



**SPC BENCHMARK 1™
FULL DISCLOSURE REPORT**

**INFORTREND TECHNOLOGY, INC.
INFORTREND EONSTOR DS 3024B**

SPC-1 V1.14

**Submitted for Review: June 12, 2015
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Table of Contents

Audit Certification	vii
Audit Certification (cont.)	viii
Letter of Good Faith	ix
Executive Summary	10
Test Sponsor and Contact Information	10
Revision Information and Key Dates	10
Tested Storage Product (TSP) Description	10
Summary of Results	11
Storage Capacities, Relationships, and Utilization	12
Response Time – Throughput Curve	15
Response Time – Throughput Data	15
Priced Storage Configuration Pricing	16
Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration	17
Priced Storage Configuration Diagram	18
Priced Storage Configuration Components	18
Configuration Information	19
Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram	19
Storage Network Configuration	19
Host System(s) and Tested Storage Configuration (TSC) Table of Components	19
Benchmark Configuration/Tested Storage Configuration Diagram	20
Host System and Tested Storage Configuration Components	21
Customer Tunable Parameters and Options	22
Tested Storage Configuration (TSC) Description	22
SPC-1 Workload Generator Storage Configuration	22
ASU Pre-Fill	23
SPC-1 Data Repository	24
Storage Capacities and Relationships	24
SPC-1 Storage Capacities	24
SPC-1 Storage Hierarchy Ratios	25
SPC-1 Storage Capacity Charts	25
Storage Capacity Utilization	27
Logical Volume Capacity and ASU Mapping	28
SPC-1 Benchmark Execution Results	29
SPC-1 Tests, Test Phases, and Test Runs	29

“Ramp-Up” Test Runs.....	30
Primary Metrics Test – Sustainability Test Phase	30
SPC-1 Workload Generator Input Parameters	31
Sustainability Test Results File	31
Sustainability – Data Rate Distribution Data (MB/second)	31
Sustainability – Data Rate Distribution Graph	31
Sustainability – I/O Request Throughput Distribution Data	32
Sustainability – I/O Request Throughput Distribution Graph	32
Sustainability – Average Response Time (ms) Distribution Data	33
Sustainability – Average Response Time (ms) Distribution Graph	33
Sustainability – Response Time Frequency Distribution Data	34
Sustainability – Response Time Frequency Distribution Graph	34
Sustainability – Measured Intensity Multiplier and Coefficient of Variation.....	35
Primary Metrics Test – IOPS Test Phase.....	36
SPC-1 Workload Generator Input Parameters	36
IOPS Test Results File.....	36
IOPS Test Run – I/O Request Throughput Distribution Data	37
IOPS Test Run – I/O Request Throughput Distribution Graph.....	37
IOPS Test Run – Average Response Time (ms) Distribution Data	38
IOPS Test Run – Average Response Time (ms) Distribution Graph	38
IOPS Test Run –Response Time Frequency Distribution Data	39
IOPS Test Run –Response Time Frequency Distribution Graph.....	39
IOPS Test Run – I/O Request Information.....	40
IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation	40
Primary Metrics Test – Response Time Ramp Test Phase	41
SPC-1 Workload Generator Input Parameters	41
Response Time Ramp Test Results File.....	41
Response Time Ramp Distribution (IOPS) Data.....	42
Response Time Ramp Distribution (IOPS) Data (<i>continued</i>)	43
Response Time Ramp Distribution (IOPS) Graph	43
SPC-1 LRT™ Average Response Time (ms) Distribution Data.....	44
SPC-1 LRT™ Average Response Time (ms) Distribution Graph	44
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation	45
Repeatability Test	46
SPC-1 Workload Generator Input Parameters	46
Repeatability Test Results File	47
Repeatability 1 LRT – I/O Request Throughput Distribution Data.....	48
Repeatability 1 LRT – I/O Request Throughput Distribution Graph	48
Repeatability 1 LRT –Average Response Time (ms) Distribution Data	49

Repeatability 1 LRT –Average Response Time (ms) Distribution Graph.....	49
Repeatability 1 IOPS – I/O Request Throughput Distribution Data	50
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph.....	50
Repeatability 1 IOPS –Average Response Time (ms) Distribution Data.....	51
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph	51
Repeatability 2 LRT – I/O Request Throughput Distribution Data.....	52
Repeatability 2 LRT – I/O Request Throughput Distribution Graph	52
Repeatability 2 LRT –Average Response Time (ms) Distribution Data	53
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph.....	53
Repeatability 2 IOPS – I/O Request Throughput Distribution Data	54
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph.....	54
Repeatability 2 IOPS –Average Response Time (ms) Distribution Data.....	55
Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph	55
Repeatability 1 (LRT) Measured Intensity Multiplier and Coefficient of Variation.....	56
Repeatability 1 (IOPS) Measured Intensity Multiplier and Coefficient of Variation	56
Repeatability 2 (LRT) Measured Intensity Multiplier and Coefficient of Variation.....	56
Repeatability 2 (IOPS) Measured Intensity Multiplier and Coefficient of Variation	57
Data Persistence Test.....	58
SPC-1 Workload Generator Input Parameters	58
Data Persistence Test Results File	58
Data Persistence Test Results.....	59
Priced Storage Configuration Availability Date.....	60
Pricing Information.....	60
Tested Storage Configuration (TSC) and Priced Storage Configuration Differences.....	60
Anomalies or Irregularities	60
Appendix A: SPC-1 Glossary	61
“Decimal” (<i>powers of ten</i>) Measurement Units.....	61
“Binary” (<i>powers of two</i>) Measurement Units.....	61
SPC-1 Data Repository Definitions.....	61
SPC-1 Data Protection Levels	62
SPC-1 Test Execution Definitions	62
I/O Completion Types	64
SPC-1 Test Run Components.....	64
Appendix B: Customer Tunable Parameters and Options.....	65
Emulex HBA QueueDepth Parameter	65
Infortrend EonStor DS 3024B Maximum Number of Tags Parameter	65

Appendix C: Tested Storage Configuration (TSC) Creation	66
TSC Creation and Configuration.....	66
HBA QueueDepth	79
Maximum Number of Tags	80
Appendix D: SPC-1 Workload Generator Storage Commands and Parameters	82
ASU Pre-Fill.....	82
Primary Metrics and Repeatability Tests	82
SPC-1 Persistence Test Run 1.....	82
Slave JVMs.....	83
SPC-2 Persistence Test.....	83
SPC-2 Persistence Test Run 1 (<i>write phase</i>).....	83
SPC-2 Persistence Test Run 2 (<i>read phase</i>).....	83
Appendix E: SPC-1 Workload Generator Input Parameters	84
runClientMaster.bat	84
runClientSlave.bat	84
SPC-1_Test.bat.....	85
runMaster.bat	85
spc2_persist2.bat.....	85

AUDIT CERTIFICATION



Jeff Lin
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 Jhonge District, New Taipei City 23544, Taiwan

June 11, 2015

The SPC Benchmark 1™ Reported Data listed below for the Infortrend EonStor DS 3024B was produced in compliance with the SPC Benchmark 1™ v1.14 Onsite Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: Infortrend EonStor DS 3024B	
Metric	Reported Result
SPC-1 IOPS™	218,007.79
SPC-1 Price-Performance	\$0.24/SPC-1 IOPS™
Total ASU Capacity	2,000,000 GB
Data Protection Level	Protected 2 (<i>mirroring</i>)
Total Price (including three-year maintenance)	\$52,185.00
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

AUDIT CERTIFICATION (CONT.)

Infotrend EonStor DS 3024B
SPC-1 Audit Certification

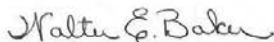
Page 2

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

Audit Notes:

There are no audit notes.

Respectfully,



Walter E. Baker
SPC Auditor

Storage Performance Council
643 Bair Island Road, Suite 103
Redwood City, CA 94062
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650.556.9384

LETTER OF GOOD FAITH



Infotrend Technology, Inc.



April 10, 2015

To: Walter E. Baker
SPC Administrator and Auditor
Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94063

Subject: SPC-1 Letter of Good Faith for the Infotrend EonStor DS 3024B

Infotrend Inc. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with v1.14 of the SPC-1 benchmark specification.

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

Sincerely,

Thomas Kao. 2015/4/10.

Thomas Kao
Senior Director
Product Planning Department

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Infotrend Technology, Inc. – http://www.infotrend.com Jeff Lin – Jeff.Lin@infotrend.com 8F, No. 102, Sec. 3, Jhongshan Rd. Jhonge District , New Taipei City 23544, Taiwan Phone: +866 (2) 2226 0020 x7082
Test Sponsor Alternate Contact	Infotrend Technology, Inc. – http://www.infotrend.com Albert Yen – albert.yen@infotrend.com 8F, No. 102, Sec. 3, Jhongshan Rd. Jhonge District , New Taipei City 23544, Taiwan Phone: +866 (2) 2226 0020 x8020
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	June 12, 2015
Date the FDR was submitted to the SPC	June 12, 2015
Date the Priced Storage Configuration is available for shipment to customers	July 13, 2015
Date the TSC completed audit certification	June 11, 2015

Tested Storage Product (TSP) Description

EonStor DS 3024B is a small form factor (SFF) and high density 2U 24-bay storage designed for 2.5” drives and all-SSD arrays. The EonStor DS 3024B is well suited for SMB and enterprise SAN/IP SAN/DAS applications while providing outstanding price-performance. Additional details about the EonStor DS 3024B are available at http://www.infotrend.com/global/products/models/ESDS_3024B.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Infortrend EonStor DS 3024B	
Metric	Reported Result
SPC-1 IOPS™	218,007.79
SPC-1 Price-Performance™	\$0.24/SPC-1 IOPS™
Total ASU Capacity	2,000.000 GB
Data Protection Level	Protected 2 (<i>mirroring</i>)
Total Price	\$52,185.00
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

A **Data Protection Level** of **Protected 2** using *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.*

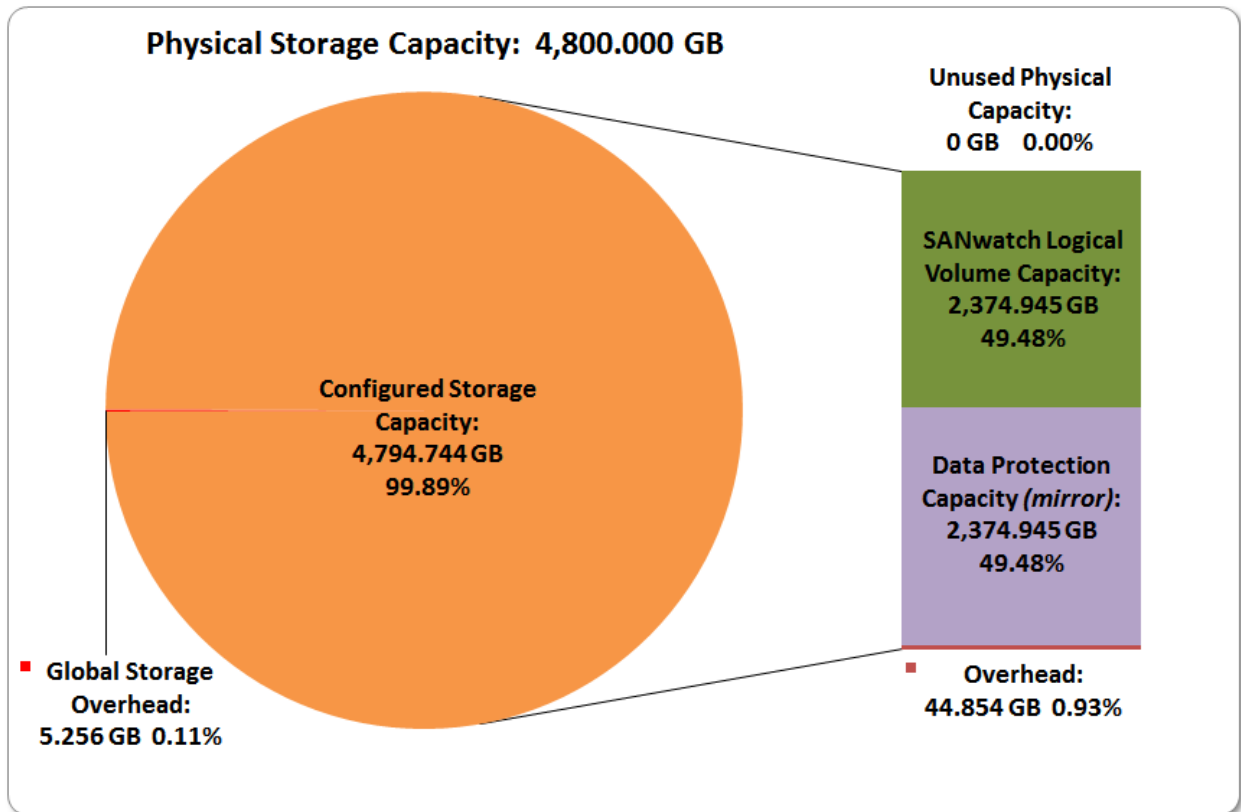
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 16.

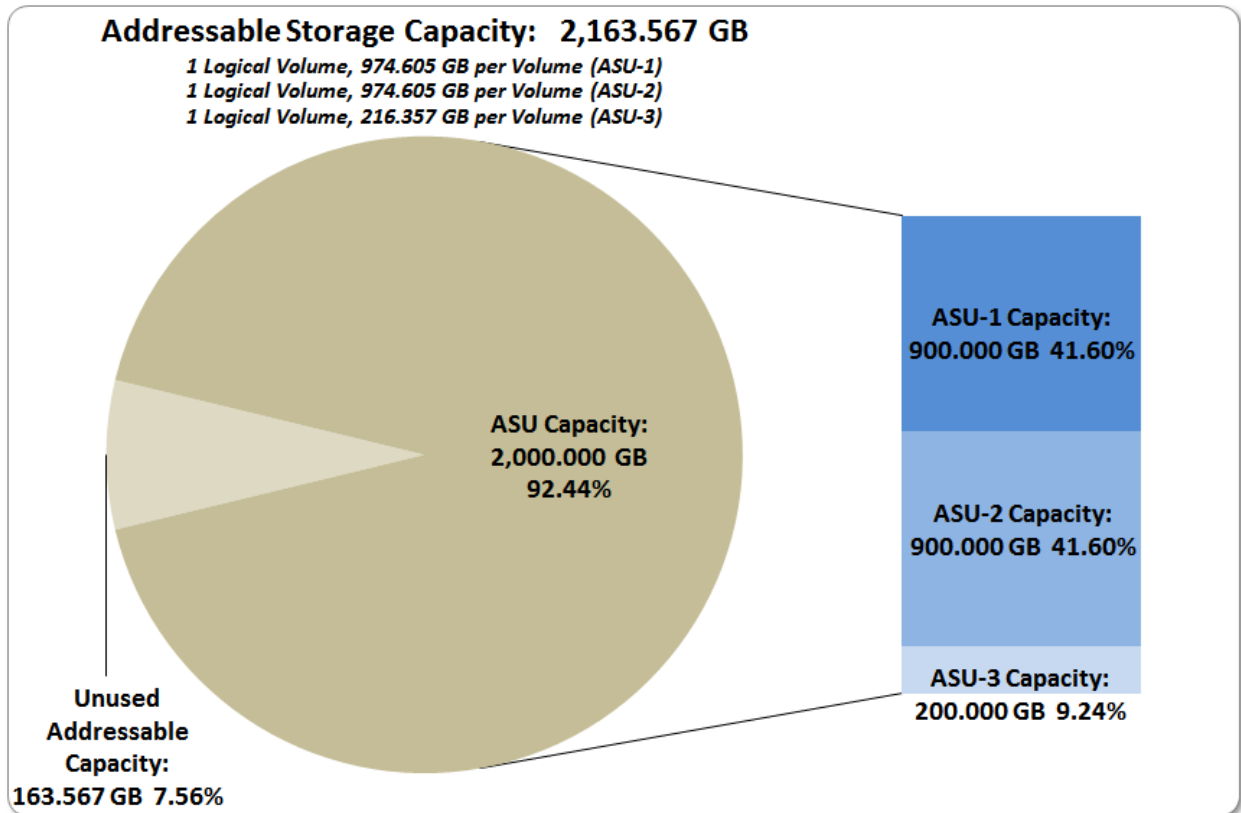
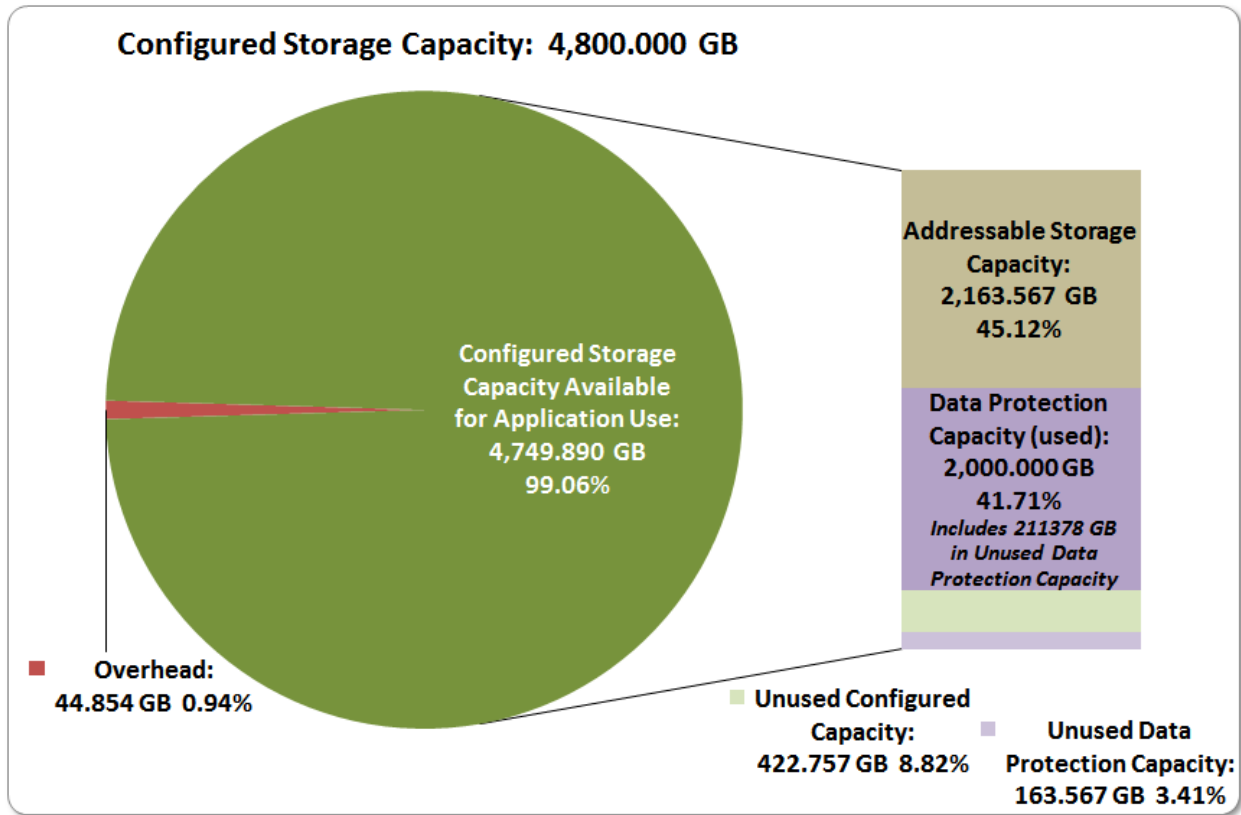
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

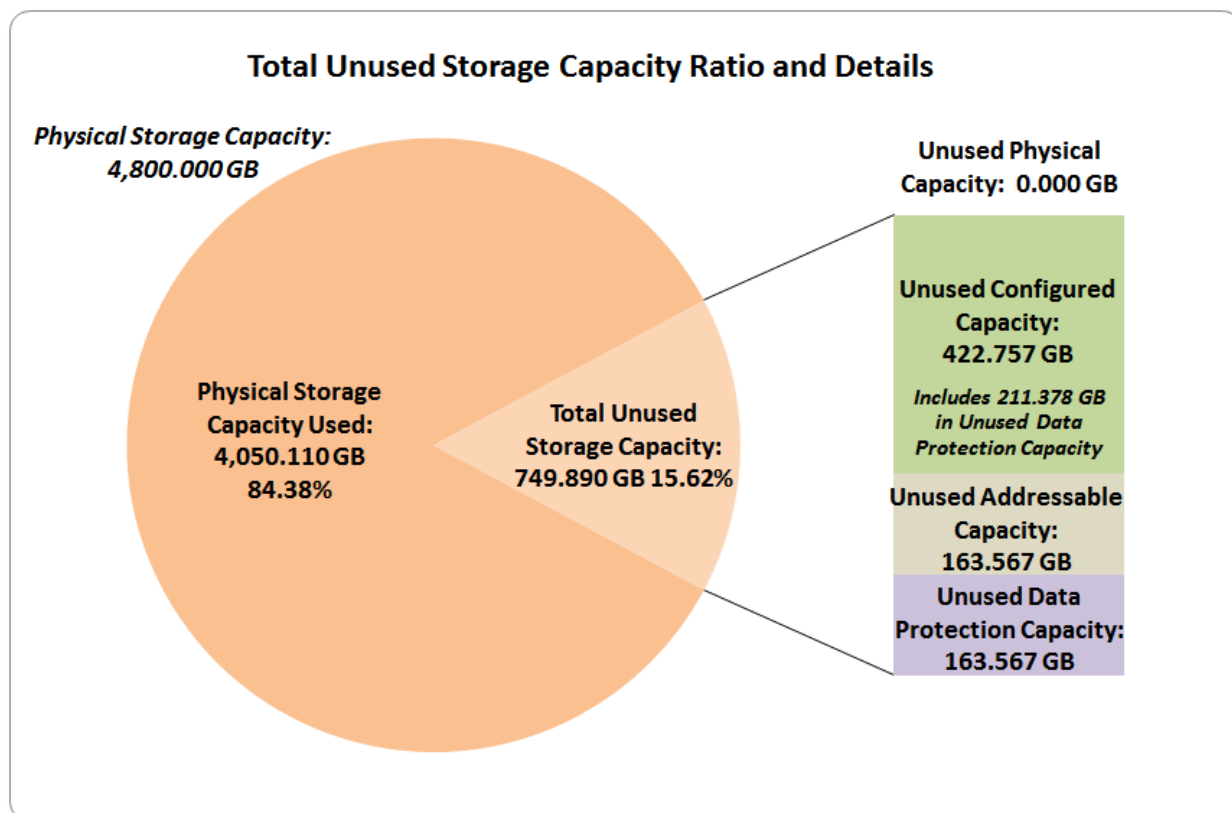
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

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.







SPC-1 Storage Capacity Utilization	
Application Utilization	41.67%
Protected Application Utilization	83.33%
Unused Storage Ratio	15.62%

Application Utilization: Total ASU Capacity (2,000.000 GB) divided by Physical Storage Capacity (4,800.000 GB).

Protected Application Utilization: (Total ASU Capacity (2,000.000 GB) plus total Data Protection Capacity (2,374.945 GB) minus unused Data Protection Capacity (374.945 GB)) divided by Physical Storage Capacity (4,800.000 GB).

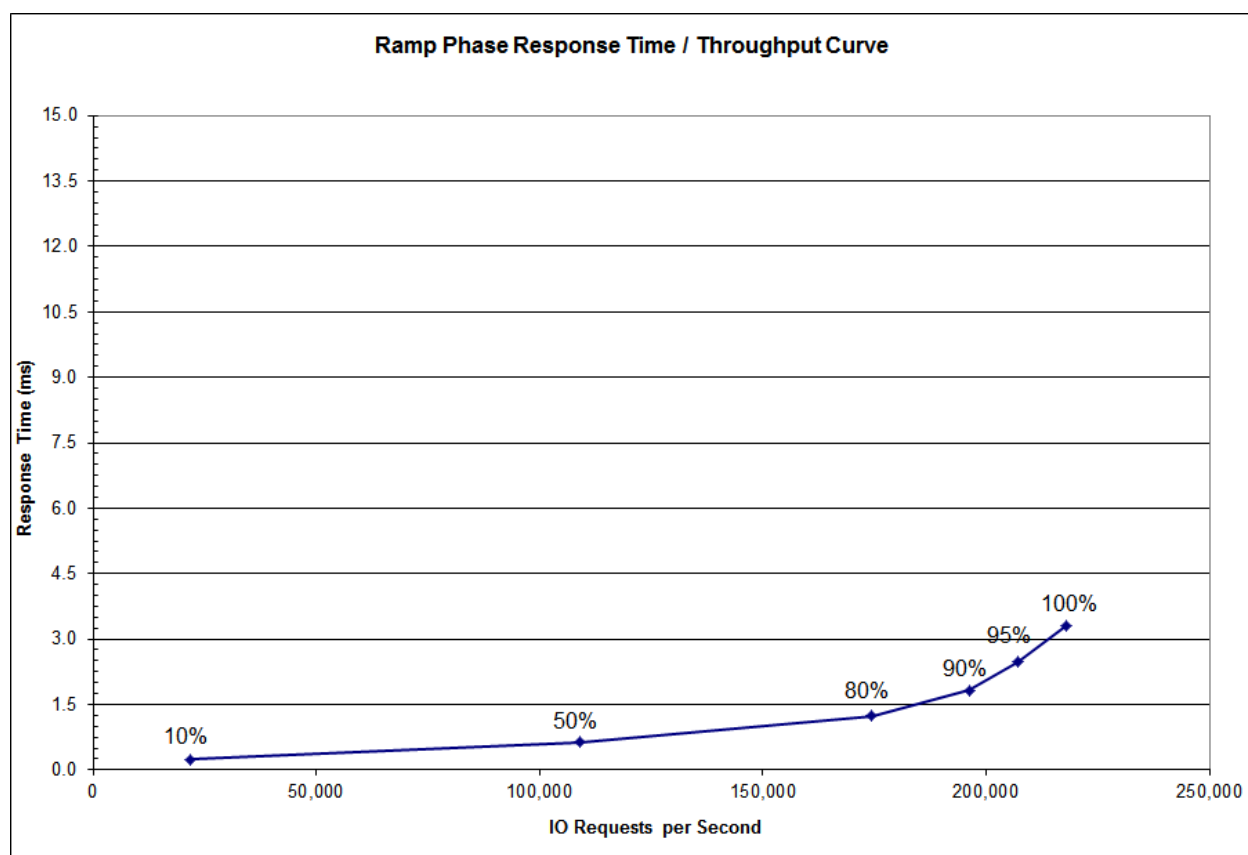
Unused Storage Ratio: Total Unused Capacity (749.890 GB) divided by Physical Storage Capacity (4,800.000 GB) and may not exceed 45%.

