



**NEC**

**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**NEC CORPORATION  
NEC STORAGE M710**

**SPC-1 V1.14**

**Submitted for Review: August 26, 2015  
Submission Identifier: A00161**

**First Edition – August 2015**

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## AUDIT CERTIFICATION



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

August 25, 2015

The SPC Benchmark 1™ Reported Data listed below for the NEC Storage M710 was produced in compliance with the SPC Benchmark 1™ v1.14 Remote Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: NEC Storage M710	
Metric	Reported Result
SPC-1 IOPS™	255,011.06
SPC-1 Price-Performance	\$3.11/SPC-1 IOPS™
Total ASU Capacity	134,739.741 GB
Data Protection Level	Protected 2 ( <i>Mirroring</i> )
Total Price (including three-year maintenance)	\$793,975.85
Currency Used	U.S. Dollars
Target Country for availability, sales and support	U.S.A.

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

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

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.)

NEC Storage M710  
SPC-1 Audit Certification

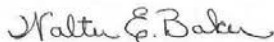
Page 2

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

**Audit Notes:**

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker  
SPC Auditor

Storage Performance Council  
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**LETTER OF GOOD FAITH**

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

Date: November 13, 2014

From: NEC Corporation

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

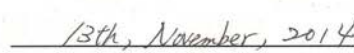
Subject: SPC-1 Letter of Good Faith for the NEC Storage M710

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

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

Signed:

Date:



Tetsuyuki Hishikawa  
General Manager for Storage Systems  
Storage Systems Department  
IT Platform Division

## EXECUTIVE SUMMARY

### Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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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 26, 2015
<b>Date the FDR was submitted to the SPC</b>	August 26, 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 25, 2015

### **Tested Storage Product (TSP) Description**

The NEC M710 SAN disk array has the high performance, capacity and availability demanded by data-intensive, mission critical environments.

Easy to operate, the M710 is well-suited for virtualized settings due to its scalability, 16Gbps or 8Gbps of fibre channel, and VMware APIs support.

Large-scale storage integration is achieved by utilizing advanced virtualization technologies, such as VMware certified and thin provisioning.

Superior security functions, such as self-encrypting HDDs, are supported on the M710 SAN disk array.

As an additional security measure, internal storage data can also be completely erased using NEC's Secure Erase Technology, which is based on approved methods defined by the U.S. Department of Defense.

## Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: NEC Storage M710	
Metric	Reported Result
SPC-1 IOPS™	255,011.06
SPC-1 Price-Performance™	\$3.11/SPC-1 IOPS™
Total ASU Capacity	134,739.741 GB
Data Protection Level	Protected 2 ( <i>Mirroring</i> )
Total Price	\$793,975.85
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

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

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

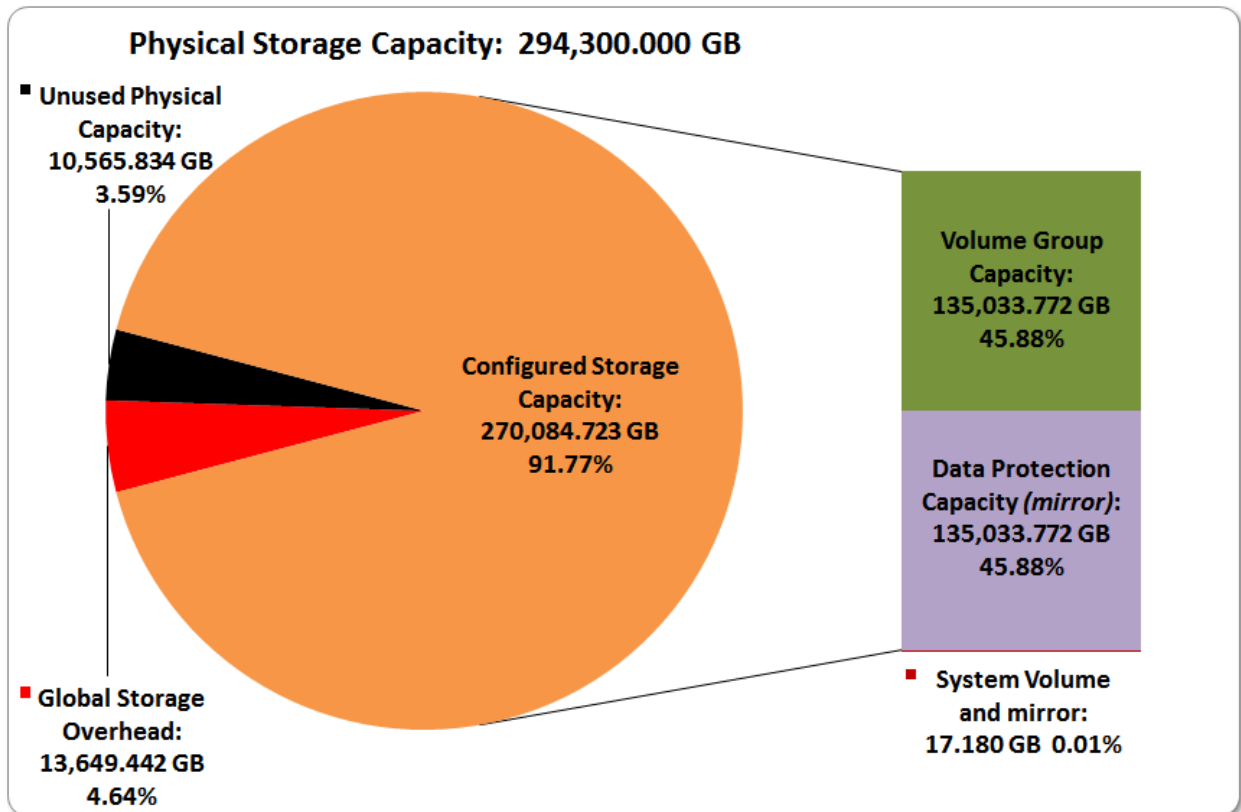
**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 17.

