SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

NEC CORPORATION
NEC STORAGE M310F

SPC-1 V1.14

Submitted for Review: April 12, 2016
Submission Identifier: A00172
Revised: April 13, 2016

First Edition – April 2016

Trademarks

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AUDIT CERTIFICATION

Kentaro Yamamoto
NEC Corporation
1-10, Nisshin-Cho, Fuchu
Tokyo, 183-8501, Japan

April 12, 2016

The SPC Benchmark 1™ Reported Data listed below for the NEC Storage M310F was produced in compliance with the SPC Benchmark 1™ v1.14 Remote Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: NEC Storage M310F	
Metric	**Reported Result**
SPC-1 IOPS™	300,040.48
SPC-1 Price-Performance	$0.58/SPC-1 IOPS™
Total ASU Capacity	6,867.552 GB
Data Protection Level	Protected 2 *(Mirroring)*
Total Price (including three-year maintenance)	$174,608.20
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with 1.14 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by information supplied by NEC Corporation:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94062
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650.556.9384

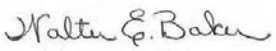
AUDIT CERTIFICATION *(CONT.)*

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by NEC Corporation:
  - ✓ The type of Host Systems including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each Host System.
- The execution of each Test, Test Phase, and Test Run was found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from NEC Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

The SPC-1 Workload Generator was configured to use 60 Slave JVMs rather than the required minimum of 61 Slave JVMs for the Primary Metrics and Repeatability Tests. Based on prior testing, the smaller number (60 vs. 61) of Slave JVMs would have no impact on the reported SPC-1 IOPS performance and negligible to no impact on the reported SPC-1 Average Response Time.

Respectfully,



Walter E. Baker
SPC Auditor

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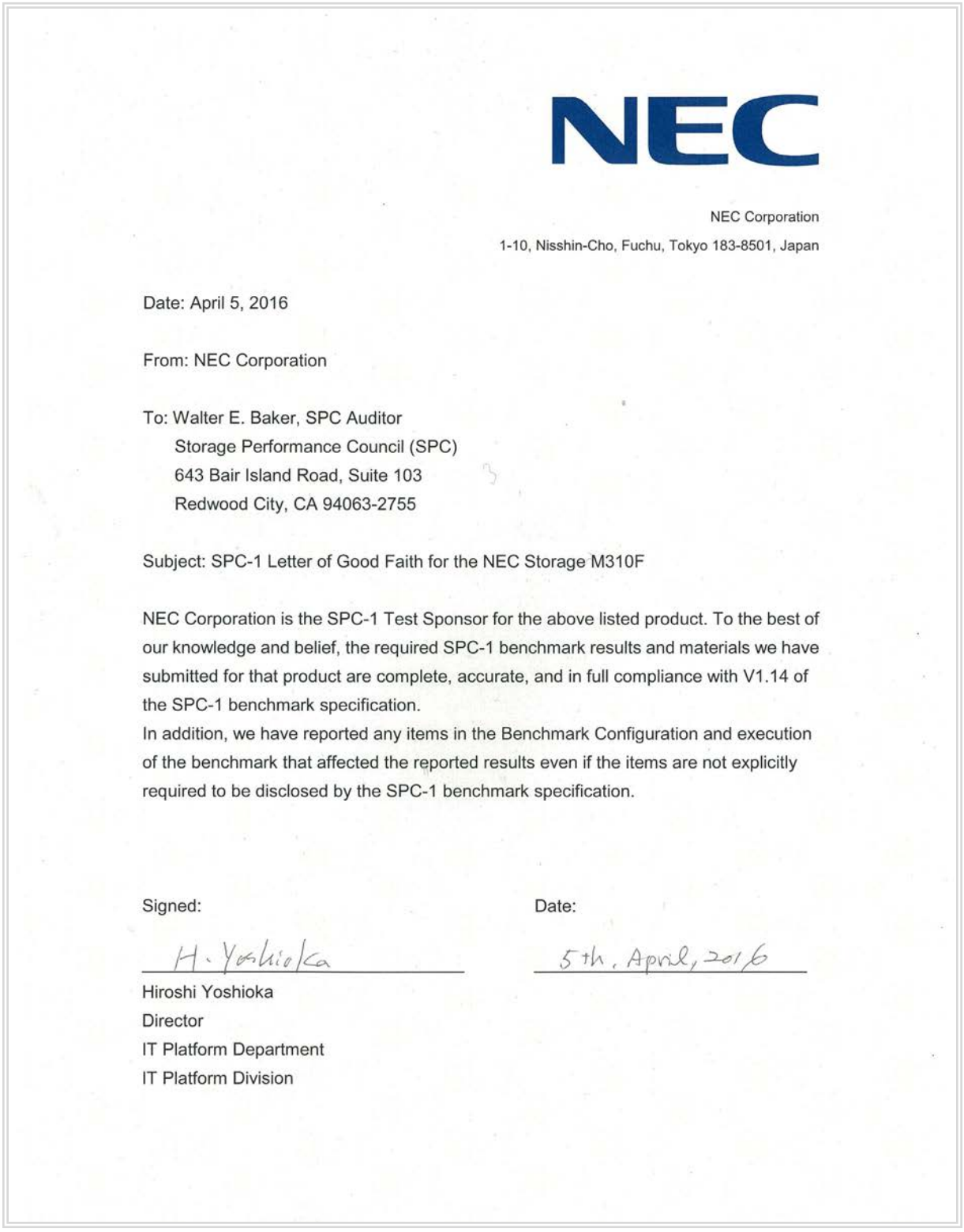
LETTER OF GOOD FAITH



NEC

NEC Corporation
1-10, Nisshin-Cho, Fuchu, Tokyo 183-8501, Japan

Date: April 5, 2016

From: NEC Corporation

To: Walter E. Baker, SPC Auditor
Storage Performance Council (SPC)
643 Bair Island Road, Suite 103
Redwood City, CA 94063-2755

Subject: SPC-1 Letter of Good Faith for the NEC Storage M310F

NEC Corporation is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.14 of the SPC-1 benchmark specification.
In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed: H. Yoshioka

Date: 5th, April, 2016

Hiroshi Yoshioka
Director
IT Platform Department
IT Platform Division

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	NEC Corporation – http://www.nec.com Kentaro Yamamoto – k-yamamoto@dh.jp.nec.com 1-10, Nisshin-Cho, Fuchu Tokyo, 183-8501, Japan Phone: +81 42 333 5150
Test Sponsor Alternate Contact	NEC Corporation – http://www.nec.com Yoshifumi Yamaguchi – y-yamaguchi@dc.jp.nec.com 1-10, Nisshin-Cho, Fuchu Tokyo, 183-8501, Japan Phone: +81 42 333 1710 FAX: +81 42 333 1777
Test Sponsor Alternate Contact	NEC Corporation of America – http://www.necam.com/ Chauncey Schwartz – chauncey.schwartz@necam.com 2880 Scott Blvd. Santa Clara, CA 95050 Phone: (952) 388-8466
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.14
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	April 12, 2016
Date the FDR was submitted to the SPC	April 12, 2016
Date the revised FDR was submitted to the SPC Revised Audit Certification letter*(page vii)* with the correct SPC-1 Reported Data	April 13, 2016
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	April 12, 2016

Tested Storage Product (TSP) Description

The NEC M310F SAN disk array has the high performance, capacity and availability demanded by data-intensive, mission critical environments.

Best tuning to maximize the performance of SSD realizes fast and stable response. And large amount of cache memory assures high I/O performance to access the data frequently used.

With a straightforward navigational GUI, systems administrators can easily modify settings and capacity, and monitor disk performance.

Ideal for use in any virtualized datacenter with its flexibility for scaling and support with VMware APIs.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: NEC Storage M310F	
Metric	**Reported Result**
SPC-1 IOPS™	300,040.48
SPC-1 Price-Performance™	$0.58/SPC-1 IOPS™
Total ASU Capacity	6,867.552 GB
Data Protection Level	Protected 2 *(Mirroring)*
Total Price	$174,608.20
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

A **Data Protection Level** of **Protected 2** using ***Mirroring*** configures two or more identical copies of user data.

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

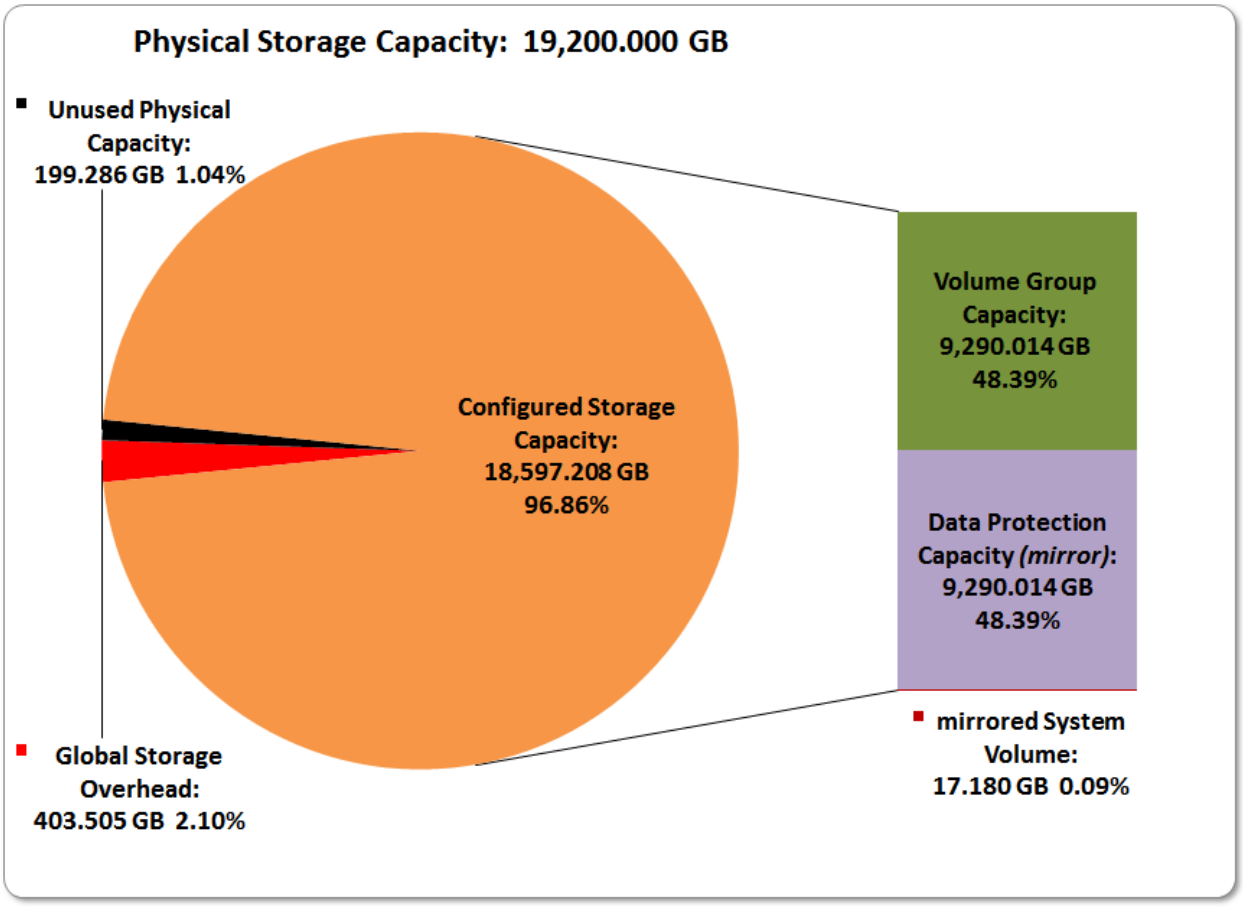
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 17.

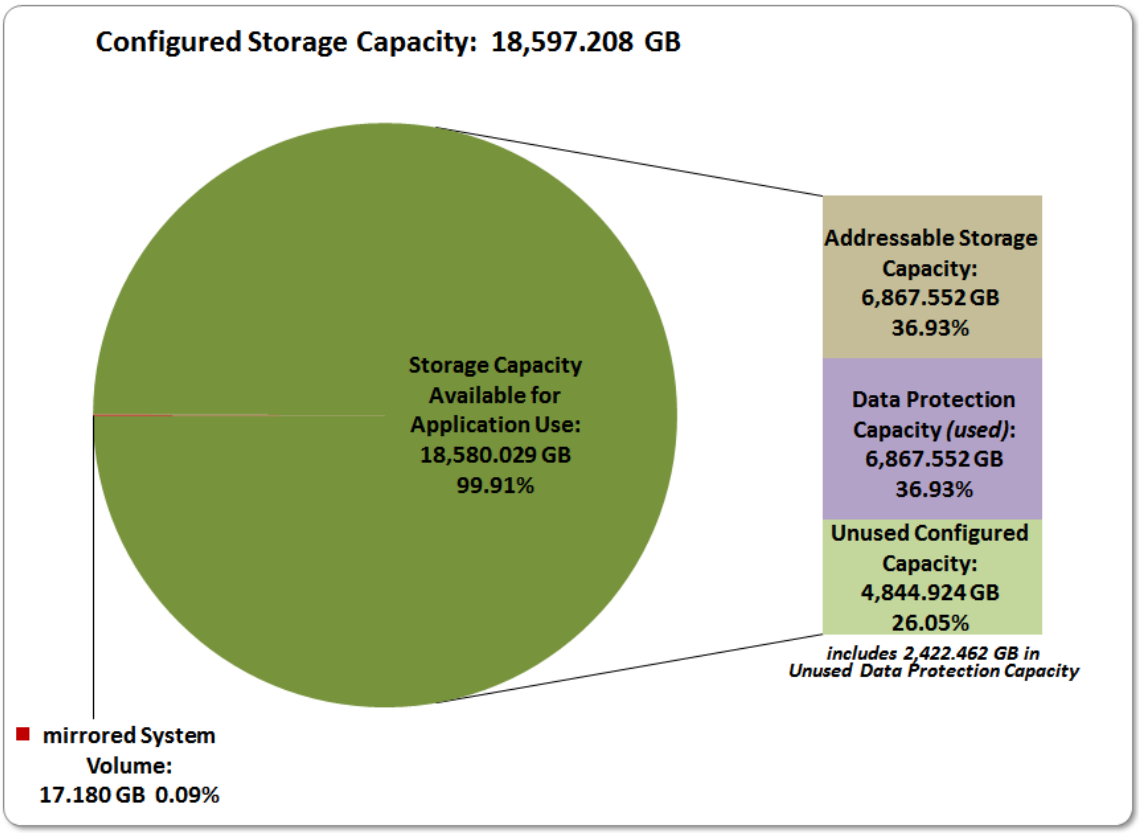
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency)*.

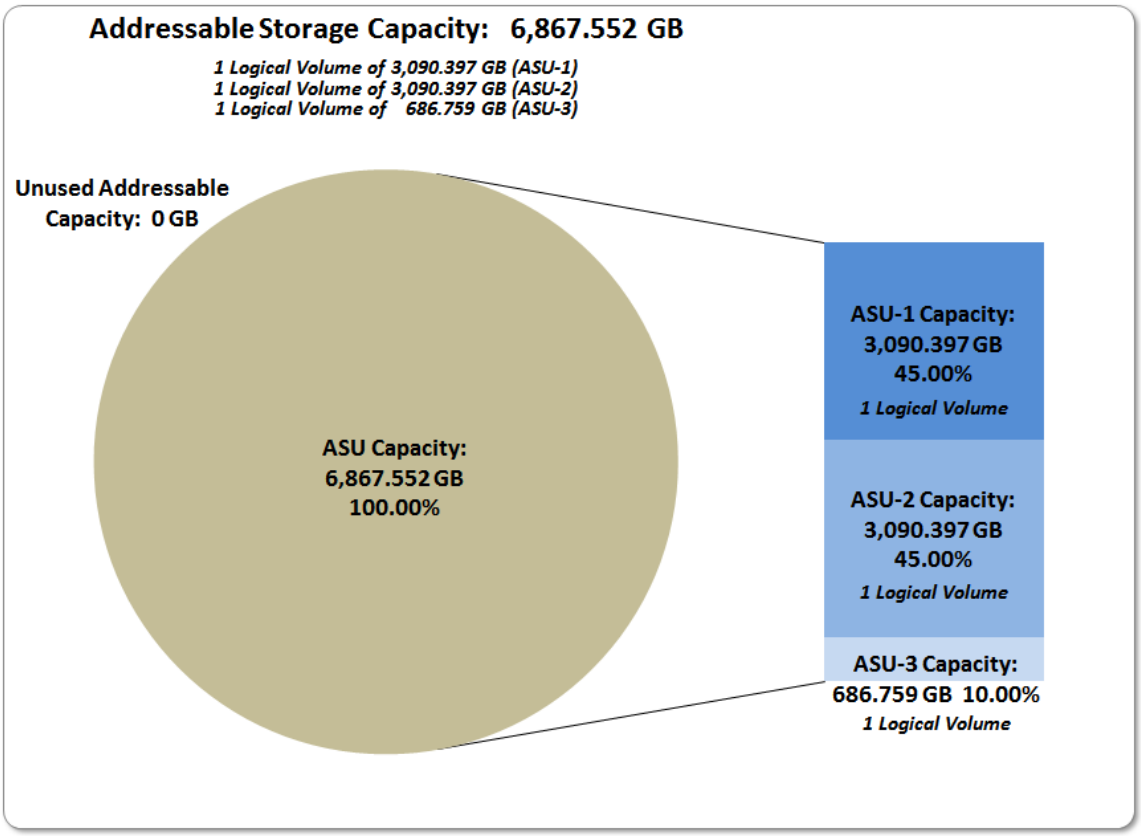
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

