



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**INFORTREND TECHNOLOGY, INC.  
INFORTREND EONSTOR DS 2024B**

**SPC-1 V1.14**

**Submitted for Review: August 25, 2015  
Submission Identifier: A00160**

**First Edition – August 2015**

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## AUDIT CERTIFICATION



Jeff Lin  
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August 24, 2015

The SPC Benchmark 1™ Reported Data listed below for the Infortrend EonStor DS 2024B 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 2024B	
Metric	Reported Result
SPC-1 IOPS™	95,995.33
SPC-1 Price-Performance	\$0.43/SPC-1 IOPS™
Total ASU Capacity	1,338.200 GB
Data Protection Level	Protected 2 (mirroring)
Total Price (including three-year maintenance)	\$41,167.00
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](mailto:AuditService@storageperformance.org)  
 650.556.9384

## AUDIT CERTIFICATION (CONT.)

Infotrend EonStor DS 2024B  
SPC-1 Audit Certification

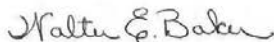
Page 2

- 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  
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## 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 2024B

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	
<b>Test Sponsor Primary Contact</b>	Infotrend Technology, Inc. – <a href="http://www.infotrend.com">http://www.infotrend.com</a> Jeff Lin – <a href="mailto:Jeff.Lin@infotrend.com">Jeff.Lin@infotrend.com</a> 8F, No. 102, Sec. 3, Jhongshan Rd. Jhonge District , New Taipei City 23544, Taiwan Phone: +866 (2) 2226 0020 x7082
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<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">http://www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@StoragePerformance.org">AuditService@StoragePerformance.org</a> 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	
<b>SPC-1 Specification revision number</b>	V1.14
<b>SPC-1 Workload Generator revision number</b>	V2.3.0
<b>Date Results were first used publicly</b>	August 25, 2015
<b>Date the FDR was submitted to the SPC</b>	August 25, 2015
<b>Date the Priced Storage Configuration is available for shipment to customers</b>	July 13, 2015
<b>Date the TSC completed audit certification</b>	August 24, 2015

### Tested Storage Product (TSP) Description

EonStor DS 2024B 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 2024B is well suited for SMB and enterprise SAN/IP SAN/DAS applications while providing excellent price-performance. Additional details about the EonStor DS 2024B are available at <http://www.infotrend.com/global/products/families/ESDS/2000>.

## Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Infortrend EonStor DS 2024B	
Metric	Reported Result
SPC-1 IOPS™	95,995.33
SPC-1 Price-Performance™	\$0.43/SPC-1 IOPS™
Total ASU Capacity	1,338.200 GB
Data Protection Level	Protected 2 ( <i>mirroring</i> )
Total Price	\$41,167.00
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.*

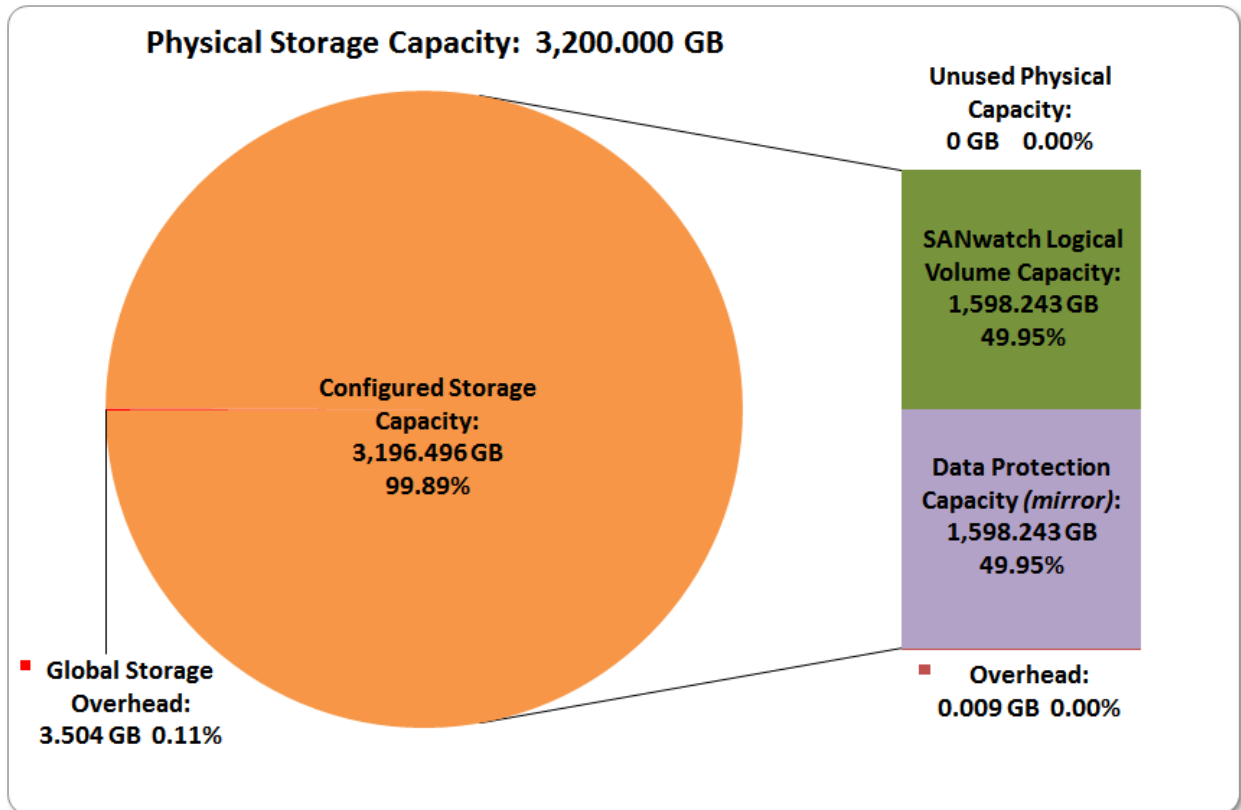
**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 16.

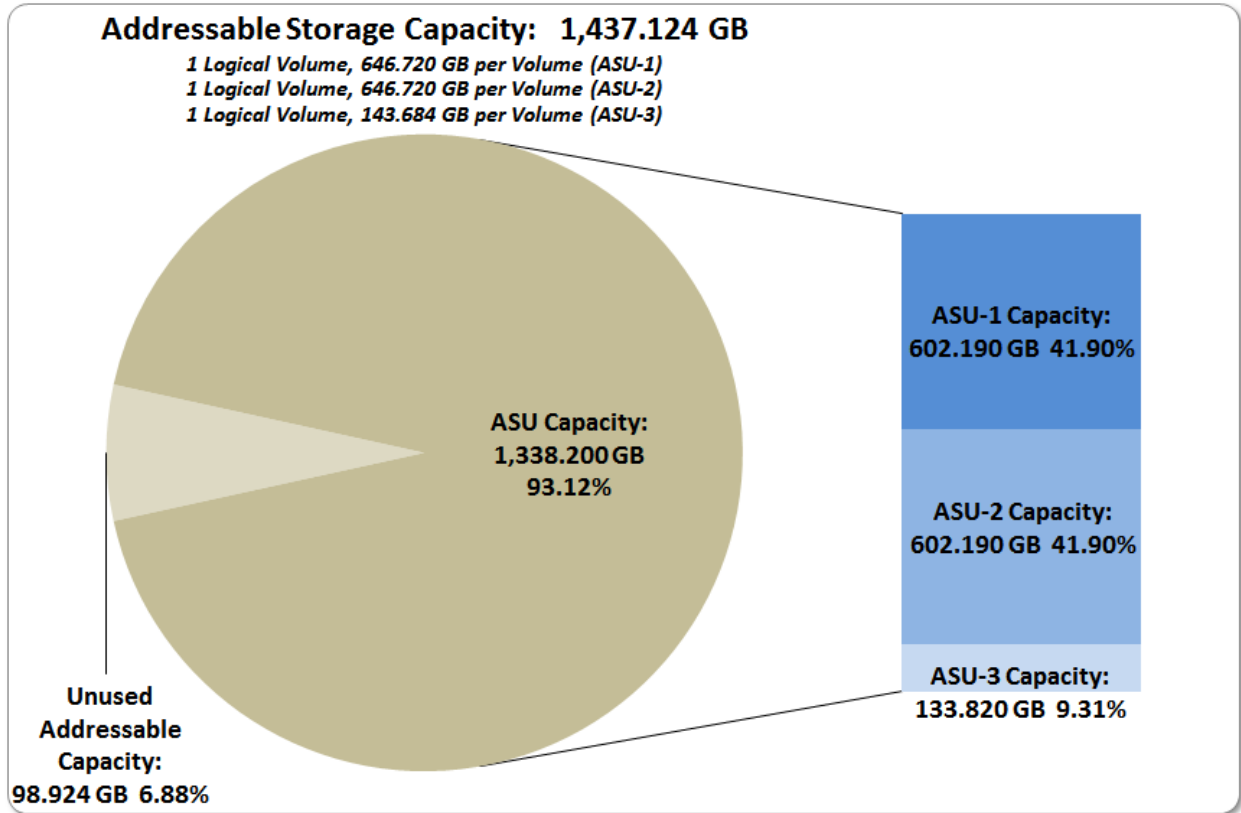
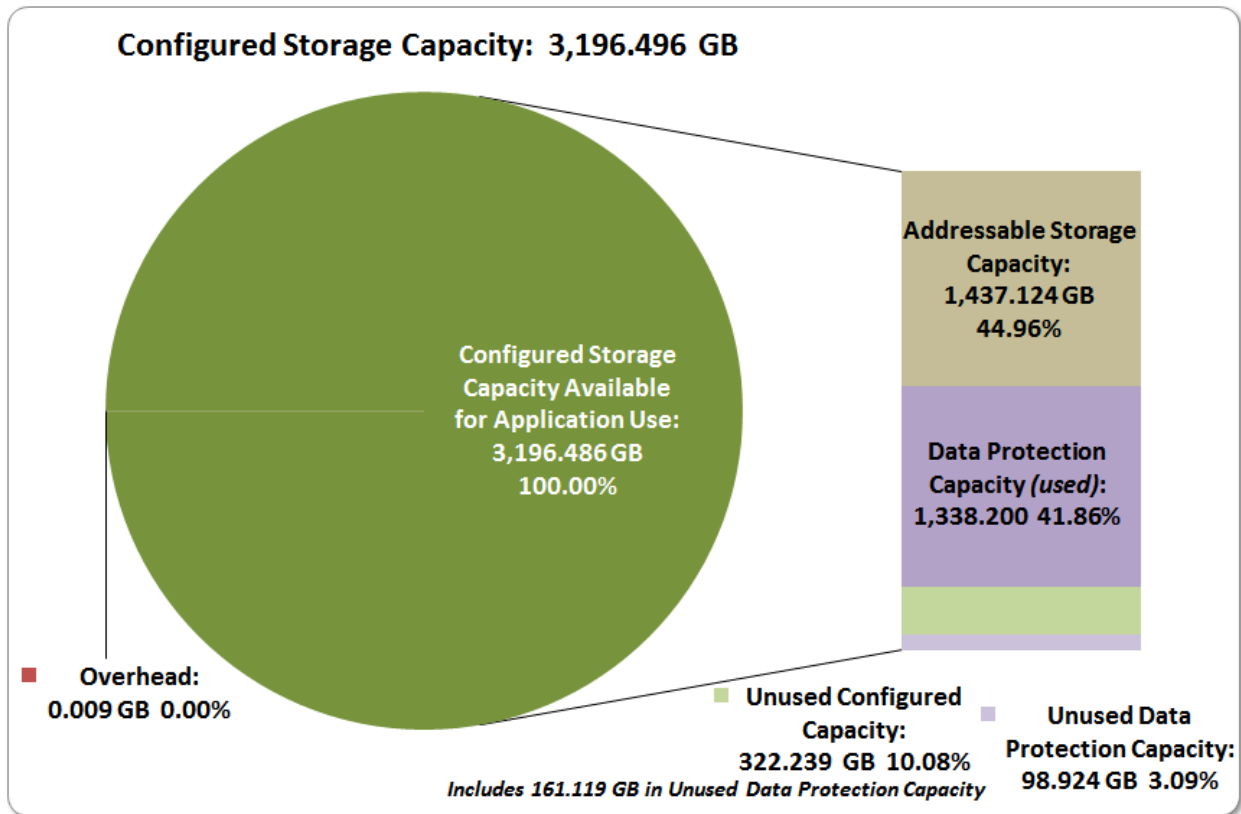
**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

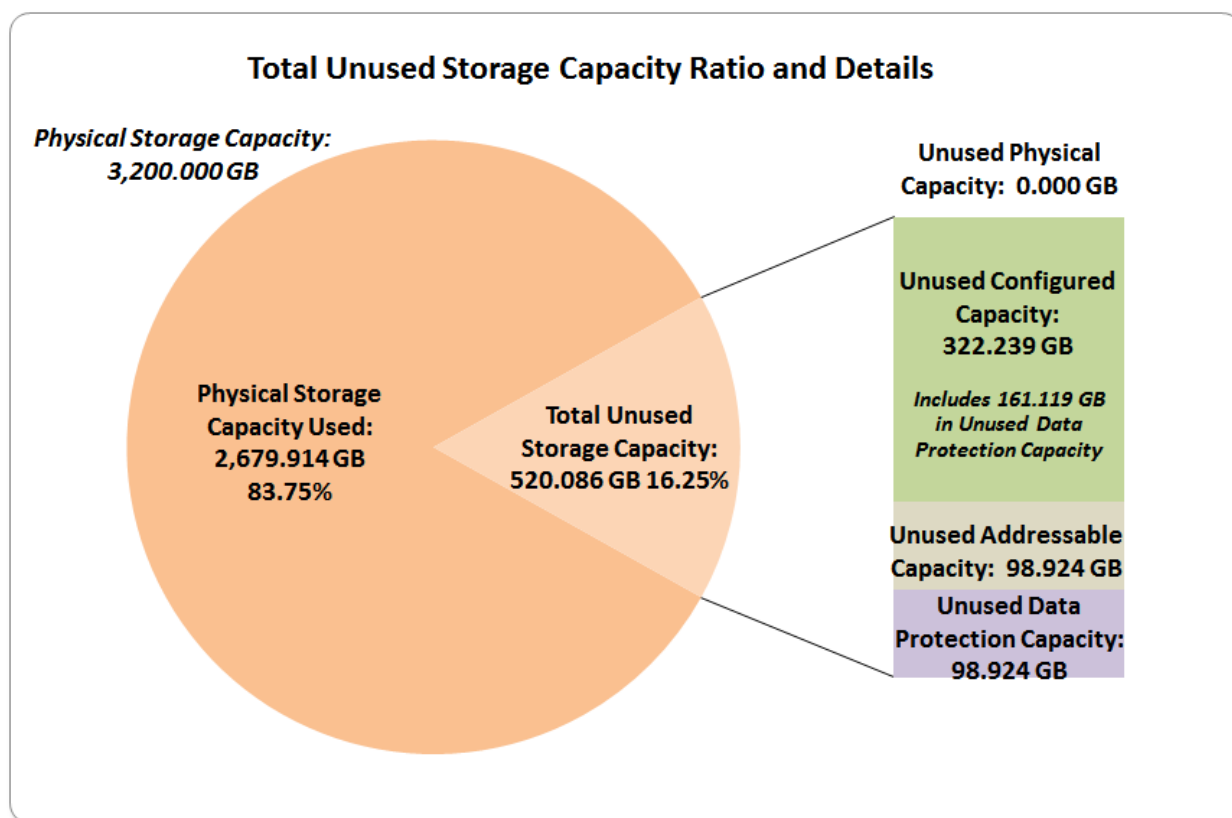
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

### 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	41.82%
Protected Application Utilization	83.64%
Unused Storage Ratio	16.25%

**Application Utilization:** Total ASU Capacity (1,338.200 GB) divided by Physical Storage Capacity (3,200.000 GB).

**Protected Application Utilization:** (Total ASU Capacity (1,338.200 GB) plus total Data Protection Capacity (1,598.243 GB) minus unused Data Protection Capacity (260.043 GB)) divided by Physical Storage Capacity (3,200.000 GB).

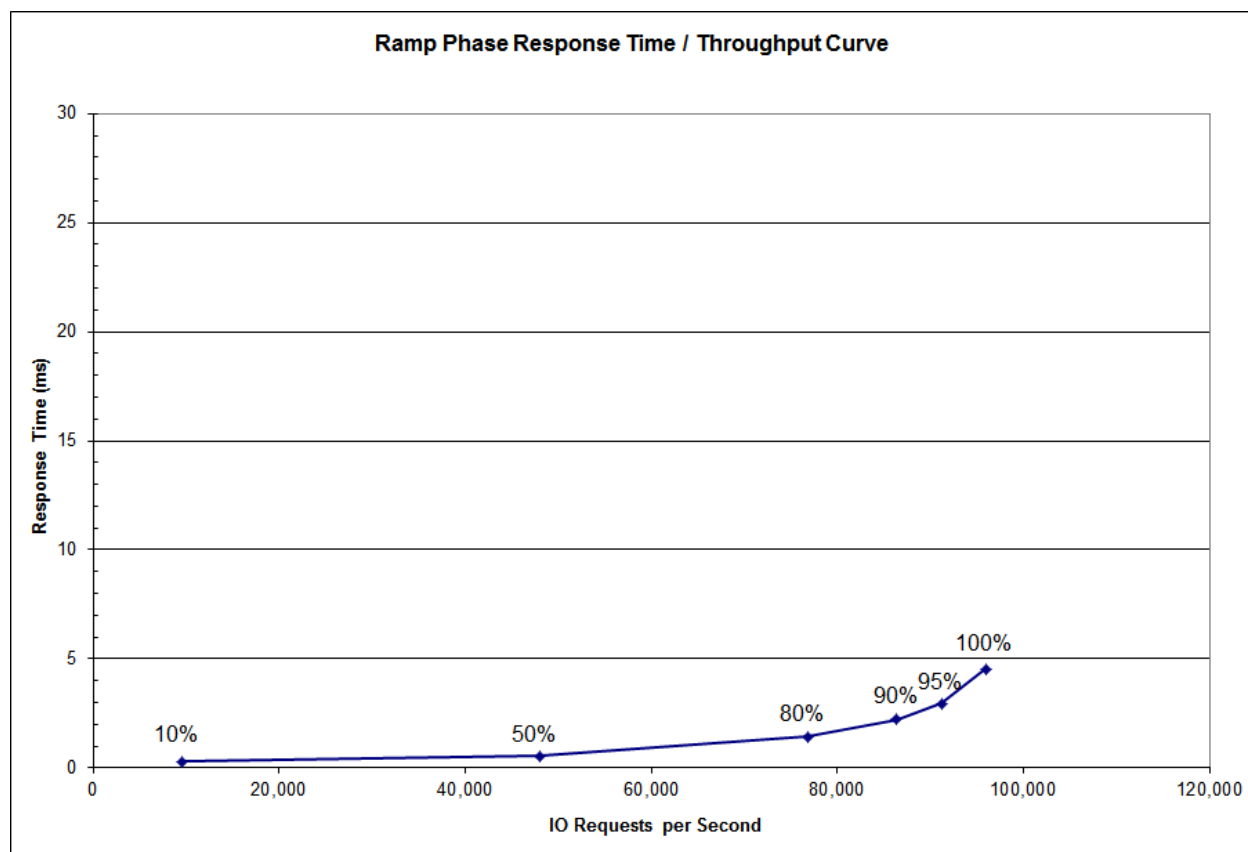
**Unused Storage Ratio:** Total Unused Capacity (520.086GB) divided by Physical Storage Capacity (3,200.000 GB) and may not exceed 45%.

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

## Response Time – Throughput Curve

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

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



## Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
<b>I/O Request Throughput</b>	9,595.20	48,006.71	76,810.89	86,400.39	91,188.55	95,994.33
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	0.29	0.55	1.42	2.23	2.95	4.53
<b>ASU-1</b>	0.28	0.55	1.63	2.67	3.62	5.78
<b>ASU-2</b>	0.27	0.47	0.88	1.21	1.49	2.04
<b>ASU-3</b>	0.32	0.60	1.21	1.74	2.18	2.99
<b>Reads</b>	0.25	0.47	1.25	1.99	2.67	4.30
<b>Writes</b>	0.31	0.60	1.53	2.39	3.14	4.69

## Priced Storage Configuration Pricing

P/N	Description	Q'ty	MSRP	Extended Price
DS2024R0CB00B	EonStor DS 2000 2U/24bay, Dual Redundant controller subsystem including 2x6Gb SAS EXP. Ports, 8x1G iSCSI ports +2x host board slot(s), 2x2GB, 2x(PeS+Fan Module), 2x (Super capacitor+Flash module), 24xHDD trays and 1xRackmount kit	1	\$7,740.00	\$7,740.00
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	16	\$895.00	\$14,320.00
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
DS2024BSK-0010	EonStor DS 2024B spare kit including 1 x RAID Controller, 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	\$6,113.00	\$6,113.00
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
DDR3NNCMD-0010	8GB DDR-III DIM module for ESDS G7i, ESDS 3000/1000/2000 and ESVA x75 subsystems	4	\$200.00	\$800.00
BH1EMF311-0010	HBA card, LPe16002B, FC-16G, Dual ports, 1 in 1 package	2	\$1,921.00	\$3,842.00
	<b>Total</b>			<b>\$41,167.00</b>

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 Priced Storage Configuration that can be remedied by the repair or replacement of a Priced Storage Configuration component.

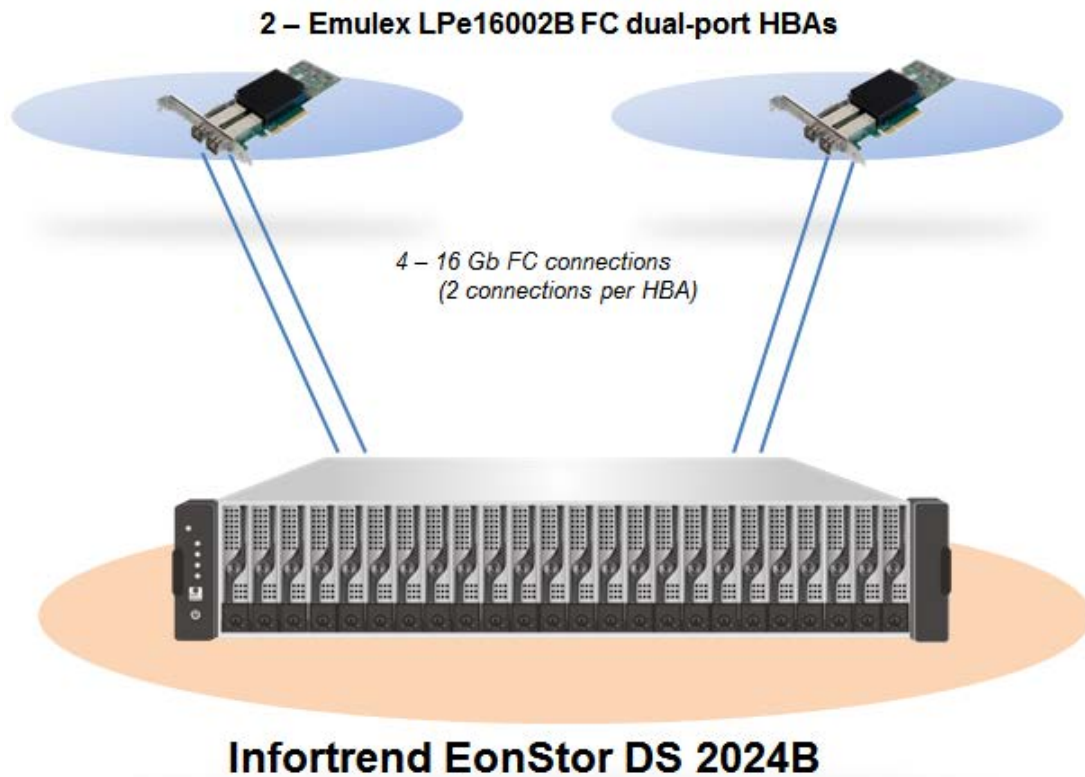
The above pricing also includes a spare kit with the components that the customer are required to have available in the case of any hardware failure (*"Parts are prepared by customer"*).