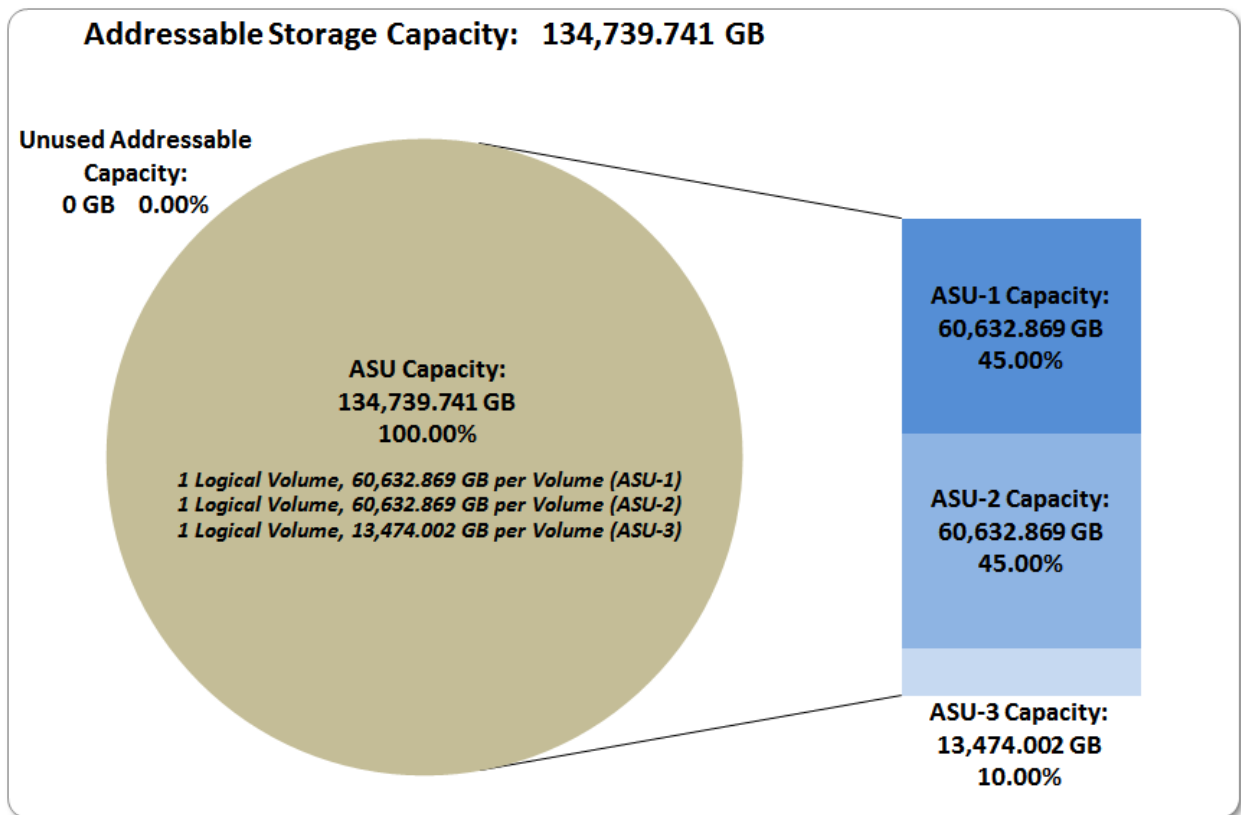
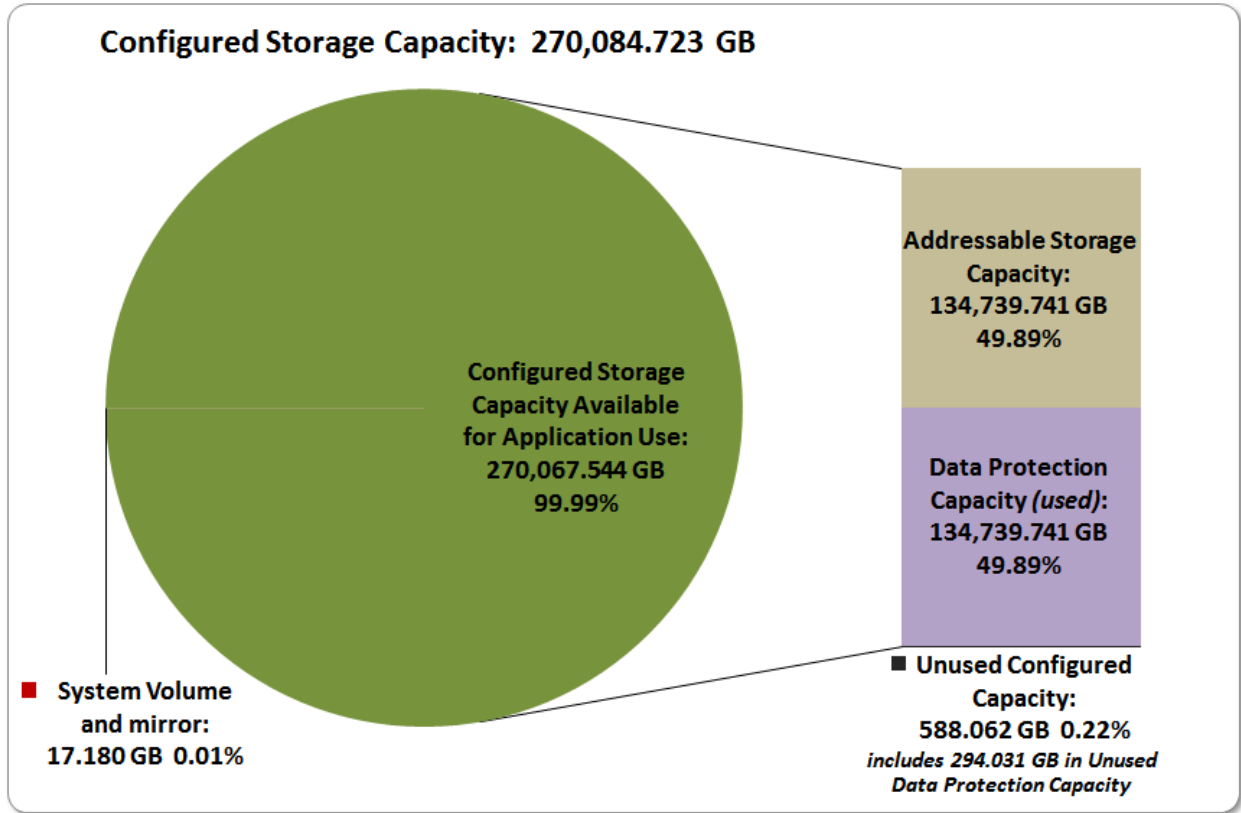
**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

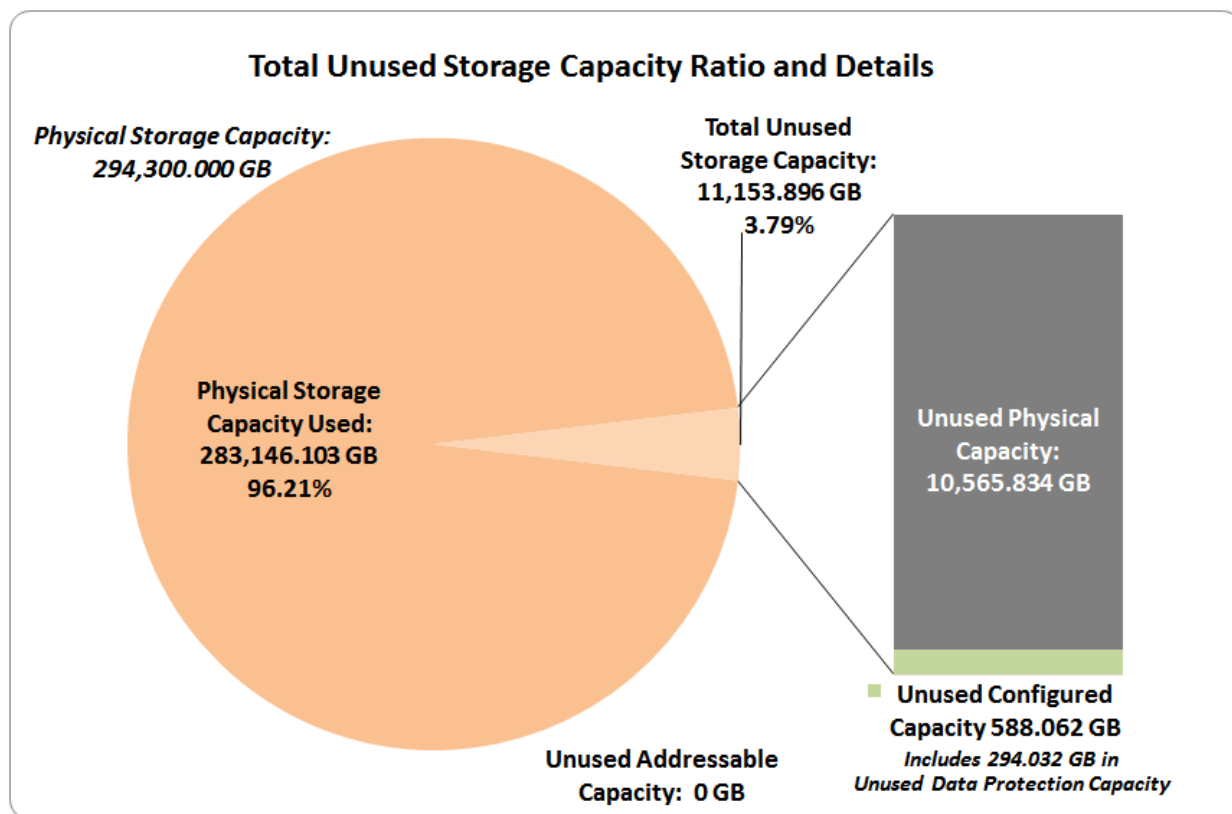
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

### Storage Capacities, Relationships, and Utilization

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







SPC-1 Storage Capacity Utilization	
Application Utilization	45.78%
Protected Application Utilization	91.57%
Unused Storage Ratio	3.79%

**Application Utilization:** Total ASU Capacity (134,739.741 GB) divided by Physical Storage Capacity (294,300.000 GB).

**Protected Application Utilization:** (Total ASU Capacity (134,739.741 GB) plus total Data Protection Capacity (135,033.772 GB) minus unused Data Protection Capacity (294.031GB)) divided by Physical Storage Capacity (294,300.000 GB).