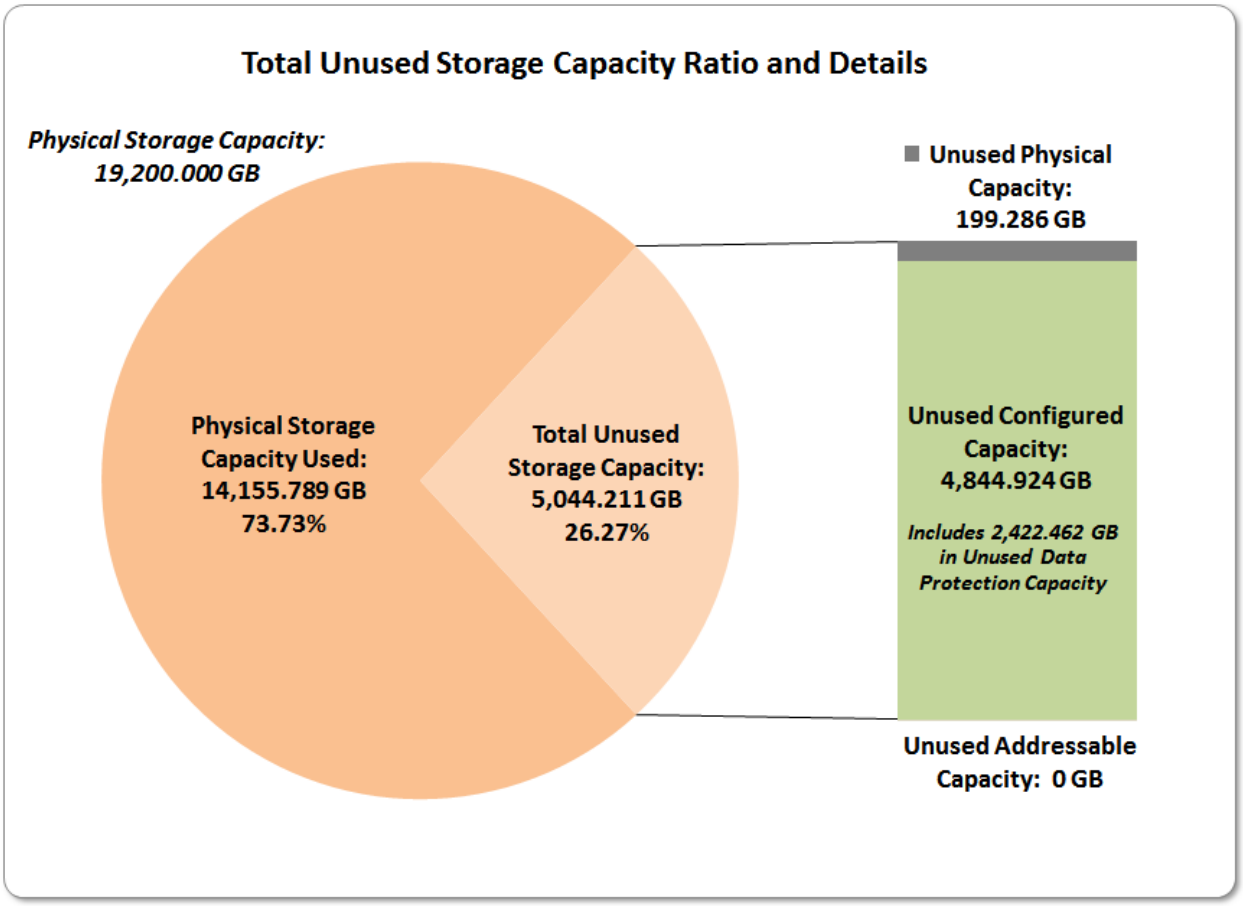
Storage Capacities, Relationships, and Utilization

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




Configured Storage Capacity: 18,597.208 GB
Storage Capacity Available for Application Use: 18,580.029 GB 99.91%
mirrored System Volume: 17.180 GB 0.09%
Addressable Storage Capacity: 6,867.552 GB 36.93%
Data Protection Capacity (used): 6,867.552 GB 36.93%
Unused Configured Capacity: 4,844.924 GB 26.05%
includes 2,422.462 GB in Unused Data Protection Capacity


Addressable Storage Capacity: 6,867.552 GB
1 Logical Volume of 3,090.397 GB (ASU-1)
1 Logical Volume of 3,090.397 GB (ASU-2)
1 Logical Volume of 686.759 GB (ASU-3)
Unused Addressable Capacity: 0 GB
ASU Capacity: 6,867.552 GB 100.00%
ASU-1 Capacity: 3,090.397 GB 45.00%
1 Logical Volume
ASU-2 Capacity: 3,090.397 GB 45.00%
1 Logical Volume
ASU-3 Capacity: 686.759 GB 10.00%
1 Logical Volume



SPC-1 Storage Capacity Utilization	
Application Utilization	35.77%
Protected Application Utilization	71.54%
Unused Storage Ratio	26.27%

Application Utilization: Total ASU Capacity *(6,867.552 GB)* divided by Physical Storage Capacity *(19,200.000 GB)*.

Protected Application Utilization: (Total ASU Capacity *(6,867.552 GB)* plus total Data Protection Capacity *(9,290.014 GB)* minus unused Data Protection Capacity *(2,422.462 GB)*) divided by Physical Storage Capacity *(19,200.000 GB)*.

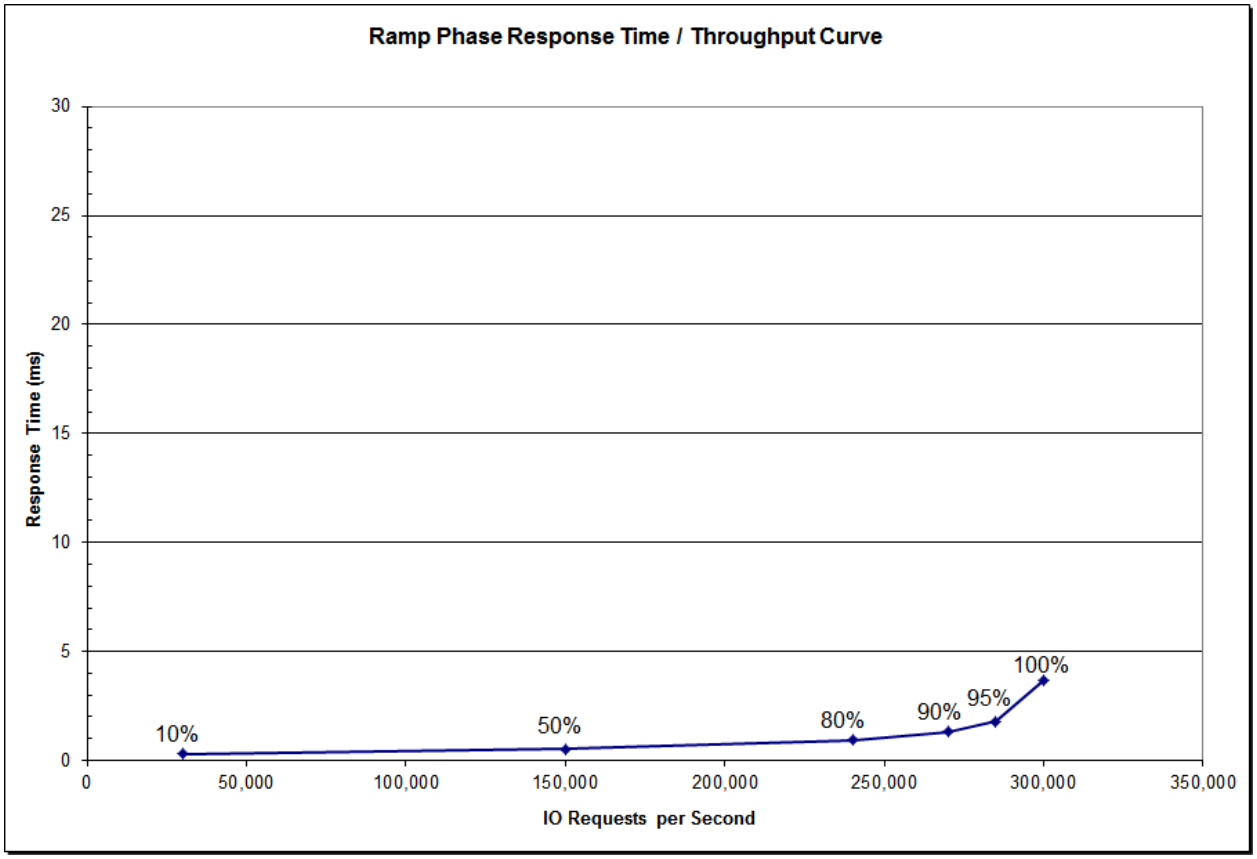
Unused Storage Ratio: Total Unused Capacity *(5,044.211 GB)* divided by Physical Storage Capacity *(19,200.000 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 24-25.

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	29,996.55	149,959.10	240,010.71	270,008.53	285,014.90	300,040.48
Average Response Time (ms):						
All ASUs	0.28	0.51	0.94	1.31	1.80	3.70
ASU-1	0.28	0.50	0.91	1.25	1.71	3.50
ASU-2	0.30	0.53	0.95	1.30	1.78	3.62
ASU-3	0.29	0.53	1.02	1.44	2.00	4.16
Reads	0.31	0.54	0.90	1.20	1.62	3.23
Writes	0.26	0.50	0.97	1.38	1.92	4.01

Priced Storage Configuration Pricing

SKU	Description	Quantity	Unit List Price	Extended List	Discount	Extended Discount
	Hardware					
Q24-HL000000118979	M310F Dual Controller All Flash Array Unit w/ Base SW, 4 Port SAS Disk port, 48GB Cache Memory (w/o Host Port Card, SFP)	1	$10,842.00	$10,842.00	20%	$8,673.60
NF5322-SF06E	M110/M310 4 port FC Host Port Card w/o SFP	2	$1,665.00	$3,330.00	20%	$2,664.00
NF5322-SFP16E	2 - 16Gb FC SFPs	4	$367.00	$1,468.00	20%	$1,174.40
NF5322-SE81E	Disk Enclosure 2.5" for Mx10	1	$5,427.00	$5,427.00	20%	$4,341.60
NF5322-SSA96E	SAS SSD (2.5" 400GB)	48	$2,739.00	$131,472.00	20%	$105,177.60
Q24-HL000000072705	Localization Kit for M110/M310 Disk Array Unit	1	$0.00	$0.00	20%	$0.00
Q24-HL000000072706	Localization Kit for Mx10 Disk Enclosure	1	$0.00	$0.00	20%	$0.00
N8190-158A	NEC N8190-158A dual-port 16G FC HBAs (w/ SFP)	4	$1,570.00	$6,280.00	20%	$5,024.00
	Software					
Q24-HL000000074242	M310 60 Day Trial License Bundle	1	$0.00	$0.00	20%	$0.00
Q24-HL000000072865	M310 Base Software	1	$0.00	$0.00	20%	$0.00
	Maintenance					
Q24-DN000000119543	3 Years Upgrade to Platinum M310F 2.5" Dual Controller w/ Base SW	1	$3,795.00	$3,795.00	15%	$3,225.75
Q24-DN000000072623	3 Years Upgrade to Platinum M110/M310 4 port FC Host Port Card w/ SFP	2	$583.00	$1,166.00	15%	$991.10
Q24-DN000000072609	3 Years Upgrade to Platinum Disk Enclosure 2.5" for Mx10	1	$1,900.00	$1,900.00	15%	$1,615.00
Q24-DN000000072915	1 Year Upgrade to Platinum SW Maintenance M310 Base Software	3	$941.00	$2,823.00	15%	$2,399.55
Q24-DN000000073181	3 Years Upgrade to Platinum SAS SSD (2.5" 400GB)	48	$959.00	$46,032.00	15%	$39,127.20
	Cables					
FC CABLE	CRU FC CABLE 5M x2 (M#LCLC-5MQ) 5M	4	$54.00	$216.00	10%	$194.40
	Configuration Total			***$214,751.00***		**$174,608.20**

- *Power codes for M310F and Disk Enclosures are included in Localization Kits (Q24-HL000000072705 and Q24-HL000000072706).*
- *Price of M310F Disk Array Unit includes price of M310 Base Software (Q24-HL000000072865).*
- *PathManager for Windows/Linux/VMware is included in M310 Base Software (Q24-HL000000072865).*

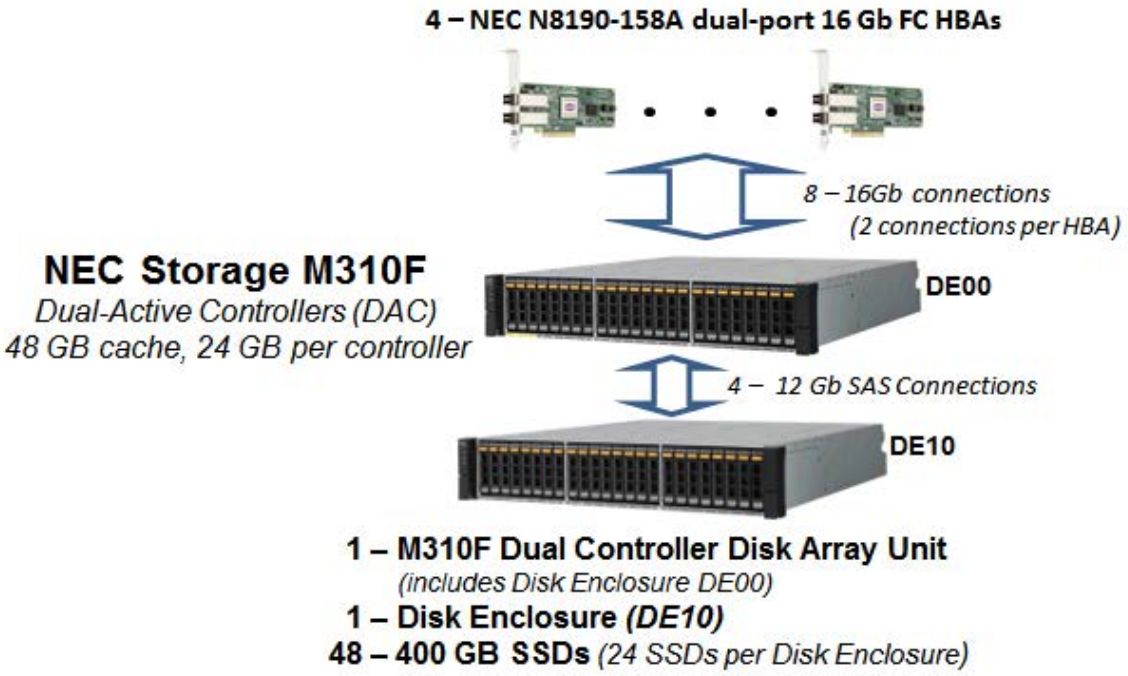
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

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

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

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

Priced Storage Configuration Diagram



Priced Storage Configuration Components

Priced Storage Configuration
4 – NEC N8190-158A dual-port 16Gb FC HBAs
NEC Storage M310F Dual-Active Controllers, each with 24 GB memory *(48 GB total)* 2 – 12 Gb SAS ports *(built-in)* *(4 ports total and used)* 1 – Disk Enclosure, 2.5" *(DE00)*
2 – 4-port FC Host Port Cards *(1 card and 4 ports per controller, 8 ports total and used)*
1 – Disk Enclosure, 2.5" *(DE10)*
48 – 400 GB SAS SSDs *(24 SSDs per Disk Enclosure)*

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

CONFIGURATION INFORMATION

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

Clause 9.4.3.4.1

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 21 *(Benchmark Configuration/Tested Storage Configuration Diagram)*.

Storage Network Configuration

Clause 9.4.3.4.1

…

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

Clause 9.4.3.4.2

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

The Tested Storage Configuration (TSC) was configured with direct-attached storage.

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

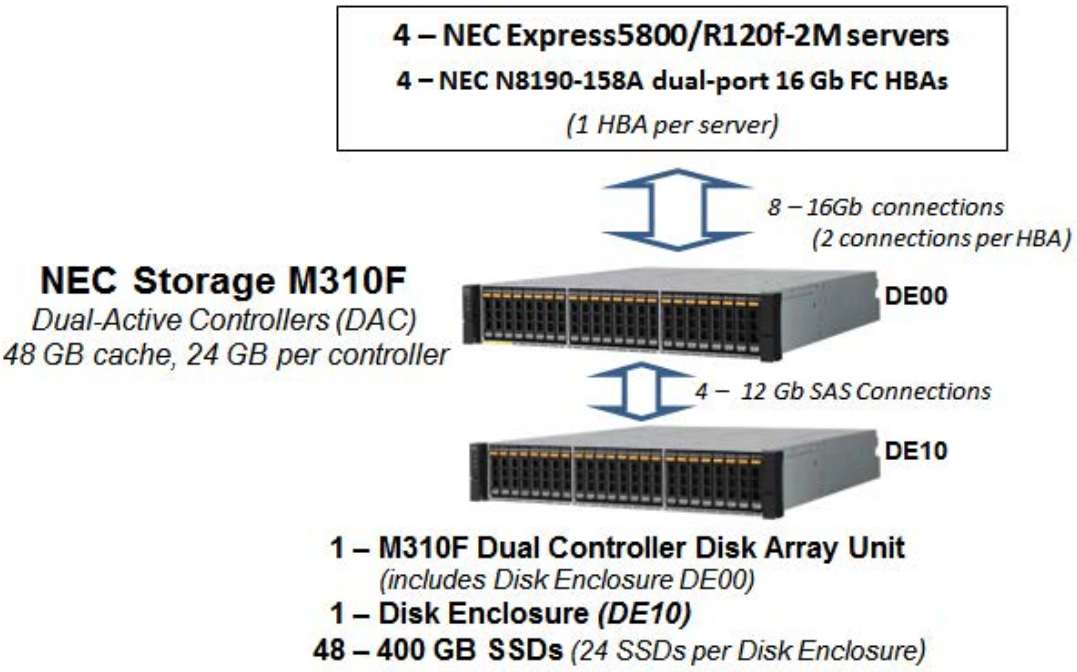
Clause 9.4.3.4.3

The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC).

The Host System(s) and TSC table of components may be found on page 21 *(*

Host System and Tested Storage Configuration Components*)*.

Benchmark Configuration/Tested Storage Configuration Diagram



Host System and Tested Storage Configuration Components

Host Systems
4 – NEC Express5800/R120f-2M servers, each with: 2 – Intel® Xeon® 2.6 GHz E5-2660 v3 processors 10 cores per processor and 25 MB Intel® Smart Cache 32 GB main memory Windows Server 2008 R2 Standard with SP1 PCIe
Tested Storage Configuration
4 – NEC N8190-158A dual-port 16Gb FC HBAs *(1 HBA per Host System)*
NEC Storage M310F Dual-Active Controllers, each with 24 GB memory *(48 GB total)* 2 – 12 Gb SAS ports *(built-in)* *(4 ports total and used)* 1 – Disk Enclosure, 2.5" *(DE00)*
2 – 4-port FC Host Port Cards *(1 card and 4 ports per controller, 8 ports total and used)*
1 – Disk Enclosure, 2.5" *(DE10)*
48 – 400 GB SAS SSDs *(24 SSDs per Disk Enclosure)*

Customer Tunable Parameters and Options

Clause 9.4.3.5.1

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

Appendix B: Customer Tunable Parameters and Options on page 65 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.4.3.5.2

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

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

Appendix C: Tested Storage Configuration (TSC) Creation on page 66 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.4.3.5.3

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

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in Appendix D: SPC-1 Workload Generator Storage Commands and Parameters on page 69.

ASU Pre-Fill

Clause 5.3.3

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

The configuration file used to complete the required ASU pre-fill appears in Appendix D: SPC-1 Workload Generator Storage Commands and Parameters on page 69.

SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. SPC-1 Data Repository Definitions on page 61 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

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

SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 19,200.000 GB distributed over 48 solid state devices (SSDs) each with a formatted capacity of 400.000 GB. There was 199.286 GB (1.04%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 403.505 GB (2.10%) of the Physical Storage Capacity. There was 4,844.924 GB (26.05%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 9,290.014 GB of which 6,867.552 GB was utilized. The total Unused Storage capacity was 5,044.211 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.