## 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**



**Dual Redundant controller system  
with 16 GB cache per controller  
(32 GB total)  
4 – 16 Gb FC ports (2 ports/controller)  
16 – 6 Gb SAS connections  
16 – 200 GB, 12Gb, 2.5” Toshiba  
PX02SMF020 MLC SSDs**

**Priced Storage Configuration Components**

<b>Priced Storage Configuration</b>
2 – Emulex LPe16002B-FC dual port 16Gb FC HBAs
<b>Infortrend EonStor DS 2024B</b>
Dual Redundant controller subsystem 16 GB cache per controller (32 GB total) 4 – 16Gb FC ports (2 ports per controller, 4 ports used) 16 – backend 6Gb SAS connections (16 connections used) 16 – 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 [19 \(Benchmark Configuration/Tested Storage Configuration Diagram\)](#).

### **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 [20 \(Host System and Tested Storage Configuration Components\)](#).

**Benchmark Configuration/Tested Storage Configuration Diagram**

**1 – Dell PowerEdge R610 rack server**

**2 – Emulex LPe16002B FC dual-port HBAs**



*4 – 16 Gb FC connections  
(2 connections per HBA)*

**Infotrend EonStor DS 2024B**

**Dual Redundant controller system  
with 16 GB cache per controller  
(32 GB total)**

**4 – 16 Gb FC ports (2 ports/controller)**

**16 – 6 Gb SAS connections**

**16 – 200 GB, 12Gb, 2.5" Toshiba  
PX02SMF020 MLC SSDs**

## Host System and Tested Storage Configuration Components

<b>Host System</b>
<p><b>1 – Dell PowerEdge R610 rack server</b></p> <ul style="list-style-type: none"> <li>2 – Intel® Xeon® 2.00 GHz E5606 processors 4 cores per processor and 8 MB Intel® Smart Cache</li> <li>32 GB main memory</li> <li>Windows Server 2008 R2 Enterprise</li> <li>PCIe</li> </ul>
<b>Tested Storage Configuration (TSC) Components</b>
<p>2 – Emulex LPe16002B-FC dual port 16Gb FC HBAs</p>
<p><b>Infortrend EonStor DS 2024B</b></p> <ul style="list-style-type: none"> <li>Dual Redundant controller subsystem 16 GB cache per controller (<i>32 GB total</i>)</li> <li>4 – 16Gb FC ports (<i>2 ports per controller, 4 ports used</i>)</li> <li>16 – backend 6Gb SAS connections (<i>16 connections used</i>)</li> <li>16 – 200 GB 12Gb 2.5" Toshiba PX02SMF020 MLC SSDs</li> </ul>

## 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 64 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 65 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 81.

## 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 [81](#).

## **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 [60](#) 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 3,200.000 GB distributed over 16 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 3.504 GB (0.11%) of the Physical Storage Capacity. There was 322.239 GB (10.08%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 93.12% of the Addressable Storage Capacity resulting in 98.924 GB (6.86%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*Mirroring*) capacity was 1,598.243 GB of which 1,338.200 GB was utilized. The total Unused Storage capacity was 520.086 GB.

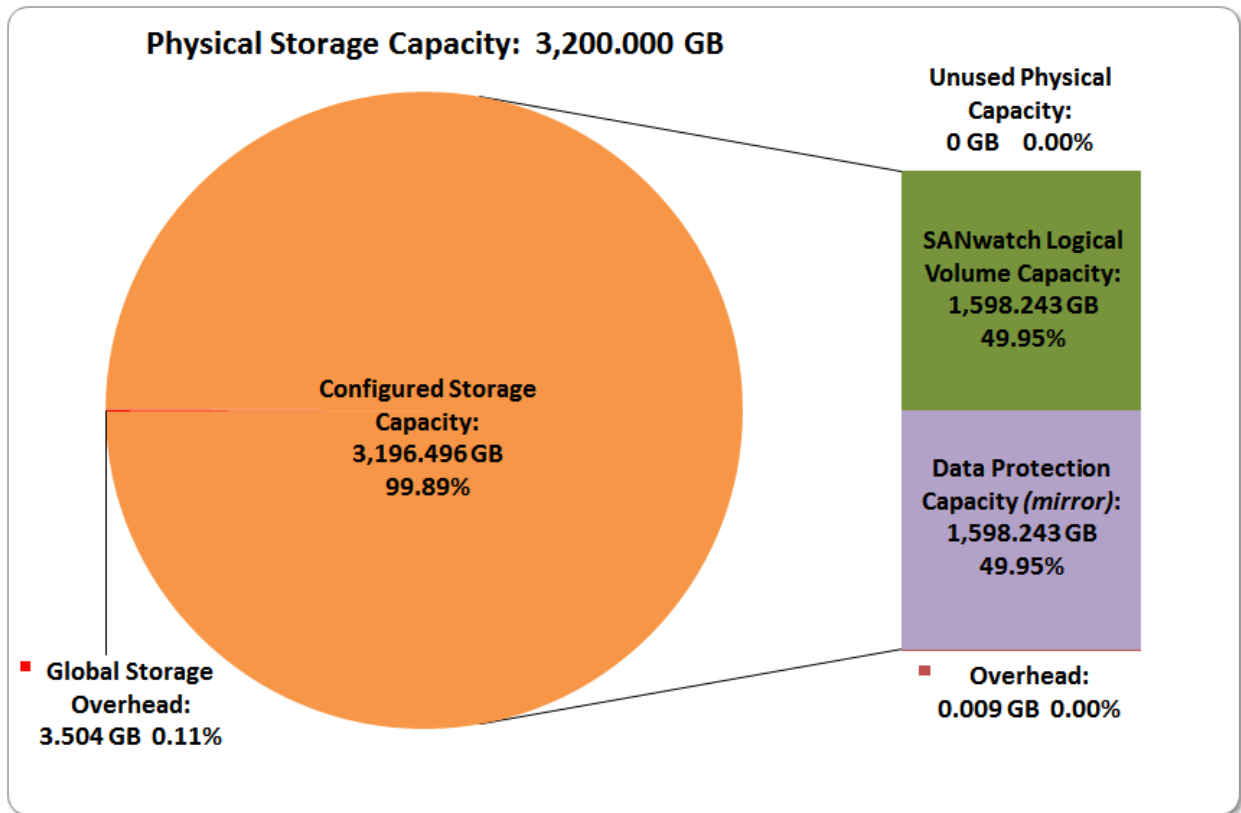
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

<b>SPC-1 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	1,338.200
Addressable Storage Capacity	Gigabytes (GB)	1,437.124
Configured Storage Capacity	Gigabytes (GB)	3,196.496
Physical Storage Capacity	Gigabytes (GB)	3,200.000
Data Protection ( <i>Mirroring</i> )	Gigabytes (GB)	1,598.243
Required Storage	Gigabytes (GB)	0.009
Global Storage Overhead	Gigabytes (GB)	3.504
Total Unused Storage	Gigabytes (GB)	520.086

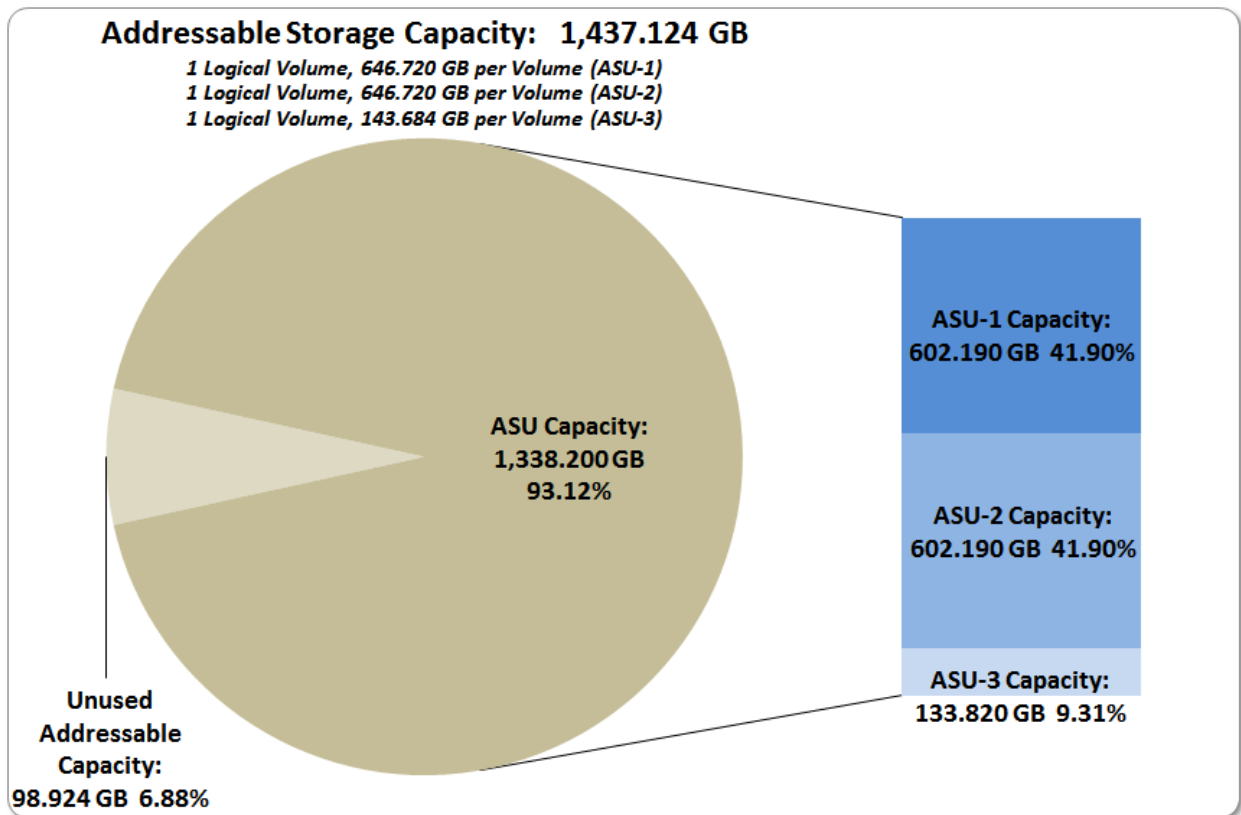
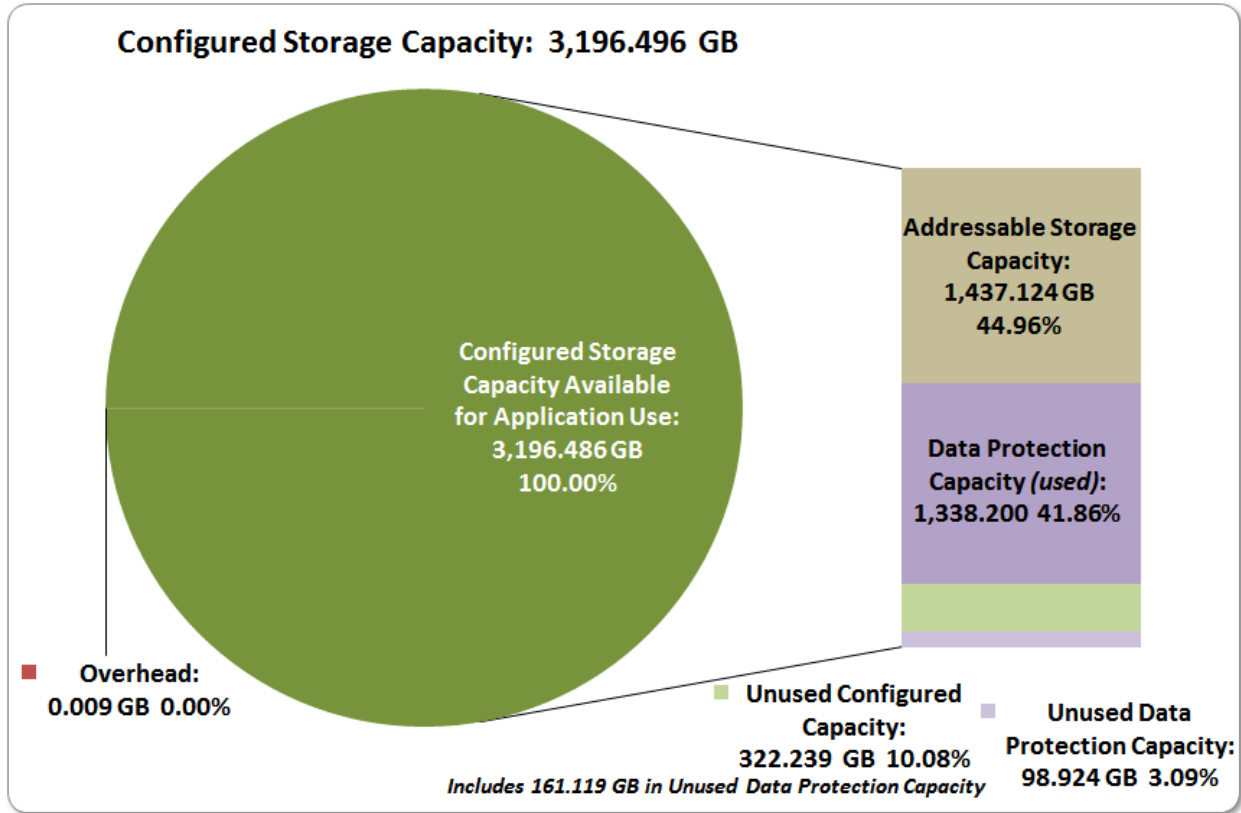
SPC-1 Storage Hierarchy Ratios

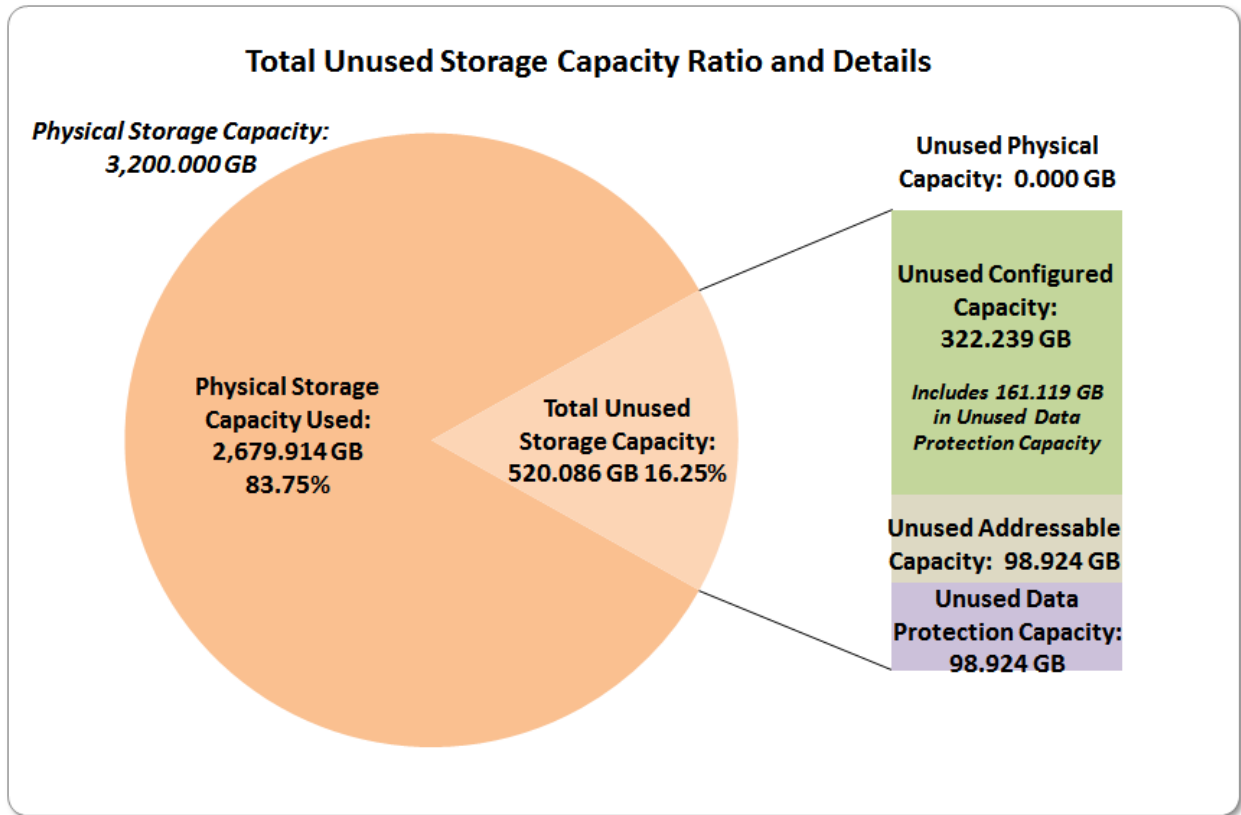
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	93.12%	41.86%	41.82%
Required for Data Protection ( <i>Mirroring</i> )		50.00%	49.95%
Addressable Storage Capacity		44.96%	44.91%
Required Storage		0.00%	0.00%
Configured Storage Capacity			99.89%
Global Storage Overhead			0.11%
Unused Storage:			
Addressable	6.86%		
Configured		10.08%	
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	41.82%
Protected Application Utilization	83.64%
Unused Storage Ratio	16.25%

## 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 (602.190 GB)	ASU-2 (602.190 GB)	ASU-3 (113.820 GB)
1 Logical Volumes 646.720 GB per Logical Volume (602.190 GB used per Logical Volume)	1 Logical Volumes 646.720 GB per Logical Volume (602.190 GB used per Logical Volume)	1 Logical Volumes 143.684 GB per Logical Volume (133.820 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 2](#) 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 60 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 [82](#).

### Sustainability Test Results File

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

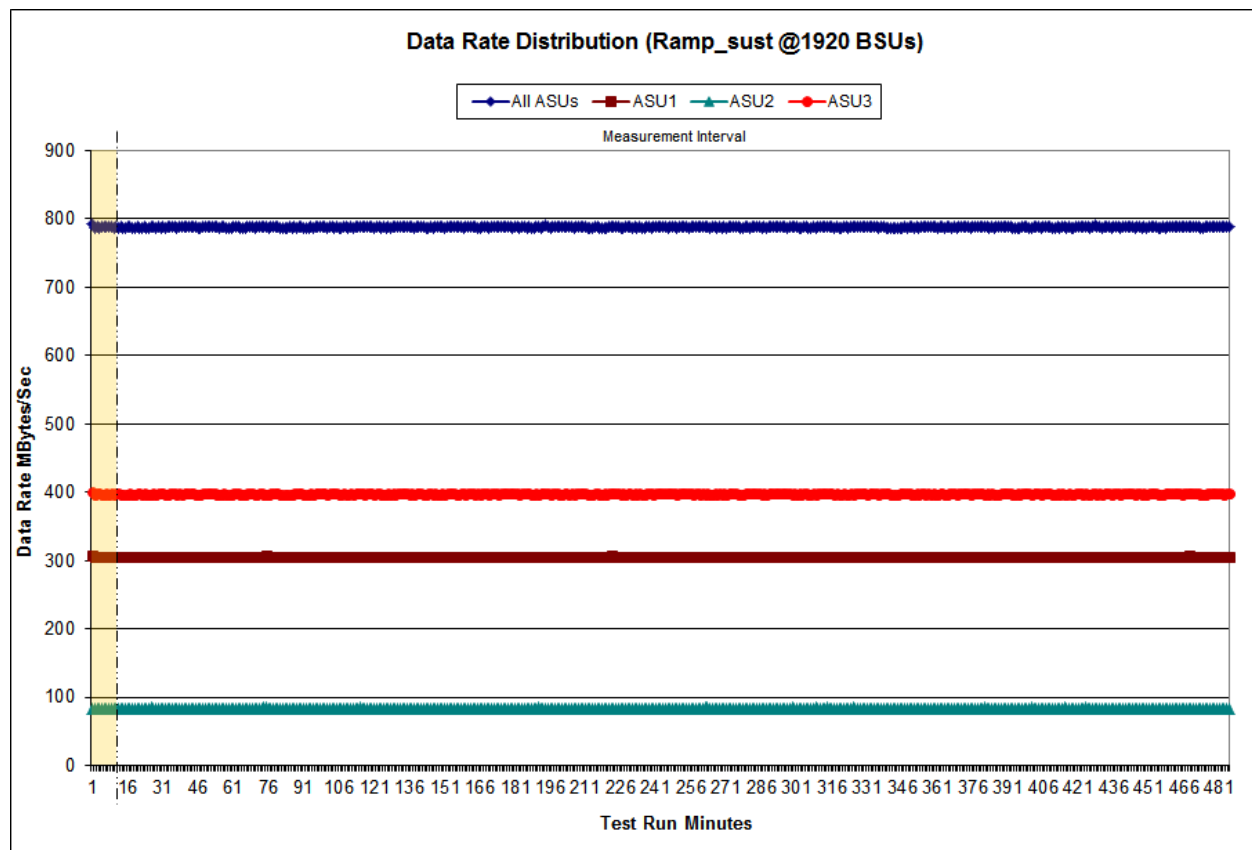
[Sustainability Test Results File](#)

