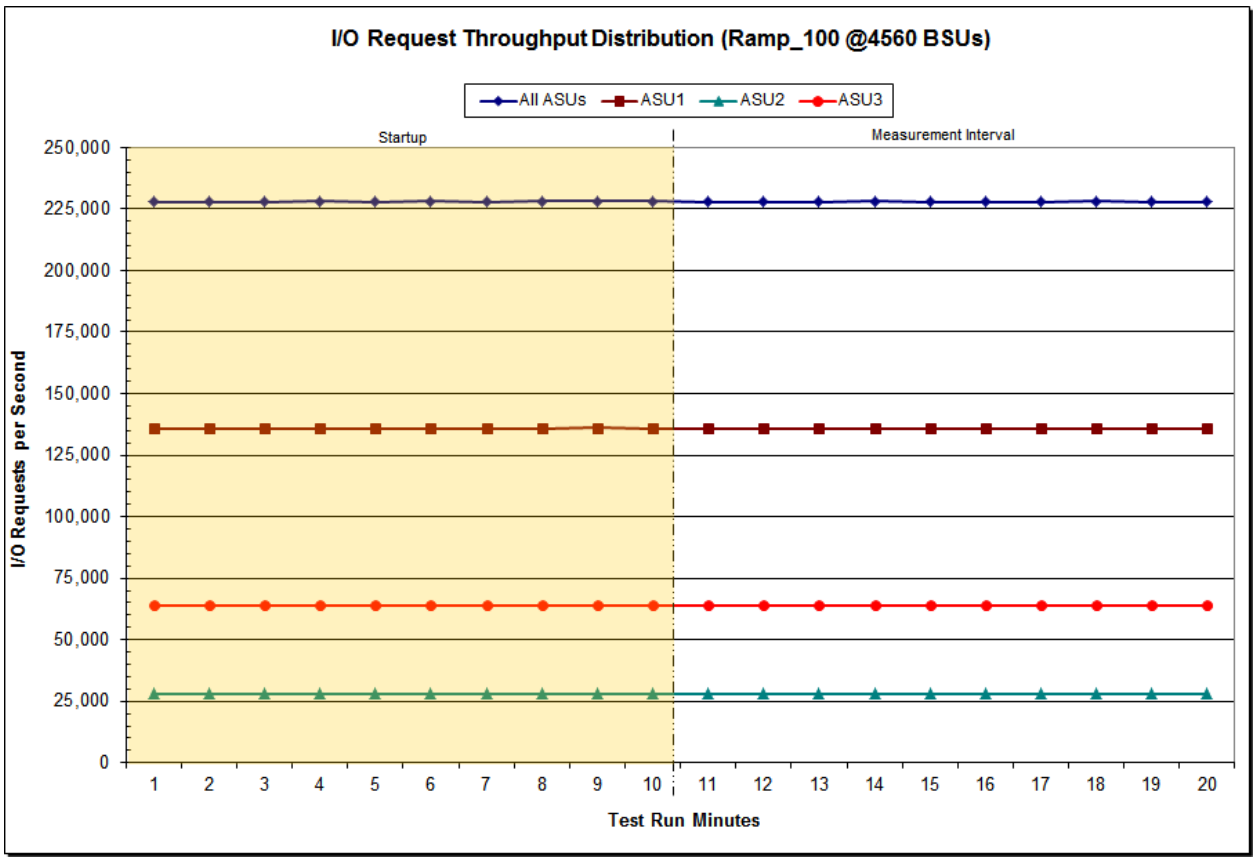
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

4,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:57:24	6:07:25	0-9	0:10:01
Measurement Interval	6:07:25	6:17:25	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*227,980.93*	*135,824.12*	*28,030.98*	*64,125.83*
1	*227,959.17*	*135,851.72*	*28,069.35*	*64,038.10*
2	*228,008.28*	*135,899.05*	*28,030.98*	*64,078.25*
3	*228,031.65*	*135,924.27*	*28,040.32*	*64,067.07*
4	*227,963.22*	*135,877.45*	*28,022.67*	*64,063.10*
5	*228,102.55*	*135,924.95*	*28,079.78*	*64,097.82*
6	*228,004.90*	*135,910.32*	*28,038.67*	*64,055.92*
7	*228,054.67*	*135,916.65*	*28,073.37*	*64,064.65*
8	*228,123.83*	*135,984.88*	*28,068.48*	*64,070.47*
9	*228,057.18*	*135,925.33*	*28,050.35*	*64,081.50*
10	228,003.88	135,877.25	28,045.90	64,080.73
11	227,981.95	135,910.18	28,010.00	64,061.77
12	227,875.15	135,844.63	28,033.25	63,997.27
13	228,024.63	135,894.72	28,040.48	64,089.43
14	227,874.83	135,824.75	28,049.10	64,000.98
15	227,950.10	135,867.97	28,069.75	64,012.38
16	228,018.85	135,871.23	28,062.98	64,084.63
17	228,064.27	135,890.13	28,067.02	64,107.12
18	227,974.75	135,829.55	28,036.97	64,108.23
19	227,934.67	135,890.45	28,003.97	64,040.25
Average	**227,970.31**	**135,870.09**	**28,041.94**	**64,058.28**

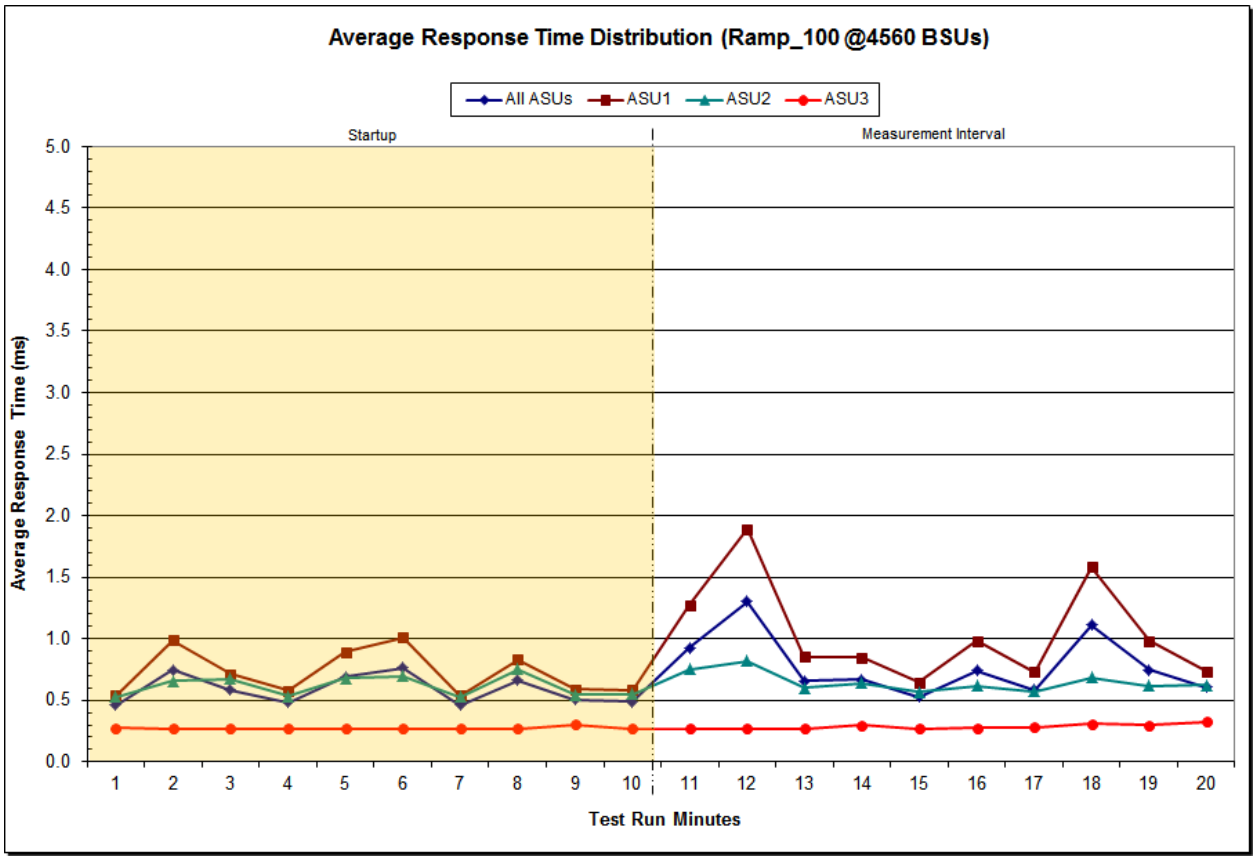
IOPS Test Run – I/O Request Throughput Distribution Graph



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

4,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:57:24	6:07:25	0-9	0:10:01
Measurement Interval	6:07:25	6:17:25	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*0.46*	*0.54*	*0.53*	*0.28*
1	*0.75*	*0.99*	*0.66*	*0.27*
2	*0.58*	*0.71*	*0.68*	*0.27*
3	*0.49*	*0.58*	*0.54*	*0.27*
4	*0.69*	*0.90*	*0.68*	*0.27*
5	*0.76*	*1.01*	*0.70*	*0.27*
6	*0.46*	*0.54*	*0.53*	*0.27*
7	*0.66*	*0.83*	*0.75*	*0.27*
8	*0.50*	*0.59*	*0.55*	*0.30*
9	*0.49*	*0.58*	*0.55*	*0.27*
10	0.93	1.27	0.75	0.27
11	1.30	1.89	0.82	0.27
12	0.66	0.86	0.60	0.27
13	0.67	0.85	0.64	0.30
14	0.53	0.64	0.57	0.27
15	0.74	0.98	0.62	0.27
16	0.58	0.73	0.57	0.28
17	1.11	1.58	0.68	0.31
18	0.75	0.98	0.62	0.30
19	0.61	0.74	0.62	0.33
Average	**0.79**	**1.05**	**0.65**	**0.29**

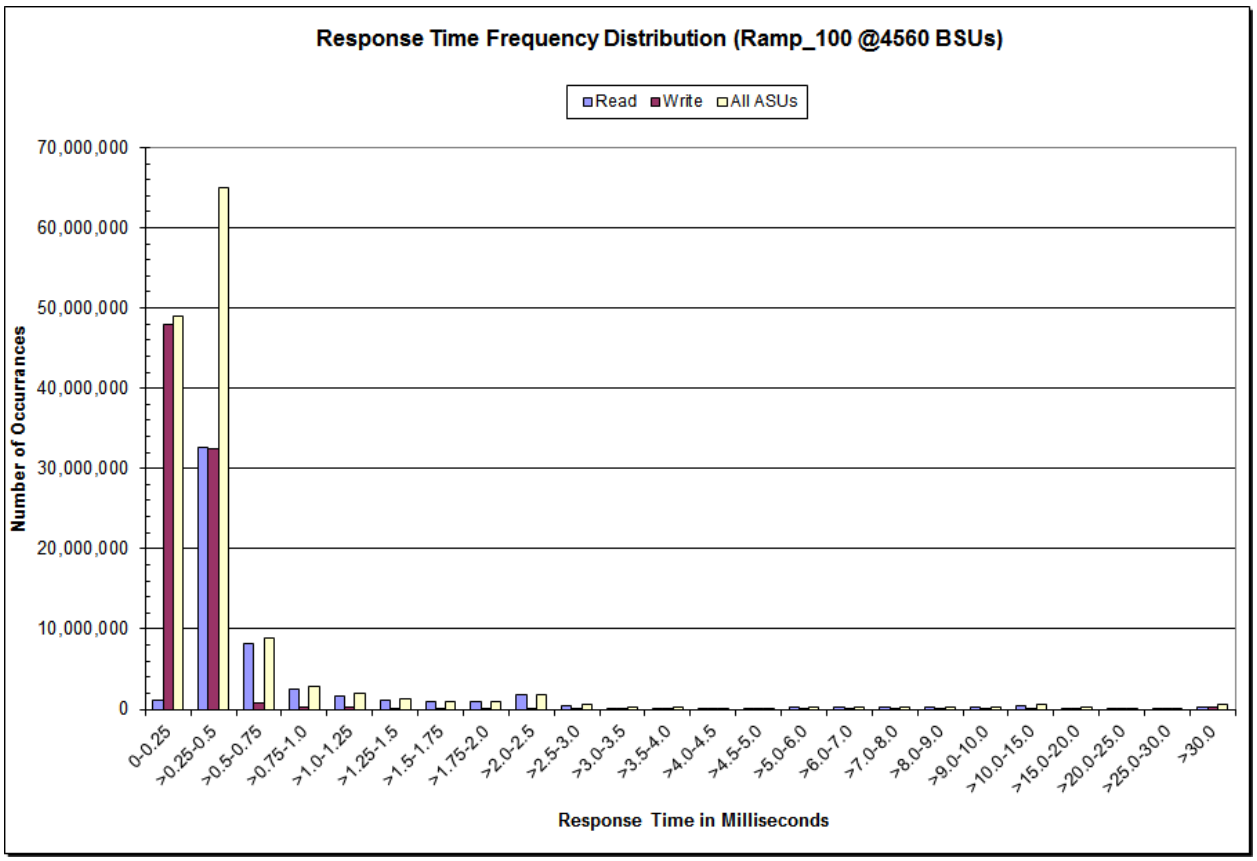
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	1,147,704	32,561,846	8,142,997	2,537,556	1,679,459	1,106,599	936,840	913,251
Write	47,866,066	32,480,426	729,279	296,886	241,331	122,461	71,010	56,645
All ASUs	49,013,770	65,042,272	8,872,276	2,834,442	1,920,790	1,229,060	1,007,850	969,896
ASU1	24,673,846	38,760,304	6,998,768	2,201,811	1,466,110	949,435	793,288	766,158
ASU2	5,947,815	7,157,516	1,401,320	489,734	343,635	225,200	190,056	187,506
ASU3	18,392,109	19,124,452	472,188	142,897	111,045	54,425	24,506	16,232
Response Time (ms)	**>2.0-2.5**	**>2.5-3.0**	**>3.0-3.5**	**>3.5-4.0**	**>4.0-4.5**	**>4.5-5.0**	**>5.0-6.0**	**>6.0-7.0**
Read	1,748,168	470,450	156,231	134,978	124,784	120,937	233,537	223,870
Write	90,550	74,403	61,640	48,513	37,585	29,931	45,615	39,197
All ASUs	1,838,718	544,853	217,871	183,491	162,369	150,868	279,152	263,067
ASU1	1,448,968	431,596	180,525	150,676	133,207	122,334	227,488	217,496
ASU2	370,787	102,218	30,433	27,290	24,791	23,832	44,027	38,176
ASU3	18,963	11,039	6,913	5,525	4,371	4,702	7,637	7,395
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	211,717	203,718	181,768	462,800	161,701	79,025	68,539	340,986
Write	33,791	29,527	27,077	90,658	61,153	48,046	45,245	205,578
All ASUs	245,508	233,245	208,845	553,458	222,854	127,071	113,784	546,564
ASU1	205,396	195,585	174,697	453,339	194,588	123,375	110,757	542,239
ASU2	33,310	31,534	28,509	88,843	28,081	3,625	2,962	3,949
ASU3	6,802	6,126	5,639	11,276	185	71	65	376

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval
136,782,074
I/O Requests Completed with Response Time = or < 30 ms
136,235,510
I/O Requests Completed with Response Time > 30 ms
546,564

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	0.001	0.001	0.001	0.001	0.002	0.001	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 86.