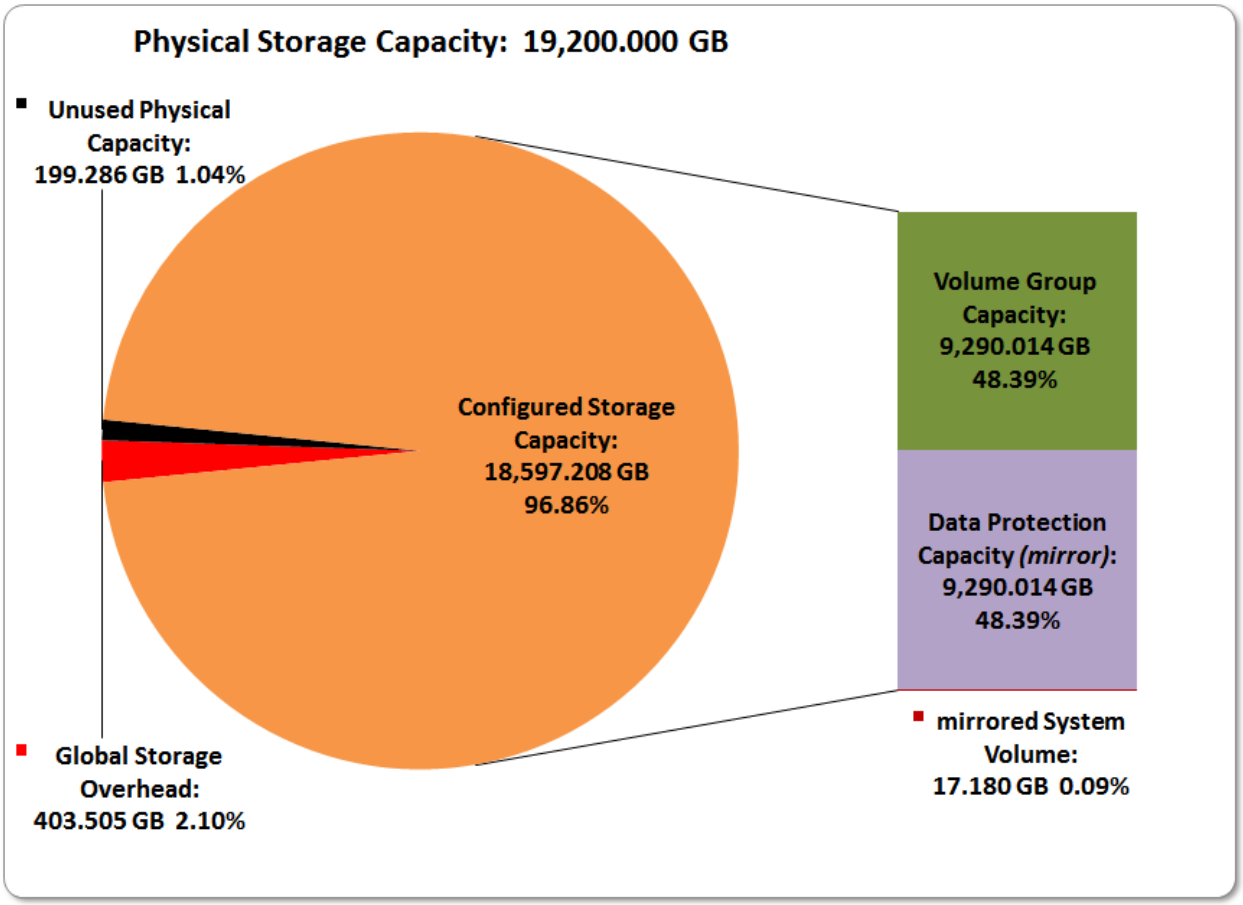
SPC-1 Storage Capacities

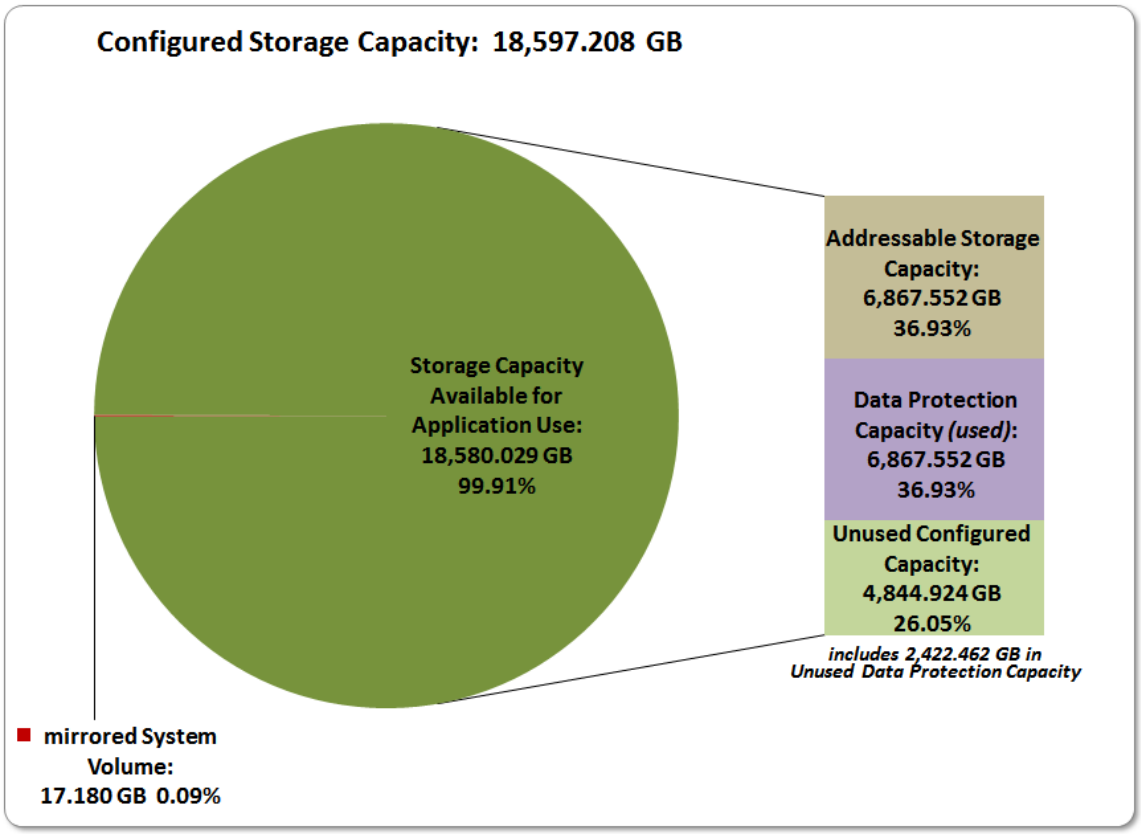
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	6,867.552
Addressable Storage Capacity	Gigabytes (GB)	6,867.552
Configured Storage Capacity	Gigabytes (GB)	18,597.208
Physical Storage Capacity	Gigabytes (GB)	19,200.000
Data Protection *(Mirroring)*	Gigabytes (GB)	9,290.014
Required Storage *(system volume/mirror)*	Gigabytes (GB)	17.180
Global Storage Overhead	Gigabytes (GB)	403.505
Total Unused Storage	Gigabytes (GB)	5,044.211

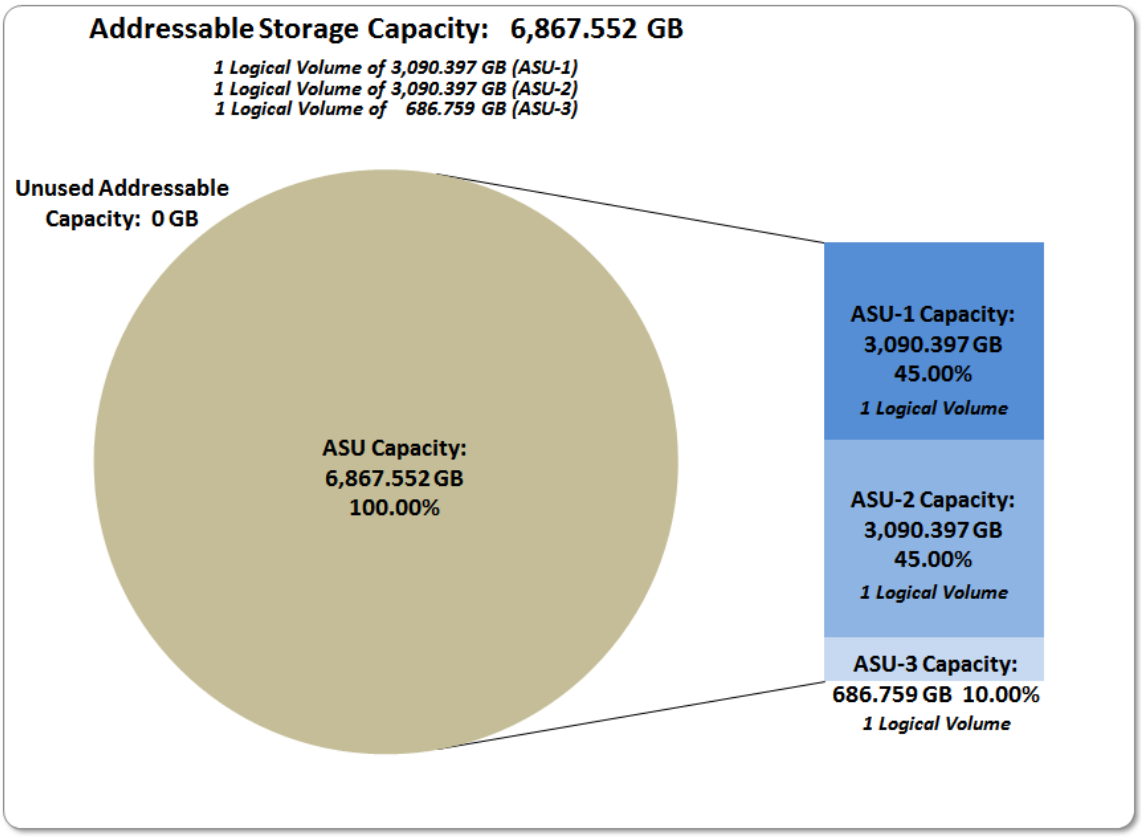
SPC-1 Storage Hierarchy Ratios

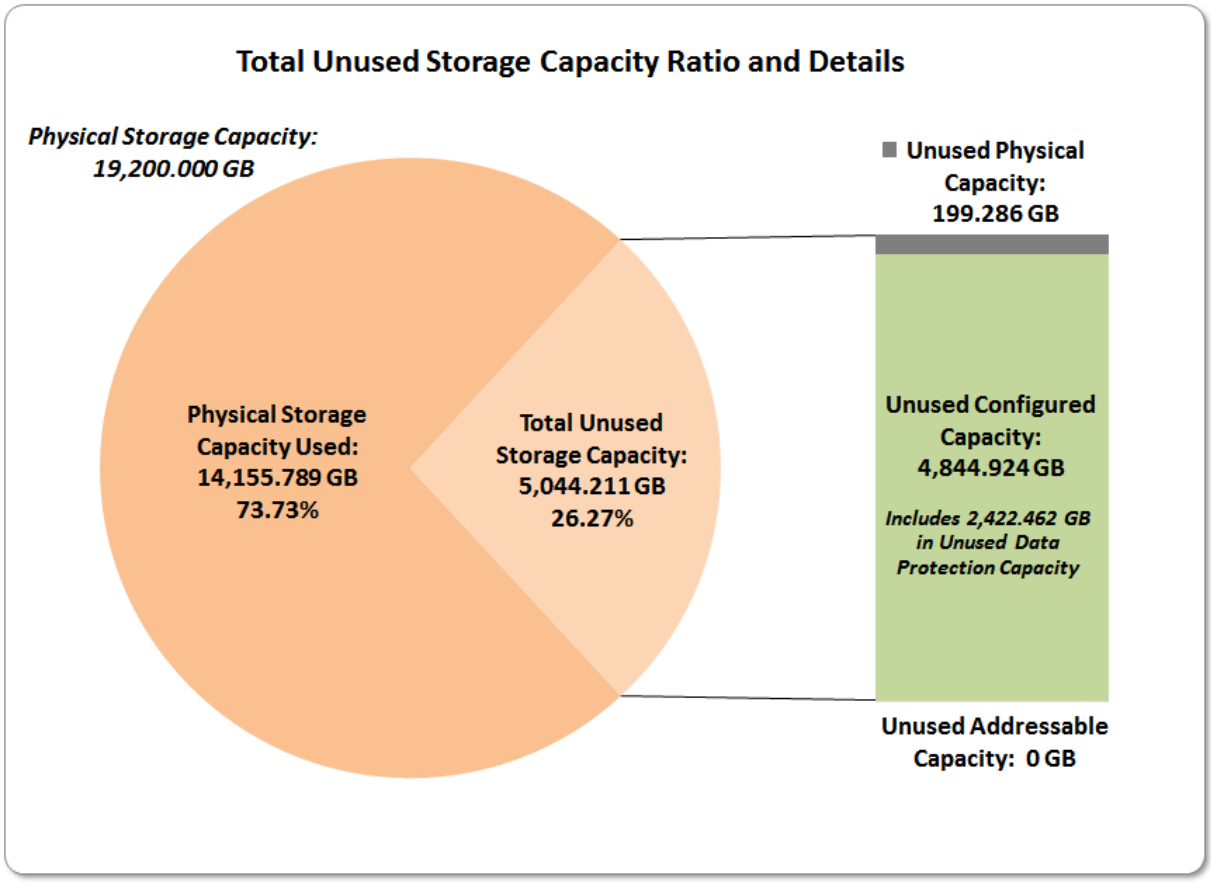
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	36.93%	35.77%
Required for Data Protection *(Mirroring)*		49.95%	48.39%
Addressable Storage Capacity		36.93%	35.77%
Required Storage *(system volume/mirror)*		0.09%	0.09%
Configured Storage Capacity			96.86%
Global Storage Overhead			2.10%
Unused Storage:			
Addressable	0.00%		
Configured		26.05%	
Physical			1.04%

SPC-1 Storage Capacity Charts




Configured Storage Capacity: 18,597.208 GB
Storage Capacity Available for Application Use: 18,580.029 GB 99.91%
Addressable Storage Capacity: 6,867.552 GB 36.93%
Data Protection Capacity (used): 6,867.552 GB 36.93%
Unused Configured Capacity: 4,844.924 GB 26.05%
includes 2,422.462 GB in Unused Data Protection Capacity
mirrored System Volume: 17.180 GB 0.09%


Addressable Storage Capacity: 6,867.552 GB
1 Logical Volume of 3,090.397 GB (ASU-1)
1 Logical Volume of 3,090.397 GB (ASU-2)
1 Logical Volume of 686.759 GB (ASU-3)
Unused Addressable Capacity: 0 GB
ASU Capacity: 6,867.552 GB 100.00%
ASU-1 Capacity: 3,090.397 GB 45.00%
1 Logical Volume
ASU-2 Capacity: 3,090.397 GB 45.00%
1 Logical Volume
ASU-3 Capacity: 686.759 GB 10.00%
1 Logical Volume



Storage Capacity Utilization

Clause 9.4.3.6.2

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

Clause 2.8.1

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

Clause 2.8.2

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

Clause 2.8.3

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

SPC-1 Storage Capacity Utilization	
Application Utilization	35.77%
Protected Application Utilization	71.54%
Unused Storage Ratio	26.27%

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 (3,090.397 GB)
1 Logical Volume 3,090.397 GB per Logical Volume (3,090.397 GB used per Logical Volume)
ASU-2 (3,090.397 GB)
1 Logical Volume 3,090.397 GB per Logical Volume (3,090.397 GB used per Logical Volume)
ASU-3 (686.759 GB)
1 Logical Volume 686.759 GB per Logical Volume (686.759 GB used per Logical Volume)

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

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. An SPC-1 glossary on page 61 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

"Ramp-Up" Test Runs

Clause 5.3.13

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

Clause 5.3.13.3

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

Clause 9.4.3.7.1

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

There were no "Ramp-Up" Test Runs executed.

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous eight (8) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.2

For the Sustainability Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in Appendix E: SPC-1 Workload Generator Input Parameters on Page 71.