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	21,794.16	109,000.67	174,400.36	196,201.86	207,101.51	218,007.79
Average Response Time (ms):						
All ASUs	0.24	0.63	1.24	1.82	2.47	3.31
ASU-1	0.24	0.62	1.30	2.03	2.88	4.09
ASU-2	0.22	0.56	1.04	1.39	1.69	1.93
ASU-3	0.26	0.68	1.19	1.57	1.94	2.27
Reads	0.23	0.55	1.12	1.67	2.34	3.29
Writes	0.25	0.68	1.32	1.92	2.55	3.32

Priced Storage Configuration Pricing

P/N	Description	Q'ty	MSRP	Extended Price
DS3024RT2B00F	EonStor DS 3000 Gen2 2U/24bay, High IOPS solutions, Dual Redundant controller subsystem including 2x6Gb SAS EXP. Ports, 8x1G iSCSI ports +2x host board slot(s), 4x8GB, 2x(PSU+FAN Module), 2x(BBU+Flash module), 24xHDD trays and 1xRackmount kit	1	11,082.00	11,082.00
RFC16G0HIO2-0010	EonStor / EonStor DS host board with 2 x 16Gb/s FC ports	2	1,260.00	2,520.00
HESTSS3020-00301	Toshiba Enterprise 2.5" SAS 12Gb/s MLC SSD, 200GB, 1 in 1 Packing	24	895.00	21,480.00
US-PSPHD-3Y304	3 Years PSP 4 - 24/7 Help Desk & Engineer Onsite Services within 4 hours. Parts are prepared by customer (HDDs included)	1	4,472.00	4,472.00
DS3024BTSK-0010	EonStor DS 3024B spare kit including 1 x RAID Controller w/2x8GB DDR-III, 1 x Host Board w/ 2 x 16Gb FC ports, 1 x Toshiba 2.5" SAS 12Gb/s MLC 200GB SSD, 1 x PSU, 1 x FC SFPs and 1 x FC cables	1	7,429.00	7,429.00
9270CFCCAB06-0010	Optical FC cable, LC-LC, MM-50/125, Duplex, LSZH, O.D.=1.8mm*2, 10 Meters	4	54.00	216.00
9370CSFP16G-0010	16Gb/s Fibre Channel SFP optical transceiver, LC, wave-length 850nm, multi-mode	4	286.00	1,144.00
BH1EMF311-0010	HBA card, LPe16002B, FC-16G, Dual ports, 1 in 1 package	2	1,921.00	3,842.00
	Total			52,185.00

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

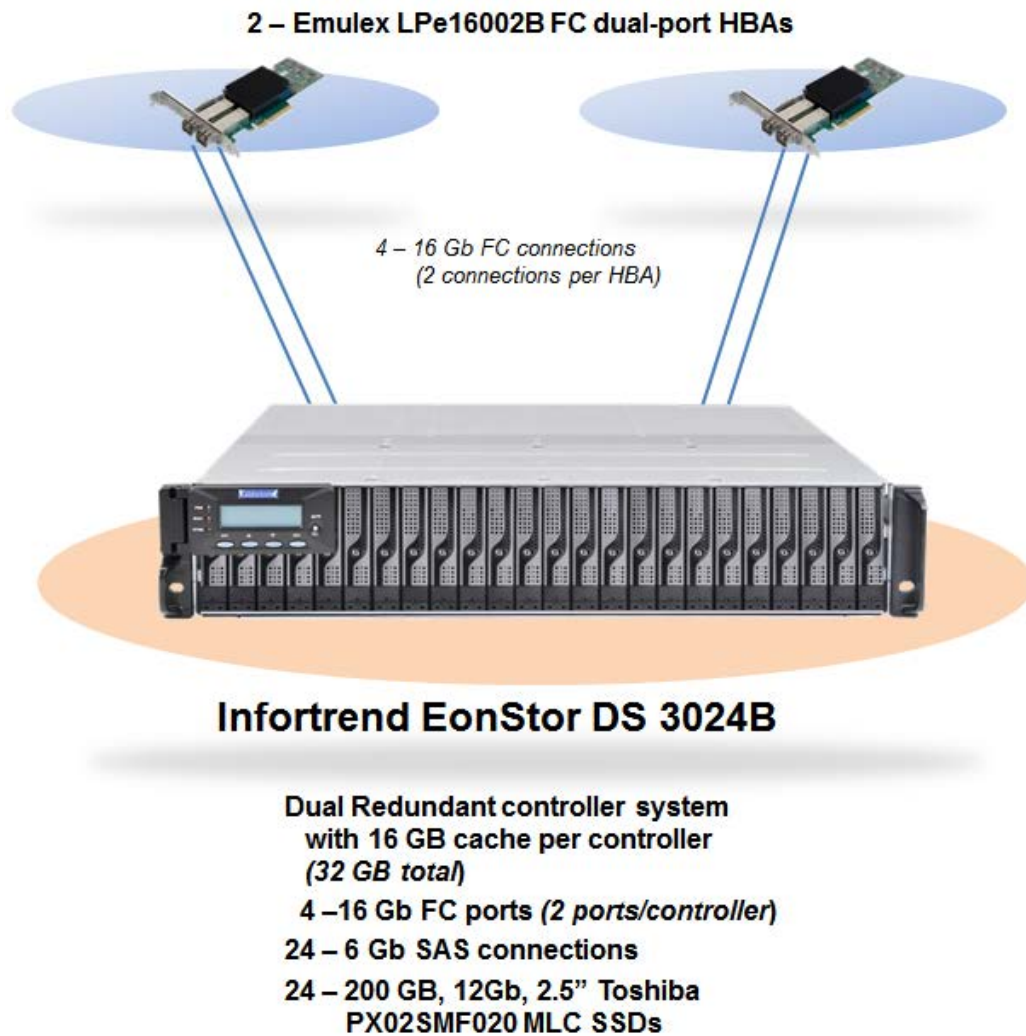
- Acknowledgement of new and existing problems within four (4) hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative Price Storage Configuration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

The above pricing also includes a spare kit with the components that the customer are required to have available in the case of any hardware failure (*"Parts are prepared by customer"*).

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
2 – Emulex LPe16002B-FC dual port 16Gb FC HBAs
Infortrend EonStor DS 3024B
Dual Redundant controller subsystem 16 GB cache per controller (32 GB total) 4 – 16Gb FC ports (2ports per controller, 4 ports used) 24 – backend 6Gb SAS connections (24 connections used) 24 – 200 GB 12Gb 2.5” Toshiba PX02SMF020 MLC SSDs

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

CONFIGURATION INFORMATION

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

Clause 9.4.3.4.1

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page [20](#) ([Benchmark Configuration/Tested Storage Configuration Diagram](#)).

Storage Network Configuration

Clause 9.4.3.4.1

...

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

Clause 9.4.3.4.2

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

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

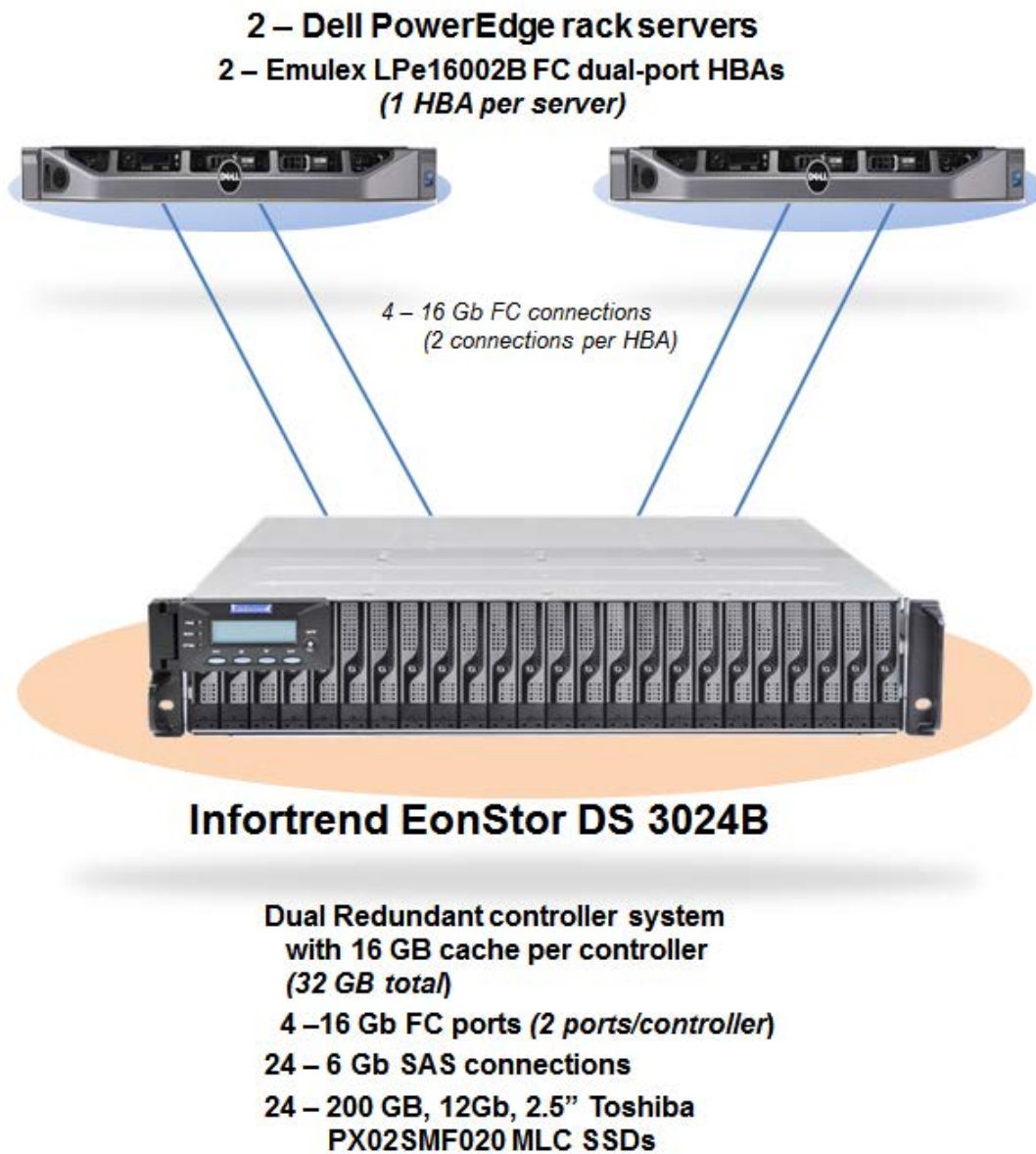
Host System(s) and Tested Storage Configuration (TSC) Table of Components

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 System
<p>2 – Dell PowerEdge R610 rack servers, each with:</p> <ul style="list-style-type: none"> 2 – Intel® Xeon® 2.00 GHz E5606 processors 4 cores per processor and 8 MB Intel® Smart Cache 32 GB main memory Windows Server 2008 R2 Enterprise PCIe
Tested Storage Configuration (TSC) Components
<p>2 – Emulex LPe16002B-FC dual port 16Gb FC HBAs</p>
<p>Infortrend EonStor DS 3024B</p> <ul style="list-style-type: none"> Dual Redundant controller subsystem 16 GB cache per controller (<i>32 GB total</i>) 4 – 16Gb FC ports (<i>2 ports per controller, 4 ports used</i>) 24 – backend 6Gb SAS connections (<i>24 connections used</i>) 24 – 200 GB 12Gb 2.5" Toshiba PX02SMF020 MLC SSDs

Customer Tunable Parameters and Options

Clause 9.4.3.5.1

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

[Appendix B: Customer Tunable Parameters and Options](#) on page [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 [82](#).

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 [82](#).

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 4,800.000 GB distributed over 24 solid state drives (SSDs) each with a formatted capacity of 200.000 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 5.256 GB (0.11%) of the Physical Storage Capacity. There was 422.757 GB (8.82%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 92.44% of the Addressable Storage Capacity resulting in 163.567 GB (7.56%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*Mirroring*) capacity was 2,374.9455 GB of which 2,000.000 GB was utilized. The total Unused Storage capacity was 749.890 GB.

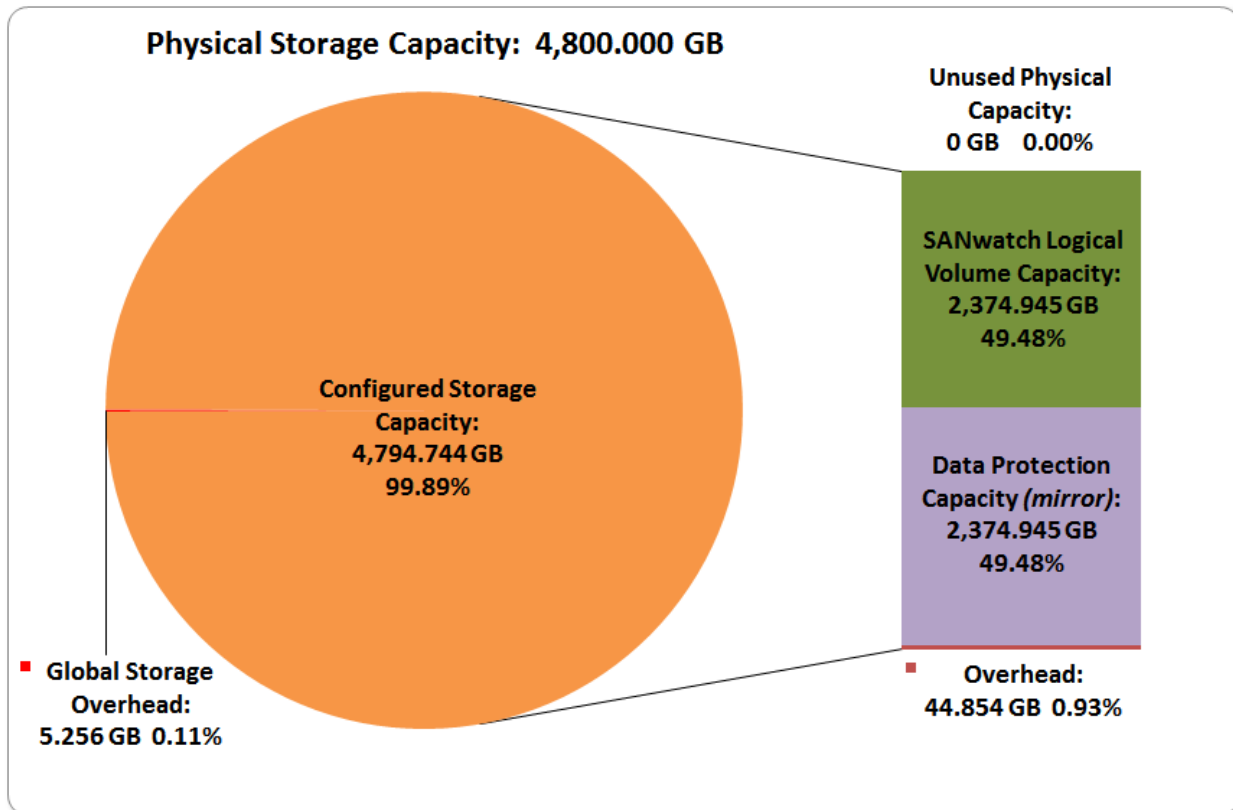
Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.

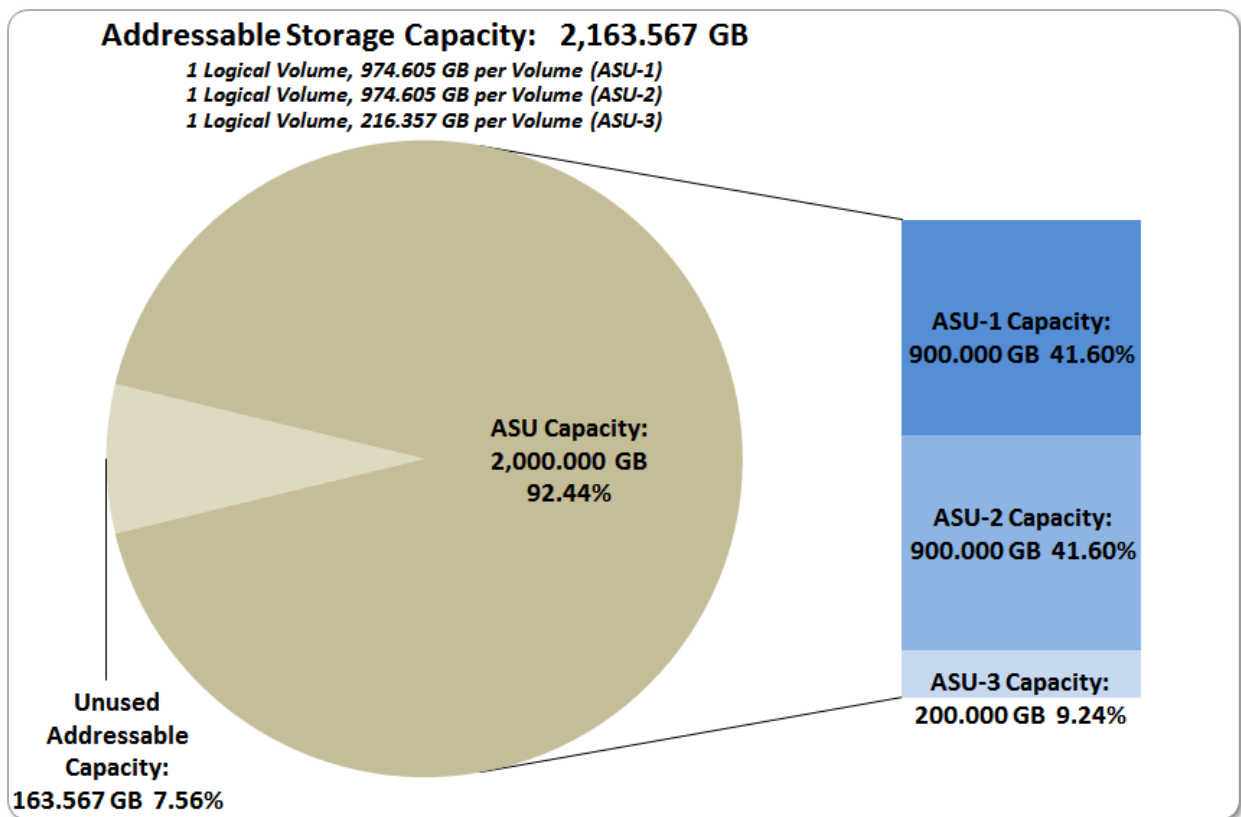
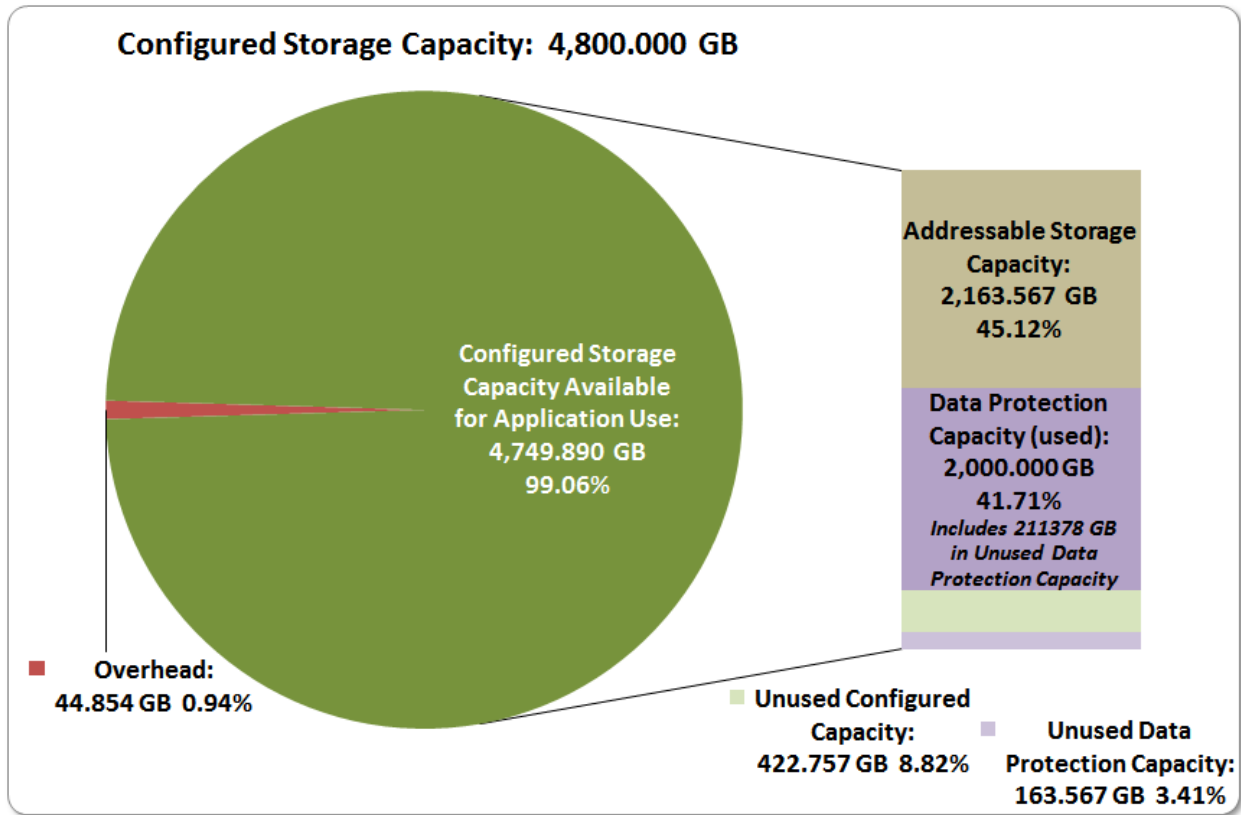
SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	2,000.000
Addressable Storage Capacity	Gigabytes (GB)	2,163.567
Configured Storage Capacity	Gigabytes (GB)	4,794.744
Physical Storage Capacity	Gigabytes (GB)	4,800.000
Data Protection (<i>Mirroring</i>)	Gigabytes (GB)	2,374.945
Required Storage (<i>system overhead</i>)	Gigabytes (GB)	44.854
Global Storage Overhead	Gigabytes (GB)	5.256
Total Unused Storage	Gigabytes (GB)	749.690

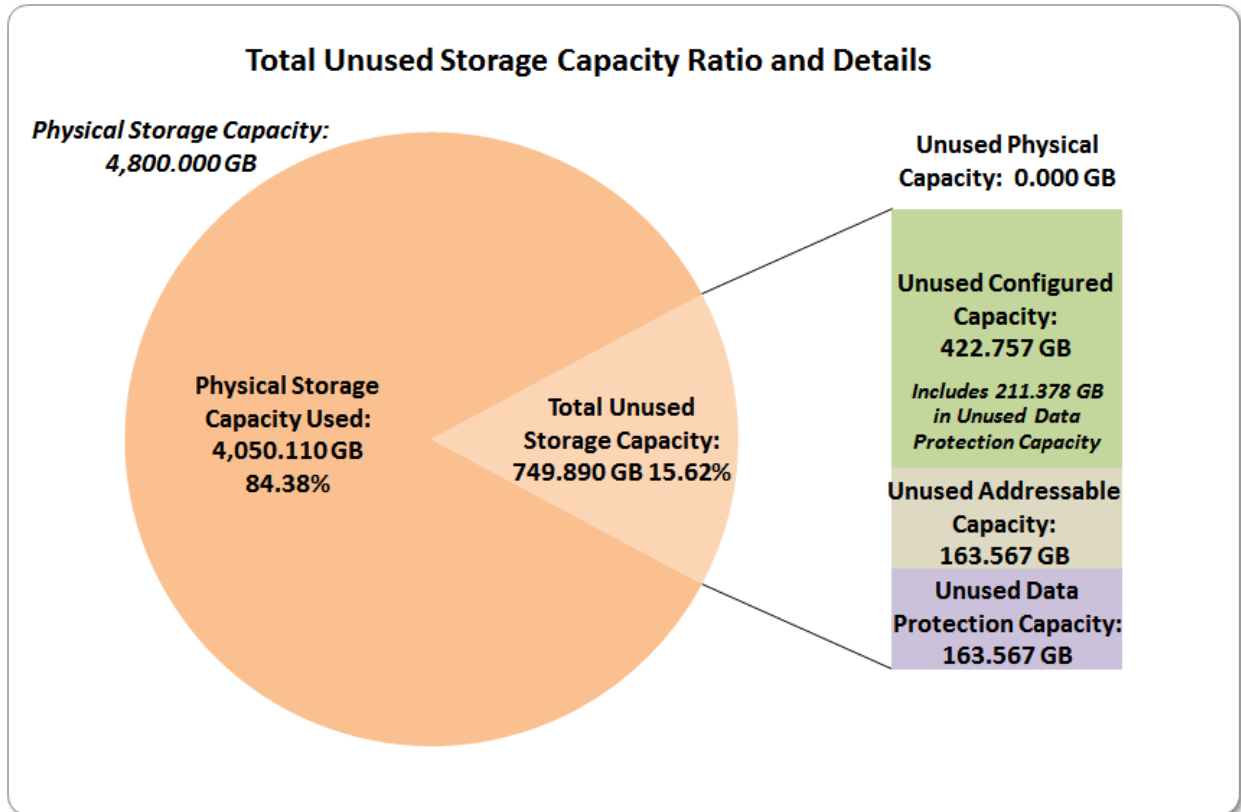
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	92.44%	41.75%	41.67%
Required for Data Protection (<i>Mirroring</i>)		49.53%	49.48%
Addressable Storage Capacity		45.12%	45.07%
Required Storage (<i>system overhead</i>)		0.94%	0.93%
Configured Storage Capacity			99.89%
Global Storage Overhead			0.11%
Unused Storage:			
Addressable	7.56%		
Configured		8.82%	
Physical			0.00%

SPC-1 Storage Capacity Charts







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	41.67%
Protected Application Utilization	83.33%
Unused Storage Ratio	15.62%

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 (900.000 GB)	ASU-2 (900.000 GB)	ASU-3 (200.000 GB)
1 Logical Volume 973.605 GB per Logical Volume (900.000 GB used per Logical Volume)	1 Logical Volume 973.605 GB per Logical Volume (900.000 GB used per Logical Volume)	1 Logical Volume 216.357 GB per Logical Volume (200.000 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 1](#) using **Mirroring** as described on page [11](#). 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 84.