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.

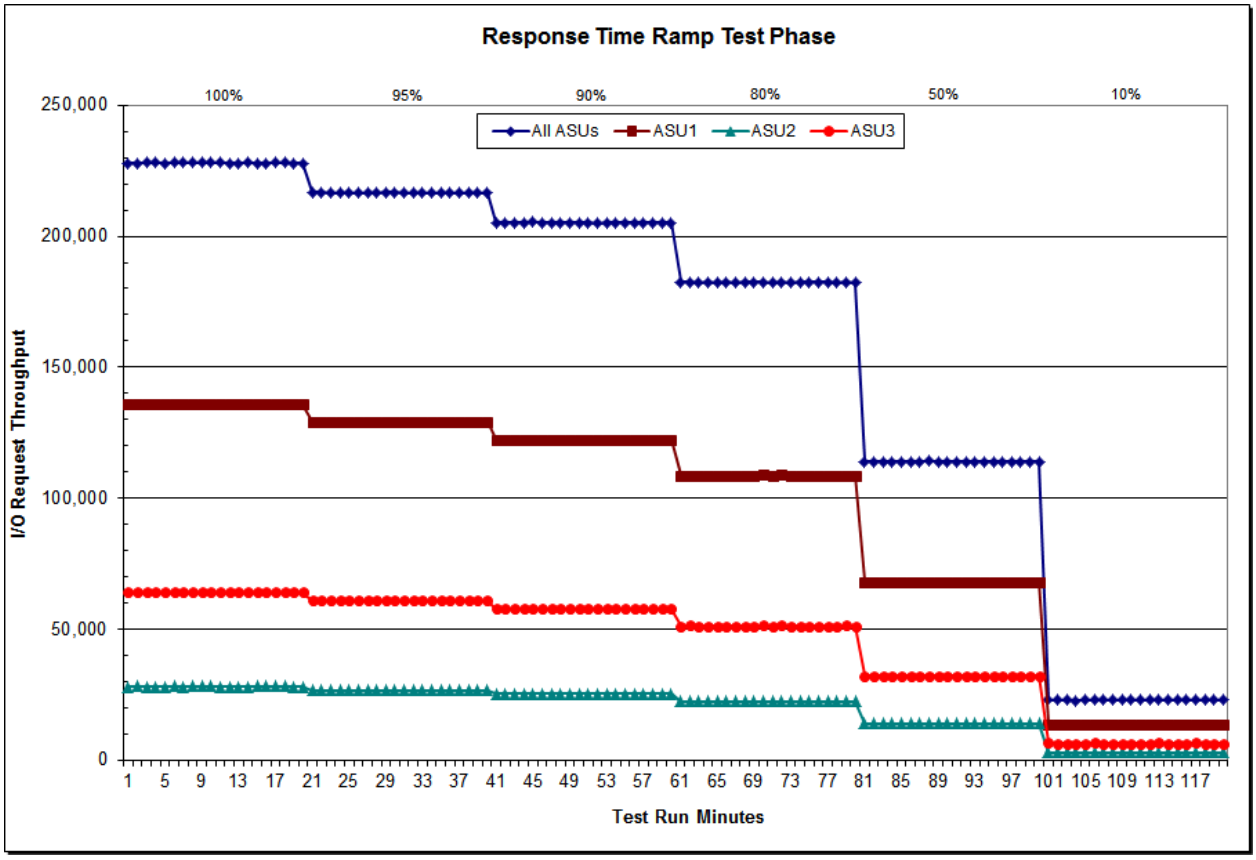
100% Load Level: 4,560 BSUs	Start	Stop	Interval	Duration	95% Load Level: 4,332 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:57:24	6:07:25	0-9	0:10:01	Start-Up/Ramp-Up	6:17:31	6:27:32	0-9	0:10:01
Measurement Interval	6:07:25	6:17:25	10-19	0:10:00	Measurement Interval	6:27:32	6:37:32	10-19	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	*(60 second intervals)*	All ASUs	ASU-1	ASU-2	ASU-3
0	*227,980.93*	*135,824.12*	*28,030.98*	*64,125.83*	*0*	*216,723.65*	*129,187.18*	*26,641.15*	*60,895.32*
1	*227,959.17*	*135,851.72*	*28,069.35*	*64,038.10*	*1*	*216,729.75*	*129,202.87*	*26,654.70*	*60,872.18*
2	*228,008.28*	*135,899.05*	*28,030.98*	*64,078.25*	*2*	*216,603.77*	*129,086.12*	*26,631.58*	*60,886.07*
3	*228,031.65*	*135,924.27*	*28,040.32*	*64,067.07*	*3*	*216,469.92*	*129,035.00*	*26,633.25*	*60,801.67*
4	*227,963.22*	*135,877.45*	*28,022.67*	*64,063.10*	*4*	*216,616.60*	*129,127.37*	*26,629.87*	*60,859.37*
5	*228,102.55*	*135,924.95*	*28,079.78*	*64,097.82*	*5*	*216,566.68*	*129,097.18*	*26,637.95*	*60,831.55*
6	*228,004.90*	*135,910.32*	*28,038.67*	*64,055.92*	*6*	*216,635.50*	*129,109.45*	*26,647.15*	*60,878.90*
7	*228,054.67*	*135,916.65*	*28,073.37*	*64,064.65*	*7*	*216,405.02*	*128,979.65*	*26,613.25*	*60,812.12*
8	*228,123.83*	*135,984.88*	*28,068.48*	*64,070.47*	*8*	*216,710.58*	*129,183.22*	*26,667.08*	*60,860.28*
9	*228,057.18*	*135,925.33*	*28,050.35*	*64,081.50*	*9*	*216,668.10*	*129,155.70*	*26,629.55*	*60,882.85*
10	228,003.88	135,877.25	28,045.90	64,080.73	**10**	216,584.53	129,066.90	26,662.22	60,855.42
11	227,981.95	135,910.18	28,010.00	64,061.77	**11**	216,540.65	129,059.53	26,615.52	60,865.60
12	227,875.15	135,844.63	28,033.25	63,997.27	**12**	216,576.23	129,070.22	26,642.97	60,863.05
13	228,024.63	135,894.72	28,040.48	64,089.43	**13**	216,607.13	129,059.38	26,655.37	60,892.38
14	227,874.83	135,824.75	28,049.10	64,000.98	**14**	216,626.68	129,103.25	26,610.25	60,913.18
15	227,950.10	135,867.97	28,069.75	64,012.38	**15**	216,633.32	129,111.73	26,652.38	60,869.20
16	228,018.85	135,871.23	28,062.98	64,084.63	**16**	216,623.30	129,093.53	26,635.12	60,894.65
17	228,064.27	135,890.13	28,067.02	64,107.12	**17**	216,538.58	129,062.52	26,612.70	60,863.37
18	227,974.75	135,829.55	28,036.97	64,108.23	**18**	216,626.93	129,120.18	26,637.02	60,869.73
19	227,934.67	135,890.45	28,003.97	64,040.25	**19**	216,574.48	129,080.13	26,666.53	60,827.82
Average	**227,970.31**	**135,870.09**	**28,041.94**	**64,058.28**	**Average**	**216,593.19**	**129,082.74**	**26,639.01**	**60,871.44**

90% Load Level: 4,104 BSUs	Start	Stop	Interval	Duration	80% Load Level: 3,648 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	6:37:37	23:13:21	0-9	16:35:44	Start-Up/Ramp-Up	6:57:43	7:07:44	0-9	0:10:01
Measurement Interval	23:13:21	23:13:21	10-19	0:00:00	Measurement Interval	7:07:44	7:17:44	10-19	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	*(60 second intervals)*	All ASUs	ASU-1	ASU-2	ASU-3
0	*205,177.57*	*122,295.53*	*25,250.17*	*57,631.87*	*0*	*182,387.73*	*108,725.23*	*22,451.30*	*51,211.20*
1	*205,236.13*	*122,366.78*	*25,235.42*	*57,633.93*	*1*	*182,461.48*	*108,715.18*	*22,454.83*	*51,291.47*
2	*205,217.32*	*122,251.62*	*25,275.85*	*57,689.85*	*2*	*182,308.48*	*108,696.42*	*22,437.37*	*51,174.70*
3	*205,234.33*	*122,334.02*	*25,231.42*	*57,668.90*	*3*	*182,365.90*	*108,745.00*	*22,418.52*	*51,202.38*
4	*205,316.15*	*122,371.48*	*25,241.53*	*57,703.13*	*4*	*182,327.85*	*108,630.78*	*22,463.37*	*51,233.70*
5	*205,134.85*	*122,289.12*	*25,227.48*	*57,618.25*	*5*	*182,426.47*	*108,731.23*	*22,439.32*	*51,255.92*
6	*205,165.82*	*122,299.15*	*25,225.02*	*57,641.65*	*6*	*182,353.20*	*108,685.23*	*22,423.98*	*51,243.98*
7	*205,144.57*	*122,237.85*	*25,246.38*	*57,660.33*	*7*	*182,386.97*	*108,722.27*	*22,426.95*	*51,237.75*
8	*205,200.75*	*122,291.98*	*25,256.25*	*57,652.52*	*8*	*182,431.10*	*108,733.83*	*22,446.60*	*51,250.67*
9	*205,189.47*	*122,319.68*	*25,204.17*	*57,665.62*	*9*	*182,476.33*	*108,791.93*	*22,413.78*	*51,270.62*
10	205,245.10	122,313.70	25,248.50	57,682.90	**10**	182,314.83	108,659.30	22,438.70	51,216.83
11	205,029.05	122,159.50	25,250.60	57,618.95	**11**	182,484.08	108,768.95	22,435.67	51,279.47
12	205,170.23	122,340.90	25,213.85	57,615.48	**12**	182,331.87	108,663.53	22,412.35	51,255.98
13	205,245.30	122,328.07	25,256.67	57,660.57	**13**	182,361.63	108,741.02	22,377.87	51,242.75
14	205,247.75	122,338.62	25,240.25	57,668.88	**14**	182,374.97	108,689.52	22,438.62	51,246.83
15	205,240.88	122,291.90	25,244.37	57,704.62	**15**	182,399.70	108,745.02	22,446.35	51,208.33
16	205,213.37	122,310.55	25,251.35	57,651.47	**16**	182,401.35	108,721.45	22,440.58	51,239.32
17	205,129.10	122,218.75	25,226.12	57,684.23	**17**	182,344.93	108,666.60	22,421.10	51,257.23
18	205,200.77	122,287.73	25,264.12	57,648.92	**18**	182,404.72	108,686.88	22,447.97	51,269.87
19	205,121.87	122,281.10	25,244.82	57,595.95	**19**	182,350.60	108,714.42	22,428.78	51,207.40
Average	**205,184.34**	**122,287.08**	**25,244.06**	**57,653.20**	**Average**	**182,376.87**	**108,705.67**	**22,428.80**	**51,242.40**