### 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

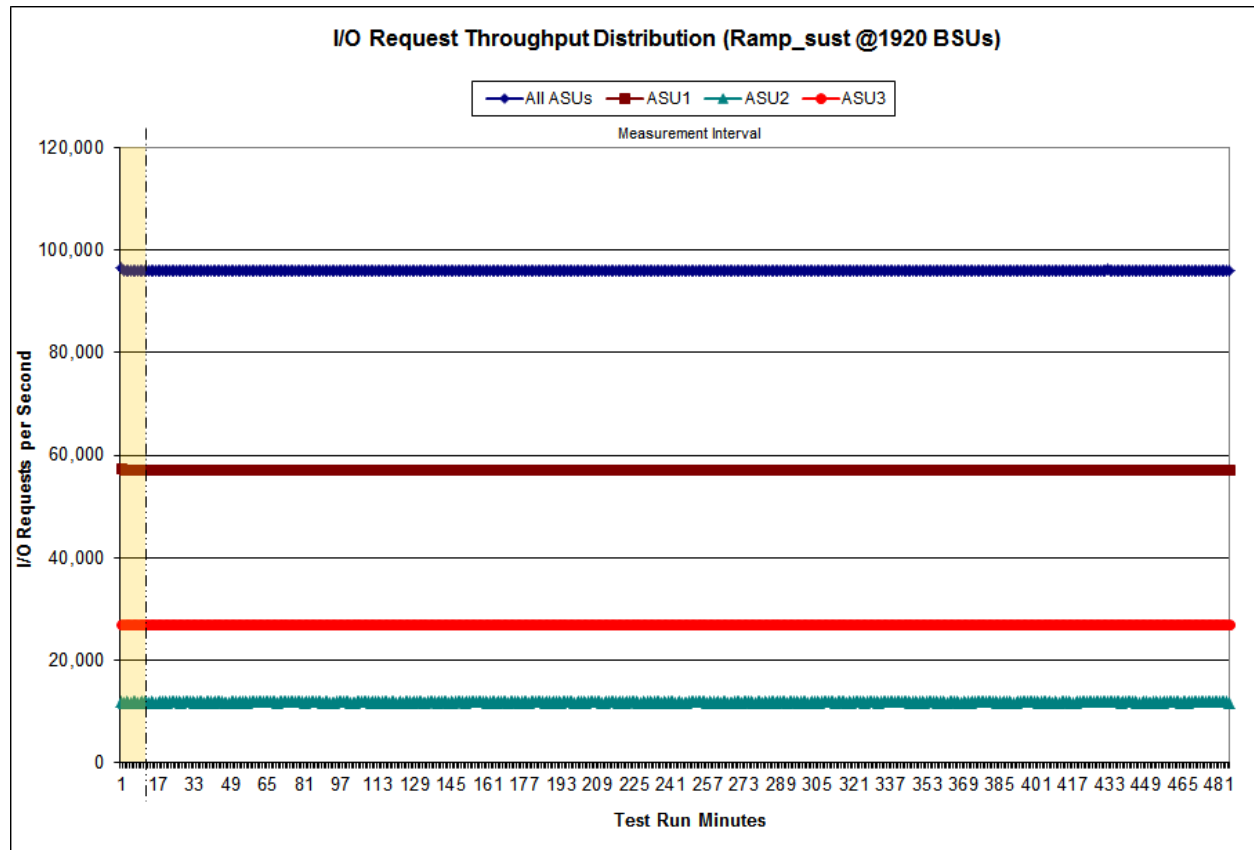


### Sustainability – I/O Request Throughput Distribution Data

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

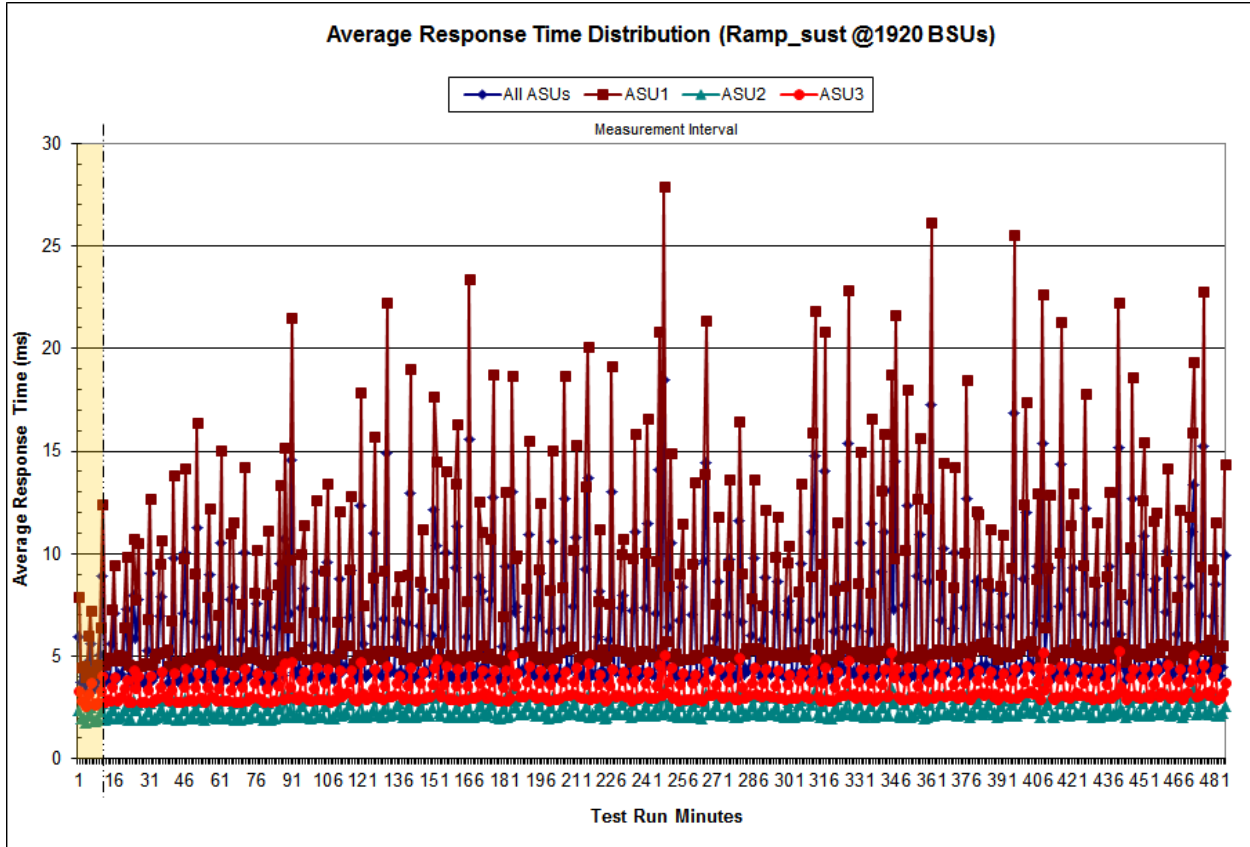


### Sustainability – Average Response Time (ms) Distribution Data

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

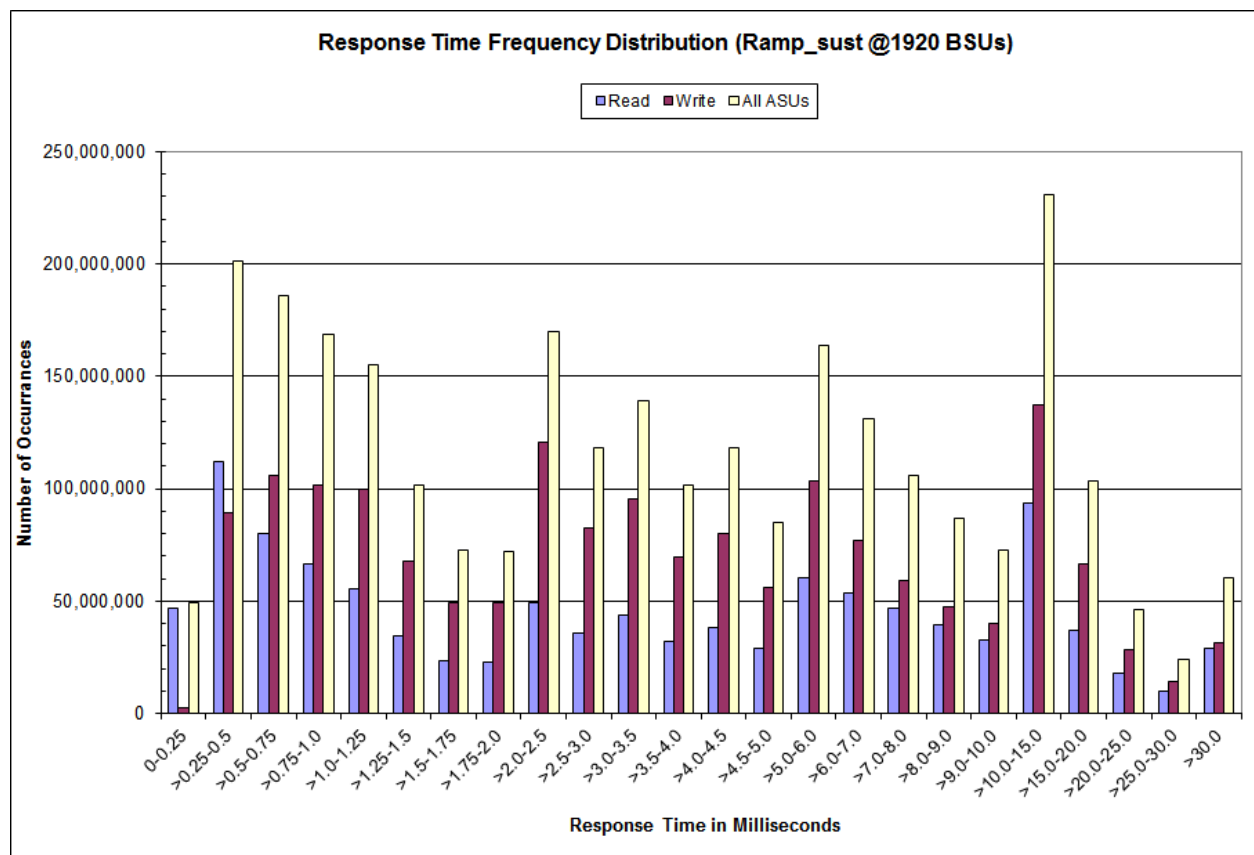




**Sustainability – Response Time Frequency Distribution Data**

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	46,907,707	112,045,539	80,182,849	66,584,986	55,375,434	34,277,982	23,717,547	22,741,536
Write	2,693,866	89,224,029	105,980,103	101,823,640	99,596,850	67,541,480	49,056,499	49,390,449
All ASUs	49,601,573	201,269,568	186,162,952	168,408,626	154,972,284	101,819,462	72,774,046	72,131,985
ASU1	17,073,203	96,712,971	102,594,093	93,487,018	82,233,078	46,139,225	31,474,109	31,360,573
ASU2	30,485,417	52,075,437	31,082,820	25,785,396	25,311,679	18,780,544	12,594,727	11,529,658
ASU3	2,042,953	52,481,160	52,486,039	49,136,212	47,427,527	36,899,693	28,705,210	29,241,754
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	49,275,223	35,583,482	43,769,862	32,052,057	38,214,152	28,798,745	60,579,809	53,815,955
Write	120,744,251	82,546,966	95,573,558	69,571,248	80,261,137	56,053,872	103,239,228	77,080,729
All ASUs	170,019,474	118,130,448	139,343,420	101,623,305	118,475,289	84,852,617	163,819,037	130,896,684
ASU1	72,219,465	48,914,809	60,549,285	44,730,785	55,483,480	42,618,529	93,268,388	86,526,694
ASU2	24,959,902	16,701,030	17,512,731	11,915,356	12,601,382	8,332,904	13,629,816	8,479,658
ASU3	72,840,107	52,514,609	61,281,404	44,977,164	50,390,427	33,901,184	56,920,833	35,890,332
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	46,634,816	39,535,132	32,966,907	93,340,299	37,174,241	18,055,499	10,048,991	28,738,796
Write	59,262,562	47,504,268	39,794,568	137,220,314	66,344,185	28,337,304	14,011,239	31,573,240
All ASUs	105,897,378	87,039,400	72,761,475	230,560,613	103,518,426	46,392,803	24,060,230	60,312,036
ASU1	78,354,262	69,855,473	61,883,997	210,498,952	97,276,959	43,824,006	22,941,009	57,788,362
ASU2	5,271,681	3,330,465	2,163,540	4,409,172	1,536,901	626,392	277,654	683,107
ASU3	22,271,435	13,853,462	8,713,938	15,652,489	4,704,566	1,942,405	841,567	1,840,567

**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	0.2180
COV	0.002	0.001	0.001	0.001	0.003	0.001	0.002	0.001

## 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 [82](#).

## IOPS Test Results File

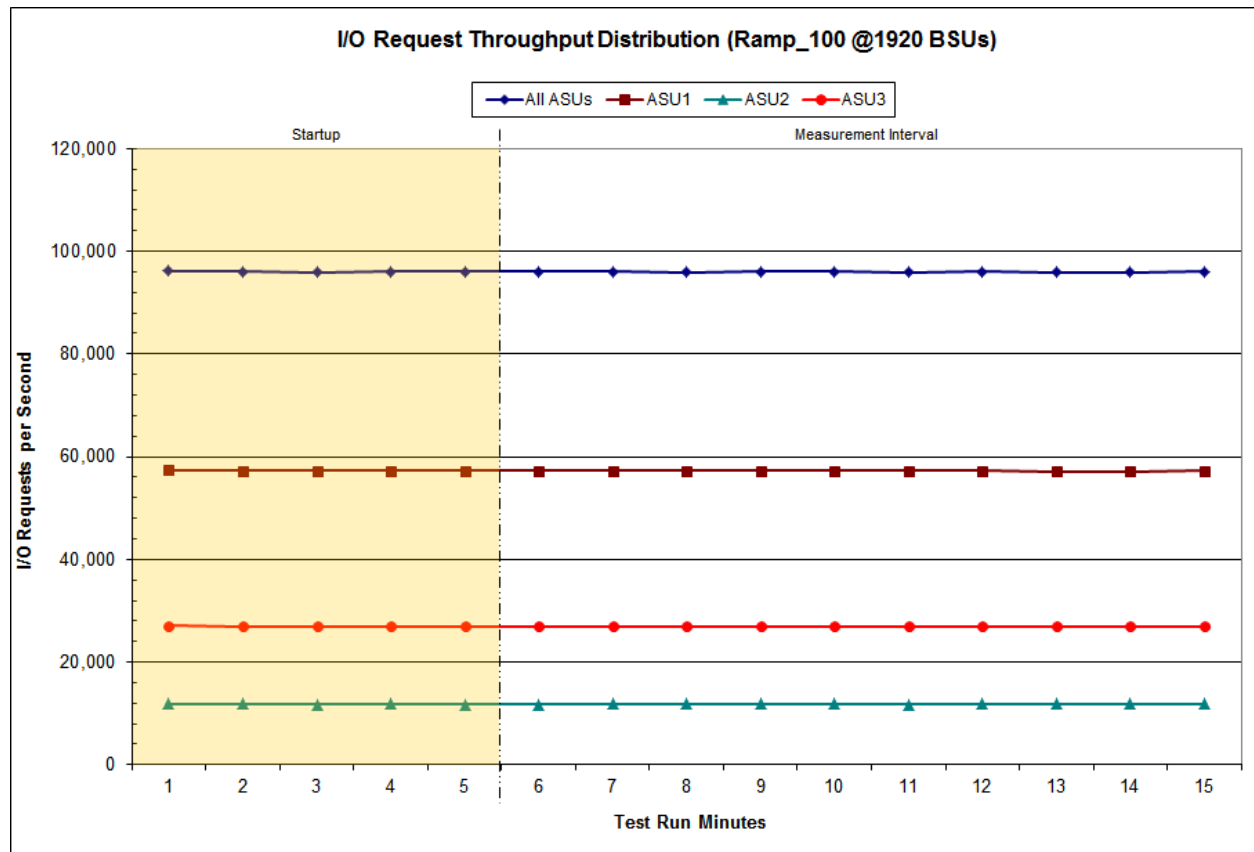
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

**IOPS Test Run – I/O Request Throughput Distribution Data**

1,920 BSUs				
	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	16:14:41	16:19:42	0-4	0:05:01
<i>Measurement Interval</i>	16:19:42	16:29:42	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	96,241.38	57,350.83	11,828.18	27,062.37
1	96,028.98	57,225.08	11,836.10	26,967.80
2	95,949.28	57,249.87	11,790.62	26,908.80
3	96,016.48	57,214.75	11,811.45	26,990.28
4	96,018.40	57,253.00	11,797.03	26,968.37
5	95,992.70	57,222.00	11,790.32	26,980.38
6	96,028.85	57,250.92	11,802.57	26,975.37
7	95,973.68	57,202.80	11,807.57	26,963.32
8	96,005.43	57,212.12	11,810.88	26,982.43
9	96,036.08	57,211.77	11,831.37	26,992.95
10	95,973.38	57,234.13	11,797.80	26,941.45
11	96,002.25	57,211.20	11,818.13	26,972.92
12	95,948.82	57,142.22	11,811.82	26,994.78
13	95,964.93	57,183.22	11,803.18	26,978.53
14	96,017.20	57,200.05	11,807.57	27,009.58
<b>Average</b>	<b>95,994.33</b>	<b>57,207.04</b>	<b>11,808.12</b>	<b>26,979.17</b>

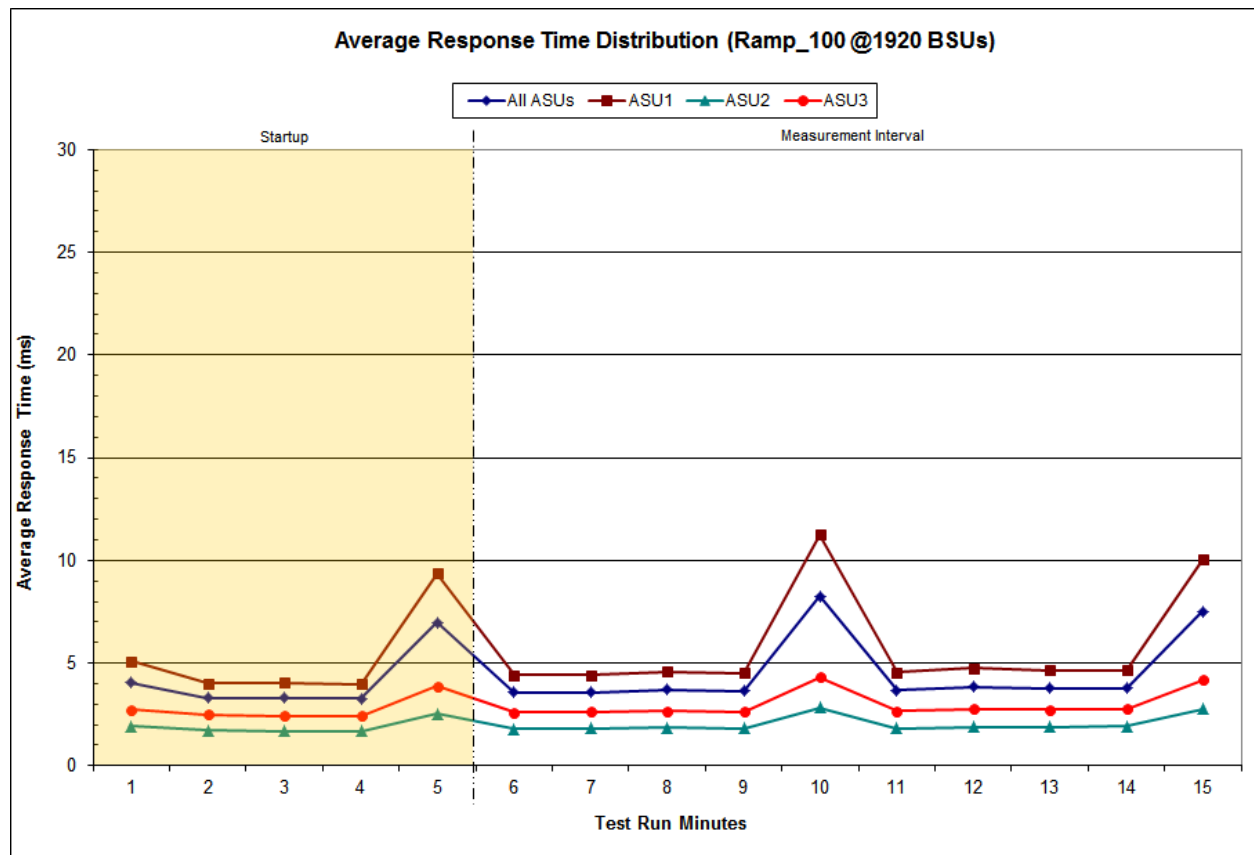
**IOPS Test Run – I/O Request Throughput Distribution Graph**



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

1,920 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	16:14:41	16:19:42	0-4	0:05:01
<i>Measurement Interval</i>	16:19:42	16:29:42	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4.03	5.07	1.94	2.74
1	3.30	4.02	1.71	2.48
2	3.31	4.05	1.69	2.44
3	3.27	3.99	1.67	2.43
4	6.99	9.37	2.54	3.87
5	3.57	4.40	1.79	2.59
6	3.58	4.40	1.81	2.61
7	3.70	4.58	1.84	2.66
8	3.65	4.51	1.83	2.64
9	8.27	11.25	2.83	4.32
10	3.68	4.54	1.82	2.66
11	3.85	4.76	1.90	2.76
12	3.77	4.65	1.88	2.73
13	3.78	4.65	1.91	2.75
14	7.50	10.05	2.75	4.18
<b>Average</b>	<b>4.53</b>	<b>5.78</b>	<b>2.04</b>	<b>2.99</b>

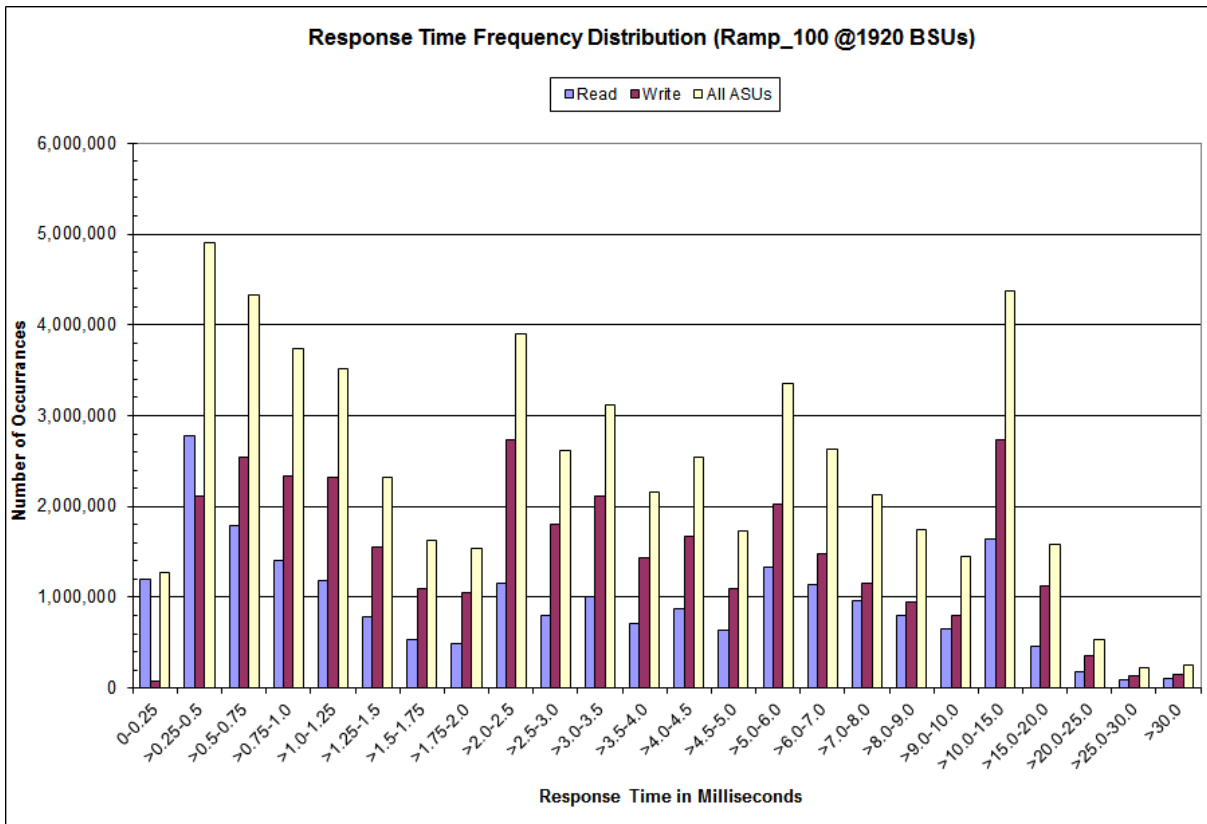
**IOPS Test Run – Average Response Time (ms) Distribution Graph**



