SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

NETAPP, INC.

NETAPP® AFF A700S

SPC-1 V1.14

SUBMITTED FOR REVIEW: JANUARY 30, 2017

SUBMISSION IDENTIFIER: A02002

First Edition – January 2017

Trademarks

Table of Contents

AUDIT CERTIFICATION

InfoSizing
The Right Metric For Sizing IT

Storage Performance Council
Certified Auditor

Jim Laing
NetApp, Inc.
7301 Kit Creek Road
Research Triangle Park, NC 27709

January 16, 2017

I verified the SPC Benchmark 1™ (SPC-1™ Revision 1.14) test execution and performance results of the following Tested Storage Product:

NETAPP® AFF A700s

The results were:

SPC-1 IOPS™	**2,400,059.26**
SPC-1 Price-Performance™	**$0.62/SPC-1 IOPS™**
Total ASU Capacity	77,504.698 GB
Data Protection Level	Protected 2 (*RAID DP®*)
Total Price (including 3-year maintenance)	$1,493,103.71
Currency Used	U.S. Dollars
Target Country for Availability, Sales and Support	USA

In my opinion, these performance results were produced in compliance with the SPC requirements for the benchmark. In particular, the following requirements were reviewed and found compliant with V1.14 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository items were verified by information supplied by NetApp, Inc.:
  - Physical Storage Capacity and requirements
  - Configured Storage Capacity and requirement
  - 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.

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

- The accuracy of the Benchmark Configuration diagram
- The tuning parameters used to configure the Benchmark Configuration
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by NetApp, Inc.:
    - The type of Host Systems, including the number of processors and the amount of 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 found compliant with all applicable requirements and constraints.
- The submitted pricing information met all applicable requirements and constraints.

The Full Disclosure Report for this result was prepared in accordance with the disclosure requirements set forth in the specification for the benchmark. The report, prepared by InfoSizing and reviewed by NetApp, Inc., can be found at www.storageperformance.org under the Submission Identifier A02002.

Additional Audit Notes:

None.

Respectfully Yours,

Doug Johnson, Certified SPC Auditor

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LETTER OF GOOD FAITH

www.netapp.com
+1 408 822 6000 Tel
+1 408 822 4501 Fax
NetApp
495 East Java Drive
Sunnyvale, CA 94089

Date: January 6, 2016

From: Mr. Octavian Tanase, Senior Vice President, ONTAP Software Systems Group
NetApp, Inc.
495 East Java Drive
Sunnyvale, CA 94089

To: Mr. Doug Johnson, Certified SPC Auditor
PerfLabs, Inc. dba InfoSizing
63 Lourdes Drive
Leominster, MA 01453-6709

Subject: SPC-1 Letter of Good Faith for the NetApp AFF A700s 12-Node Cluster

NetApp Inc. is the test sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 results and materials we have submitted for that product are complete, accurate, and in full compliance with version 1.14 of the SPC-1 benchmark specification.

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

Signed: Date: 1/9/2017

Name and title of an appropriate
Test Sponsor senior executive

OCTAVIAN TANASE
SVP OSSG/ ONTAP

Date of Signature

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	NetApp, Inc. http://www.netapp.com/ Jim Laing jim.laing@netapp.com 7301 Kit Creek Road Research Triangle Park, NC 27709 Phone: (919) 476-4648 FAX: (919) 476-4272
Test Sponsor Alternate Contact	NetApp, Inc. http://www.netapp.com/ Scott Lane scott.lane@netapp.com 7301 Kit Creek Road Research Triangle Park, NC 27709 Phone: (919) 476-5484 FAX: (919) 476-4272
Auditor	InfoSizing – http://www.sizing.com/ Doug Johnson – doug@sizing.com 63 Lourdes Drive Leominster, MA 01453 Phone: (978) 343-6562

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.14
SPC-1 Workload Generator revision number	V2.5.2
Date Results were first used publicly	January 30, 2017
Date the FDR was submitted to the SPC	January 30, 2017
Date the Priced Storage Configuration is available for shipment to customers	February 28, 2017
Date the Tested Storage Configuration completed audit certification	January 16, 2017

Tested Storage Product (TSP) Description

Designed specifically for flash, NetApp® All Flash FAS (AFF) A700s systems deliver industry-leading performance, capacity density, scalability, security and network connectivity in a dense form factor. At up to millions of IOPS and sub-millisecond latency per cluster, it is the fastest all-flash array built on a unified scale-out architecture. Therefore, the A700s is an ideal solution for business-critical workloads. The AFF A700s system allows customers to complete twice the work at half the latency as compared with the previous generation of AFF systems.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: NetApp® AFF A700s	
Metric	**Reported Result**
SPC-1 IOPS™	2,400,059.26
SPC-1 Price-Performance™	$0.62/SPC-1 IOPS™
Total ASU Capacity	77,504.698 GB
Data Protection Level	Protected 2 (*RAID DP*®)
Total Price	$1,493,103.71
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

A **Data Protection Level** of **Protected 2** is provided by using NetApp ***RAID DP®*** technology, which provides double-parity RAID protection against data loss with negligible performance overhead and no cost penalty compared to single-parity RAID.

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

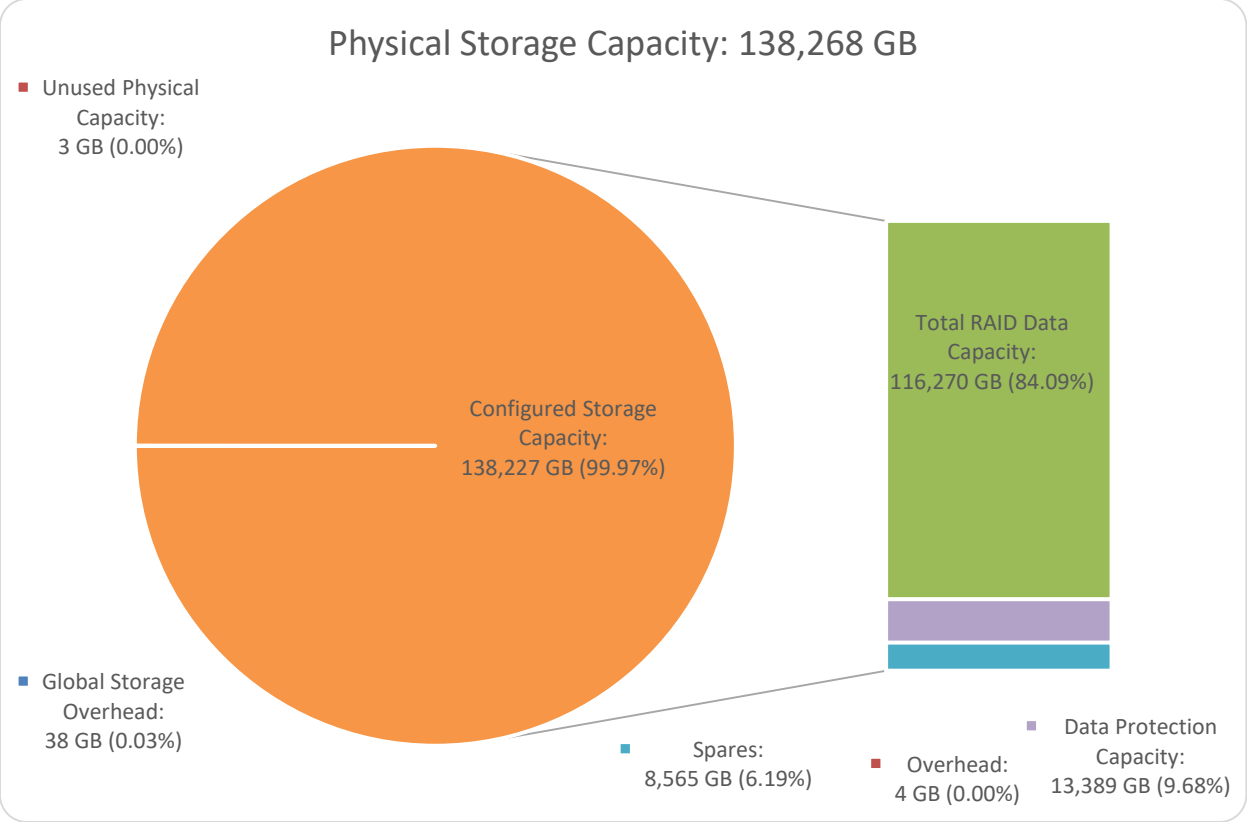
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support.

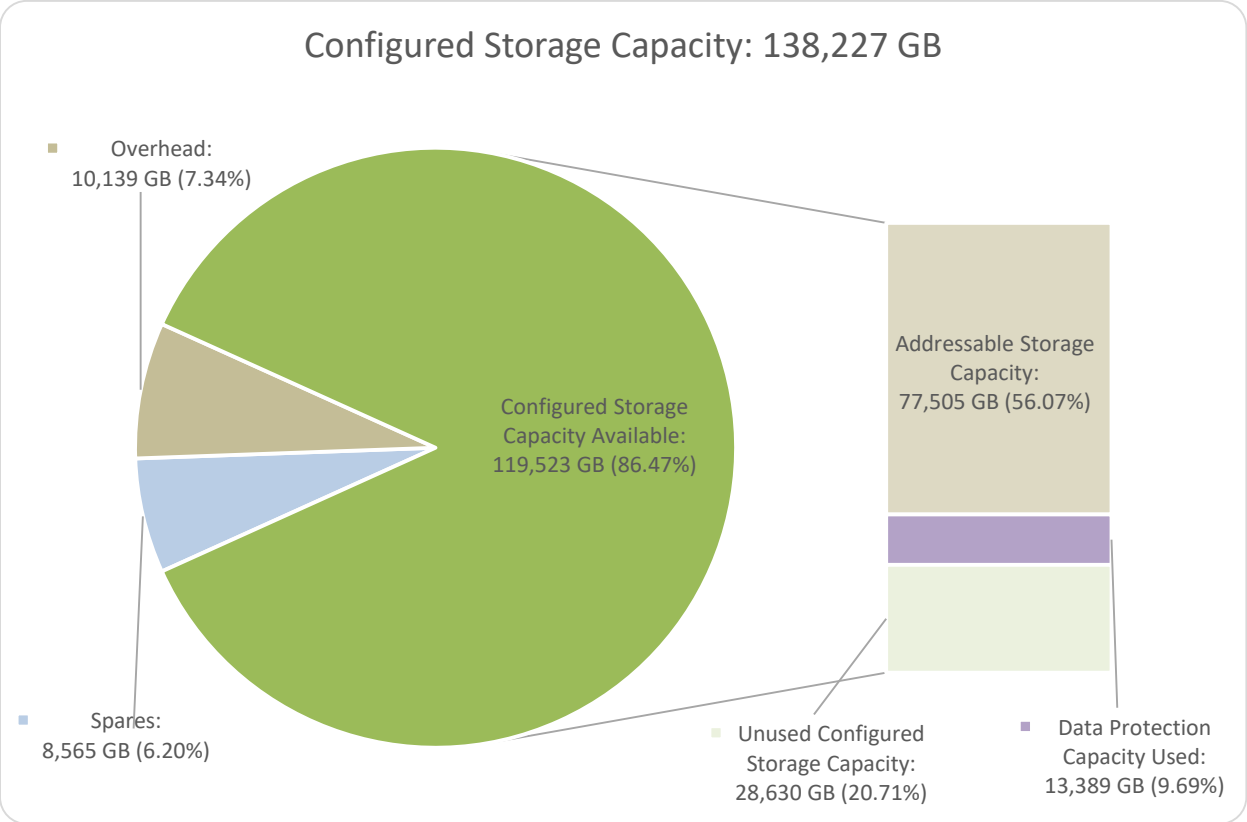
Currency Used is the formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency).*

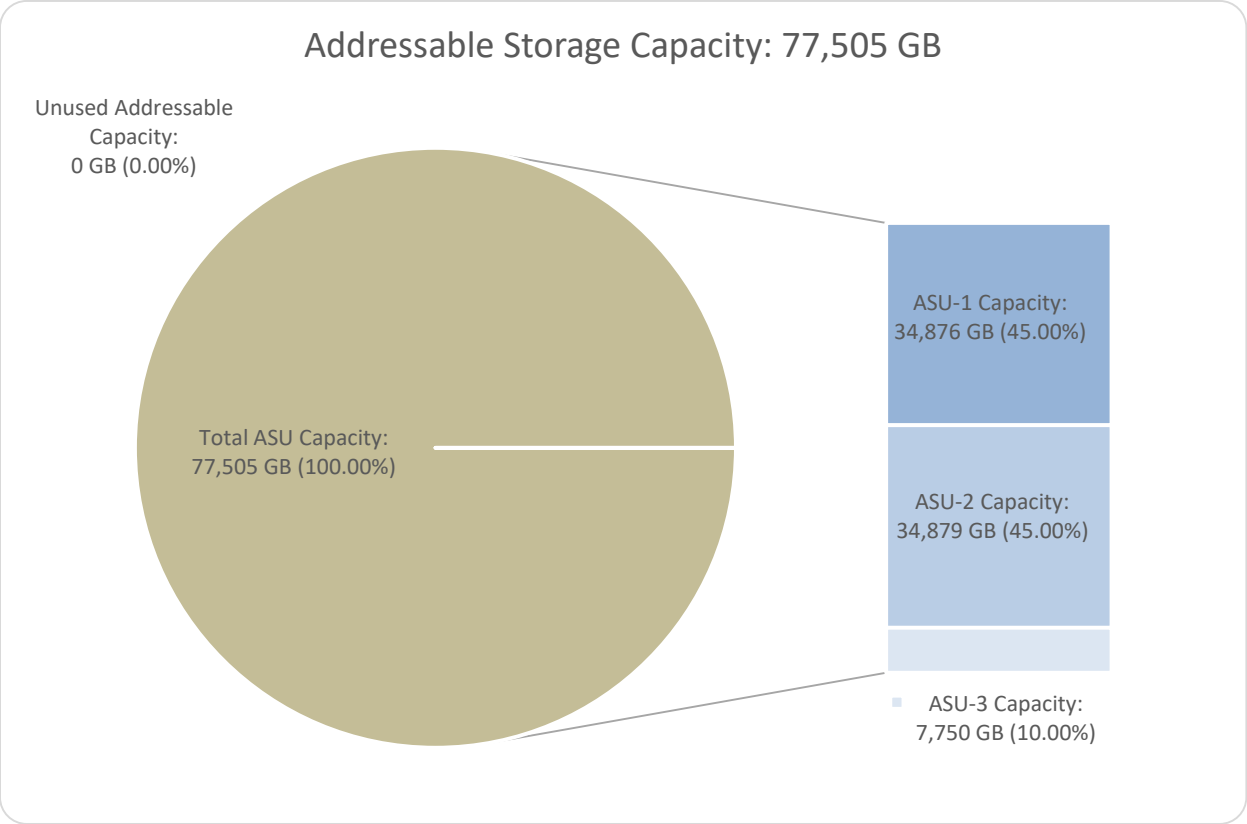
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly from a third-party supplier.

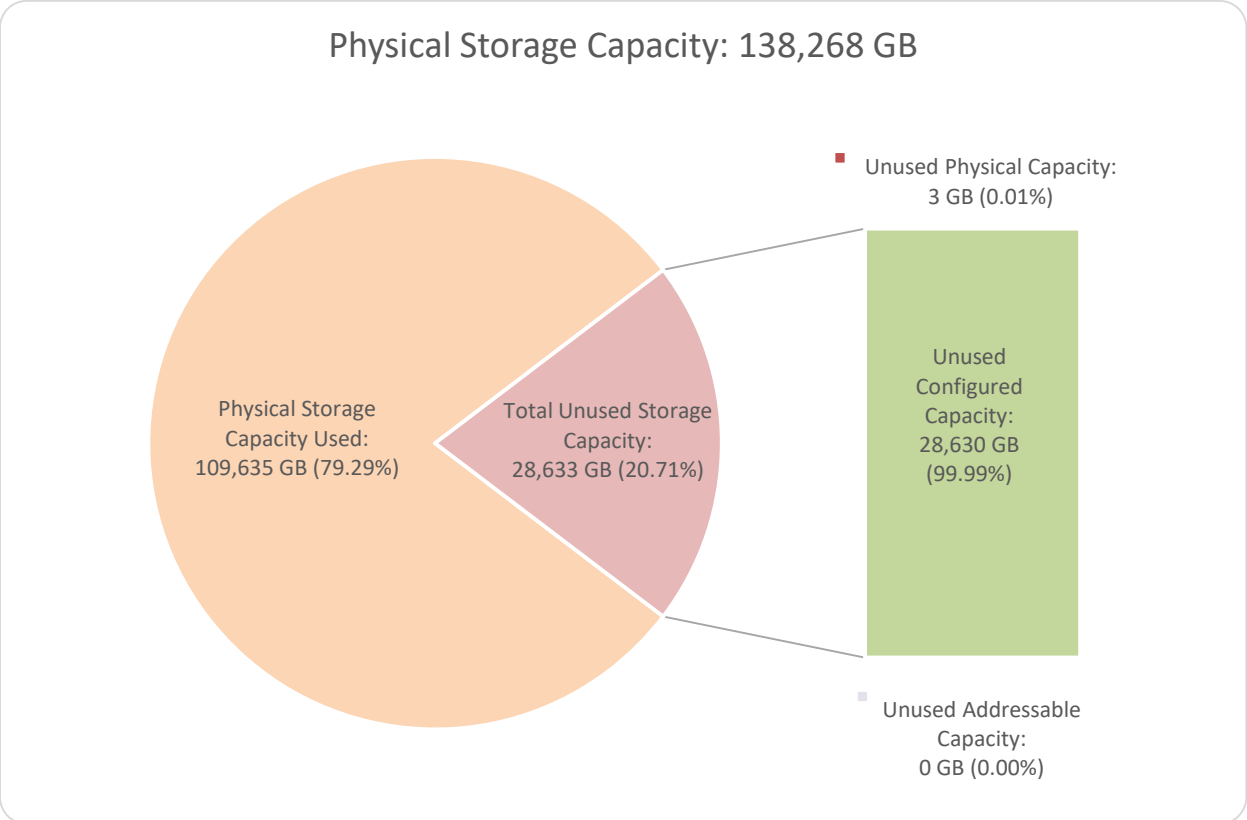
Storage Capacities, Relationships, and Utilization

The following four charts and the following table document the various storage capacities, used in this benchmark, their relationships, and the storage utilization values that must be reported. For the sake of readability, the capacity values in these charts are reported as integer values rather than the decimal values listed elsewhere in this document.