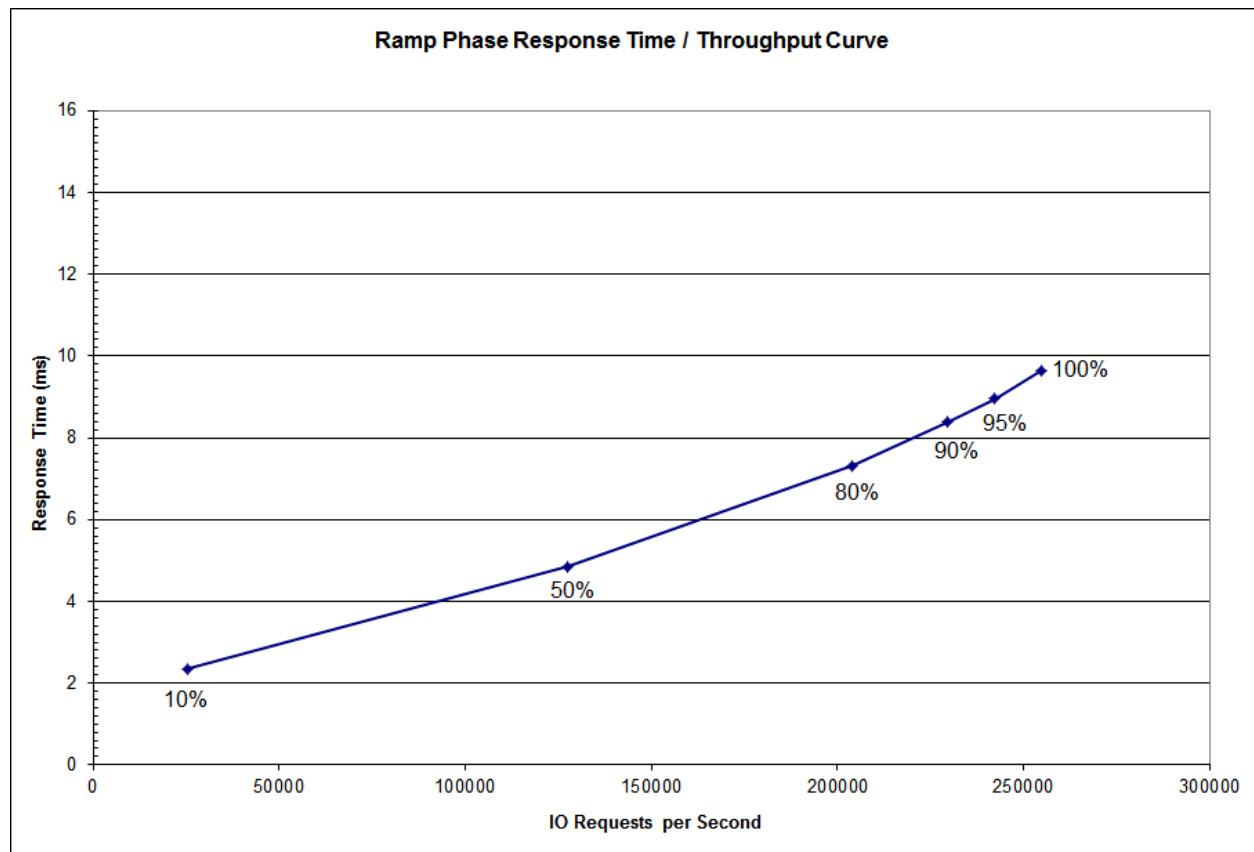
**Unused Storage Ratio:** Total Unused Capacity (11,153.897 GB) divided by Physical Storage Capacity (294,300.000 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 27-28.

### 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>	25,505.67	127,491.21	203,981.77	229,479.20	242,274.38	255,011.06
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	2.34	4.85	7.32	8.37	8.96	9.65
<b>ASU-1</b>	2.99	6.06	9.25	10.75	11.57	12.52
<b>ASU-2</b>	2.55	5.86	9.51	11.35	12.29	13.43
<b>ASU-3</b>	0.87	1.85	2.26	2.03	1.98	1.92
<b>Reads</b>	4.85	10.39	16.08	18.80	20.21	21.88
<b>Writes</b>	0.71	1.25	1.61	1.59	1.63	1.68



## Priced Storage Configuration Pricing

SKU	Description	Quantity	Unit List Price	Extended List	Discount	Discounted Price
<b>Hardware</b>						
Q24-FR000000072050	Ordering Part number for SAN Storage M710 Disk Array	1	0.00	0.00	20%	0.00
NF5322-SFP16E	2 - 16Gb FC SFPs	16	367.00	5,872.00	20%	4,697.60
NF5372-SR00E	M710 Dual Controller Disk Array Unit w Base SW (w 2 - 4 port Disk Port Cards, w/o Host Port Card, SFP or Cache Memory)	1	94,177.00	94,177.00	20%	75,341.60
Q24-HL000000072891	Localization Kit for M510/M710 Disk Array Unit	1	0.00	0.00	20%	0.00
NF5372-SF06WE	M710 2 - 4 port FC Host Port Cards (4 ports per Controller) w/o SFP	4	3,491.00	13,964.00	20%	11,171.20
NF5372-SD01WE	M710 2 - 4 port Disk Port Cards (4 ports per Controller)	3	2,961.00	8,883.00	20%	7,106.40
NF5372-SC04E	M710 Cache Memory 96GB per Controller (192GB total cache)	1	8,881.00	8,881.00	20%	7,104.80
NF5322-SMA75E	SAS Disk Drive(2.5" 15krpm/300GB)	939	489.00	459,171.00	20%	367,336.80
NF5322-SMA78E	SAS Disk Drive(2.5" 15krpm/600GB)	21	643.00	13,503.00	20%	10,802.40
NF5322-SE81E	Disk Enclosure 2.5 inch for Mx10	40	5,427.00	217,080.00	20%	173,664.00
Q24-HL000000072706	Localization Kit for Mx10 Disk Enclosure	40	0.00	0.00	20%	0.00
NF9100-SF26E	Front Bezel (4U Black, w/ NEC Logo) for Mx10	1	123.00	123.00	20%	98.40
NF9100-SF22E	Front Bezel (2U Black, w/ NEC Logo) for Mx10	40	90.00	3,600.00	20%	2,880.00
N8190-158	NEC N8190-158 dual-port 16G FC HBAs (w/ SFP)	16	1,570.00	25,120.00	20%	20,096.00
<b>Software</b>						
Q24-HL000000074244	M710 60 Day Trial License Bundle	1	0.00	0.00	20%	0.00
Q24-HL000000072867	M710 Base Software	1	0.00	0.00	20%	0.00
<b>Maintenance</b>						
Q24-DN000000072502	3 Years Upgrade to Platinum M710 Dual Controller w /Base SW	1	16,571.00	16,571.00	15%	14,085.35
Q24-DN000000072693	3 Years Upgrade to Platinum M710 2 - 4 port FC Host Port Cards (4 ports per Controller)	4	1,222.00	4,888.00	15%	4,154.80
Q24-DN000000072700	3 Years Upgrade to Platinum M710 2 - 4 port Disk Port Cards (4 ports per Controller)	3	1,037.00	3,111.00	15%	2,644.35
Q24-DN000000072588	3 Years Upgrade to Platinum M710 Cache Memory 96GB per Controller (192GB Total)	1	3,109.00	3,109.00	15%	2,642.65
Q24-DN000000072609	3 Years Upgrade to Platinum Disk Enclosure 2.5 inch for Mx10	40	1,900.00	76,000.00	15%	64,600.00
Q24-DN000000072939	1 Year Platinum SW Maintenance M710 Base Software	3	5,620.00	16,860.00	15%	14,331.00
<b>Cables and Racks</b>						
Power Strips	Power Strips (8 outlets)	12	78.00	936.00	10%	842.40
RACK	Rack 42U	3	1,799.00	5,397.00	10%	4,857.30
NF9120-SJ93	2 - 3M Mini SAS HD Cables	12	439.00	5,268.00	10%	4,741.20
FC CABLE	CRU FC CABLE 5M x2 (M#LCLC-5MQ) 5M	16	54.00	864.00	10%	777.60
<b>Configuration Total</b>				<b>\$983,378.00</b>		<b>\$793,975.85</b>

- Power codes for M710 and Disk Enclosures are included in Localization Kits (Q24-HL000000072891 and Q24-HL000000072706)
- The M710 Disk Array Unit price includes M710 Base Software (Q24-HL000000072867)
- PathManager for Windows/Linux/VMware is included in M710 Base Software (Q24-HL000000072867)

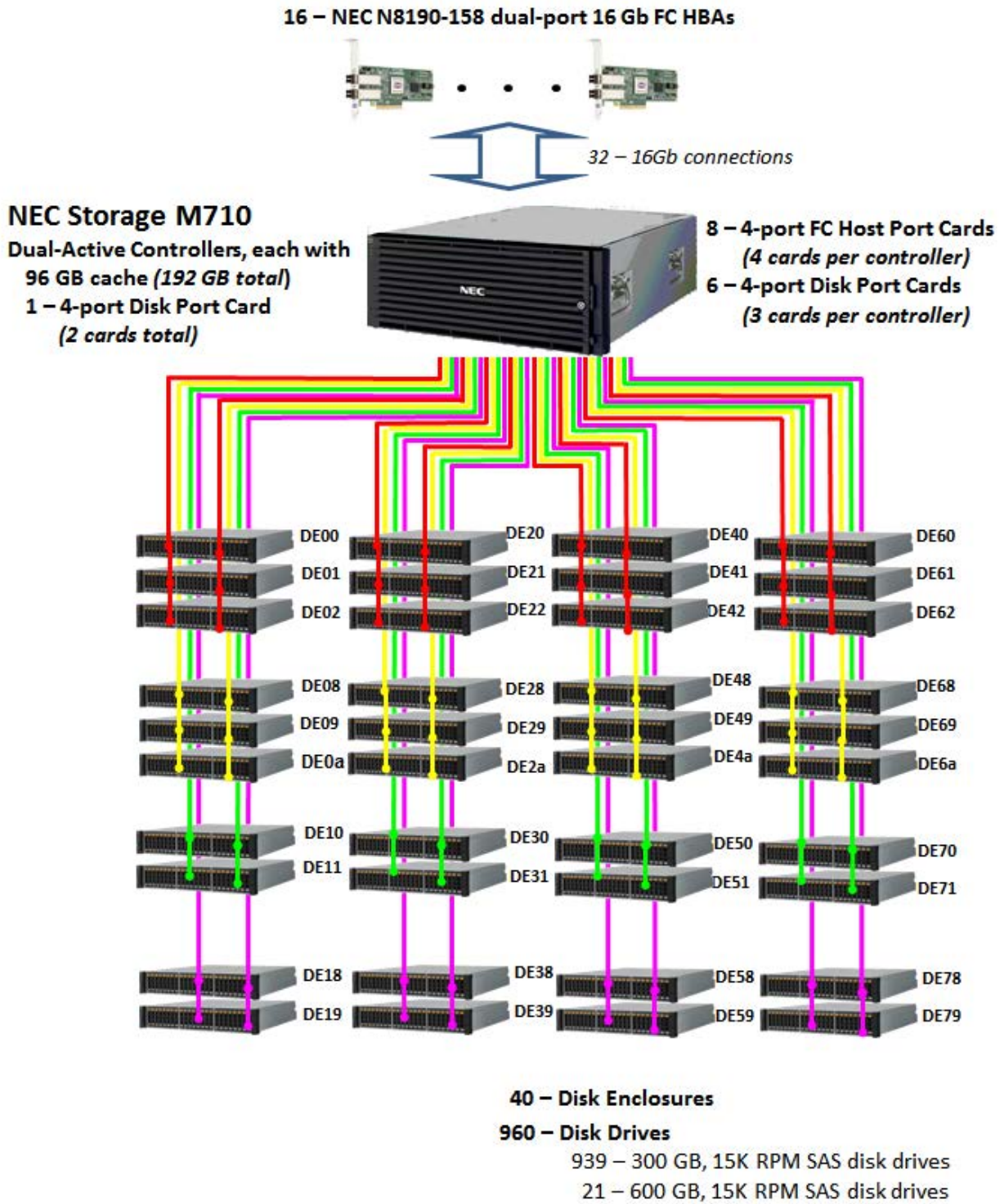
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