Sustainability Test Results File

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

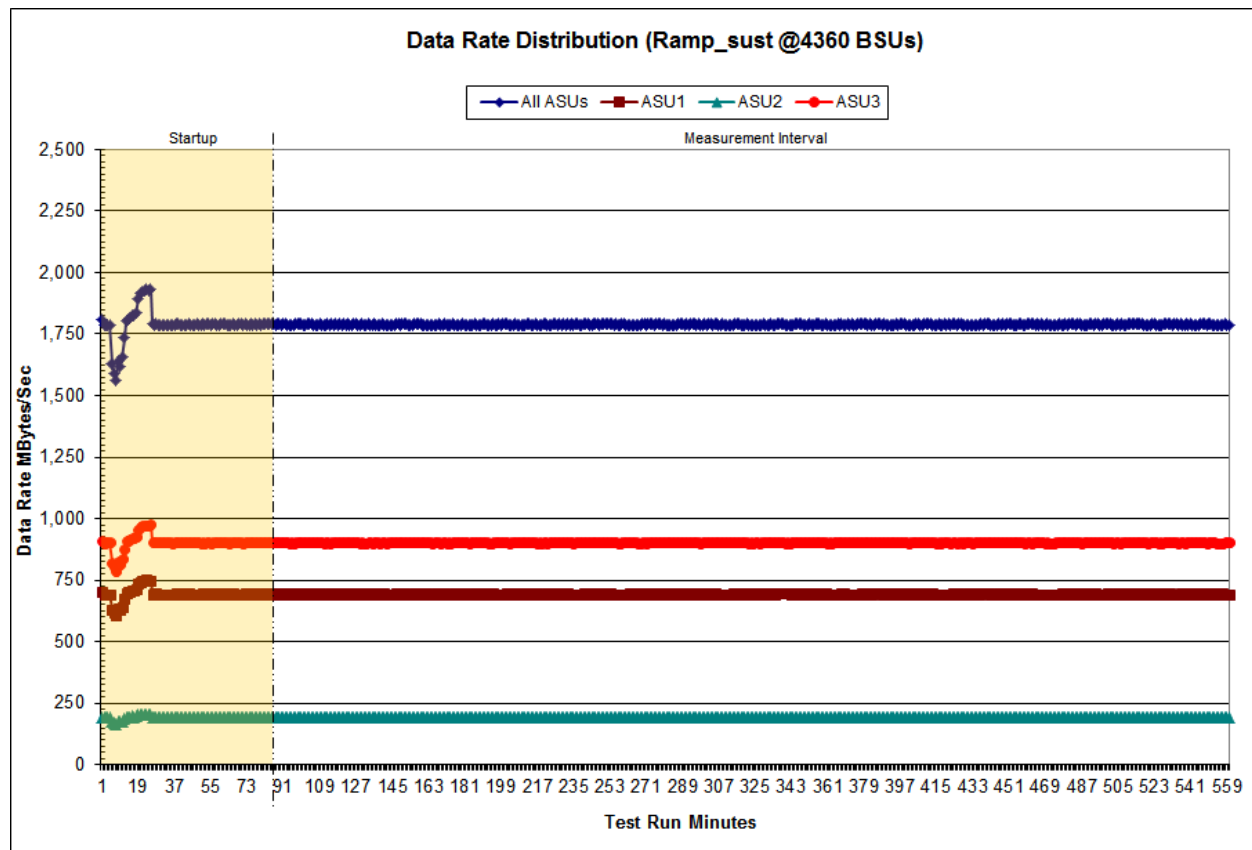
[Sustainability Test Results File](#)

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

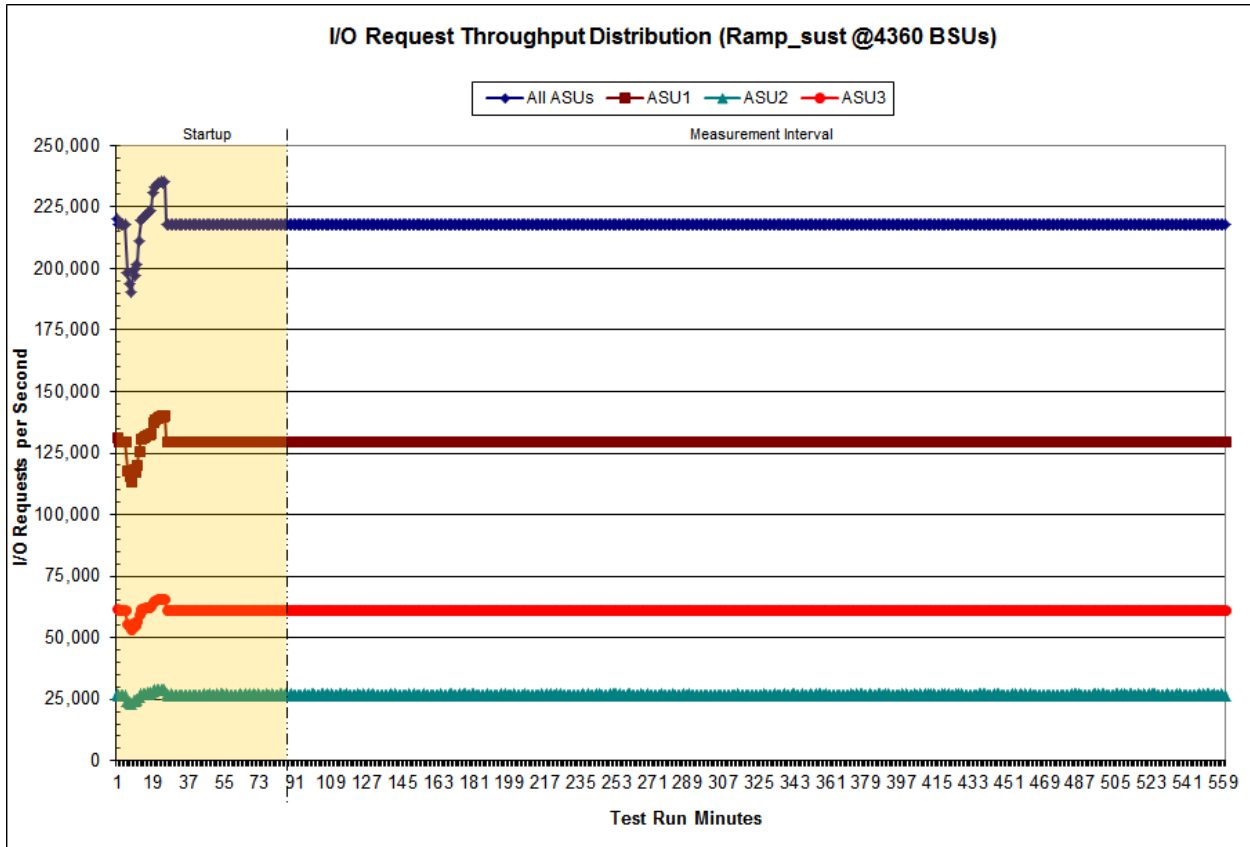


Sustainability – I/O Request Throughput Distribution Data

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

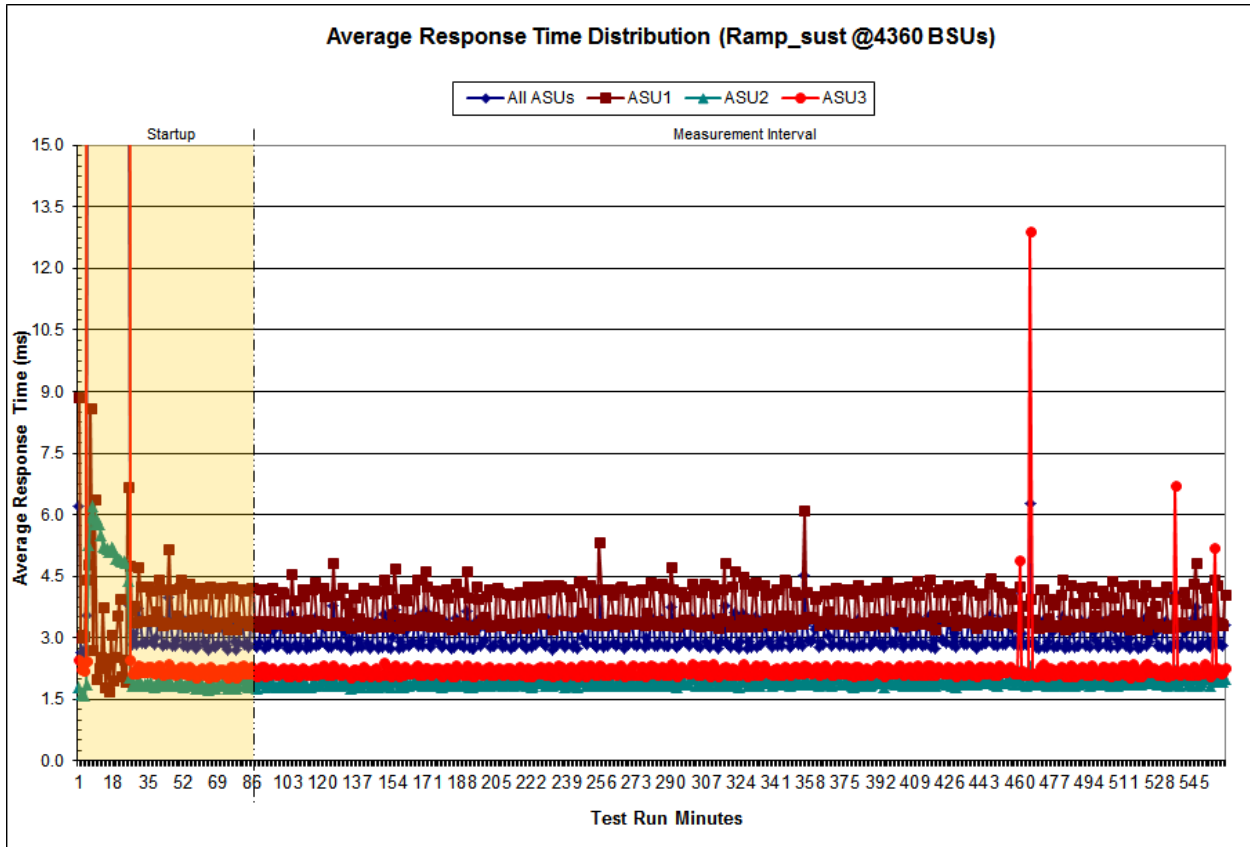


Sustainability – Average Response Time (ms) Distribution Data

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](#)

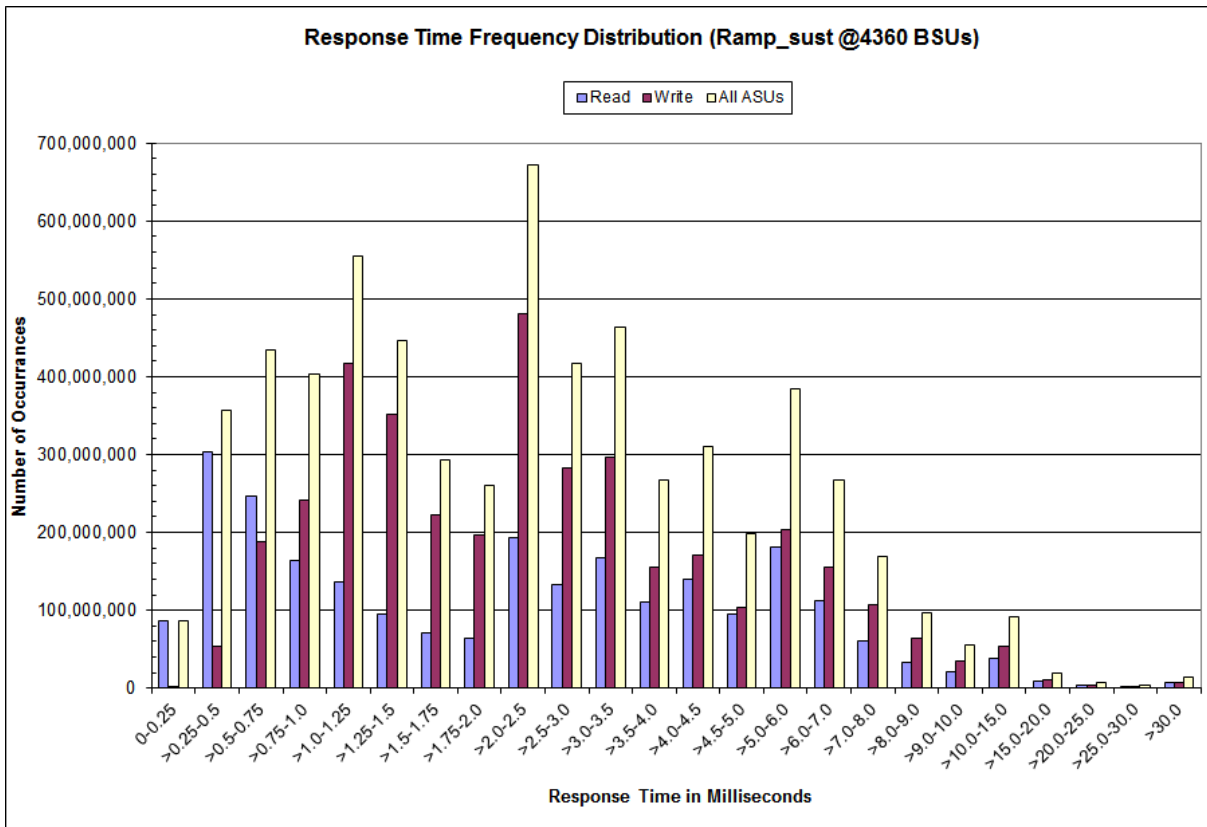
Sustainability – Average Response Time (ms) Distribution Graph



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	86,960,917	302,798,234	246,860,335	163,377,047	136,745,974	94,918,531	70,932,190	64,129,584
Write	59,826	53,869,708	187,945,460	240,711,380	417,724,066	351,683,830	222,040,083	196,672,649
All ASUs	87,020,743	356,667,942	434,805,795	404,088,427	554,470,040	446,602,361	292,972,273	260,802,233
ASU1	27,778,986	234,555,978	317,650,884	249,783,850	226,851,878	123,980,414	86,930,735	82,242,546
ASU2	59,223,635	111,875,598	67,196,956	58,276,176	87,346,946	73,650,410	44,655,858	37,622,103
ASU3	18,122	10,236,366	49,957,955	96,028,401	240,271,216	248,971,537	161,385,680	140,937,584
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	192,408,451	133,316,312	167,303,359	111,085,068	140,395,579	95,780,671	181,462,591	112,059,649
Write	480,281,558	283,529,787	296,574,386	156,120,529	170,355,937	103,415,024	203,192,745	156,049,746
All ASUs	672,690,009	416,846,099	463,877,745	267,205,597	310,751,516	199,195,695	384,655,336	268,109,395
ASU1	267,627,481	196,640,980	267,191,113	184,919,430	252,876,668	177,143,547	362,980,422	259,109,231
ASU2	84,602,460	47,227,541	40,526,664	16,668,219	12,050,789	5,086,481	5,969,117	3,121,328
ASU3	320,460,068	172,977,578	156,159,968	65,617,948	45,824,059	16,965,667	15,705,797	5,878,836
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	60,800,776	33,539,207	20,453,276	37,959,275	9,500,505	4,098,671	2,500,102	6,745,728
Write	107,798,751	63,600,426	35,118,946	53,514,913	10,001,677	3,584,589	1,951,714	6,475,491
All ASUs	168,599,527	97,139,633	55,572,222	91,474,188	19,502,182	7,683,260	4,451,816	13,221,219
ASU1	162,807,468	92,814,547	52,301,090	83,859,607	16,165,555	5,304,854	2,717,461	7,697,120
ASU2	2,180,157	1,671,035	1,323,328	3,825,717	2,264,581	1,662,578	1,196,802	3,022,851
ASU3	3,611,902	2,654,051	1,947,804	3,788,864	1,072,046	715,828	537,553	2,501,248

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0/0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.002	0.001	0.002	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 [84](#).

IOPS Test Results File

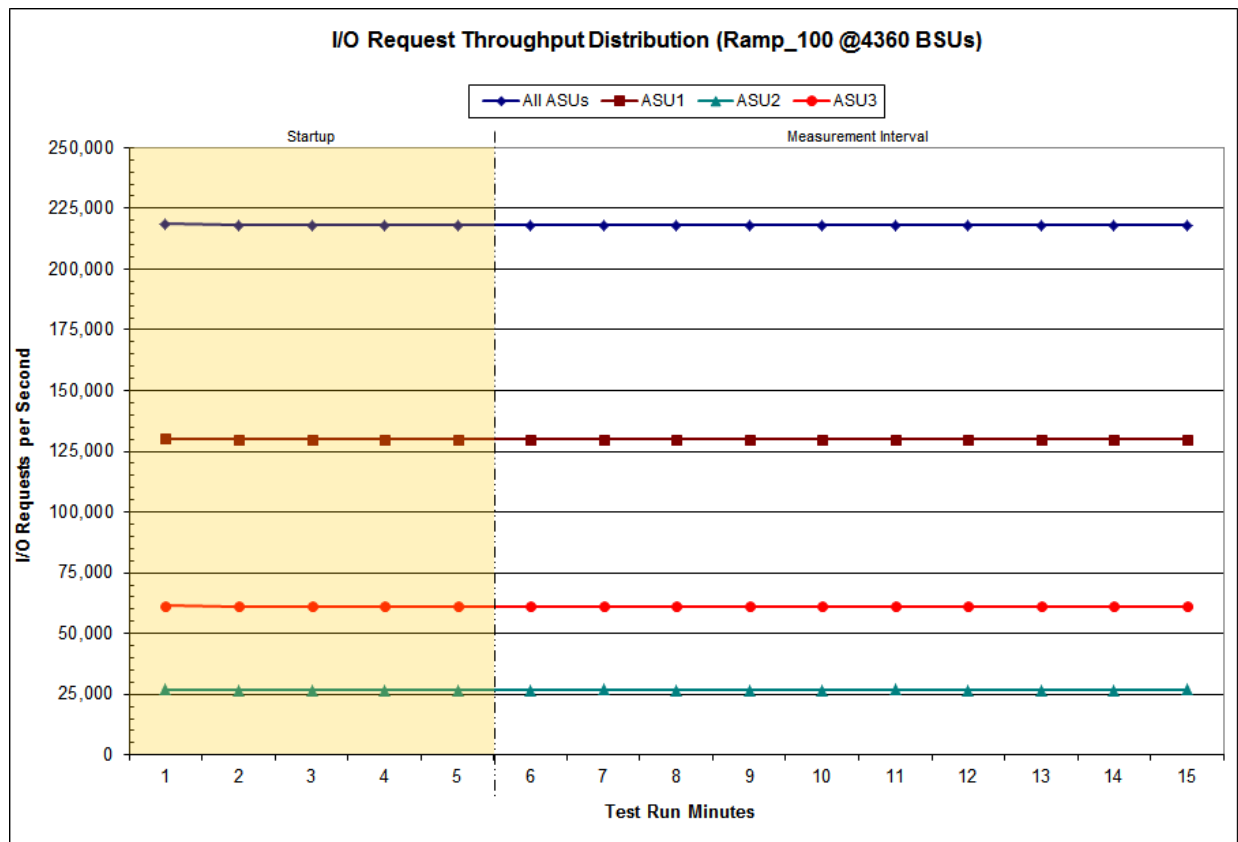
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

4,360 BSUs				
	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:02:13	12:07:14	0-4	0:05:01
Measurement Interval	12:07:14	12:17:14	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	218,504.78	130,209.43	26,881.32	61,414.03
1	217,976.80	129,963.07	26,794.85	61,218.88
2	218,033.52	130,004.63	26,790.50	61,238.38
3	218,120.55	130,003.23	26,821.13	61,296.18
4	217,924.32	129,913.72	26,755.42	61,255.18
5	218,012.73	129,919.10	26,801.97	61,291.67
6	218,068.07	129,990.08	26,845.03	61,232.95
7	218,011.15	129,931.98	26,815.45	61,263.72
8	217,976.27	129,890.63	26,825.15	61,260.48
9	217,978.10	129,901.45	26,804.53	61,272.12
10	218,024.67	129,968.32	26,828.32	61,228.03
11	218,016.28	129,970.47	26,791.52	61,254.30
12	218,018.88	129,897.40	26,827.28	61,294.20
13	217,983.65	129,901.67	26,826.38	61,255.60
14	217,988.08	129,942.97	26,844.20	61,200.92
Average	218,007.79	129,931.41	26,820.98	61,255.40

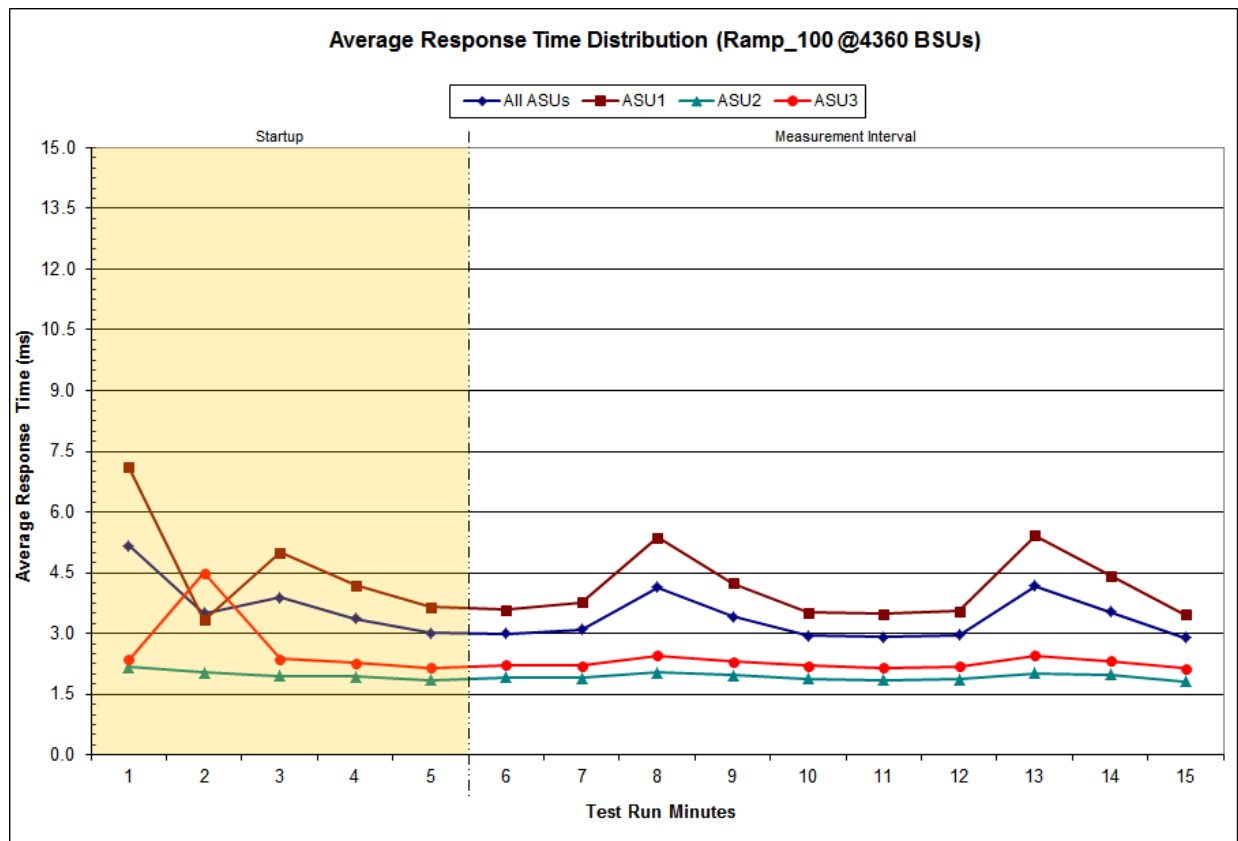
IOPS Test Run – I/O Request Throughput Distribution Graph