Physical Storage Capacity: 138,268 GB
Unused Physical Capacity: 3 GB (0.00%)
Configured Storage Capacity: 138,227 GB (99.97%)
Total RAID Data Capacity: 116,270 GB (84.09%)
Global Storage Overhead: 38 GB (0.03%)
Spares: 8,565 GB (6.19%)
Overhead: 4 GB (0.00%)
Data Protection Capacity: 13,389 GB (9.68%)


Configured Storage Capacity: 138,227 GB
Overhead: 10,139 GB (7.34%)
Configured Storage Capacity Available: 119,523 GB (86.47%)
Addressable Storage Capacity: 77,505 GB (56.07%)
Spares: 8,565 GB (6.20%)
Unused Configured Storage Capacity: 28,630 GB (20.71%)
Data Protection Capacity Used: 13,389 GB (9.69%)


Addressable Storage Capacity: 77,505 GB
Unused Addressable Capacity: 0 GB (0.00%)
Total ASU Capacity: 77,505 GB (100.00%)
ASU-1 Capacity: 34,876 GB (45.00%)
ASU-2 Capacity: 34,879 GB (45.00%)
ASU-3 Capacity: 7,750 GB (10.00%)


Physical Storage Capacity: 138,268 GB
Unused Physical Capacity: 3 GB (0.01%)
Physical Storage Capacity Used: 109,635 GB (79.29%)
Total Unused Storage Capacity: 28,633 GB (20.71%)
Unused Configured Capacity: 28,630 GB (99.99%)
Unused Addressable Capacity: 0 GB (0.00%)

SPC-1 Storage Capacity Utilization	
Application Utilization	56.05%
Protected Application Utilization	65.74%
Unused Storage Ratio	20.71%

Application Utilization: Total ASU Capacity *(*77,504.698 *GB)* divided by Physical Storage Capacity *(138,268.335 GB).*

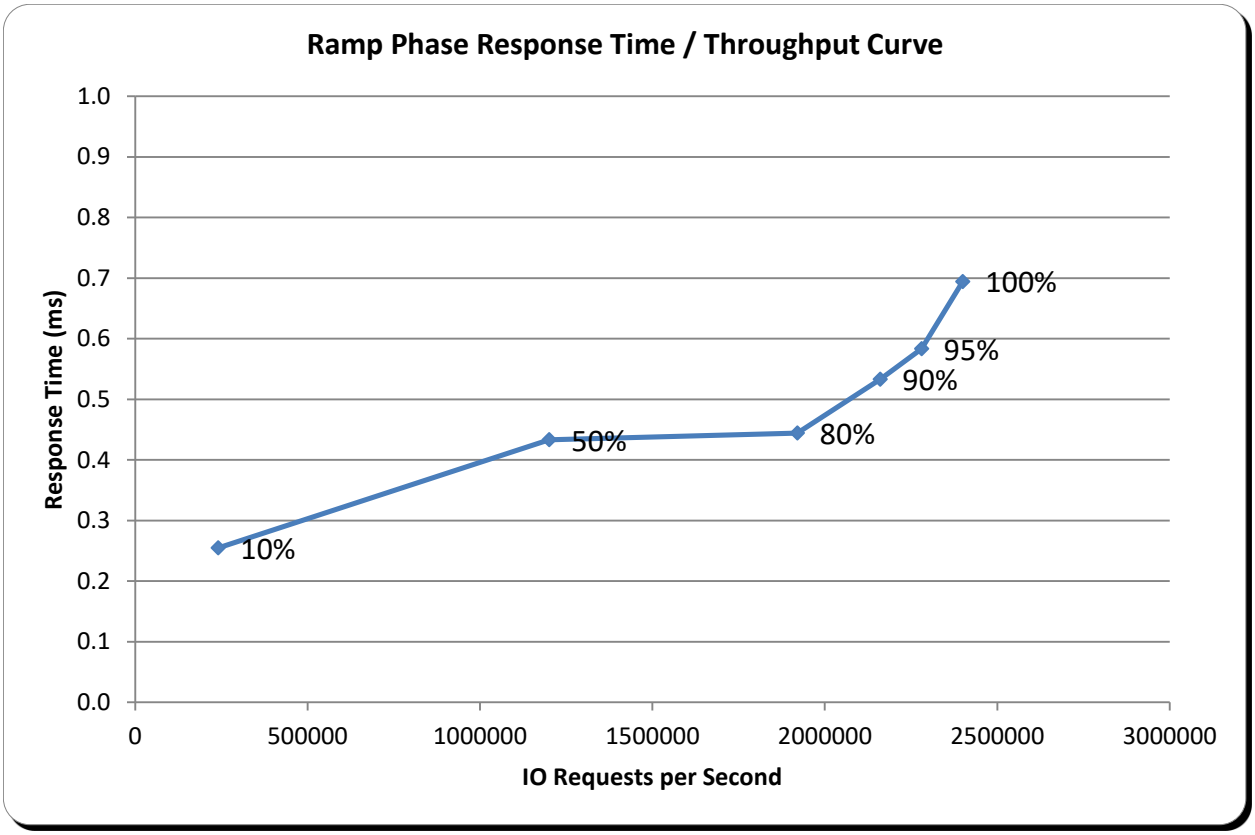
Protected Application Utilization: (Total ASU Capacity *(*77,504.698 *GB)* plus total Data Protection Capacity *(13,388.822 GB)* minus unused Data Protection Capacity *(0.000 GB)*) divided by Physical Storage Capacity *(138,268.335 GB).*

Unused Storage Ratio: Total Unused Capacity *(28,633.083 GB)* divided by Physical Storage Capacity *(138,268.335 GB)* and may not exceed 45%.

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	240,006.77	1,200,037.20	1,919,996.60	2,160,087.79	2,280,031.04	2,400,059.26
Avg. Response Time (ms)						
All ASUs	0.25	0.43	0.44	0.53	0.58	0.69
ASU-1	0.24	0.41	0.43	0.52	0.58	0.69
ASU-2	0.26	0.41	0.42	0.49	0.53	0.61
ASU-3	0.29	0.49	0.48	0.57	0.62	0.74
Reads	0.21	0.36	0.38	0.46	0.50	0.60
Writes	0.28	0.48	0.49	0.58	0.63	0.76

Priced Storage Configuration Pricing

Part Number	Description	Source	US List Price per Unit	Discount	Price per Unit	Quantity	Total Price
AFF-A700S-101-C	AFF A700s HA + 24x960GB SSD drives (HA pair + 24x960GB SSD internal drives)	NetApp	$ 265,070.00	50%	$ 132,535.00	6	$ 795,210.00
SW-FLASH-BASE-BUNDLE-C	ONTAP,Per-0.1TB,Flash,BASEBNDL,Ult-Perf,-C (BASE BNDL pricing for AFFA700s - OS + Protocols)	NetApp	$ 654.00	50%	$ 327.00	1382	$ 452,044.80
X-6510-48-16G-R6	Switch,Brocade 6510 48-Pt FF Ent 16G SWL SFPs	NetApp	$ 48,715.00	50%	$ 24,357.50	2	$ 48,715.00
X190001	Cisco Nexus 3132Q-X, 32 QSFP+ ports, low power, latency	NetApp	$ 13,000.00	50%	$ 6,500.00	2	$ 13,000.00
X66100-1	Cable,Direct Attach CU SFP+,40Gb,1m	NetApp	$ 250.00	50%	$ 125.00	2	$ 250.00
Panduit FX2ERLNLNSNM002	Cable,Cntlr-Switch,2m,Pair,LC/LC,Op (Fiber)	3rd Party Quote	$ 20.65		$ 20.65	48	$ 991.20
Panduit FX2ERLNLNSNM010	Cable,Host-Switch,10m,Pair,LC/LC,Op (Fiber)	3rd Party Quote	$ 34.25		$ 34.25	30	$ 1,027.50
X66031A	Cable,12Gb,Mini SAS HD to HD,1m (NVRAM10p to NVRAM10p HSL Link)	NetApp	$ 26.72	50%	$ 13.36	12	$ 160.32
Qlogic 2672-CK	Qlogic 16Gig 2port HBA for servers	3rd Party Quote	$ 1,290.00		$ 1,290.00	15	$ 19,350.00
X66100-5	Cable,Direct Attach CU SFP+,40Gb,5m	NetApp	$ 375.00	50%	$ 187.50	24	$ 4,500.00
X8712C-EN-R6-C	PDU, 1-Phase, 24 Outlet, 30A, NEMA, -C, R6	NetApp	$ 550.00	50%	$ 275.00	2	$ 550.00
X870E-EN-R6-C	Cab,Lighted,Empty,No PDU,No Rails,EN,-C	NetApp	$ 5,680.00	50%	$ 2,840.00	1	$ 2,840.00
X8778-R6-C	Mounting Bracket, Tie-Down, 32X0, -C, R6	NetApp	$ 50.00	50%	$ 25.00	12	$ 300.00
CS-O2-4HR- VA	HW Support,Premium2,4hr,y	NetApp	$ 49,701	50%	$ 24,850.32	6	$ 149,101.89
PS-TM-CONSULT-NB-DY-TE-ZA	Consulting Day+TE NonBus,ZA Exp. 1yr. from PO	NetApp	$ 5,063.00		$ 5,063.00	1	$ 5,063.00
Total ($)							$ 1,493,103.71

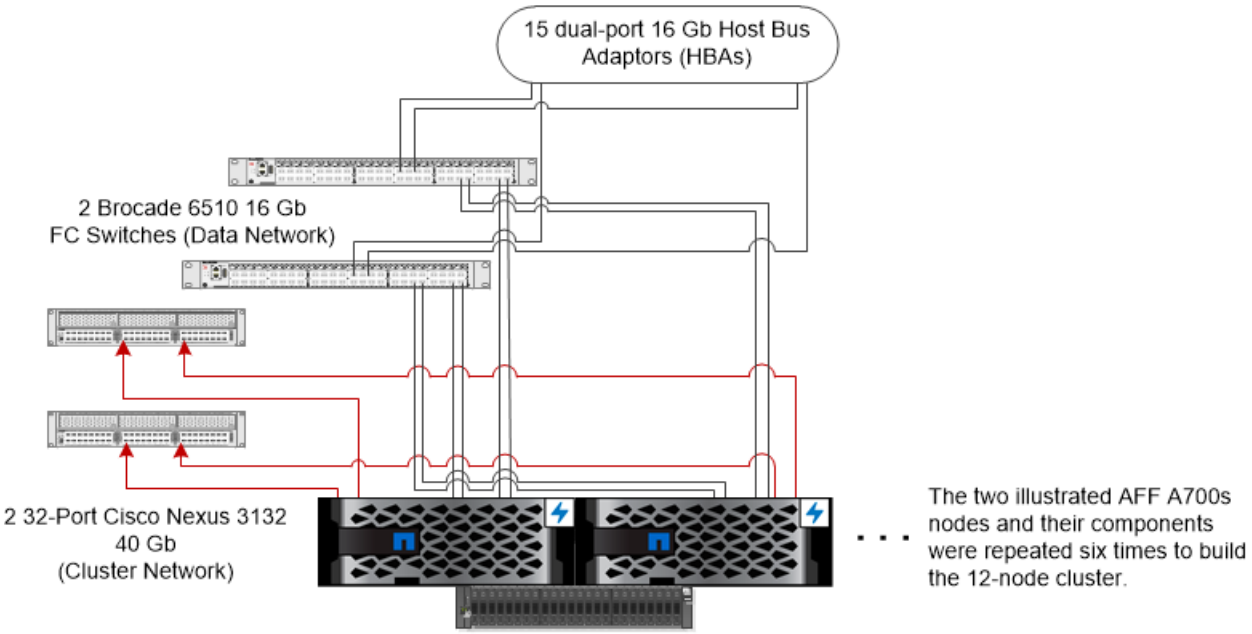
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- 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 Tested Storage Configuration and Priced Storage Configuration

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

Priced Storage Configuration Diagram



NetApp AFF A700s Storage System
6 HA controller pairs (NetApp AFF A700s) (12 controller nodes total)
Each node includes:

- 512 GB memory/cache
- Internal SSDs – 24 x 960 GB SAS SSDs per HA pair
- 4 FC 32 Gb FC front-end connections (48 total) in a multipath high availability (HA) configuration
- 2 Cisco Nexus 3132 40 Gb 32-port switches (cluster network)
- 2 Brocade 6510 16 Gb 48-port switches (data network)
- 144 internal 960 GB solid state drives

Priced Storage Configuration Components

Priced Storage Configuration
15 QLogic QLE2672 dual-port 16 GB HBAs
2 Brocade 6510 16 GB, 48-port FC switches (data network)

NetApp® AFF A700s
• 6 HA controller pairs in 4RU chassis
• 2 controller nodes per chassis
• 12 controller nodes total. Each node includes:
  o 512 GB memory/cache (6144 GB total)
  o 4 32 GB FC front-end connections (48 total and used)
  o Internal 12 GB SAS (no cards, no cables)

2 Cisco Nexus 3132Q-X 40 GB 32 QSFP+ ports (cluster network)
144 960 GB Solid State Drives (SSDs) (24 SSDs per HA controller pair)
1 Cabinet – deep, heavy, no PDU, no rail
2 PDUs – 1-phase, 24 outlet, 30A NEMA

In the remainder of this document, the appropriate Full Disclosure Report requirement, from the SPC-1 benchmark specification, is presented in italics. The requirement is then followed by the information required to fulfill it.

CONFIGURATION INFORMATION

Benchmark Configuration / Tested Storage Configuration Diagram

Clause 9.4.3.4.1

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

Please see 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 highlevel network illustration as shown in Figure 9-8. In that case, a separate, detailed network configuration diagram will also be included as described in Clause 9.4.3.4.2.

Clause 9.4.3.4.2

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

The storage network configuration is illustrated in the Benchmark Configuration / Tested Storage Configuration Diagram.

There were no specific port mappings for any of the switches in the Tested Storage Configuration. However, one of the ports on each HBA was connected to one data network switch, and the other port on each HBA was connected to the other data network switch. This same approach was applied to the connections from the controller nodes to the data network switches and the cluster network switches. This approach was used to improve reliability and redundancy in a business-critical environment and not for performance reasons.

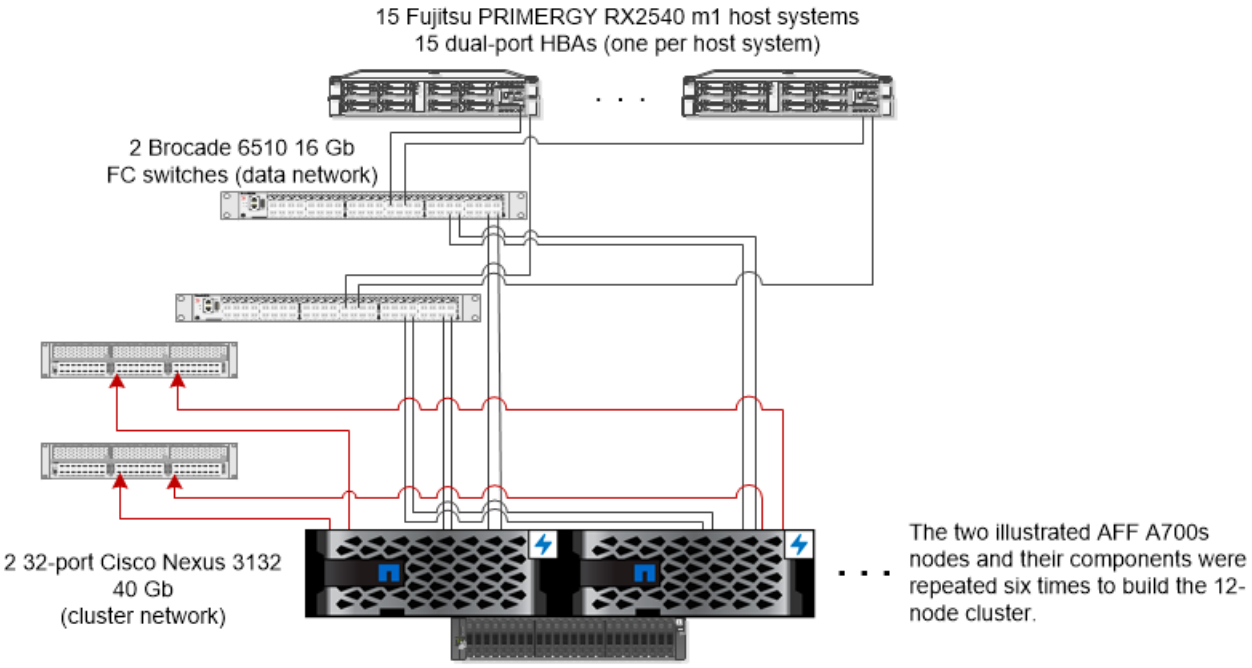
Host System(s) and Tested Storage Configuration Table of Components

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).

Please see Host System and Tested Storage Configuration Components.

Benchmark Configuration/Tested Storage Configuration Diagram



NetApp AFF A700s storage system
6 HA controller pairs (NetApp AFF A700s) (12 controller nodes total).
Each node includes:

- 512 GB memory/cache
- Internal SSD drives – 24 x 960 GB SAS SSDs per HA pair
- 4 FC 32 Gb FC front-end connections (48 total)
- (in a multipath high availability (HA) configuration)
- 2 Cisco Nexus 3132 40 Gb 32-port switches (cluster network)
- 2 Brocade 6510 16 Gb 48-port switches (data network)
- 144 internal 960 GB solid state drives

Host System and Tested Storage Configuration Components

Host Systems
15 Fujitsu PRIMERGY RX2540 m1 host servers, each with: • 2 Intel® Xeon® 2.30 GHz E5-2670 processors, each with 6 cores and 30720 KB L3 Cache • 256 GB main memory • Red Hat Enterprise Linux Server 6.8 (64-bit) • PCIe 3.0
Priced Storage Configuration
15 QLogic QLE2672 dual-port 16 GB HBAs
2 Brocade 6510 16 GB, 48-port FC switches (data network)

NetApp® AFF A700s
• 6 HA controller pairs in 4RU chassis
• 2 controller nodes per chassis
• 12 controller nodes total. Each node includes:
  ○ 512 GB memory/cache (6144 GB total)
  ○ 4 32 GB FC front-end connections (48 total and used)
  ○ Internal 12 GB SAS (no cards, no cables)

2 Cisco Nexus 3132Q-X 40 GB 32 QSFP+ ports (cluster network)
144 960 GB SSDs (24 SSDs per HA controller pair)
1 cabinet – deep, heavy, no PDU, and no rail
2 PDUs – 1-phase, 24 outlet, 30A NEMA

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.

Please see Appendix B.

Tested Storage Configuration 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.*

Please see Appendix C.

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.

Please see Appendix D.

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 DATA REPOSITORY

This section documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. SPC-1 Data Repository Definitions contains term definitions 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 138,268.335 GB distributed over 144 solid state devices (SSDs) each with a formatted capacity of 960.197 GB. There was 3.170 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 37.748 GB (0.03%) of the Physical Storage Capacity. There was 28,629.912 GB (20.71%) 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 *(RAID DP®)* capacity was 13,388.822 GB of which 13,388.822 GB was utilized. The total Unused Storage capacity was 28,633.083 GB.