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

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

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

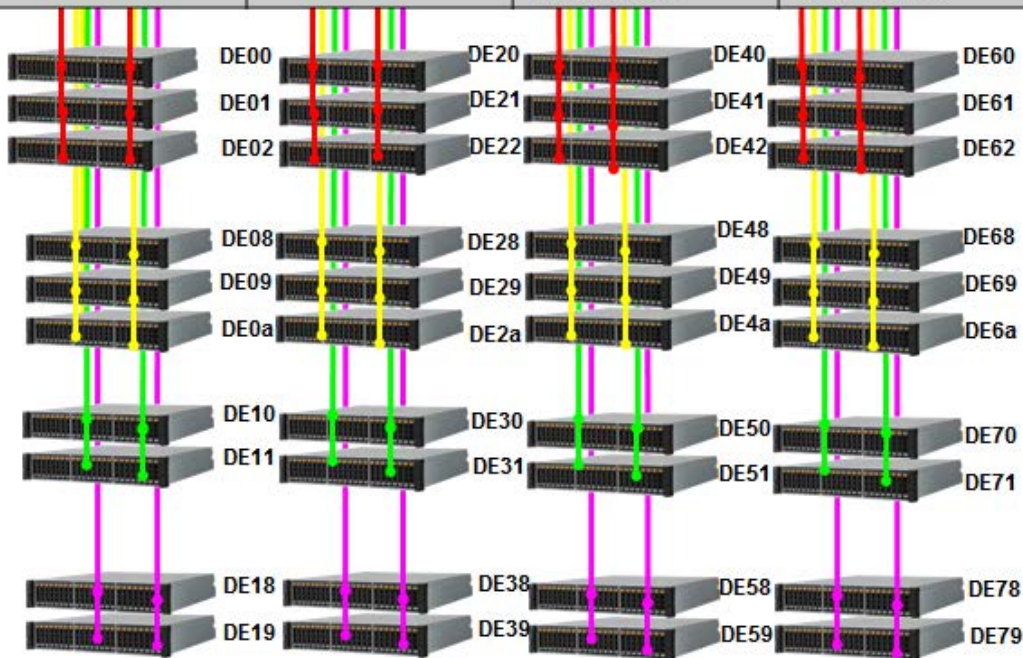
### Priced Storage Configuration Diagram



The distribution of disk drives to disk enclosures is documented on page [20](#).

### Distribution of Disk Drives to Disk Enclosures

DE00 (2.5"): 24 - 300 GB HDD	DE20 (2.5"): 24 - 300 GB HDD	DE40 (2.5"): 24 - 300 GB HDD	DE60 (2.5"): 24 - 300 GB HDD
DE01 (2.5"): 24 - 300 GB HDD	DE21 (2.5"): 24 - 300 GB HDD	DE41 (2.5"): 24 - 300 GB HDD	DE61 (2.5"): 24 - 300 GB HDD
DE02 (2.5"): 24 - 300 GB HDD	DE22 (2.5"): 24 - 300 GB HDD	DE42 (2.5"): 24 - 300 GB HDD	DE62 (2.5"): 22 - 300 GB HDD 2 - 600 GB HDD
DE08 (2.5"): 24 - 300 GB HDD	DE28 (2.5"): 12 - 300 GB HDD 12 - 600 GB HDD	DE48 (2.5"): 24 - 300 GB HDD	DE68 (2.5"): 23 - 300 GB HDD 1 - 600 GB HDD
DE09 (2.5"): 24 - 300 GB HDD	DE29 (2.5"): 24 - 300 GB HDD	DE49 (2.5"): 24 - 300 GB HDD	DE69 (2.5"): 24 - 300 GB HDD
DE0a (2.5"): 24 - 300 GB HDD	DE2a (2.5"): 23 - 300 GB HDD 1 - 600 GB HDD	DE4a (2.5"): 24 - 300 GB HDD	DE6a (2.5"): 24 - 300 GB HDD
DE10 (2.5"): 24 - 300 GB HDD	DE30 (2.5"): 24 - 300 GB HDD	DE50 (2.5"): 24 - 300 GB HDD	DE70 (2.5"): 24 - 300 GB HDD
DE11 (2.5"): 24 - 300 GB HDD	DE31 (2.5"): 24 - 300 GB HDD	DE51 (2.5"): 24 - 300 GB HDD	DE71 (2.5"): 22 - 300 GB HDD 2 - 600 GB HDD
DE18 (2.5"): 23 - 300 GB HDD 1 - 600 GB HDD	DE38 (2.5"): 24 - 300 GB HDD	DE58 (2.5"): 24 - 300 GB HDD	DE78 (2.5"): 24 - 300 GB HDD
DE19 (2.5"): 24 - 300 GB HDD	DE39 (2.5"): 24 - 300 GB HDD	DE59 (2.5"): 23 - 300 GB HDD 1 - 600 GB HDD	DE79 (2.5"): 23 - 300 GB HDD 1 - 600 GB HDD



40 – Disk Enclosures, 960 – Disk Drives

939 – 300 GB, 15K RPM SAS HDDs, 21 – 600 GB, 15K RPM SAS HDDs

### Priced Storage Configuration Components

<b>Priced Storage Configuration</b>
16 – NEC N8190-158 dual-port 16Gb FC HBAs
<b>NEC Storage M710</b> Dual-Active Controllers, each with 96 GB memory ( <i>192 GB total</i> ) 1 – 4-port Disk Port Card ( <i>2 cards total, 8 ports total and used</i> )
8 – 4-port FC Host Port Cards ( <i>4 cards, 16 ports per controller, 32 ports total and used</i> )
6 – 4-port Disk Port Cards ( <i>3 cards, 12 ports per controller; 24 ports total and used</i> )
40 – Disk Enclosures, 2.5"
960 – 15K RPM SAS disk drives (HDDs) 939 – 300 GB HDDs 21 – 600 GB HDDs
3 – 42U Racks with 12 power strips ( <i>8 outlets per strip</i> )



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 [23 \(Benchmark Configuration/Tested Storage Configuration Diagram\)](#).