Sustainability Test Results File

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

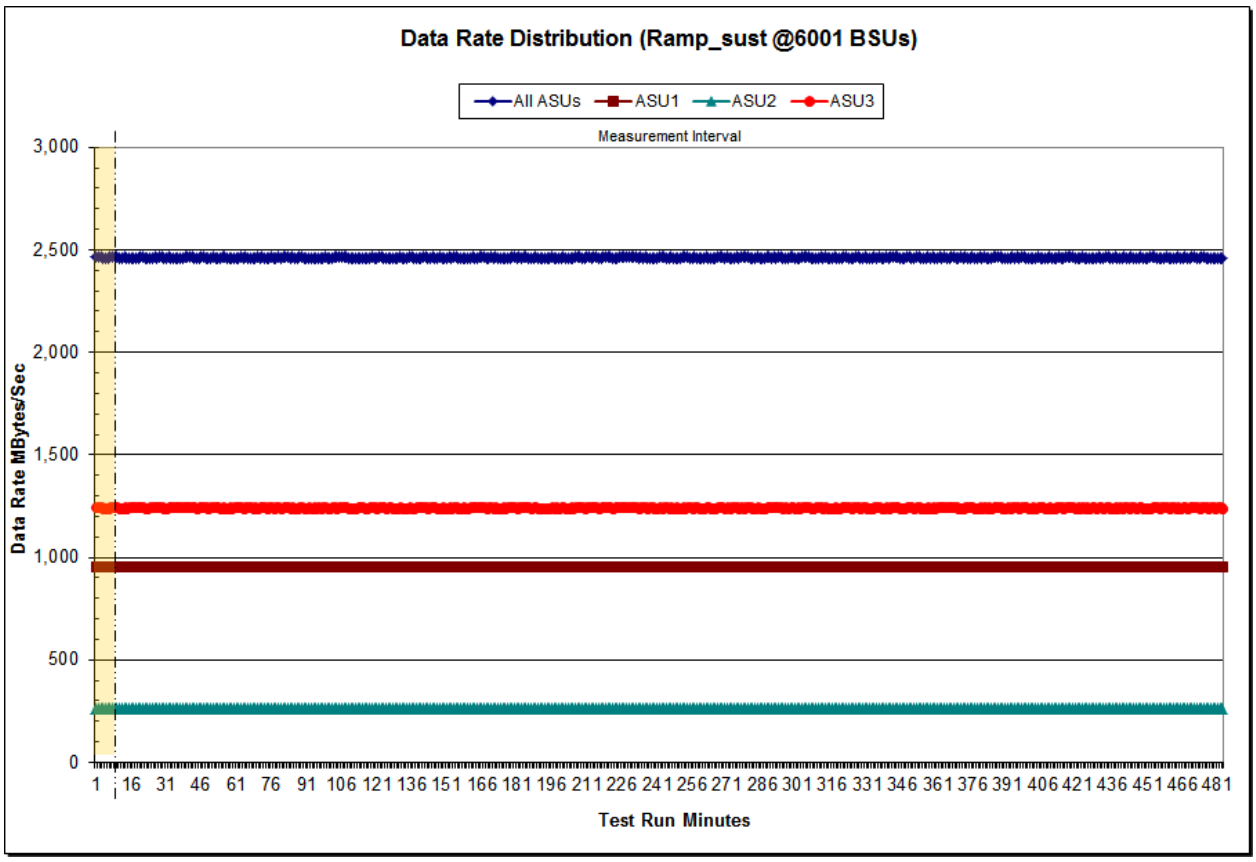
Sustainability Test Results File

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

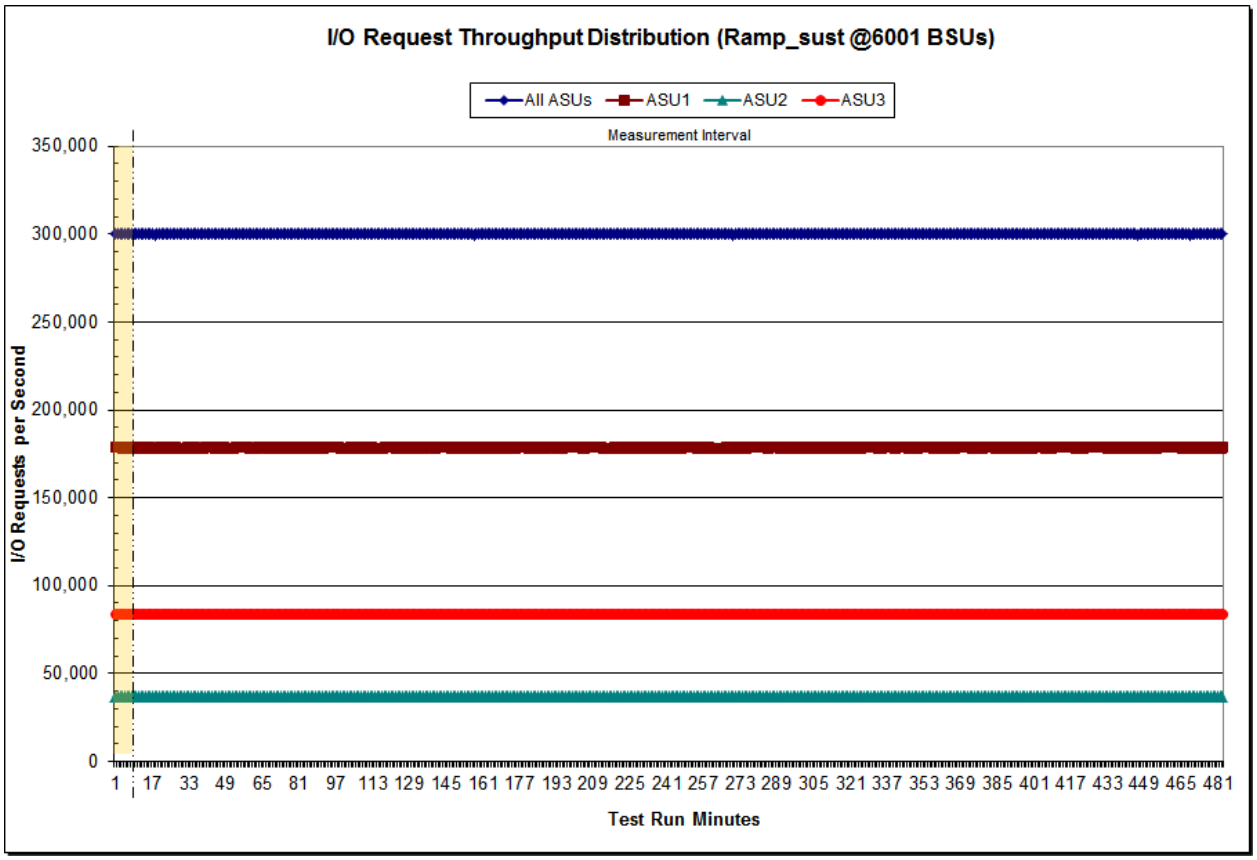


Sustainability – I/O Request Throughput Distribution Data

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

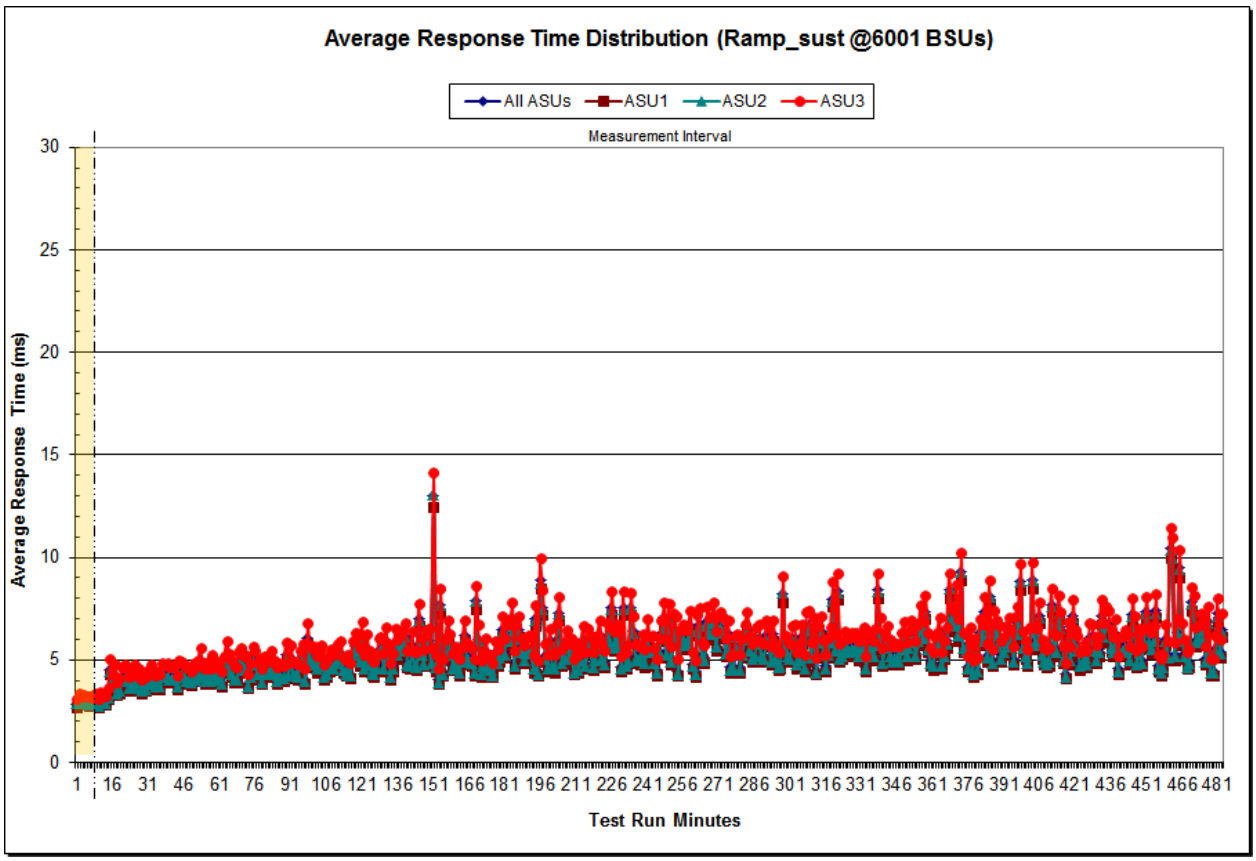


Sustainability – Average Response Time (ms) Distribution Data

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



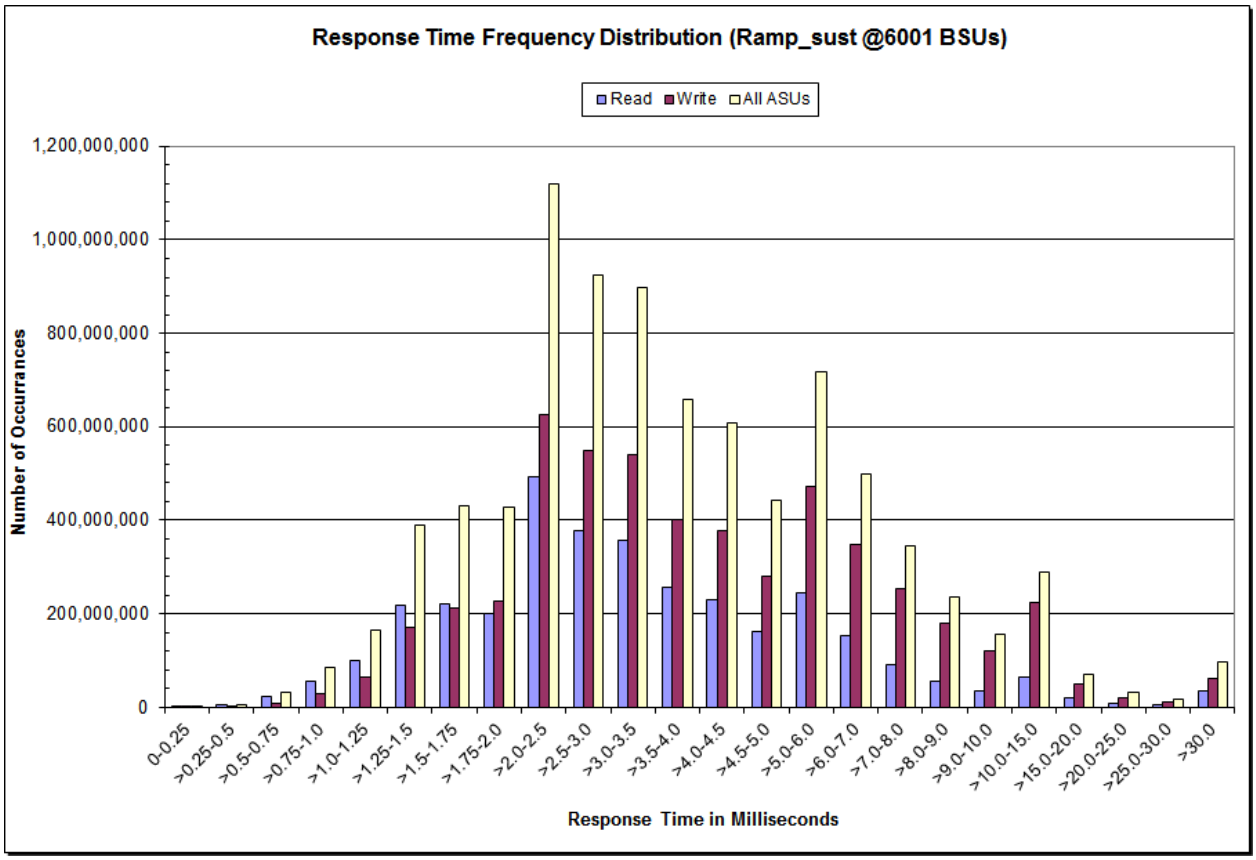
Sustainability – Response Time Frequency Distribution Data

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	302,159	4,770,124	23,337,455	54,891,424	99,192,509	216,952,799	219,804,757	201,281,659
Write	687	408,463	7,677,645	29,987,558	64,913,009	171,828,749	212,615,655	226,126,742
All ASUs	302,846	5,178,587	31,015,100	84,878,982	164,105,518	388,781,548	432,420,412	427,408,401
ASU1	290,634	4,676,290	24,585,228	62,486,059	116,878,090	267,358,455	286,490,266	275,077,325
ASU2	11,981	350,503	3,429,963	10,381,984	20,690,909	49,719,683	55,433,228	54,560,231
ASU3	231	151,794	2,999,909	12,010,939	26,536,519	71,703,410	90,496,918	97,770,845

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	491,907,649	377,359,752	356,437,939	256,291,972	230,497,455	161,608,371	245,310,029	151,782,295
Write	626,248,621	548,573,059	540,341,122	402,512,266	377,288,576	280,209,384	472,294,990	348,621,489
All ASUs	1,118,156,270	925,932,811	896,779,061	658,804,238	607,786,031	441,817,755	717,605,019	500,403,784
ASU1	699,157,017	561,067,043	535,444,461	388,895,665	354,804,552	254,780,482	405,456,047	273,580,814
ASU2	141,889,246	116,224,553	111,936,263	81,949,100	75,195,014	54,281,372	86,959,790	59,305,120
ASU3	277,110,007	248,641,215	249,398,337	187,959,473	177,786,465	132,755,901	225,189,182	167,517,850

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	91,839,343	55,642,705	34,983,189	63,946,483	18,840,943	9,709,493	6,272,192	35,221,820
Write	253,993,475	178,858,171	122,115,544	224,264,301	50,240,542	21,132,680	12,398,193	60,692,729
All ASUs	345,832,818	234,500,876	157,098,733	288,210,784	69,081,485	30,842,173	18,670,385	95,914,549
ASU1	182,690,569	120,281,877	78,944,286	142,012,471	35,051,159	16,340,927	10,115,757	53,878,846
ASU2	40,003,434	26,527,392	17,479,929	31,382,003	7,650,137	3,556,507	2,200,849	11,815,614
ASU3	123,138,815	87,691,607	60,674,518	114,816,310	26,380,189	10,944,739	6,353,779	30,220,089

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.3

For the IOPS Test Phase the FDR shall contain:

1. *I/O Request Throughput Distribution (data and graph).*
2. *A Response Time Frequency Distribution.*
3. *An Average Response Time Distribution.*
4. *The human readable Test Run Results File produced by the Workload Generator.*
5. *A listing or screen image of all input parameters supplied to the Workload Generator.*
6. *The total number of I/O Requests completed in the Measurement Interval as well as the number of I/O Requests with a Response Time less than or equal to 30 milliseconds and the number of I/O Requests with a Response Time greater than 30 milliseconds.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in Appendix E: SPC-1 Workload Generator Input Parameters on Page 71.

IOPS Test Results File

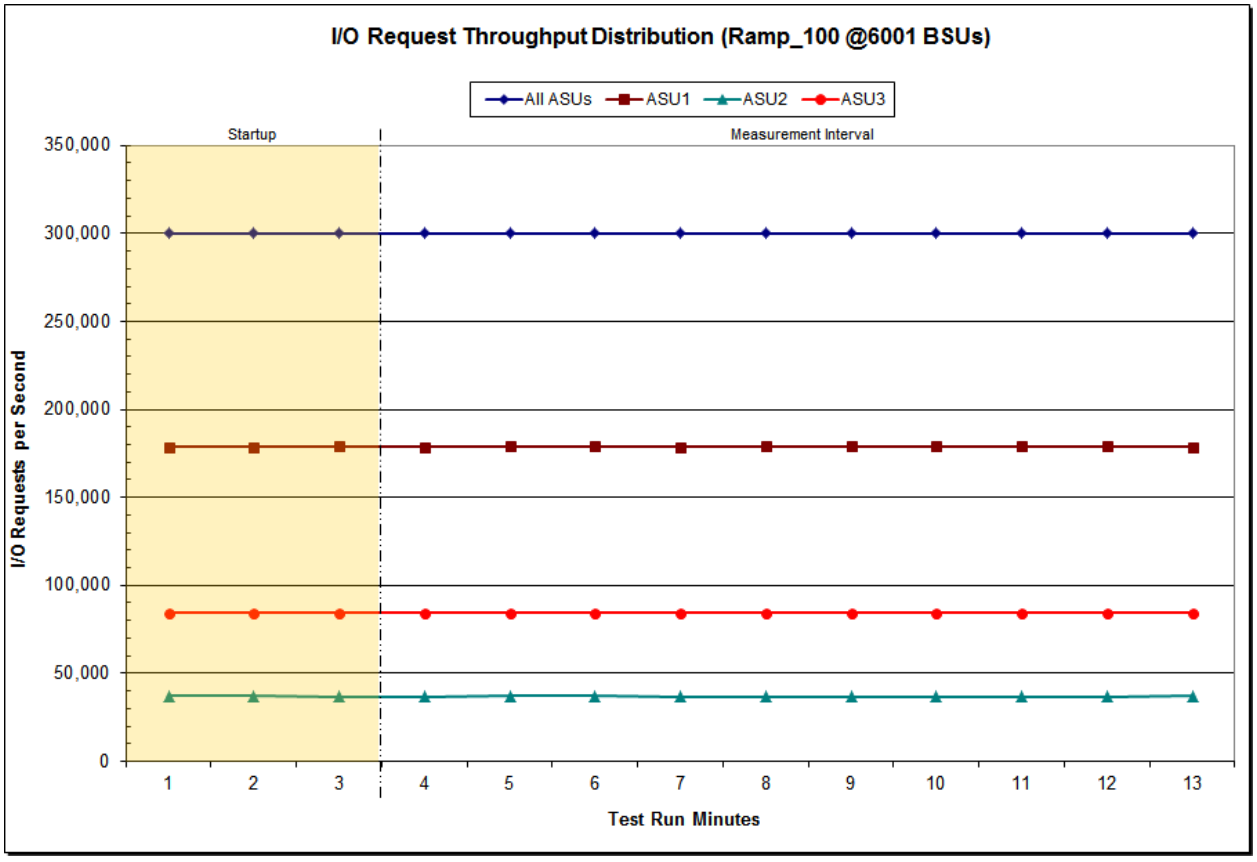
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

6,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:48:23	9:51:24	0-2	0:03:01
Measurement Interval	9:51:24	10:01:24	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	299,956.78	178,786.20	36,912.93	84,257.65
1	300,048.28	178,813.25	36,922.53	84,312.50
2	299,987.10	178,862.88	36,846.80	84,277.42
3	299,970.13	178,780.95	36,907.58	84,281.60
4	300,162.40	178,941.22	36,915.12	84,306.07
5	300,083.65	178,839.93	36,911.57	84,332.15
6	299,988.02	178,755.27	36,911.07	84,321.68
7	299,991.95	178,832.08	36,889.12	84,270.75
8	300,050.90	178,844.30	36,870.33	84,336.27
9	300,070.93	178,875.30	36,901.32	84,294.32
10	299,984.12	178,824.70	36,861.92	84,297.50
11	300,041.13	178,868.73	36,887.05	84,285.35
12	300,061.60	178,811.75	36,942.40	84,307.45
Average	***300,040.48***	***178,837.42***	***36,899.75***	***84,303.31***