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

4,360 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:02:13	12:07:14	0-4	0:05:01
<i>Measurement Interval</i>	12:07:14	12:17:14	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5.16	7.11	2.17	2.35
1	3.51	3.34	2.05	4.50
2	3.89	5.00	1.95	2.37
3	3.38	4.20	1.93	2.27
4	3.01	3.65	1.85	2.16
5	3.00	3.59	1.92	2.22
6	3.11	3.78	1.91	2.22
7	4.14	5.37	2.04	2.46
8	3.42	4.25	1.98	2.31
9	2.94	3.51	1.89	2.20
10	2.92	3.49	1.86	2.16
11	2.97	3.56	1.87	2.19
12	4.17	5.43	2.03	2.46
13	3.54	4.44	1.99	2.32
14	2.90	3.48	1.82	2.14
Average	3.31	4.09	1.93	2.27

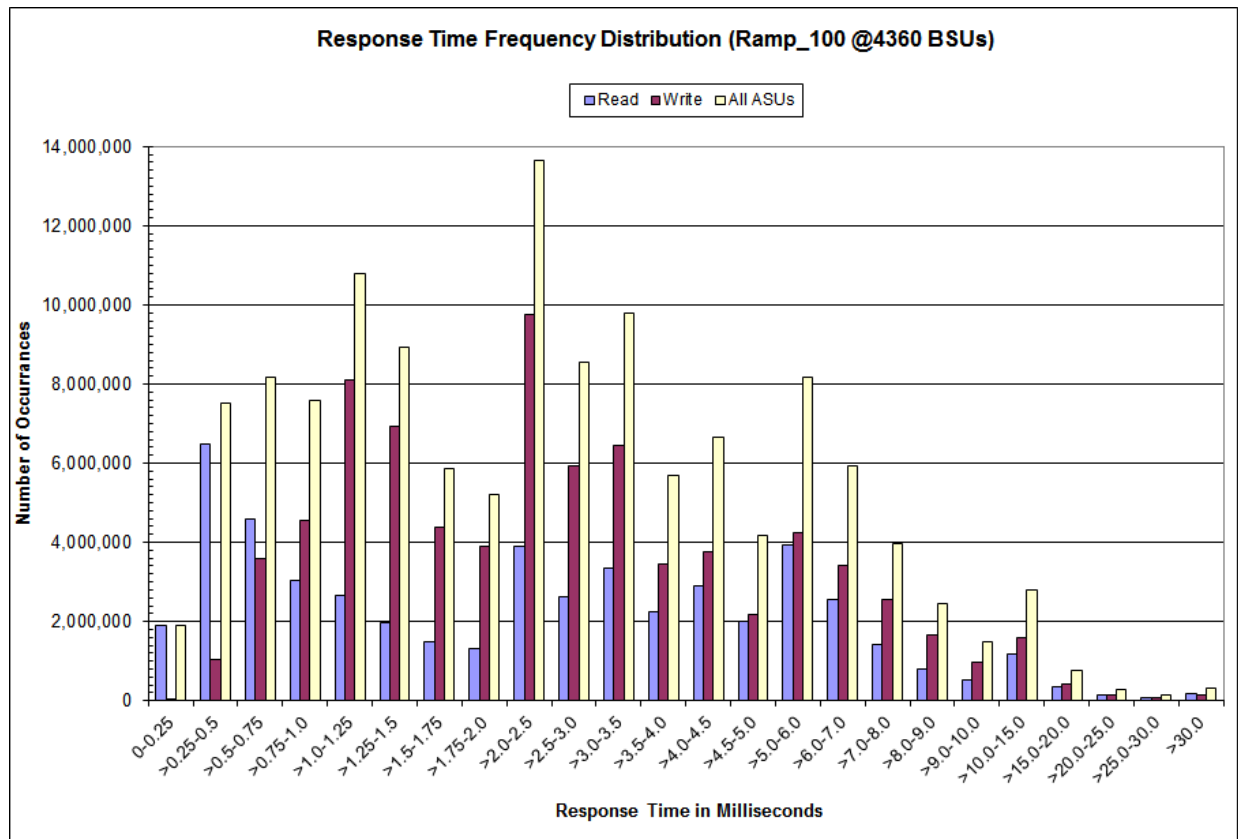
IOPS Test Run – Average Response Time (ms) Distribution Graph



IOPS Test Run –Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	1,904,923	6,492,243	4,590,842	3,022,506	2,660,534	1,971,881	1,475,471	1,304,348
Write	888	1,029,517	3,580,649	4,547,743	8,119,186	6,942,871	4,397,573	3,903,963
All ASUs	1,905,811	7,521,760	8,171,491	7,570,249	10,779,720	8,914,752	5,873,044	5,208,311
ASU1	688,630	4,995,456	5,854,222	4,590,827	4,339,127	2,497,178	1,766,331	1,645,926
ASU2	1,216,941	2,335,981	1,372,103	1,170,065	1,756,093	1,486,649	899,119	756,994
ASU3	240	190,323	945,166	1,809,357	4,684,500	4,930,925	3,207,594	2,805,391
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	3,893,309	2,613,971	3,343,336	2,242,314	2,902,792	1,995,360	3,920,203	2,541,581
Write	9,770,240	5,921,990	6,453,524	3,441,061	3,762,349	2,184,085	4,253,736	3,401,754
All ASUs	13,663,549	8,535,961	9,796,860	5,683,375	6,665,141	4,179,445	8,173,939	5,943,335
ASU1	5,354,621	3,824,821	5,247,432	3,635,443	5,086,695	3,570,915	7,583,153	5,733,515
ASU2	1,745,646	1,008,826	929,293	407,392	316,826	131,416	147,553	67,917
ASU3	6,563,282	3,702,314	3,620,135	1,640,540	1,261,620	477,114	443,233	141,903
Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	1,433,471	809,870	524,342	1,184,833	352,463	143,213	78,938	176,134
Write	2,549,705	1,654,886	957,235	1,594,954	402,856	139,365	68,592	146,273
All ASUs	3,983,176	2,464,756	1,481,577	2,779,787	755,319	282,578	147,530	322,407
ASU1	3,857,942	2,374,101	1,414,522	2,624,588	687,297	236,330	114,510	234,701
ASU2	45,218	33,414	26,437	76,781	45,763	33,273	23,791	59,041
ASU3	80,016	57,241	40,618	78,418	22,259	12,975	9,229	28,665

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
130,803.873	130.481.466	322,407

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	0.2811	0.0699	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 15.

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 [84](#).

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

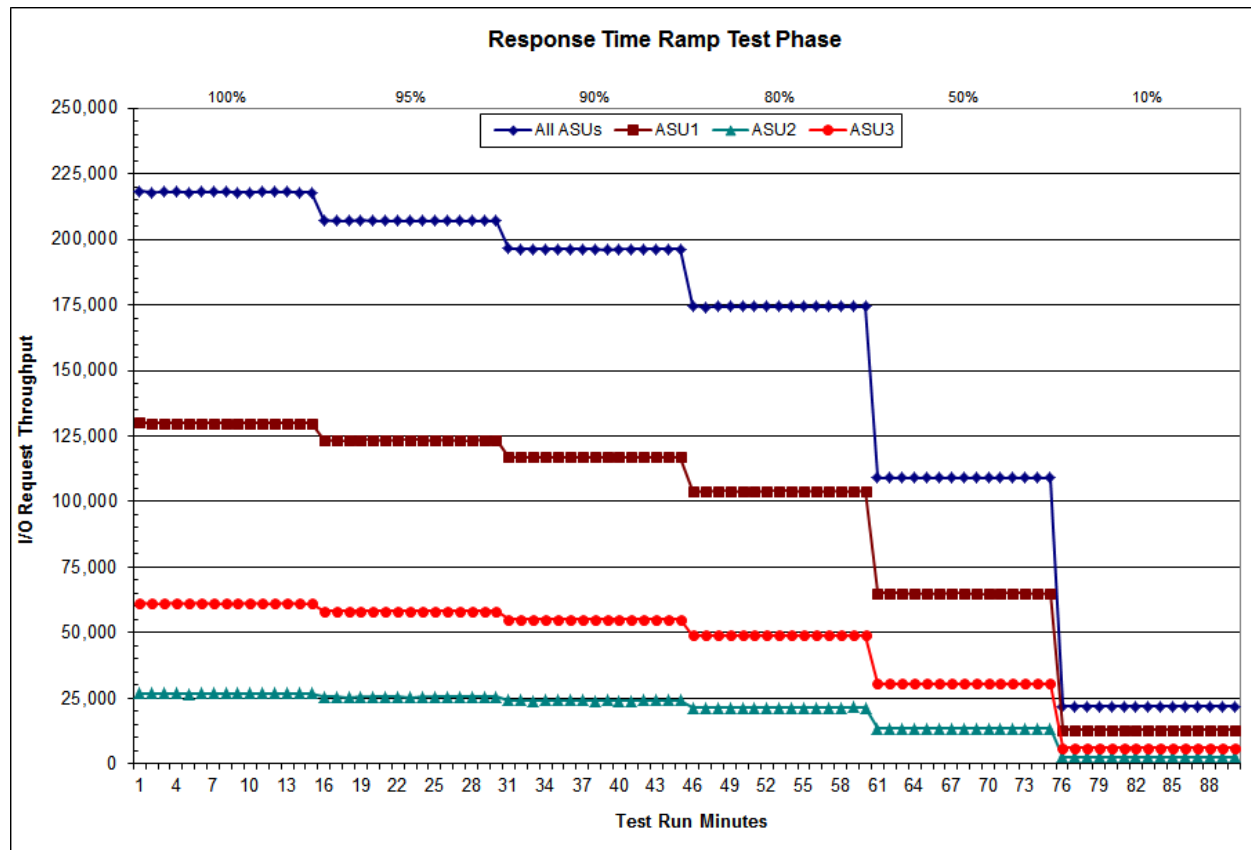
The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data table and graph for completeness.

Response Time Ramp Distribution (IOPS)									
100% Load Level: 4,360 BSUs					95% Load Level: 4,142 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:02:13	12:07:14	0-4	0:05:01	Start-Up/Ramp-Up	12:18:27	12:23:28	0-4	0:05:01
Measurement Interval	12:07:14	12:17:14	5-14	0:10:00	Measurement Interval	12:23:28	12:33:28	5-14	0:10:00
<i>(60 second intervals)</i>	All ASUs	ASU-1	ASU-2	ASU-3	<i>(60 second intervals)</i>	All ASUs	ASU-1	ASU-2	ASU-3
0	218,504.78	130,209.43	26,881.32	61,414.03	0	207,399.80	123,624.53	25,503.18	58,272.08
1	217,976.80	129,963.07	26,794.85	61,218.88	1	207,117.30	123,418.13	25,482.72	58,216.45
2	218,033.52	130,004.63	26,790.50	61,238.38	2	206,992.22	123,402.10	25,425.88	58,164.23
3	218,120.55	130,003.23	26,821.13	61,296.18	3	207,194.43	123,505.13	25,482.22	58,207.08
4	217,924.32	129,913.72	26,755.42	61,255.18	4	207,139.20	123,477.95	25,475.43	58,185.82
5	218,012.73	129,919.10	26,801.97	61,291.67	5	207,113.47	123,408.23	25,478.40	58,226.83
6	218,068.07	129,990.08	26,845.03	61,232.95	6	207,130.70	123,471.03	25,453.23	58,206.43
7	218,011.15	129,931.98	26,815.45	61,263.72	7	207,119.72	123,522.93	25,421.75	58,175.03
8	217,976.27	129,890.63	26,825.15	61,260.48	8	207,104.00	123,479.35	25,467.77	58,156.88
9	217,978.10	129,901.45	26,804.53	61,272.12	9	206,960.43	123,342.15	25,478.65	58,139.63
10	218,024.67	129,968.32	26,828.32	61,228.03	10	207,189.20	123,499.62	25,466.07	58,223.52
11	218,016.28	129,970.47	26,791.52	61,254.30	11	207,005.50	123,388.47	25,449.92	58,167.12
12	218,018.88	129,897.40	26,827.28	61,294.20	12	207,096.53	123,392.08	25,470.87	58,233.58
13	217,983.65	129,901.67	26,826.38	61,255.60	13	207,153.48	123,441.97	25,457.97	58,253.55
14	217,988.08	129,942.97	26,844.20	61,200.92	14	207,142.03	123,518.92	25,473.40	58,149.72
Average	218,007.79	129,931.41	26,820.98	61,255.40	Average	207,101.51	123,446.48	25,461.80	58,193.23
90% Load Level: 3,924 BSUs					80% Load Level: 3,488 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:34:30	12:39:31	0-4	0:05:01	Start-Up/Ramp-Up	12:50:34	12:55:35	0-4	0:05:01
Measurement Interval	12:39:31	12:49:31	5-14	0:10:00	Measurement Interval	12:55:35	13:05:35	5-14	0:10:00
<i>(60 second intervals)</i>	All ASUs	ASU-1	ASU-2	ASU-3	<i>(60 second intervals)</i>	All ASUs	ASU-1	ASU-2	ASU-3
0	196,508.43	117,108.68	24,189.52	55,210.23	0	174,581.98	104,071.87	21,444.98	49,065.13
1	196,229.30	116,934.60	24,133.03	55,161.67	1	174,254.92	103,828.82	21,420.67	49,005.43
2	196,201.77	116,939.42	24,099.73	55,162.62	2	174,461.90	103,951.50	21,485.60	49,024.80
3	196,182.28	116,912.17	24,165.80	55,104.32	3	174,403.08	103,956.90	21,446.02	49,000.17
4	196,164.83	116,873.50	24,152.67	55,138.67	4	174,382.72	103,929.47	21,427.62	49,025.63
5	196,170.40	116,894.93	24,136.22	55,139.25	5	174,311.52	103,859.73	21,456.33	48,995.45
6	196,246.35	116,985.70	24,138.28	55,122.37	6	174,387.02	103,994.62	21,434.93	48,957.47
7	196,180.88	116,934.22	24,093.92	55,152.75	7	174,431.68	103,979.75	21,466.70	48,985.23
8	196,077.23	116,873.23	24,138.10	55,065.90	8	174,367.78	103,953.02	21,411.90	49,002.87
9	196,195.85	116,930.50	24,112.82	55,152.53	9	174,413.47	103,918.02	21,465.57	49,029.88
10	196,224.70	116,984.82	24,108.80	55,131.08	10	174,419.50	103,988.32	21,446.03	48,985.15
11	196,229.50	116,950.57	24,142.15	55,136.78	11	174,349.93	103,905.95	21,446.37	48,997.62
12	196,255.62	116,928.10	24,142.48	55,185.03	12	174,385.22	103,949.80	21,472.62	48,962.80
13	196,222.93	116,892.30	24,154.10	55,176.53	13	174,458.00	103,921.28	21,505.07	49,031.65
14	196,215.08	116,933.25	24,171.02	55,110.82	14	174,479.50	104,004.82	21,461.47	49,013.22
Average	196,201.86	116,930.76	24,133.79	55,137.31	Average	174,400.36	103,947.53	21,456.70	48,996.13

Response Time Ramp Distribution (IOPS) Data (continued)

50% Load Level: 2,180 BSUs					10% Load Level: 436 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:06:19	13:11:20	0-4	0:05:01	Start-Up/Ramp-Up	13:21:47	13:26:48	0-4	0:05:01
Measurement Interval	13:11:20	13:21:20	5-14	0:10:00	Measurement Interval	13:26:48	13:36:48	5-14	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	109,113.78	65,055.10	13,425.22	30,633.47	0	21,819.97	13,006.65	2,674.72	6,138.60
1	109,015.55	65,013.45	13,398.15	30,603.95	1	21,806.93	12,986.72	2,685.05	6,135.17
2	109,024.52	65,006.58	13,368.68	30,649.25	2	21,796.85	12,980.02	2,692.90	6,123.93
3	108,984.53	64,942.13	13,423.15	30,619.25	3	21,802.22	12,993.67	2,684.35	6,124.20
4	108,990.98	64,981.57	13,402.47	30,606.95	4	21,802.42	13,003.75	2,683.60	6,115.07
5	108,951.75	64,932.48	13,433.67	30,585.60	5	21,793.18	12,990.98	2,682.03	6,120.17
6	108,970.40	64,968.60	13,390.08	30,611.72	6	21,810.33	13,003.87	2,672.35	6,134.12
7	109,056.78	64,998.05	13,390.38	30,668.35	7	21,802.00	12,997.08	2,679.53	6,125.38
8	108,969.05	64,946.17	13,398.22	30,624.67	8	21,767.62	12,973.03	2,685.20	6,109.38
9	108,977.53	64,948.25	13,414.13	30,615.15	9	21,806.57	13,000.50	2,680.82	6,125.25
10	108,965.87	64,963.70	13,392.87	30,609.30	10	21,804.98	13,000.40	2,677.90	6,126.68
11	109,055.92	64,996.43	13,444.98	30,614.50	11	21,788.78	12,988.18	2,680.28	6,120.32
12	109,020.10	64,982.40	13,413.88	30,623.82	12	21,801.62	12,999.67	2,677.58	6,124.37
13	109,014.35	64,942.70	13,430.35	30,641.30	13	21,791.98	12,985.05	2,693.13	6,113.80
14	109,024.98	64,979.22	13,408.97	30,636.80	14	21,774.48	12,983.43	2,671.13	6,119.92
Average	109,000.67	64,965.80	13,411.75	30,623.12	Average	21,794.16	12,992.22	2,680.00	6,121.94

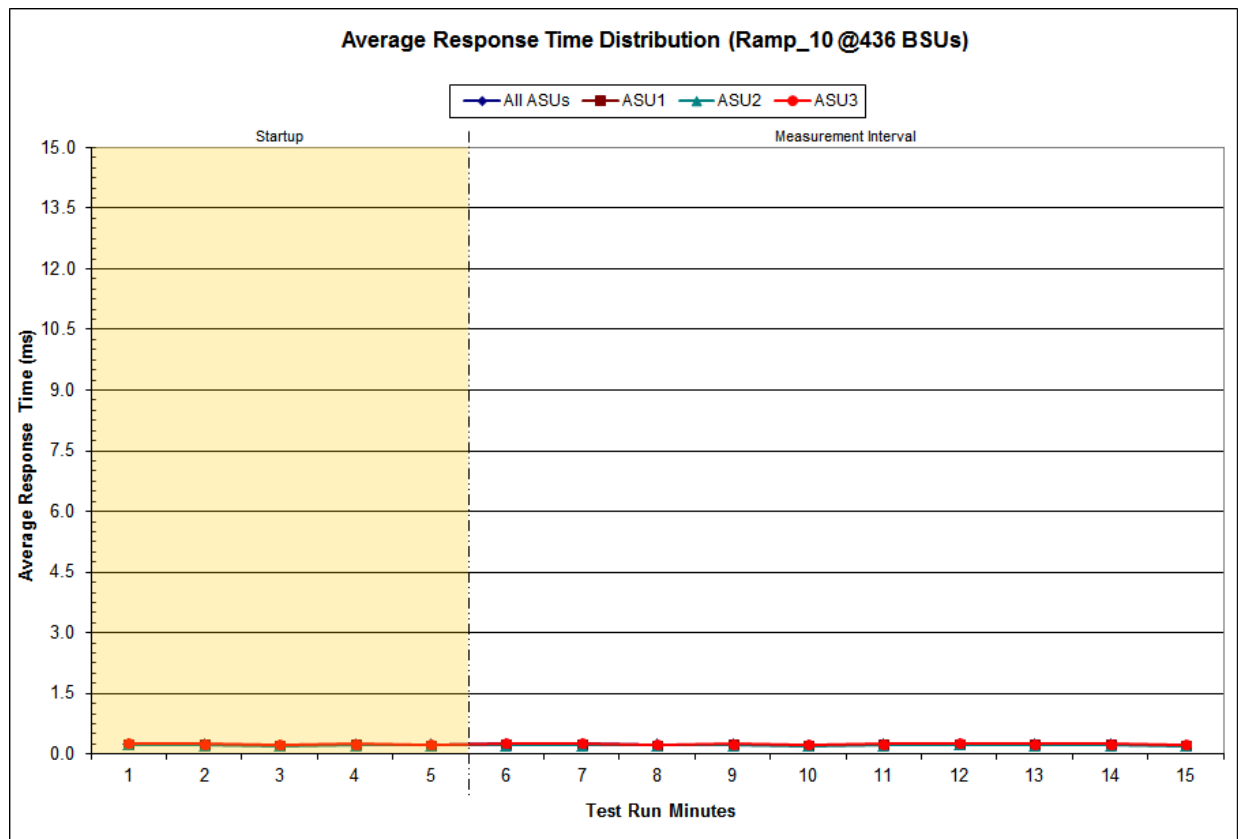
Response Time Ramp Distribution (IOPS) Graph



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

436 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:21:47	13:26:48	0-4	0:05:01
<i>Measurement Interval</i>	13:26:48	13:36:48	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.23	0.23	0.21	0.24
1	0.24	0.24	0.22	0.26
2	0.23	0.23	0.21	0.24
3	0.24	0.24	0.22	0.26
4	0.23	0.23	0.21	0.24
5	0.25	0.24	0.23	0.27
6	0.25	0.24	0.23	0.27
7	0.23	0.23	0.21	0.24
8	0.24	0.24	0.22	0.26
9	0.23	0.23	0.21	0.24
10	0.24	0.23	0.22	0.26
11	0.25	0.24	0.23	0.28
12	0.24	0.23	0.22	0.25
13	0.24	0.24	0.22	0.26
14	0.23	0.23	0.21	0.24
Average	0.24	0.24	0.22	0.26

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2101	0.0181	0.0699	0.0350	0.2809
COV	0.004	0.002	0.004	0.002	0.006	0.003	0.004	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 [84](#).