**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	1,200,453	2,782,024	1,787,808	1,402,722	1,186,463	778,071	531,239	487,817
Write	78,308	2,119,666	2,542,645	2,341,718	2,327,482	1,547,236	1,097,010	1,051,999
All ASUs	1,278,761	4,901,690	4,330,453	3,744,440	3,513,945	2,325,307	1,628,249	1,539,816
ASU1	504,793	2,472,795	2,389,413	2,089,711	1,855,692	1,060,572	713,249	675,680
ASU2	714,289	1,167,623	688,086	545,506	553,479	409,266	265,451	234,356
ASU3	59,679	1,261,272	1,252,954	1,109,223	1,104,774	855,469	649,549	629,780
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	1,161,324	807,172	1,013,824	716,641	869,630	637,217	1,327,822	1,143,231
Write	2,732,640	1,809,869	2,109,965	1,440,219	1,676,132	1,091,811	2,022,813	1,484,908
All ASUs	3,893,964	2,617,041	3,123,789	2,156,860	2,545,762	1,729,028	3,350,635	2,628,139
ASU1	1,704,947	1,131,392	1,434,078	1,027,527	1,294,190	965,121	2,099,147	1,894,145
ASU2	540,138	346,873	365,781	230,553	244,522	147,492	236,126	137,048
ASU3	1,648,879	1,138,776	1,323,930	898,780	1,007,050	616,415	1,015,362	596,946
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	968,640	804,402	652,722	1,635,349	461,497	174,290	83,858	100,143
Write	1,154,739	947,286	803,033	2,730,825	1,121,138	353,744	140,325	156,196
All ASUs	2,123,379	1,751,688	1,455,755	4,366,174	1,582,635	528,034	224,183	256,339
ASU1	1,686,923	1,486,476	1,291,821	4,078,957	1,511,176	503,244	214,586	238,221
ASU2	82,299	50,805	32,449	62,377	17,027	5,973	2,333	4,975
ASU3	354,157	214,407	131,485	224,840	54,432	18,817	7,264	13,143

**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
57,596,066	57,339,727	256,339

### 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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.003	0.002	0.002	0.001

## 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 [82](#).

## Response Time Ramp Test Results File

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

[95% Load Level](#)

[90% Load Level](#)

[80% Load Level](#)

[50% Load Level](#)

[10% Load Level](#)



### Response Time Ramp Distribution (IOPS) Data

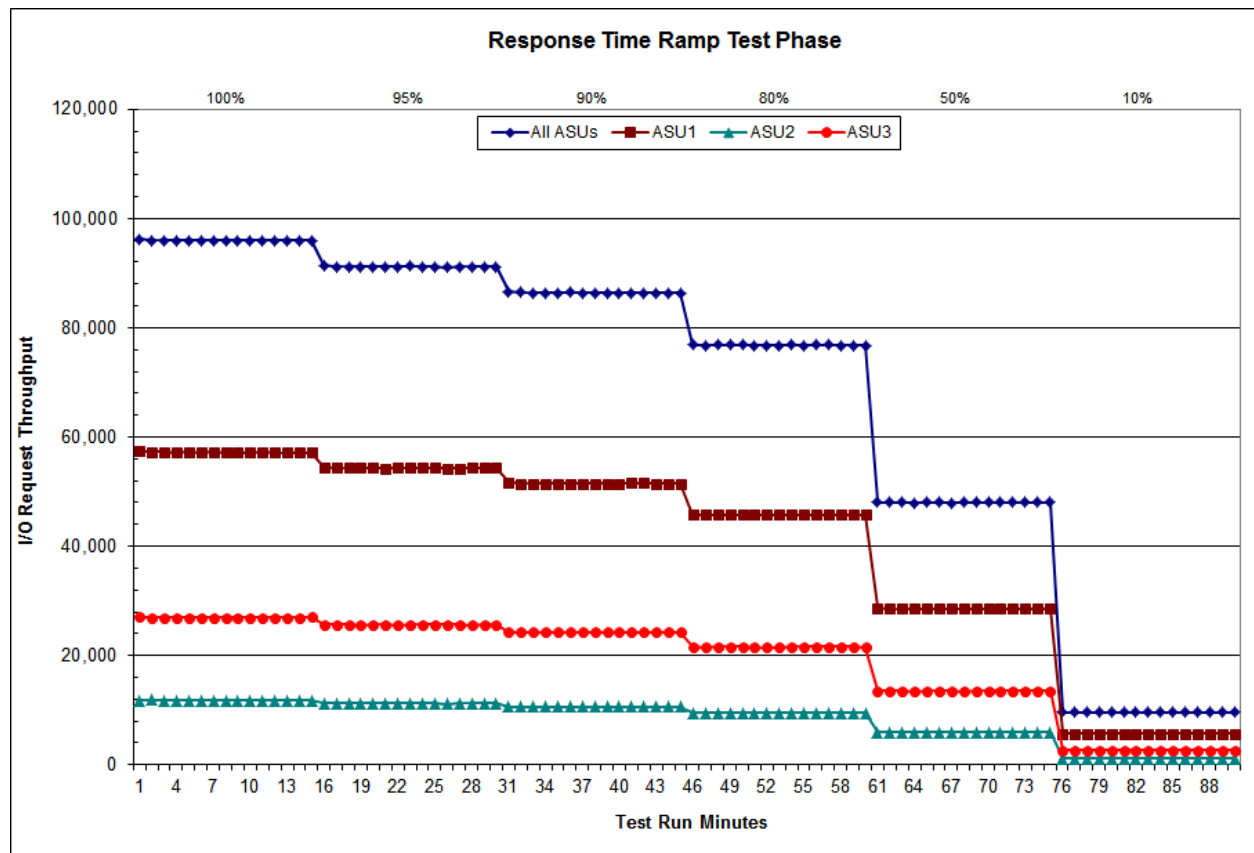
The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data table and graph for completeness.

100% Load Level: 1,920 BSUs					95% Load Level: 1,824 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:14:41	16:19:42	0-4	0:05:01	Start-Up/Ramp-Up	16:29:57	16:34:58	0-4	0:05:01
Measurement Interval	16:19:42	16:29:42	5-14	0:10:00	Measurement Interval	16:34:58	16:44:58	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	96,241.38	57,350.83	11,828.18	27,062.37	0	91,386.12	54,477.20	11,247.85	25,661.07
1	96,028.98	57,225.08	11,836.10	26,967.80	1	91,206.95	54,361.93	11,219.70	25,625.32
2	95,949.28	57,249.87	11,790.62	26,908.80	2	91,178.73	54,343.85	11,208.55	25,626.33
3	96,016.48	57,214.75	11,811.45	26,990.28	3	91,200.15	54,375.52	11,235.03	25,589.60
4	96,018.40	57,253.00	11,797.03	26,968.37	4	91,195.97	54,364.48	11,211.80	25,619.68
5	95,992.70	57,222.00	11,790.32	26,980.38	5	91,189.15	54,313.62	11,228.58	25,646.95
6	96,028.85	57,250.92	11,802.57	26,975.37	6	91,130.37	54,327.00	11,213.63	25,589.73
7	95,973.68	57,202.80	11,807.57	26,963.32	7	91,249.95	54,412.30	11,221.37	25,616.28
8	96,005.43	57,212.12	11,810.88	26,982.43	8	91,232.32	54,387.85	11,209.02	25,635.45
9	96,036.08	57,211.77	11,831.37	26,992.95	9	91,231.33	54,374.75	11,235.80	25,620.78
10	95,973.38	57,234.13	11,797.80	26,941.45	10	91,102.20	54,273.52	11,201.22	25,627.47
11	96,002.25	57,211.20	11,818.13	26,972.92	11	91,180.32	54,302.92	11,237.48	25,639.92
12	95,948.82	57,142.22	11,811.82	26,994.78	12	91,189.12	54,372.33	11,233.78	25,583.00
13	95,964.93	57,183.22	11,803.18	26,978.53	13	91,186.65	54,343.98	11,220.32	25,622.35
14	96,017.20	57,200.05	11,807.57	27,009.58	14	91,194.05	54,316.20	11,243.38	25,634.47
<b>Average</b>	<b>95,994.33</b>	<b>57,207.04</b>	<b>11,808.12</b>	<b>26,979.17</b>	<b>Average</b>	<b>91,188.55</b>	<b>54,342.45</b>	<b>11,224.46</b>	<b>25,621.64</b>
90% Load Level: 1,728 BSUs					80% Load Level: 1,536 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:45:11	16:50:12	0-4	0:05:01	Start-Up/Ramp-Up	17:00:22	17:05:23	0-4	0:05:01
Measurement Interval	16:50:12	17:00:12	5-14	0:10:00	Measurement Interval	17:05:23	17:15:23	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	86,659.83	51,666.17	10,660.38	24,333.28	0	76,864.42	45,804.75	9,450.63	21,609.03
1	86,441.77	51,527.52	10,625.38	24,288.87	1	76,758.18	45,752.63	9,447.07	21,558.48
2	86,378.20	51,475.22	10,650.42	24,252.57	2	76,842.32	45,807.30	9,450.27	21,584.75
3	86,378.93	51,480.92	10,604.68	24,293.33	3	76,835.53	45,812.67	9,432.85	21,590.02
4	86,341.03	51,467.93	10,600.98	24,272.12	4	76,831.57	45,782.52	9,470.67	21,578.38
5	86,435.35	51,509.38	10,649.25	24,276.72	5	76,805.65	45,784.78	9,455.98	21,564.88
6	86,377.98	51,512.63	10,627.82	24,237.53	6	76,781.90	45,779.53	9,449.02	21,553.35
7	86,420.13	51,501.43	10,637.05	24,281.65	7	76,805.62	45,810.68	9,441.82	21,553.12
8	86,412.85	51,519.40	10,637.63	24,255.82	8	76,834.67	45,802.37	9,453.77	21,578.53
9	86,395.23	51,494.88	10,628.13	24,272.22	9	76,791.77	45,729.03	9,447.75	21,614.98
10	86,410.95	51,539.25	10,621.80	24,249.90	10	76,853.95	45,771.37	9,467.00	21,615.58
11	86,412.18	51,536.18	10,625.60	24,250.40	11	76,848.28	45,829.78	9,440.53	21,577.97
12	86,388.78	51,493.45	10,614.80	24,280.53	12	76,813.18	45,789.30	9,441.33	21,582.55
13	86,343.70	51,446.85	10,621.27	24,275.58	13	76,820.02	45,798.83	9,441.92	21,579.27
14	86,406.75	51,489.37	10,613.67	24,303.72	14	76,753.85	45,753.32	9,444.67	21,555.87
<b>Average</b>	<b>86,400.39</b>	<b>51,504.28</b>	<b>10,627.70</b>	<b>24,268.41</b>	<b>Average</b>	<b>76,810.89</b>	<b>45,784.90</b>	<b>9,448.38</b>	<b>21,577.61</b>

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

50% Load Level: 960 BSUs					10% Load Level: 192 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:15:32	17:20:33	0-4	0:05:01	Start-Up/Ramp-Up	17:30:39	17:35:40	0-4	0:05:01
Measurement Interval	17:20:33	17:30:33	5-14	0:10:00	Measurement Interval	17:35:40	17:45:40	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	48,083.45	28,650.55	5,912.25	13,520.65	0	9,619.20	5,739.30	1,181.88	2,698.02
1	48,020.13	28,600.82	5,912.77	13,506.55	1	9,607.78	5,726.80	1,179.88	2,701.10
2	48,018.58	28,610.30	5,907.88	13,500.40	2	9,602.98	5,732.12	1,186.65	2,684.22
3	47,956.35	28,596.02	5,894.05	13,466.28	3	9,608.28	5,738.33	1,176.53	2,693.42
4	48,014.62	28,605.17	5,914.72	13,494.73	4	9,596.08	5,711.38	1,177.72	2,706.98
5	47,996.18	28,575.65	5,933.90	13,486.63	5	9,582.50	5,712.60	1,177.85	2,692.05
6	47,971.52	28,576.65	5,901.02	13,493.85	6	9,604.28	5,723.00	1,182.48	2,698.80
7	47,995.98	28,631.23	5,898.80	13,465.95	7	9,600.92	5,719.58	1,178.85	2,702.48
8	48,004.43	28,603.60	5,904.17	13,496.67	8	9,590.78	5,717.65	1,175.33	2,697.80
9	47,996.50	28,590.72	5,909.03	13,496.75	9	9,584.62	5,708.88	1,173.05	2,702.68
10	47,999.53	28,607.10	5,899.68	13,492.75	10	9,606.48	5,723.12	1,179.78	2,703.58
11	48,028.42	28,623.32	5,926.37	13,478.73	11	9,601.07	5,728.68	1,185.15	2,687.23
12	48,018.02	28,630.57	5,902.62	13,484.83	12	9,590.17	5,719.03	1,178.67	2,692.47
13	48,033.65	28,620.72	5,919.47	13,493.47	13	9,594.00	5,722.98	1,174.33	2,696.68
14	48,022.82	28,614.77	5,904.37	13,503.68	14	9,597.20	5,715.97	1,180.38	2,700.85
<b>Average</b>	<b>48,006.71</b>	<b>28,607.43</b>	<b>5,909.94</b>	<b>13,489.33</b>	<b>Average</b>	<b>9,595.20</b>	<b>5,719.15</b>	<b>1,178.59</b>	<b>2,697.46</b>

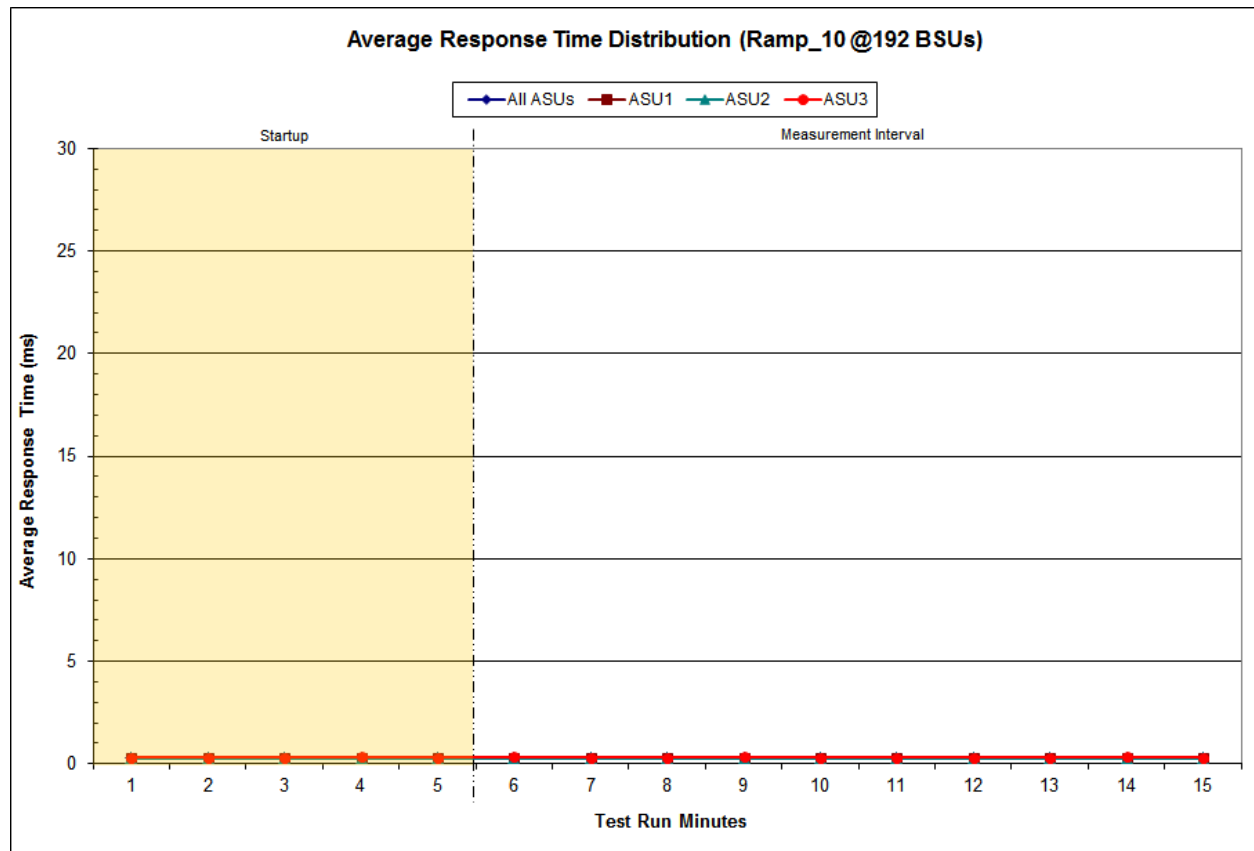
**Response Time Ramp Distribution (IOPS) Graph**



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

192 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:30:39	17:35:40	0-4	0:05:01
<i>Measurement Interval</i>	17:35:40	17:45:40	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.28	0.26	0.27	0.31
1	0.28	0.27	0.27	0.31
2	0.28	0.27	0.27	0.31
3	0.30	0.29	0.28	0.33
4	0.28	0.26	0.27	0.31
5	0.32	0.32	0.29	0.35
6	0.28	0.27	0.27	0.31
7	0.28	0.27	0.27	0.31
8	0.30	0.29	0.28	0.33
9	0.28	0.27	0.27	0.31
10	0.28	0.26	0.27	0.31
11	0.28	0.27	0.27	0.31
12	0.28	0.27	0.27	0.31
13	0.30	0.29	0.28	0.33
14	0.28	0.27	0.27	0.31
<b>Average</b>	<b>0.29</b>	<b>0.28</b>	<b>0.27</b>	<b>0.32</b>

**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	0.0351	0.2808	0.0701	0.2100	0.0179	0.0700	0.0350	0.2811
COV	0.007	0.001	0.003	0.002	0.009	0.005	0.007	0.002

## Repeatability Test

### Clause 5.4.5

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

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

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

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

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

### Clause 9.4.3.7.5

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [82](#).

**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™
<b>Primary Metrics</b>	<b>95,994.33</b>
<b>Repeatability Test Phase 1</b>	96,000.33
<b>Repeatability Test Phase 2</b>	95,987.00

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™
<b>Primary Metrics</b>	<b>0.29 ms</b>
<b>Repeatability Test Phase 1</b>	0.28 ms
<b>Repeatability Test Phase 2</b>	0.27 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).

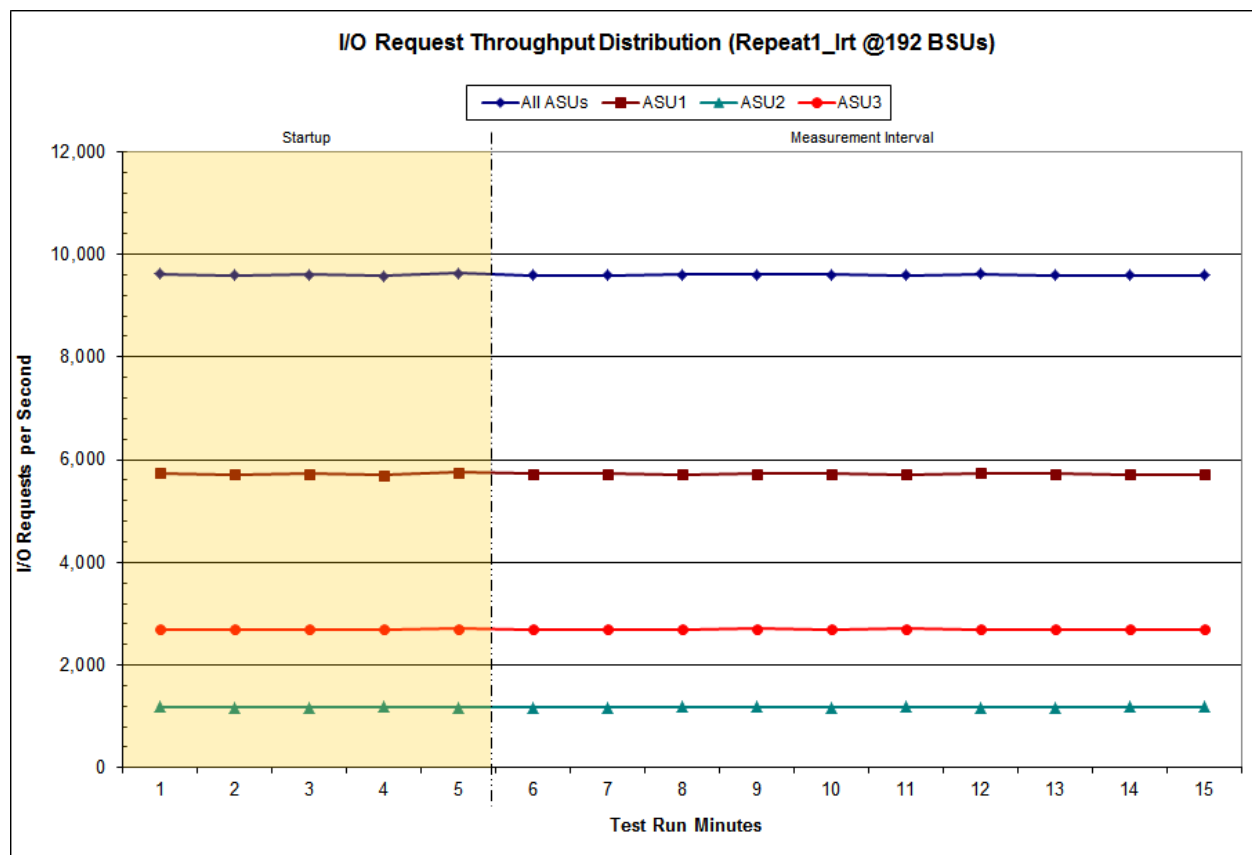
A link to the test result file generated from each Repeatability Test Run is listed below.