Response Time Ramp Distribution (IOPS) Data *(continued)*

50% Load Level: 2,280 BSUs	Start	Stop	Interval	Duration	10% Load Level: 456 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:17:47	7:27:48	0-9	0:10:01	Start-Up/Ramp-Up	7:37:50	7:47:51	0-9	0:10:01
Measurement Interval	7:27:48	7:37:48	10-19	0:10:00	Measurement Interval	7:47:51	7:57:51	10-19	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	*(60 second intervals)*	All ASUs	ASU-1	ASU-2	ASU-3
0	*113,957.83*	*67,892.92*	*14,013.08*	*32,051.83*	*0*	*22,800.05*	*13,560.97*	*2,807.28*	*6,431.80*
1	*113,926.48*	*67,899.95*	*14,007.42*	*32,019.12*	*1*	*22,807.45*	*13,591.40*	*2,801.55*	*6,414.50*
2	*114,028.22*	*67,964.58*	*14,014.55*	*32,049.08*	*2*	*22,801.58*	*13,603.58*	*2,791.65*	*6,406.35*
3	*114,003.87*	*67,948.78*	*14,008.78*	*32,046.30*	*3*	*22,770.20*	*13,571.18*	*2,796.82*	*6,402.20*
4	*114,035.80*	*67,963.10*	*14,021.68*	*32,051.02*	*4*	*22,785.63*	*13,589.03*	*2,796.43*	*6,400.17*
5	*114,023.92*	*67,962.10*	*14,018.78*	*32,043.03*	*5*	*22,830.72*	*13,604.18*	*2,801.88*	*6,424.65*
6	*113,966.53*	*67,898.10*	*14,033.77*	*32,034.67*	*6*	*22,799.57*	*13,598.77*	*2,801.38*	*6,399.42*
7	*114,084.22*	*67,957.53*	*14,034.88*	*32,091.80*	*7*	*22,801.63*	*13,603.70*	*2,794.65*	*6,403.28*
8	*113,981.97*	*67,937.17*	*14,012.17*	*32,032.63*	*8*	*22,796.78*	*13,594.02*	*2,800.83*	*6,401.93*
9	*113,951.65*	*67,879.35*	*14,034.48*	*32,037.82*	*9*	*22,847.92*	*13,625.03*	*2,809.53*	*6,413.35*
10	114,035.30	67,984.77	14,023.13	32,027.40	**10**	22,774.70	13,579.92	2,798.83	6,395.95
11	113,986.38	67,921.72	14,037.82	32,026.85	**11**	22,808.55	13,610.88	2,798.15	6,399.52
12	114,028.00	67,963.53	14,012.82	32,051.65	**12**	22,807.33	13,566.97	2,812.52	6,427.85
13	113,952.30	67,897.33	14,000.98	32,053.98	**13**	22,823.20	13,616.45	2,798.32	6,408.43
14	113,925.40	67,919.52	14,007.57	31,998.32	**14**	22,786.17	13,595.95	2,797.38	6,392.83
15	113,975.53	67,972.12	13,998.67	32,004.75	**15**	22,812.92	13,606.37	2,806.25	6,400.30
16	113,912.10	67,933.98	14,019.23	31,958.88	16	22,835.02	13,610.90	2,806.03	6,418.08
17	114,030.10	68,001.22	14,019.68	32,009.20	17	22,812.32	13,611.90	2,796.25	6,404.17
18	114,007.57	67,955.27	14,038.92	32,013.38	18	22,820.88	13,614.35	2,811.32	6,395.22
19	113,986.68	67,940.77	14,005.48	32,040.43	19	22,805.25	13,597.70	2,801.82	6,405.73
Average	**113,983.94**	**67,949.02**	**14,016.43**	**32,018.49**	**Average**	**22,808.63**	**13,601.14**	**2,802.69**	**6,404.81**

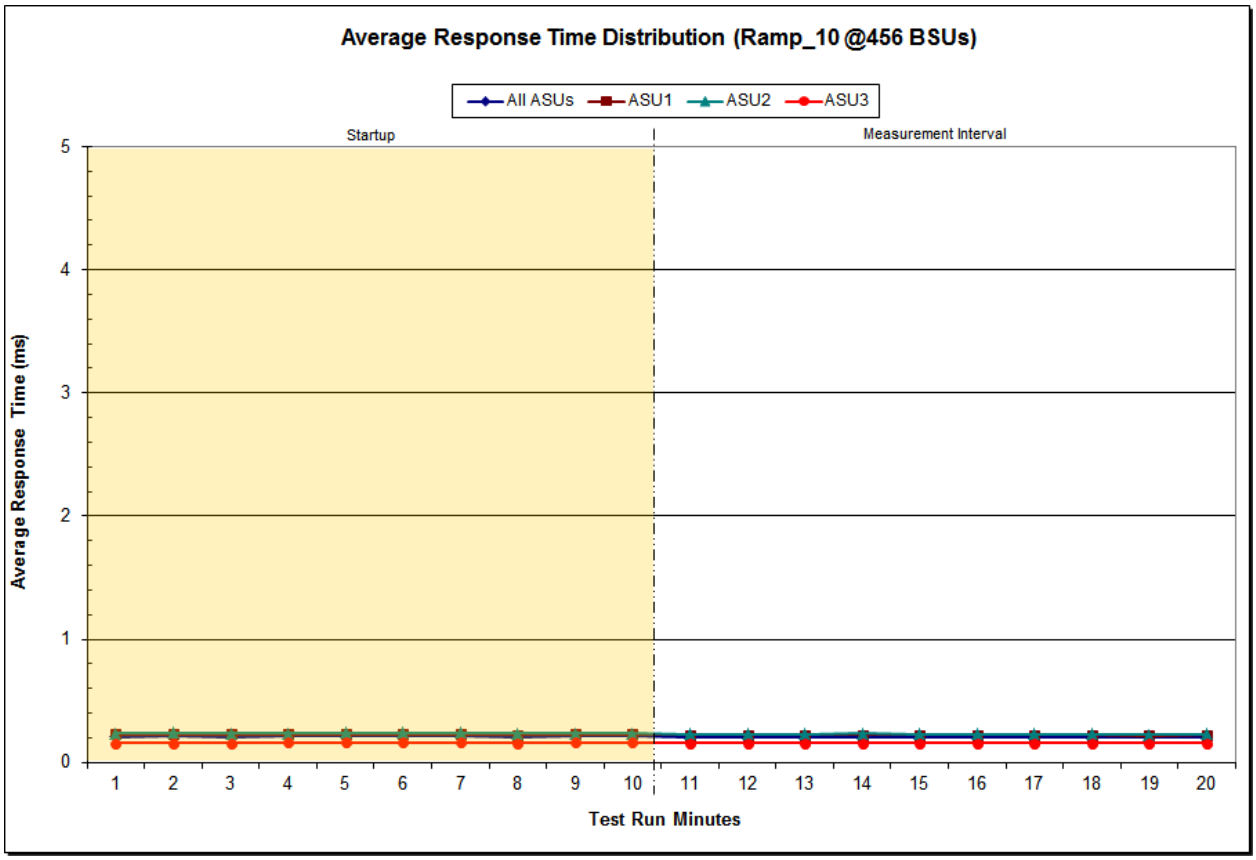
Response Time Ramp Distribution (IOPS) Graph



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

456 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:37:50	7:47:51	0-9	0:10:01
Measurement Interval	7:47:51	7:57:51	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*0.21*	*0.23*	*0.24*	*0.16*
1	*0.21*	*0.23*	*0.24*	*0.16*
2	*0.21*	*0.23*	*0.23*	*0.16*
3	*0.21*	*0.23*	*0.24*	*0.16*
4	*0.21*	*0.23*	*0.24*	*0.16*
5	*0.21*	*0.23*	*0.24*	*0.16*
6	*0.21*	*0.23*	*0.24*	*0.16*
7	*0.21*	*0.23*	*0.23*	*0.16*
8	*0.21*	*0.23*	*0.23*	*0.16*
9	*0.21*	*0.23*	*0.23*	*0.16*
10	0.21	0.22	0.23	0.16
11	0.21	0.22	0.23	0.16
12	0.21	0.22	0.23	0.16
13	0.21	0.23	0.23	0.16
14	0.21	0.22	0.23	0.16
15	0.20	0.22	0.23	0.16
16	0.20	0.22	0.23	0.16
17	0.21	0.22	0.23	0.16
18	0.20	0.22	0.23	0.16
19	0.20	0.22	0.23	0.16
Average	**0.21**	**0.22**	**0.23**	**0.16**

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	0.0349	0.2811	0.0700	0.2102	0.0180	0.0699	0.0350	0.2808
COV	0.006	0.002	0.003	0.002	0.004	0.003	0.004	0.002

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 86.

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	***227,970.31***
Repeatability Test Phase 1	228,009.87
Repeatability Test Phase 2	228,048.16

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	***0.21***
Repeatability Test Phase 1	0.19
Repeatability Test Phase 2	0.24

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 plus 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)

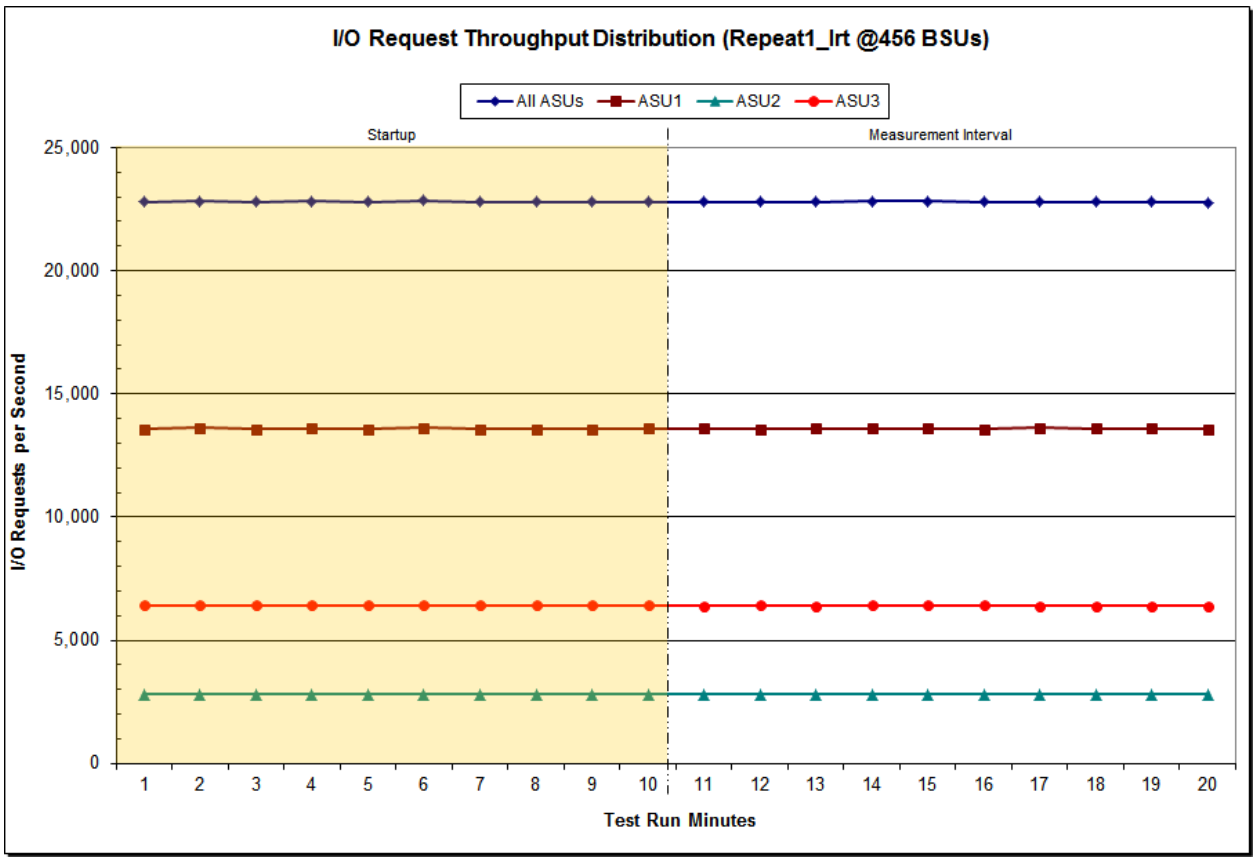
Repeatability Test Phase 2, Test Run 1 (LRT)

Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

456 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:57:58	8:07:58	0-9	0:10:00
Measurement Interval	8:07:58	8:17:58	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*22,790.13*	*13,569.38*	*2,801.45*	*6,419.30*
1	*22,820.73*	*13,613.52*	*2,797.17*	*6,410.05*
2	*22,797.60*	*13,574.45*	*2,810.27*	*6,412.88*
3	*22,812.77*	*13,591.20*	*2,800.83*	*6,420.73*
4	*22,792.67*	*13,572.45*	*2,802.33*	*6,417.88*
5	*22,857.87*	*13,633.05*	*2,809.30*	*6,415.52*
6	*22,795.07*	*13,574.58*	*2,807.75*	*6,412.73*
7	*22,796.17*	*13,572.75*	*2,808.48*	*6,414.93*
8	*22,785.80*	*13,573.70*	*2,796.38*	*6,415.72*
9	*22,792.52*	*13,584.23*	*2,799.30*	*6,408.98*
10	22,782.13	13,592.17	2,794.98	6,394.98
11	22,787.85	13,568.37	2,806.02	6,413.47
12	22,787.02	13,589.17	2,810.62	6,387.23
13	22,822.38	13,599.78	2,806.55	6,416.05
14	22,817.70	13,606.60	2,800.43	6,410.67
15	22,791.37	13,580.33	2,803.20	6,407.83
16	22,805.20	13,609.65	2,802.75	6,392.80
17	22,796.20	13,593.35	2,803.95	6,398.90
18	22,788.85	13,586.45	2,802.42	6,399.98
19	22,777.67	13,574.80	2,806.15	6,396.72
Average	**22,795.64**	**13,590.07**	**2,803.71**	**6,401.86**