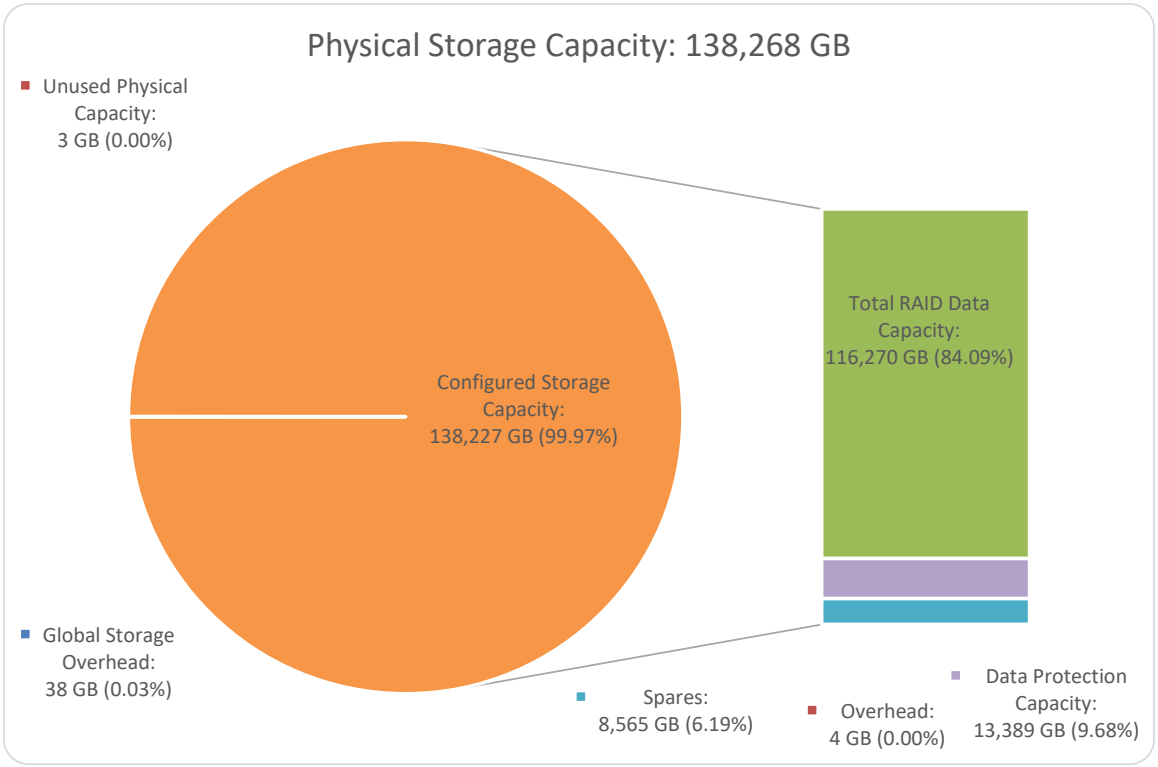
Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.

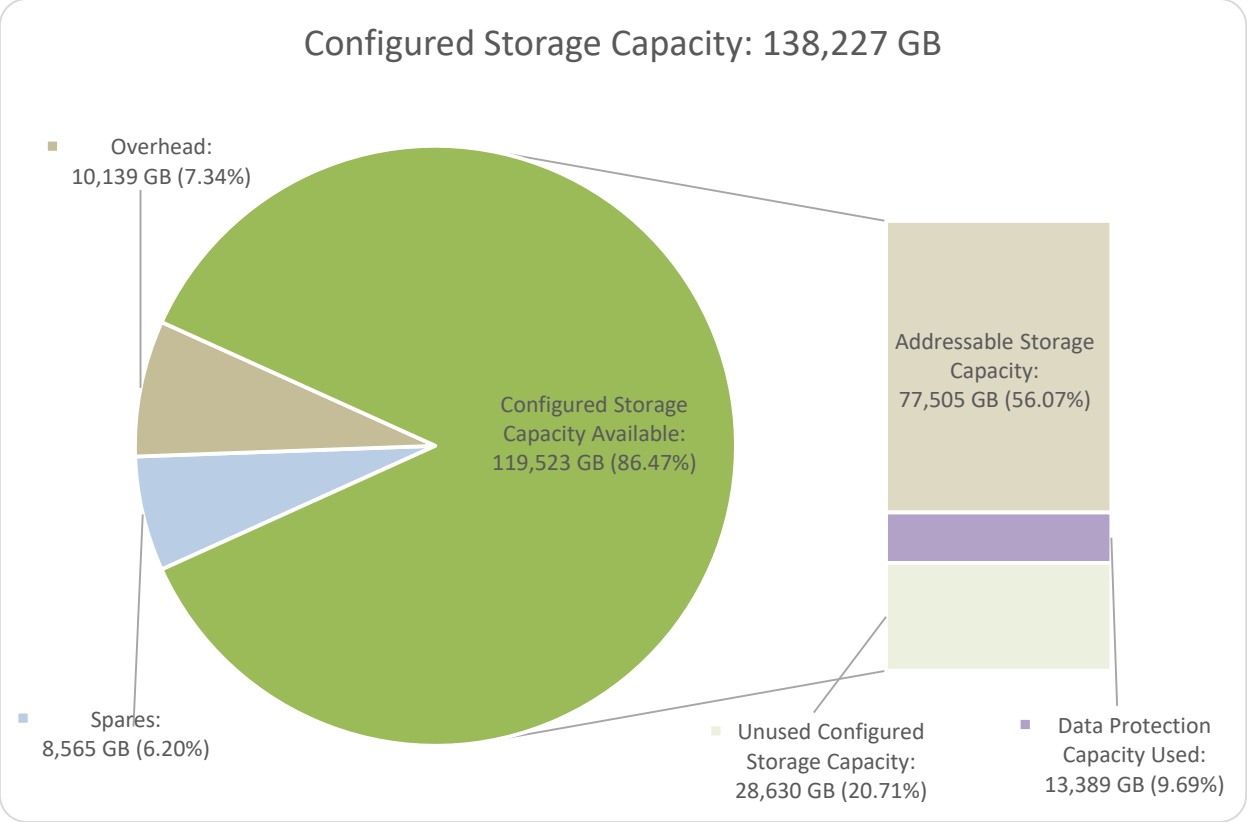
SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	77,504.698
Addressable Storage Capacity	Gigabytes (GB)	77,504.698
Configured Storage Capacity	Gigabytes (GB)	138,227.415
Physical Storage Capacity	Gigabytes (GB)	138,268.335
Data Protection *(RAID DP®)*	Gigabytes (GB)	13,388.822
Required Storage *(sparing capacity)*	Gigabytes (GB)	18,703.982
Global Storage Overhead	Gigabytes (GB)	37.748
Total Unused Storage	Gigabytes (GB)	28,633.083

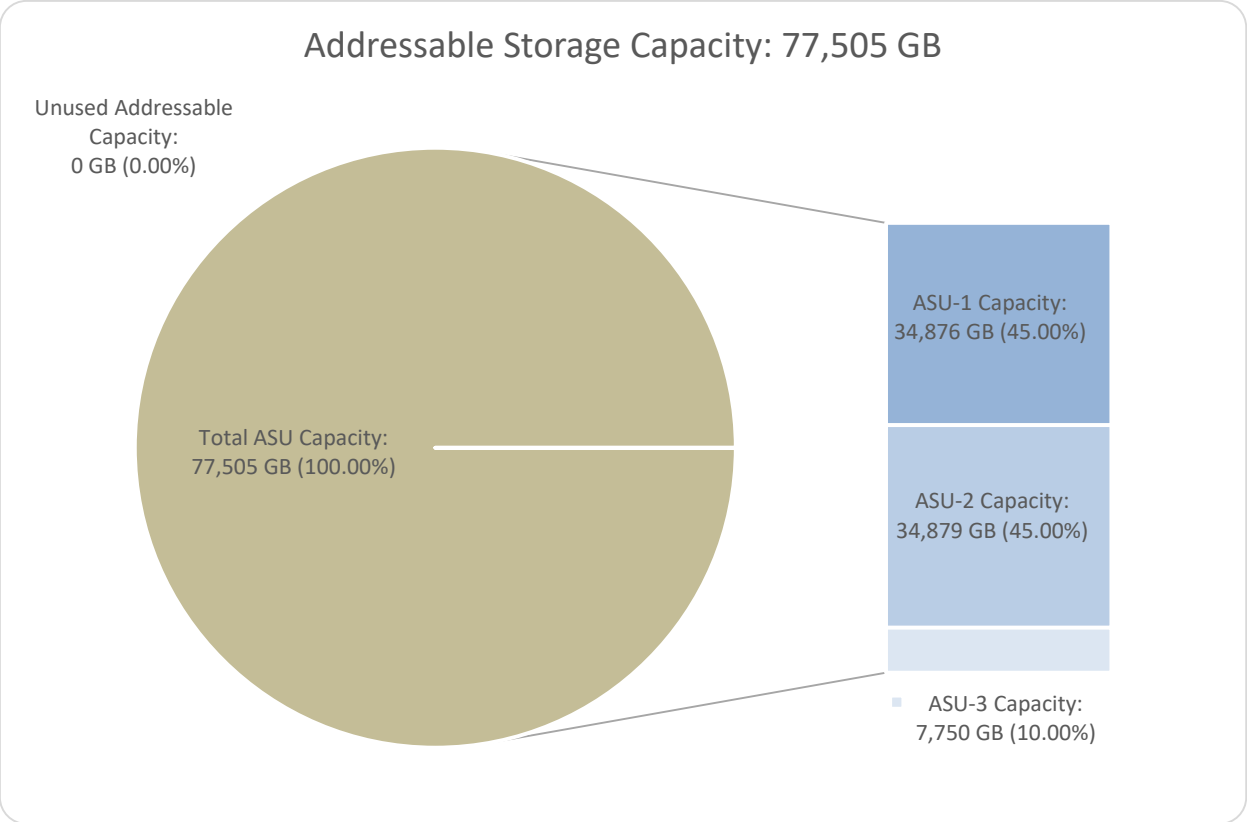
SPC-1 Storage Hierarchy Ratios

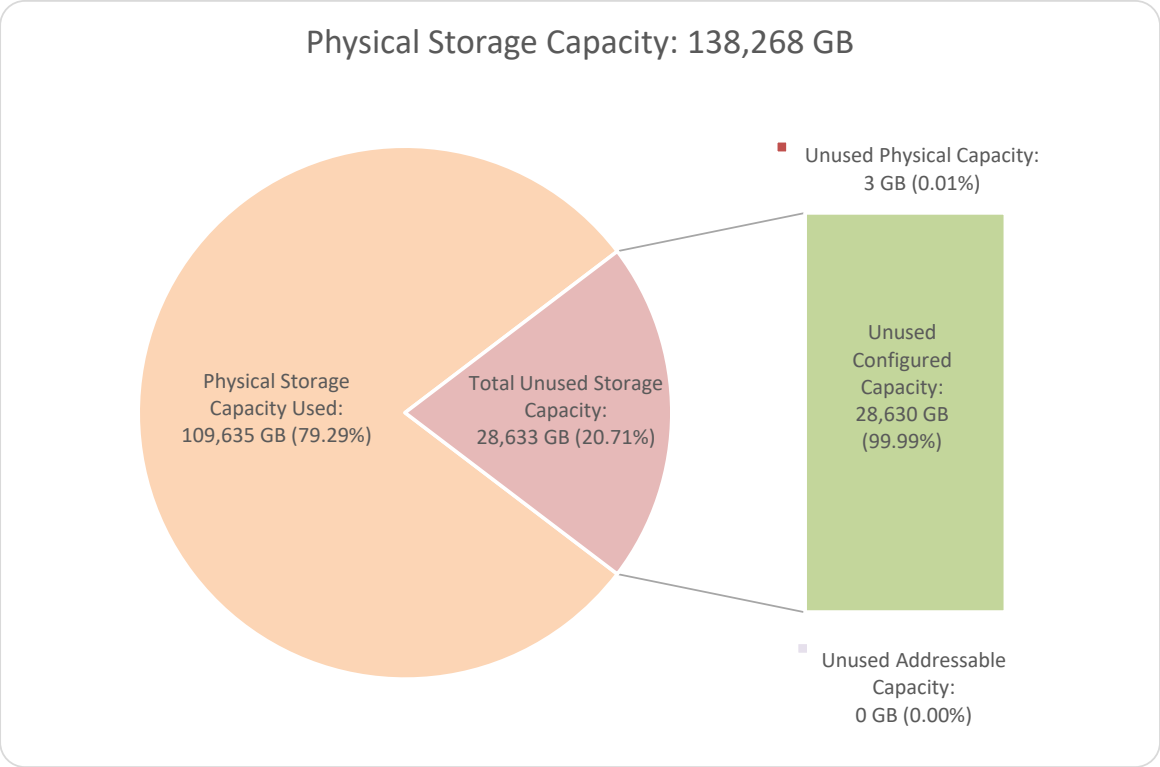
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	56.07%	56.05%
Required for Data Protection (*RAID DP®*)		9.68%	9.68%
Addressable Storage Capacity		56.07%	56.05%
Required Storage (sparing capacity)		13.53%	13.52%
Configured Storage Capacity			99.97%
Global Storage Overhead			0.03%
Unused Storage:			
Addressable	0.00%		
Configured		20.71%	
Physical			0.00%

SPC-1 Storage Capacity Charts




Configured Storage Capacity: 138,227 GB
Overhead:
10,139 GB (7.34%)
Configured Storage Capacity Available:
119,523 GB (86.47%)
Addressable Storage Capacity:
77,505 GB (56.07%)
Spares:
8,565 GB (6.20%)
Unused Configured Storage Capacity:
28,630 GB (20.71%)
Data Protection Capacity Used:
13,389 GB (9.69%)


Addressable Storage Capacity: 77,505 GB
Unused Addressable Capacity:
0 GB (0.00%)
Total ASU Capacity:
77,505 GB (100.00%)
ASU-1 Capacity:
34,876 GB (45.00%)
ASU-2 Capacity:
34,879 GB (45.00%)
ASU-3 Capacity:
7,750 GB (10.00%)



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	56.05%
Protected Application Utilization	65.74%
Unused Storage Ratio	20.71%

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 (34,875.806 GB)	**ASU-2 (34,878.775 GB)**	**ASU-3 (7,750.117 GB)**
1 Logical Volume 34,875.806 GB per Logical Volume (34,875.806 GB used per Logical Volume)	1 Logical Volume 34,878.775 GB per Logical Volume (34,878.775 GB used per Logical Volume)	1 Logical Volume 7,750.117 GB per Logical Volume (7,750.117 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was Protected 2 using *RAID DP*®.

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 in Appendix A 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:

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

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.

Sustainability Test Results File

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

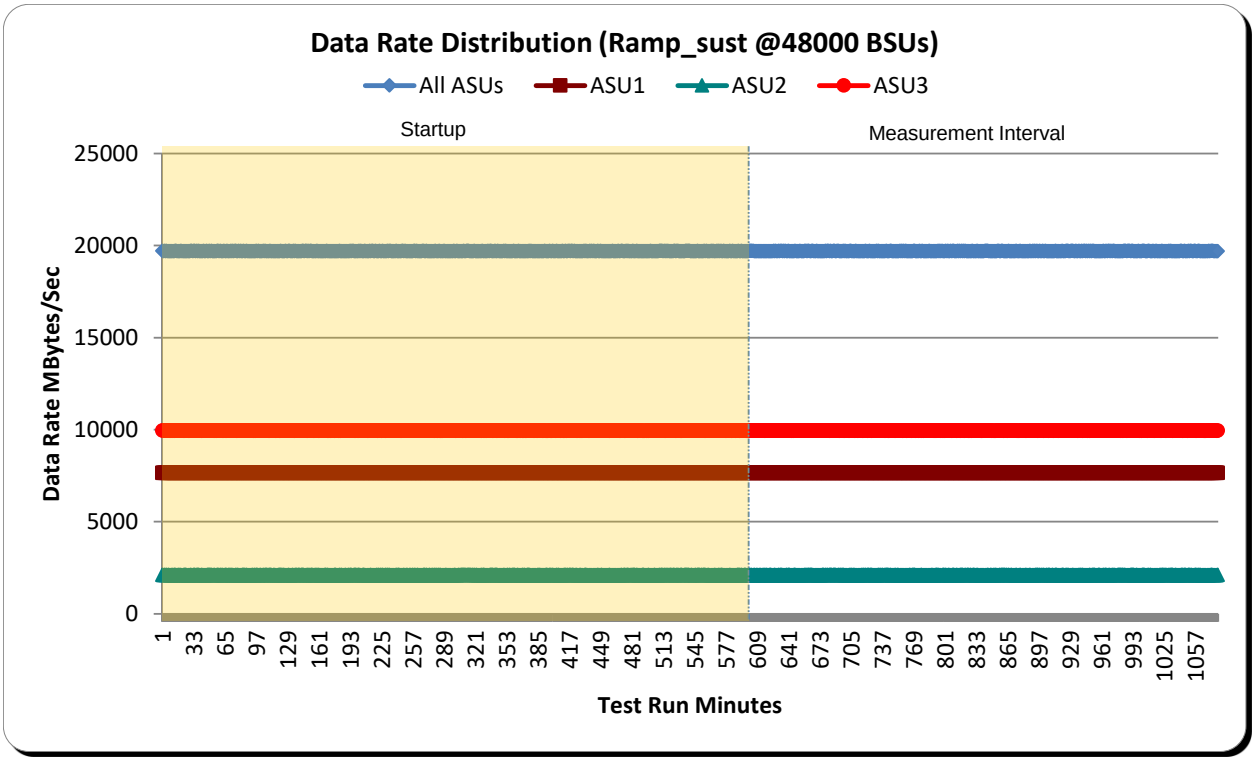
Sustainability Test Results File

Sustainability – Data Rate Distribution Data (MB/second)