### **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.

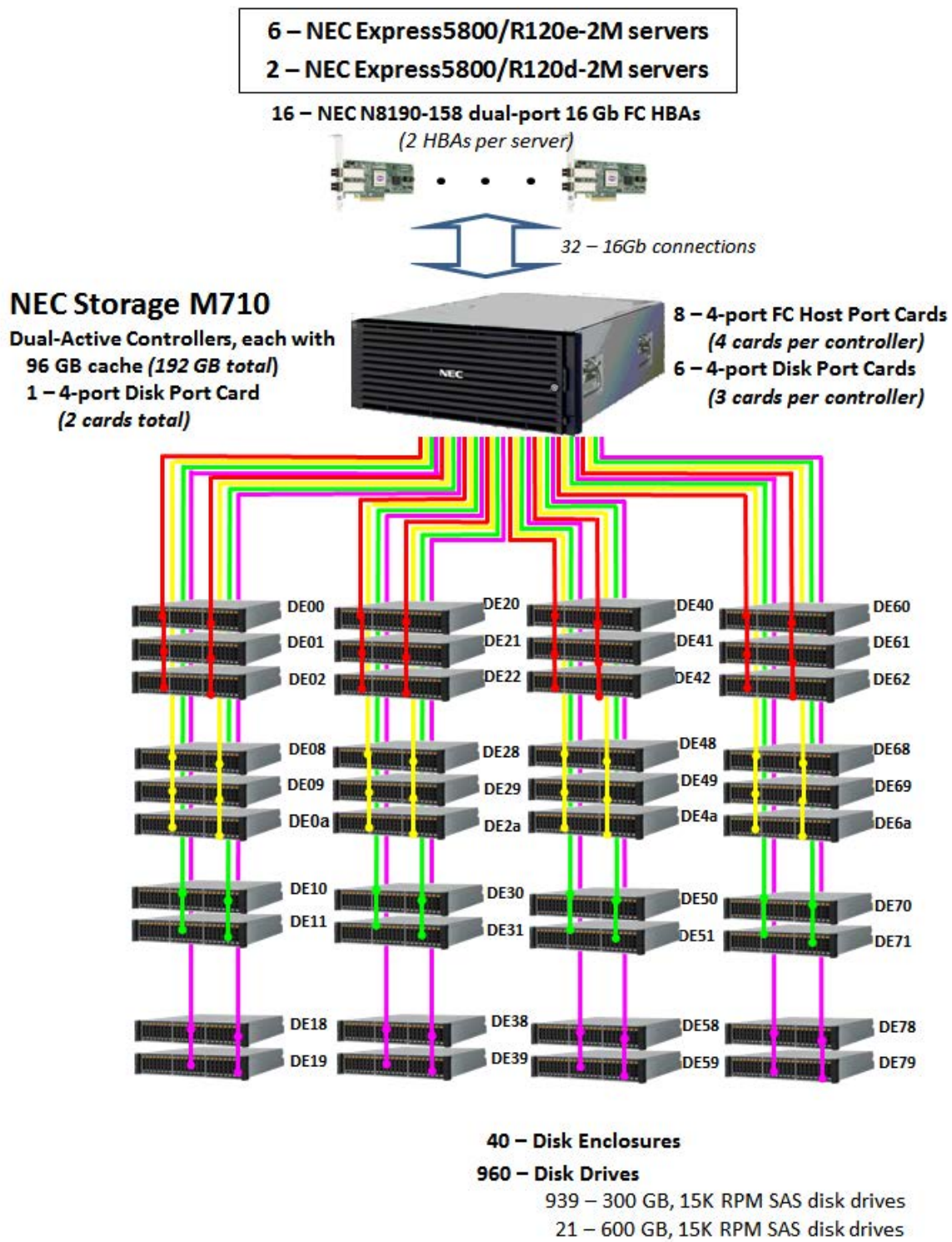
### **Host System(s) and Tested Storage Configuration (TSC) Table of Components**

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

### Benchmark Configuration/Tested Storage Configuration Diagram



The distribution of disk drives to disk enclosures is documented on page [20](#).

### Host System and Tested Storage Configuration Components

Host Systems
<p><b>6 – NEC Express5800/R120e-2M servers</b>, each with:</p> <ul style="list-style-type: none"> <li>2 – Intel® Xeon® 2.6 GHz E5-2630 v2 processors 6 cores per processor and 15 MB Intel® Smart Cache</li> <li>16 GB main memory</li> <li>Windows Server 2008 R2 Standard with SP1</li> <li>PCIe</li> </ul>
<p><b>2 – NEC Express5800/R120d-2M servers</b>, each with:</p> <ul style="list-style-type: none"> <li>2 – Intel® Xeon® 2.5 GHz E5-2640 v2 processors 6 cores per processor and 15 MB Intel® Smart Cache</li> <li>16 GB main memory</li> <li>Windows Server 2008 R2 Standard with SP1</li> <li>PCIe</li> </ul>
Tested Storage Configuration (TSC) Components
<p>16 – NEC N8190-158 dual-port 16Gb FC HBAs</p>
<p><b>NEC Storage M710</b></p> <p>Dual-Active Controllers, each with</p> <ul style="list-style-type: none"> <li>96 GB memory (<i>192 GB total</i>)</li> <li>1 – 4-port Disk Port Card (<i>2 cards total, 8 ports total and used</i>)</li> </ul>
<p>8 – 4-port FC Host Port Cards (<i>4 cards, 16 ports per controller, 32 ports total and used</i>)</p>
<p>6 – 4-port Disk Port Cards (<i>3 cards, 12 ports per controller; 24 ports total and used</i>)</p>
<p>40 – Disk Enclosures, 2.5"</p>
<p>960 – 15K RPM SAS disk drives (HDDs)</p> <ul style="list-style-type: none"> <li>939 – 300 GB HDDs</li> <li>21 – 600 GB HDDs</li> </ul>
<p>3 – 42U Racks with 12 power strips (<i>8 outlets per strip</i>)</p>



## 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 68 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 69 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 88.

## 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 88.

## **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 [64](#) 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 294,300.000 GB distributed over 960 disk drives. That capacity was distributed between 939 disk drives with a formatted capacity of 300.00 GB per disk drive and 21 disk drives with a formatted capacity of 600.00 GB per disk drive. There was 10,565.834 GB (3.59%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 13,649,442 GB (4.64%) of the Physical Storage Capacity. There was 588.062 GB (0.22%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*Mirroring*) capacity was 135,033.772 GB of which 134,739.741 GB was utilized. The total Unused Storage capacity was 11,153.897 GB.

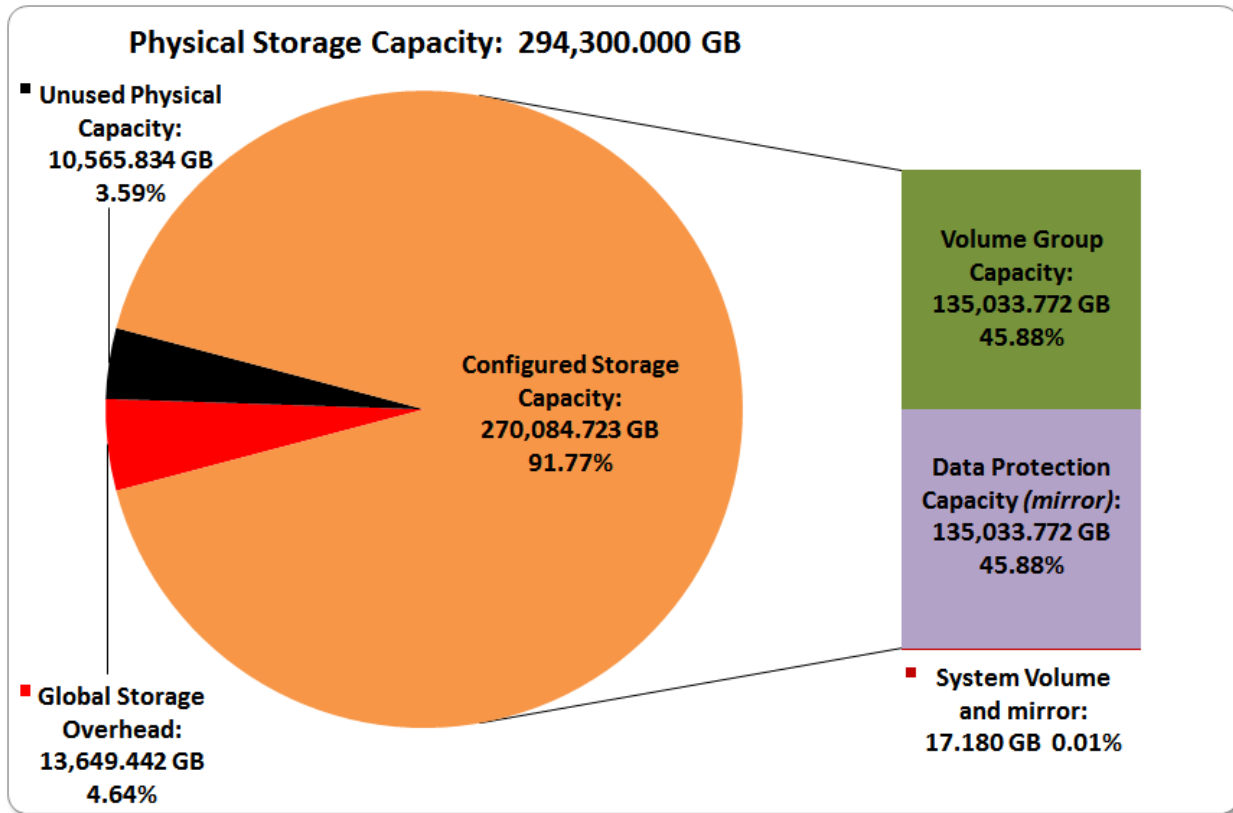
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