- [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**

192 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:45:57	17:50:57	0-4	0:05:00
<i>Measurement Interval</i>	17:50:57	18:00:57	5-14	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
0	9,618.03	5,735.32	1,184.08	2,698.63
1	9,585.67	5,712.50	1,176.60	2,696.57
2	9,599.78	5,721.90	1,178.78	2,699.10
3	9,577.25	5,705.02	1,180.23	2,692.00
4	9,632.00	5,747.90	1,179.97	2,704.13
5	9,585.12	5,719.65	1,173.67	2,691.80
6	9,596.10	5,724.35	1,179.28	2,692.47
7	9,599.87	5,718.35	1,184.10	2,697.42
8	9,609.68	5,724.37	1,182.35	2,702.97
9	9,603.67	5,723.15	1,179.53	2,700.98
10	9,596.65	5,711.23	1,180.48	2,704.93
11	9,611.93	5,737.80	1,178.22	2,695.92
12	9,597.27	5,728.82	1,167.95	2,700.50
13	9,594.80	5,716.92	1,182.75	2,695.13
14	9,592.15	5,712.73	1,186.33	2,693.08
<b>Average</b>	<b>9,598.72</b>	<b>5,721.74</b>	<b>1,179.47</b>	<b>2,697.52</b>

**Repeatability 1 LRT – I/O Request Throughput Distribution Graph**



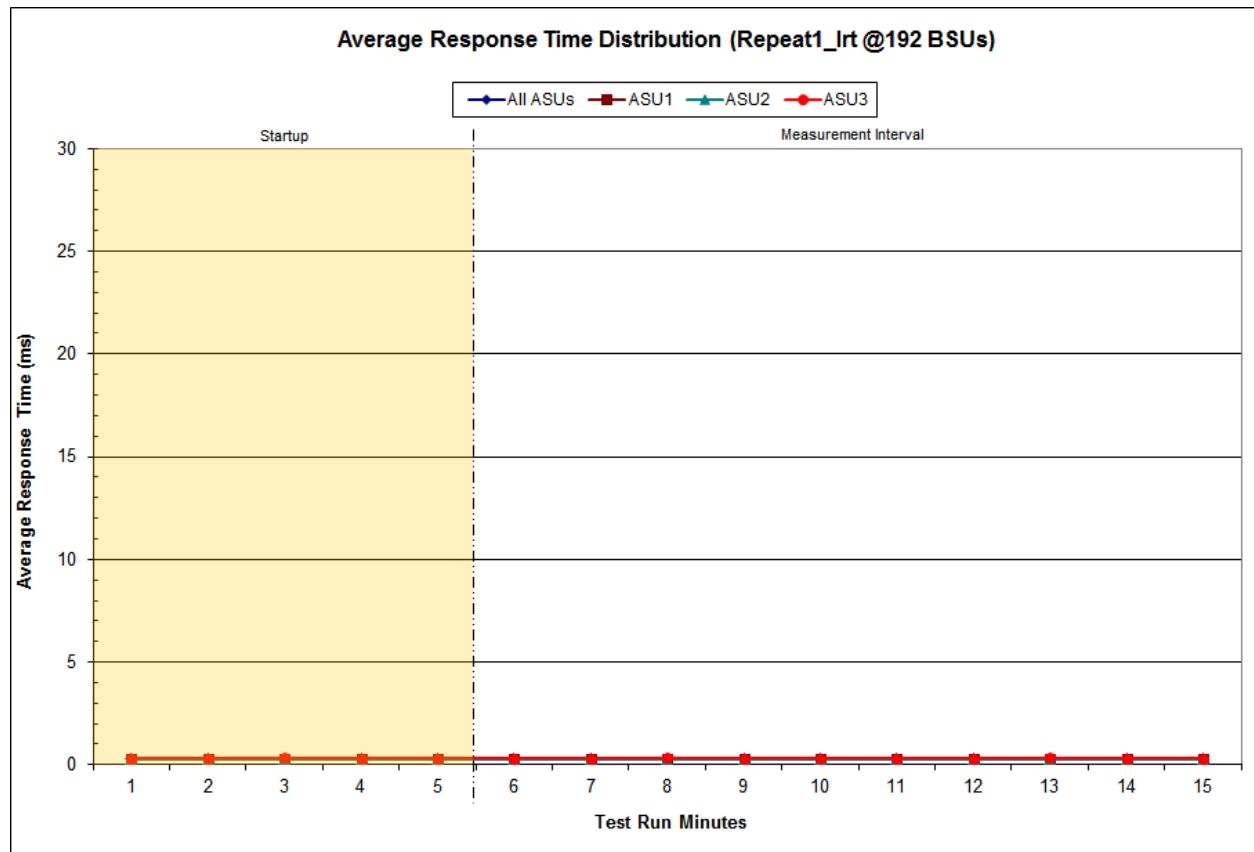
**Repeatability 1 LRT –Average Response Time (ms) Distribution Data**

192 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:45:57	17:50:57	0-4	0:05:00
<i>Measurement Interval</i>	17:50:57	18:00:57	5-14	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.29	0.28	0.28	0.32
1	0.28	0.27	0.27	0.31
2	0.31	0.30	0.28	0.33
3	0.28	0.26	0.27	0.31
4	0.28	0.26	0.27	0.31
5	0.28	0.26	0.27	0.31
6	0.28	0.26	0.26	0.31
7	0.30	0.29	0.28	0.33
8	0.28	0.26	0.27	0.31
9	0.28	0.26	0.27	0.31
10	0.28	0.26	0.27	0.31
11	0.28	0.27	0.27	0.31
12	0.30	0.29	0.28	0.33
13	0.28	0.26	0.27	0.31
14	0.28	0.26	0.27	0.31
<i>Average</i>	<i>0.28</i>	<i>0.27</i>	<i>0.27</i>	<i>0.31</i>

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

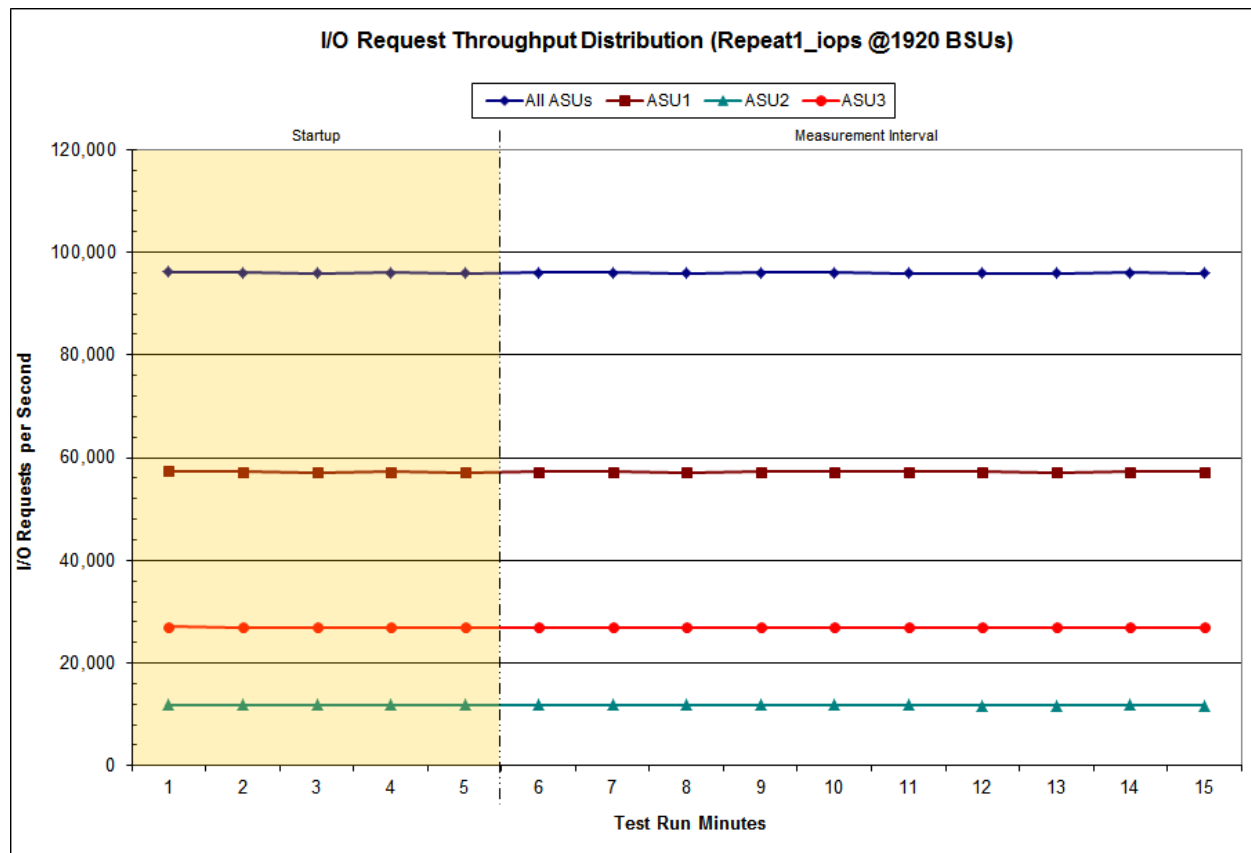




**Repeatability 1 IOPS – I/O Request Throughput Distribution Data**

1,920 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:01:14	18:06:15	0-4	0:05:01
<i>Measurement Interval</i>	18:06:15	18:16:15	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	96,217.55	57,341.25	11,838.10	27,038.20
1	95,995.98	57,236.02	11,815.28	26,944.68
2	95,954.97	57,179.27	11,808.33	26,967.37
3	95,987.92	57,205.02	11,817.07	26,965.83
4	95,920.83	57,148.17	11,815.65	26,957.02
5	96,051.05	57,242.55	11,834.63	26,973.87
6	96,050.82	57,220.65	11,823.90	27,006.27
7	95,947.03	57,150.33	11,802.48	26,994.22
8	96,016.32	57,238.17	11,816.93	26,961.22
9	96,036.22	57,246.02	11,812.05	26,978.15
10	95,969.40	57,199.20	11,804.15	26,966.05
11	95,974.00	57,221.28	11,788.53	26,964.18
12	95,962.90	57,185.28	11,797.12	26,980.50
13	96,039.98	57,220.22	11,837.52	26,982.25
14	95,955.62	57,197.10	11,794.42	26,964.10
<b>Average</b>	<b>96,000.33</b>	<b>57,212.08</b>	<b>11,811.17</b>	<b>26,977.08</b>

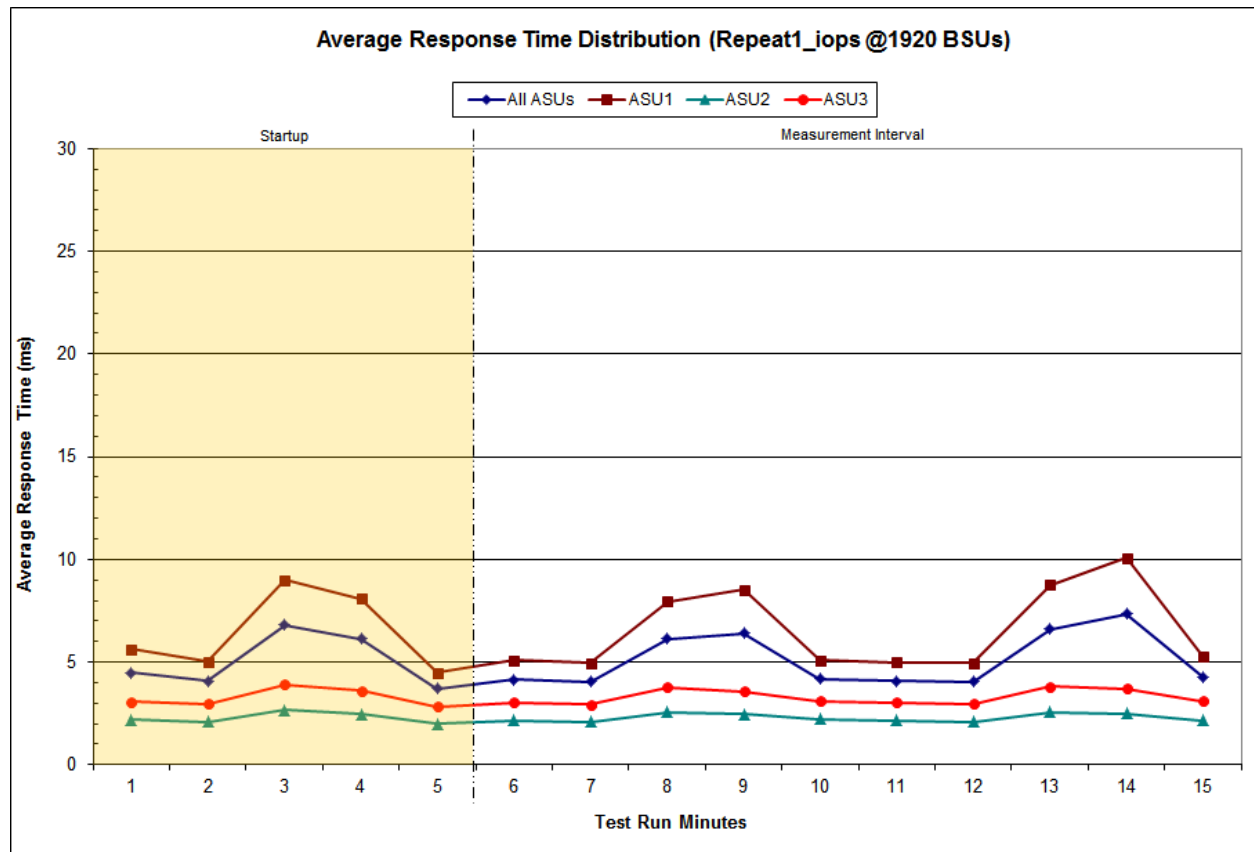
**Repeatability 1 IOPS – I/O Request Throughput Distribution Graph**



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

1,920 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:01:14	18:06:15	0-4	0:05:01
<i>Measurement Interval</i>	18:06:15	18:16:15	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4.48	5.62	2.18	3.08
1	4.09	5.03	2.09	2.98
2	6.79	8.99	2.66	3.93
3	6.13	8.07	2.46	3.61
4	3.71	4.48	1.99	2.83
5	4.15	5.09	2.15	3.04
6	4.03	4.95	2.08	2.94
7	6.12	7.96	2.57	3.77
8	6.39	8.53	2.46	3.57
9	4.18	5.10	2.22	3.10
10	4.08	4.97	2.15	3.04
11	4.04	4.95	2.09	2.97
12	6.61	8.76	2.58	3.82
13	7.34	10.06	2.51	3.71
14	4.29	5.29	2.17	3.09
<b>Average</b>	<b>5.12</b>	<b>6.56</b>	<b>2.30</b>	<b>3.30</b>

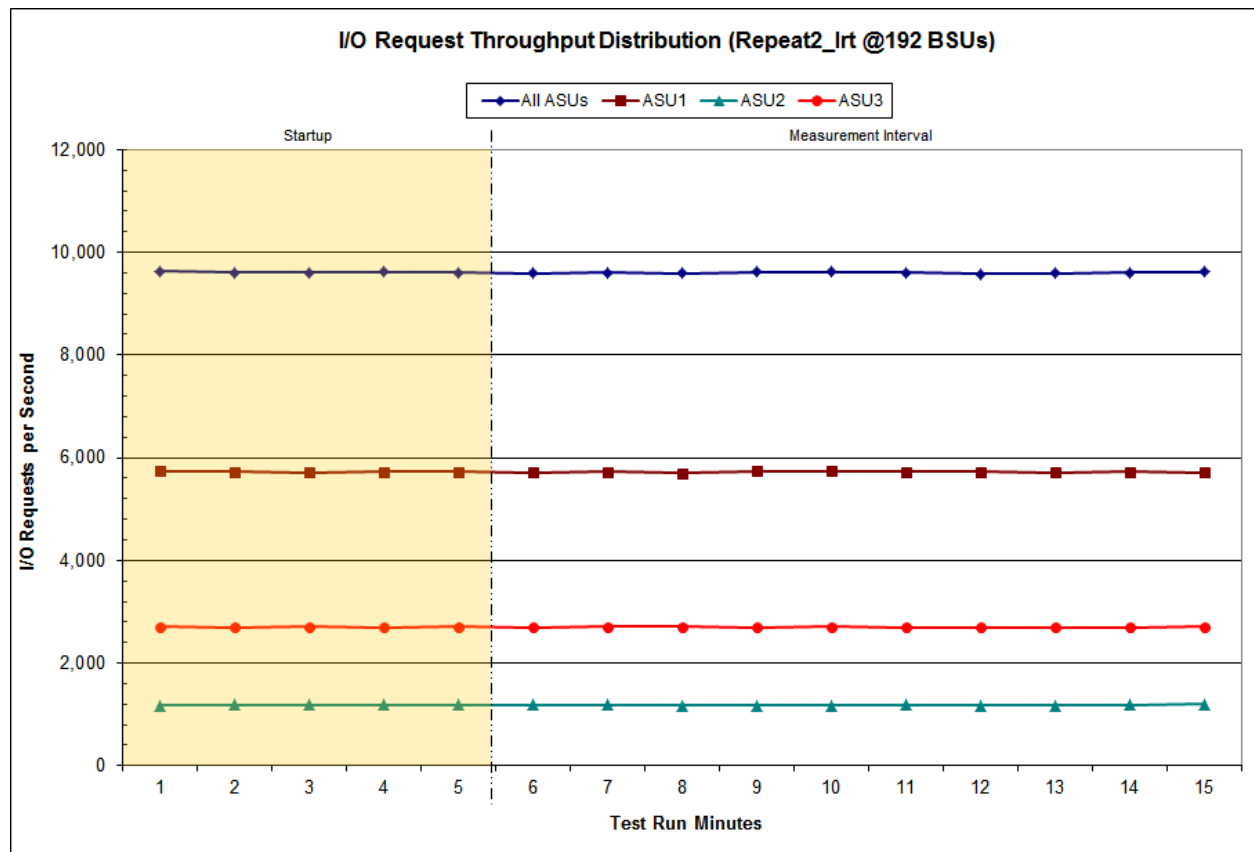
**Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph**



**Repeatability 2 LRT – I/O Request Throughput Distribution Data**

192 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:16:31	18:21:31	0-4	0:05:00
<i>Measurement Interval</i>	18:21:31	18:31:31	5-14	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
0	9,628.50	5,745.00	1,171.75	2,711.75
1	9,610.63	5,730.85	1,182.23	2,697.55
2	9,606.78	5,714.55	1,188.17	2,704.07
3	9,612.82	5,728.03	1,188.20	2,696.58
4	9,607.92	5,721.38	1,181.12	2,705.42
5	9,597.22	5,716.23	1,186.13	2,694.85
6	9,608.42	5,720.73	1,183.23	2,704.45
7	9,585.32	5,704.30	1,173.02	2,708.00
8	9,612.52	5,740.13	1,178.38	2,694.00
9	9,617.28	5,732.57	1,178.65	2,706.07
10	9,603.97	5,728.18	1,181.20	2,694.58
11	9,582.17	5,719.05	1,173.53	2,689.58
12	9,584.82	5,710.40	1,179.32	2,695.10
13	9,611.53	5,725.23	1,187.93	2,698.37
14	9,614.02	5,717.15	1,193.65	2,703.22
<b>Average</b>	<b>9,601.73</b>	<b>5,721.40</b>	<b>1,181.51</b>	<b>2,698.82</b>

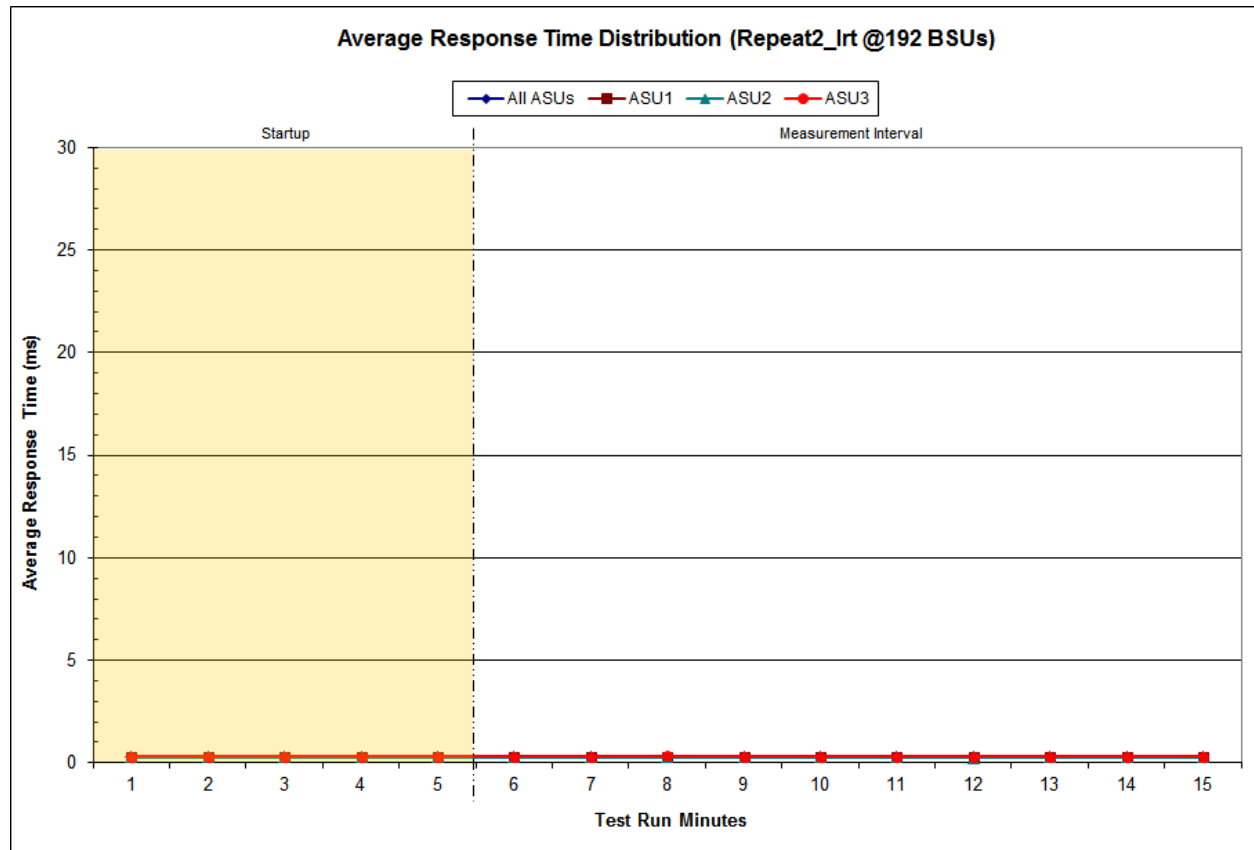
**Repeatability 2 LRT – I/O Request Throughput Distribution Graph**