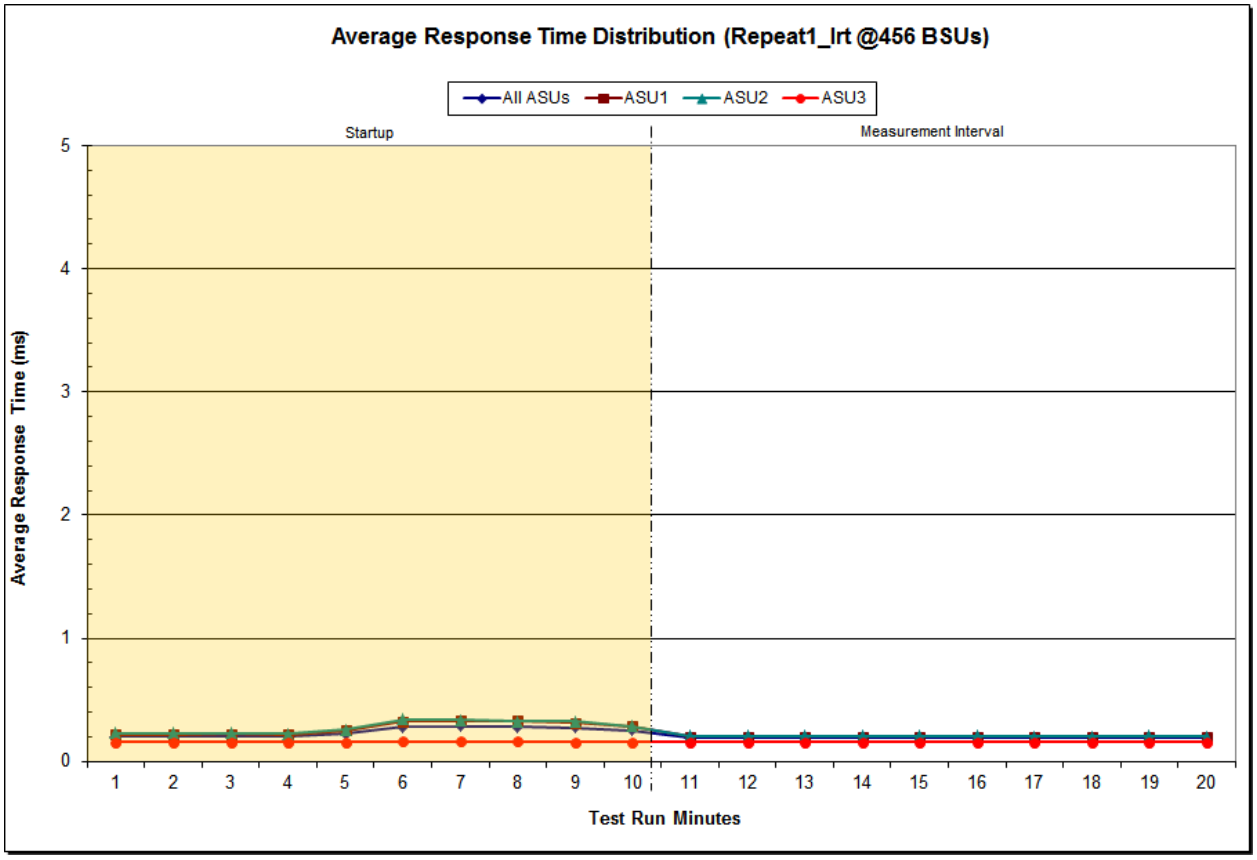
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

456 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:57:58	8:07:58	0-9	0:10:00
Measurement Interval	8:07:58	8:17:58	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*0.20*	*0.22*	*0.23*	*0.16*
1	*0.20*	*0.22*	*0.23*	*0.16*
2	*0.20*	*0.22*	*0.23*	*0.16*
3	*0.20*	*0.22*	*0.23*	*0.16*
4	*0.23*	*0.25*	*0.26*	*0.16*
5	*0.28*	*0.33*	*0.34*	*0.16*
6	*0.28*	*0.33*	*0.34*	*0.16*
7	*0.28*	*0.33*	*0.33*	*0.16*
8	*0.27*	*0.32*	*0.32*	*0.16*
9	*0.25*	*0.29*	*0.29*	*0.16*
10	0.19	0.20	0.20	0.16
11	0.19	0.20	0.21	0.16
12	0.19	0.20	0.21	0.16
13	0.19	0.20	0.21	0.16
14	0.19	0.20	0.20	0.16
15	0.19	0.20	0.21	0.16
16	0.19	0.20	0.20	0.16
17	0.19	0.20	0.20	0.16
18	0.19	0.20	0.20	0.16
19	0.19	0.20	0.20	0.16
Average	**0.19**	**0.20**	**0.21**	**0.16**

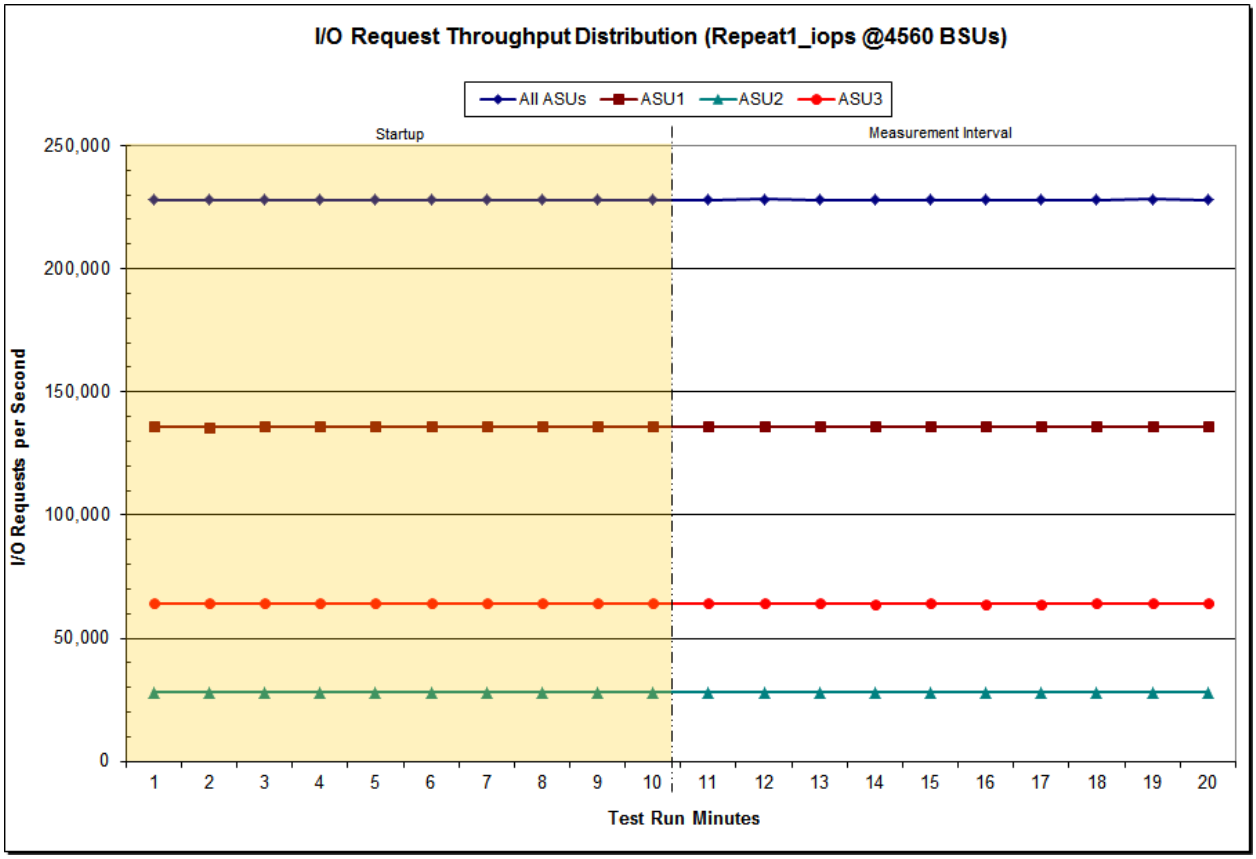
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

4,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:18:05	8:28:06	0-9	0:10:01
Measurement Interval	8:28:06	8:38:06	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*228,017.35*	*135,896.15*	*28,022.22*	*64,098.98*
1	*227,890.22*	*135,805.95*	*28,024.82*	*64,059.45*
2	*227,941.43*	*135,843.32*	*28,051.60*	*64,046.52*
3	*228,006.33*	*135,868.20*	*28,051.38*	*64,086.75*
4	*227,942.18*	*135,880.27*	*28,016.05*	*64,045.87*
5	*227,986.13*	*135,891.87*	*28,052.72*	*64,041.55*
6	*227,930.65*	*135,853.53*	*28,031.55*	*64,045.57*
7	*228,066.98*	*135,975.15*	*28,044.40*	*64,047.43*
8	*227,943.92*	*135,867.48*	*28,025.77*	*64,050.67*
9	*227,945.12*	*135,889.47*	*28,005.47*	*64,050.18*
10	228,034.85	135,872.85	28,041.15	64,120.85
11	228,074.95	135,893.83	28,088.87	64,092.25
12	228,073.00	135,869.38	28,068.60	64,135.02
13	227,900.07	135,887.98	28,012.92	63,999.17
14	228,043.50	135,894.67	28,019.33	64,129.50
15	227,961.70	135,914.97	28,036.88	64,009.85
16	227,927.85	135,891.10	28,016.10	64,020.65
17	227,961.13	135,884.15	28,040.03	64,036.95
18	228,109.60	135,990.73	28,060.90	64,057.97
19	228,012.00	135,838.45	28,061.50	64,112.05
Average	**228,009.87**	**135,893.81**	**28,044.63**	**64,071.43**

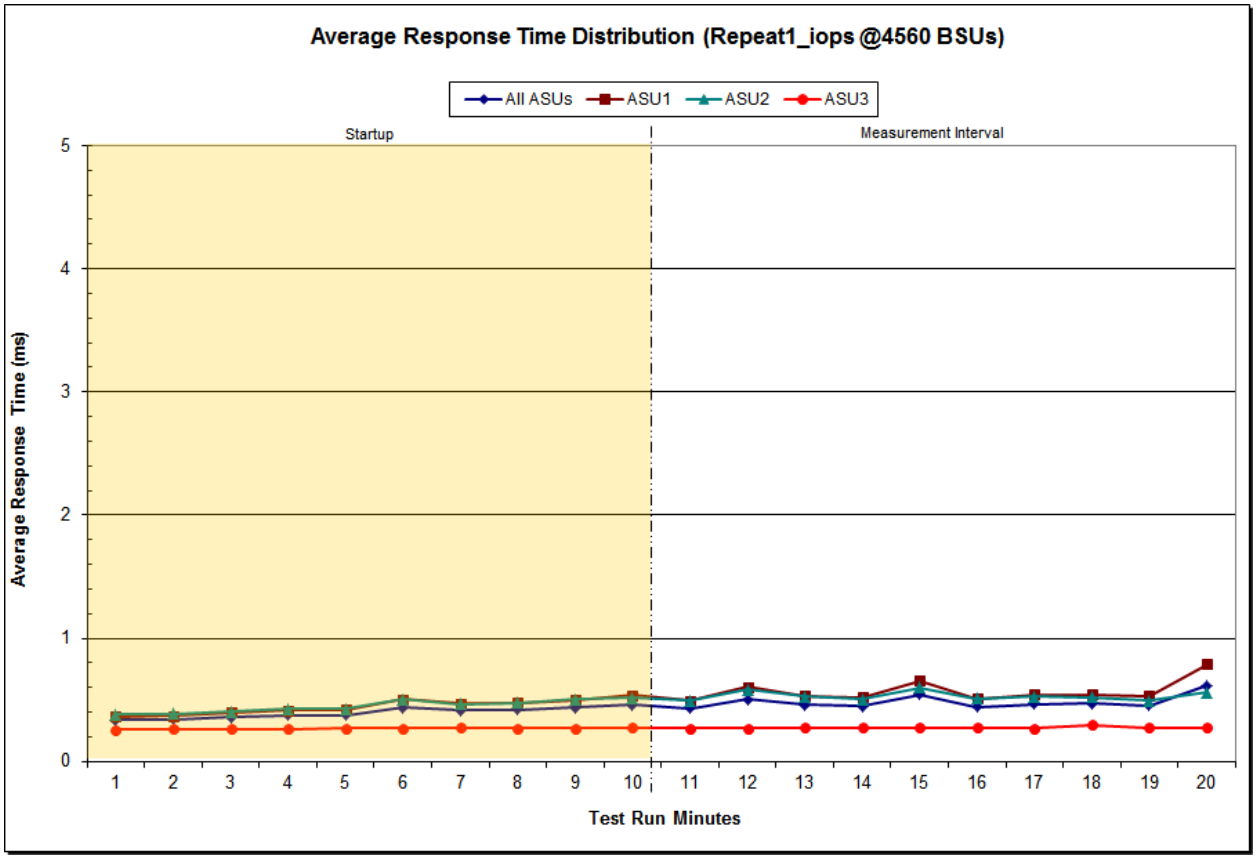
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

4,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:18:05	8:28:06	0-9	0:10:01
Measurement Interval	8:28:06	8:38:06	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*0.34*	*0.36*	*0.38*	*0.26*
1	*0.34*	*0.37*	*0.39*	*0.26*
2	*0.36*	*0.40*	*0.40*	*0.26*
3	*0.37*	*0.42*	*0.42*	*0.27*
4	*0.38*	*0.42*	*0.43*	*0.27*
5	*0.44*	*0.50*	*0.50*	*0.27*
6	*0.41*	*0.47*	*0.47*	*0.27*
7	*0.42*	*0.48*	*0.48*	*0.27*
8	*0.43*	*0.50*	*0.50*	*0.27*
9	*0.46*	*0.54*	*0.52*	*0.27*
10	0.43	0.49	0.49	0.27
11	0.51	0.60	0.58	0.27
12	0.46	0.53	0.53	0.27
13	0.45	0.52	0.50	0.27
14	0.54	0.66	0.60	0.27
15	0.44	0.51	0.51	0.27
16	0.46	0.54	0.53	0.27
17	0.47	0.54	0.52	0.30
18	0.46	0.53	0.49	0.27
19	0.61	0.79	0.56	0.27
Average	**0.48**	**0.57**	**0.53**	**0.27**