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

Sustainability Data Rate Table

Sustainability – Data Rate Distribution Graph

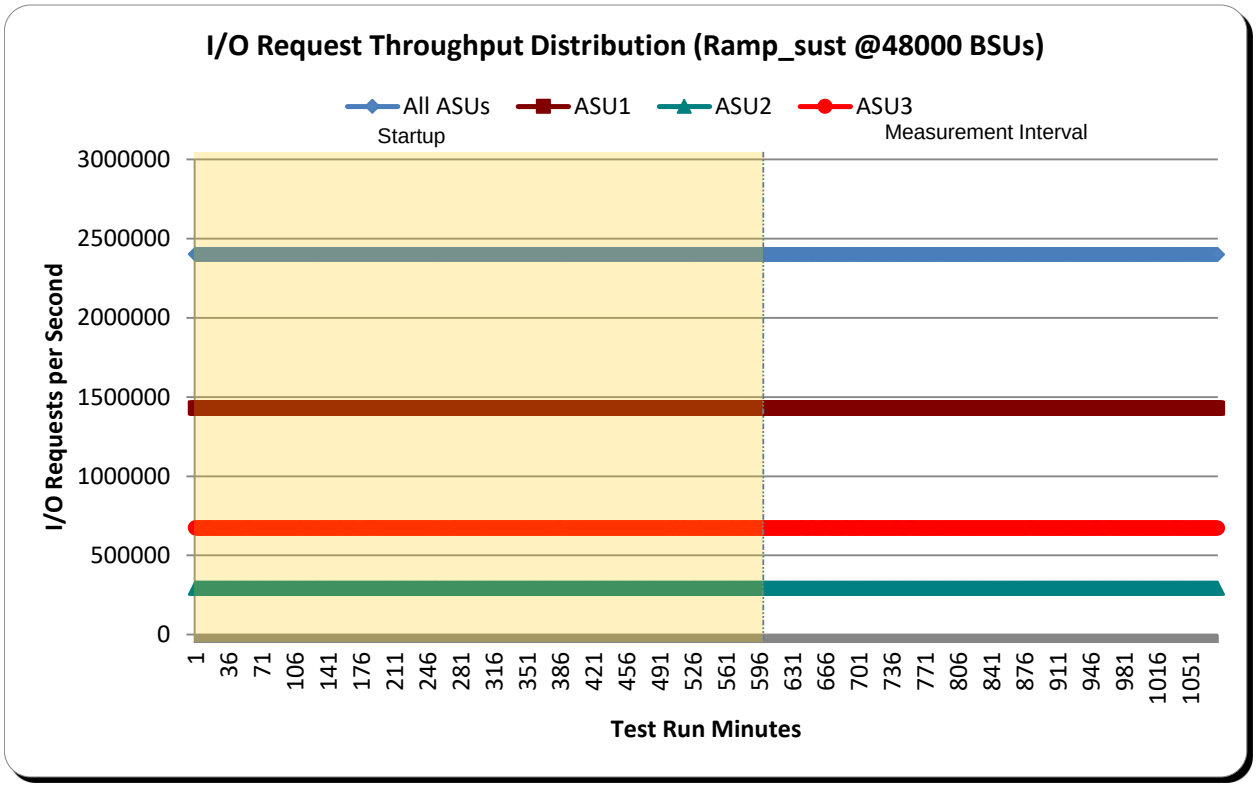


Sustainability – I/O Request Throughput Distribution Data

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

Sustainability I/O Request Throughput Table

Sustainability – I/O Request Throughput Distribution Graph

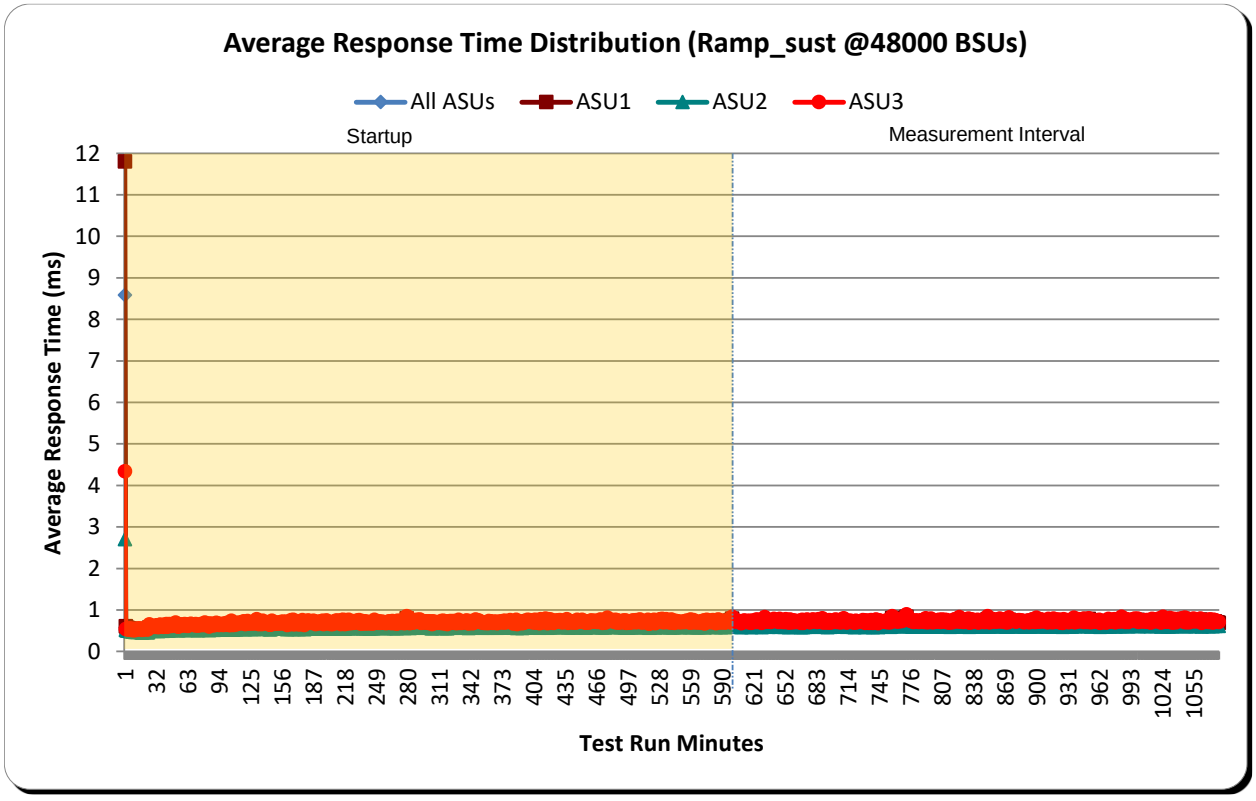


Sustainability – Average Response Time (ms) Distribution Data

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

Sustainability Average Response Time Table

Sustainability – Average Response Time (ms) Distribution Graph



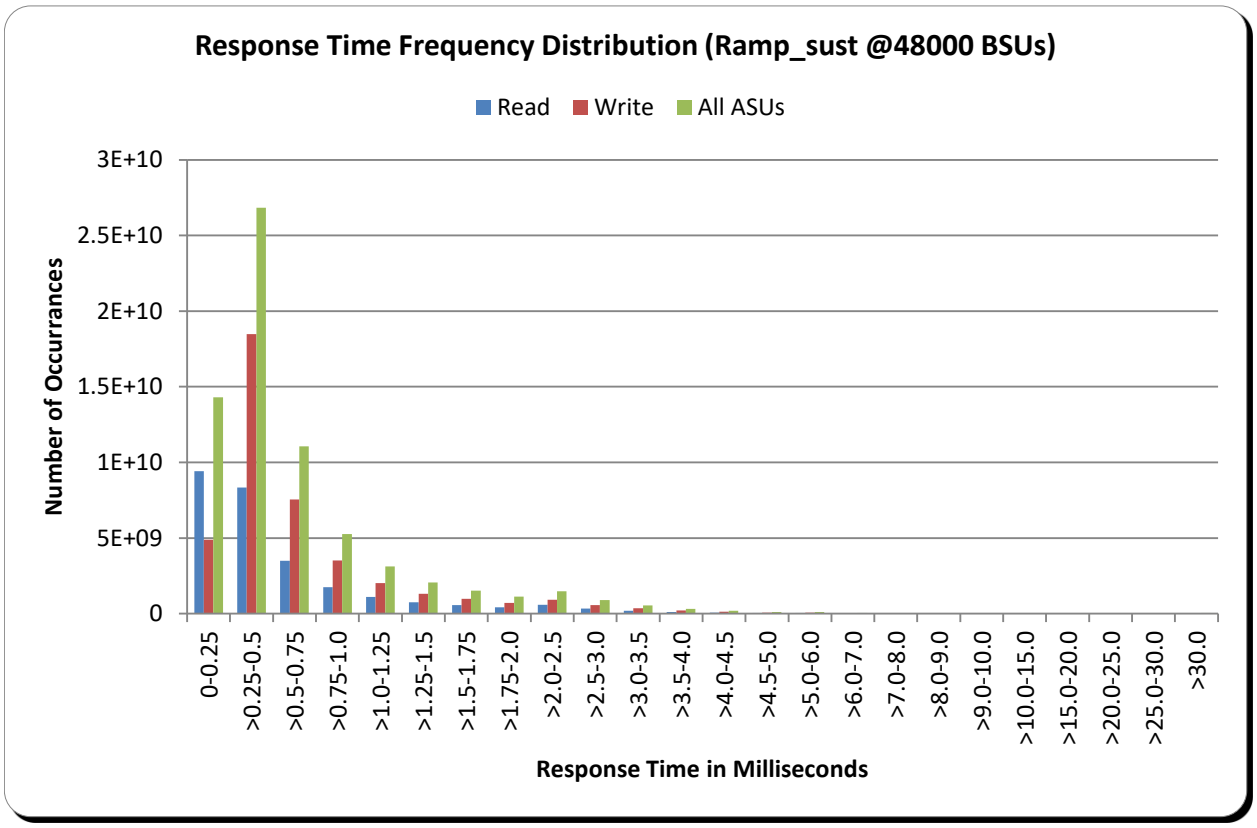
Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	9,424,534,283	8,347,995,112	3,495,246,006	1,748,269,176	1,096,871,974	747,379,950	555,305,043	422,975,523
Write	4,883,039,173	18,486,491,970	7,558,362,896	3,515,743,951	2,013,900,417	1,321,984,292	970,221,069	708,440,058
All ASUs	14,307,573,456	26,834,487,082	11,053,608,902	5,264,013,127	3,110,772,391	2,069,364,242	1,525,526,112	1,131,415,581
ASU1	9,130,284,759	15,039,608,696	6,637,218,294	3,258,661,857	1,943,845,843	1,282,268,191	934,266,813	691,670,784
ASU2	2,850,229,848	2,818,221,175	1,059,590,390	503,507,717	311,920,250	216,871,460	164,959,174	125,549,276
ASU3	2,327,058,849	8,976,657,211	3,356,800,218	1,501,843,553	855,006,298	570,224,591	426,300,125	314,195,521

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	577,717,155	340,076,333	198,339,281	114,715,242	68,285,957	39,633,787	37,062,103	13,365,467
Write	911,504,324	559,690,348	355,139,097	205,211,409	120,669,050	71,281,611	70,309,826	28,350,809
All ASUs	1,489,221,479	899,766,681	553,478,378	319,926,651	188,955,007	110,915,398	107,371,929	41,716,276
ASU1	907,105,522	532,893,605	323,386,700	188,311,301	110,517,972	64,480,771	62,019,334	23,864,506
ASU2	172,275,981	108,750,525	66,850,848	38,645,088	23,274,165	13,690,129	13,104,609	4,839,262
ASU3	409,839,976	258,122,551	163,240,830	92,970,262	55,162,870	32,744,498	32,247,986	13,012,508

Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	5,486,844	2,832,027	1,833,912	5,349,682	3,978,859	3,112,010	2,166,886	7,696,027
Write	12,701,200	6,583,013	4,014,787	10,514,821	7,110,302	5,716,398	4,248,815	28,316,747
All ASUs	18,188,044	9,415,040	5,848,699	15,864,503	11,089,161	8,828,408	6,415,701	36,012,774
ASU1	10,369,307	5,390,471	3,385,886	9,423,939	6,845,949	5,543,826	3,995,896	20,028,048
ASU2	1,954,185	938,484	555,431	1,446,921	920,641	587,805	373,242	2,525,923
ASU3	5,864,552	3,086,085	1,907,382	4,993,643	3,322,571	2,696,777	2,046,563	13,458,803

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	0.000	0.000	0.000	0.000	0.001	0.000	0.000	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.

IOPS Test Results File

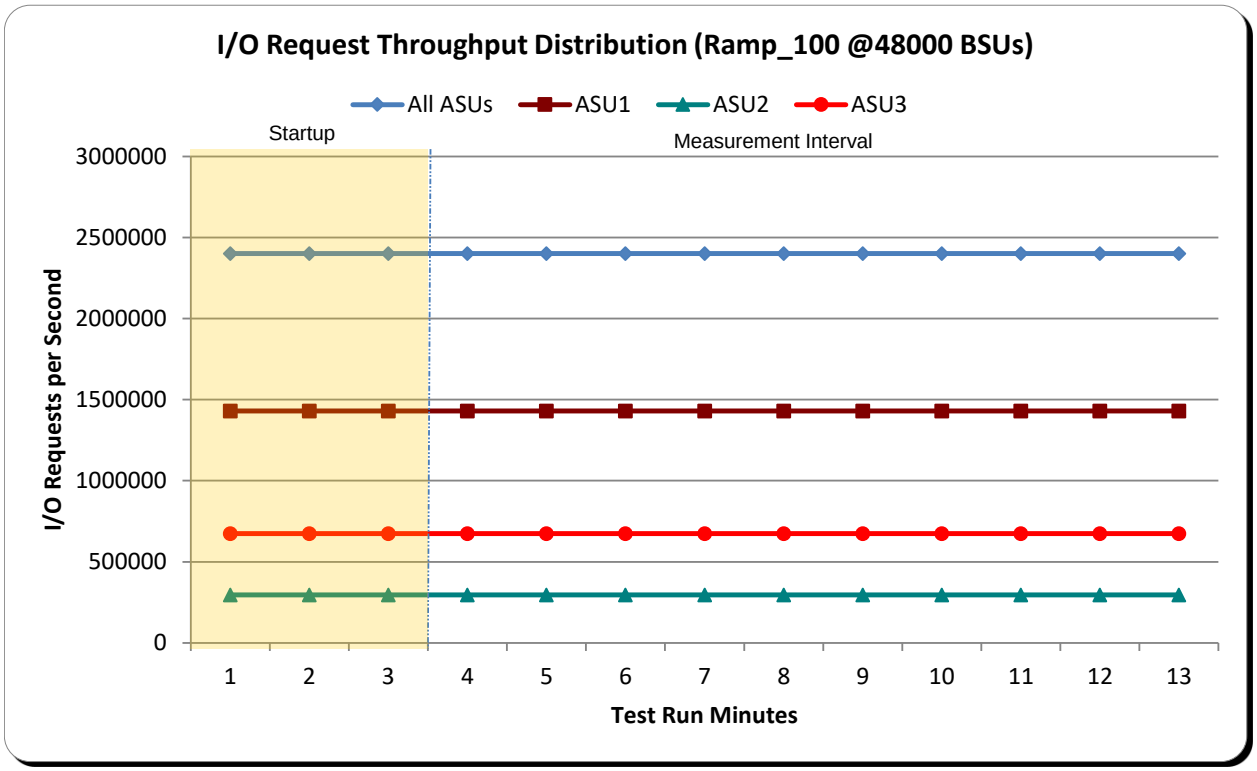
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:27	0:07:28	0-2	0:03:01
Measurement Interval	0:07:28	0:17:28	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2,400,725.40	1,430,749.45	295,281.53	674,694.42
1	2,400,036.78	1,430,280.65	295,191.12	674,565.02
2	2,399,882.17	1,430,250.47	295,280.40	674,351.30
3	2,400,118.52	1,430,405.70	295,163.85	674,548.97
4	2,399,849.35	1,430,164.73	295,201.47	674,483.15
5	2,400,050.43	1,430,280.85	295,350.03	674,419.55
6	2,400,157.35	1,430,462.77	295,257.98	674,436.60
7	2,399,868.68	1,430,244.85	295,138.08	674,485.75
8	2,400,454.82	1,430,244.85	295,138.08	674,485.75
9	2,400,098.72	1,430,599.70	295,165.72	674,333.30
10	2,399,798.92	1,430,316.92	295,132.17	674,349.83
11	2,400,185.73	1,430,597.13	295,207.72	674,380.88
12	2,400,010.10	1,430,343.33	295,209.98	674,456.78
Average	**2,400,059.26**	**1,430,414.16**	**295,210.19**	**674,434.91**

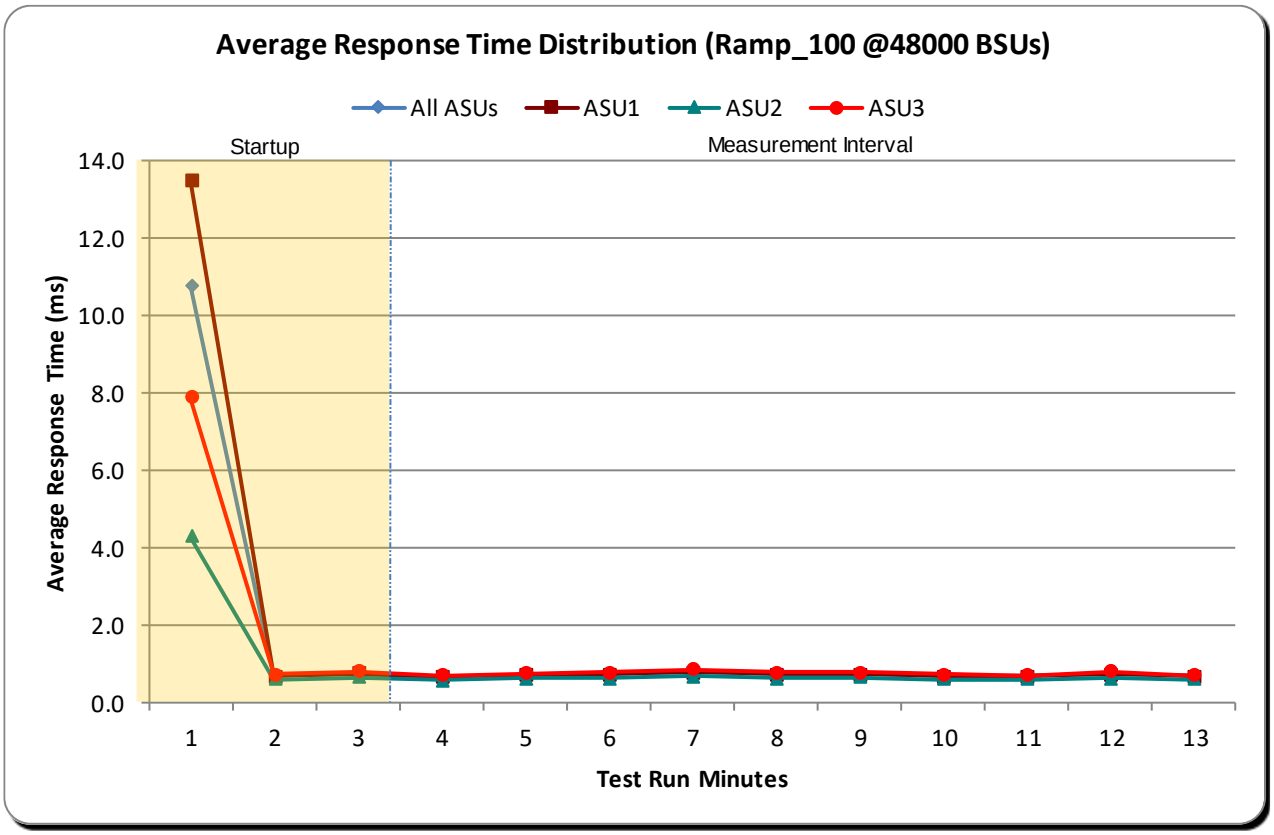
IOPS Test Run – I/O Request Throughput Distribution Graph