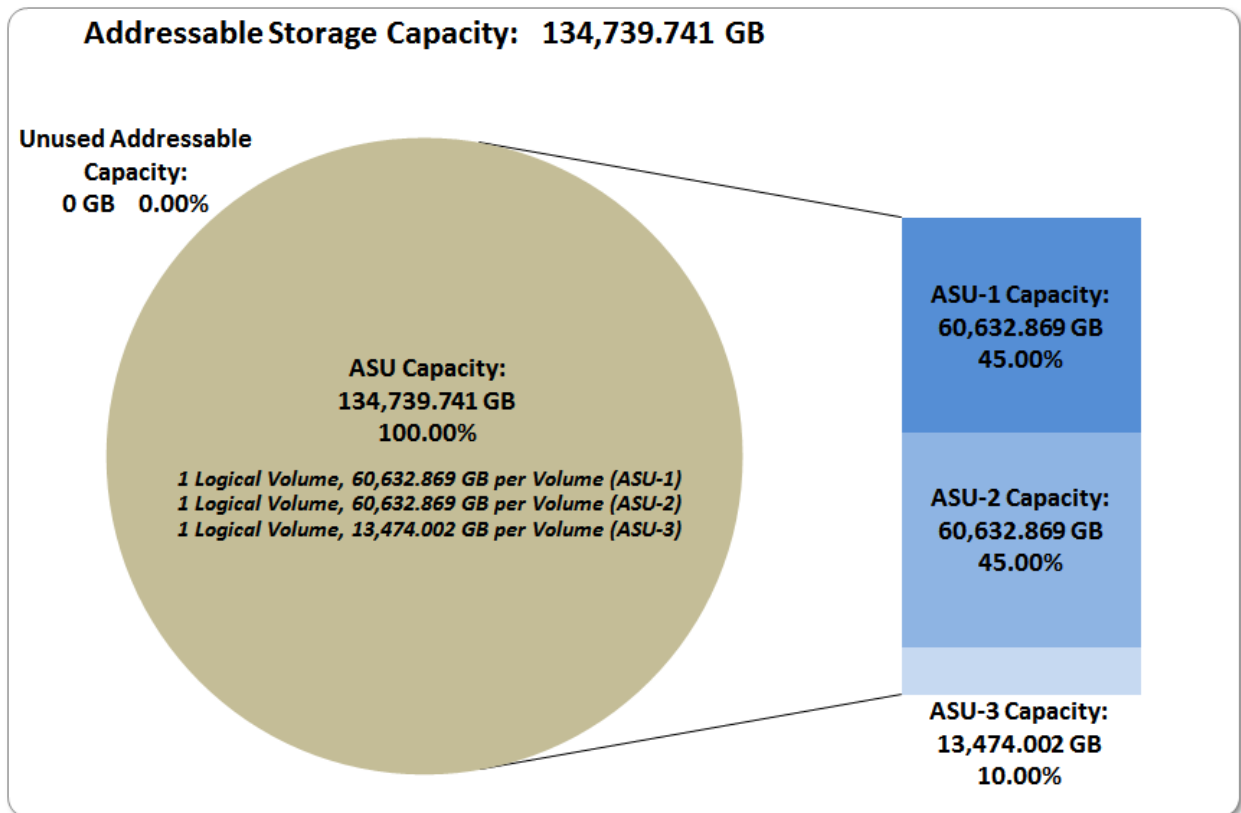
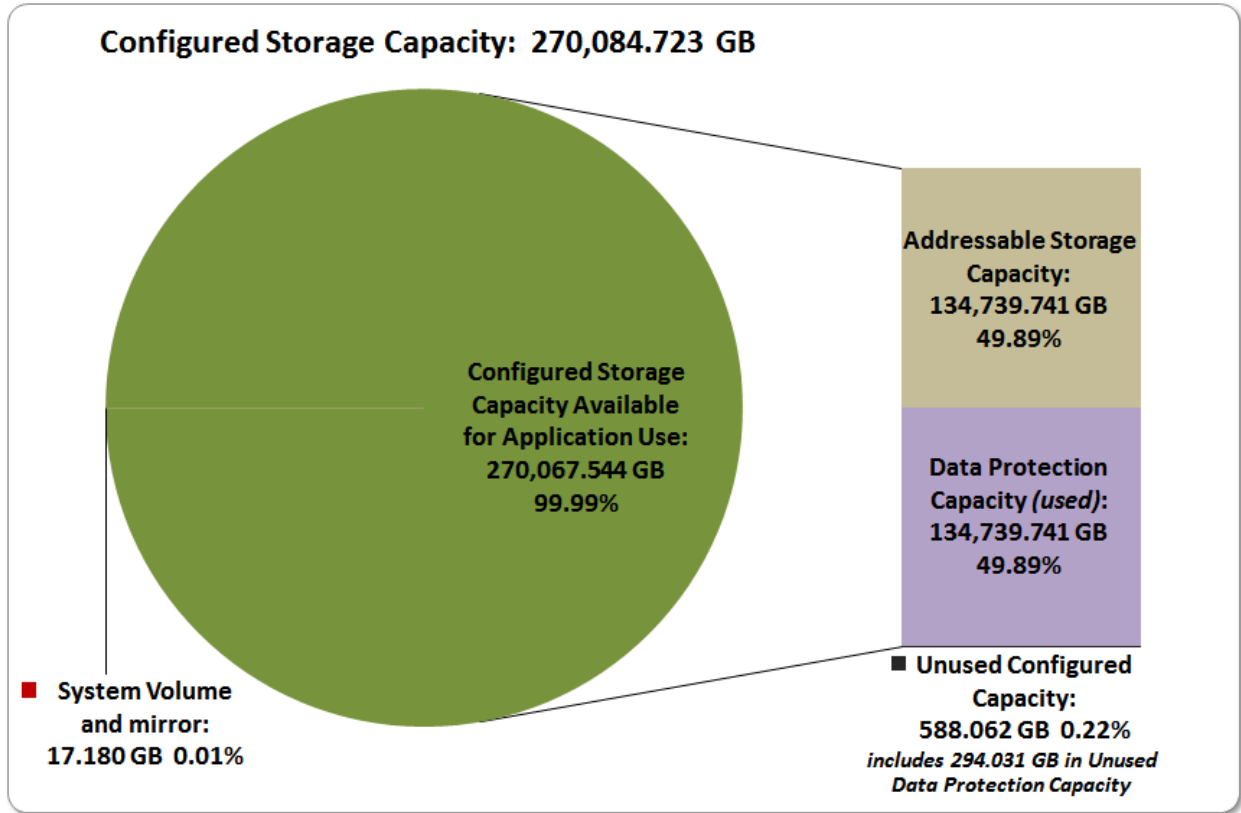
<b>SPC-1 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	134,739.741
Addressable Storage Capacity	Gigabytes (GB)	134,739.741
Configured Storage Capacity	Gigabytes (GB)	270,084.723
Physical Storage Capacity	Gigabytes (GB)	294,300.000
Data Protection ( <i>Mirroring</i> )	Gigabytes (GB)	135,033.772
Required Storage ( <i>system overhead</i> )	Gigabytes (GB)	17.180
Global Storage Overhead	Gigabytes (GB)	13,649.442
Total Unused Storage	Gigabytes (GB)	11,153.897

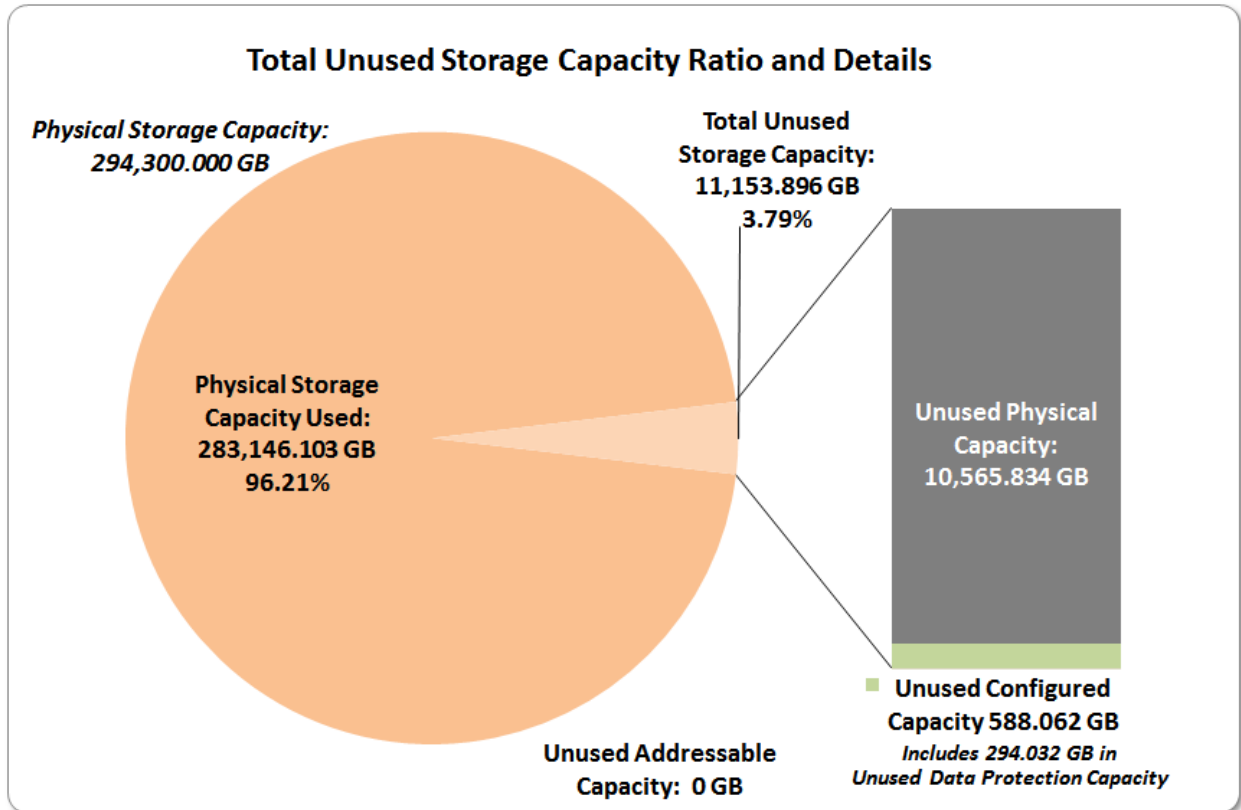
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	49.89%	45.78%
Required for Data Protection ( <i>Mirroring</i> )		50.00%	45.88%
Addressable Storage Capacity		49.89%	45.78%
Required Storage ( <i>system overhead</i> )		0.01%	0.01%
Configured Storage Capacity			91.77%
Global Storage Overhead			4.64%
Unused Storage:			
Addressable	0.00%		
Configured		0.22%	
Physical			3.59%