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	218,007.79
Repeatability Test Phase 1	217,975.00
Repeatability Test Phase 2	217,982.43

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 be greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
Primary Metrics	0.24 ms
Repeatability Test Phase 1	0.24 ms
Repeatability Test Phase 2	0.24 ms

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

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

[Repeatability Test Phase 1, Test Run 1 \(LRT\)](#)

[Repeatability Test Phase 1, Test Run 2 \(IOPS\)](#)

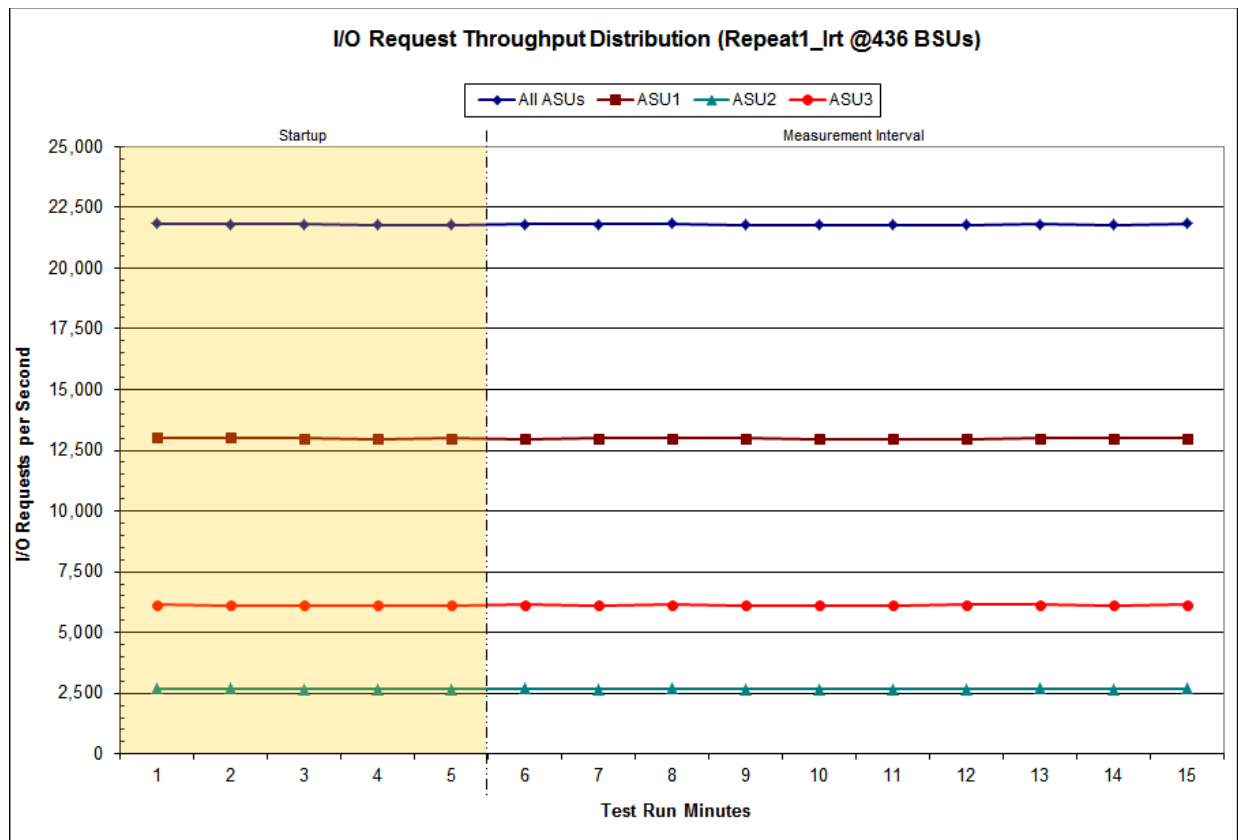
[Repeatability Test Phase 2, Test Run 1 \(LRT\)](#)

[Repeatability Test Phase 2, Test Run 2 \(IOPS\)](#)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

436 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:37:32	13:42:32	0-4	0:05:00
Measurement Interval	13:42:32	13:52:32	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	21,846.62	13,016.33	2,689.87	6,140.42
1	21,819.02	13,013.70	2,692.10	6,113.22
2	21,810.92	12,996.88	2,681.08	6,132.95
3	21,781.45	12,980.15	2,681.73	6,119.57
4	21,777.98	12,982.00	2,671.32	6,124.67
5	21,804.18	12,975.00	2,692.42	6,136.77
6	21,796.73	13,004.43	2,672.17	6,120.13
7	21,840.63	13,008.75	2,687.00	6,144.88
8	21,776.67	12,981.47	2,680.05	6,115.15
9	21,780.57	12,971.47	2,679.27	6,129.83
10	21,777.77	12,969.18	2,676.73	6,131.85
11	21,784.67	12,975.57	2,672.25	6,136.85
12	21,813.45	12,981.73	2,693.58	6,138.13
13	21,785.38	12,982.15	2,682.42	6,120.82
14	21,826.67	12,991.13	2,689.90	6,145.63
Average	21,798.67	12,984.09	2,682.58	6,132.01

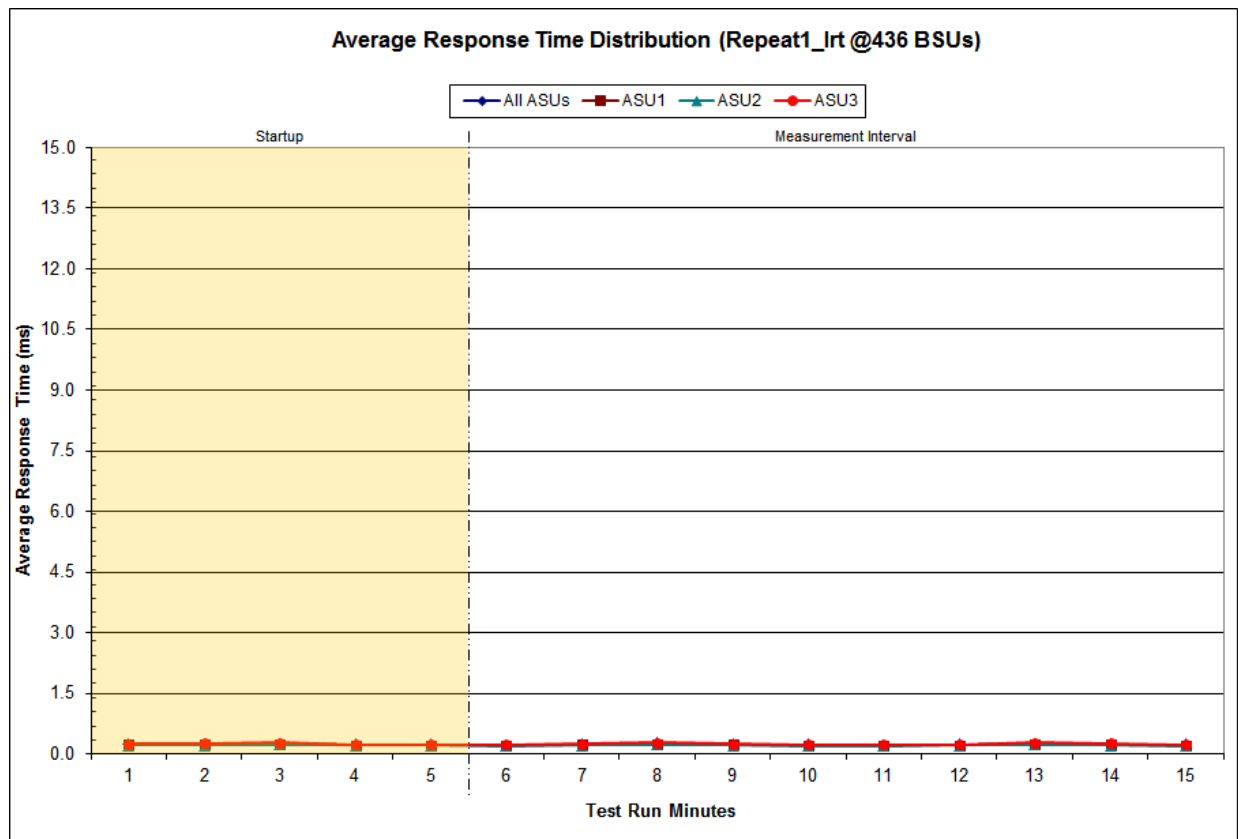
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

436 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:37:32	13:42:32	0-4	0:05:00
<i>Measurement Interval</i>	13:42:32	13:52:32	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.23	0.23	0.22	0.25
1	0.25	0.24	0.23	0.27
2	0.26	0.26	0.24	0.28
3	0.23	0.23	0.21	0.24
4	0.23	0.23	0.21	0.24
5	0.23	0.23	0.21	0.24
6	0.24	0.23	0.22	0.25
7	0.27	0.26	0.24	0.29
8	0.24	0.23	0.22	0.25
9	0.23	0.23	0.21	0.24
10	0.23	0.23	0.21	0.24
11	0.23	0.23	0.21	0.24
12	0.26	0.26	0.24	0.28
13	0.25	0.24	0.23	0.27
14	0.23	0.23	0.21	0.24
Average	0.24	0.24	0.22	0.26

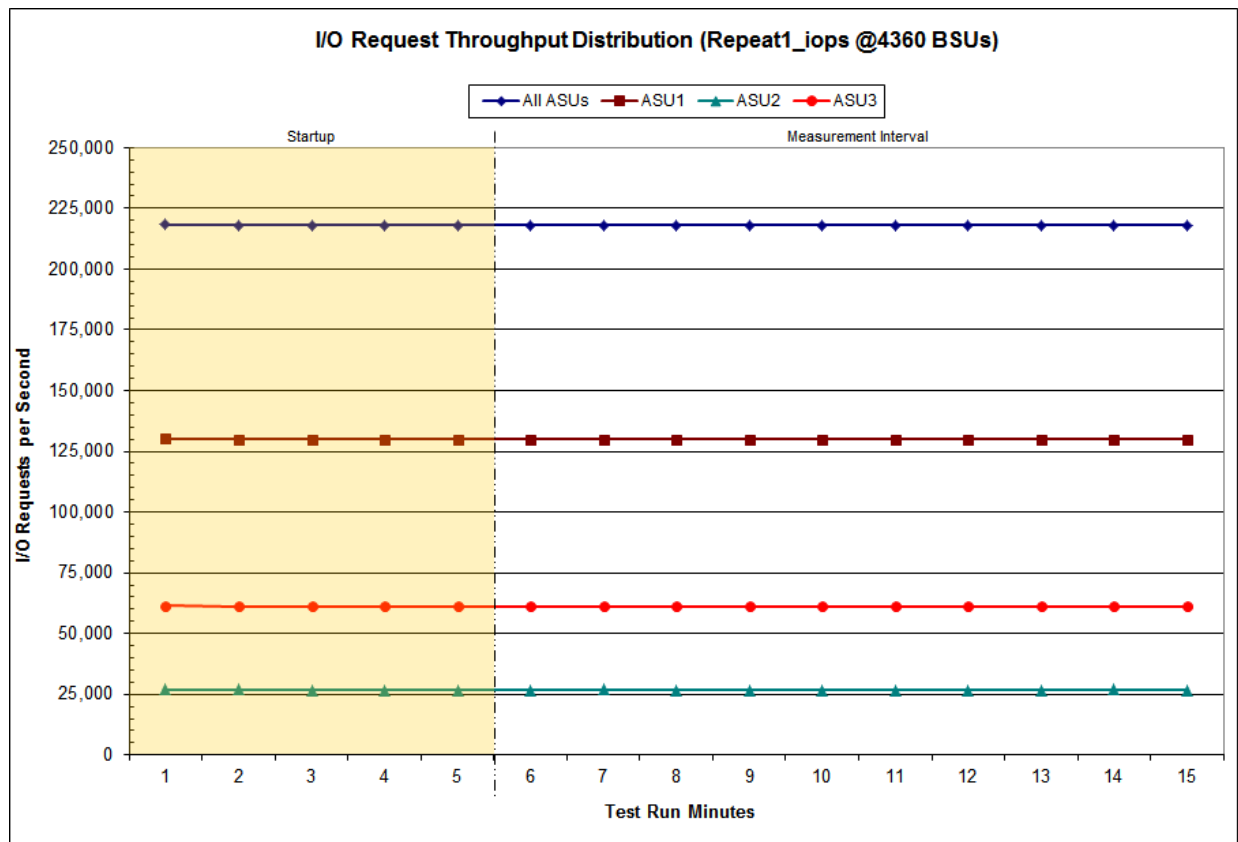
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

4,360 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:53:43	13:58:44	0-4	0:05:01
<i>Measurement Interval</i>	13:58:44	14:08:44	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	218,421.75	130,176.30	26,860.63	61,384.82
1	218,017.48	129,914.97	26,836.42	61,266.10
2	217,963.37	129,861.55	26,801.57	61,300.25
3	217,966.47	129,873.82	26,817.93	61,274.72
4	218,060.55	130,017.82	26,788.92	61,253.82
5	217,943.62	129,904.67	26,818.98	61,219.97
6	217,974.77	129,911.05	26,844.90	61,218.82
7	217,936.33	129,852.15	26,819.40	61,264.78
8	217,946.05	129,917.50	26,811.88	61,216.67
9	218,090.33	130,028.67	26,800.52	61,261.15
10	217,968.95	129,933.72	26,793.07	61,242.17
11	217,936.98	129,896.97	26,826.30	61,213.72
12	218,005.60	129,931.25	26,811.03	61,263.32
13	217,982.02	129,947.48	26,833.35	61,201.18
14	217,965.33	129,853.23	26,824.37	61,287.73
Average	217,975.00	129,917.67	26,818.38	61,238.95

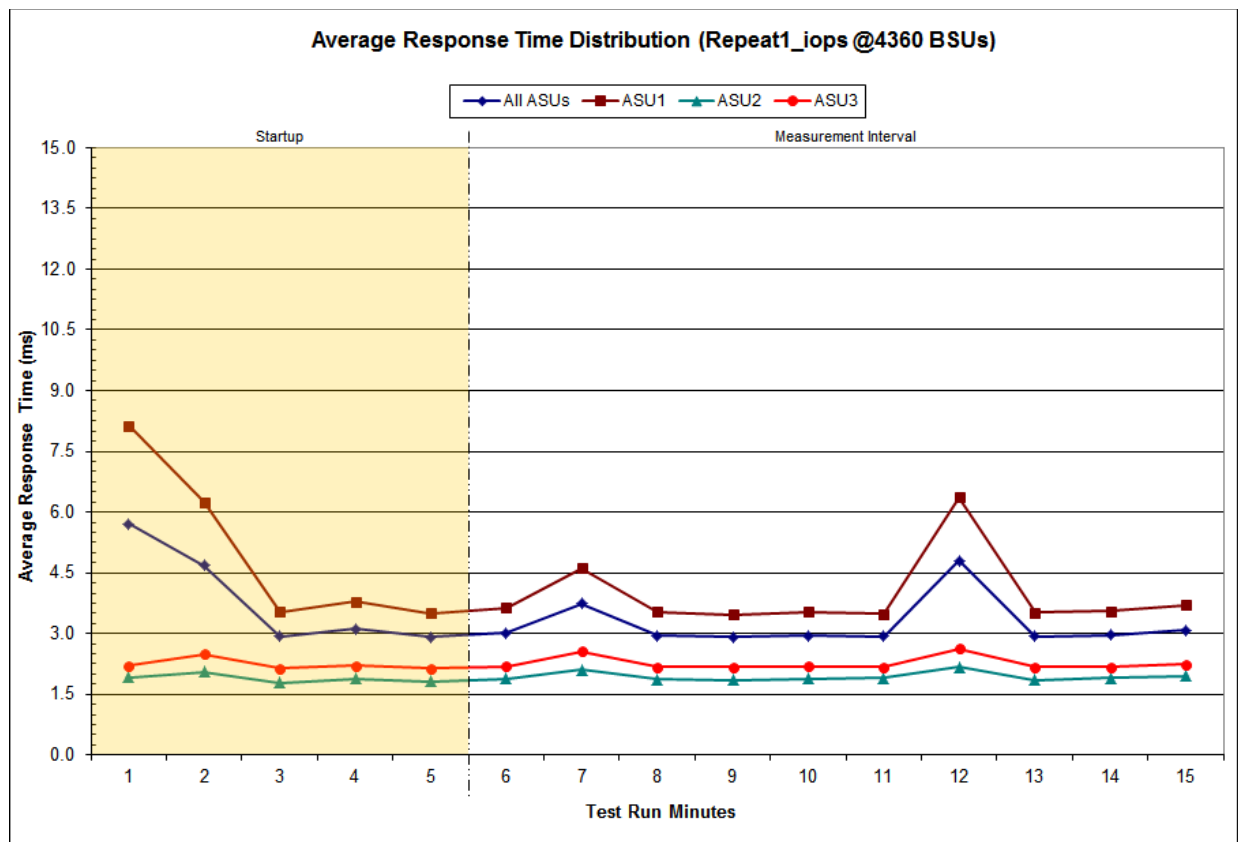
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

4,360 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:53:43	13:58:44	0-4	0:05:01
<i>Measurement Interval</i>	13:58:44	14:08:44	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5.71	8.14	1.92	2.20
1	4.68	6.25	2.06	2.50
2	2.93	3.53	1.79	2.14
3	3.11	3.79	1.89	2.21
4	2.92	3.51	1.82	2.14
5	3.02	3.64	1.89	2.20
6	3.73	4.62	2.11	2.55
7	2.95	3.54	1.88	2.17
8	2.91	3.47	1.86	2.17
9	2.95	3.53	1.88	2.18
10	2.93	3.49	1.90	2.18
11	4.80	6.36	2.18	2.63
12	2.93	3.51	1.86	2.17
13	2.96	3.55	1.90	2.18
14	3.07	3.70	1.95	2.24
Average	3.23	3.94	1.94	2.27

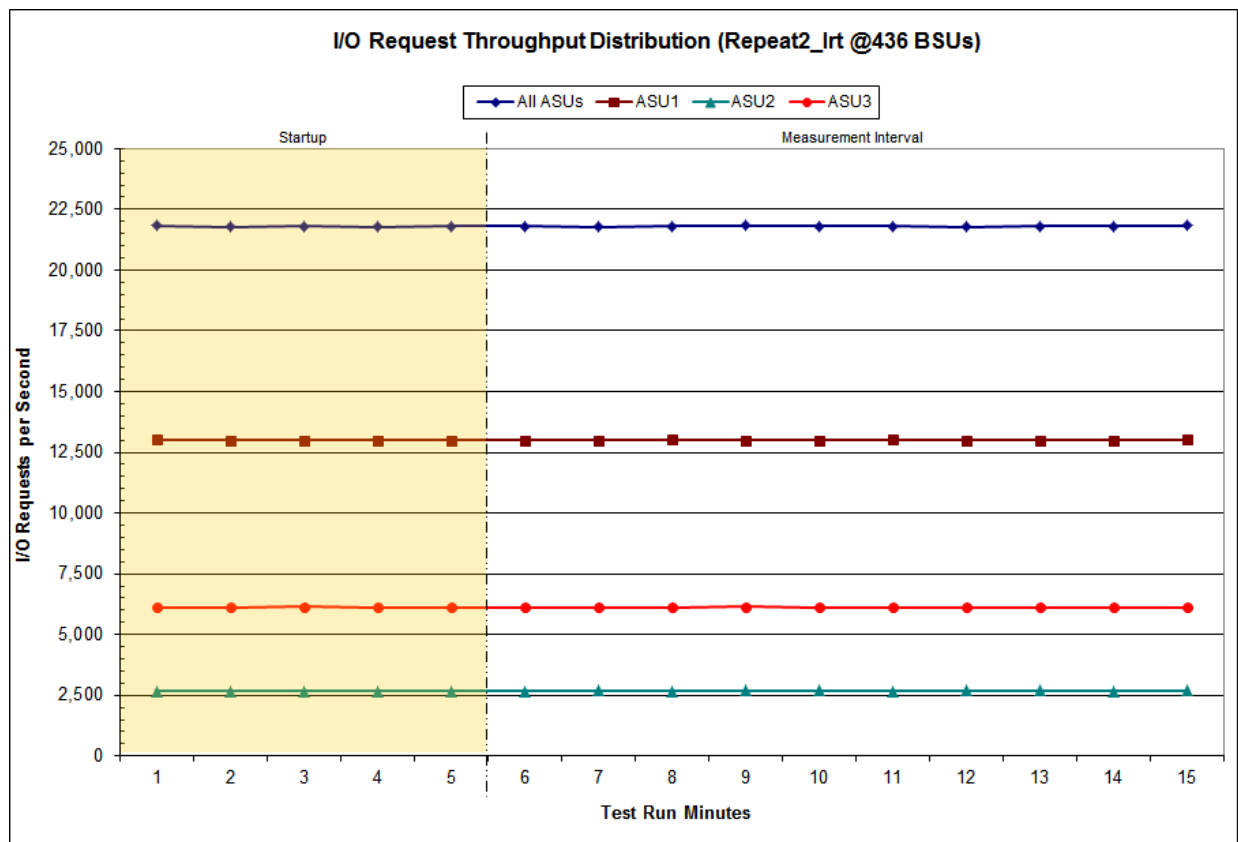
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

436 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:09:34	14:14:34	0-4	0:05:00
Measurement Interval	14:14:34	14:24:34	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	21,826.03	13,015.63	2,678.50	6,131.90
1	21,789.30	12,987.23	2,676.00	6,126.07
2	21,812.20	12,989.52	2,679.18	6,143.50
3	21,782.18	12,981.13	2,681.80	6,119.25
4	21,805.20	12,996.90	2,680.93	6,127.37
5	21,817.62	13,004.18	2,682.62	6,130.82
6	21,784.93	12,983.33	2,683.02	6,118.58
7	21,817.57	13,016.45	2,682.58	6,118.53
8	21,820.37	12,987.73	2,688.95	6,143.68
9	21,805.60	12,999.77	2,696.35	6,109.48
10	21,811.02	13,027.60	2,674.18	6,109.23
11	21,786.77	12,984.75	2,684.17	6,117.85
12	21,803.52	12,989.53	2,688.77	6,125.22
13	21,795.15	12,988.67	2,682.07	6,124.42
14	21,823.03	13,015.13	2,685.97	6,121.93
Average	21,806.56	12,999.72	2,684.87	6,121.98

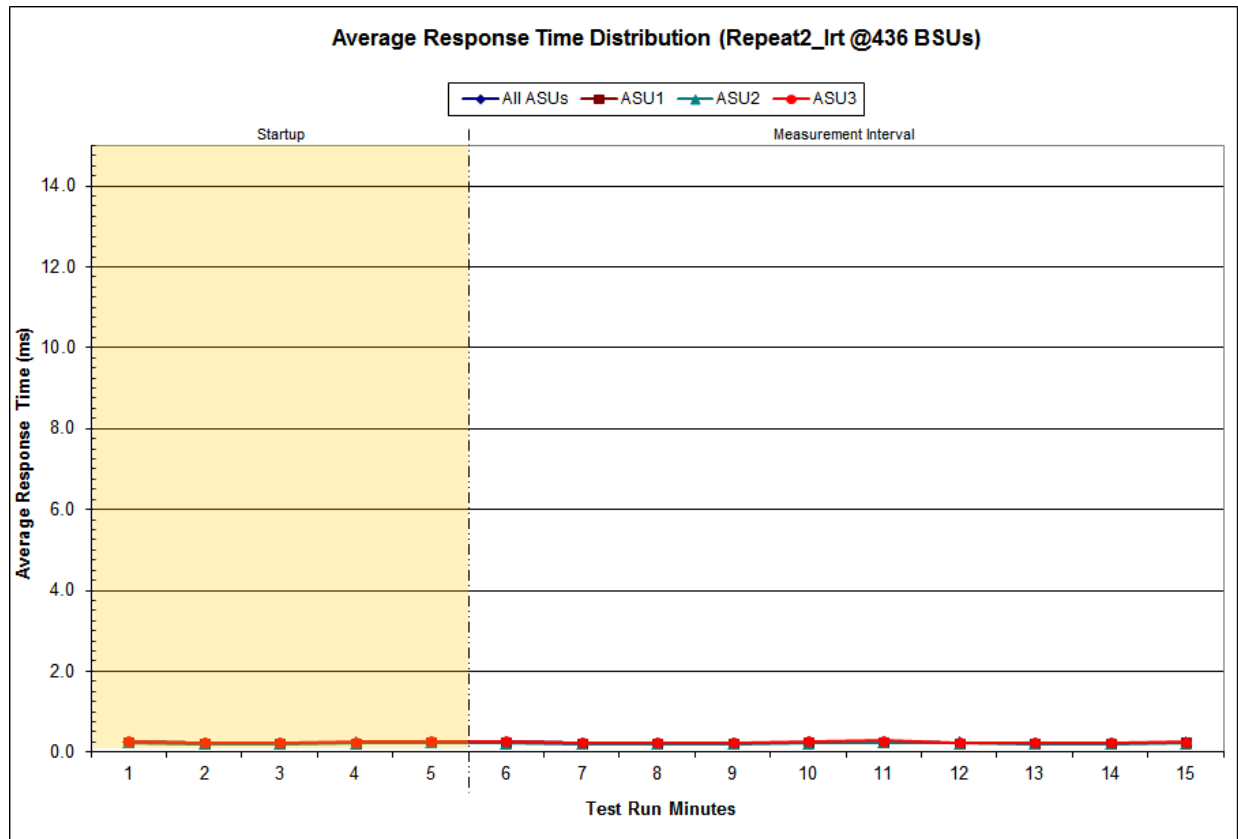
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

436 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:09:34	14:14:34	0-4	0:05:00
<i>Measurement Interval</i>	14:14:34	14:24:34	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.25	0.25	0.23	0.27
1	0.23	0.23	0.21	0.24
2	0.23	0.22	0.21	0.24
3	0.23	0.23	0.21	0.25
4	0.25	0.24	0.23	0.27
5	0.25	0.25	0.23	0.27
6	0.23	0.22	0.21	0.24
7	0.23	0.22	0.21	0.24
8	0.23	0.23	0.21	0.24
9	0.24	0.24	0.22	0.26
10	0.26	0.26	0.24	0.28
11	0.23	0.23	0.21	0.24
12	0.23	0.22	0.21	0.24
13	0.23	0.23	0.21	0.24
14	0.23	0.23	0.22	0.25
Average	0.24	0.23	0.22	0.25