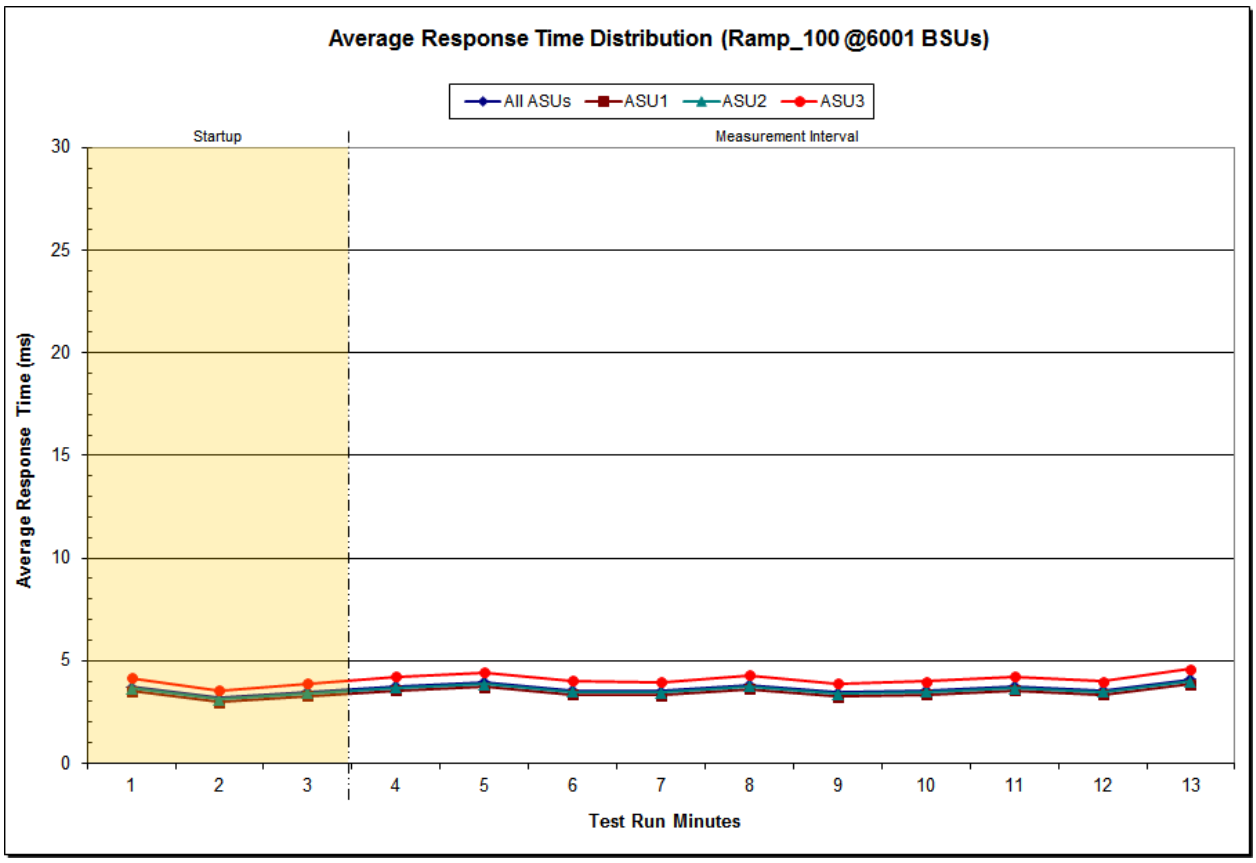
IOPS Test Run – I/O Request Throughput Distribution Graph



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

6,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:48:23	9:51:24	0-2	0:03:01
Measurement Interval	9:51:24	10:01:24	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	3.71	3.52	3.65	4.15
1	3.16	2.99	3.11	3.56
2	3.48	3.29	3.41	3.90
3	3.77	3.56	3.68	4.23
4	3.94	3.72	3.86	4.44
5	3.57	3.36	3.48	4.03
6	3.52	3.33	3.45	3.97
7	3.84	3.63	3.76	4.31
8	3.45	3.25	3.37	3.88
9	3.55	3.36	3.48	3.98
10	3.75	3.54	3.65	4.23
11	3.55	3.36	3.48	3.98
12	4.08	3.87	4.00	4.58
Average	***3.70***	***3.50***	***3.62***	***4.16***

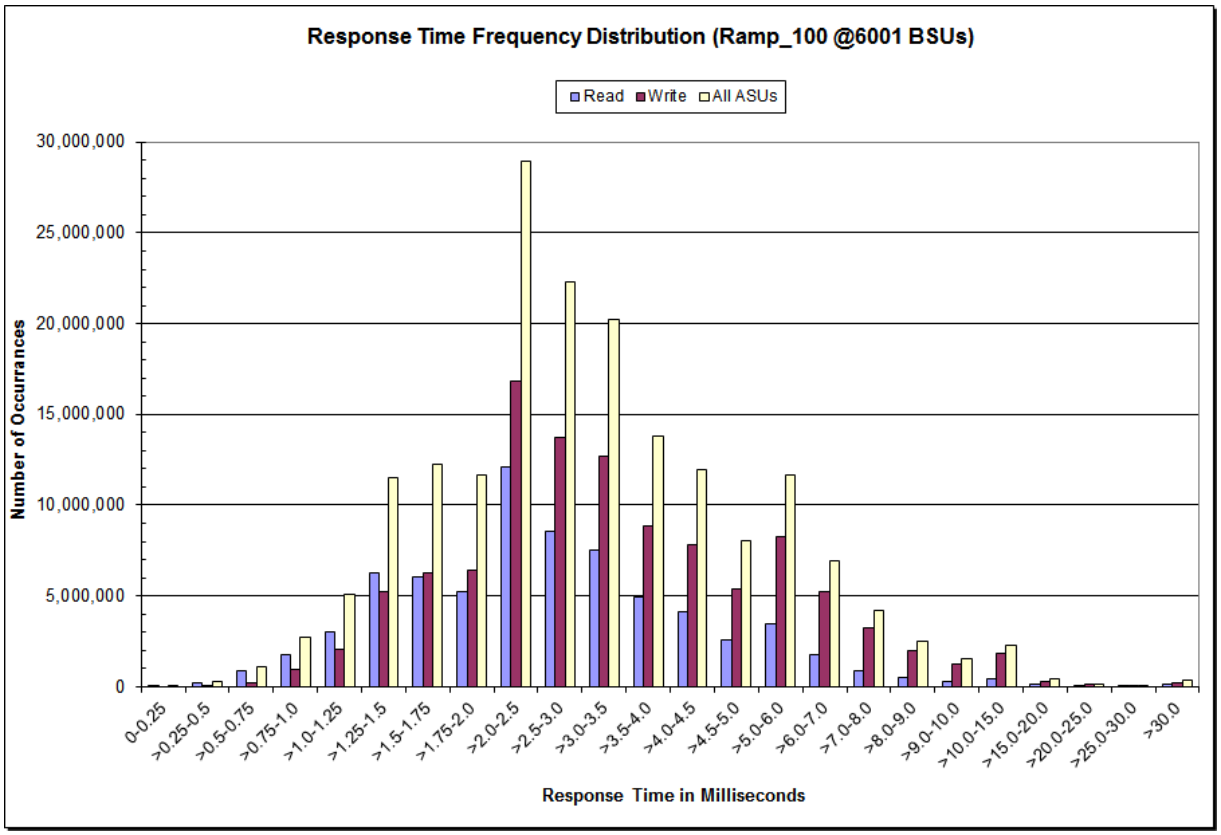
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	18,508	245,204	861,174	1,783,339	3,043,536	6,297,404	6,010,931	5,257,988
Write	1	12,081	246,077	957,077	2,033,316	5,239,374	6,241,656	6,400,732
All ASUs	18,509	257,285	1,107,251	2,740,416	5,076,852	11,536,778	12,252,587	11,658,720
ASU1	18,044	241,477	906,067	2,040,572	3,622,257	7,886,550	8,020,104	7,383,895
ASU2	465	11,408	105,351	315,782	622,221	1,459,530	1,563,992	1,487,331
ASU3	0	4,400	95,833	384,062	832,374	2,190,698	2,668,491	2,787,494
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	12,130,551	8,578,255	7,522,706	4,966,800	4,115,309	2,594,077	3,425,802	1,749,786
Write	16,852,579	13,731,842	12,711,415	8,861,158	7,815,482	5,410,775	8,237,119	5,205,621
All ASUs	28,983,130	22,310,097	20,234,121	13,827,958	11,930,791	8,004,852	11,662,921	6,955,407
ASU1	17,779,422	13,210,226	11,756,768	7,907,398	6,713,512	4,416,265	6,254,607	3,580,415
ASU2	3,673,236	2,794,113	2,519,239	1,713,109	1,465,777	971,947	1,385,378	799,986
ASU3	7,530,472	6,305,758	5,958,114	4,207,451	3,751,502	2,616,640	4,022,936	2,575,006
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	903,924	483,213	273,491	428,563	100,179	44,966	27,091	134,615
Write	3,262,124	2,016,225	1,233,658	1,863,552	301,716	103,643	54,632	233,166
All ASUs	4,166,048	2,499,438	1,507,149	2,292,115	401,895	148,609	81,723	367,781
ASU1	2,066,801	1,202,778	710,324	1,064,766	195,019	76,371	43,545	204,206
ASU2	465,761	271,919	160,364	239,550	43,371	16,730	9,420	43,637
ASU3	1,633,486	1,024,741	636,461	987,799	163,505	55,508	28,758	119,938

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval
180,022,433
I/O Requests Completed with Response Time = or < 30 ms
179,654,652
I/O Requests Completed with Response Time > 30 ms
367,781

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 16.

In addition, the Average Response Time measured during the 10% Test Run is the value for the SPC-1 LRT™ metric. That value represents the Average Response Time of a lightly loaded TSC.

Clause 9.4.3.7.4

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in Appendix E: SPC-1 Workload Generator Input Parameters on Page 71.

Response Time Ramp Test Results File

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

95% Load Level

90% Load Level

80% Load Level

50% Load Level

10% Load Level

Response Time Ramp Distribution (IOPS) Data

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

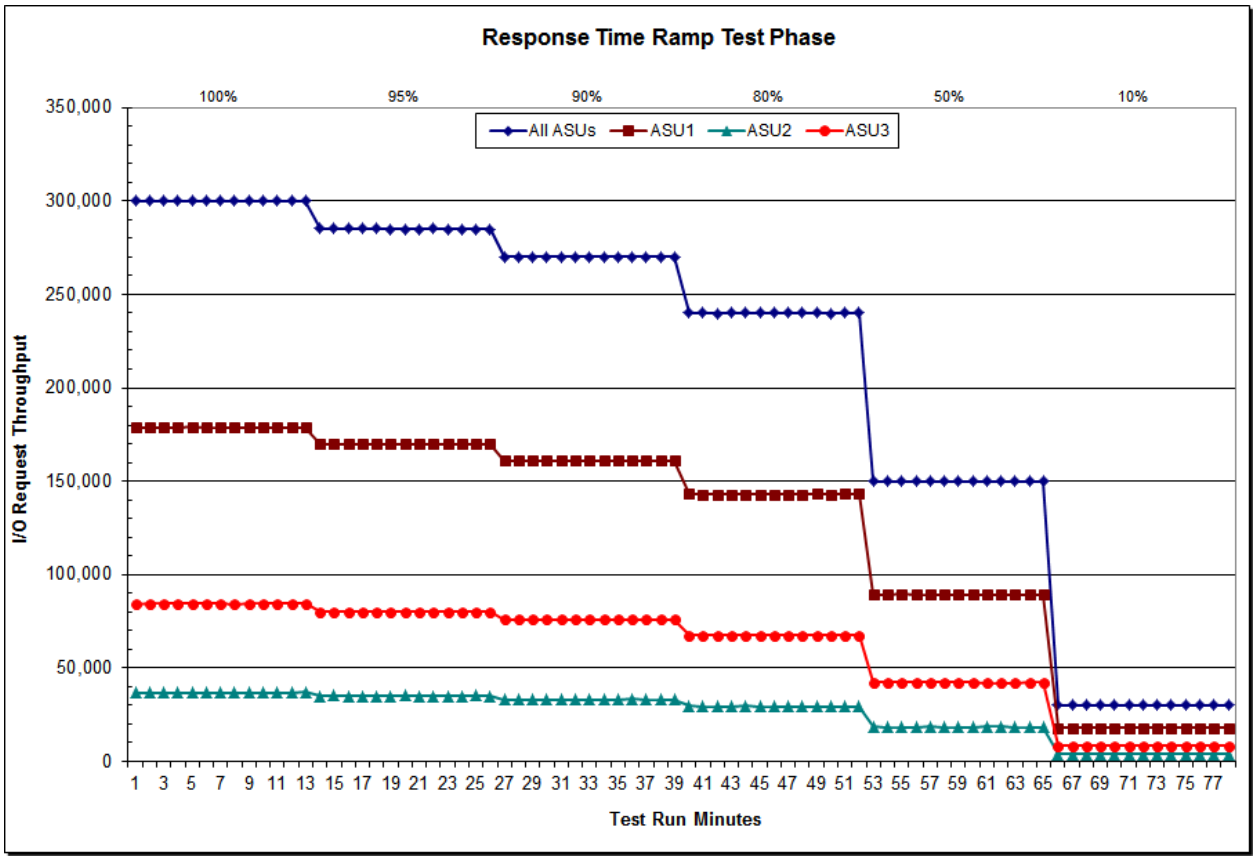
100% Load Level: 6,001 BSUs	Start	Stop	Interval	Duration	95% Load Level: 5,700 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	9:48:23	9:51:24	0-3	0:03:01	Start-Up/Ramp-Up	10:02:08	10:05:09	0-3	0:03:01
Measurement Interval	9:51:24	10:01:24	3-12	0:10:00	Measurement Interval	10:05:09	10:15:09	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	*(60 second intervals)*	All ASUs	ASU-1	ASU-2	ASU-3
0	299,956.78	178,786.20	36,912.93	84,257.65	0	285,096.83	169,938.27	35,070.82	80,087.75
1	300,048.28	178,813.25	36,922.53	84,312.50	1	285,102.83	169,881.20	35,121.03	80,100.60
2	299,987.10	178,862.88	36,846.80	84,277.42	2	285,079.32	169,863.07	35,073.90	80,142.35
3	299,970.13	178,780.95	36,907.58	84,281.60	3	285,065.80	169,891.40	35,036.78	80,137.62
4	300,162.40	178,941.22	36,915.12	84,306.07	4	285,089.62	169,905.67	35,088.88	80,095.07
5	300,083.65	178,839.93	36,911.57	84,332.15	5	285,054.08	169,883.30	35,070.00	80,100.78
6	299,988.02	178,755.27	36,911.07	84,321.68	6	284,956.70	169,792.90	35,097.52	80,066.28
7	299,991.95	178,832.08	36,889.12	84,270.75	7	284,949.33	169,852.35	35,042.28	80,054.70
8	300,050.90	178,844.30	36,870.33	84,336.27	8	285,069.42	169,888.60	35,077.22	80,103.60
9	300,070.93	178,875.30	36,901.32	84,294.32	9	284,986.20	169,839.57	35,059.22	80,087.42
10	299,984.12	178,824.70	36,861.92	84,297.50	10	284,933.65	169,828.48	35,057.78	80,047.38
11	300,041.13	178,868.73	36,887.05	84,285.35	11	285,011.03	169,798.37	35,101.55	80,111.12
12	300,061.60	178,811.75	36,942.40	84,307.45	12	285,033.15	169,916.35	35,008.85	80,107.95
Average	***300,040.48***	***178,837.42***	***36,899.75***	***84,303.31***	*Average*	***285,014.90***	***169,859.70***	***35,064.01***	***80,091.19***

90% Load Level: 5,400 BSUs	Start	Stop	Interval	Duration	80% Load Level: 4,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:15:52	10:18:53	0-3	0:03:01	Start-Up/Ramp-Up	10:29:33	10:32:34	0-3	0:03:01
Measurement Interval	10:18:53	10:28:53	3-12	0:10:00	Measurement Interval	10:32:34	10:42:34	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	*(60 second intervals)*	All ASUs	ASU-1	ASU-2	ASU-3
0	270,016.95	160,908.40	33,204.83	75,903.72	0	240,047.87	143,071.57	29,549.45	67,426.85
1	269,948.78	160,925.05	33,187.70	75,836.03	1	239,972.43	143,020.05	29,494.20	67,458.18
2	269,991.08	160,900.70	33,201.18	75,889.20	2	239,858.68	142,944.82	29,515.62	67,398.25
3	270,014.08	160,909.78	33,224.75	75,879.55	3	239,999.40	143,062.78	29,503.03	67,433.58
4	270,102.68	160,986.67	33,231.33	75,884.68	4	240,024.02	143,021.37	29,548.20	67,454.45
5	270,067.50	160,979.93	33,176.32	75,911.25	5	240,036.83	143,020.37	29,538.98	67,477.48
6	269,917.72	160,838.68	33,193.23	75,885.80	6	240,037.60	143,016.57	29,539.23	67,481.80
7	269,999.20	160,923.63	33,199.75	75,875.82	7	239,959.98	142,996.92	29,492.57	67,470.50
8	269,924.85	160,904.40	33,197.98	75,822.47	8	240,066.80	143,062.77	29,526.87	67,477.17
9	270,015.83	160,869.52	33,257.00	75,889.32	9	240,035.98	143,112.10	29,494.75	67,429.13
10	269,978.43	160,881.80	33,229.57	75,867.07	10	239,858.92	142,918.02	29,532.28	67,408.62
11	269,980.92	160,888.63	33,170.78	75,921.50	11	240,039.57	143,109.95	29,513.42	67,416.20
12	270,084.05	160,999.65	33,186.90	75,897.50	12	240,048.00	143,110.68	29,502.70	67,434.62
Average	***270,008.53***	***160,918.27***	***33,206.76***	***75,883.50***	*Average*	***240,010.71***	***143,043.15***	***29,519.20***	***67,448.36***

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

50% Load Level: 3,000 BSUs	Start	Stop	Interval	Duration	10% Load Level: 600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:43:05	10:46:06	0-3	0:03:01	Start-Up/Ramp-Up	10:56:25	10:59:26	0-3	0:03:01
Measurement Interval	10:46:06	10:56:06	3-12	0:10:00	Measurement Interval	10:59:26	11:09:26	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	*(60 second intervals)*	All ASUs	ASU-1	ASU-2	ASU-3
0	150,060.55	89,432.97	18,461.87	42,165.72	0	30,007.53	17,879.92	3,687.58	8,440.03
1	149,981.92	89,393.08	18,449.10	42,139.73	1	29,990.20	17,868.83	3,691.25	8,430.12
2	150,051.37	89,481.12	18,432.43	42,137.82	2	29,987.32	17,860.52	3,703.28	8,423.52
3	149,944.65	89,360.42	18,442.50	42,141.73	3	29,996.85	17,859.58	3,700.02	8,437.25
4	149,994.73	89,386.13	18,452.87	42,155.73	4	29,985.12	17,878.70	3,683.40	8,423.02
5	149,937.38	89,354.57	18,438.20	42,144.62	5	29,995.13	17,891.05	3,690.78	8,413.30
6	149,911.55	89,347.65	18,444.55	42,119.35	6	29,988.07	17,855.48	3,689.38	8,443.20
7	149,976.08	89,422.38	18,432.80	42,120.90	7	30,017.87	17,896.00	3,682.20	8,439.67
8	149,939.22	89,383.73	18,463.95	42,091.53	8	29,990.90	17,866.82	3,690.25	8,433.83
9	149,931.67	89,383.78	18,455.30	42,092.58	9	29,981.38	17,877.62	3,680.25	8,423.52
10	149,923.55	89,403.68	18,426.35	42,093.52	10	29,991.78	17,878.28	3,694.63	8,418.87
11	149,992.78	89,404.22	18,439.42	42,149.15	11	30,007.10	17,906.07	3,682.80	8,418.23
12	150,039.40	89,414.68	18,449.07	42,175.65	12	30,011.28	17,889.05	3,691.95	8,430.28
Average	***149,959.10***	***89,386.13***	***18,444.50***	***42,128.48***	***Average***	***29,996.55***	***17,879.87***	***3,688.57***	***8,428.12***