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

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:27	0:07:28	0-2	0:03:01
Measurement Interval	0:07:28	0:17:28	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	10.78	13.49	4.27	7.86
1	0.68	0.67	0.58	0.73
2	0.74	0.73	0.62	0.80
3	0.64	0.64	0.57	0.69
4	0.69	0.68	0.60	0.73
5	0.71	0.70	0.62	0.75
6	0.78	0.77	0.66	0.84
7	0.70	0.70	0.61	0.75
8	0.71	0.70	0.61	0.75
9	0.67	0.66	0.59	0.71
10	0.66	0.67	0.58	0.70
11	0.72	0.71	0.62	0.78
12	0.66	0.65	0.58	0.70
Average	0.69	0.69	0.61	0.74

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



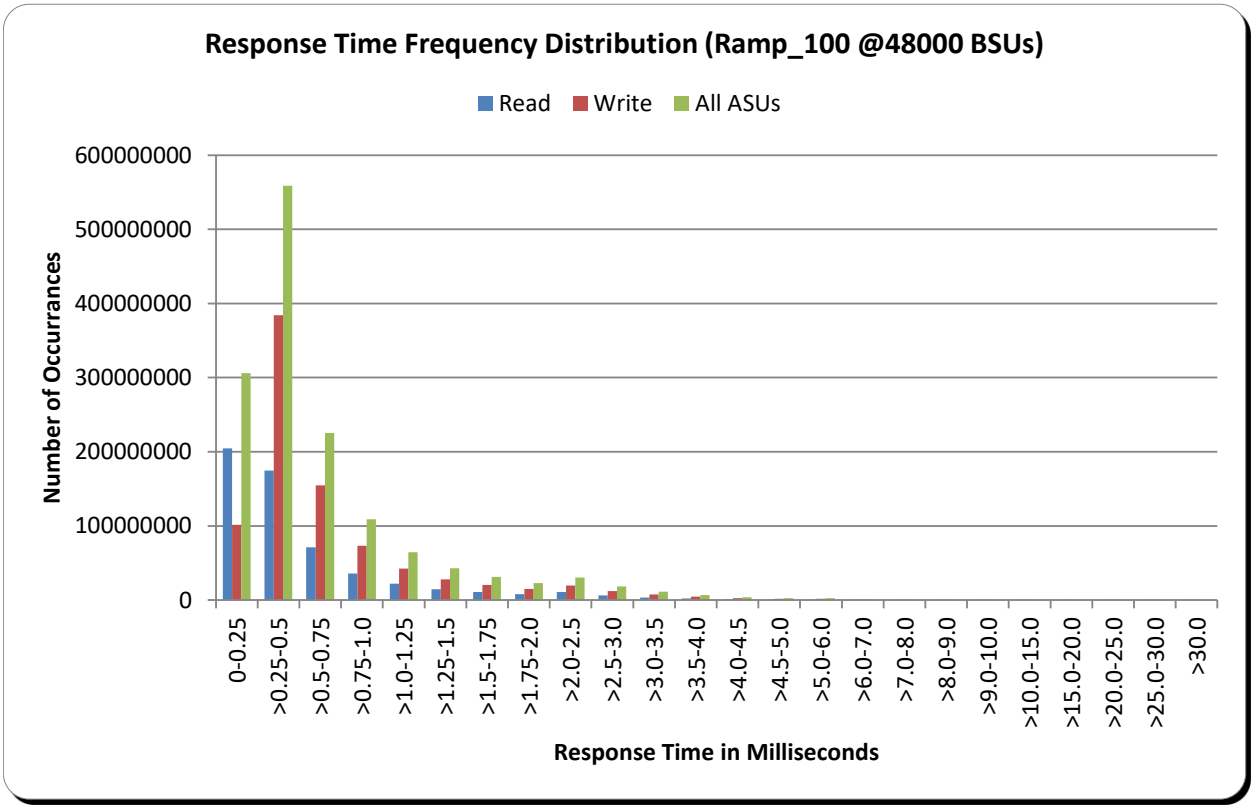
IOPS Test Run –Response Time Frequency Distribution Data

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	204,417,739	174,555,308	71,007,916	35,840,545	22,146,386	14,784,197	10,748,881	8,015,590
Write	101,681,991	384,335,104	154,526,881	73,060,273	42,493,737	27,991,591	20,537,357	15,050,224
All ASUs	306,099,730	558,890,412	225,534,797	108,900,818	64,640,123	42,775,788	31,286,238	23,065,814
ASU1	196,827,979	313,099,493	135,273,678	67,421,037	40,347,807	26,418,039	19,027,348	13,933,839
ASU2	60,719,425	58,833,460	21,564,288	10,295,872	6,354,138	4,392,629	3,323,644	2,518,862
ASU3	48,552,326	186,957,459	68,696,831	31,183,909	17,938,178	11,965,120	8,935,246	6,613,113

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	10,736,397	6,185,538	3,588,369	2,079,341	1,246,472	740,870	730,279	295,192
Write	19,480,384	12,000,687	7,692,671	4,531,882	2,723,019	1,643,526	1,689,158	730,846
All ASUs	30,216,781	18,186,225	11,281,040	6,611,223	3,969,491	2,384,396	2,419,437	1,026,038
ASU1	18,076,550	10,508,364	6,407,214	3,781,933	2,250,869	1,346,615	1,364,679	579,876
ASU2	3,454,109	2,181,190	1,351,085	785,093	479,573	286,030	282,771	110,404
ASU3	8,686,122	5,496,671	3,522,741	2,044,197	1,239,049	751,751	771,987	335,758

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	141,806	83,340	58,094	169,572	98,248	71,488	44,022	122,107
Write	360,566	206,867	137,443	371,078	197,029	140,752	96,639	446,638
All ASUs	502,372	290,207	195,537	540,650	295,277	212,240	140,661	568,745
ASU1	286,670	166,678	114,068	316,417	174,576	127,426	83,522	312,893
ASU2	47,869	24,606	14,599	36,606	17,774	10,779	6,080	35,081
ASU3	167,833	98,923	66,870	187,627	102,927	74,035	51,059	220,771

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
1,440,034,040	1,439,465,295	568,745

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

The Response Time Ramp Test Phase consists of five Test Runs, one each at 95%, 90%, 80%, 50%, and 10% of the load point (100%) used to generate the SPC-1 IOPS™ primary metric. Each of the five Test Runs has a Measurement Interval of ten (10) minutes. The Response Time Ramp Test Phase immediately follows the IOPS Test Phase without any interruption or manual intervention.

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 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*
4. *Distribution.*
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.

Response Time Ramp Test Results File

A link to each test result file generated from each Response Time Ramp Test Run is 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.

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:27	0:07:28	0-2	0:03:01
Measurement Interval	0:07:28	0:17:28	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,400,725.40	1,430,749.45	295,281.53	674,694.42
1	2,400,036.78	1,430,280.65	295,191.12	674,565.02
2	2,399,882.17	1,430,250.47	295,280.40	674,351.30
3	2,400,118.52	1,430,405.70	295,163.85	674,548.97
4	2,399,849.35	1,430,164.73	295,201.47	674,483.15
5	2,400,050.43	1,430,280.85	295,350.03	674,419.55
6	2,400,157.35	1,430,462.77	295,257.98	674,436.60
7	2,399,868.68	1,430,244.85	295,138.08	674,485.75
8	2,400,454.82	1,430,244.85	295,138.08	674,485.75
9	2,400,098.72	1,430,599.70	295,165.72	674,333.30
10	2,399,798.92	1,430,316.92	295,132.17	674,349.83
11	2,400,185.73	1,430,597.13	295,207.72	674,380.88
12	2,400,010.10	1,430,343.33	295,209.98	674,456.78
Average	**2,400,059.26**	**1,430,414.16**	**295,210.19**	**674,434.91**

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:27	0:07:28	0-2	0:03:01
Measurement Interval	0:07:28	0:17:28	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,400,725.40	1,430,749.45	295,281.53	674,694.42
1	2,400,036.78	1,430,280.65	295,191.12	674,565.02
2	2,399,882.17	1,430,250.47	295,280.40	674,351.30
3	2,400,118.52	1,430,405.70	295,163.85	674,548.97
4	2,399,849.35	1,430,164.73	295,201.47	674,483.15
5	2,400,050.43	1,430,280.85	295,350.03	674,419.55
6	2,400,157.35	1,430,462.77	295,257.98	674,436.60
7	2,399,868.68	1,430,244.85	295,138.08	674,485.75
8	2,400,454.82	1,430,244.85	295,138.08	674,485.75
9	2,400,098.72	1,430,599.70	295,165.72	674,333.30
10	2,399,798.92	1,430,316.92	295,132.17	674,349.83
11	2,400,185.73	1,430,597.13	295,207.72	674,380.88
12	2,400,010.10	1,430,343.33	295,209.98	674,456.78
Average	**2,400,059.26**	**1,430,414.16**	**295,210.19**	**674,434.91**

43200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:13:58	1:16:59	0-2	0:03:01
Measurement Interval	1:16:59	1:26:59	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,160,173.83	1,287,510.23	265,731.63	606,931.97
1	2,160,039.48	1,287,391.13	265,633.45	607,014.90
2	2,160,027.88	1,287,473.63	265,583.18	606,971.07
3	2,159,800.28	1,287,193.43	265,701.30	606,905.55
4	2,160,211.15	1,287,450.68	265,624.38	607,136.08
5	2,160,097.08	1,287,428.73	265,698.15	606,970.20
6	2,160,258.50	1,287,533.45	265,822.43	606,902.62
7	2,159,948.02	1,287,308.08	265,654.50	606,985.43
8	2,160,194.78	1,287,308.08	265,654.50	606,985.43
9	2,160,046.17	1,287,414.67	265,712.82	606,918.68
10	2,160,292.60	1,287,493.72	265,583.15	607,215.73
11	2,159,986.35	1,287,345.60	265,665.75	606,975.00
12	2,160,042.93	1,287,297.63	265,635.50	607,109.80
Average	**2,160,087.79**	**1,287,412.28**	**265,675.03**	**607,000.48**

38400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:47:06	1:50:07	0-2	0:03:01
Measurement Interval	1:50:07	2:00:07	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1,919,866.00	1,144,147.75	236,219.47	539,498.78
1	1,919,802.52	1,144,298.45	236,194.40	539,309.67
2	1,920,106.43	1,144,379.63	236,144.92	539,581.88
3	1,919,998.62	1,144,345.40	236,301.15	539,352.07
4	1,920,111.15	1,144,287.10	236,165.58	539,658.47
5	1,919,962.77	1,144,337.63	236,240.22	539,384.92
6	1,920,081.72	1,144,326.48	236,126.42	539,628.82
7	1,919,878.53	1,144,144.43	236,098.00	539,636.10
8	1,919,912.00	1,144,144.43	236,098.00	539,636.10
9	1,919,967.32	1,144,426.05	236,127.00	539,414.27
10	1,920,117.53	1,144,603.20	236,063.82	539,450.52
11	1,919,950.63	1,144,340.73	236,132.63	539,477.27
12	1,919,985.75	1,144,528.20	236,128.97	539,328.58
Average	**1,919,996.60**	**1,144,358.56**	**236,150.48**	**539,487.56**

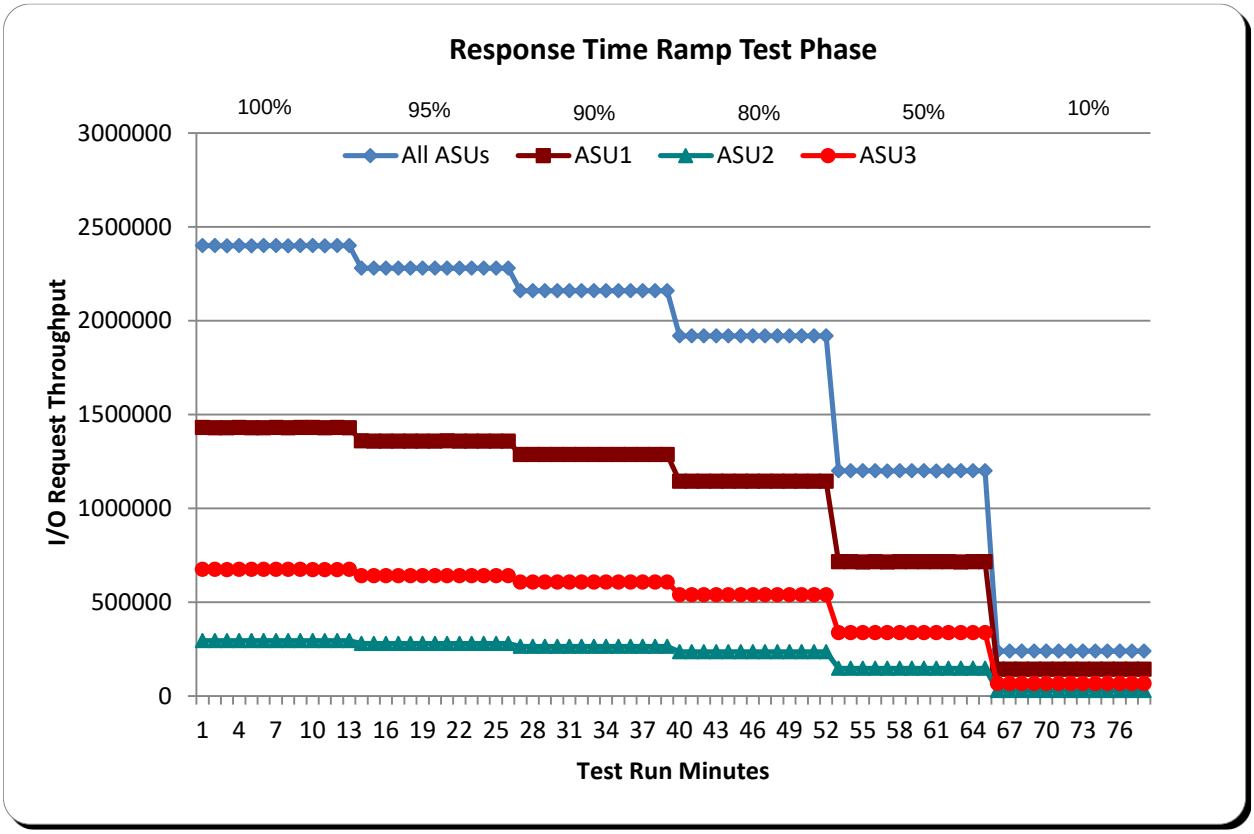
24000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:16:21	2:19:22	0-2	0:03:01
Measurement Interval	2:19:22	2:29:22	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1,200,176.38	715,330.68	147,569.75	337,275.95
1	1,200,129.07	715,327.95	147,633.02	337,168.10
2	1,199,944.28	715,020.03	147,630.77	337,293.48
3	1,200,110.82	715,178.45	147,586.72	337,345.65
4	1,199,805.12	715,075.93	147,534.37	337,194.82
5	1,199,949.60	715,179.30	147,570.42	337,199.88
6	1,200,219.67	715,301.92	147,594.23	337,323.52
7	1,200,017.08	715,177.90	147,669.50	337,169.68
8	1,199,802.53	715,177.90	147,669.50	337,169.68
9	1,200,256.87	715,411.12	147,631.07	337,214.68
10	1,199,875.97	715,085.62	147,524.42	337,265.93
11	1,200,080.65	715,243.02	147,616.02	337,221.62
12	1,200,253.73	715,470.27	147,549.87	337,233.60
Average	**1,200,037.20**	**715,226.65**	**147,573.99**	**337,236.56**

4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:40:44	2:43:45	0-2	0:03:01
Measurement Interval	2:43:45	2:53:45	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
8	239,939.70	143,040.45	29,501.25	67,398.00
1	240,064.45	143,030.98	29,519.78	67,513.68
2	240,006.53	143,071.38	29,518.30	67,416.85
3	240,002.30	143,034.23	29,514.17	67,453.90
4	239,932.62	142,962.63	29,511.17	67,458.82
5	240,018.30	143,026.02	29,555.03	67,437.25
6	240,075.67	143,063.73	29,527.48	67,484.45
7	240,047.25	143,120.58	29,524.80	67,401.87
8	239,939.70	143,120.58	29,524.80	67,401.87
9	239,924.75	142,971.05	29,532.87	67,420.83
10	240,042.97	143,021.12	29,533.78	67,488.07
11	240,119.52	143,084.00	29,575.25	67,460.27
12	239,964.65	143,025.92	29,494.17	67,444.57
Average	**240,006.77**	**143,034.97**	**29,527.00**	**67,444.80**

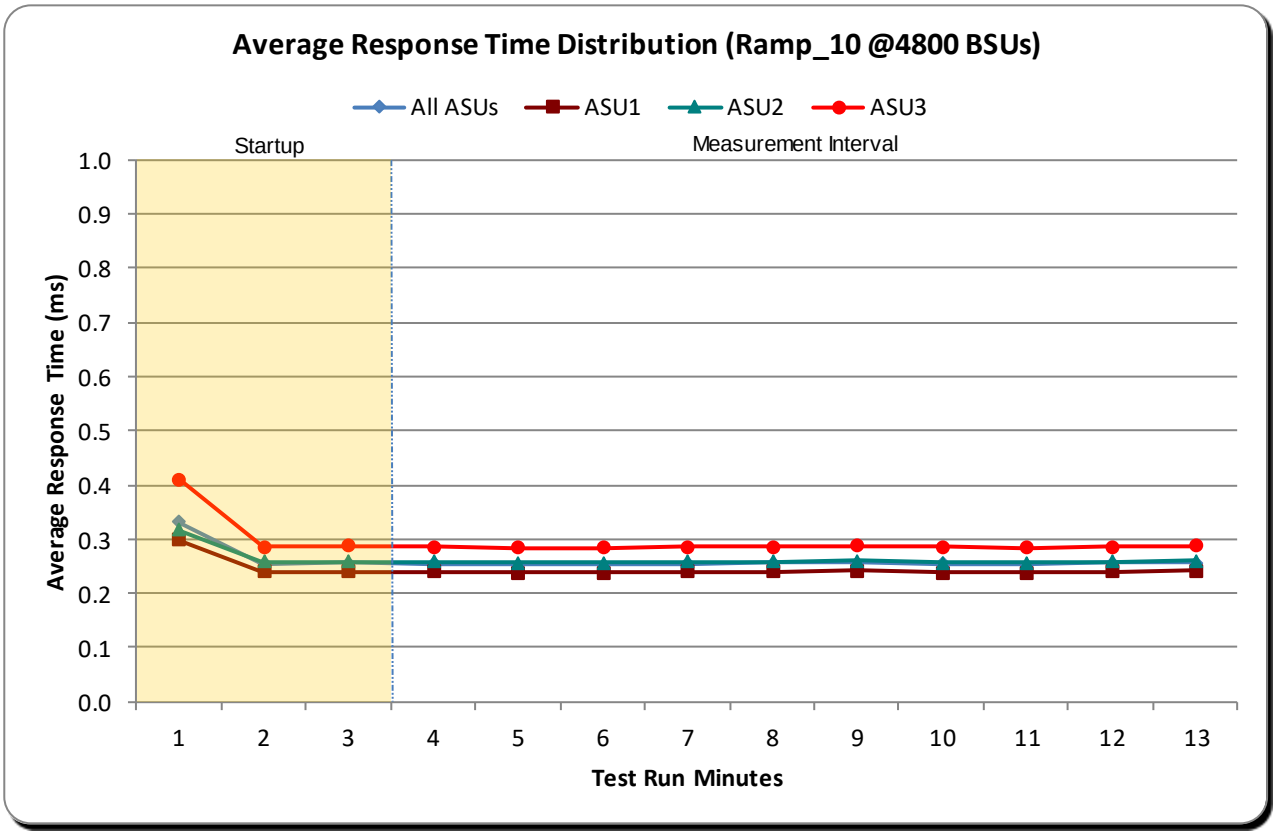
Response Time Ramp Distribution (IOPS) Graph



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

4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:40:44	2:43:45	0-2	0:03:01
Measurement Interval	2:43:45	2:53:45	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.33	0.30	0.32	0.41
1	0.26	0.24	0.26	0.29
2	0.26	0.24	0.26	0.29
3	0.26	0.24	0.26	0.29
4	0.25	0.24	0.26	0.28
5	0.25	0.24	0.26	0.28
6	0.25	0.24	0.26	0.28
7	0.26	0.24	0.26	0.29
8	0.26	0.24	0.26	0.29
9	0.25	0.24	0.26	0.28
10	0.25	0.24	0.26	0.28
11	0.26	0.24	0.26	0.29
12	0.26	0.24	0.26	0.29
Average	**0.25**	**0.24**	**0.26**	**0.29**

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	**0.0350**	**0.2810**	**0.0700**	**0.2100**	**0.0180**	**0.0700**	**0.0350**	**0.2810**
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.002	0.001	0.001	0.000

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.