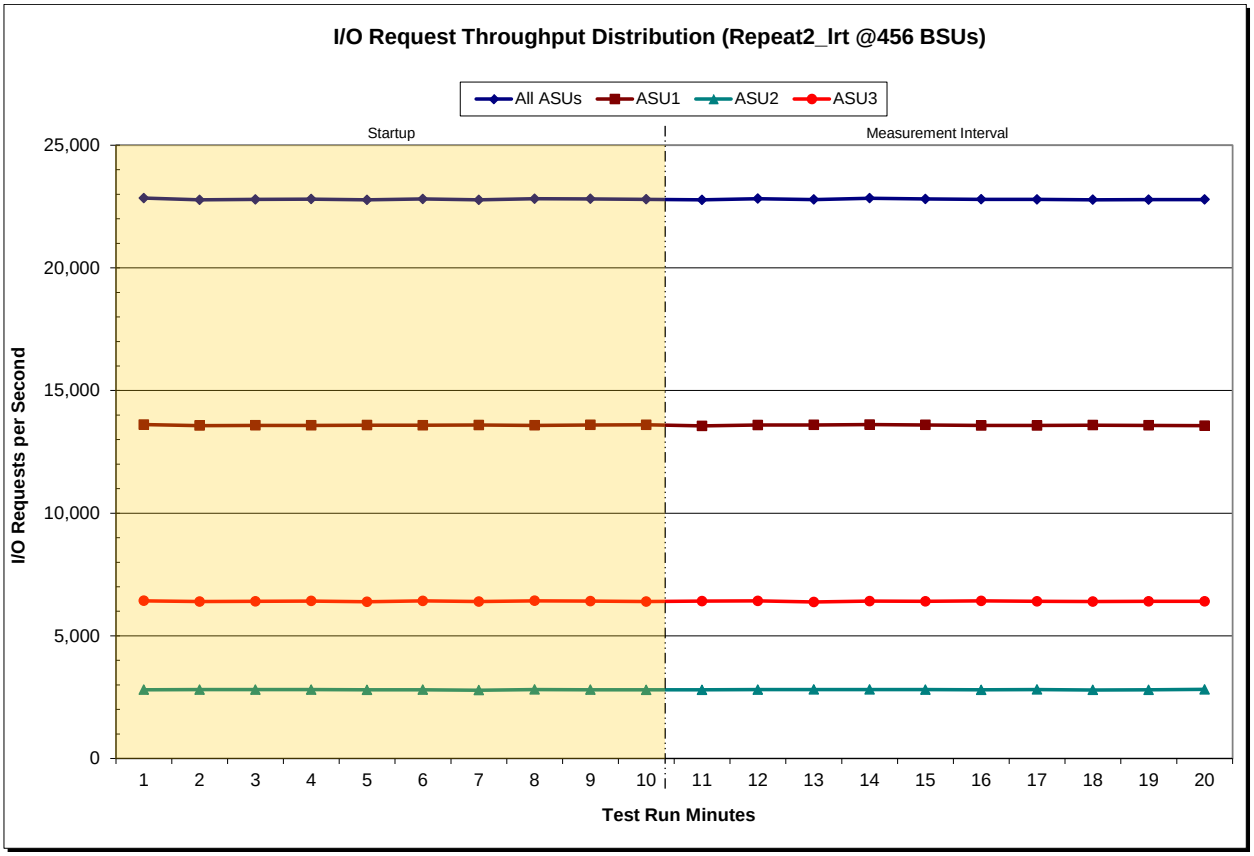
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

456 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:38:11	8:48:11	0-9	0:10:00
Measurement Interval	8:48:11	8:58:11	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*22,842.68*	*13,612.92*	*2,803.78*	*6,425.98*
1	*22,773.93*	*13,571.72*	*2,806.95*	*6,395.27*
2	*22,791.90*	*13,580.08*	*2,805.55*	*6,406.27*
3	*22,802.80*	*13,577.85*	*2,806.77*	*6,418.18*
4	*22,774.38*	*13,586.95*	*2,798.67*	*6,388.77*
5	*22,809.80*	*13,584.72*	*2,800.48*	*6,424.60*
6	*22,772.35*	*13,590.75*	*2,785.90*	*6,395.70*
7	*22,818.60*	*13,580.50*	*2,811.63*	*6,426.47*
8	*22,813.65*	*13,595.33*	*2,804.37*	*6,413.95*
9	*22,793.80*	*13,600.18*	*2,797.83*	*6,395.78*
10	22,772.90	13,559.12	2,798.90	6,414.88
11	22,823.88	13,594.37	2,807.48	6,422.03
12	22,787.85	13,597.27	2,810.58	6,380.00
13	22,837.83	13,612.80	2,811.55	6,413.48
14	22,810.05	13,599.18	2,806.98	6,403.88
15	22,795.73	13,575.32	2,796.48	6,423.93
16	22,791.83	13,574.65	2,812.50	6,404.68
17	22,777.93	13,586.72	2,794.37	6,396.85
18	22,782.85	13,579.35	2,796.58	6,406.92
19	22,785.17	13,563.67	2,816.65	6,404.85
Average	**22,796.60**	**13,584.24**	**2,805.21**	**6,407.15**

Repeatability 2 LRT – I/O Request Throughput Distribution Graph



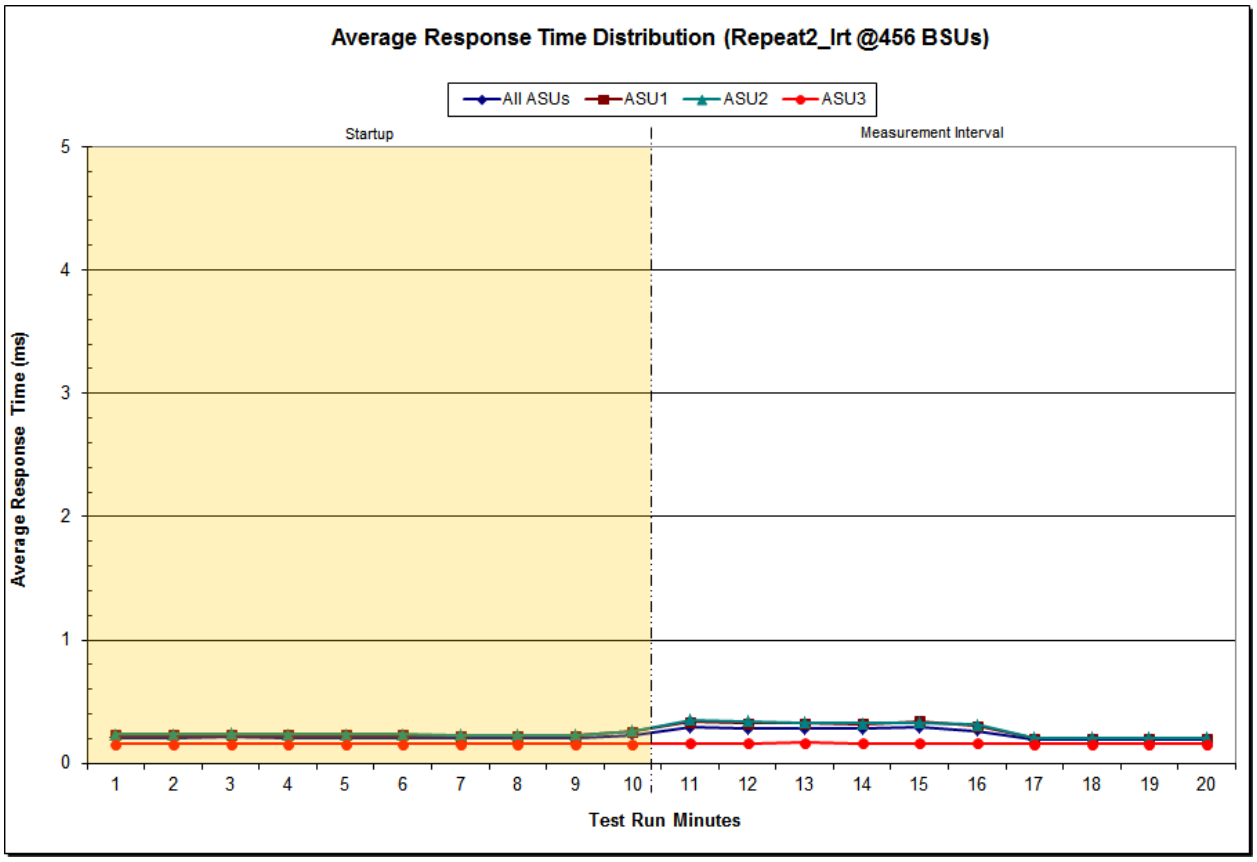
Repeatability 2 LRT –Average Response Time (ms) Distribution Data

In addition to appearing on the previous page, the *"Repeatability 2 LRT – Average Response Time (ms) Distribution Data"* table is also available via the following URL:

Repeatability 2 LRT – Average Response Time Distribution Data Table

456 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:38:11	8:48:11	0-9	0:10:00
Measurement Interval	8:48:11	8:58:11	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*0.21*	*0.23*	*0.23*	*0.16*
1	*0.21*	*0.23*	*0.23*	*0.16*
2	*0.21*	*0.23*	*0.24*	*0.16*
3	*0.21*	*0.23*	*0.23*	*0.16*
4	*0.21*	*0.23*	*0.23*	*0.16*
5	*0.21*	*0.23*	*0.23*	*0.16*
6	*0.21*	*0.23*	*0.23*	*0.16*
7	*0.20*	*0.22*	*0.23*	*0.16*
8	*0.20*	*0.22*	*0.23*	*0.16*
9	*0.23*	*0.26*	*0.26*	*0.16*
10	0.29	0.34	0.35	0.16
11	0.28	0.32	0.34	0.16
12	0.28	0.32	0.33	0.17
13	0.28	0.32	0.32	0.16
14	0.29	0.34	0.33	0.16
15	0.27	0.30	0.31	0.16
16	0.19	0.20	0.20	0.16
17	0.19	0.20	0.20	0.16
18	0.19	0.20	0.21	0.16
19	0.19	0.20	0.21	0.16
Average	**0.24**	**0.28**	**0.28**	**0.16**

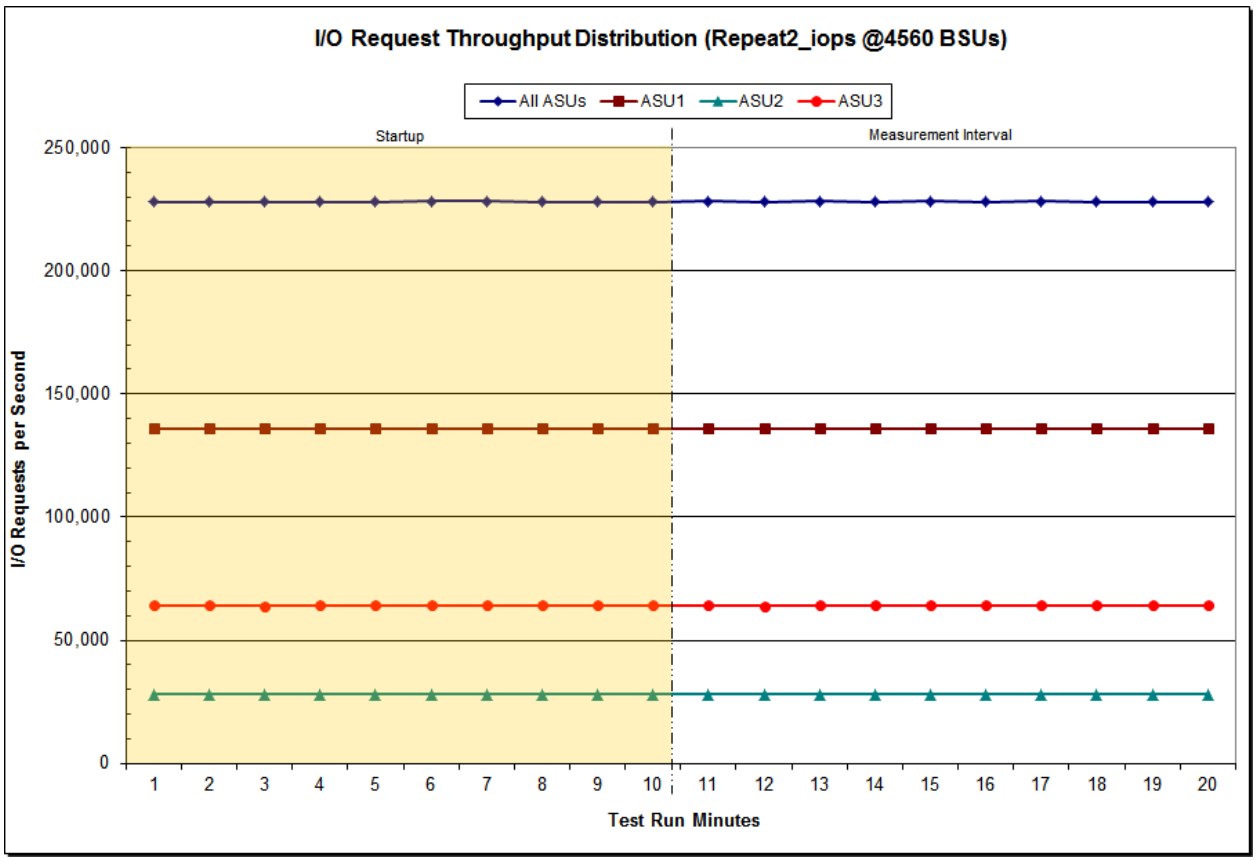
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