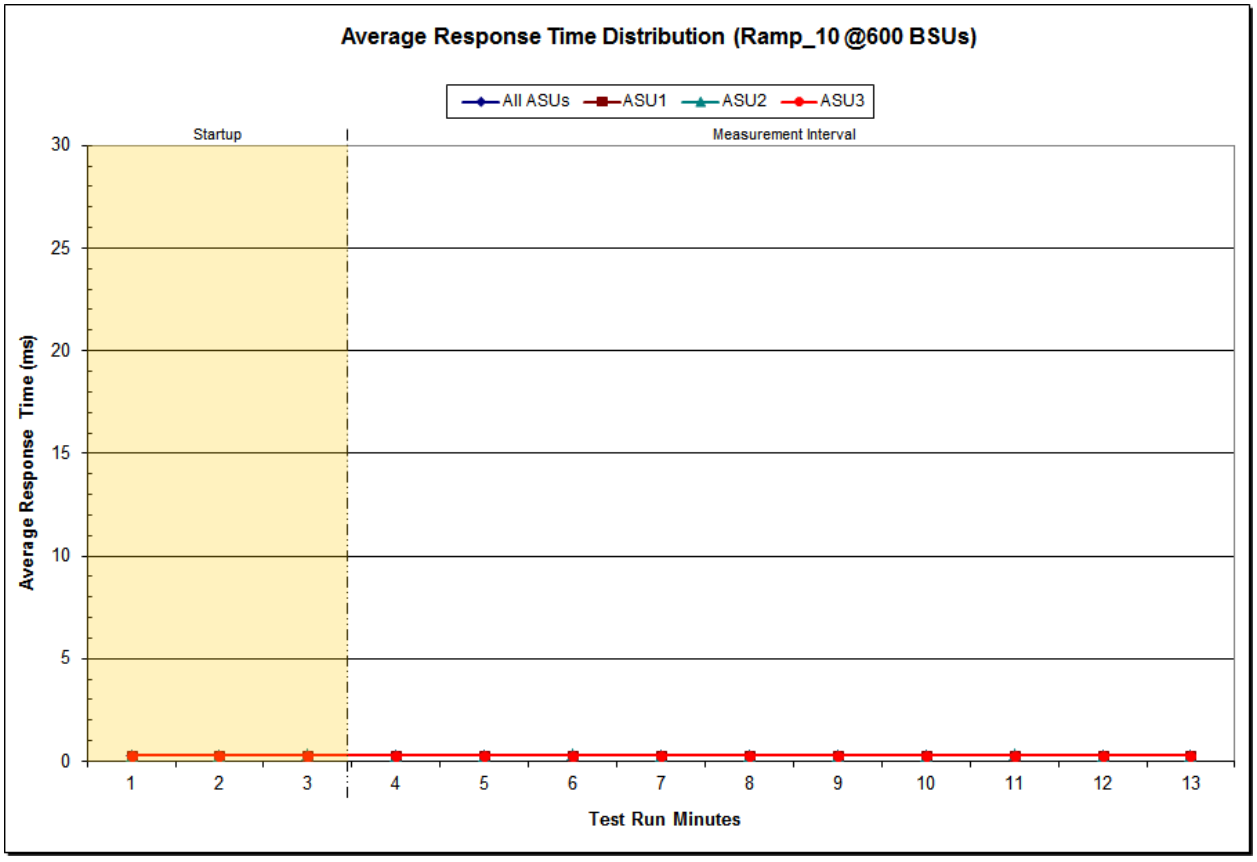
Response Time Ramp Distribution (IOPS) Graph



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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:56:25	10:59:26	0-2	0:03:01
Measurement Interval	10:59:26	11:09:26	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.29	0.28	0.30	0.29
1	0.28	0.28	0.30	0.29
2	0.29	0.28	0.30	0.29
3	0.28	0.28	0.30	0.29
4	0.28	0.28	0.30	0.29
5	0.29	0.28	0.30	0.29
6	0.28	0.28	0.29	0.28
7	0.28	0.28	0.29	0.28
8	0.28	0.28	0.30	0.29
9	0.28	0.28	0.29	0.28
10	0.29	0.28	0.30	0.29
11	0.28	0.28	0.30	0.29
12	0.28	0.28	0.30	0.28
Average	***0.28***	***0.28***	***0.30***	***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	0.2811	0.0701	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.004	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Repeatability Test

Clause 5.4.5

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ primary metric and the SPC-1 LRT™ metric generated in earlier Test Runs.

There are two identical Repeatability Test Phases. Each Test Phase contains two Test Runs. Each of the Test Runs will have a Measurement Interval of no less than ten (10) minutes. The two Test Runs in each Test Phase will be executed without interruption or any type of manual intervention.

The first Test Run in each Test Phase is executed at the 10% load point. The Average Response Time from each of the Test Runs is compared to the SPC-1 LRT™ metric. Each Average Response Time value must be less than the SPC-1 LRT™ metric plus 5% or less than the SPC-1 LRT™ metric plus one (1) millisecond (ms).

The second Test Run in each Test Phase is executed at the 100% load point. The I/O Request Throughput from the Test Runs is compared to the SPC-1 IOPS™ primary metric. Each I/O Request Throughput value must be greater than the SPC-1 IOPS™ primary metric minus 5%. In addition, the Average Response Time for each Test Run cannot exceed 30 milliseconds.

If any of the above constraints are not met, the benchmark measurement is invalid.

Clause 9.4.3.7.5

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in Appendix E: SPC-1 Workload Generator Input Parameters on Page 71.

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	***300,040.48***
Repeatability Test Phase 1	300,037.82
Repeatability Test Phase 2	299,990.72

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	***0.28***
Repeatability Test Phase 1	0.28
Repeatability Test Phase 2	0.28

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)

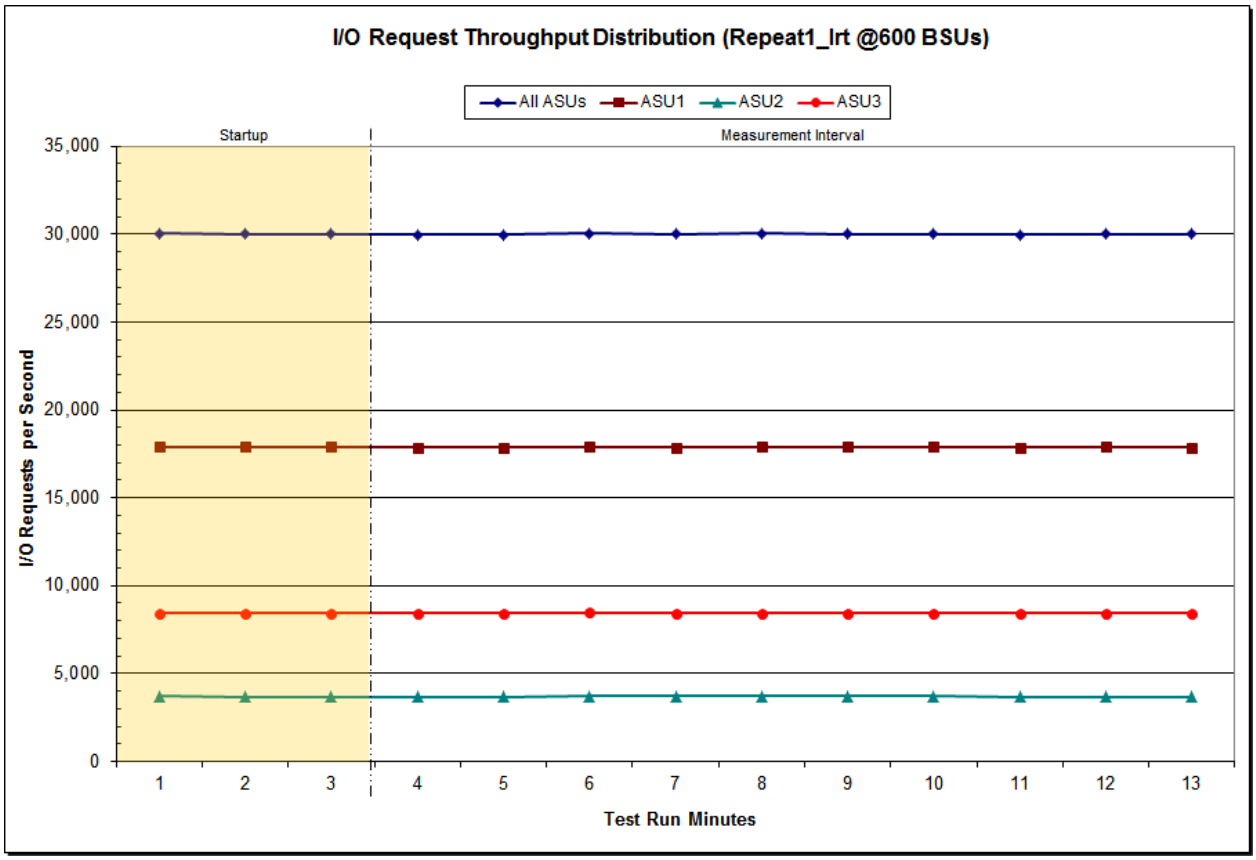
Repeatability Test Phase 2, Test Run 1 (LRT)

Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:10:08	11:13:08	0-2	0:03:00
Measurement Interval	11:13:08	11:23:08	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	30,044.03	17,911.72	3,692.52	8,439.80
1	30,008.93	17,898.35	3,684.58	8,426.00
2	30,005.95	17,888.00	3,682.15	8,435.80
3	29,954.77	17,863.37	3,679.55	8,411.85
4	29,989.00	17,870.88	3,681.35	8,436.77
5	30,043.95	17,897.87	3,695.57	8,450.52
6	29,998.10	17,876.20	3,691.23	8,430.67
7	30,035.63	17,916.23	3,699.37	8,420.03
8	30,013.28	17,896.02	3,691.32	8,425.95
9	30,027.25	17,897.30	3,697.92	8,432.03
10	29,988.53	17,872.38	3,688.35	8,427.80
11	30,017.67	17,890.07	3,689.90	8,437.70
12	29,995.42	17,875.88	3,689.63	8,429.90
Average	***30,006.36***	***17,885.62***	***3,690.42***	***8,430.32***

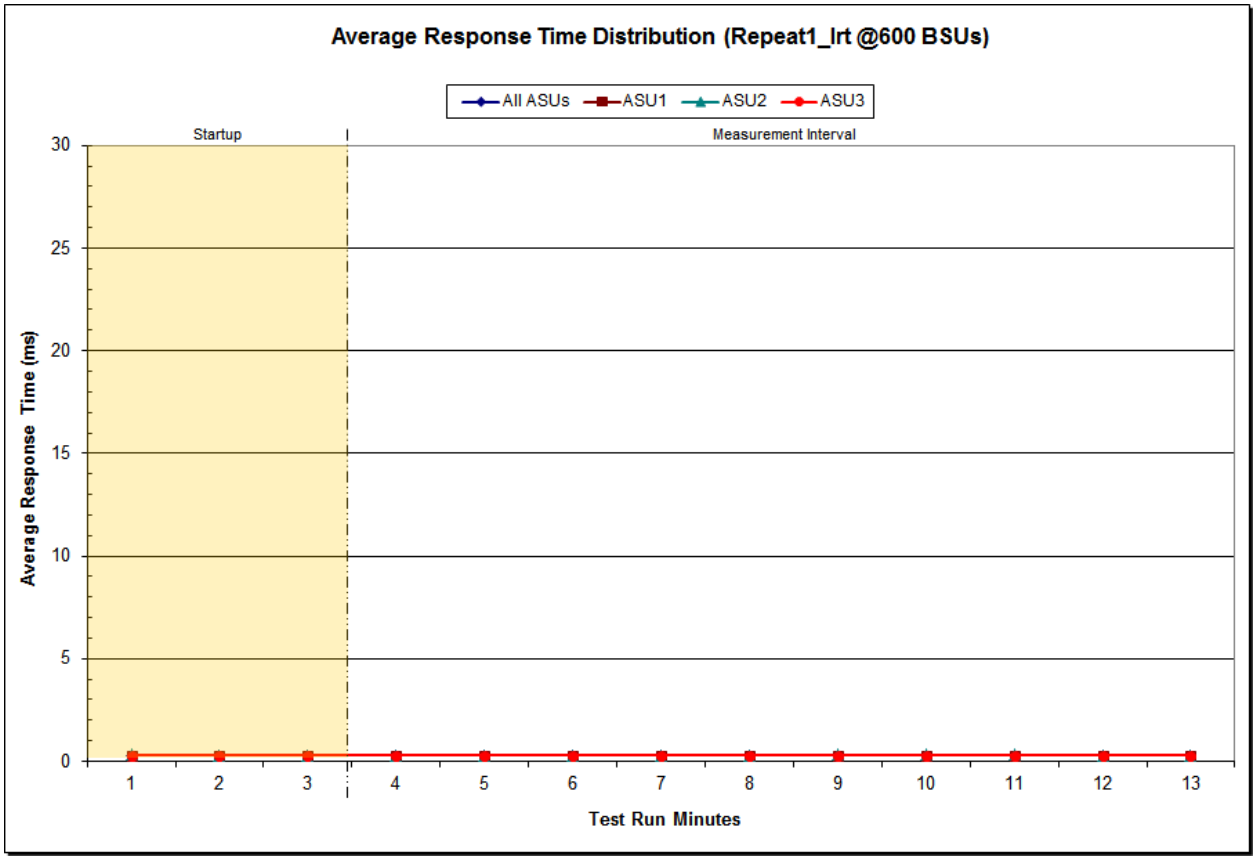
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:10:08	11:13:08	0-2	0:03:00
Measurement Interval	11:13:08	11:23:08	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.29	0.28	0.30	0.29
1	0.28	0.27	0.29	0.28
2	0.28	0.28	0.30	0.28
3	0.28	0.27	0.29	0.28
4	0.28	0.27	0.29	0.28
5	0.28	0.27	0.29	0.28
6	0.28	0.28	0.30	0.29
7	0.28	0.28	0.30	0.29
8	0.29	0.28	0.30	0.29
9	0.29	0.29	0.31	0.29
10	0.29	0.29	0.30	0.29
11	0.29	0.28	0.30	0.29
12	0.28	0.28	0.30	0.29
Average	***0.28***	***0.28***	***0.30***	***0.29***

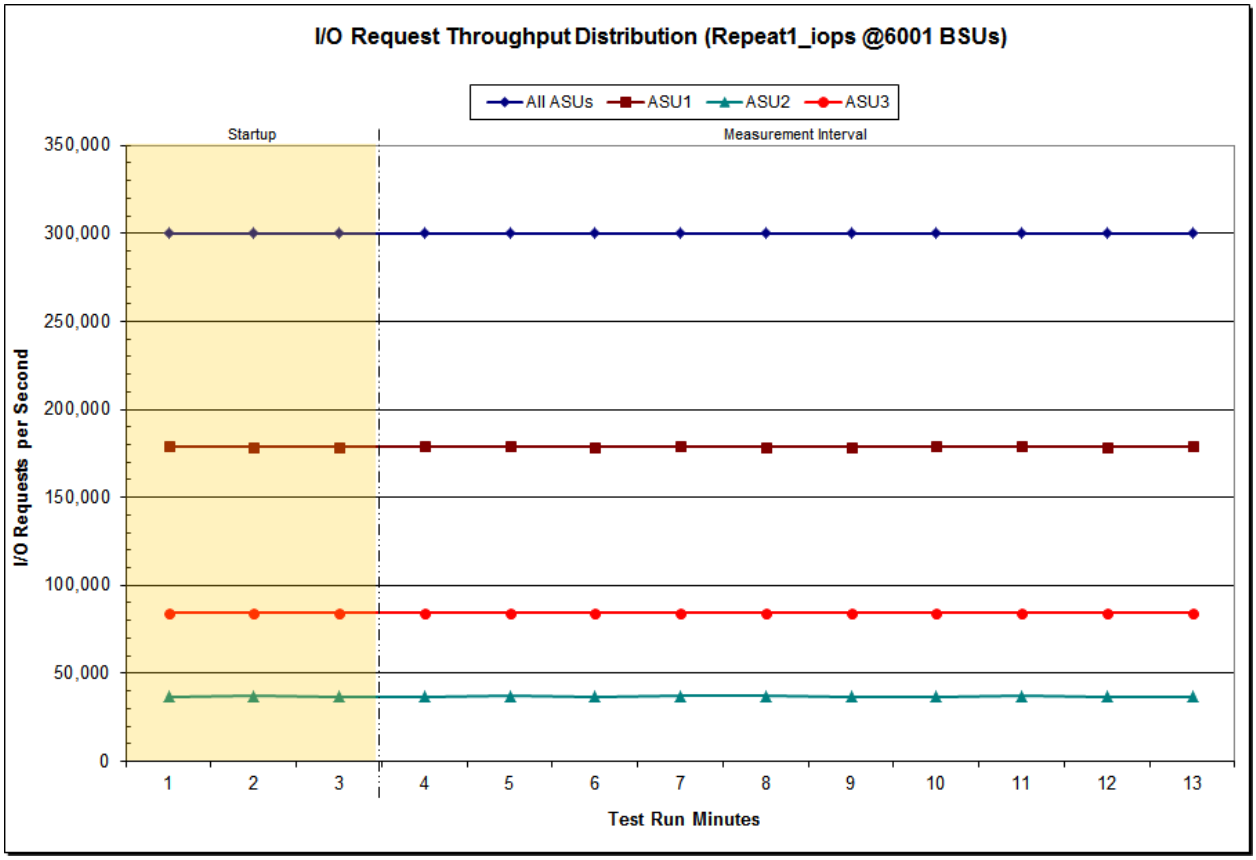
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

6,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:23:54	11:26:55	0-2	0:03:01
Measurement Interval	11:26:55	11:36:55	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	300,047.98	178,836.47	36,882.48	84,329.03
1	300,026.30	178,774.52	36,912.07	84,339.72
2	299,916.55	178,732.48	36,894.33	84,289.73
3	299,963.67	178,841.85	36,858.07	84,263.75
4	300,068.32	178,880.53	36,912.52	84,275.27
5	300,023.22	178,807.70	36,891.65	84,323.87
6	300,010.13	178,854.00	36,926.30	84,229.83
7	300,072.73	178,787.58	36,925.38	84,359.77
8	300,027.47	178,819.95	36,889.23	84,318.28
9	300,035.62	178,855.80	36,898.47	84,281.35
10	300,085.32	178,879.25	36,916.72	84,289.35
11	300,079.20	178,801.67	36,906.15	84,371.38
12	300,012.53	178,860.93	36,883.53	84,268.07
Average	***300,037.82***	***178,838.93***	***36,900.80***	***84,298.09***