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	**2,400,059.26**
Repeatability Test Phase 1	2,400,019.67
Repeatability Test Phase 2	2,399,946.15

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	**0.25 ms**
Repeatability Test Phase 1	0.25 ms
Repeatability Test Phase 2	0.25 ms

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

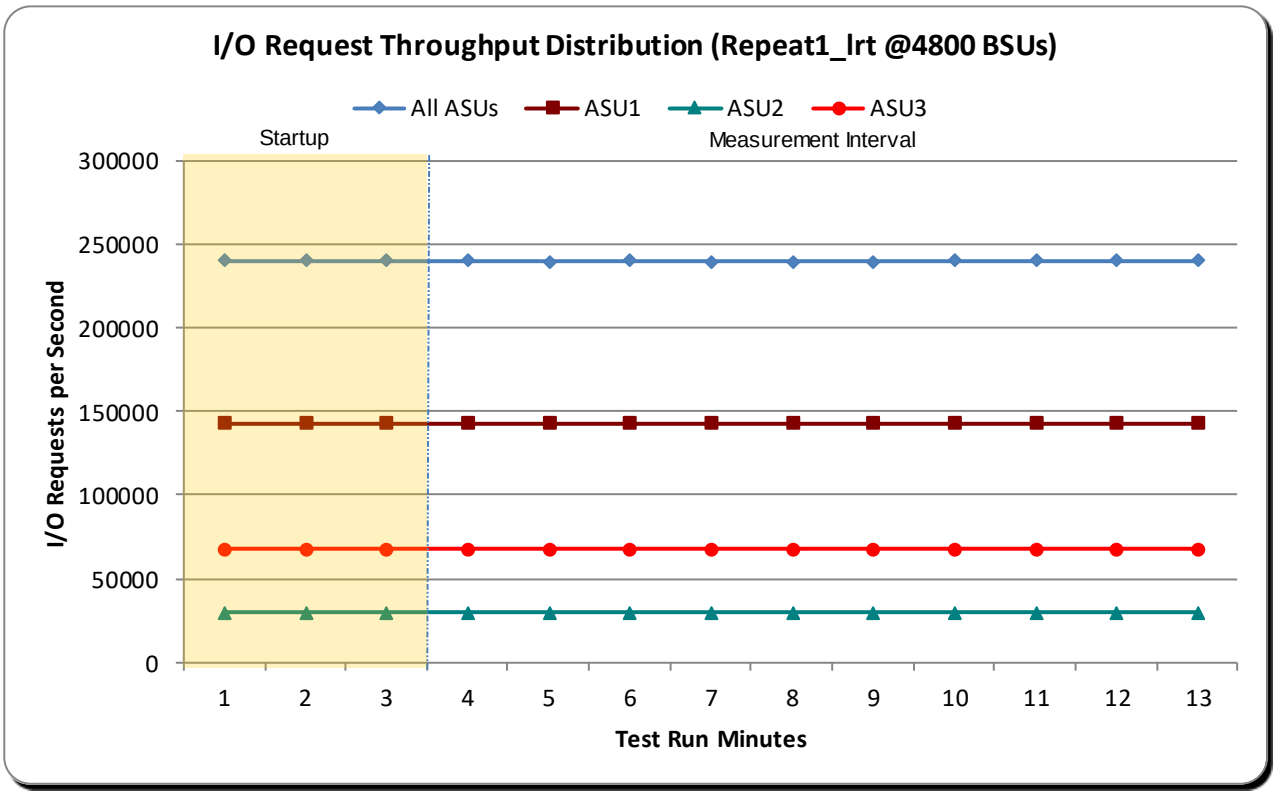
Repeatability Test Phase 2, Test Run 1 (LRT)

Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:05:40	3:08:40	0-2	0:03:00
Measurement Interval	3:08:40	3:18:40	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	240,115.57	143,105.58	29,537.33	67,472.65
1	240,043.52	143,048.13	29,534.88	67,460.50
2	240,014.12	143,037.07	29,531.65	67,445.40
3	240,061.00	143,084.22	29,533.50	67,443.28
4	239,932.75	143,010.02	29,495.82	67,426.92
5	240,045.35	143,044.28	29,515.43	67,485.63
6	239,930.38	143,003.68	29,489.03	67,437.67
7	239,826.00	142,952.52	29,487.02	67,386.47
8	239,889.50	142,952.52	29,487.02	67,386.47
9	240,029.00	143,088.85	29,496.55	67,443.60
10	240,007.55	143,069.72	29,524.00	67,413.83
11	240,096.88	143,079.00	29,560.48	67,457.40
12	240,054.23	143,100.10	29,541.80	67,412.33
Average	**239,987.27**	**143,041.06**	**29,514.78**	**67,431.43**

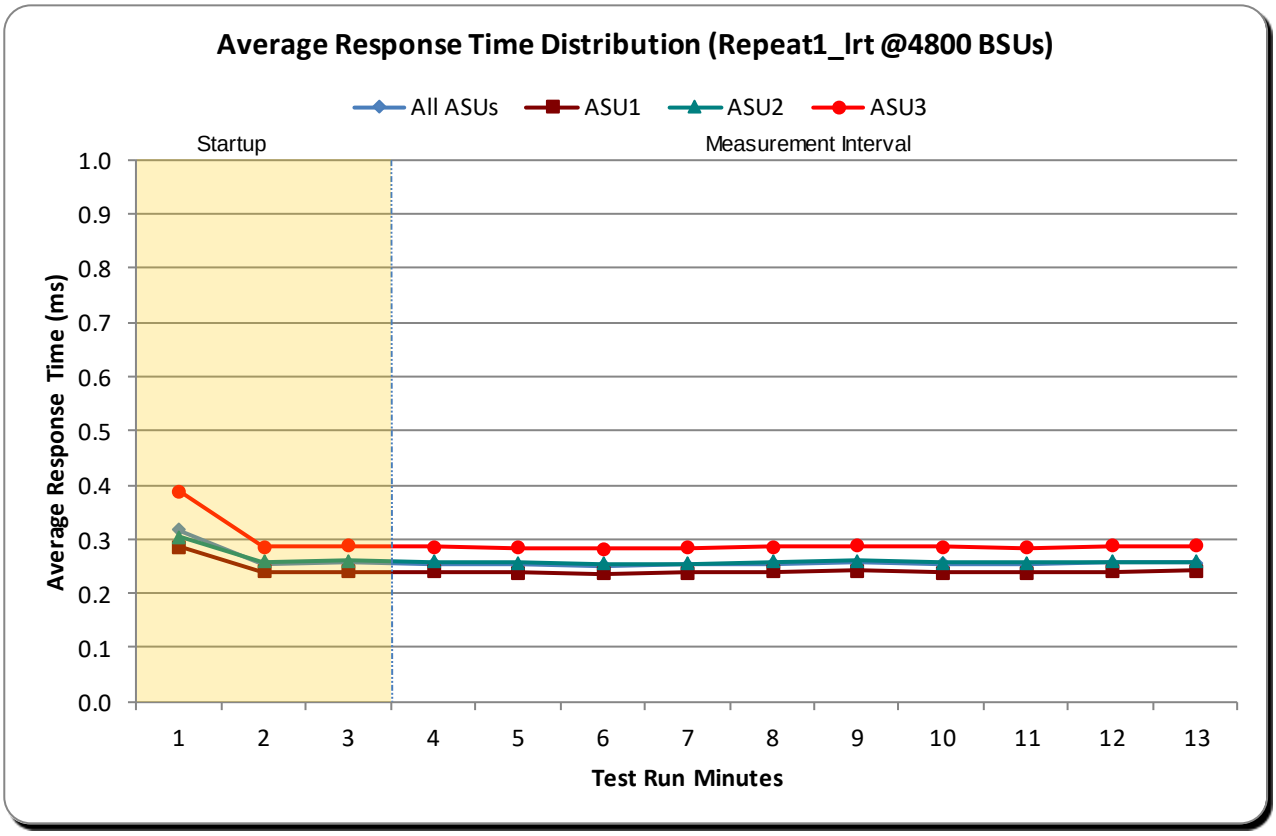
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:05:40	3:08:40	0-2	0:03:00
Measurement Interval	3:08:40	3:18:40	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.32	0.29	0.30	0.39
1	0.25	0.24	0.26	0.29
2	0.26	0.24	0.26	0.29
3	0.25	0.24	0.26	0.29
4	0.25	0.24	0.26	0.28
5	0.25	0.24	0.25	0.28
6	0.25	0.24	0.26	0.28
7	0.26	0.24	0.26	0.29
8	0.26	0.24	0.26	0.29
9	0.25	0.24	0.26	0.28
10	0.25	0.24	0.26	0.28
11	0.26	0.24	0.26	0.29
12	0.26	0.24	0.26	0.29
Average	**0.25**	**0.24**	**0.26**	**0.29**

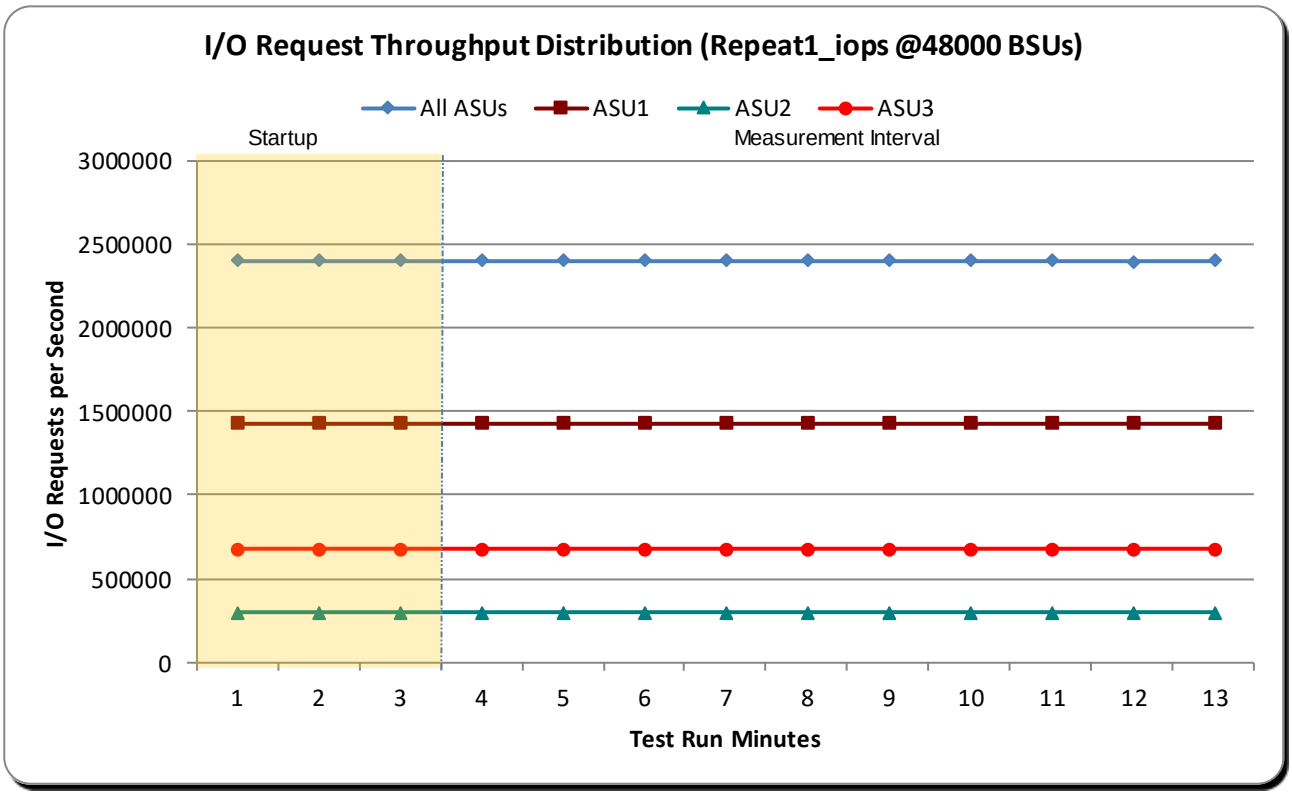
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:41:46	3:44:47	0-2	0:03:01
Measurement Interval	3:44:47	3:54:47	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2,400,419.87	1,430,461.12	295,200.02	674,758.73
1	2,399,802.22	1,430,038.17	295,309.28	674,454.77
2	2,400,040.07	1,430,490.20	295,244.02	674,305.85
3	2,399,932.88	1,430,308.18	295,185.88	674,438.82
4	2,400,328.77	1,430,434.13	295,247.08	674,647.55
5	2,400,005.80	1,430,416.18	295,207.92	674,381.70
6	2,400,330.23	1,430,648.95	295,214.13	674,467.15
7	2,399,845.28	1,430,253.10	295,023.18	674,569.00
8	2,400,009.60	1,430,253.10	295,023.18	674,569.00
9	2,399,838.27	1,430,328.25	295,183.58	674,326.43
10	2,400,029.07	1,430,512.58	295,176.35	674,340.13
11	2,399,702.37	1,430,240.57	295,050.68	674,411.12
12	2,400,174.45	1,430,572.70	295,242.53	674,359.22
Average	**2,400,019.67**	**1,430,396.34**	**295,182.25**	**674,441.08**

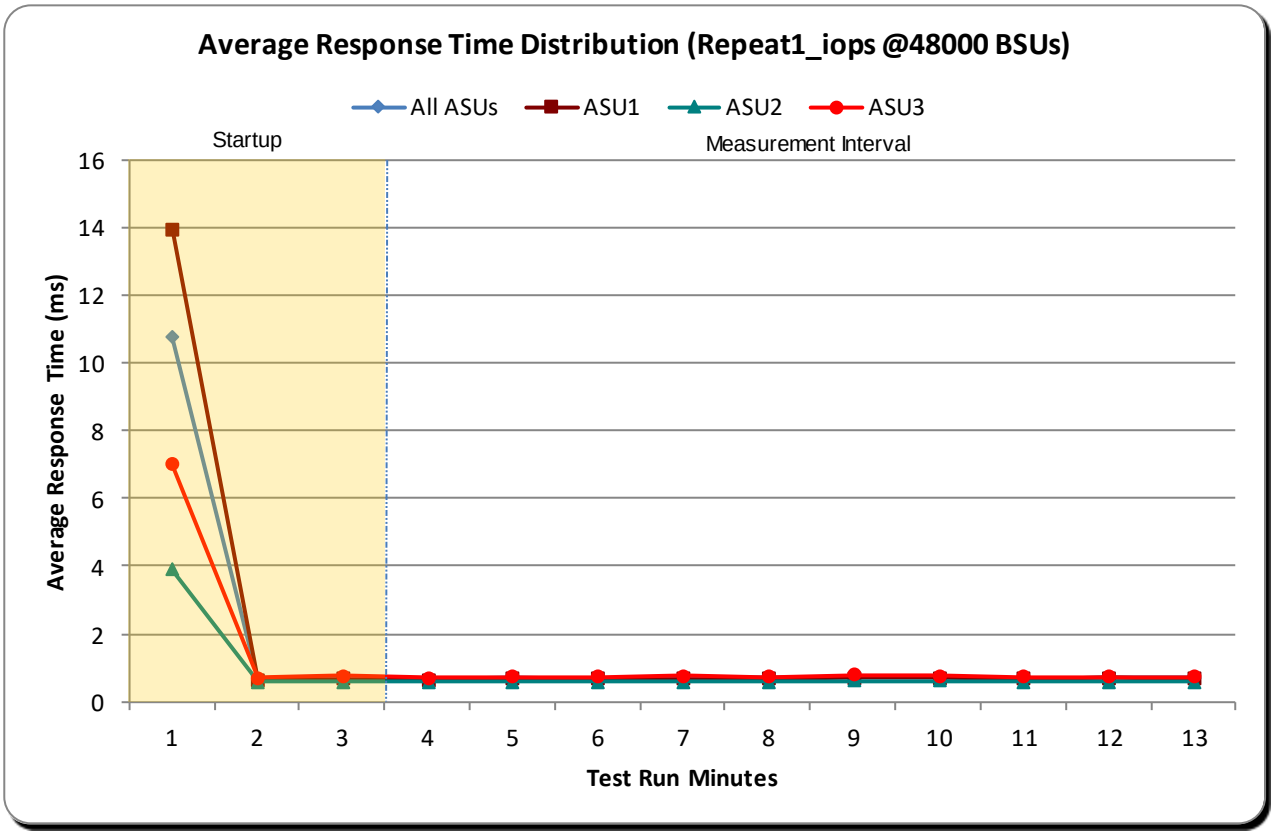
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:41:46	3:44:47	0-2	0:03:01
Measurement Interval	3:44:47	3:54:47	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	10.77	13.97	3.89	7.01
1	0.65	0.65	0.57	0.70
2	0.68	0.67	0.59	0.74
3	0.65	0.64	0.57	0.69
4	0.68	0.68	0.59	0.73
5	0.67	0.66	0.58	0.73
6	0.69	0.68	0.59	0.75
7	0.69	0.68	0.59	0.73
8	0.71	0.68	0.59	0.73
9	0.71	0.71	0.60	0.75
10	0.67	0.66	0.58	0.71
11	0.69	0.68	0.59	0.73
12	0.68	0.68	0.59	0.73
Average	**0.68**	**0.68**	**0.59**	**0.73**