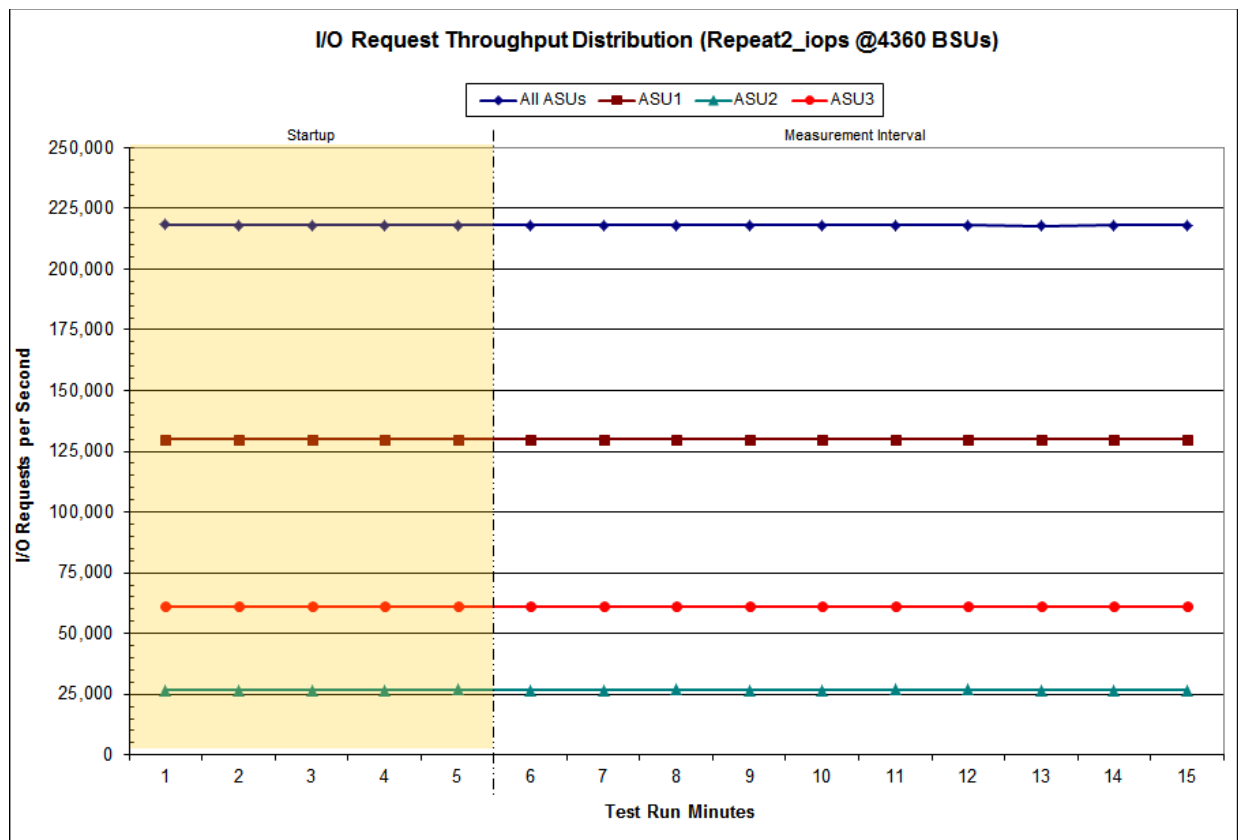
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

4,360 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:25:46	14:30:47	0-4	0:05:01
<i>Measurement Interval</i>	14:30:47	14:40:47	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	218,228.43	130,070.58	26,821.87	61,335.98
1	218,028.63	129,981.07	26,823.13	61,224.43
2	217,935.60	129,899.50	26,798.30	61,237.80
3	218,042.47	129,911.43	26,826.58	61,304.45
4	217,985.47	129,903.92	26,829.95	61,251.60
5	218,038.02	129,926.07	26,798.12	61,313.83
6	217,963.85	129,946.62	26,812.45	61,204.78
7	217,959.68	129,879.50	26,842.83	61,237.35
8	217,977.93	129,909.55	26,800.60	61,267.78
9	217,995.55	129,904.25	26,821.87	61,269.43
10	218,016.05	129,926.55	26,829.20	61,260.30
11	218,004.23	129,877.60	26,828.78	61,297.85
12	217,918.50	129,925.85	26,788.28	61,204.37
13	217,944.20	129,865.33	26,814.53	61,264.33
14	218,006.32	129,897.05	26,827.30	61,281.97
Average	217,982.43	129,905.84	26,816.40	61,260.20

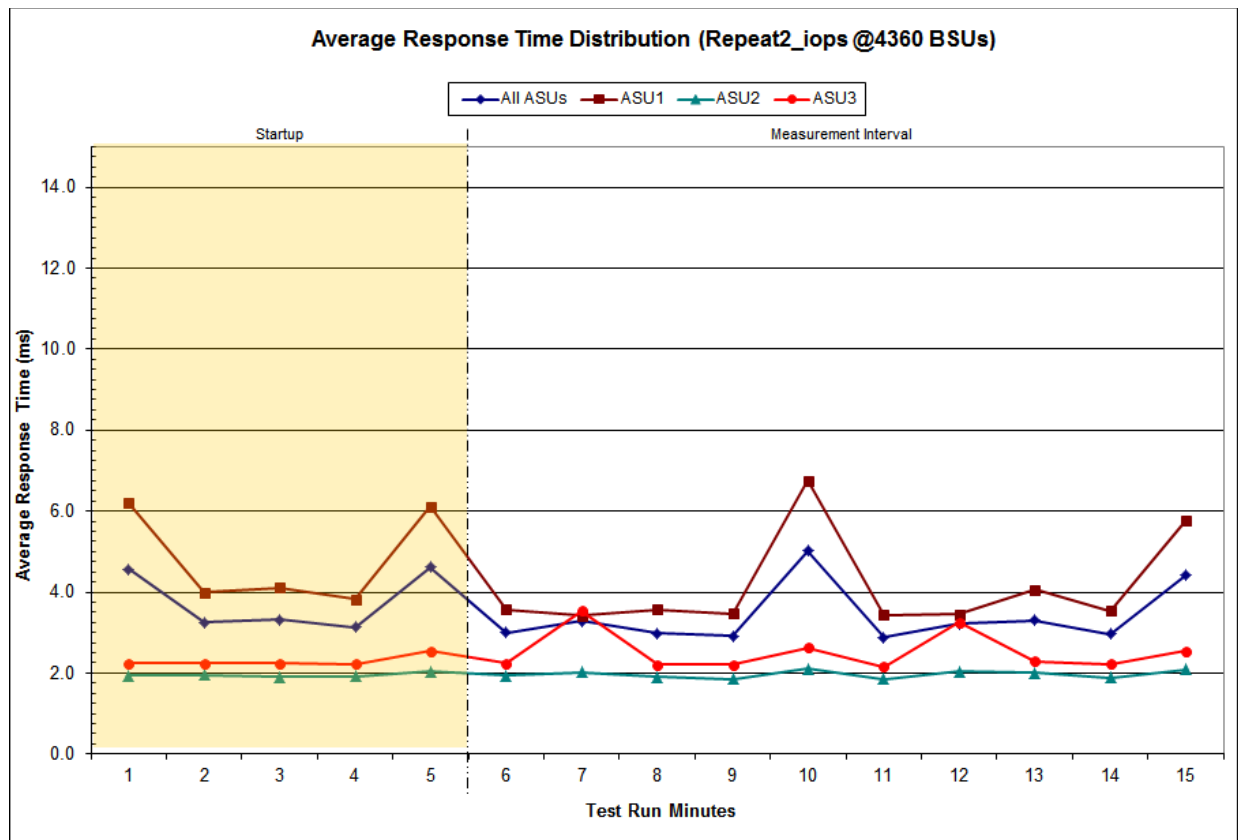
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

4,360 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	14:25:46	14:30:47	0-4	0:05:01
<i>Measurement Interval</i>	14:30:47	14:40:47	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4.56	6.19	1.94	2.25
1	3.25	4.00	1.95	2.23
2	3.32	4.12	1.90	2.25
3	3.14	3.82	1.92	2.22
4	4.61	6.12	2.04	2.54
5	3.00	3.57	1.93	2.24
6	3.28	3.42	2.01	3.54
7	2.98	3.57	1.90	2.22
8	2.92	3.47	1.86	2.20
9	5.02	6.75	2.11	2.63
10	2.89	3.44	1.85	2.16
11	3.22	3.46	2.04	3.25
12	3.31	4.06	2.00	2.29
13	2.96	3.54	1.89	2.22
14	4.41	5.76	2.10	2.55
<i>Average</i>	<i>3.40</i>	<i>4.10</i>	<i>1.97</i>	<i>2.53</i>

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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	0.2807	0.0699	0.2101	0.0180	0.0700	0.0350	0.2813
COV	0.004	0.001	0.005	0.001	0.004	0.003	0.003	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	0.0701	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.001	0.000	0.001	0.001	0.004	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	0.0349	0.2812	0.0699	0.2101	0.0180	0.0701	0.0351	0.2807
COV	0.005	0.002	0.003	0.001	0.005	0.004	0.003	0.002

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
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 [84](#).

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	359,775
Total Number of Logical Blocks Verified	328,203
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	5 minutes
Size in bytes of each Logical Block	1024
Number of Failed I/O Requests in the process of the Test	0

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

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

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.4.3.9

The committed delivery data for general availability (Availability Date) of all products that comprise the Priced Storage Configuration must be reported. When the Priced Storage Configuration includes products or components with different availability dates, the reported Availability Date for the Priced Storage Configuration must be the date at which all components are committed to be available.

The Infortrend EonStor DS 3024B as documented in this Full Disclosure Report will become available on July 13, 2015 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 16.

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 16.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the Infortrend EonStor DS 3024B.

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 gibibyte (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.

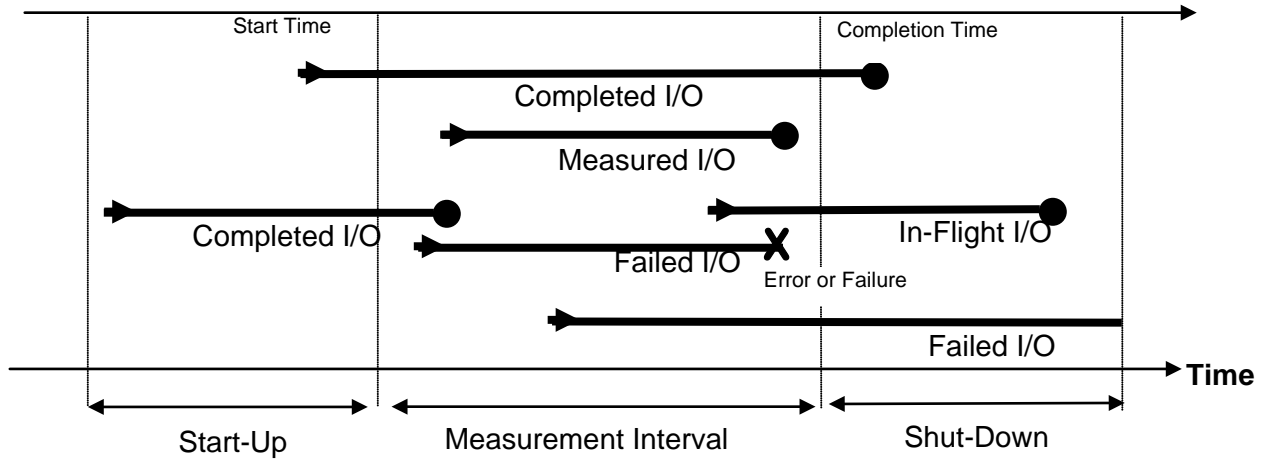
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

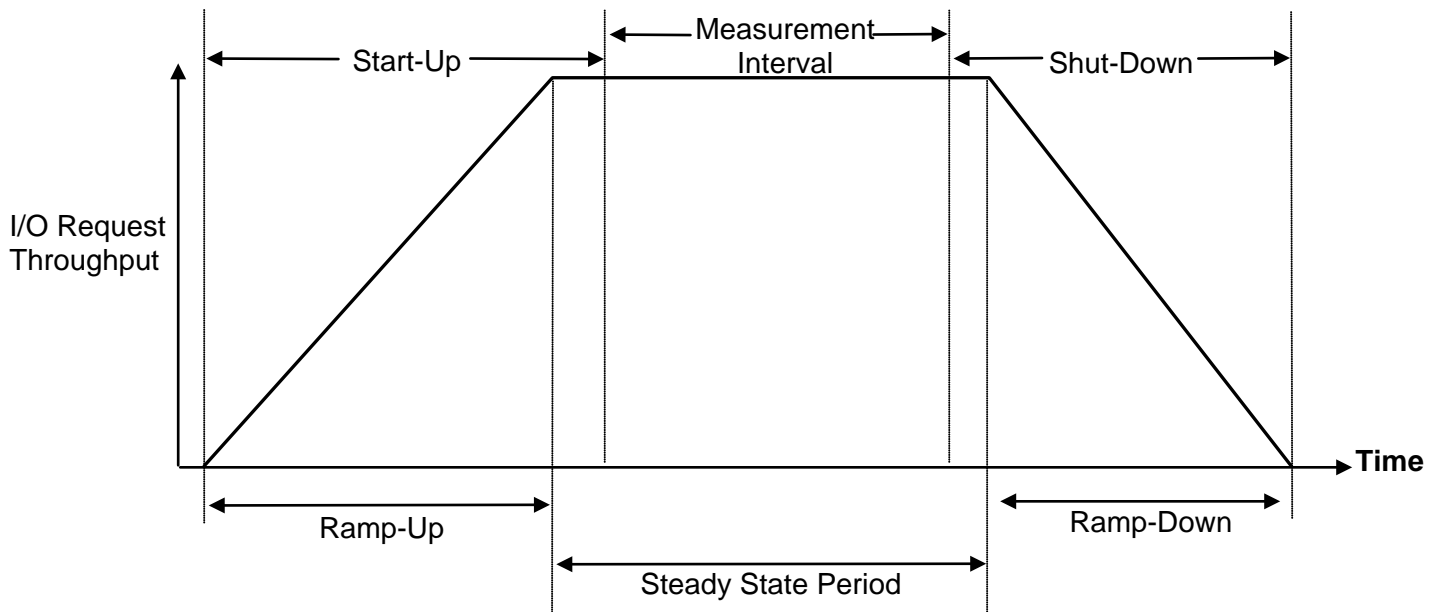
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have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

Emulex HBA QueueDepth Parameter

This parameter was changed for each HBA to specify a maximum number of outstanding I/O requests (*queue depth*) of 254. The parameter value was changed by using the Emulex OnCommand® Manager as described on page [79](#) in the [HBA QueueDepth](#) section of Appendix C.

Infotrend EonStor DS 3024B Maximum Number of Tags Parameter

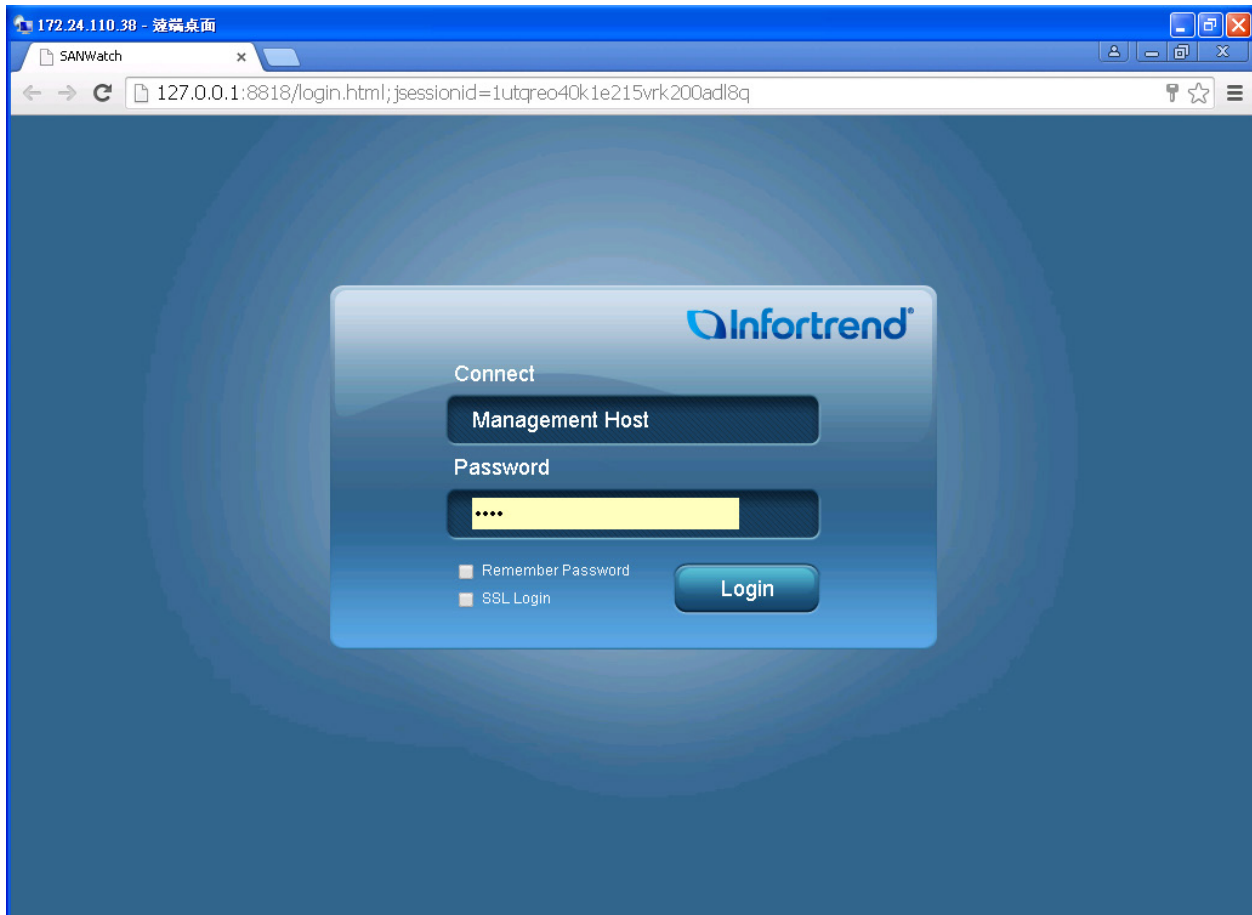
This parameter specifies support for Tagged Command Queuing (TCQ) and Native Command Queuing (NCQ), which can intelligently reorder host requests to streamline random accesses for IOPS-intensive, multi-user applications.

This parameter value was changed by using Infotrend's SANWatch as described on page [80](#) in the [Maximum Number of Tags](#) section of Appendix C.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

TSC Creation and Configuration

Step 1: Launch Infortrend's SANWatch on the Master Host system, or any other server than is configured on the same network subnet as the TSC, to begin the TSC creation and configuration process.

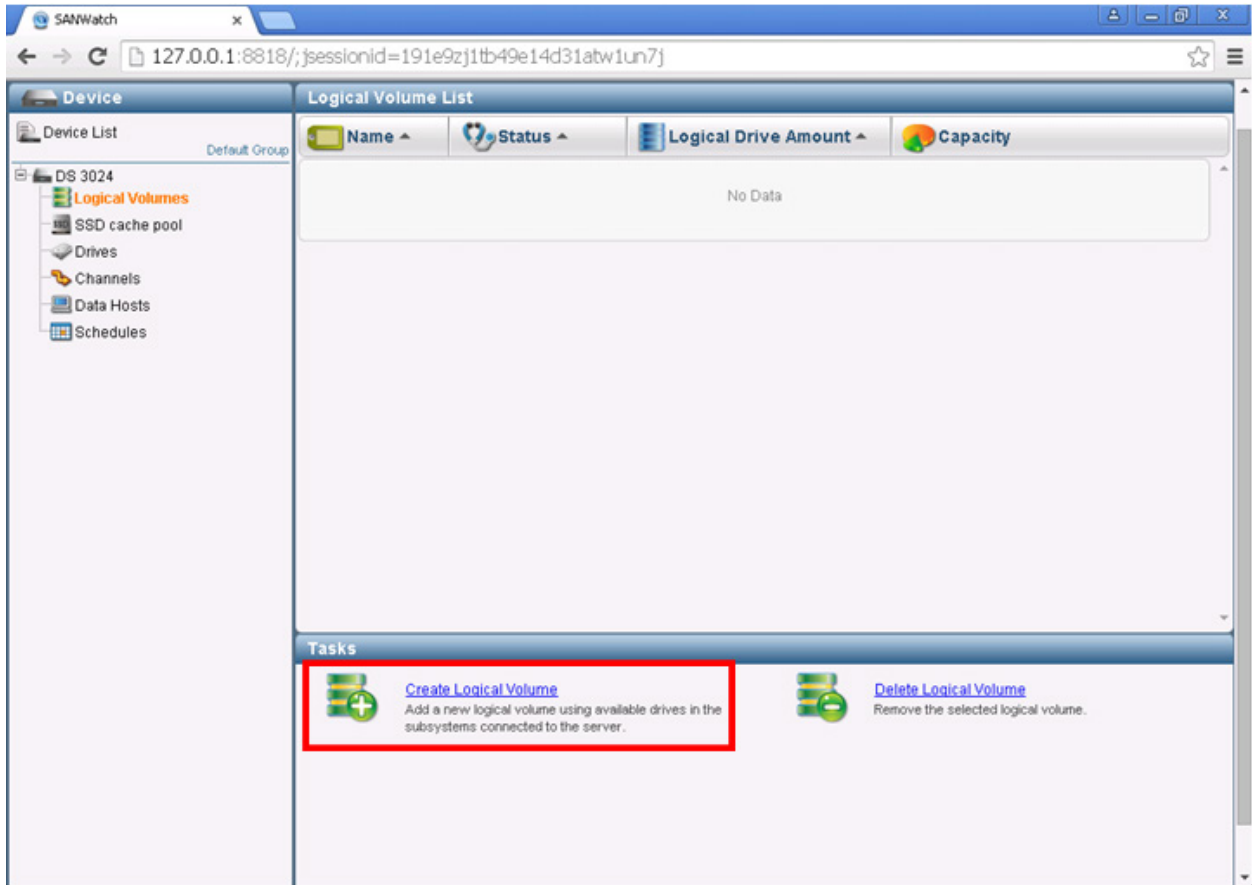


Step 2: Select the EonStor DS 3024 and check its status.

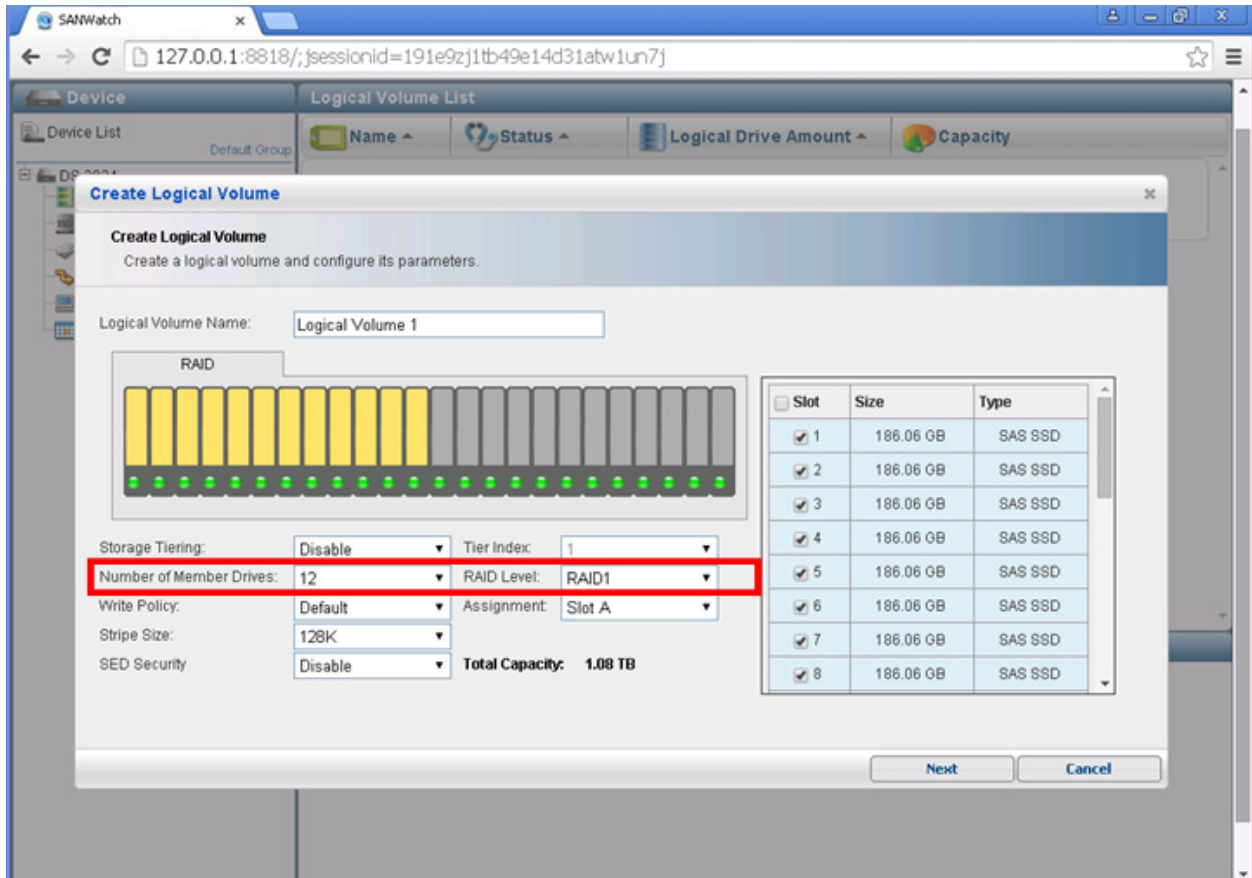
The screenshot displays the SANWatch web interface for a device named 'DS 3024'. The browser address bar shows the URL '127.0.0.1:8818/;jsessionid=191e9zj1tb49e14d31atw1un7j'. The interface is divided into several sections:

- Device List:** Shows 'DS 3024' under the 'Default Group'.
- Status:**
 - Subsystem Information:** Model: DS 3024RT2B, IP Address: 172.24.110.35, Service ID: 524377 (0x80059), Controller ID: 80059, Firmware Version: 6.11C.04. Status: OK (green checkmark), Recent Events: No Event.
 - Performance:** Includes a graph for CPU and Memory usage (both at 0%), and a throughput/IOPS graph showing Read: 0.00 and Write: 0.00 MB/s.
 - Capacity:** Total Capacity: 4.36 TB. Configured Space: 4.36 TB, Available Space: 0 MB (0%).
- Tasks:** Includes links for Quick Setup, Enclosure View, Information, System Settings, Event Log, and System Maintenance.