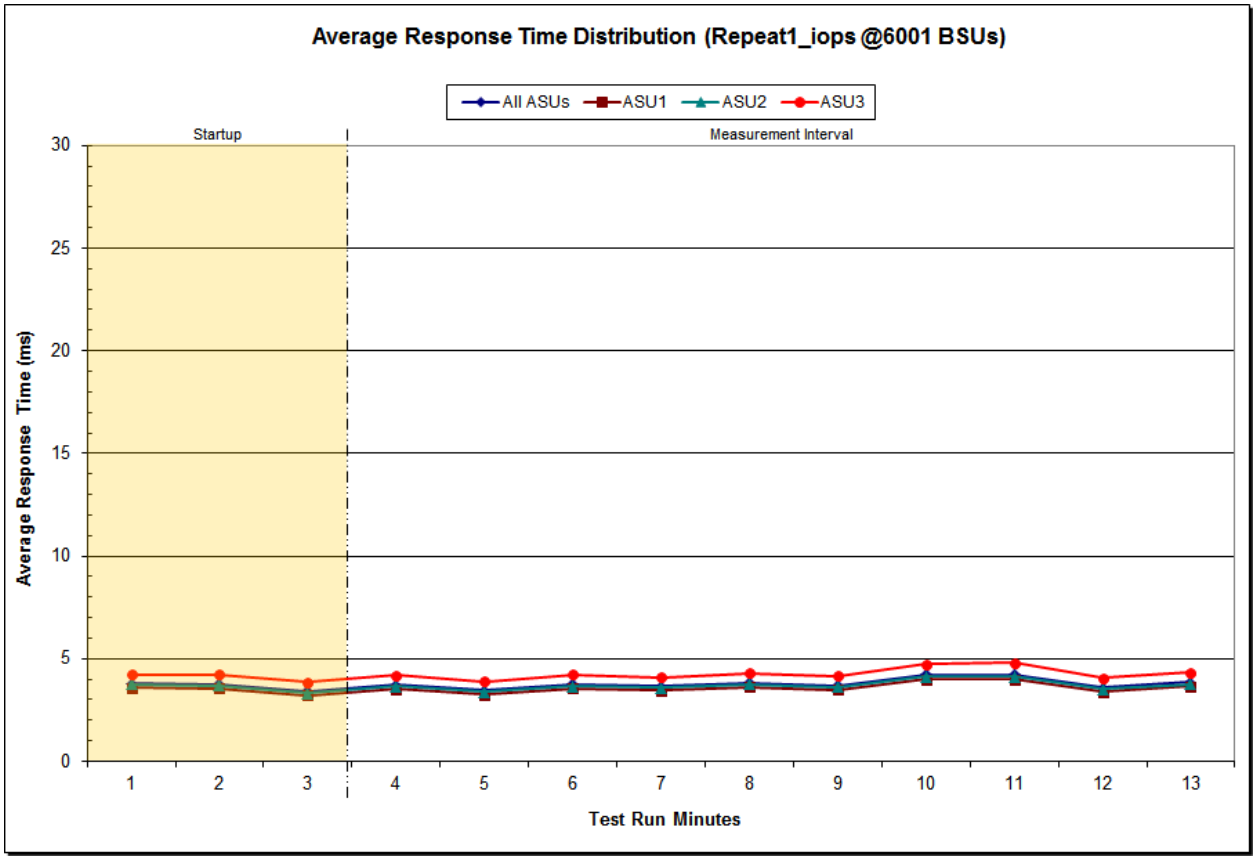
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

6,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:23:54	11:26:55	0-2	0:03:01
Measurement Interval	11:26:55	11:36:55	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	3.79	3.60	3.75	4.23
1	3.75	3.54	3.69	4.21
2	3.41	3.21	3.33	3.84
3	3.73	3.53	3.65	4.20
4	3.44	3.25	3.38	3.88
5	3.75	3.54	3.65	4.22
6	3.64	3.44	3.57	4.10
7	3.82	3.60	3.74	4.30
8	3.69	3.49	3.61	4.16
9	4.21	3.98	4.11	4.74
10	4.24	4.00	4.13	4.79
11	3.59	3.39	3.51	4.04
12	3.85	3.64	3.77	4.34
Average	***3.80***	***3.59***	***3.71***	***4.28***

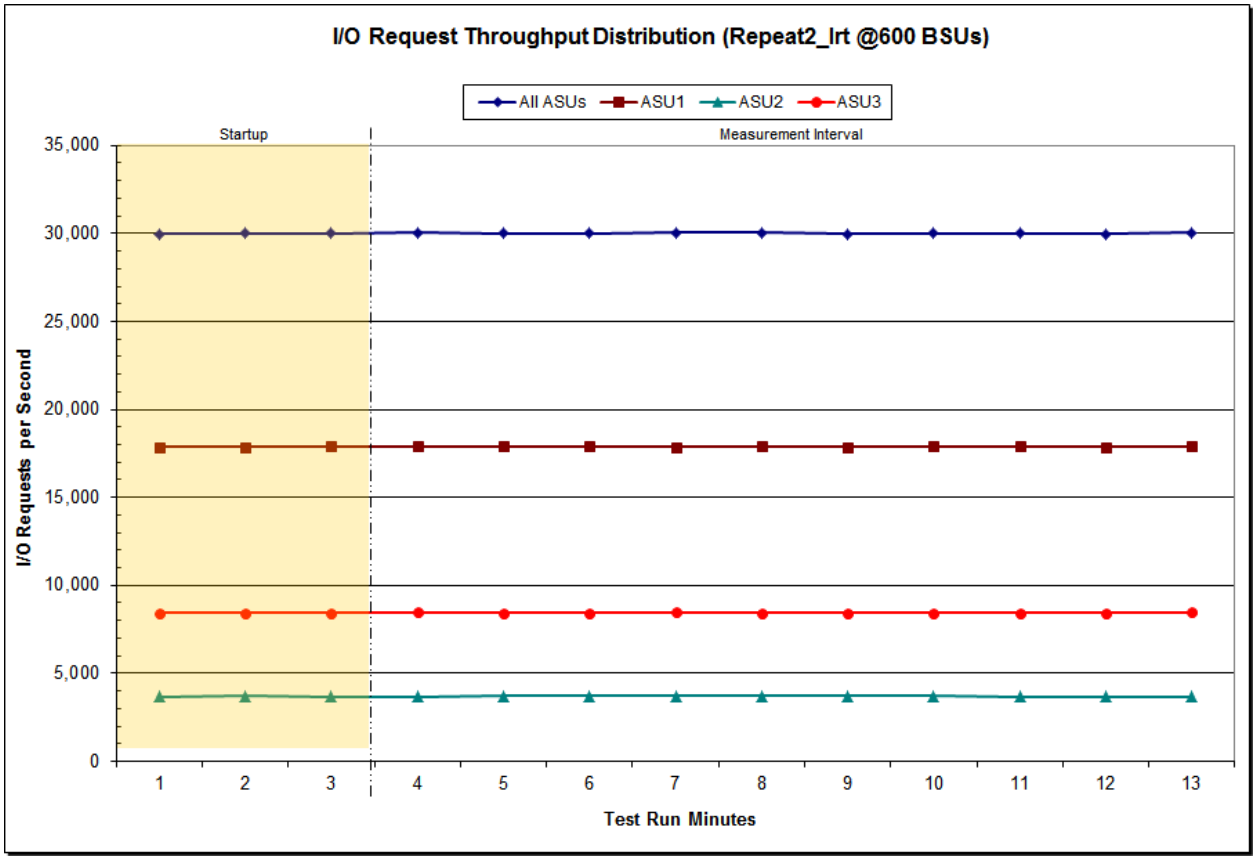
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:37:37	11:40:37	0-2	0:03:00
Measurement Interval	11:40:37	11:50:37	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	29,972.60	17,848.12	3,689.48	8,435.00
1	30,008.33	17,878.23	3,695.32	8,434.78
2	30,012.95	17,893.75	3,679.93	8,439.27
3	30,043.43	17,907.38	3,685.48	8,450.57
4	30,010.67	17,888.48	3,697.97	8,424.22
5	30,026.32	17,900.58	3,694.62	8,431.12
6	30,033.37	17,878.32	3,694.87	8,460.18
7	30,034.12	17,888.73	3,702.52	8,442.87
8	29,981.80	17,869.78	3,694.38	8,417.63
9	30,015.63	17,899.35	3,694.17	8,422.12
10	30,019.07	17,913.33	3,678.95	8,426.78
11	29,970.87	17,864.33	3,684.55	8,421.98
12	30,042.97	17,907.08	3,680.87	8,455.02
Average	***30,017.82***	***17,891.74***	***3,690.84***	***8,435.25***

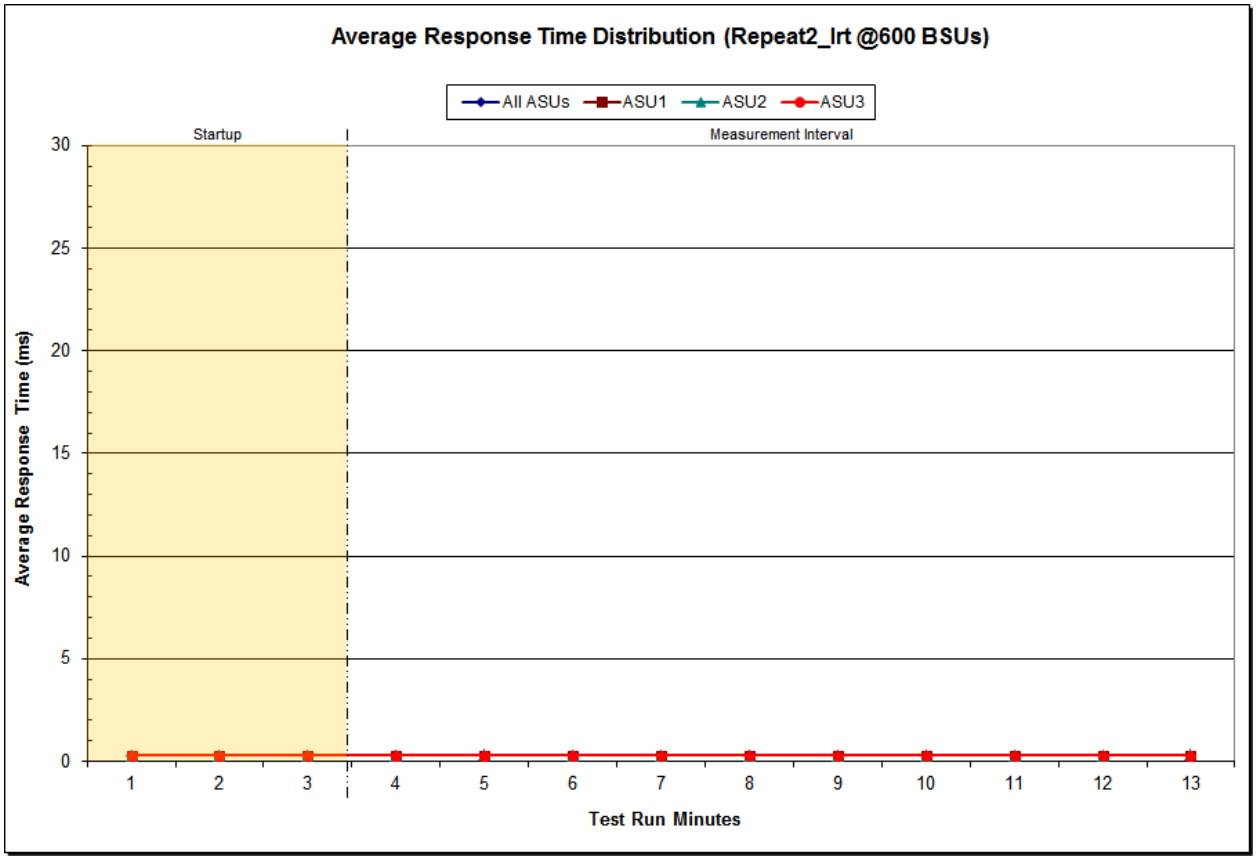
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:37:37	11:40:37	0-2	0:03:00
Measurement Interval	11:40:37	11:50:37	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.29	0.28	0.30	0.29
1	0.28	0.28	0.30	0.29
2	0.28	0.27	0.29	0.28
3	0.28	0.28	0.30	0.28
4	0.29	0.28	0.30	0.29
5	0.28	0.28	0.29	0.28
6	0.28	0.28	0.30	0.29
7	0.28	0.28	0.30	0.29
8	0.28	0.28	0.30	0.29
9	0.28	0.28	0.30	0.29
10	0.28	0.28	0.29	0.28
11	0.29	0.28	0.30	0.29
12	0.29	0.28	0.30	0.29
Average	***0.28***	***0.28***	***0.30***	***0.29***

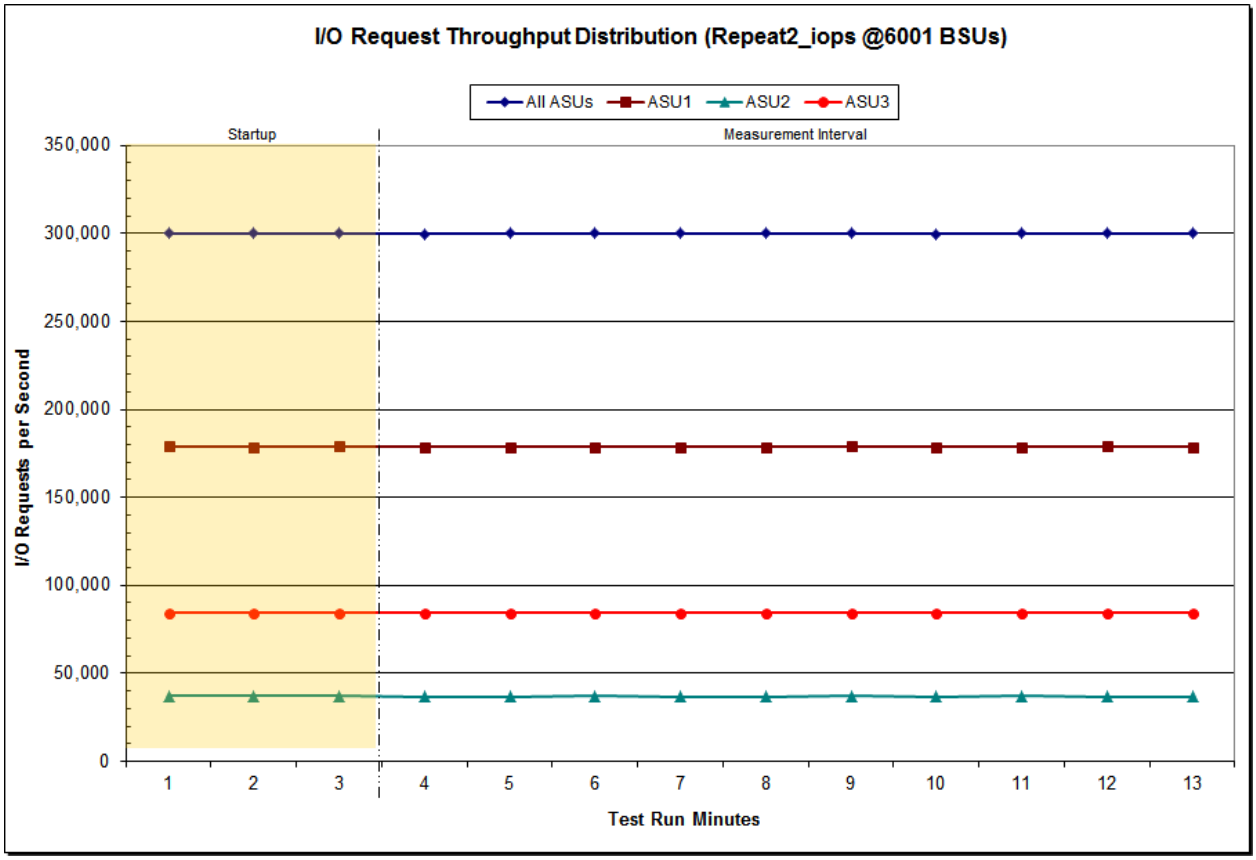
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

6,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:51:21	11:54:22	0-2	0:03:01
Measurement Interval	11:54:22	12:04:22	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	300,065.77	178,855.33	36,915.47	84,294.97
1	300,055.57	178,792.00	36,921.35	84,342.22
2	300,092.23	178,865.73	36,936.05	84,290.45
3	299,882.58	178,735.20	36,902.13	84,245.25
4	299,929.33	178,785.05	36,899.62	84,244.67
5	299,992.63	178,803.92	36,939.80	84,248.92
6	300,030.77	178,775.45	36,896.07	84,359.25
7	299,934.80	178,779.03	36,875.78	84,279.98
8	300,104.43	178,868.92	36,928.85	84,306.67
9	299,834.72	178,744.97	36,857.45	84,232.30
10	300,049.02	178,818.60	36,928.05	84,302.37
11	300,129.40	178,844.18	36,886.20	84,399.02
12	300,019.48	178,801.67	36,883.95	84,333.87
Average	***299,990.72***	***178,795.70***	***36,899.79***	***84,295.23***

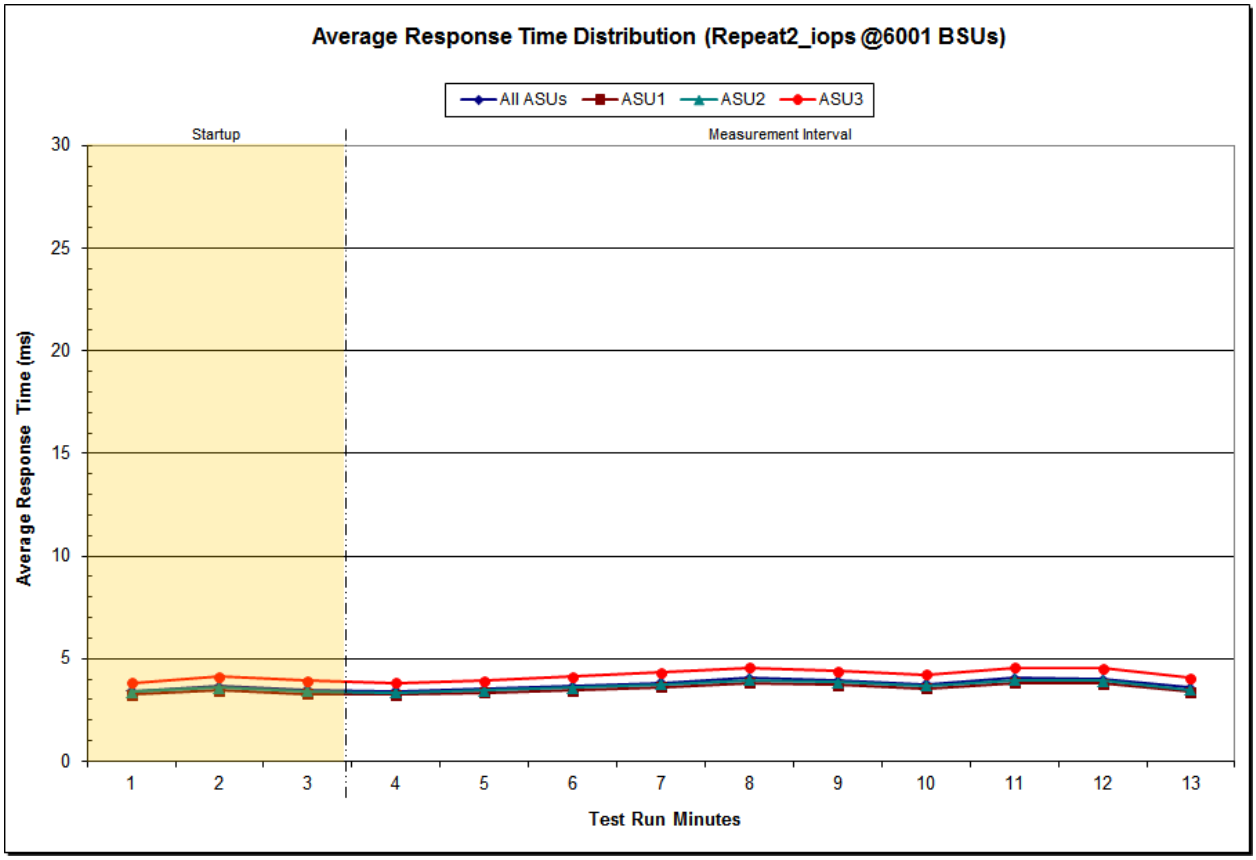
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

6,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:51:21	11:54:22	0-2	0:03:01
Measurement Interval	11:54:22	12:04:22	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	3.42	3.24	3.39	3.82
1	3.67	3.46	3.60	4.14
2	3.48	3.29	3.41	3.92
3	3.42	3.23	3.36	3.84
4	3.52	3.33	3.46	3.94
5	3.65	3.46	3.58	4.11
6	3.83	3.62	3.74	4.33
7	4.05	3.83	3.96	4.56
8	3.92	3.70	3.85	4.39
9	3.77	3.56	3.68	4.23
10	4.04	3.81	3.96	4.56
11	4.00	3.78	3.91	4.52
12	3.58	3.38	3.49	4.05
Average	***3.78***	***3.57***	***3.70***	***4.25***

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	0.2809	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.005	0.001	0.002	0.001	0.006	0.001	0.004	0.001

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

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

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2811	0.0699	0.2100	0.0180	0.0700	0.0349	0.2810
COV	0.005	0.001	0.003	0.002	0.006	0.002	0.003	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
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

Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in Appendix E: SPC-1 Workload Generator Input Parameters on Page 71.