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

192 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:16:31	18:21:31	0-4	0:05:00
<i>Measurement Interval</i>	18:21:31	18:31:31	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.28	0.27	0.26	0.30
1	0.27	0.26	0.26	0.30
2	0.30	0.29	0.27	0.32
3	0.27	0.26	0.26	0.30
4	0.27	0.26	0.26	0.30
5	0.27	0.26	0.26	0.30
6	0.27	0.26	0.26	0.30
7	0.30	0.29	0.27	0.32
8	0.27	0.26	0.26	0.30
9	0.27	0.26	0.26	0.30
10	0.27	0.26	0.26	0.30
11	0.27	0.26	0.26	0.30
12	0.29	0.29	0.27	0.32
13	0.27	0.26	0.26	0.30
14	0.27	0.26	0.26	0.30
<i>Average</i>	<i>0.27</i>	<i>0.26</i>	<i>0.26</i>	<i>0.30</i>

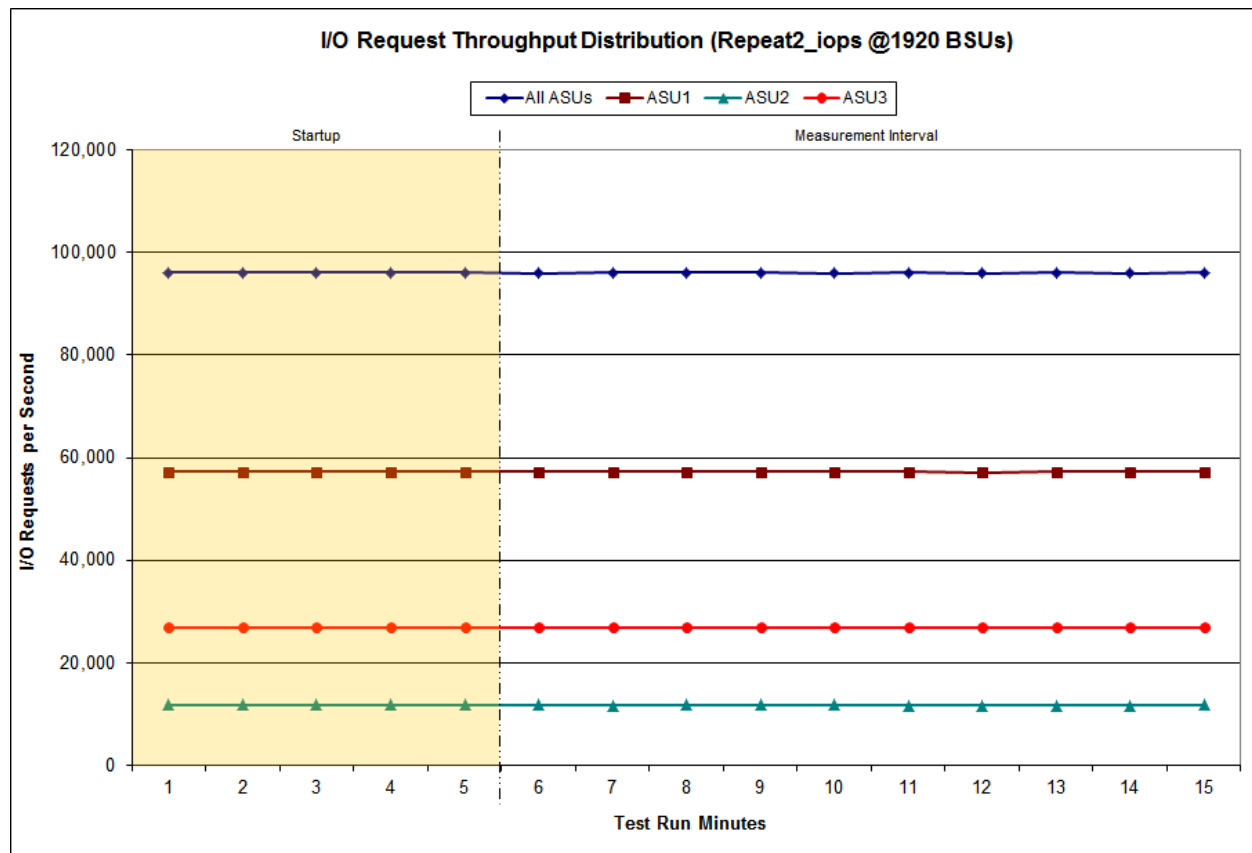
**Repeatability 2 LRT –Average Response Time (ms) Distribution Graph**



### Repeatability 2 IOPS – I/O Request Throughput Distribution Data

1,920 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:31:51	18:36:52	0-4	0:05:01
<i>Measurement Interval</i>	18:36:52	18:46:52	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	96,103.05	57,288.00	11,830.10	26,984.95
1	95,986.60	57,230.73	11,813.35	26,942.52
2	96,016.67	57,242.15	11,806.13	26,968.38
3	96,068.35	57,234.43	11,831.63	27,002.28
4	95,999.92	57,225.77	11,799.27	26,974.88
5	95,963.93	57,191.23	11,819.77	26,952.93
6	96,005.75	57,222.77	11,795.75	26,987.23
7	96,068.08	57,242.65	11,823.65	27,001.78
8	95,983.25	57,200.77	11,804.97	26,977.52
9	95,968.47	57,191.30	11,821.48	26,955.68
10	95,997.45	57,211.37	11,791.18	26,994.90
11	95,906.28	57,160.65	11,793.63	26,952.00
12	95,991.48	57,192.02	11,793.87	27,005.60
13	95,955.58	57,196.35	11,790.62	26,968.62
14	96,029.68	57,235.00	11,826.67	26,968.02
<b>Average</b>	<b>95,987.00</b>	<b>57,204.41</b>	<b>11,806.16</b>	<b>26,976.43</b>

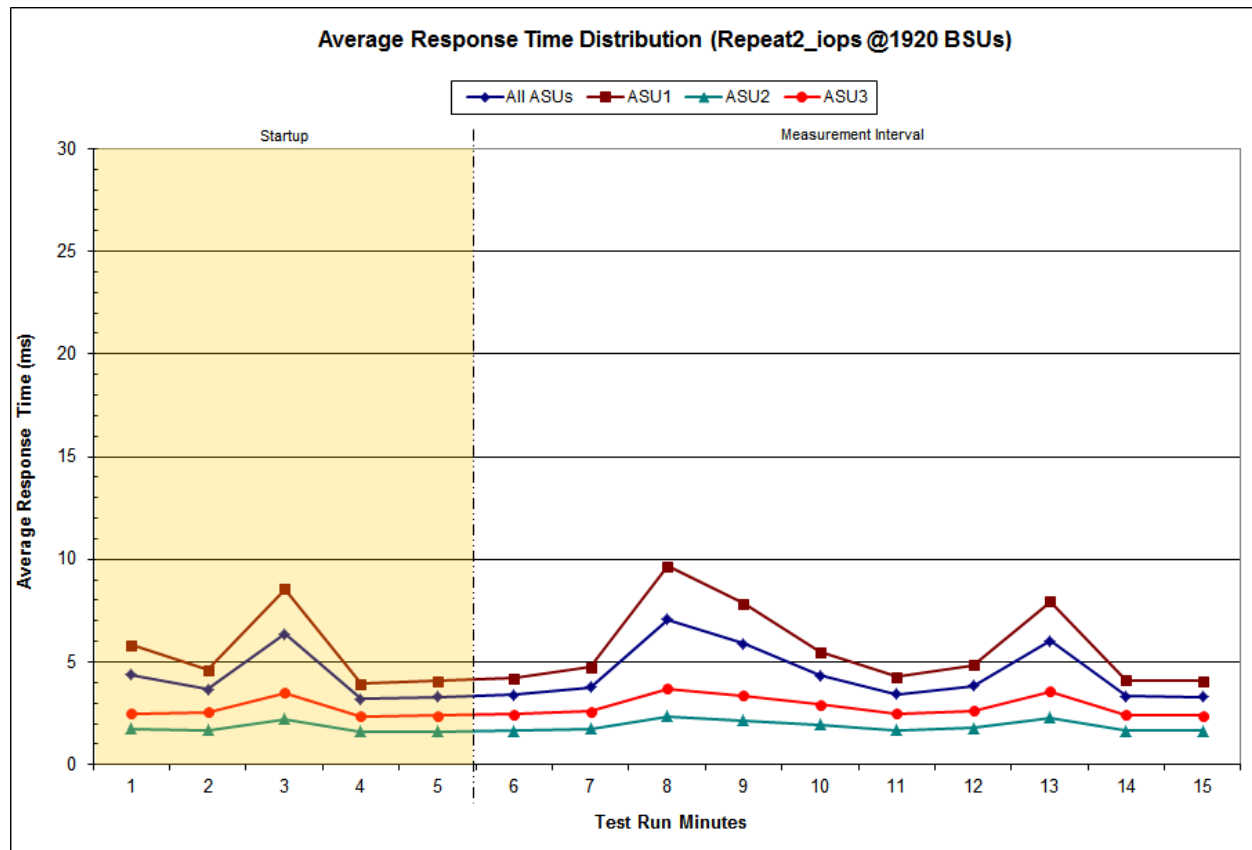
### Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

1,920 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:31:51	18:36:52	0-4	0:05:01
<i>Measurement Interval</i>	18:36:52	18:46:52	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4.40	5.83	1.76	2.50
1	3.67	4.61	1.70	2.55
2	6.35	8.55	2.23	3.50
3	3.22	3.95	1.63	2.37
4	3.29	4.07	1.62	2.38
5	3.40	4.21	1.66	2.45
6	3.77	4.75	1.74	2.59
7	7.09	9.67	2.37	3.70
8	5.89	7.85	2.17	3.36
9	4.34	5.49	1.97	2.93
10	3.45	4.26	1.68	2.48
11	3.84	4.84	1.77	2.62
12	6.02	7.94	2.30	3.57
13	3.32	4.10	1.64	2.41
14	3.31	4.07	1.64	2.41
<b>Average</b>	<b>4.44</b>	<b>5.72</b>	<b>1.89</b>	<b>2.85</b>

**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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0351	0.2809	0.0700	0.2101	0.0180	0.0700	0.0349	0.2810
COV	0.006	0.002	0.002	0.003	0.011	0.006	0.006	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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.000	0.002	0.001	0.003	0.002	0.002	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0699	0.2100	0.0180	0.0701	0.0349	0.2811
COV	0.010	0.002	0.006	0.003	0.011	0.007	0.007	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	0.2809	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.002	0.001	0.003	0.002	0.003	0.001



## 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 [82](#).

## 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

<b>Data Persistence Test Results</b>	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	230,527,648
Total Number of Logical Blocks Verified	119,793,648
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 9.4.3.9**

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

The Infortrend EonStor DS 2024B 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 2024B.

## **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.

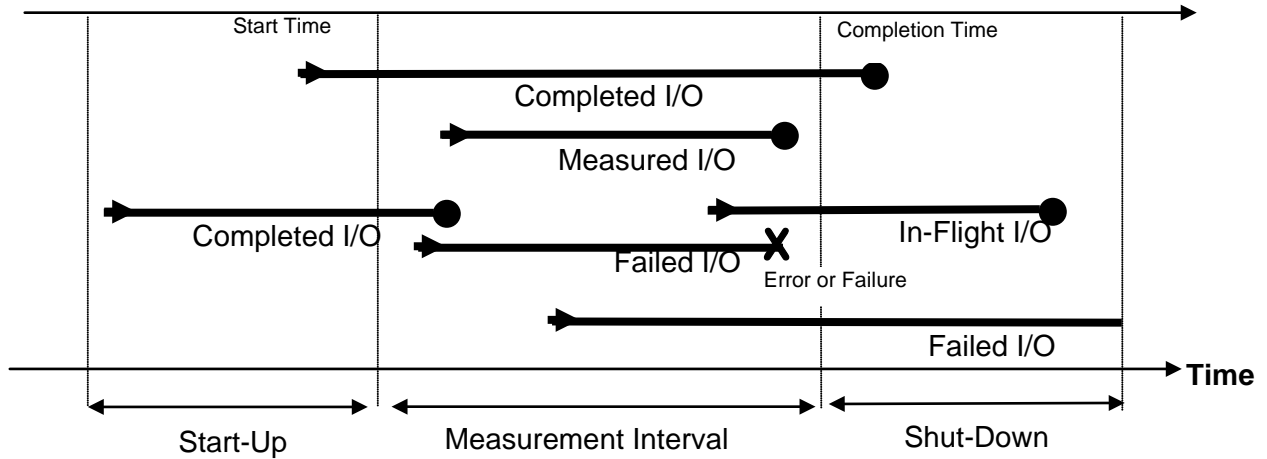
**Steady State:** The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

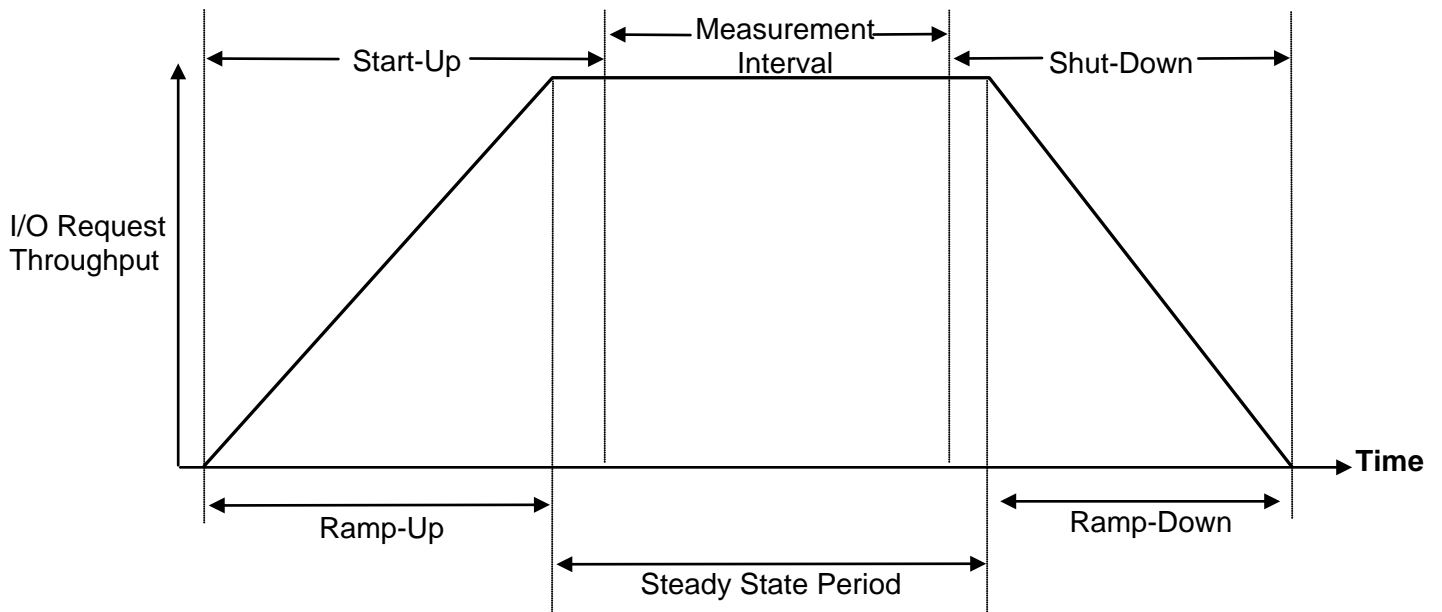
**Test Run:** The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall 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 [77](#) in the [HBA QueueDepth](#) section of Appendix C.

### **Infotrend EonStor DS 2024B 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.

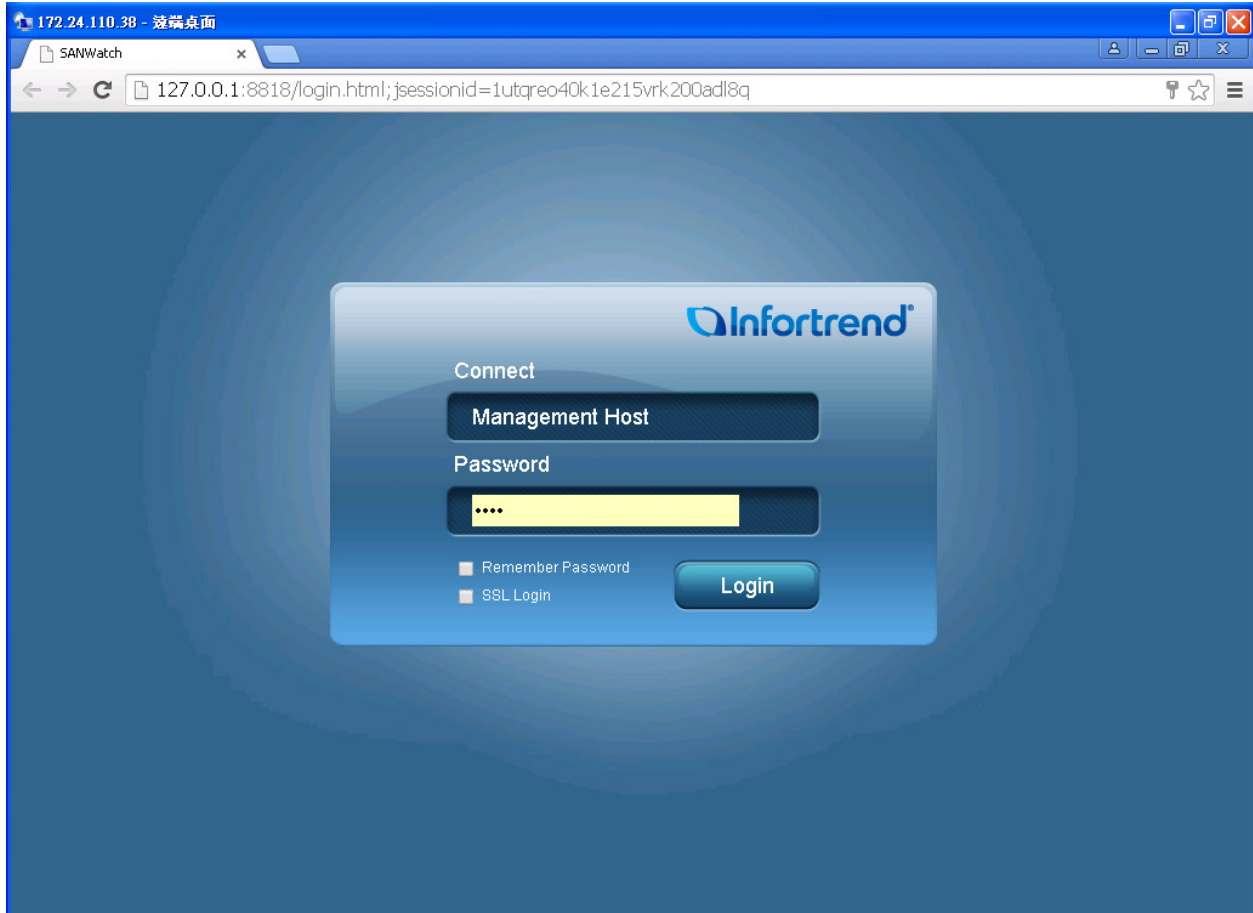
This parameter value was changed by using Infotrend's SANWatch as described on page [79](#) in the [Maximum Number of Tags](#) section of Appendix C.



## **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.

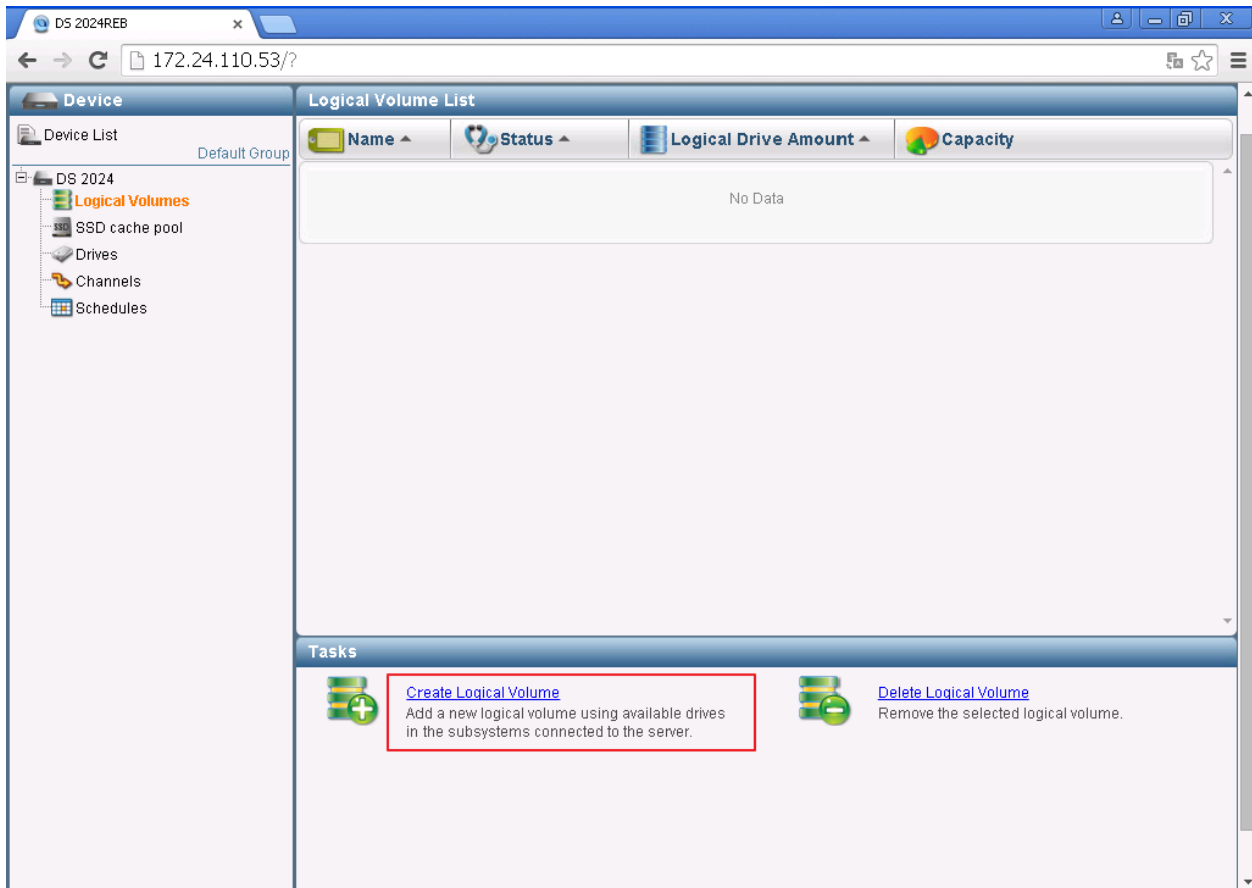


**Step 2:** Select the EonStor DS 2024 and check its status.

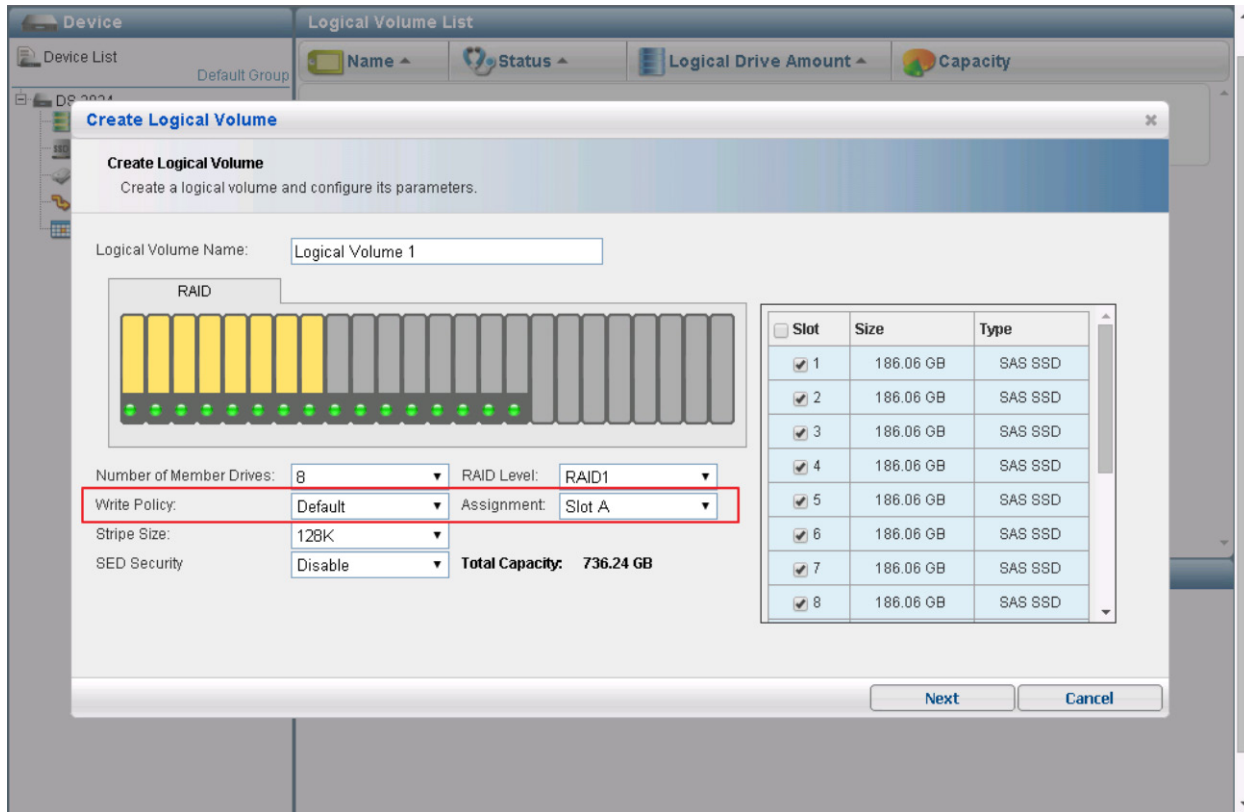
The screenshot displays the web interface for an EonStor DS 2024 device. The browser address bar shows the URL 172.24.110.53/?. The interface is divided into several sections:

- Device List:** Shows a single device named "DS 2024" under the "Default Group".
- Status:** Contains "Subsystem Information" with the following details:
  - Model:** DS 2024REB
  - IP Address:** 172.24.110.53
  - Service ID:** 8608143 (0x83598F)
  - Controller ID:** 3598F
  - Firmware Version:** 6.11C.04
  - Status:** OK (indicated by a green checkmark)
  - Recent Events:** No Event
- Capacity:** A circular gauge shows "Total Capacity: 2.9 TB". The legend indicates:
  - Configured Space: 0 MB (0%)
  - Available Space: 2.9 TB (100%)
- Tasks:** A list of actionable links:
  - Quick Setup:** Follow the step-by-step setup wizard to configure the hard drives inside the selected device.
  - Enclosure View:** See the detailed information of enclosures connected to the system.
  - Information:** View the overall system information.
  - System Settings:** Configure generic system parameters.
  - Event Log:** View the system events and device operation logs.
  - System Maintenance:** View the total **Isolated Logical Drive(s)**, applicable **Invalid Host LUN Mapping(s)**, and **Other(s)**.

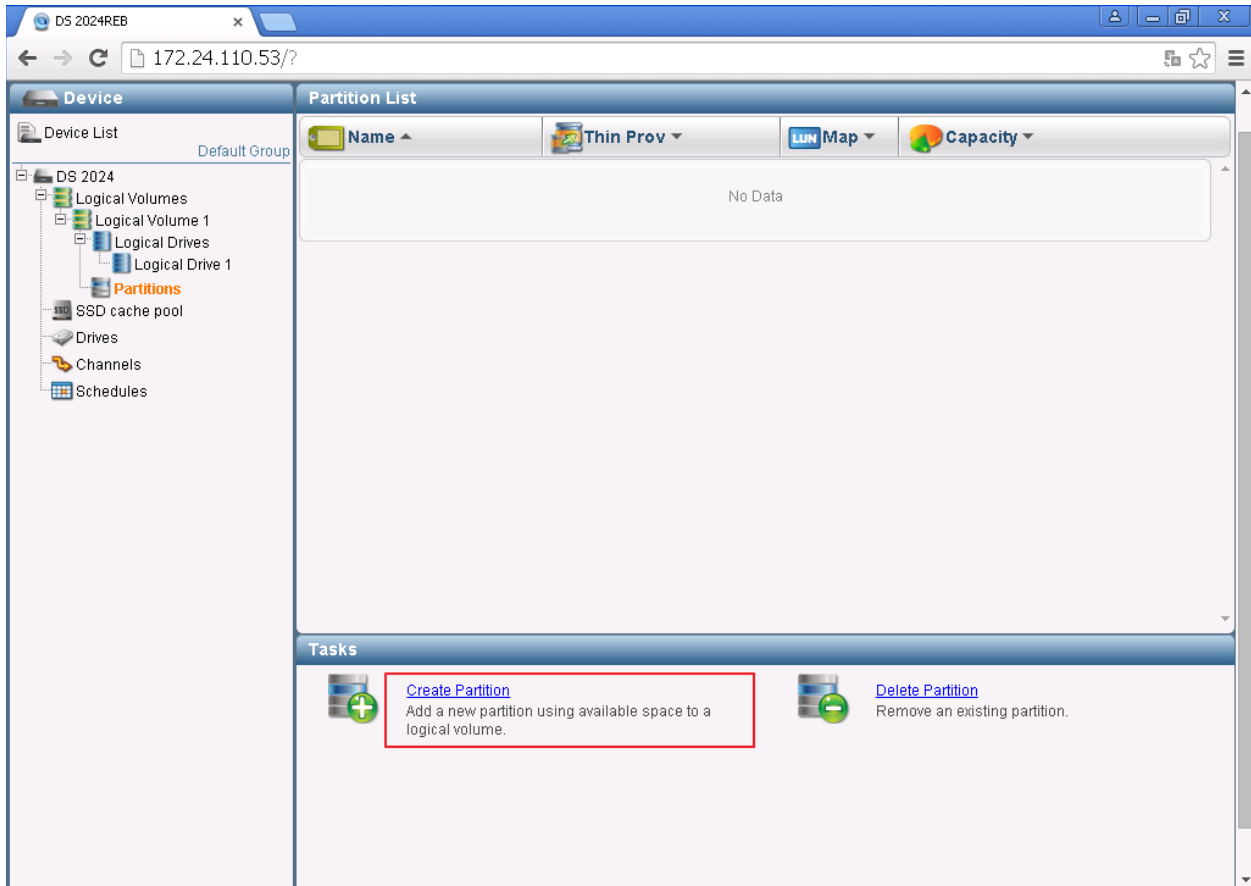
**Step 3:** Select **Logical Volumes** and click **Create Logical Volume**.



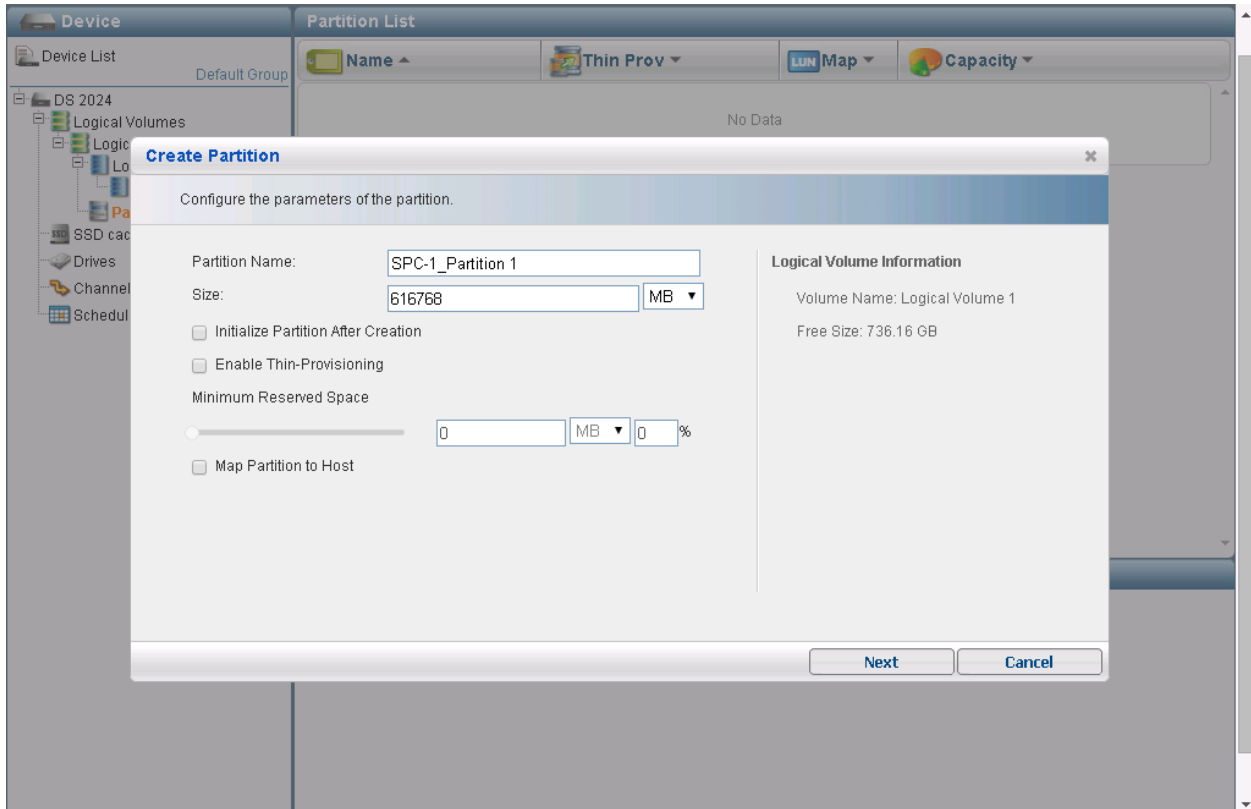
**Step 4:** Create **Logical Volume 1**, assign to **Slot A (Controller A)** and select 8 SAS SSDs as the member drives using RAID-1. Then click **Next**.



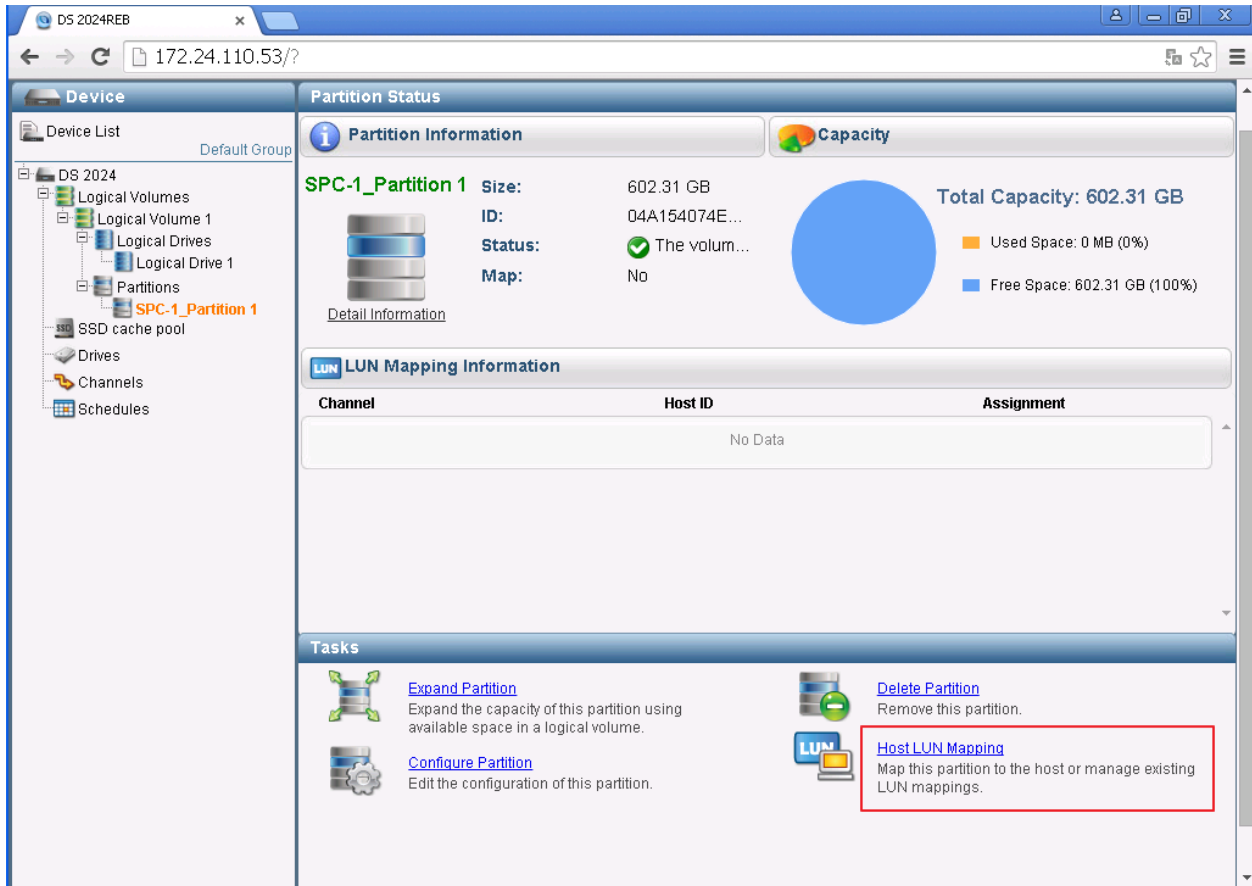
**Step 5:** Click **Create Partition** to create a partition.



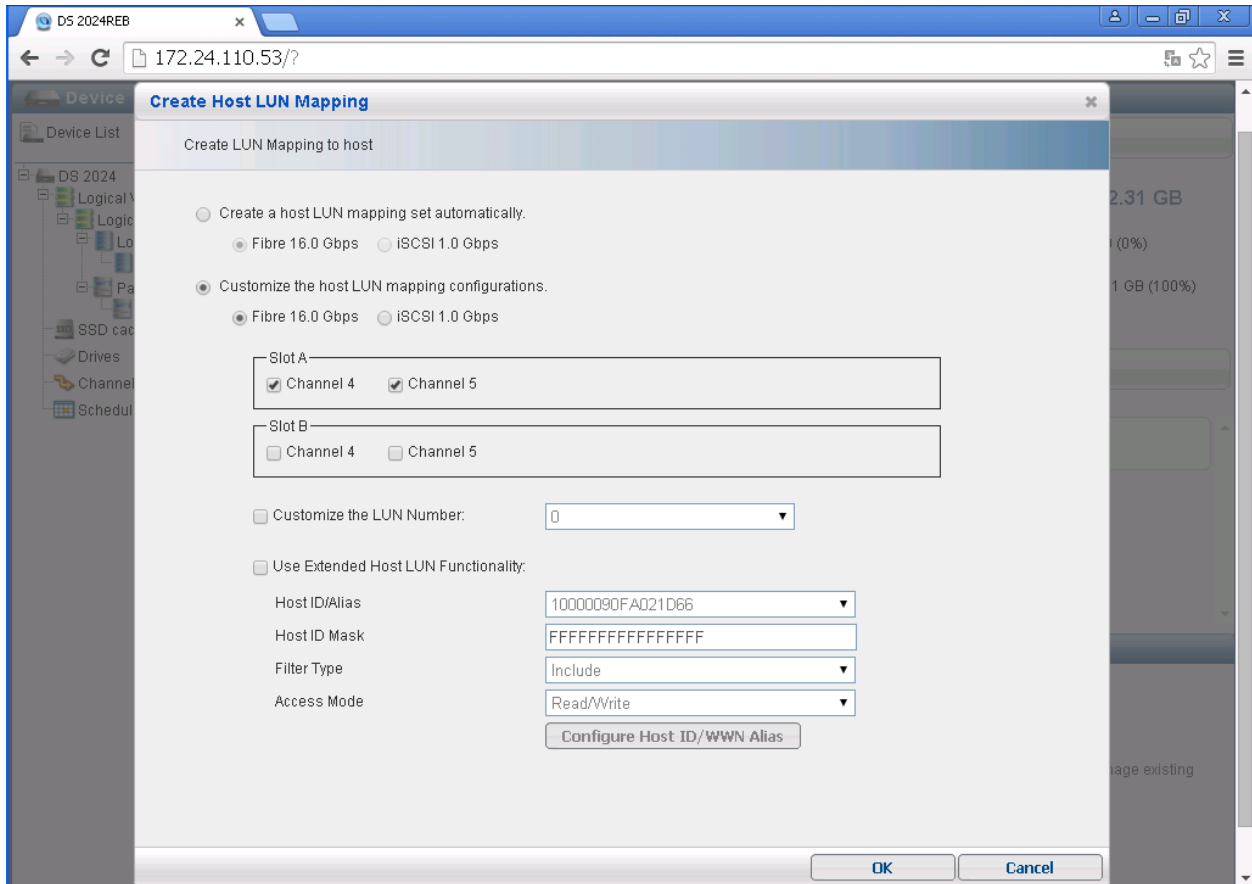
**Step 6:** Create the partition, **SPC-1\_Partition-1** and set the partition size to 616,768 MB. Then click **Next**.



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



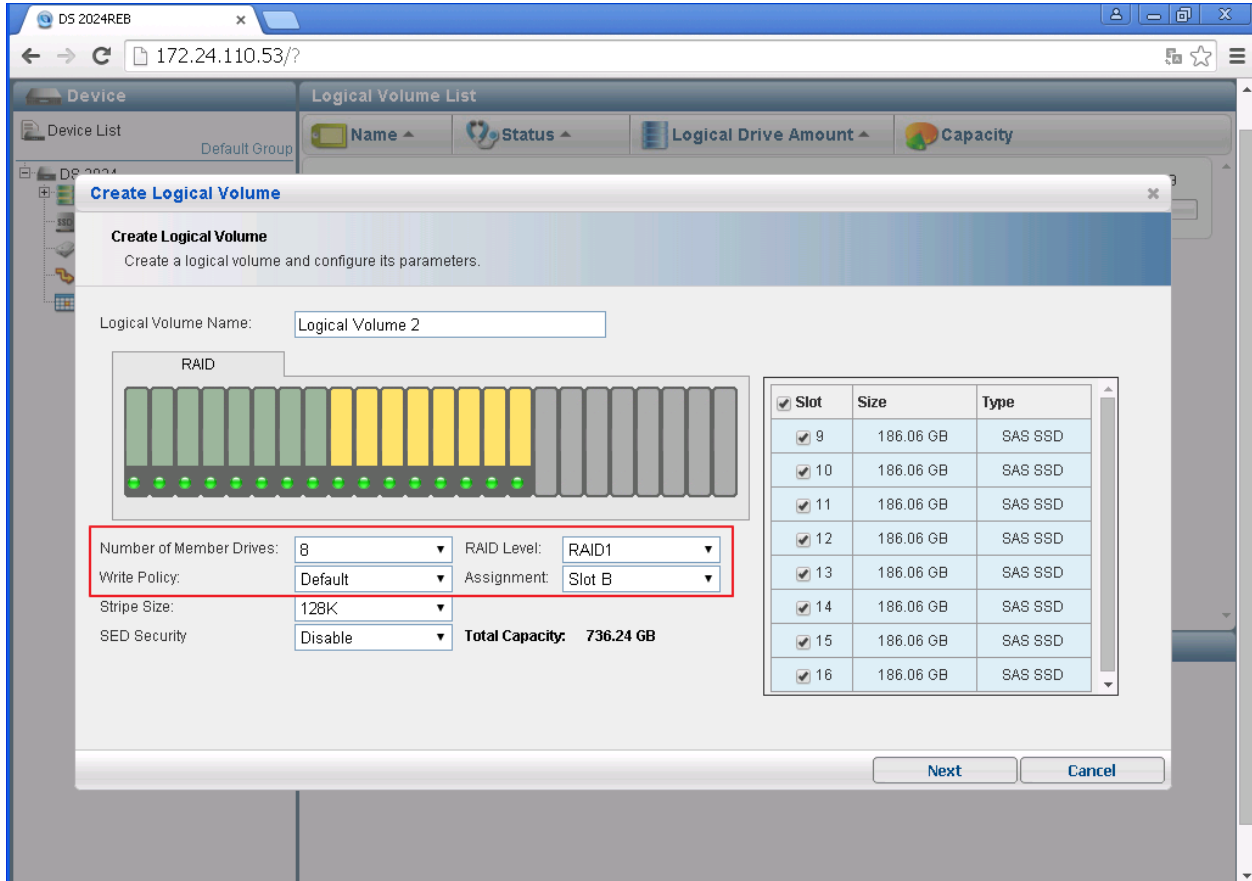
**Step 8:** Select **Customize the host LUN mapping configurations, Fibre 16.0 Gbps** and **Channel 4/Channel 5** for **Slot A (Controller A)**. Then click **OK**.