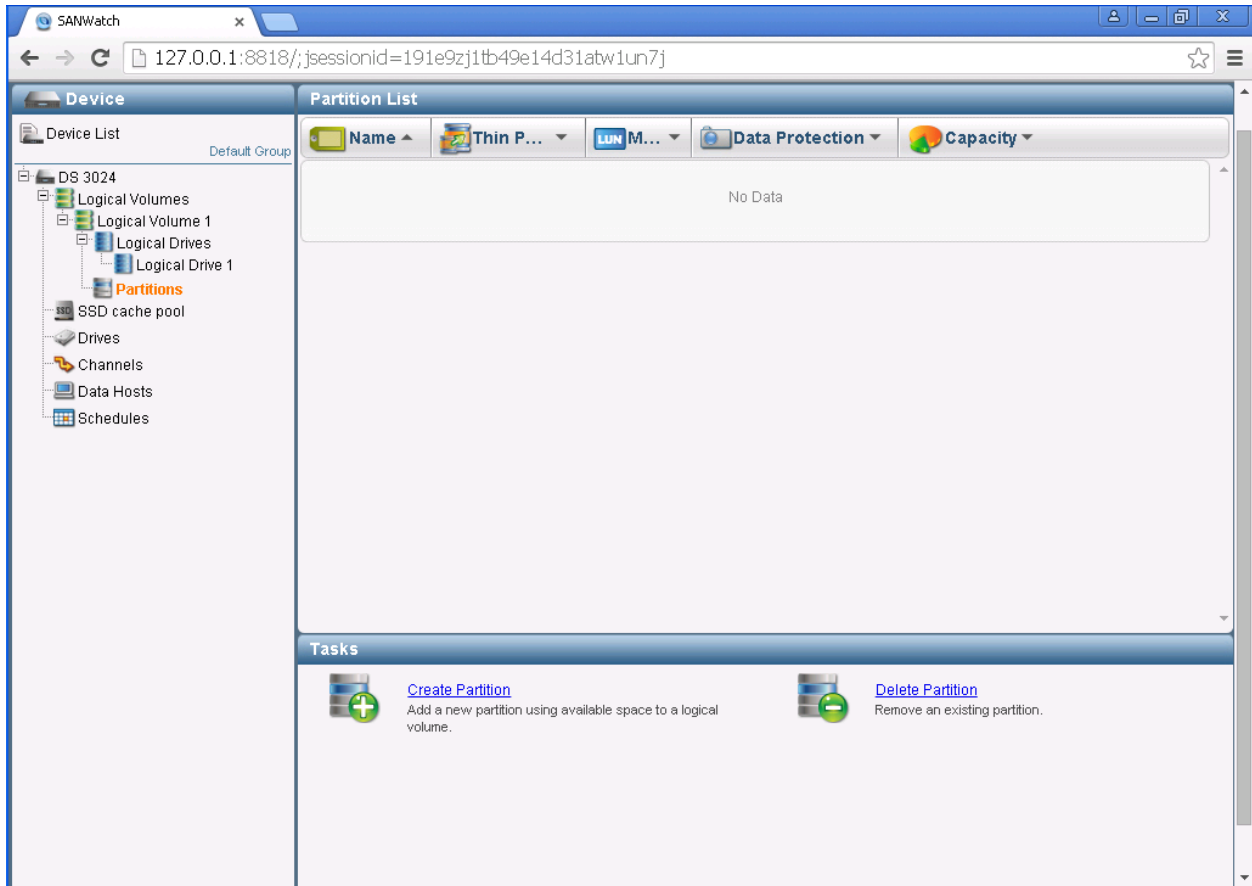
Step 3: Select **Logical Volumes** and click **Create Logical Volume**.



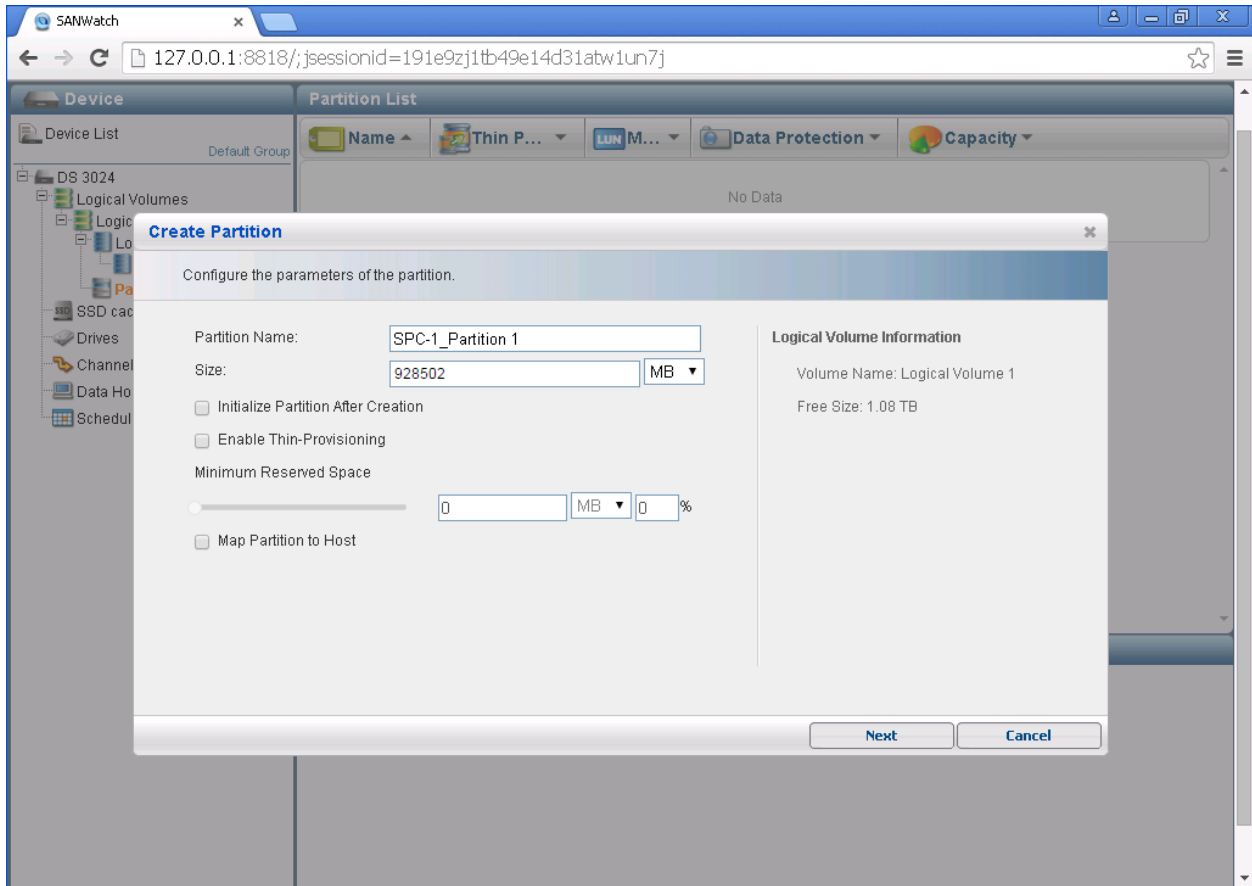
Step 4: Create **Logical Volume 1**, assign to **Slot A (Controller A)** and select 12 SAS SSDs as the member drives using RAID-1. Then click **Next**.



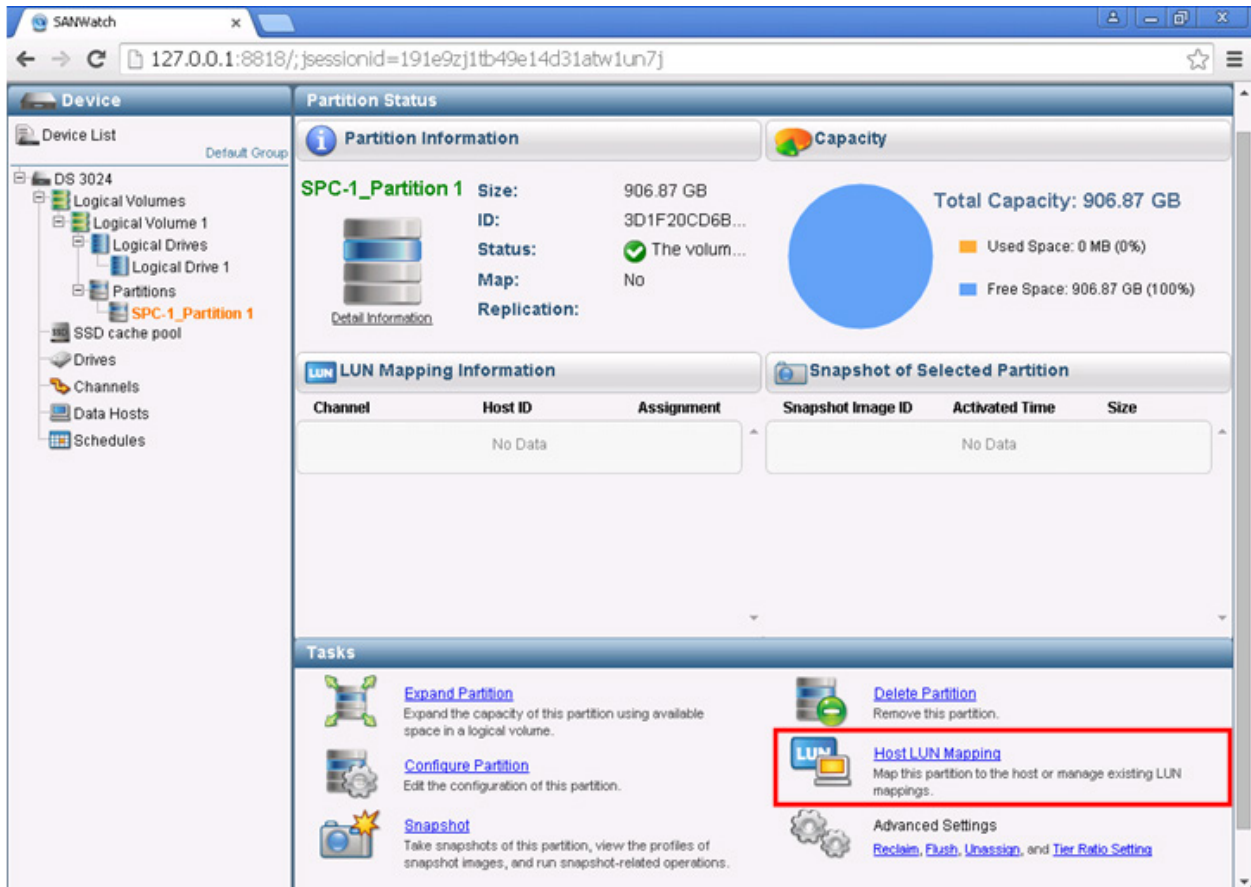
Step 5: Click **Create Partition** to create a partition.



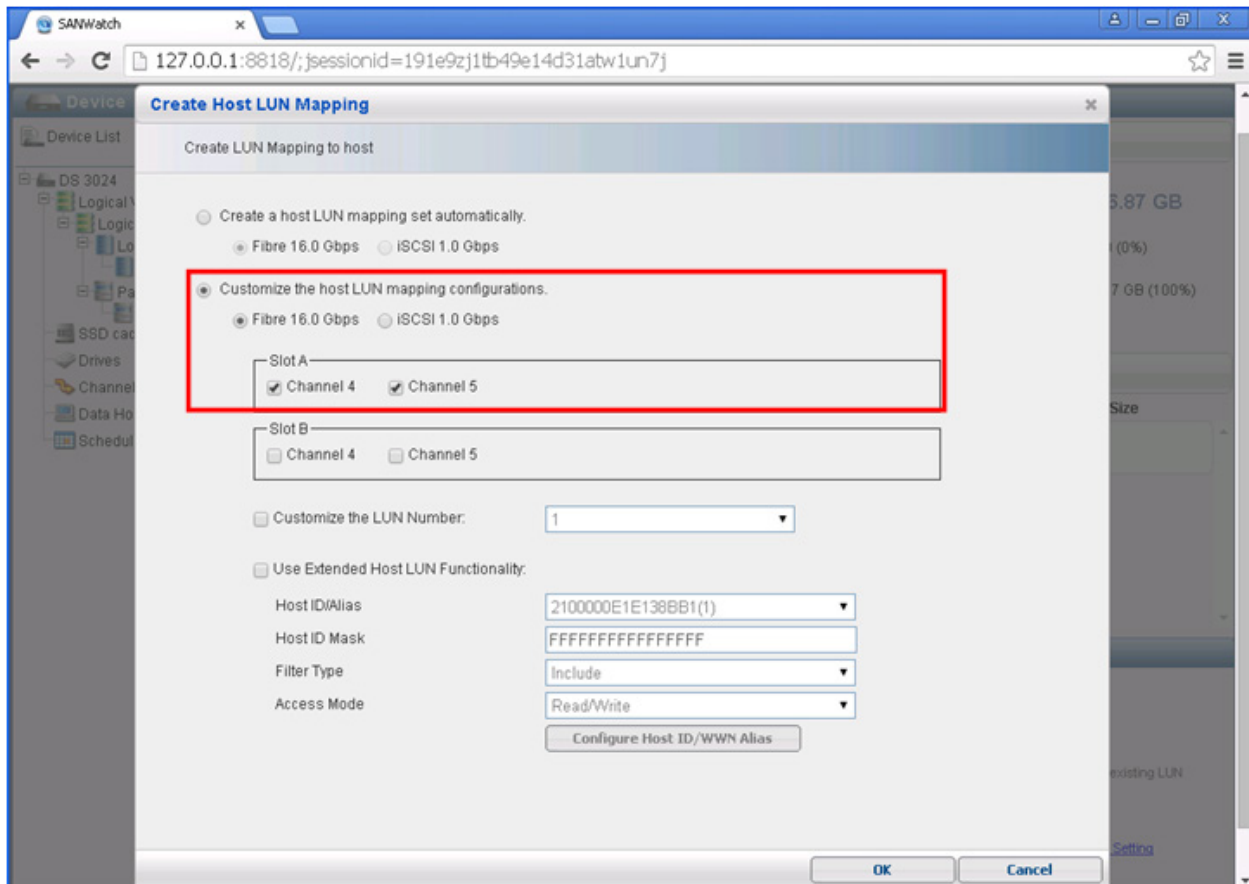
Step 6: Create the partition, **SPC-1_Partition-1** and set the partition size to 928,502 MB. Then click **Next**.



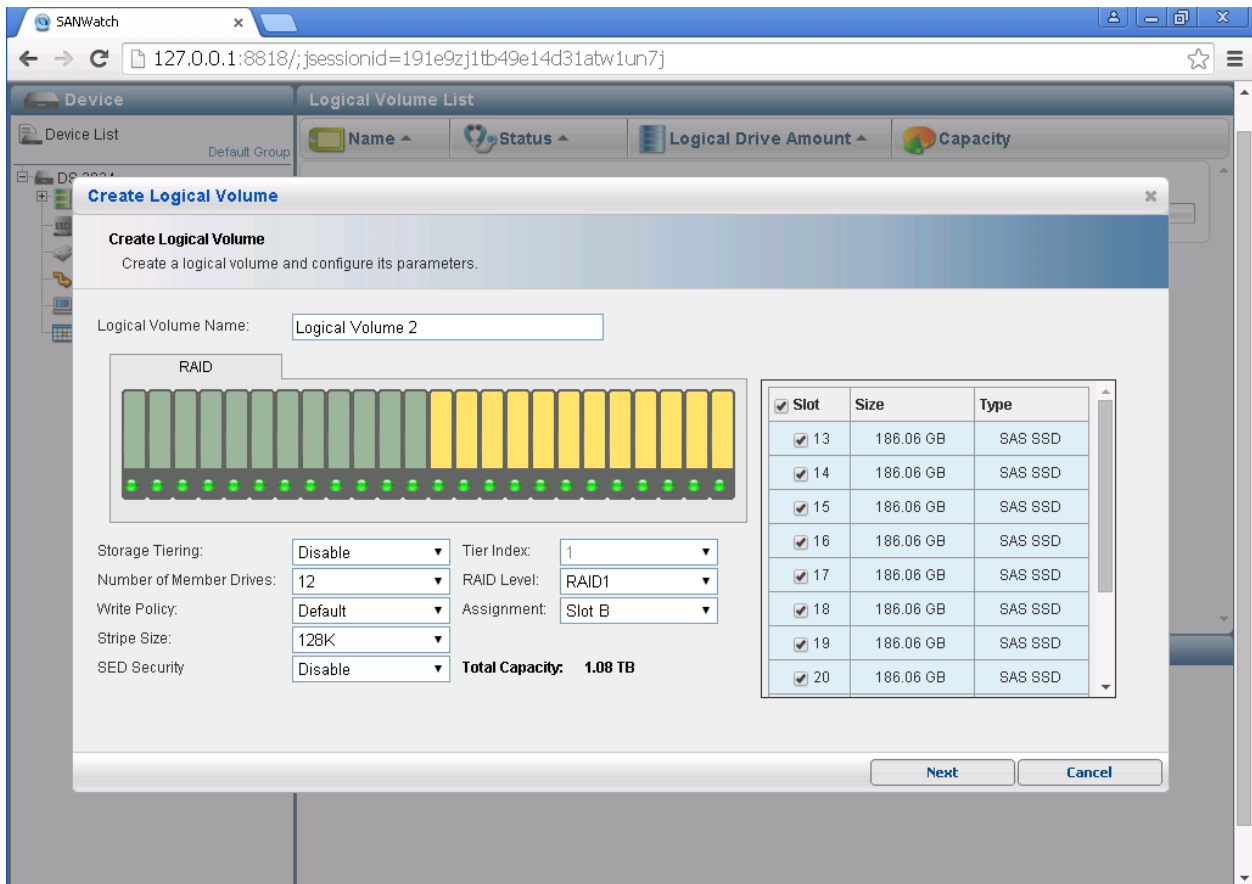
Step 7: Click **Host LUN Mapping** to map partition, **SPC-1_Partition-1**, to the two Host Systems.



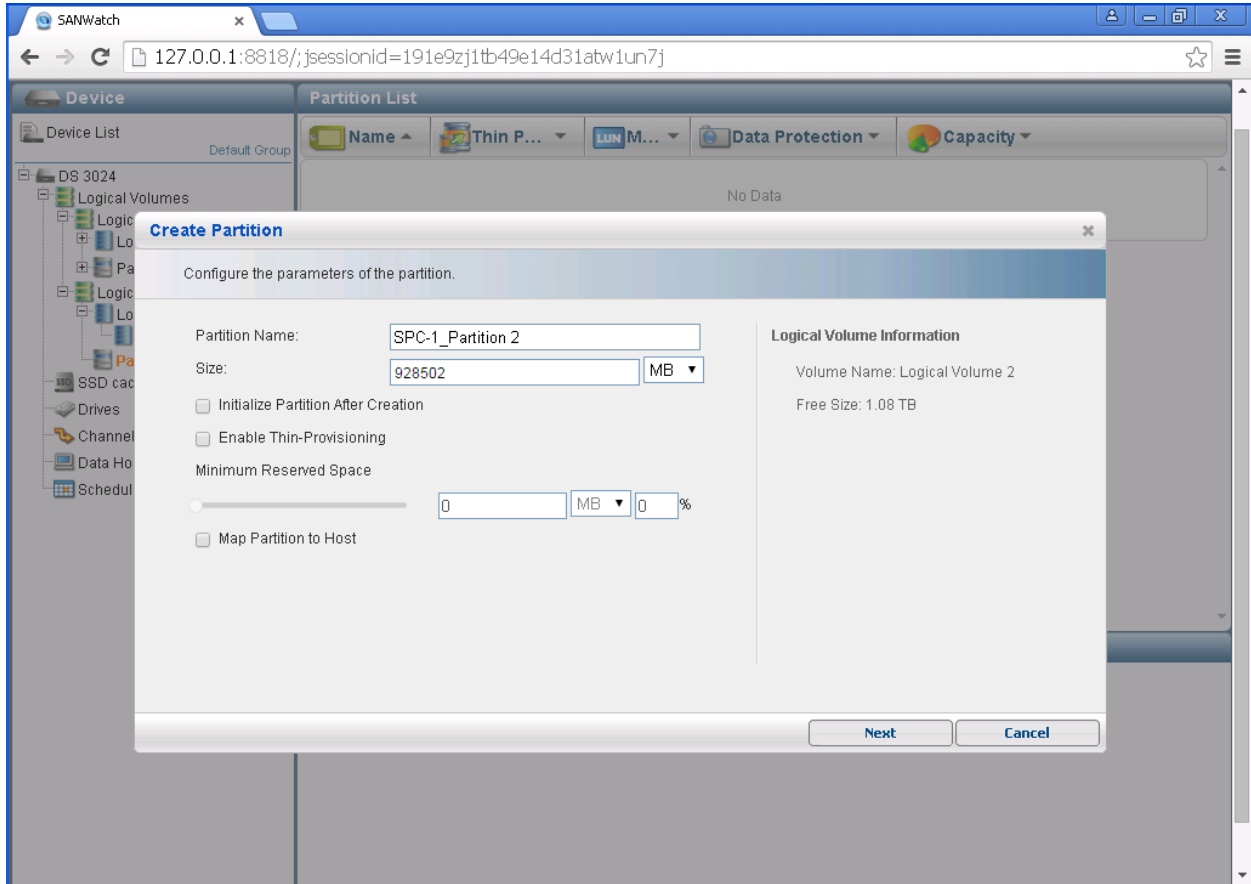
Step 8: Select **Customize the host LUN mapping configurations, Fibre 16.0 Gbps** and **Channel 4/Channel 5** for **Slot A (Controller A)**. Then click **OK**.



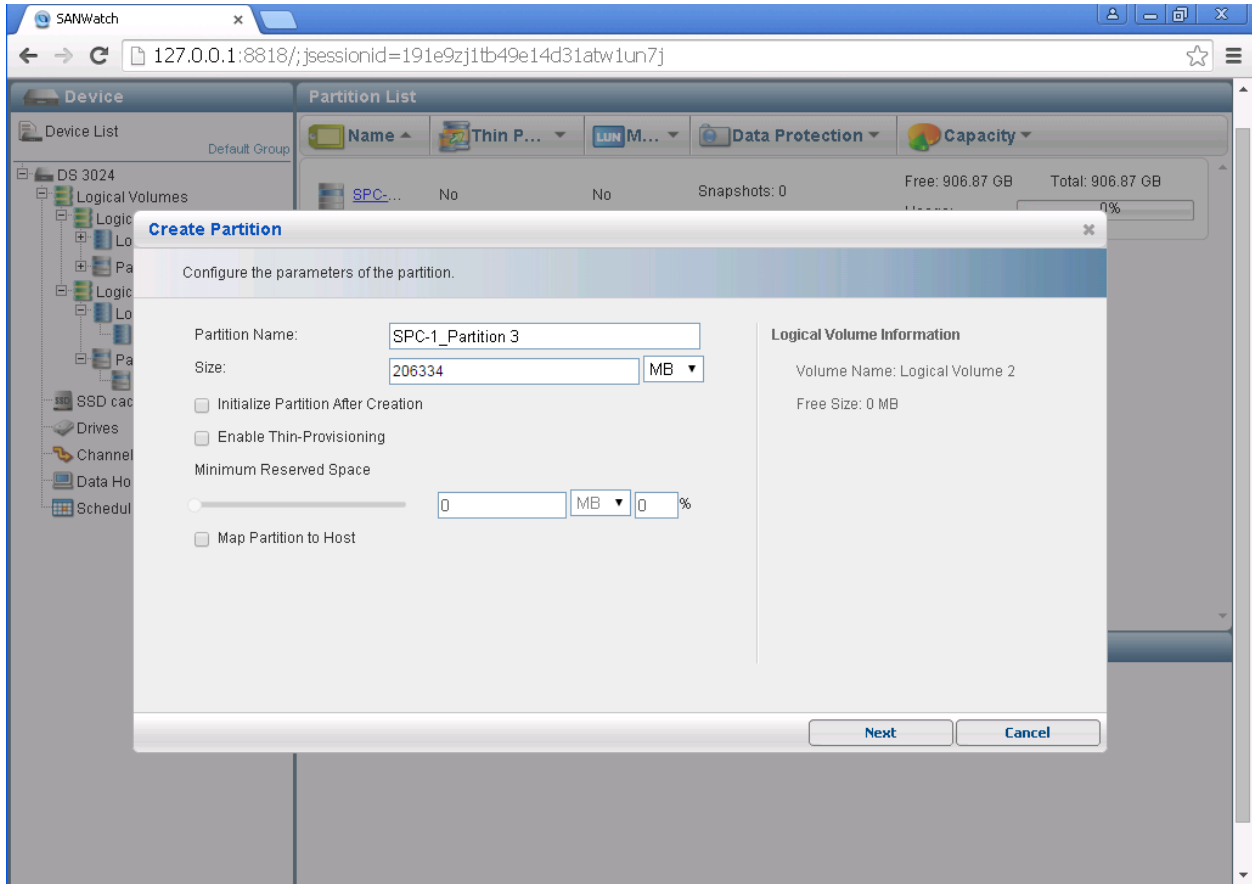
Step 9: Repeat [Step 3](#) (Select **Logical Volumes** and click **Create Logical Volume**), Create **Logical Volume 2**, assign to **Slot B (Controller B)** and select the remaining 12 SAS SSDs as the member drives using RAID-1. Then click **Next**.