4,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:58:18	9:08:19	0-9	0:10:01
Measurement Interval	9:08:19	9:18:19	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*228,011.05*	*135,892.43*	*28,055.38*	*64,063.23*
1	*227,978.67*	*135,850.25*	*28,045.02*	*64,083.40*
2	*227,904.23*	*135,821.40*	*28,069.20*	*64,013.63*
3	*228,070.73*	*135,911.93*	*28,057.02*	*64,101.78*
4	*227,936.00*	*135,849.60*	*28,044.47*	*64,041.93*
5	*228,129.37*	*135,972.37*	*28,056.73*	*64,100.27*
6	*228,077.78*	*135,894.27*	*28,052.63*	*64,130.88*
7	*227,991.38*	*135,898.08*	*28,017.83*	*64,075.47*
8	*228,006.57*	*135,900.18*	*28,015.52*	*64,090.87*
9	*228,006.68*	*135,906.83*	*28,049.08*	*64,050.77*
10	228,122.97	135,963.02	28,093.62	64,066.33
11	227,970.10	135,855.40	28,086.97	64,027.73
12	228,133.50	135,956.12	28,072.58	64,104.80
13	228,049.73	135,915.73	28,071.88	64,062.12
14	228,086.33	135,895.17	28,092.92	64,098.25
15	228,010.55	135,946.87	28,021.77	64,041.92
16	228,078.25	135,990.97	28,026.65	64,060.63
17	227,979.02	135,854.43	28,043.02	64,081.57
18	228,002.48	135,852.35	28,057.47	64,092.67
19	228,048.67	135,926.70	28,056.85	64,065.12
Average	**228,048.16**	**135,915.68**	**28,062.37**	**64,070.11**

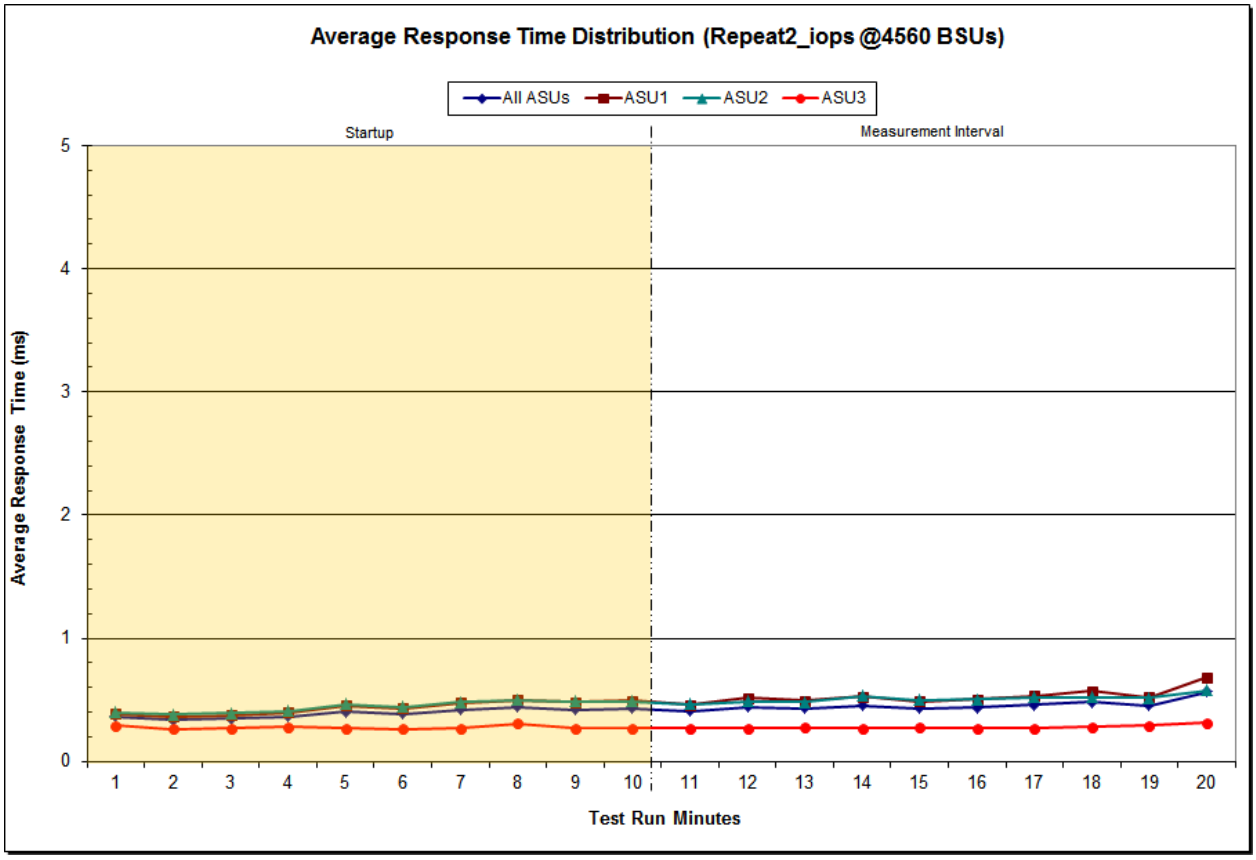
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

4,560 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	8:58:18	9:08:19	0-9	0:10:01
Measurement Interval	9:08:19	9:18:19	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	*0.36*	*0.39*	*0.40*	*0.29*
1	*0.34*	*0.37*	*0.38*	*0.26*
2	*0.35*	*0.38*	*0.39*	*0.27*
3	*0.36*	*0.39*	*0.41*	*0.28*
4	*0.40*	*0.45*	*0.46*	*0.27*
5	*0.39*	*0.43*	*0.44*	*0.27*
6	*0.42*	*0.48*	*0.48*	*0.27*
7	*0.44*	*0.50*	*0.50*	*0.31*
8	*0.42*	*0.48*	*0.49*	*0.27*
9	*0.43*	*0.49*	*0.49*	*0.27*
10	0.41	0.46	0.46	0.27
11	0.44	0.52	0.49	0.27
12	0.43	0.49	0.48	0.27
13	0.45	0.53	0.53	0.27
14	0.43	0.49	0.50	0.27
15	0.44	0.50	0.50	0.27
16	0.46	0.53	0.52	0.27
17	0.48	0.57	0.52	0.28
18	0.46	0.52	0.51	0.29
19	0.57	0.68	0.58	0.31
Average	**0.46**	**0.53**	**0.51**	**0.28**

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	0.2101	0.0180	0.0700	0.0350	0.2808
COV	0.003	0.001	0.002	0.001	0.006	0.003	0.005	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	0.002	0.000	0.001	0.001	0.002	0.001	0.002	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0699	0.2100	0.0179	0.0701	0.0350	0.2811
COV	0.005	0.001	0.002	0.002	0.007	0.003	0.004	0.002

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	0.2809
COV	0.001	0.000	0.001	0.000	0.001	0.001	0.002	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 86.

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	547,140,912
Total Number of Logical Blocks Verified	218,180,144
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

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 entire Priced Storage Configuration, 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 AccelStor NeoSapphire 3602.

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.

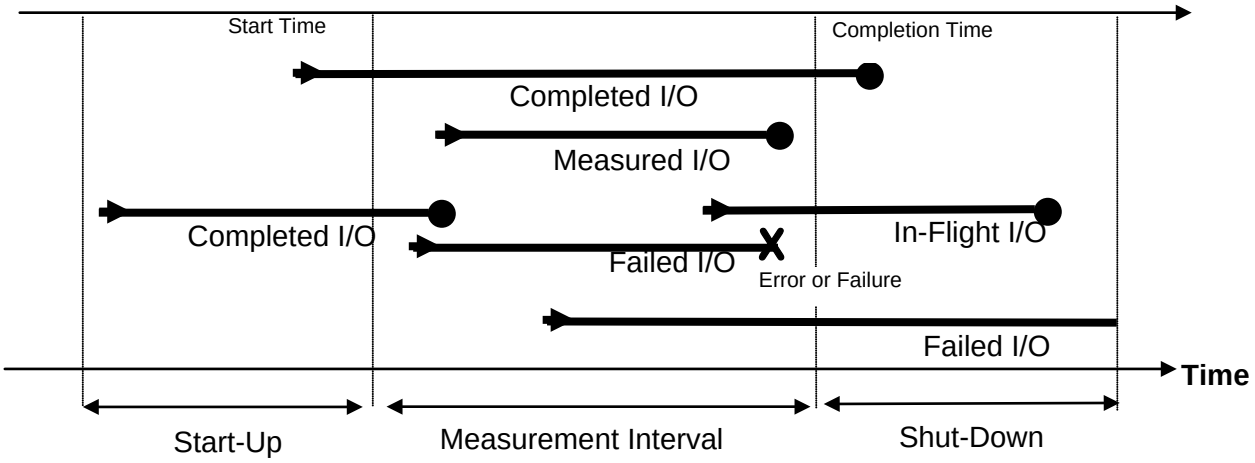
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

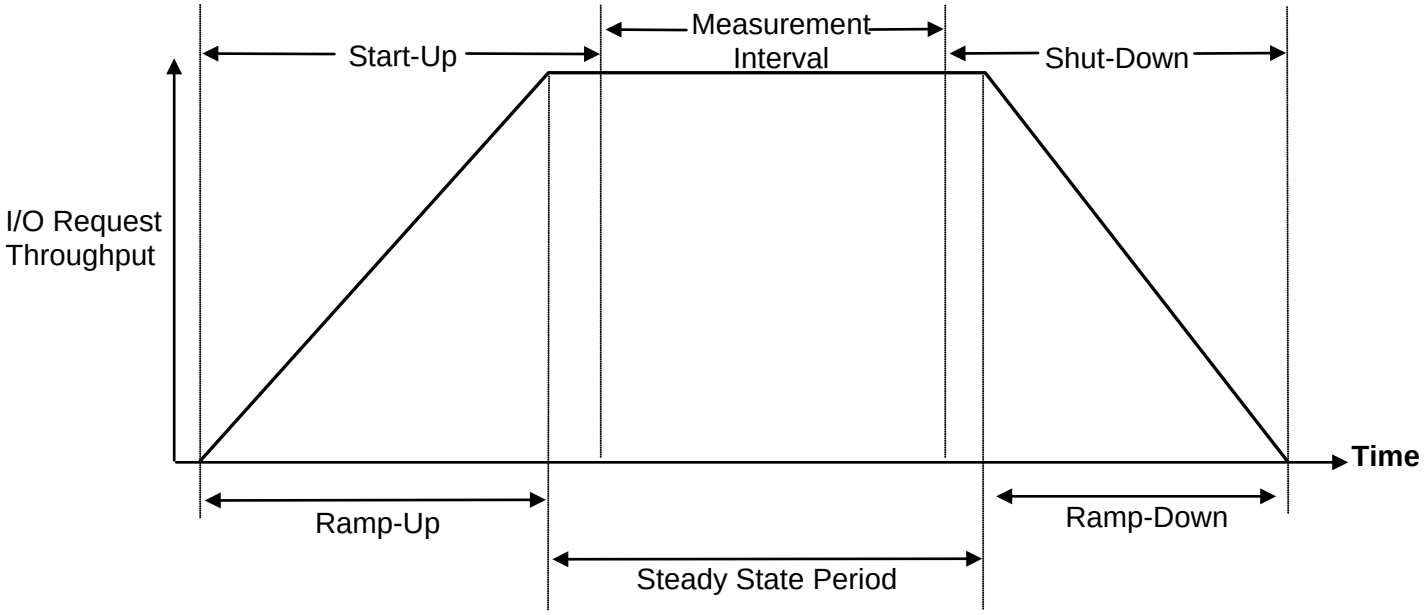
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have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

The following customer tunable parameters or options were changed from their default values for this set of audited benchmark measurements:

1. Set the Emulex queue depth to 128 via a CLI command session on the Host System using the following command:

   modprobe lpfc lpfc_lun_queue_depth=128

2. Set the **nr_requests** parameter of each SSD to **512** via a CLI command session on the Host System using the following command:

   echo 512 > /sys/block/sd*/queue/nr_requests

3. Configure use of the default multipath daemon as follows:
   a. Set the **path_selector** value in the **etc/multipath.conf** file to ***round-robin 0***.
   b. Set the **nr_requests** parameter for each multipath SSD to ***40960*** via a CLI command session on the Host System using the following command:

      echo 40960 > /sys/block/dm-*/queue/nr_requests

4. Change the disk scheduler from ***cfq*** to ***noop*** by adding ***elevator=noop*** into the **/boot/grub/grub.conf** file.

5. Set all CPU cores to performance mode via a CLI command session on the Host System using the following command:

   echo performance > /sys/devices/system/cpu/cpu*/cpufreq/scaling_governor

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Pre-Configuration Prior to Customer Delivery

The AccelStor NeoSapphire 3602 is pre-configured, prior to customer delivery, to provide fault tolerance protection via AccelStor's FlexiRemap technology.