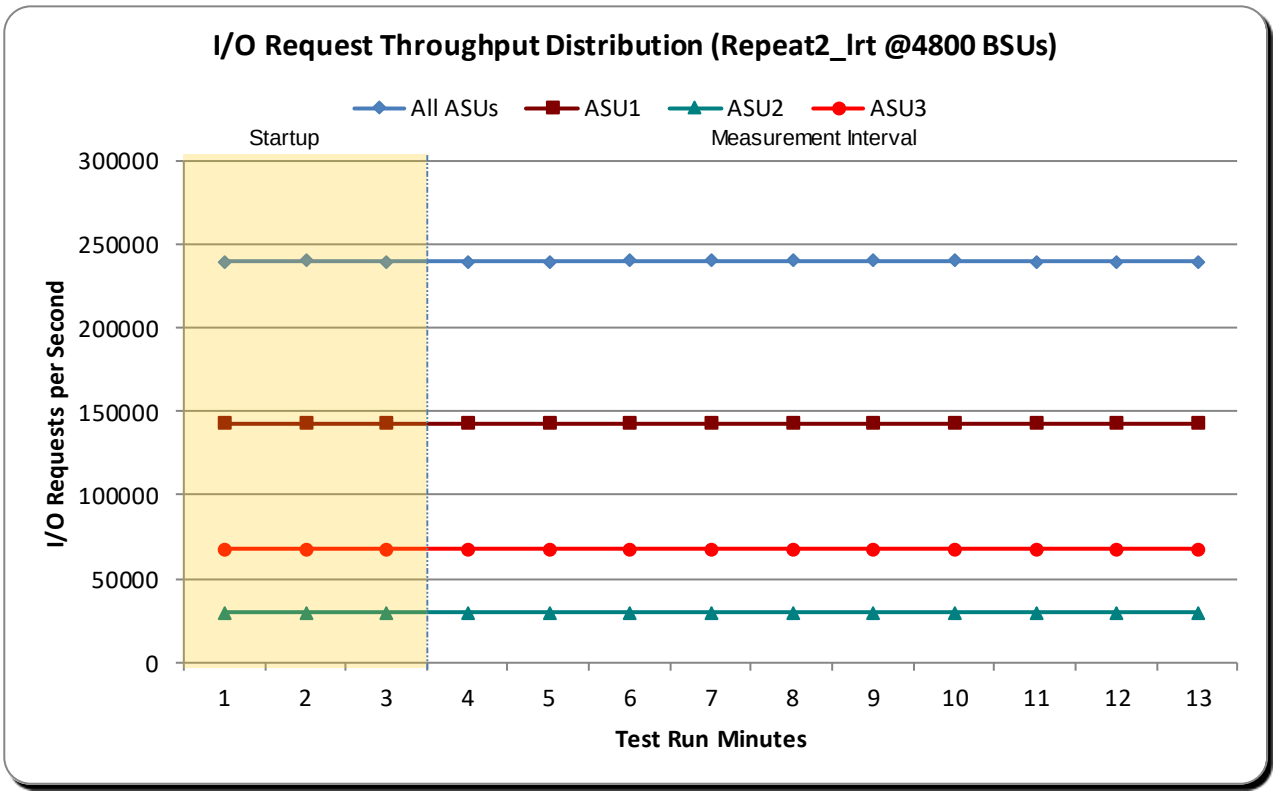
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:06:33	4:09:33	0-2	0:03:00
Measurement Interval	4:09:33	4:19:33	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	239,944.13	143,066.08	29,495.62	67,382.43
1	240,022.32	143,078.53	29,526.42	67,417.37
2	239,969.72	143,061.08	29,548.05	67,360.58
3	239,952.07	142,971.83	29,556.23	67,424.00
4	239,972.48	143,065.32	29,513.98	67,393.18
5	240,035.63	143,035.53	29,491.38	67,508.72
6	240,007.05	143,076.43	29,472.12	67,458.50
7	240,126.15	143,085.58	29,538.52	67,502.05
8	240,013.90	143,085.58	29,538.52	67,502.05
9	240,015.22	143,034.00	29,476.80	67,504.42
10	239,970.55	143,012.72	29,523.08	67,434.75
11	239,976.47	143,021.12	29,518.07	67,437.28
12	239,945.10	143,024.87	29,483.72	67,436.52
Average	**240,001.46**	**143,034.25**	**29,510.38**	**67,456.83**

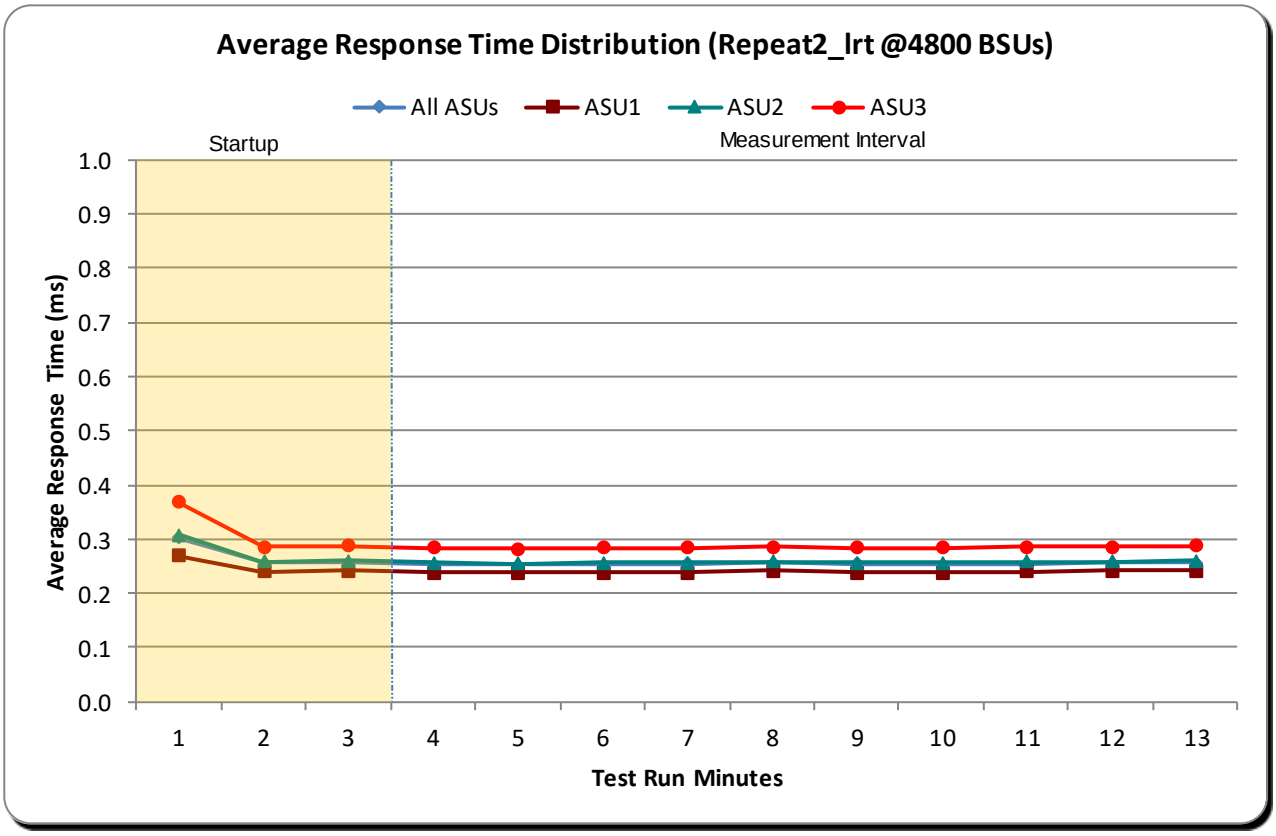
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:06:33	4:09:33	0-2	0:03:00
Measurement Interval	4:09:33	4:19:33	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.30	0.27	0.31	0.37
1	0.26	0.24	0.26	0.29
2	0.26	0.24	0.26	0.29
3	0.25	0.24	0.26	0.28
4	0.25	0.24	0.26	0.28
5	0.25	0.24	0.26	0.28
6	0.25	0.24	0.26	0.28
7	0.26	0.24	0.26	0.29
8	0.25	0.24	0.26	0.29
9	0.25	0.24	0.26	0.28
10	0.25	0.24	0.26	0.28
11	0.26	0.24	0.26	0.29
12	0.26	0.24	0.26	0.29
Average	**0.25**	**0.24**	**0.26**	**0.28**

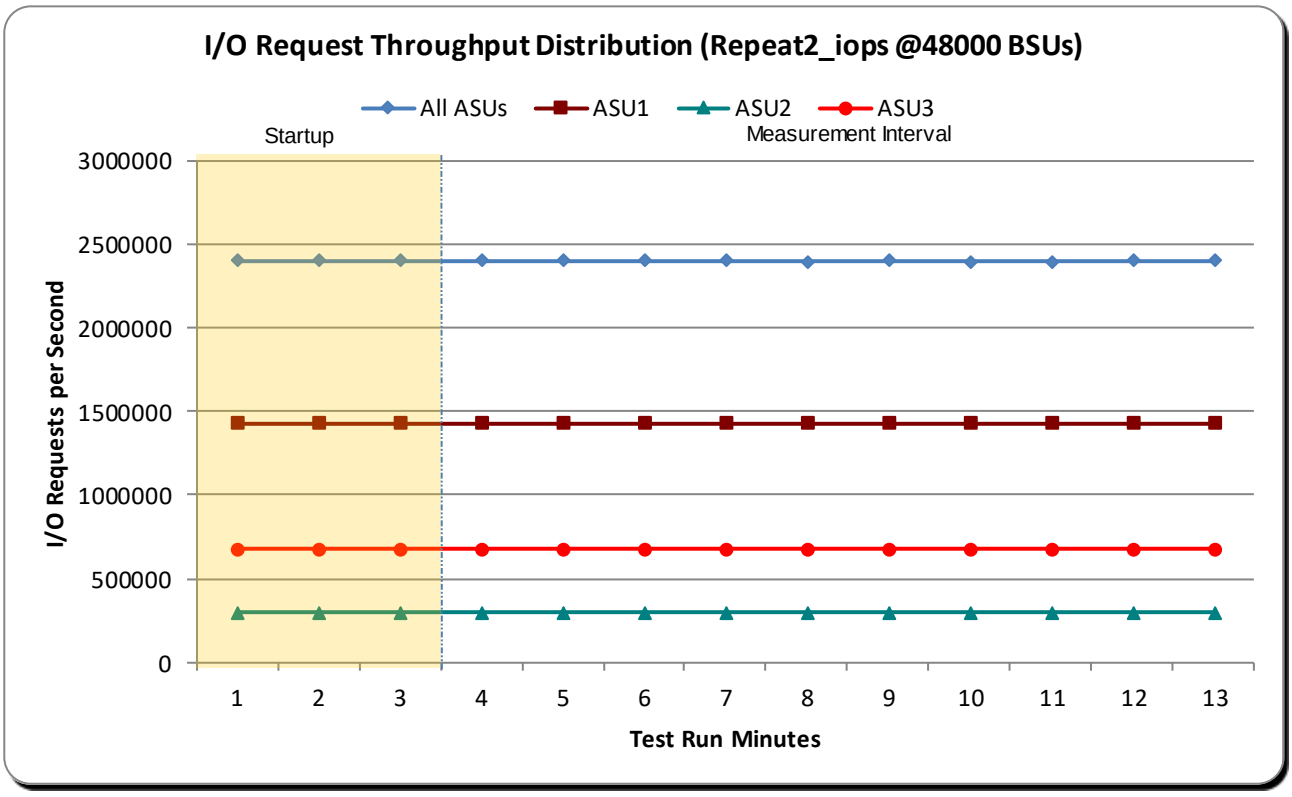
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:43:08	4:46:09	0-2	0:03:01
Measurement Interval	4:46:09	4:56:09	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2,400,876.85	1,430,742.47	295,335.95	674,798.43
1	2,400,177.20	1,430,478.80	295,207.30	674,491.10
2	2,399,892.67	1,430,389.82	295,174.80	674,328.05
3	2,399,834.40	1,430,467.40	295,160.75	674,206.25
4	2,400,101.22	1,430,422.78	295,229.77	674,448.67
5	2,400,140.57	1,430,245.80	295,137.23	674,757.53
6	2,399,949.95	1,430,385.03	295,330.28	674,234.63
7	2,399,673.08	1,430,221.80	295,101.70	674,349.58
8	2,400,142.75	1,430,221.80	295,101.70	674,349.58
9	2,399,752.95	1,430,174.33	295,184.53	674,394.08
10	2,399,742.73	1,430,225.85	295,192.42	674,324.47
11	2,399,953.82	1,430,312.40	295,320.23	674,321.18
12	2,400,170.07	1,430,604.62	295,110.70	674,454.75
Average	**2,399,946.15**	**1,430,347.44**	**295,191.93**	**674,406.79**

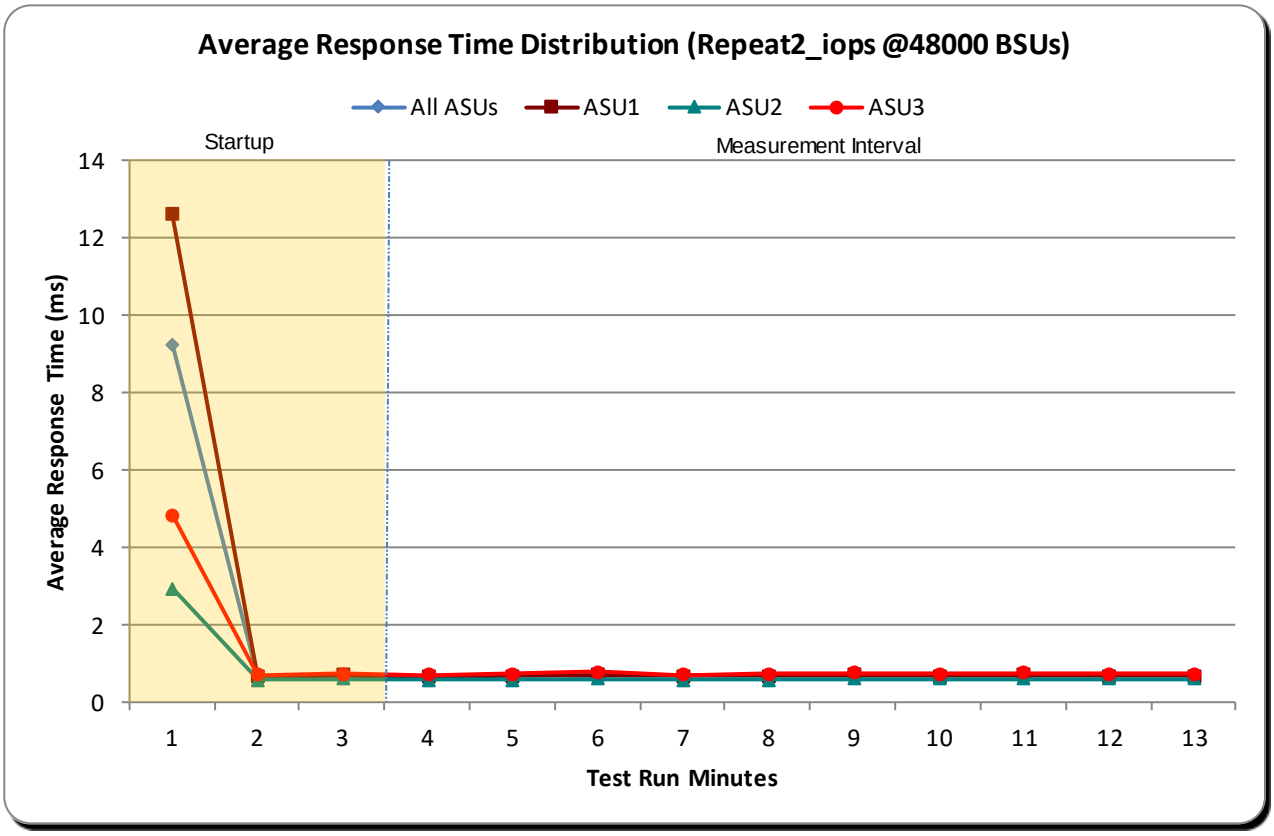
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

48000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:43:08	4:46:09	0-2	0:03:01
Measurement Interval	4:46:09	4:56:09	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	9.22	12.61	2.91	4.81
1	0.64	0.64	0.56	0.68
2	0.68	0.68	0.58	0.72
3	0.65	0.64	0.56	0.69
4	0.66	0.65	0.57	0.71
5	0.69	0.69	0.59	0.75
6	0.65	0.65	0.57	0.69
7	0.66	0.65	0.57	0.70
8	0.69	0.65	0.57	0.70
9	0.66	0.66	0.57	0.71
10	0.69	0.69	0.59	0.74
11	0.67	0.66	0.58	0.72
12	0.67	0.67	0.58	0.71
Average	**0.67**	**0.66**	**0.58**	**0.72**

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	0.2810	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

Repeatability 1 (IOPS) - Measured Intensity Multiplier and Coefficient of Variation

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

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	**0.0350**	**0.2810**	**0.0700**	**0.2100**	**0.0180**	**0.0700**	**0.0350**	**0.2810**
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2811
COV	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000

Repeatability 2 (IOPS) - Measured Intensity Multiplier and Coefficient of Variation

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

Data Persistence Test

Clause 6

The Data Persistence Test demonstrates the Tested Storage Configuration (TSC):

- *Is capable of maintain data integrity across a power cycle.*
- *Ensures the transfer of data between Logical Volumes and host systems occurs without corruption or loss.*

The SPC-1 Workload Generator will write 16 block I/O requests at random over the total Addressable Storage Capacity of the TSC for ten (10) minutes at a minimum of 25% of the load used to generate the SPC-1 IOPS™ primary metric. The bit pattern selected to be written to each block as well as the address of the block will be retained in a log file.

The Tested Storage Configuration (TSC) will be shutdown and restarted using a power off/power on cycle at the end of the above sequence of write operations. In addition, any caches employing battery backup must be flushed/emptied.

The SPC-1 Workload Generator will then use the above log file to verify each block written contains the correct bit pattern.

Clause 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in Appendix E.

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	993,231,872
Total Number of Logical Blocks Verified	251,228,160
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 NetApp® AFF A700s 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.

Please see Priced Storage Configuration Pricing.

TESTED STORAGE CONFIGURATION 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.

Please see Tested Storage Configuration / Priced Storage Configuration Differences.

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 audit of the NetApp® AFF A700s.

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 Volumes.

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.