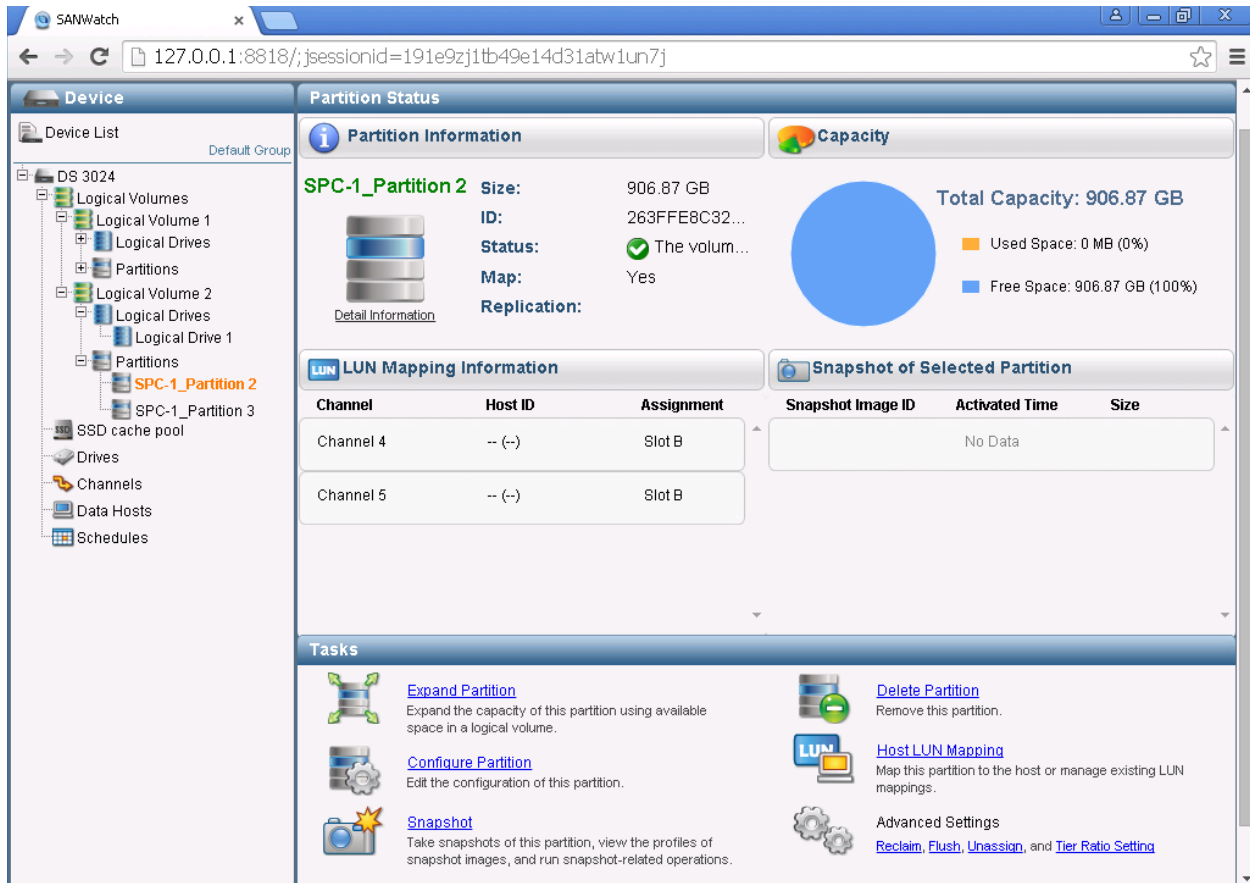
Step 10: Repeat [Step 5](#) to create the first partition for Logical Volume2, **SPC-1_Partition-2**, and set the partition size to 928,502 MB. Then click **Next**.



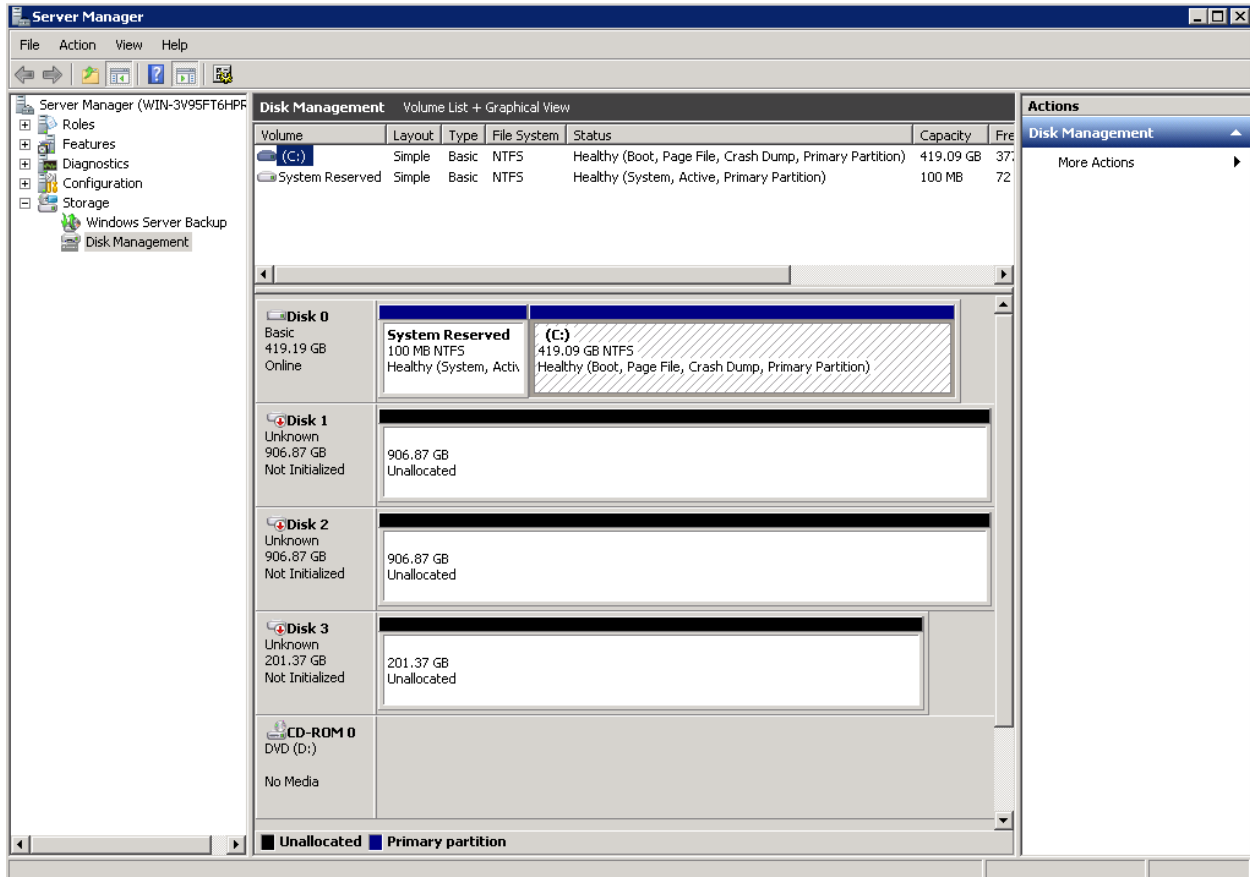
Step 11: Repeat [Step 5](#) to create the second partition for Logical Volume2, **SPC-1_Partition-3**, and set the partition size to 206,334 MB. Then click **Next**.



Step 12: As was done for Slot A (Controller A) in [Step 7](#) and [Step 8](#), map partitions, **SPC-1_Partition-2** and **SPC-1_Partition-3**, with selections of **Customize the host LUN mapping configurations, Fibre 16.0 Gbps** and **Channel 4/Channel 5** for **Slot B (Controller B)**. Then click **OK** after mapping each partition.



Step 13: On each Host System, start the **Windows Server Management** utility and click **Disk Management** to display the configured Windows “disks”. Verify the above three mapped partitions are correctly listed as new “disks”.

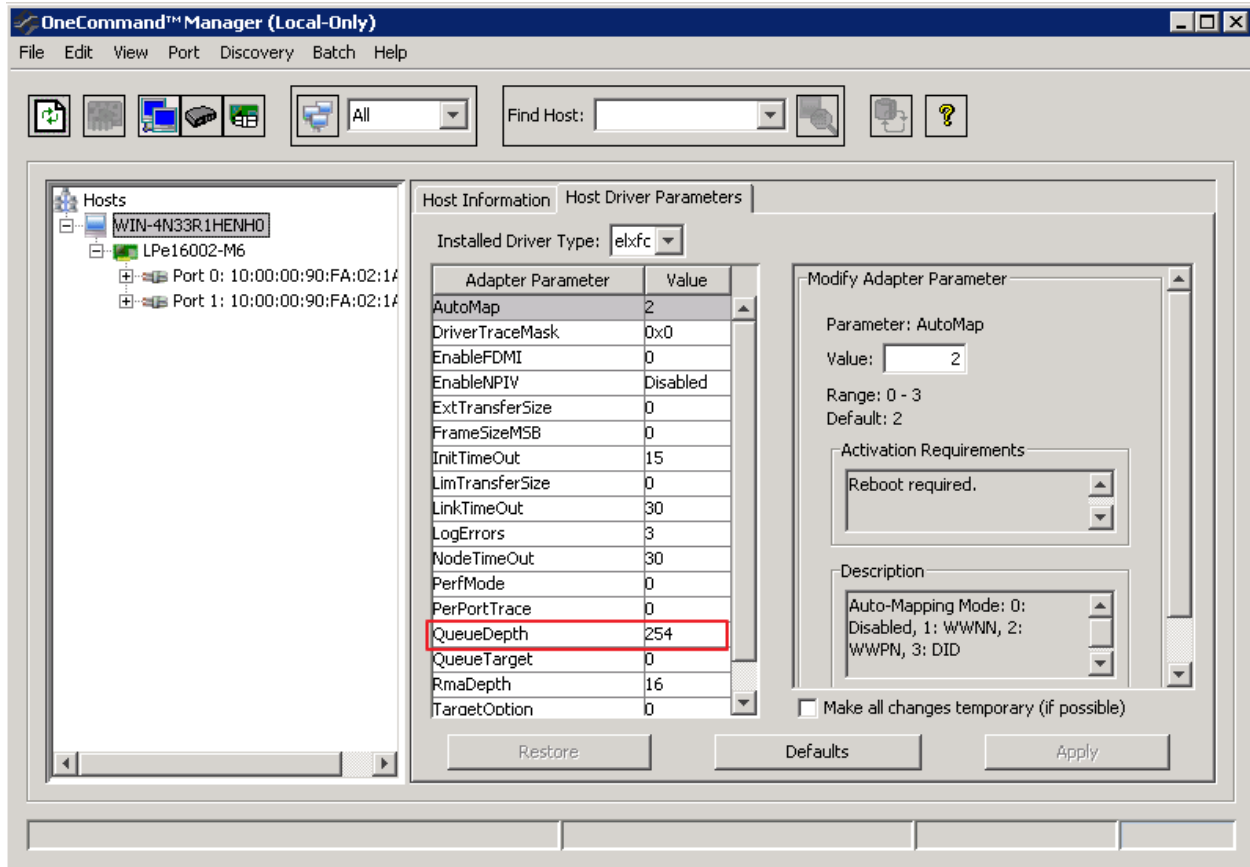


HBA QueueDepth

On each Host System, download the Emulex OneCommand® Manager from the Emulex website, using the following URL, in order to change the HBA **QueueDepth** parameter.

<http://www.emulex.com/products/software-solutions/onecommand-manager/overview/>

Execute the OneCommand® Manager, on each Host System, to change the **QueueDepth** parameter from its default of 32 to the value of 254 used in the benchmark measurements.



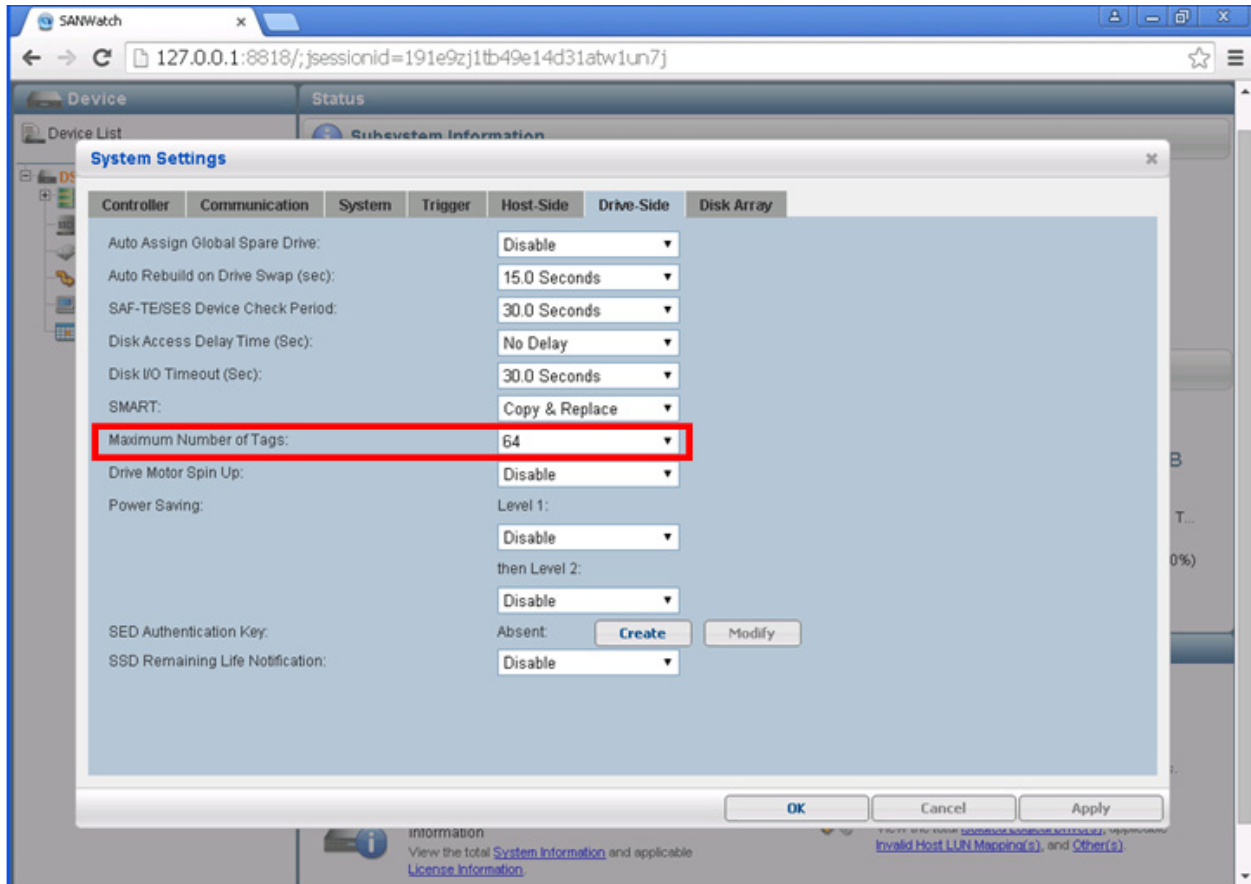
Maximum Number of Tags

Step 1: Execute Infortrend's SANWatch on the Master Host System, select the DS 3024 and click **System Settings**.

The screenshot shows the SANWatch web interface for a device named DS 3024. The interface is divided into several sections:

- Device List:** Shows the selected device DS 3024.
- Status:** Displays subsystem information including Model (DS 3024RT2B), IP Address (172.24.110.35), Service ID (524377), Controller ID (80059), and Firmware Version (6.11C.04). The status is OK and there are no recent events.
- Performance:** Includes a graph for CPU and Memory usage, and a section for Performance Monitoring (Throughput and IOPS) with a line graph showing Read and Write speeds (0.00 MB/s).
- Capacity:** Shows a pie chart for Total Capacity (4.36 TB), with Configured Space (4.36 TB) and Available Space (0 MB, 0%).
- Tasks:** A list of actions including Quick Setup, Enclosure View, Information, System Settings (highlighted with a red box), Event Log, and System Maintenance.

Step 2: Change the **Maximum Number of Tags** parameter value from the default value of 8 to the value of 64 used in the benchmark measurements.



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

ASU Pre-Fill

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

```
compratio=1
sd=default,threads=8
sd=asu1_1,lun=\\.\\physicalDrive1,threads=4
sd=asu2_1,lun=\\.\\physicalDrive2,threads=4
sd=asu3_1,lun=\\.\\physicalDrive3,threads=4
wd=default,rdpct=0,seek=-1,xfersize=128k
wd=wd1,sd=asu1_1
wd=wd2,sd=asu2_1
wd=wd3,sd=asu3_1
rd=asuprefill,wd=wd*,iorate=max,elapsed=21600,interval=60
```

Primary Metrics and Repeatability Tests

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

```
host=master
slave=(slave1,slave2,slave3,slave4,slave5,slave6,slave7,slave8,slave9,slave10,slave11,slave12,slave13,slave14,slave15,slave16,slave17,slave18,slave19,slave20,slave21,slave22,slave23,slave24,slave25,slave26,slave27,slave28,slave29,slave30,slave31,slave32,slave33,slave34,slave35,slave36,slave37,slave38,slave39,slave40,slave41,slave42,slave43,slave44,slave45,slave46,slave47,slave48,slave49,slave50)
sd=asu1_1,lun=\\.\\physicalDrive1,size=900g
sd=asu2_1,lun=\\.\\physicalDrive2,size=900g
sd=asu3_1,lun=\\.\\physicalDrive3,size=200g
```

SPC-1 Persistence Test Run 1

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

```
sd=asu1_1,lun=\\.\\physicalDrive1,size=900g
sd=asu2_1,lun=\\.\\physicalDrive2,size=900g
sd=asu3_1,lun=\\.\\physicalDrive3,size=200g
```

Slave JVMs

Each Slave JVM was invoked with a command and parameter file similar to the example listed below. The difference in each file was **host** parameter value, which was unique to each Slave JVM, e.g. **slave1...slave50**. The files for the first 25 Slave JVMs specified the Master Host System, **master=localhost**, and the remaining 25 Slave JVMs specified the Slave Host System, **master=172.24.110.56**.

```
master=localhost
host=slave1
sd=asu1_1,lun=\\.\\physicalDrive1
sd=asu2_1,lun=\\.\\physicalDrive2
sd=asu3_1,lun=\\.\\physicalDrive3
```

SPC-2 Persistence Test

If approved by the SPC Auditor, the SPC-2 Persistence Test may be used to meet the SPC-1 persistence requirements. Both the SPC-1 and SPC-2 Persistence Tests provide the same level of functionality and verification of data integrity.

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

```
host=localhost,jvms=1,maxstreams=200
sd=asu1_1,host=localhost,lun=\\.\\physicalDrive1,size=900g
sd=asu2_1,host=localhost,lun=\\.\\physicalDrive2,size=900g
sd=asu3_1,host=localhost,lun=\\.\\physicalDrive3,size=200g
maxlatestart=1
reportinginterval=5
segmentlength=512m
rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1
rd=default,rdpct=0,xfersize=1024k
rd=TR1-155s_SPC-2-persist-w,streams=155
```

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

```
host=localhost,jvms=1,maxstreams=200
sd=asu1_1,host=localhost,lun=\\.\\physicalDrive1,size=900g
sd=asu2_1,host=localhost,lun=\\.\\physicalDrive2,size=900g
sd=asu3_1,host=localhost,lun=\\.\\physicalDrive3,size=200g
maxlatestart=1
reportinginterval=5
segmentlength=512m
maxpersistenceerrors=5
rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1-155s_SPC-2-persist-r
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

The first two scripts, **runClientMaster.bat** and **runClientSlave.bat**, were started manually on the appropriate Host System to start the 50 Slave JVMs used in the benchmark measurements.

After the 50 Slave JVMs were started successfully, the **SPC-1_Test.bat** script was started manually on the Master Host System. That script called the standard **vdbench.bat** script to execute the required ASU pre-fill and upon completion of that first step, called the **runMaster.bat** script to execute the Primary Metrics Test (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*), the Repeatability Test (*Repeatability Test Phase 1 and Repeatability Test Phase 2*), a reduced level SPC-1 Persistence Test Run 1 (*write phase*) and the SPC-2 Persistence Test Run 1 (*write phase*).

After the required TSC power off/power on cycle, the **spc2_persist2.bat** script was started to execute the SPC-2 Persistence Test Run 2 (*read phase*).

runClientMaster.bat

```
@echo off
start java spc1 -f slave1.txt -o slave1
start java spc1 -f slave2.txt -o slave2
start java spc1 -f slave3.txt -o slave3
start java spc1 -f slave4.txt -o slave4
start java spc1 -f slave5.txt -o slave5
start java spc1 -f slave6.txt -o slave6
start java spc1 -f slave7.txt -o slave7
start java spc1 -f slave8.txt -o slave8
start java spc1 -f slave9.txt -o slave9
start java spc1 -f slave10.txt -o slave10
start java spc1 -f slave11.txt -o slave11
start java spc1 -f slave12.txt -o slave12
start java spc1 -f slave13.txt -o slave13
start java spc1 -f slave14.txt -o slave14
start java spc1 -f slave15.txt -o slave15
start java spc1 -f slave16.txt -o slave16
start java spc1 -f slave17.txt -o slave17
start java spc1 -f slave18.txt -o slave18
start java spc1 -f slave19.txt -o slave19
start java spc1 -f slave20.txt -o slave20
start java spc1 -f slave21.txt -o slave21
start java spc1 -f slave22.txt -o slave22
start java spc1 -f slave23.txt -o slave23
start java spc1 -f slave24.txt -o slave24
start java spc1 -f slave25.txt -o slave25
```

runClientSlave.bat

```
@echo off

start java spc1 -f slave26.txt -o slave26
start java spc1 -f slave27.txt -o slave27
start java spc1 -f slave28.txt -o slave28
start java spc1 -f slave29.txt -o slave29
start java spc1 -f slave30.txt -o slave30
start java spc1 -f slave31.txt -o slave31
start java spc1 -f slave32.txt -o slave32
start java spc1 -f slave33.txt -o slave33
start java spc1 -f slave34.txt -o slave34
```

```
start java spc1 -f slave35.txt -o slave35
start java spc1 -f slave36.txt -o slave36
start java spc1 -f slave37.txt -o slave37
start java spc1 -f slave38.txt -o slave38
start java spc1 -f slave39.txt -o slave39
start java spc1 -f slave40.txt -o slave40
start java spc1 -f slave41.txt -o slave41
start java spc1 -f slave42.txt -o slave42
start java spc1 -f slave43.txt -o slave43
start java spc1 -f slave44.txt -o slave44
start java spc1 -f slave45.txt -o slave45
start java spc1 -f slave46.txt -o slave46
start java spc1 -f slave47.txt -o slave47
start java spc1 -f slave48.txt -o slave48
start java spc1 -f slave49.txt -o slave49
start java spc1 -f slave50.txt -o slave50
```

SPC-1_Test.bat

```
rem
rem PreFill ASU space with vdbench
rem
call C:\vdbench50401\vdbench.bat -f ASU-PreFill-script.cfg -o prefill.out

rem runMaster
call runMaster.bat
```

runMaster.bat

```
rem Metrics sustainability -
copy /y spc1_metrics.cfg spc1.cfg
java metrics -b 4360 -t 28800 -s 4800:300

rem Repeatability Runs
java repeat1 -b 4360 -s 300
java repeat2 -b 4360 -s 300

rem Reduced level SPC-1 Persistence Test Run 1 (write phase)
taskkill /im java.exe /f
copy /y spc1_persist.cfg spc1.cfg
java -Xmx32768m -Xms32768m persist1 -b 436

rem SPC-2 "init" and Persistence Test Run 1 (write phase)
cd c:\spc\spc2
java -Xmx32768m -Xms32768m -cp c:\spc\spc2 vdbench -w SPC2 -f
c:\spc\spc2\persist1.cfg -o c:\spc\spc2\spc2_init -init
java -Xmx32768m -Xms32768m -cp c:\spc\spc2 vdbench -w SPC2 -f
c:\spc\spc2\persist1.cfg -o c:\spc\spc2\spc2_persist1

rem TSC power off/power cycle
rem run spc2_persist2 (read phase)
```

spc2_persist2.bat

```
rem SPC-2 Persistence Test Run 2 (read phase)
java -Xmx32768m -Xms32768m -cp c:\spc\spc2 vdbench -w SPC2 -f
c:\spc\spc2\persist2.cfg -o c:\spc\spc2\spc2_persist2
```