The pre-configuration details are described below:

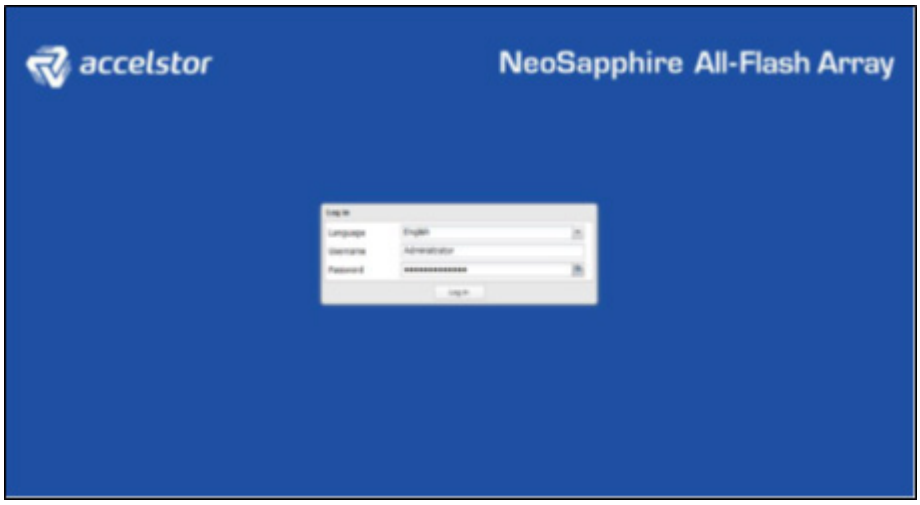
- The configured storage devices (SSDs) are divided into two equally sized groups. In the case of this SPC-1 Tested Storage Configuration (TSC) each group contained five SSDs.
- Fault tolerance protection (parity) is distributed equally across each of the group equal to the capacity of a single SSD. That fault tolerance protection results in the equivalent of two SSDs dedicated to parity, one SSD equivalent per group.
- The remaining capacity, after subtracting the above parity capacity, is partitioned as described below, for the AccelStor NeoSapphire 3602:
  - 66.1732% of the remaining capacity, equally distributed across the two groups, is allocated for application use..
  - 33.8268% of the remaining capacity, equally distributed across the two groups, is reserved for system use and unavailable for application use.

SPC-1 TSC Creation and Configuration

Accessing the Web-Based Management Interface

The web-based management interface is access by completing the following steps:

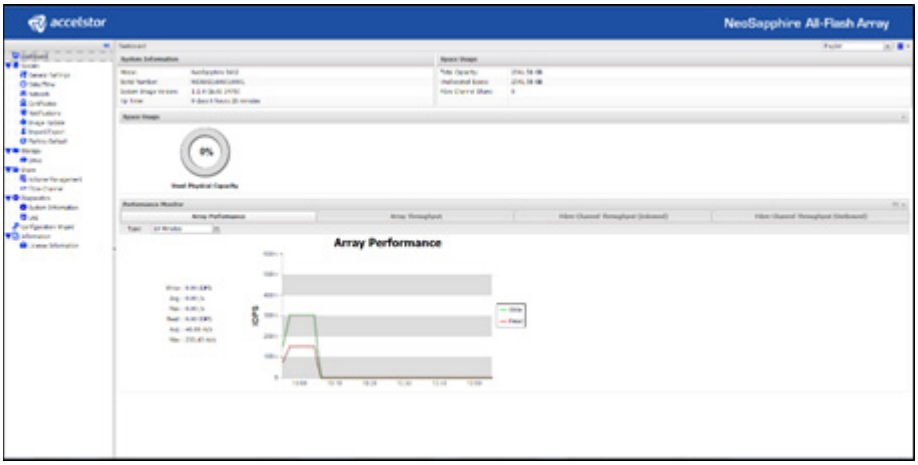
1. Ensure the computer is connected to the same network as the benchmark configuration and can access the nodes on the network. The IP address and subnet mask of the system are 192.168.1.1 and 255.255.255.0, respectively, under factory-default settings.
2. Connect to http://192.168.1.1 using a supported web browser.
3. The **Log in** pane is displayed.



The all-flash array is initially configured with a default administrator user defined as follows:

Username: **Administrator**
Password: **Administrator**

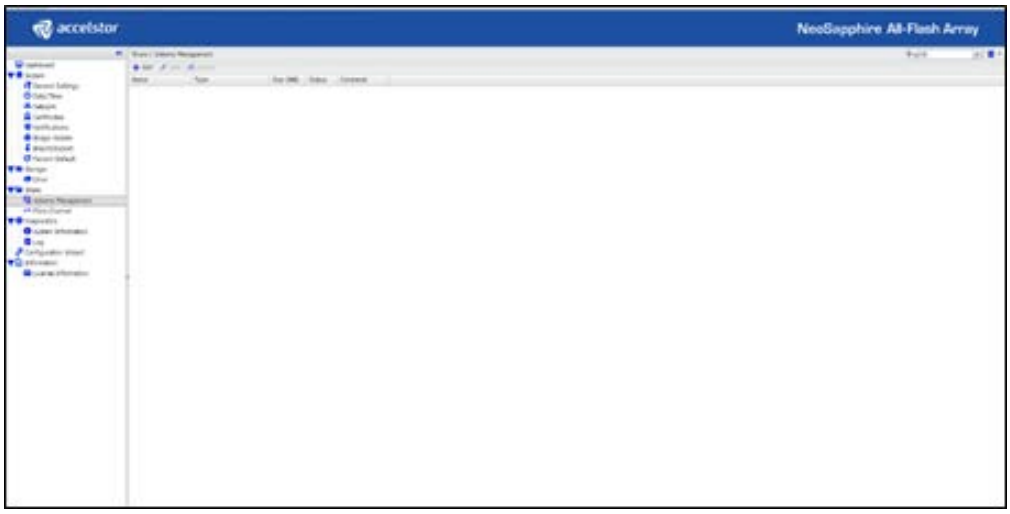
4. After logging in the web management pane is displayed



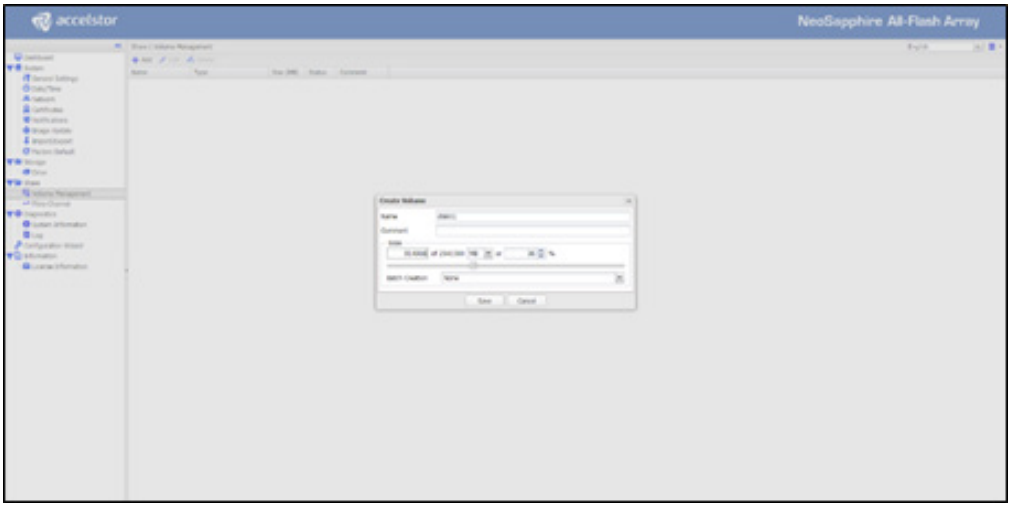
Create Volumes

Create the three SPC-1 Logical Volumes as follows:

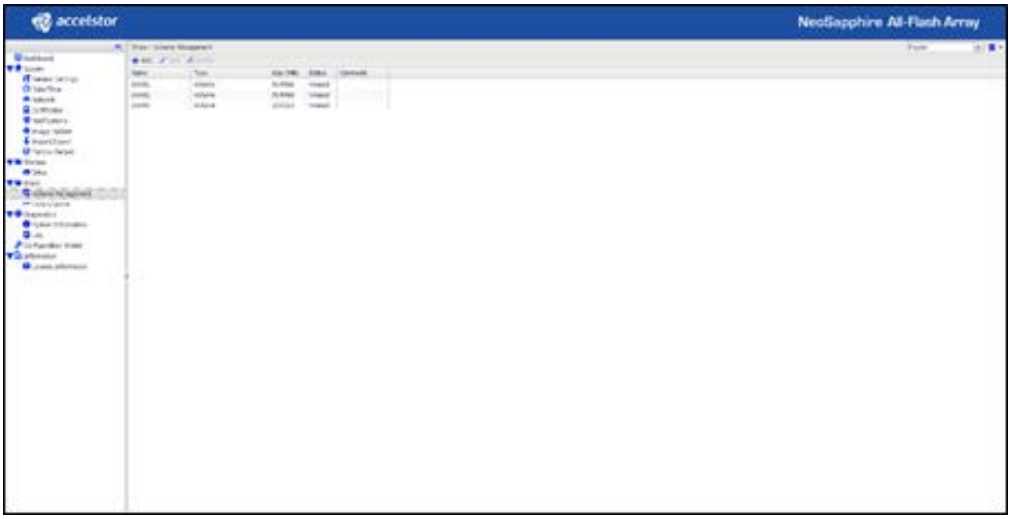
1. Choose **Volume Management** and click **Add** to create volume.



2. Change the value of the size box to 914,966 MB.



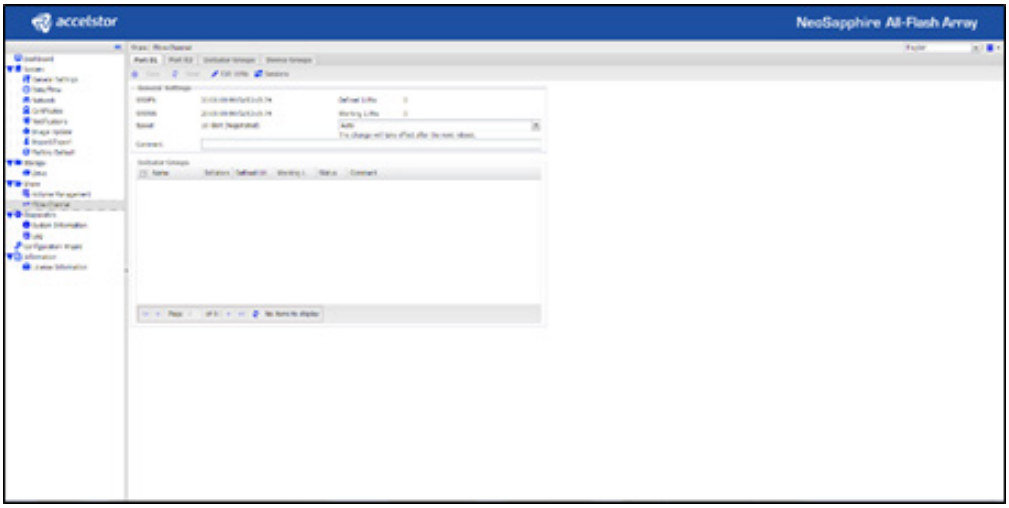
3. Repeat steps #1 and #2 to create the second volume of 914,966 MB and the third volume of 203,323 MB.



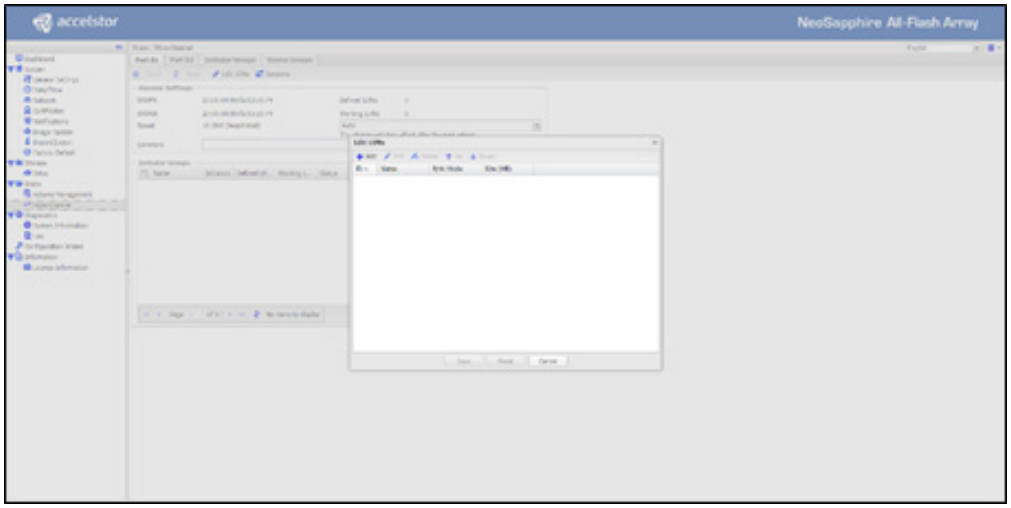
Configure Fiber Channel Ports

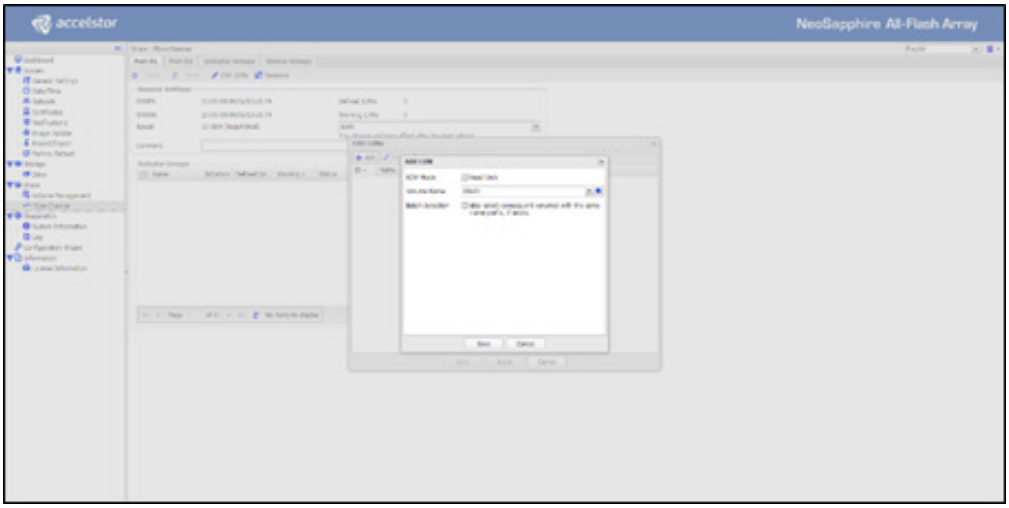
Associate all three logical volumes with the two fiber channel ports as follows:

1. Choose **Fiber Channel** > **Port 01**.



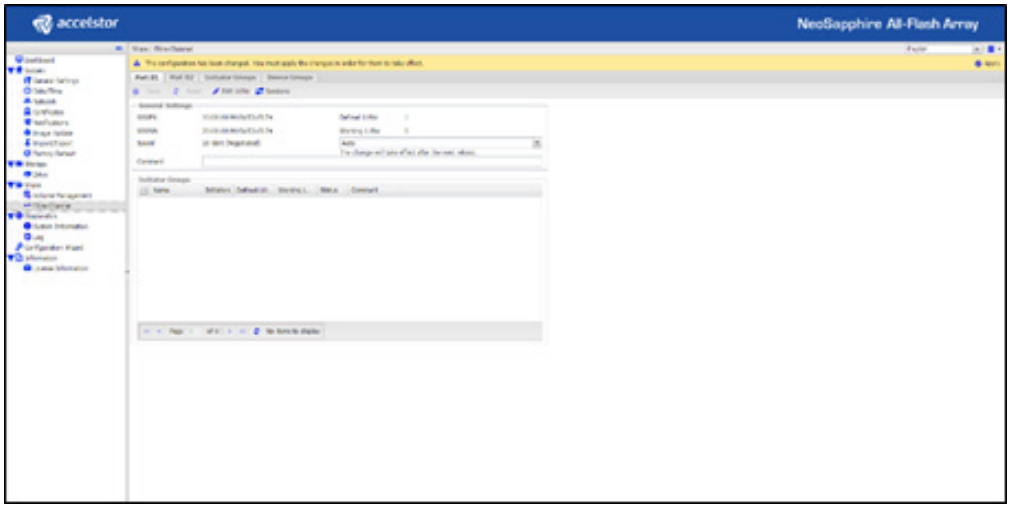
2. Choose **Edit LUNs > Add** to associate the first volume with fiber channel port 01.



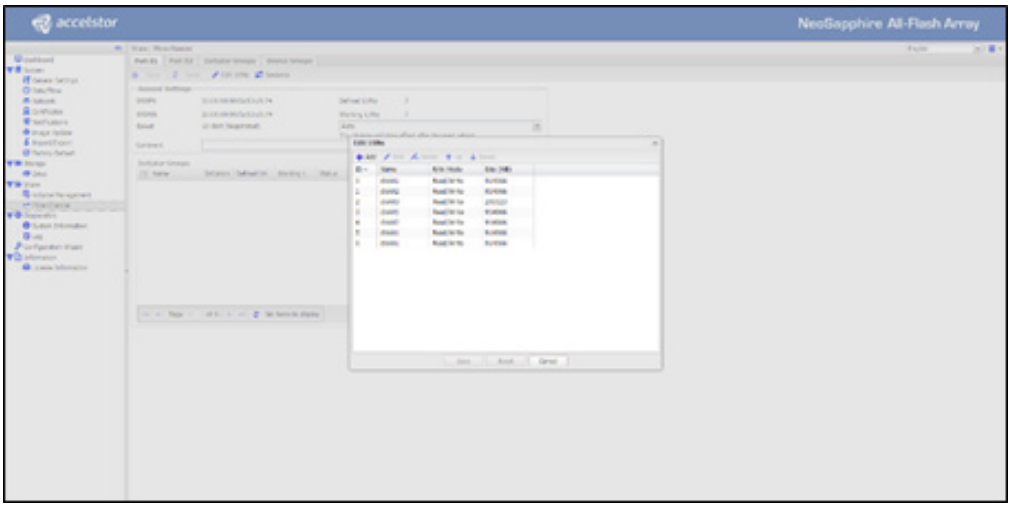


3. Repeat step #2 to associate the remaining two volumes with fiber channel port 01.
4. Choose **Fiber Channel > Port 02**.
5. Repeat step #2 to associate the three volumes with fiber channel port 02.

6. Click **Apply** to apply all configuration changes.



7. The configuration is complete as illustrated below.



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

ASU Pre-Fill

The content of the command and parameter file used in the benchmark to execute the required ASU pre-fill operation is listed below.

```
*
* This will produce a random data pattern of the entire LBA range using LSFR 32bit
*
* Execute as: vdbench -f prefill.parm -o prefill-out
*
compratio=1
*
* All SPC AUS LUNs (note that all sd's must be defined prior to the wd's)
*
sd=default,threads=8
sd=asu1,lun=/dev/mapper/mpathb,size=914966446080,openflags=o_direct,threads=8
sd=asu2,lun=/dev/mapper/mpathc,size=914966446080,openflags=o_direct,threads=8
sd=asu3,lun=/dev/mapper/mpatha,size=203323080704,openflags=o_direct,threads=8
*
* The applied prefill workload
*
wd=wd1,sd=asu1,rdpct=0,seekpct=-1,xfersize=512K
wd=wd2,sd=asu2,rdpct=0,seekpct=-1,xfersize=512K
wd=wd3,sd=asu3,rdpct=0,seekpct=-1,xfersize=512K
*
rd=asu_prefill,wd=wd*,iorate=max,elapsed=360000,interval=10
```

Primary Metrics and Repeatability Tests

The content of SPC-1 Workload Generator command and parameter file used in this benchmark to execute the Primary Metrics *(Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase)* and Repeatability *(Repeatability Test Phase 1 and Repeatability Test Phase 2)* Tests is listed below.

```
host=master
slaves=(slave1,slave2,slave3,slave4,slave5,slave6,slave7,slave8,slave9,slave10,slave
11,slave12,slave13,slave14,slave15,slave16,slave17,slave18,slave19,slave20,slave21,s
lave22,slave23,slave24,slave25,slave26,slave27,slave28,slave29,slave30,slave31,slave
32,slave33,slave34,slave35,slave36,slave37,slave38,slave39,slave40,slave41,slave42,s
lave43,slave44,slave45,slave46)

javaparms="-Xmx768m -Xms768m -Xss512k"

sd=asu1_1,size=914966446080,lun=/dev/mapper/mpathb
sd=asu2_1,size=914966446080,lun=/dev/mapper/mpathc
sd=asu3_1,size=203323080704,lun=/dev/mapper/mpatha
```

SPC-1 Persistence Test

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

```
sd=asu1_1,size=914966446080,lun=/dev/mapper/mpathb
sd=asu2_1,size=914966446080,lun=/dev/mapper/mpathc
sd=asu3_1,size=203323080704,lun=/dev/mapper/mpatha
```

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. **slave1**…**slave44**.

```
master=localhost
host=slave1
sd=asu1_1,lun=/dev/mapper/mpathb
sd=asu2_1,lun=/dev/mapper/mpathc
sd=asu3_1,lun=/dev/mapper/mpatha
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

The **start_spc.sh** script was invoked to execute the following in an uninterrupted sequence:

- Execute the required ASU pre-fill.
- Invoke a script, **slave_auto_run.sh**, to start all of the Slave JVMs.
- Execute the Primary Metrics Test *(Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase).*
- Execute the Repeatability Test *(Repeatability Test Phase 1 and Repeatability Test Phase 2),*.
- Terminate the Slave JVMs.
- Activate the appropriate configuration file for the SPC-1 Persistence Test.
- Execute the SPC-1 Persistence Test Run 1 *(write phase).*

Invoke the **spc_persist2.sh** script to execute the SPC-1 Persistence Test Run 2 *(read phase)* after completing the required Tested Storage Configuration power off/power on cycle.

start_spc.sh

```
#!/bin/sh

echo "***Start prefill ASUs***"
bash vdbench -f prefill.parm -o prefill-out

echo "***Start the Slave JVM***"
bash slave_auto_run.sh &

sleep 10

echo "***Start the SPC-1 metrics***"
cp -f spc1_bsu4560.cfg spc1.cfg
java -Xmx768m -Xms768m -Xss512k metrics -b 4560 -t 28800 -s 600

echo "***Start the SPC-1 repeatability***"
java -Xmx768m -Xms768m -Xss512k repeat1 -b 4560 -s 600
java -Xmx768m -Xms768m -Xss512k repeat2 -b 4560 -s 600

echo "Kill slave java"
killall -9 java

#echo "***Start SPC-1 Persistence Test Run 1***"
cp -f spc1_persist.cfg spc1.cfg
java -Xmx4096m -Xms4096m -Xss512k persist1 -b 4560

echo "***Powerdown and restart to run SPC-1 Persistence Test Run 2***"
echo "***Powerdown and restart to run SPC-1 Persistence Test Run 2***"
echo "***Powerdown and restart to run SPC-1 Persistence Test Run 2***"
```

slave_auto_run.sh

```
for x in {1..46}; do java spc1 -fslave_cfg/slave$x.txt & done
```

spc_persist2.sh

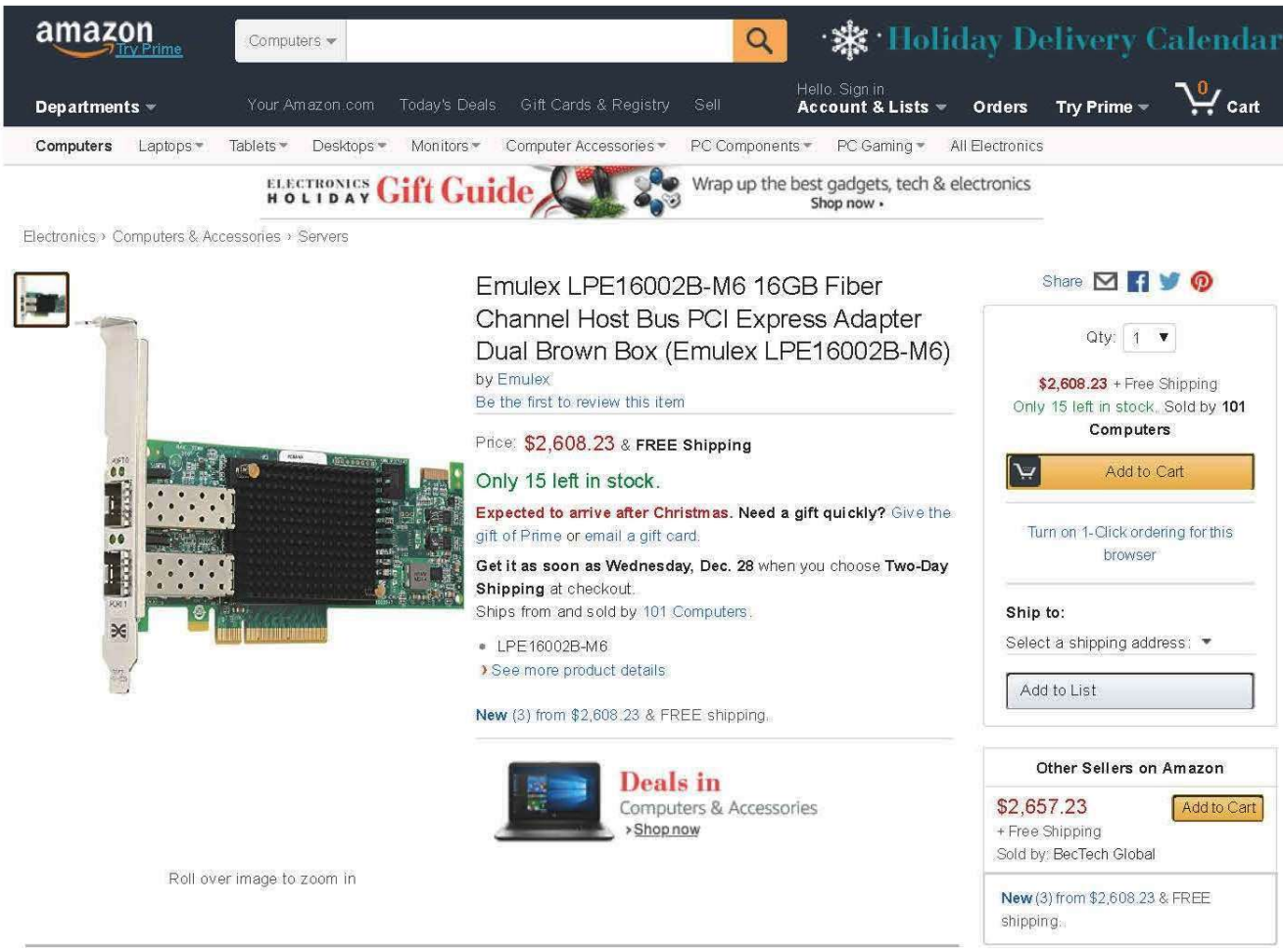
```
#!/bin/sh

#echo "***Start SPC-1 Persistence Test Run 2***"
cp -f spc1_persist.cfg spc1.cfg
java -Xmx4096m -Xms4096m -Xss512k persist2
```

APPENDIX F: THIRD-PARTY QUOTATION

Emulex LPE 16002B-M6 Network Interface Card

2016/12/23 Amazon.com: Emulex LPE16002B-M6 16GB Fiber Channel Host Bus PCI Express Adapter Dual Brown Box (Emulex LPE16002B-M6): Cor



Tripp Lite Fiber Patch Cables (LC/LC)

2016/12/23 Amazon.com: Tripp Lite 10Gb Duplex Multimode 50/125 OM3 LSZH Fiber Patch Cable (LC/LC) - Aqua, 1M (3-ft.)(N820-01M): Electro