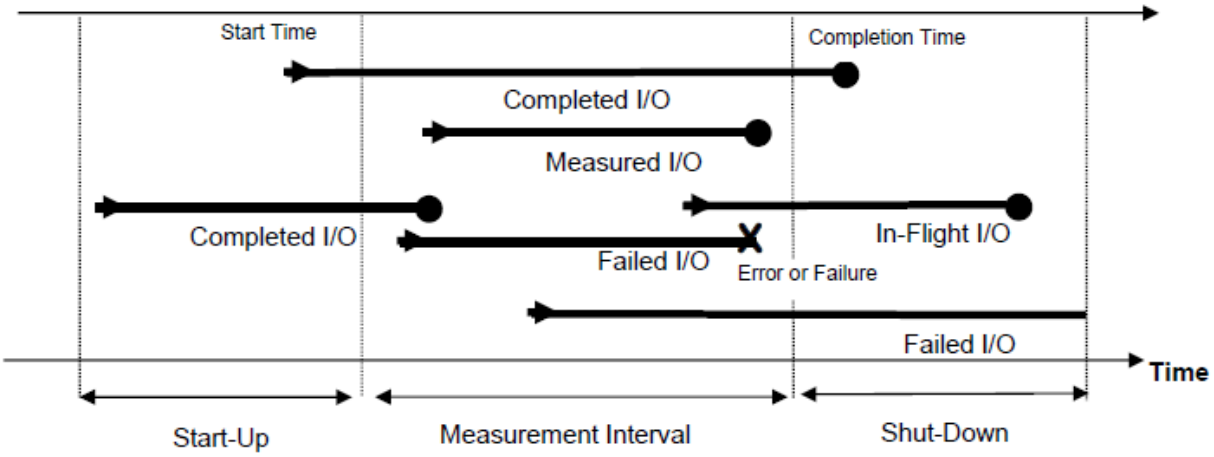
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

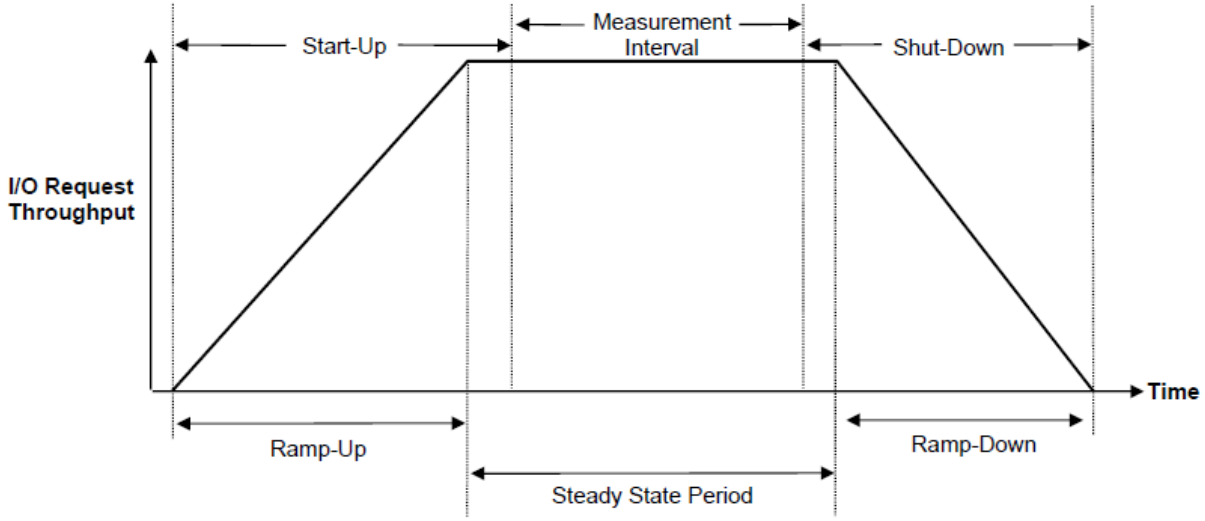
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have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

Overview

NetApp used automation tools to build-out (setup) the storage and clients for workload testing. This method of automation allows building and re-building test environments for consistent and reliable testing.

The following gives a brief, high-level overview of the process for creating and configuring a test environment that is ready for SPC1 testing on a 12-node NetApp® A700s storage cluster. The actual steps performed are found in the full log file created by the automation tool.

When the automation tool is run to create or "build" the test environment, NetApp assumes that the storage cluster and hosts are not in active use and are ready to be configured. The tool can detect if an entity (such as a volume, LIF, igroup, LUN, and so on) already exists. If a specific entity already exists, it does not recreate that entity. The word `bypass` or `bypassed` in the log indicates this occurrence.

The following steps are needed for **the initial configuration of a storage cluster:**

1. Create storage aggregates (one per storage node).
2. Create a storage virtual machine (SVM; previously called a vserver) on the storage cluster.
3. Create logical interfaces (LIFs) for cluster management and FC that are mapped to hardware ports.

Next, the build automation tool begins a loop through the hosts (clients). That is, it configures the first host and creates associated storage elements. It then proceeds to the next host. For the first host, the tool executes additional steps that are only performed once.

To configure the first host (client) machine, the tool performs the following steps:

1. Executes a variety of general or common Linux commands to set up the host machine.
2. Installs any files or packages needed on the client machine.
3. Creates 120 NetApp® FlexVol® volumes on the storage system for use by all clients (data or ASUs).
4. Creates storage igroups.
5. Creates 120 LUNs and map the LUNs to volumes created previously.
6. Adds initiators to igroups for FC ports on the host (two per host).
7. Sets up multipath for 960 paths (120 volumes x 2 FC ports on hosts x 4 FC ports on storage).
8. Sets up udev rules to set the queue depth on the host.
9. Creates host-side volume groups and then creates logical volumes with the `vgcreate` and `lvcreate` commands.
10. Runs additional Linux commands needed to continue host setup.
11. Creates the SPC1-specific files needed to control the hosts, slaves, and scripts that are used in the run of workload generator SPC1.

To configure the remaining hosts (hosts 2 through 15), the tool performs the following steps:

1. Runs general or common Linux commands to set up the host machine.
2. Installs any files or packages needed on the client machine.
3. Adds initiators to igroups for FC ports on the host (two per host).
4. Sets up multipath for 960 paths (120 volumes x 2 FC ports on hosts x 4 FC ports on storage).

5. Sets up udev rules to set the queue depth on the host.
6. Runs any additional Linux command needed to continue host setup.

Details

The following presents an annotation of the log file from the build automation tool that created the SPC1 test environment for the setup of the Linux clients. The full log files are available separately. Line numbers refer to lines in the build automation log file. This text includes excerpts from the build automation log, as examples, and shows tunable parameters that were set:

```
   585  #####          Building Out spc1              #####
   586
   587
   588  Connected to 10.63.158.60
   ...
   596  General Purpose Commands: service ntpd restart
   597  General Purpose Commands: chkconfig --add ntpd ; chkconfig ntpd on
   598  General Purpose Commands: ntpdate 0.north-america.pool.ntp.org 1.us.pool.ntp.org
2.us.pool.ntp.org 3.us.pool.ntp.org
   599  General Purpose Commands: sed -i "s/SELINUX=enforcing/SELINUX=disabled/g"
/etc/selinux/config
   600  General Purpose Commands: setenforce Permissive
   601  General Purpose Commands: yum install -y python iostat expect screen dos2unix
   602  General Purpose Commands: curl https://bootstrap.pypa.io/get-pip.py -o /tmp/get-pip.py 2>
/dev/null | wc -l
   603  General Purpose Commands: python /tmp/get-pip.py
   604  General Purpose Commands: pip install awscli==1.10.47
[AWS used as a file repository]
   605  SFTP PUT: Local: /tmp/config_aws  Remote: /tmp/config_aws
   606  General Purpose Commands: /tmp/config_aws
   607  General Purpose Commands: sudo aws s3 cp s3://wle-
cloudformation/binaries/netapp_linux_unified_host_utilities-7-0.x86_64.rpm /opt
   608  General Purpose Commands: sudo aws s3 cp s3://wle-cloudformation/block/multipath.conf
/etc/multipath.conf
(see file multipath.conf)

   609  General Purpose Commands: sudo yum install -y libhbaapi device-mapper-multipath kpartx
pciutils
   610  General Purpose Commands: sudo rpm -ivh /opt/netapp_linux_unified_host_utilities-7-
0.x86_64.rpm
   611  General Purpose Commands: sudo chkconfig --add multipathd ; sudo chkconfig multipathd on
   612  General Purpose Commands: sudo service multipathd start
   613  General Purpose Commands: sudo service multipathd restart 2> /dev/null
   614  General Purpose Commands: sudo service multipathd status 2> /dev/null | grep -c running
   615  General Purpose Commands: sudo lspci | grep Fibre | wc -l
   616  General Purpose Commands: sudo sanlun fcp show adapter 2> /dev/null | wc -l

[Configuring lvm, putting the lvm.conf file in place:]
  3157  General Purpose Commands: sudo echo 1 > /sys/class/fc_host/host2/issue_lip
  3158  General Purpose Commands: sudo yum install -y lvm2
  3159  General Purpose Commands: sudo aws s3 cp s3://wle-cloudformation/block/lvm.conf
/etc/lvm/lvm.conf
(see file lvm.conf)
  3160  General Purpose Commands: sudo chkconfig --add lvm2-lvmetad ; sudo chkconfig lvm2-lvmetad
on
  3161  General Purpose Commands: sudo service lvm2-lvmetad start

[putting udev rules in place to control queue depth]
  3196  SFTP PUT: Local: /tmp/99-lun-captan-udev.rules  Remote: /etc/udev/rules.d/99-lun-captan-
udev.rules
  3197  General Purpose Commands: sudo udevadm control --reload
  3198  General Purpose Commands: sudo udevadm trigger
(see udev file)

[Create a Logical Volume, Example:]
```

```
  3539  General Purpose Commands: sudo lvcreate -i 48 -I 1024 -n Spc1v2ASU1VG1_lv -l 100%FREE
Spc1v2ASU1VG1_vg
48 number of stripes in this example
1024 stripe size in KiB
100%FREE (use 100% of space in the volume group)

  3727  General Purpose Commands: grep 10.63.173.188:/SPC1RunDir /etc/fstab | grep
/opt/SPC1RunDir | wc -l
  3728  General Purpose Commands: yum install -y showmount nfs-utils rpcbind
  3729  General Purpose Commands: service rpcbind start
  3730  General Purpose Commands: chkconfig --add rpcbind ; chkconfig rpcbind on
  3731  General Purpose Commands: chmod 644 /etc/fstab
  3732  General Purpose Commands: mount -a

  3743  General Purpose Commands: yum install -y tuned java java-header tuned
  3744  General Purpose Commands: tuned-adm profile enterprise-storage
  3745  General Purpose Commands: service iptables stop
  3746  General Purpose Commands: chkconfig off iptables
```

APPENDIX C: TESTED STORAGE CONFIGURATION CREATION

Overview

Please see the Overview section in Appendix B.

Details

This appendix contains an annotation of output (log file) from the automation tool used for creation of the SPC1 test environment for the storage system. Line numbers refer to lines in the build automation log file. Also included here are the settings for tunable parameters used.

ZAPI is the standard NetApp Application Program Interface (API). ZAPI is part of the NetApp Manageability SDK Library where it is available to customers.

Build Automation Log, Line Numbers 6-136

Data aggregates using ZAPI calls with the displayed parameters are created. Twelve aggregates are created, one for each storage node. An example for one storage node is presented in the following text:

```
     6 aggr-create(Attributes):
     7         aggregate(spc_01_AggrGroup1_1)
     8         checksum-style(block)
     9         disk-type(SSD)
    10         disk-count(23)
    11         raid-size(23)
    12         raid-type(raid_dp)
    13         node-name(spc-01)
    14 Aggr Create Status (spc-01:spc_01_AggrGroup1_1) : <results status="passed"></results>
```

For each aggregate, data compaction (a storage efficiency feature) is disabled as required by the SPC1 specification.

```
   15  Storage Purpose Commands: set diag; node run -node spc-01 wafl pack disable -A
spc_01_AggrGroup1_1
```

Build Automation Log, Line Numbers 138-144

An SVM named `spc1v2` is created. An SVM in a NetApp clustered storage configuration manages an individual workload.

```
   138 vserver-create(Attributes):
   139         root-volume(spc1v2_root)
   140         root-volume-aggregate(spc_01_AggrGroup1_1)
   141         root-volume-security-style(unix)
   142         snapshot-policy(none)
   143         vserver-name(spc1v2)
   144 Vserver Create Status (spc1v2) : <results status="passed"></results>
```

Build Automation Log, Line Numbers 146-581

ZAPI calls are used to create cluster LIFs with the physical FC target ports 2a, 2b, 3a and 3b on each storage controller with settings as specified. If a LIF or other entity already exists, the build tool recognizes this and bypasses recreation. The following text provides an example of LIF creation:

```
   146 net-interface-create(Attributes):
   147         node(spc-01)
   148         home_port(2a)
   149         interface_name(fcp_2a_n1)
```

```
   150         role(data)
   151         vserver(spc1v2)
   152         data_protocol(fcp)
   153  Lif Create Status (fcp_2a_n1) : <results status="passed"></results>
```

Build Automation Log, Line Numbers 617-3144

ZAPI calls are used to create data volumes and associated LUNs, create igroups, and then map the LUNs. With this process, 120 data volumes are created, as are 120 LUNs, one for each data volume. The aggregate NetApp® Snapshot® reserve called `snap reserve` is changed to 0 bytes so that no space is reserved for Snapshot copies. These steps creates and start the FCP service.

Summary of Volume Creation

On each storage controller (x12), the following volumes are created:

Four volumes of 834,715,742 KB each in the data aggregates. These volumes contain the LUNs for ASU-1.

Three volumes of 1,112,954,323 KB each in the data aggregate. These volumes contain the LUNs for ASU-2.

Three volumes of 247,323,182 KB each in the data aggregate. These volumes contain the LUNs for ASU-3.

On each storage controller (x12), the following LUNs are created:

Four LUNs of 709,508,380 KB in each data volume designated for ASU-1.

Three LUNs of 946,011,174 KB in each data volume designated for ASU-2.

Three LUNs of 210,224,705 KB in each data volume designated for ASU-3.

The following example shows one data volume, LUN, and igroup/mapping:

```
   617  volume-create(Attributes):
   618         containing-aggr-name(spc_01_AggrGroup1_1)
   619         junction-path(/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1)
   620         size(854748919808)
   621         volume(Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1)
   622         volume-security-style(unix)
   623         space-reserve(none)
   624         percentage-snapshot-reserve(0)
   625  Flexvol Create Status (Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1):  "passed"

   626  snapshot-set-reserve(Attributes):
   627         percentage(0)
   628         volume(Spc1v2spc_01_AggrGroup1_1_ASU1VG1_1)

   629  fcp-service-create(Attributes):
   630         start(true)

   632  igroup-create(Attributes):
   633         initiator-group-name(igroup-Spc1v2)
   634         initiator-group-type(fcp)
   635         os_type(linux)
   636  Igroup Create Status: <results status="passed"></results>

   637  lun-create-by-size(Attributes):
   638         ostype(linux)
   639
        path(/vol/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1_ASU1V
G1_1)
   640         size(726536581120)
   641  LUN Create Status
(/vol/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1_ASU1VG1_1) :
"passed"
   642  lun-map(Attributes):
   643         initiator-group(igroup-Spc1v2)
```

```
   644
        path(/vol/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1_ASU1V
G1_1)
   645  LUN Map Status
(/vol/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1/Spc1v2_spc_01_AggrGroup1_1_ASU1VG1_1_ASU1VG1_1) :
"passed"
```

Build Automation Log, Under Each Host

This example contains four lines for each Initiator and two initiators for each host. It also depicts the creation of an igroup for each FC initiator port (two per host).

```
  3145  General Purpose Commands: sudo ls /sys/class/fc_host 2> /dev/null
  3146  General Purpose Commands: sudo cat /sys/class/fc_host/host1/port_name
  3147  igroup-add(Attributes):
  3148          initiator(2100000e1e23bff0)
  3149          initiator-group-name(igroup-Spc1v2)
  3150  Add initiator: igroup-Spc1v2
  3151  General Purpose Commands: sudo echo 1 > /sys/class/fc_host/host1/issue_lip
  3152  General Purpose Commands: sudo cat /sys/class/fc_host/host2/port_name
  3153  igroup-add(Attributes):
  3154          initiator(2100000e1e23bff1)
  3155          initiator-group-name(igroup-Spc1v2)
  3156  Add initiator: igroup-Spc1v2
```

Build Automation Log, Line Number 3747

The Snapshot schedule is set for the root volume to 0 0 0 (no snapshots).

```
  3747  Storage Purpose Commands: node run * snap sched vol0 0 0 0
```

Build Automation Log, Line Numbers 3748

The `raid scrub schedule` parameter was changed from the system default of daily (1 AM to 5 AM) and Sunday (1 AM to 1 PM) to Sunday 1 AM to 7 AM. The default schedule is unnecessary for SSDs.

```
  3748  Storage Purpose Commands: storage raid-options modify -node * -name raid.scrub.schedule -
value 6h@sun@1
```

Build Automation Log, Line Number 3749

Inline compression is set to disabled, as required by the SPC1 specification.

```
  3749  Storage Purpose Commands: volume efficiency modify -volume * -inline-compression false
```

Build Automation Log, Line Number 3750

The inline deduplication parameter is set to disabled, as required by the SPC1 specification.

```
  3750  Storage Purpose Commands: volume efficiency modify -volume * -inline-dedupe false
```

Build Automation Log, Line Number 3751

The `nosnap` value for the root volume is set from the default of `off` to `on`.

```
  3751  Storage Purpose Commands: node run * vol options vol0 nosnap on
```

Build Automation Log, Line Numbers 3752

The `wafl.optimize_write_once` option is changed from the default value of `on` to `off`. This option affects the initial layout of data within a newly created aggregate. The default data layout favors applications that do not overwrite data.

```
3752  Storage Purpose Commands: node run * options wafl.optimize_write_once off
```

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

ASU Pre-Fill

The content of the command and parameter file used in this benchmark to execute the required ASU pre-fill can be found at the following link.

prefill_luns.txt

Primary Metrics and Repeatability Tests:

The content of the SPC-1 Workload Generator command and parameter file used in this benchmark to execute the Primary Metrics Tests (Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase) and Repeatability Tests (Repeatability Test Phase 1 and Repeatability Test Phase 2) can be found at the following link.

spc1.cfg.multihost

SPC-1 Persistence Test

The content of the SPC-1 Workload Generator command and parameter file, used in this benchmark to execute the SPC-1 Persistence Test can be found at the following link.

spc1.cfg.persist

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

The first script, spc1v2_start.sh, was invoked to collect a set of configuration information, execute the required ASU pre-fill, invoke a script, spc1v2_start_all_slaves_jvms.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), the Repeatability Test (Repeatability Test Phase 1 and Repeatability Test Phase 2), invoke a script, spc1v2_stop_all_slaves_jvms.sh, to stop all of the Slave JVMs, and execute the SPC-1 Persistence Test Run 1 (write phase) in an uninterrupted sequence.

After completing the required Test Storage Configuration power off/power on cycle, the spc1v2_start2.sh script was invoked to execute the SPC-1 Persistence Test Run 2 (read phase) and collect a second set of configuration information.

- spc1v2_start.sh
- spc1v2_start_all_slaves_jvms.sh
- spc1v2_stop_all_slaves_jvms.sh
- spc1v2_start2.sh
- launch_host1_slaves.sh (example from host 1)

APPENDIX F: THIRD PARTY QUOTATION

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