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	45.78%
Protected Application Utilization	91.57%
Unused Storage Ratio	3.79%

### 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 (60,632.869 GB)	ASU-2 (60,632.869 GB)	ASU-3 (13,474.002 GB)
1 Logical Volume 60,632.869 GB per Logical Volume (60,632.869 GB used per Logical Volume)	1 Logical Volume 60,632.869 GB per Logical Volume (60,632.869 GB used per Logical	1 Logical Volume 13,474.002 GB per Logical Volume (13,474.002 GB used per Logical Volume)

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

## **SPC-1 BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. An [SPC-1 glossary](#) on page 64 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 90.

### Sustainability Test Results File

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

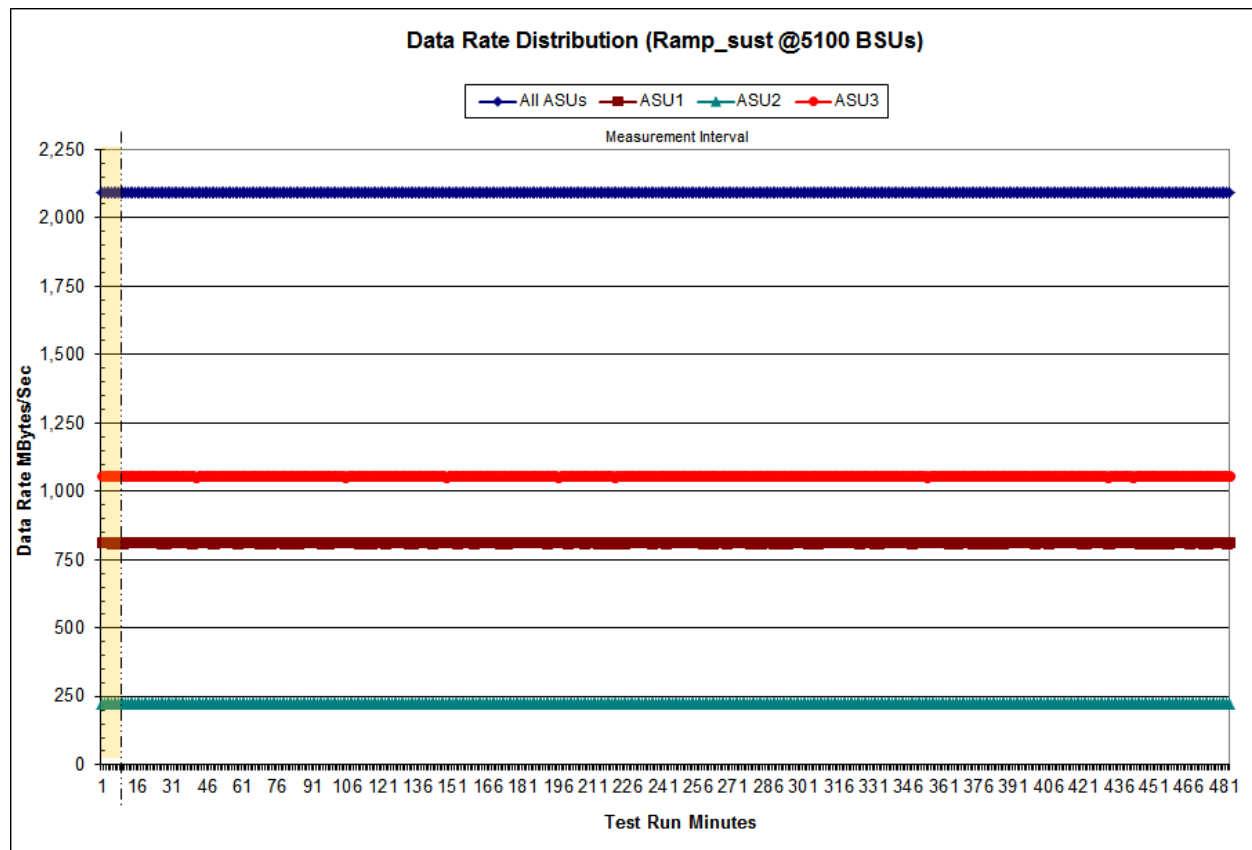
[Sustainability Test Results File](#)