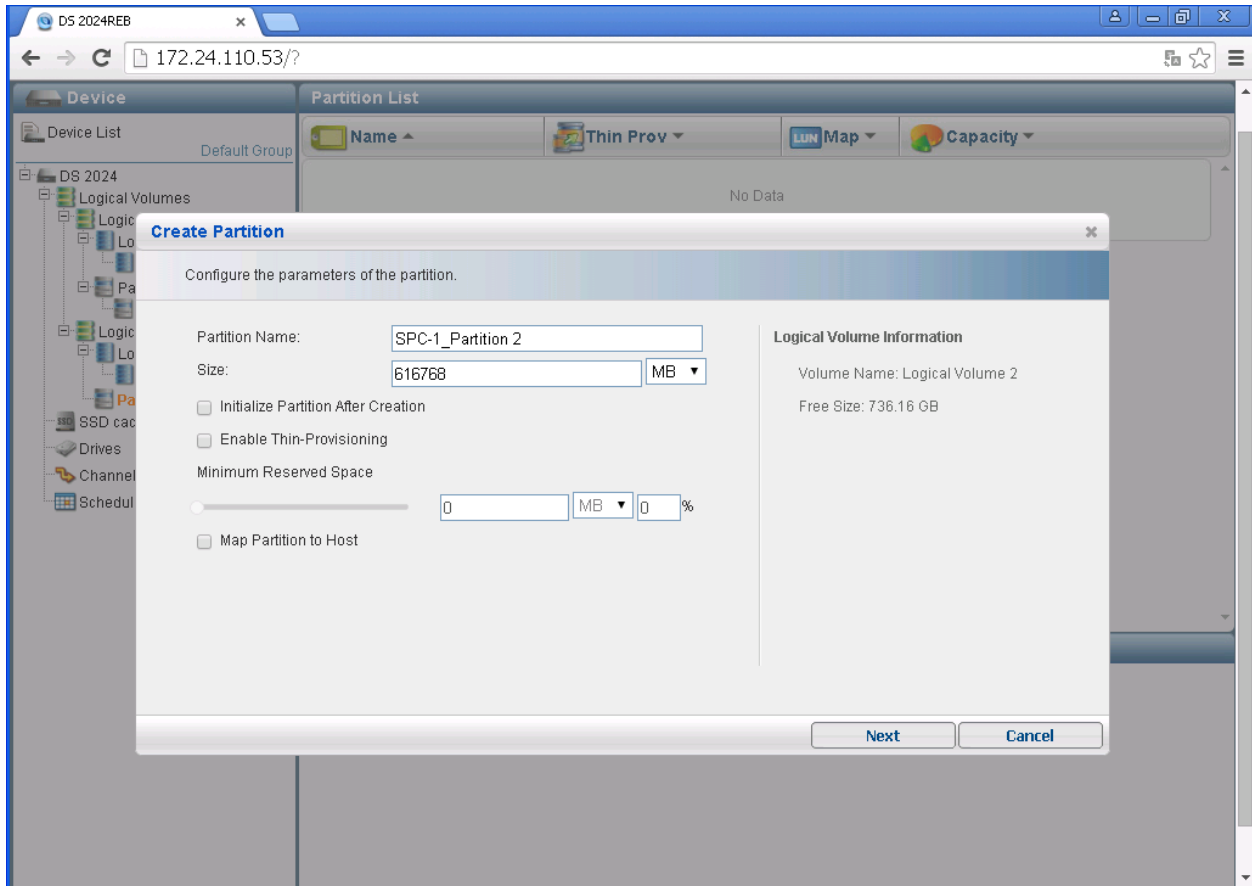


**Step 9:** Repeat [Step 3](#) (Select **Logical Volumes** and click **Create Logical Volume**)

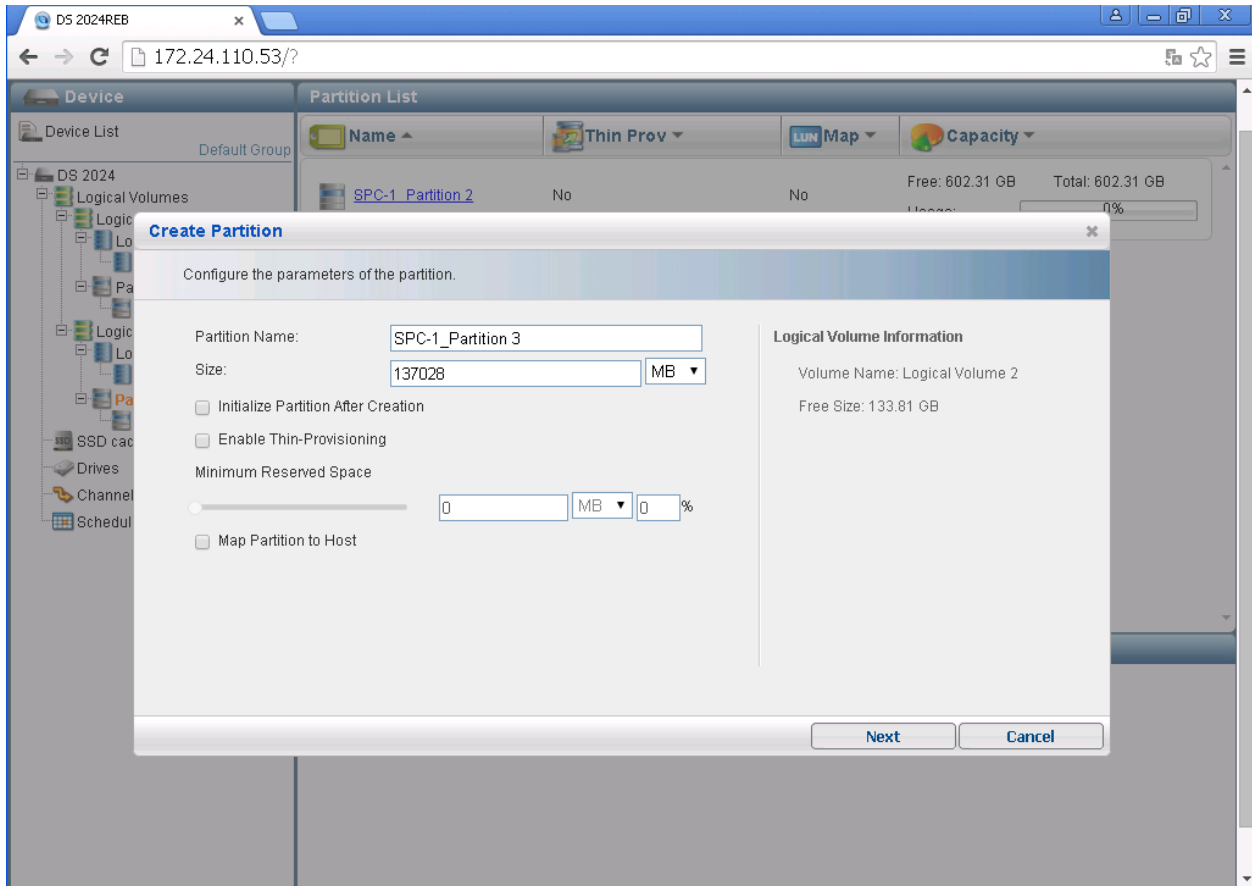
Create **Logical Volume 2**, assign to **Slot B** (Controller B) and select the remaining 8 SAS SSDs as the member drives using RAID-1. Then click **Next**



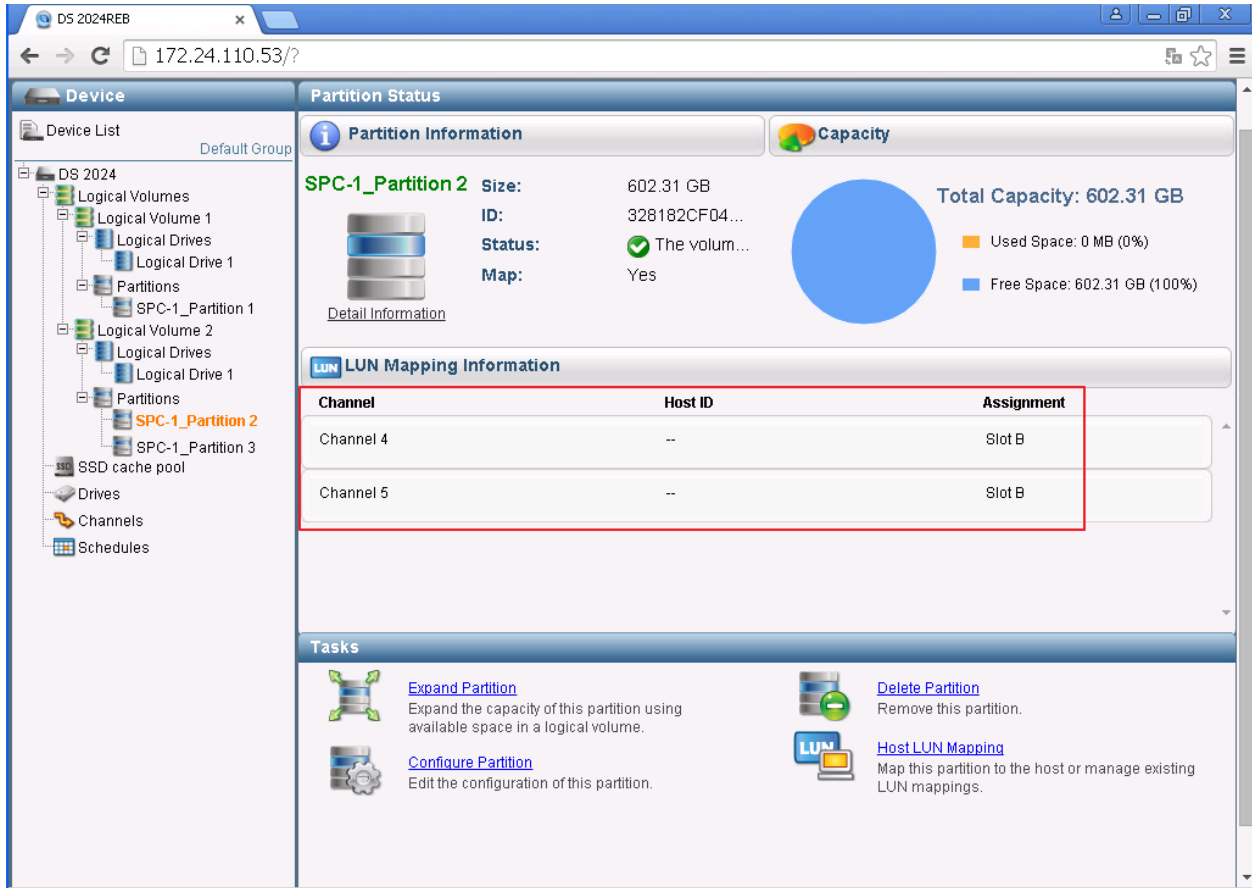
**Step 10:** Repeat [Step 5](#) to create the first partition for Logical Volume2, **SPC-1\_Partition-2**, and set the partition size to 616,768 MB. Then click **Next**.



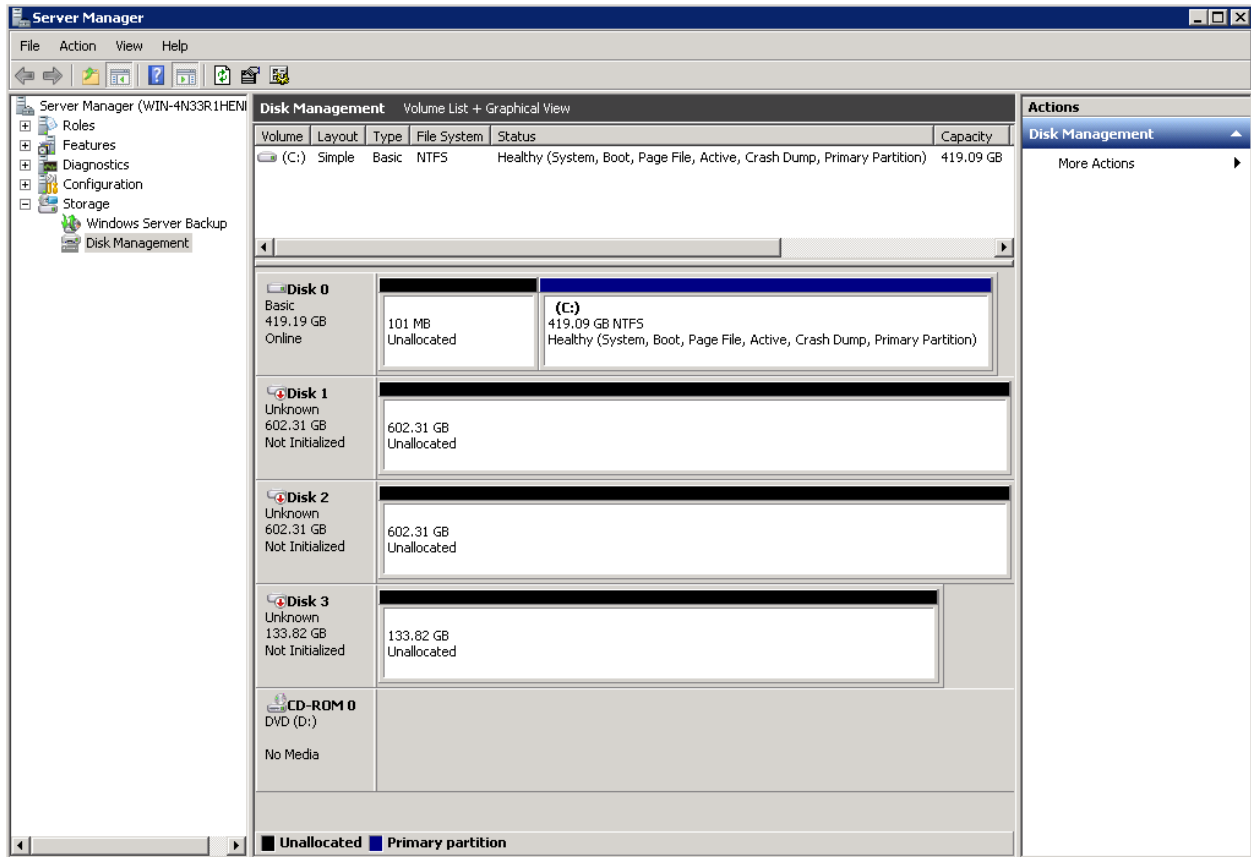
**Step 11:** Repeat [Step 5](#) to create the second partition for Logical Volume2, **SPC-1\_Partition-3**, and set the partition size to 137,028 MB. Then click **Next**.



**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”.

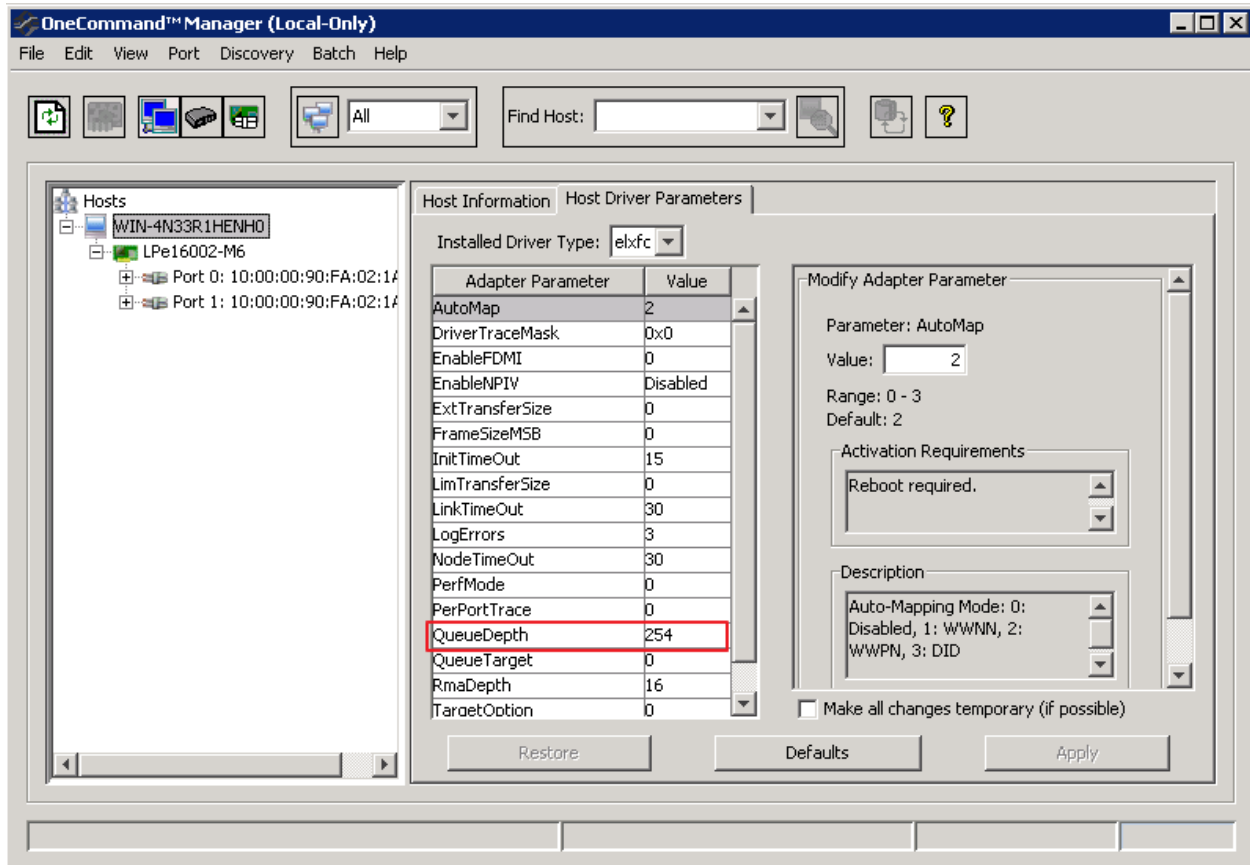


## HBA QueueDepth

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 the Host System, to change the **QueueDepth** parameter from its default of 32 to the value of 254 used in the benchmark measurements.



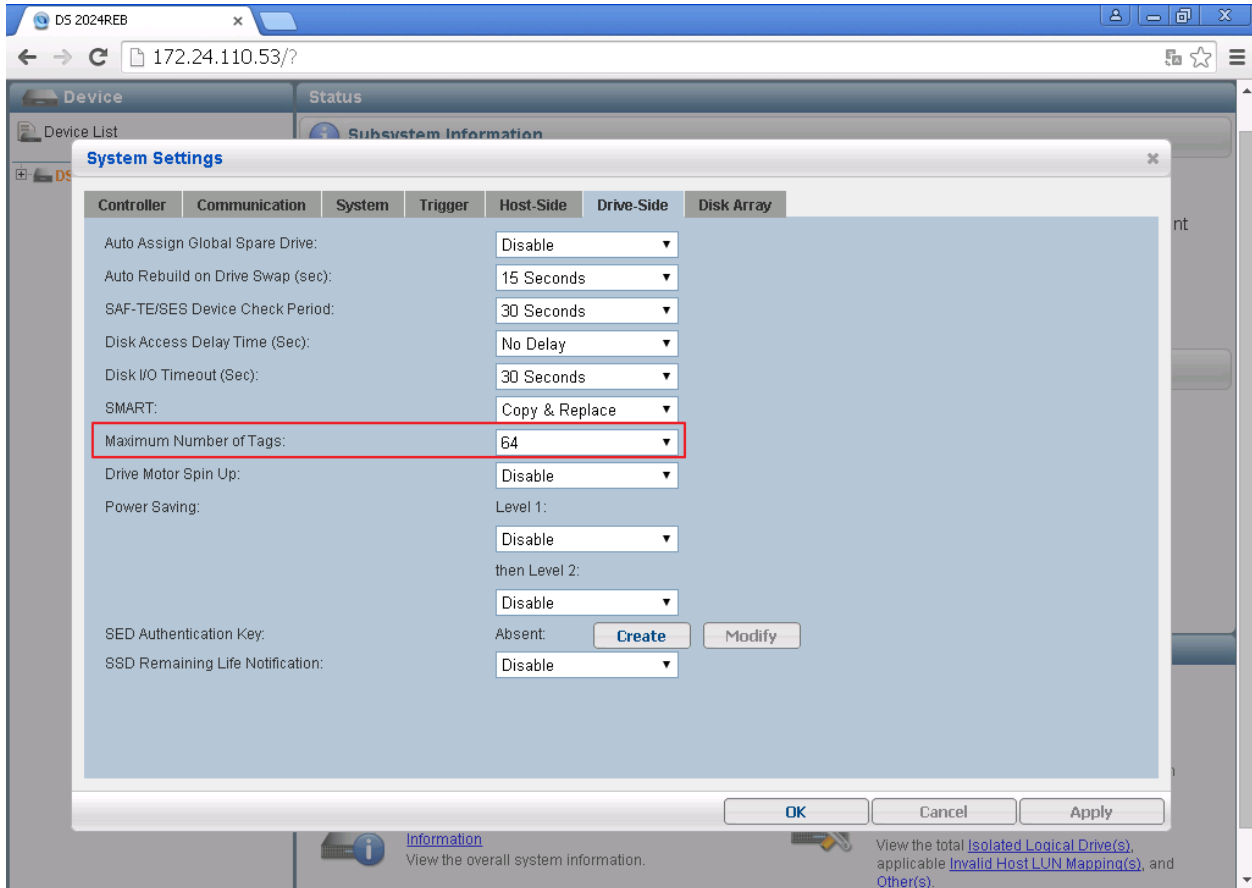
## Maximum Number of Tags

**Step 1:** Execute Infortrend's SANWatch on the Master Host System, select the DS 2024 and click **System Settings**.

The screenshot displays the Infortrend SANWatch web interface for a device named DS 2024. The browser address bar shows the URL 172.24.110.53/?. The interface is divided into several sections:

- Device List:** Shows the selected device DS 2024 under the Default Group.
- Status:** Contains a 'Subsystem Information' section with the following details:
  - Model: DS 2024REB
  - IP Address: 172.24.110.53
  - Service ID: 8608143 (0x83598F)
  - Controller ID: 3598F
  - Firmware Version: 6.11C.04
  - Status: OK (indicated by a green checkmark)
  - Recent Events: No Event
- Capacity:** A pie chart shows the storage capacity usage. Total Capacity is 2.9 TB. Configured Space is 1.45 TB (50%), and Available Space is 1.45 TB (50%).
- Tasks:** A list of actions is provided, with 'System Settings' highlighted in a red box. The tasks include:
  - [Quick Setup](#): Follow the step-by-step setup wizard to configure the hard drives inside the selected device.
  - [Enclosure View](#): See the detailed information of enclosures connected to the system.
  - [Information](#): View the overall system information.
  - [System Settings](#): Configure generic system parameters.
  - [Event Log](#): View the system events and device operation logs.
  - [System Maintenance](#): View the total [Isolated Logical Drive\(s\)](#), applicable [Invalid Host LUN Mapping\(s\)](#), and [Other\(s\)](#).

**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, Repeatability and SPC-1 Persistence 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*), Repeatability (*Repeatability Test Phase 1 and Repeatability Test Phase 2*), and SPC-1 Persistence Tests is listed below.

```
sd=asu1_1,lun=\\.\physicalDrive1,size=602.19g
sd=asu2_1,lun=\\.\physicalDrive2,size=602.19g
sd=asu3_1,lun=\\.\physicalDrive3,size=133.82g
```

## **APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS**

The following script, **SPC-1\_Test.bat**, was executed to complete the following in an uninterrupted execution sequence:

- Call the the standard **vdbench.bat** script to execute the required ASU pre-fill.
- Call the **runMaster.bat** script which invoked the commands to execute the following:
  - 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*).
  - Persistence Test Run 1 (*write phase*).

The **spc1\_persist2.bat** was executed after the required TSC power off/poweron cycle to invoke the command to execut the SPC-2 Persistence Test Run 2 (*read phase*).

### **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 -

java metrics -b 1920 -t 28800 -s 300:300

rem Repeatability Runs
java -Xmx8192m -Xms8192m repeat1 -b 1920 -s 300
java -Xmx8192m -Xms8192m repeat2 -b 1920 -s 300

rem Persist runs
java -Xmx8192m -Xms8192m persist1 -b 1920

rem power off & on ports on Ethernet switched PDU
rem run SPC-1_persist2
```

### **spc1\_persist2.bat**

```
rem SPC-1 Persistence Test Run 2 (read phase)
java -Xmx8192m -Xms8192m persist2
```