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	71,947,344
Total Number of Logical Blocks Verified	61,954,656
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 NEC Storage M310F as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

Pricing information may be found in the Priced Storage Configuration Pricing section on page 17.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 17.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

The SPC-1 Workload Generator was configured to use 60 Slave JVMs rather than the required minimum of 61 Slave JVMs for the Primary Metrics and Repeatability Tests. Based on prior testing, the smaller number (60 vs. 61) of Slave JVMs would have no impact on the reported SPC-1 IOPS performance and negligible to no impact on the reported SPC-1 Average Response Time.

APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

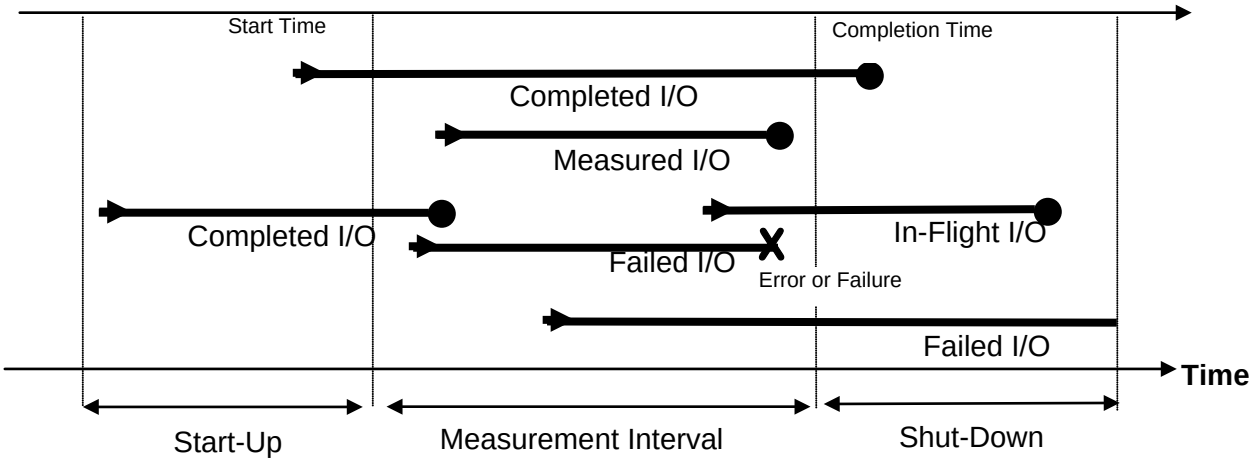
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

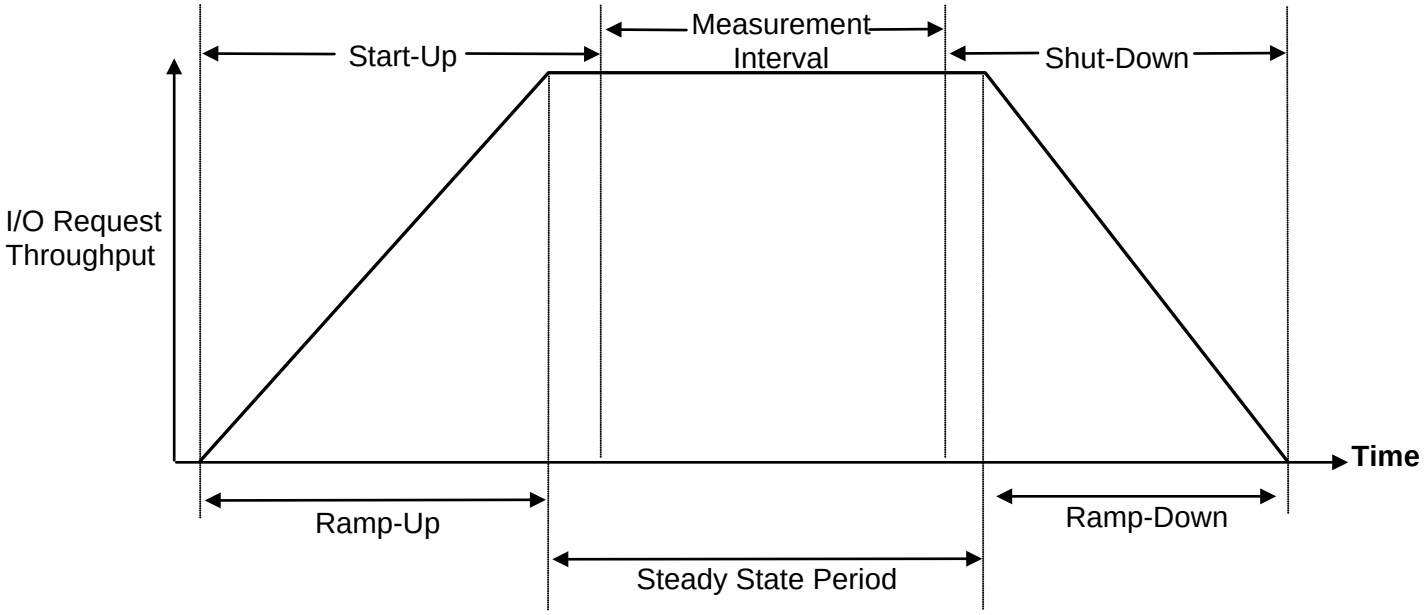
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have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

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

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

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

A CLI session is started with the NEC Storage M310F, via one of the Host Systems, using telnet to enter the commands described below.

Telnet Login and Enter Maintenance Mode

Start a telnet client on one of the Host System and specify the IP address of the NEC Storage M310F *(10.1.0.11 is the default value).*

Enter ***sysadmin*** as the username at the first prompt and ***sys123*** *(default value)* at the second prompt to logon to the NEC Storage M310F.

The following command will place the NEC Storage M310F into maintenance mode:

```
iSMcfg setseize -mode on
```

Create Volume Group (Pools)

The following commands will create 8 RAID-1 volume groups (pools), using 6 SSDs for each volume group:

```
iSMcfg poolbind -type dynamic -poolnumber 0000h -poolname Pool0000 -raid 1 -pdg 00h
-pdn 0000h-0005h -time 0

iSMcfg poolbind -type dynamic -poolnumber 0001h -poolname Pool0001 -raid 1 -pdg 00h
-pdn 0006h-000bh -time 0

iSMcfg poolbind -type dynamic -poolnumber 0002h -poolname Pool0002 -raid 1 -pdg 00h
-pdn 000ch-0011h -time 0

iSMcfg poolbind -type dynamic -poolnumber 0003h -poolname Pool0003 -raid 1 -pdg 00h
-pdn 0012h-0017h -time 0

iSMcfg poolbind -type dynamic -poolnumber 0004h -poolname Pool0004 -raid 1 -pdg 00h
-pdn 1000h-1005h -time 0

iSMcfg poolbind -type dynamic -poolnumber 0005h -poolname Pool0005 -raid 1 -pdg 00h
-pdn 1006h-100bh -time 0

iSMcfg poolbind -type dynamic -poolnumber 0006h -poolname Pool0006 -raid 1 -pdg 00h
-pdn 100ch-1011h -time 0

iSMcfg poolbind -type dynamic -poolnumber 0007h -poolname Pool0007 -raid 1 -pdg 00h
-pdn 1012h-1017h -time 0
```

Create Logical Disks

The following commands will create 32 logical disks, 4 logical disks per volume group (pool):

```
iSMcfg ldbind -poolnumber 0000h -ldn 0000h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0000h -ldn 0001h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0000h -ldn 0002h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0000h -ldn 0003h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0001h -ldn 0004h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0001h -ldn 0005h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0001h -ldn 0006h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0001h -ldn 0007h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0002h -ldn 0008h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0002h -ldn 0009h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0002h -ldn 000ah  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0002h -ldn 000bh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0003h -ldn 000ch  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0003h -ldn 000dh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0003h -ldn 000eh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0003h -ldn 000fh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0004h -ldn 0010h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0004h -ldn 0011h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0004h -ldn 0012h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0004h -ldn 0013h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0005h -ldn 0014h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0005h -ldn 0015h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0005h -ldn 0016h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0005h -ldn 0017h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0006h -ldn 0018h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0006h -ldn 0019h  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0006h -ldn 001ah  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0006h -ldn 001bh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0007h -ldn 001ch  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0007h -ldn 001dh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0007h -ldn 001eh  -capacity 200 -unit gb -time 0
iSMcfg ldbind -poolnumber 0007h -ldn 001fh  -capacity 200 -unit gb -time 0
```

Exit Maintenance Mode and Telnet Logoff

The following command will exit maintenance mode:

```
iSMcfg setseize -mode off -force
```

The telnet session is terminated with the ***exit*** command.

SPC-1 Logical Volume Creation

The following steps are executed on a single Host System, using the Windows Disk Management utility, to create the SPC-1 Logical Volumes.

a) Start the Windows Disk Management utility and confirm that the 32 logical disks are presented as 32 Windows "Disks".

b) Initialize and convert all 32 Windows "Disks" to GPT Disks.

c) Convert all 32 Windows "Disks" to Dynamic Disks.

d) Create a Windows striped (RAID-0) volume for ASU-1 as follows:
   i. Select 32 Windows "Disks".
   ii. Set the capacity of each stripe to 92,101 MB
   iii. Assign drive letter "E" to the volume.
   iv. Do not format the volume.

e) Create a Windows striped (RAID-0) volume for ASU-2 as follows:
   i. Select 32 Windows "Disks".
   ii. Set the capacity of each stripe to 92,101 MB
   iii. Assign drive letter "F" to the volume.
   iv. Do not format the volume.

f) Create a Windows striped (RAID-0) volume for ASU-3 as follows:
   i. Select 32 Windows "Disks".
   ii. Set the capacity of each stripe to 20,467 MB
   iii. Assign drive letter "G" to the volume.
   iv. Do not format the volume.

g) Reboot all of the Host Systems.

h) After the reboot completes, start the Windows Disk Management utility on each of the Host Systems.

i) On each Host System, select either the import foreign disk or reactivate Windows stripe sets option, as necessary, then assign drive letters to the stripe sets as were defined in steps **'d' – 'f'** above.

Note: The values listed above as MB represent 1,048,576 bytes (MiB) per unit rather than 1,000,000 bytes.

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

ASU Pre-Fill

```
compratio=1

sd=default,threads=8

sd=sd1,lun=\\.\e:,size=3090396741632
sd=sd2,lun=\\.\f:,size=3090396741632
sd=sd3,lun=\\.\g:,size=686758559744


wd=default,rdpct=0,seek=-1,xfersize=1048576
wd=wd1,sd=sd1
wd=wd2,sd=sd2
wd=wd3,sd=sd3
rd=PREPSSD,wd=wd*,iorate=max,elapsed=999990,interval=10
```

Primary Metrics and Repeatability Tests

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

```
* spc1_metrics.cfg

host=master

#  ns72/73/74/75 15slaves
slaves=(ns72_1,ns72_2,ns72_3,ns72_4,ns72_5,ns72_6,ns72_7,ns72_8,ns72_9,ns72_10,ns72_
11,ns72_12,ns72_13,ns72_14,ns72_15,ns73_1,ns73_2,ns73_3,ns73_4,ns73_5,ns73_6,ns73_7,
ns73_8,ns73_9,ns73_10,ns73_11,ns73_12,ns73_13,ns73_14,ns73_15,ns74_1,ns74_2,ns74_3,n
s74_4,ns74_5,ns74_6,ns74_7,ns74_8,ns74_9,ns74_10,ns74_11,ns74_12,ns74_13,ns74_14,ns7
4_15,ns75_1,ns75_2,ns75_3,ns75_4,ns75_5,ns75_6,ns75_7,ns75_8,ns75_9,ns75_10,ns75_11,
ns75_12,ns75_13,ns75_14,ns75_15)



sd=asu1_1,lun=\\.\e:,size=3090396741632
sd=asu2_1,lun=\\.\f:,size=3090396741632
sd=asu3_1,lun=\\.\g:,size=686758559744
```

SPC-1 Persistence Test

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

```
* spc1_persist.cfg



sd=asu1_1,lun=\\.\e:,size=3090396741632
sd=asu2_1,lun=\\.\f:,size=3090396741632
sd=asu3_1,lun=\\.\g:,size=686758559744
```

Slave JVMs

The Slave JVM command and parameter files are documented in the Slave JVMs section of *Appendix E: SPC-1 Workload Generator Input Parameters*.

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

There were 60 Slave JVMs used in the Primary Metrics and Repeatability Tests. Those Slave JVMs were started as the first step in the execution sequence. The Slave JVMs section below documents that step.

The following script, **master_script_1_M310f.bat**, was then executed to invoke the following in an uninterrupted execution sequence:

- Generate the first set of detailed storage configuration information required for a remote audit,
- The ASU pre-fill script, **prepssd.bat**.
- The commands to execute the Primary Metrics Test *(Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase)*, Repeatability Test *(Repeatability Test Phase 1 and Repeatability Test Phase 2)*, and SPC-1 Persistence Test Run 1 *(write phase)*.
- A script, **shutdown.bat**, to power off the TSC.

The following script, **master_script_2_M310f.bat**, was executed after the required TSC power off/power on cycle to execute the SPC-1 Persistence Test Run 2 *(read phase)* and generate the second set of detailed storage configuration information required for a remote audit.

Slave JVMs

There were 60 Slave JVMs used in the Primary Metrics and Repeatability Tests. The script, **start_slave_15.bat**, listed below, illustrates the commands to start the 15 Slave JVMs (**ns72_s1** – **ns72_s15**) that executed on the first Host System (**ns72**).

start_slave_15.bat

```
start java -Xmx1024m -Xms1024m spc1 -fns72_s1.parm -ons72_s1
start java -Xmx1024m -Xms1024m spc1 -fns72_s2.parm -ons72_s2
start java -Xmx1024m -Xms1024m spc1 -fns72_s3.parm -ons72_s3
start java -Xmx1024m -Xms1024m spc1 -fns72_s4.parm -ons72_s4
start java -Xmx1024m -Xms1024m spc1 -fns72_s5.parm -ons72_s5
start java -Xmx1024m -Xms1024m spc1 -fns72_s6.parm -ons72_s6
start java -Xmx1024m -Xms1024m spc1 -fns72_s7.parm -ons72_s7
start java -Xmx1024m -Xms1024m spc1 -fns72_s8.parm -ons72_s8
start java -Xmx1024m -Xms1024m spc1 -fns72_s9.parm -ons72_s9
start java -Xmx1024m -Xms1024m spc1 -fns72_s10.parm -ons72_s10
start java -Xmx1024m -Xms1024m spc1 -fns72_s11.parm -ons72_s11
start java -Xmx1024m -Xms1024m spc1 -fns72_s12.parm -ons72_s12
start java -Xmx1024m -Xms1024m spc1 -fns72_s13.parm -ons72_s13
start java -Xmx1024m -Xms1024m spc1 -fns72_s14.parm -ons72_s14
start java -Xmx1024m -Xms1024m spc1 -fns72_s15.parm -ons72_s15
```

The following scripts were used to start the remaining 45 Slave JVMs on the remaining 3 Host Systems (**ns73** – **ns75**):

- **ns73: start_slave_15.bat**
- **ns74: start_slave_15.bat**
- **ns75: start_slave_15.bat**

The only difference in each of the four script files is the **–f** parameter value to specify the appropriate configuration file (**ns72_s1.parm…ns75_s15.parm**) and **–o** parameter to specify the appropriate output directory (**ns72_s1…ns75_s15**) for each of the 60 Slave JVMs.

The file, listed below, is the configuration file for the first Slave JVM (**ns72_s1**).

ns72_s1.parm

```
host=ns72_1
master=192.168.10.172

sd=asu1_1,lun=\\.\e:
sd=asu2_1,lun=\\.\f:
sd=asu3_1,lun=\\.\g:
```

The following sets of configuration files were used for the remaining 59 Slave JVMs. The only difference in those configuration files is the **host= parameter** value, which specifies the appropriate Slave JVM (**ns72_s2**…**ns74_s15**).

- **ns72_s2.parm** – **ns72_s15.parm**
- **ns73_s1.parm** – **ns73_s15.parm**
- **ns74_s1.parm** – **ns74_s15.parm**
- **ns75_s1.parm** – **ns75_s15.parm**

master_script_M310f.bat

```
call profile.bat
call prepssd.bat

copy /y spc1_metrics.cfg spc1.cfg
java metrics -b 6001 -t 28800
java repeat1 -b 6001
java repeat2 -b 6001

copy /y spc1_persist.cfg spc1.cfg
java persist1 -b 600
call shutdown.bat
```

ASU Pre-Fill

The following script was invoked to execute the required ASU pre-fill using the command and parameter file documented in *Appendix D: SPC-1 Workload Generator Storage Commands and Parameters* on page 69.

prepssd.bat

```
c:\spc\vdbench503rc11\vdbenchJRE32 -f c:\spc\prepssd.txt -o c:\spc\ssdprep
```

TSC Power Off

The following script and command file were used to execute the required TSC power off after completion of SPC-1 Persistence Test Run 1.

shutdown.bat

```
c:\spc\teraterm\ttermpro.exe /M=c:\spc\teraterm\M310F_shutdown.ttl
```

M310F_shutdown.ttl

```
;; connection user/password
HOSTADDR = '192.168.70.230'
USERNAME = 'sysadmin'
PASSWORD = 'sys123'
;=================================================
;; config
COMMAND = HOSTADDR
strconcat COMMAND ':23 /nossh /T=1'
;; connect
connect COMMAND
;; login
wait 'login: '
sendln USERNAME
wait 'Password: '
sendln PASSWORD

;; command1
wait 'sysadmin@M310F-0# '
sendln 'iSMenv gettime'

;; command2
wait 'sysadmin@M310F-0# '
sendln 'iSMview -all'

;; command3
wait 'sysadmin@M310F-0# '
sendln 'iSMcfg shutdown -time 5'

;; finish
sendln 'exit'

end
```

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

The following script, was executed after the required TSC power off/power on cycle to execute the SPC-1 Persistence Test Run 2 *(read phase)* and generate the second set of detailed storage configuration information required for a remote audit.

master_script_2_M310f.bat

```
java persist2

call profile.bat
```