### 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

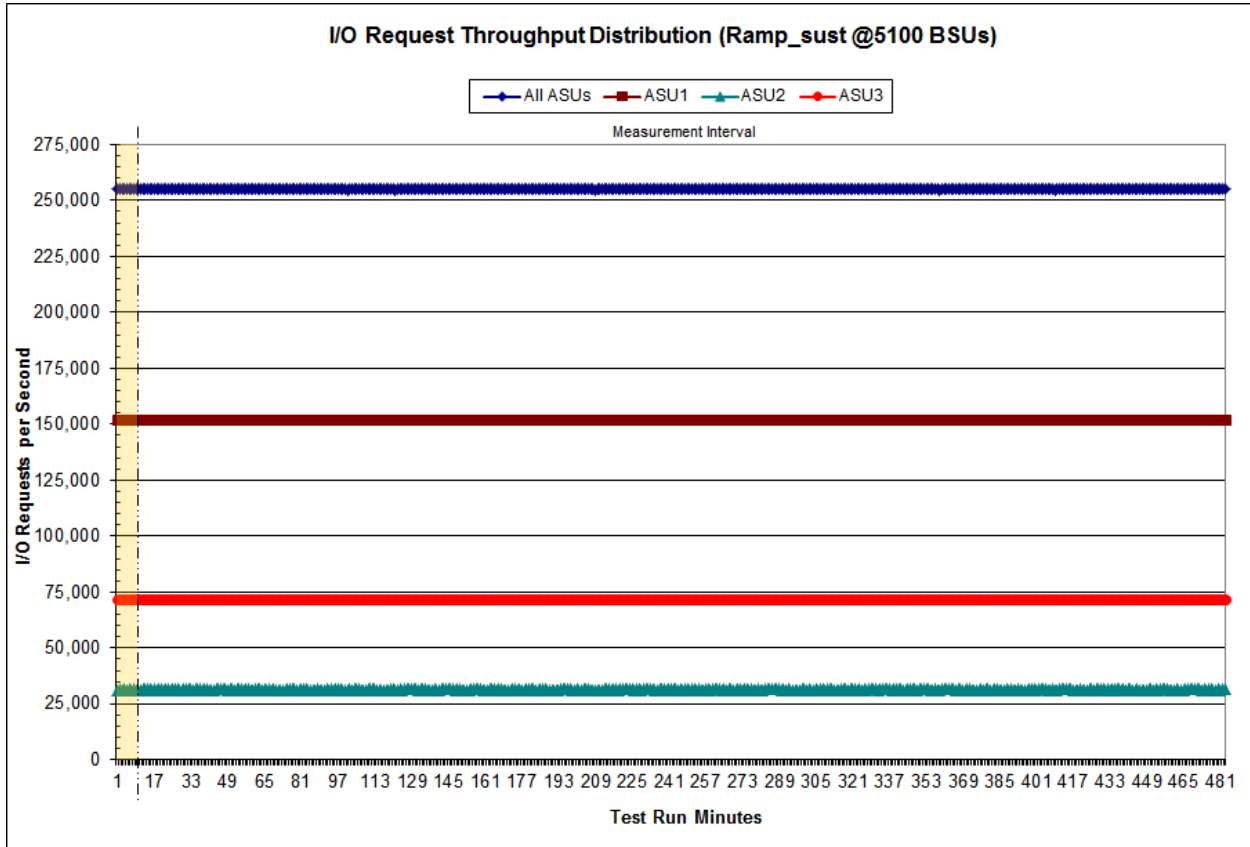


### Sustainability – I/O Request Throughput Distribution Data

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

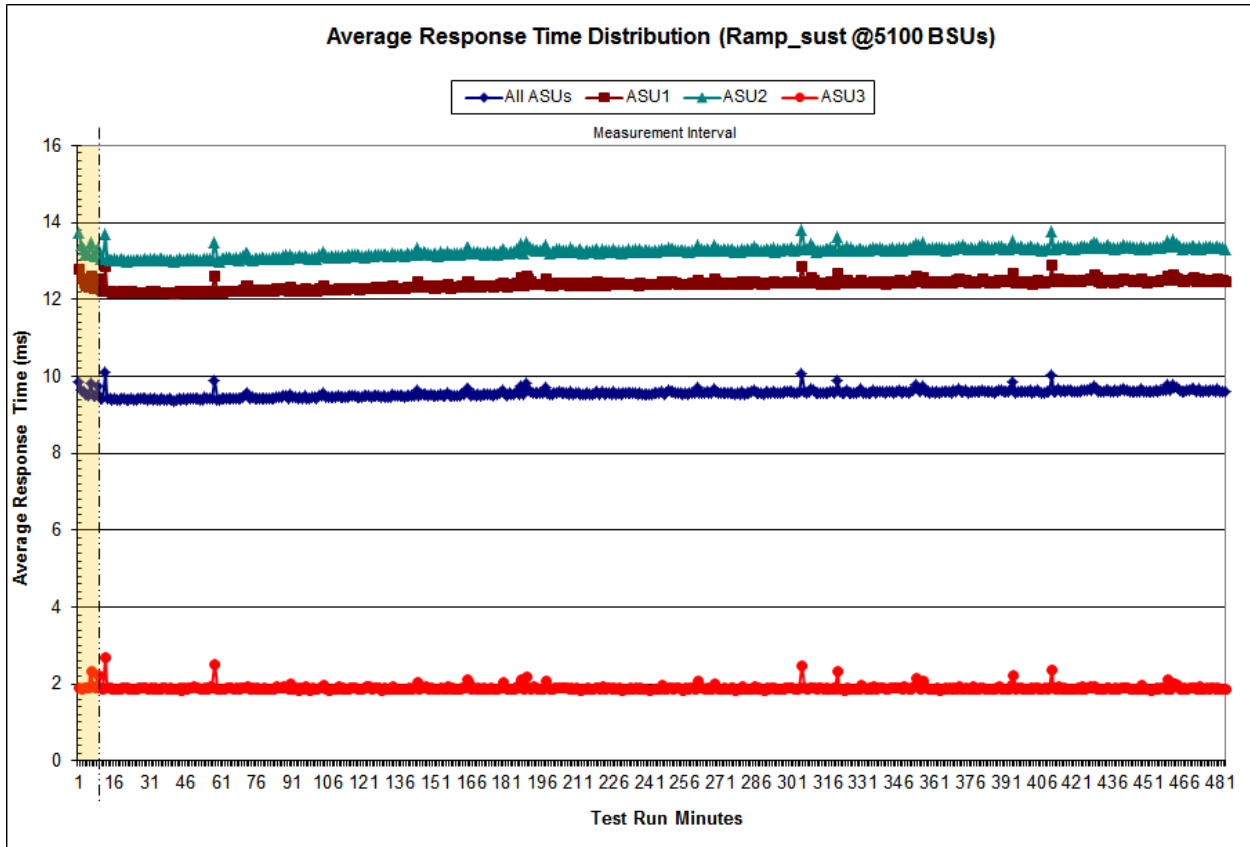


### Sustainability – Average Response Time (ms) Distribution Data

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](#)

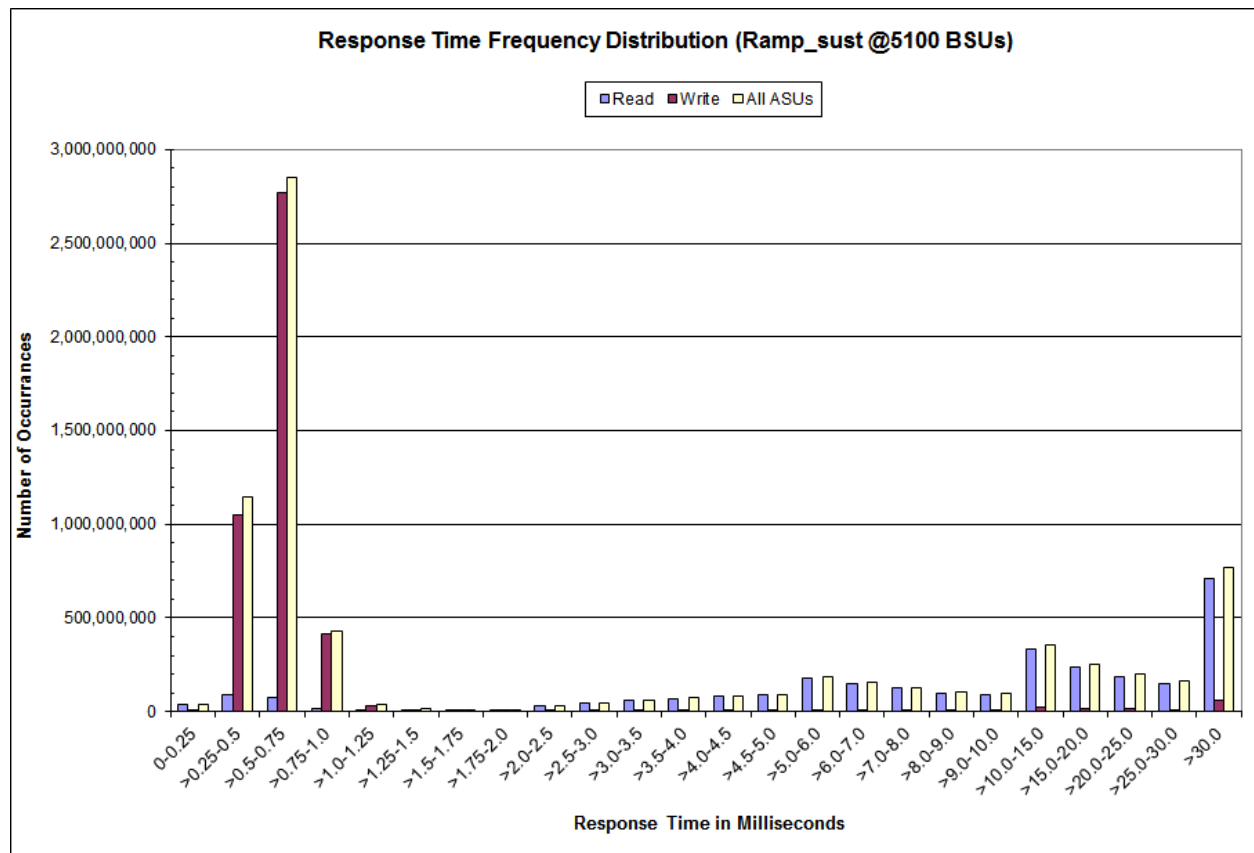
### Sustainability – Average Response Time (ms) Distribution Graph



**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	35,655,350	93,504,040	77,443,141	17,041,081	7,767,993	8,143,578	8,136,496	10,052,241
Write	4,802	1,052,987,179	2,770,454,988	412,457,206	33,612,383	7,372,632	3,098,116	1,953,703
All ASUs	35,660,152	1,146,491,219	2,847,898,129	429,498,287	41,380,376	15,516,210	11,234,612	12,005,944
ASU1	33,181,084	575,103,045	1,258,096,483	161,034,189	16,502,256	9,140,415	8,319,178	9,979,497
ASU2	2,477,346	144,691,080	307,646,895	39,753,570	4,395,321	2,231,564	1,121,153	846,393
ASU3	1,722	426,697,094	1,282,154,751	228,710,528	20,482,799	4,144,231	1,794,281	1,180,054
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	30,086,236	44,365,872	57,514,983	69,611,184	83,020,524	90,369,944	177,396,970	150,291,517
Write	2,751,900	2,735,887	2,374,432	2,713,858	2,424,242	2,861,864	5,456,209	5,370,665
All ASUs	32,838,136	47,101,759	59,889,415	72,325,042	85,444,766	93,231,808	182,853,179	155,662,182
ASU1	28,454,871	40,971,735	52,253,350	62,805,947	74,386,839	80,877,814	157,380,022	132,744,761
ASU2	2,702,496	4,456,040	6,180,793	7,891,039	9,602,254	10,703,030	22,339,089	19,812,949
ASU3	1,680,769	1,673,984	1,455,272	1,628,056	1,455,673	1,650,964	3,134,068	3,104,472
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	124,322,688	99,812,930	90,782,403	336,388,311	237,260,837	185,391,391	151,402,043	710,690,640
Write	5,257,195	5,098,852	4,931,183	21,902,205	17,962,252	14,635,285	11,876,602	57,292,897
All ASUs	129,579,883	104,911,782	95,713,586	358,290,516	255,223,089	200,026,676	163,278,645	767,983,537
ASU1	110,160,235	88,694,916	80,735,254	298,112,249	208,726,228	161,666,777	130,927,251	596,725,889
ASU2	16,408,512	13,297,996	12,132,661	46,986,060	35,139,180	28,920,585	24,694,142	138,905,700
ASU3	3,011,136	2,918,870	2,845,671	13,192,207	11,357,681	9,439,314	7,657,252	32,351,948

**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	0.007	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.002	0.001	0.001	0.000

## Primary Metrics Test – IOPS Test Phase

### Clause 5.4.4.2

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

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

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

### Clause 9.4.3.7.3

*For the IOPS Test Phase the FDR shall contain:*

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [90](#).

## IOPS Test Results File

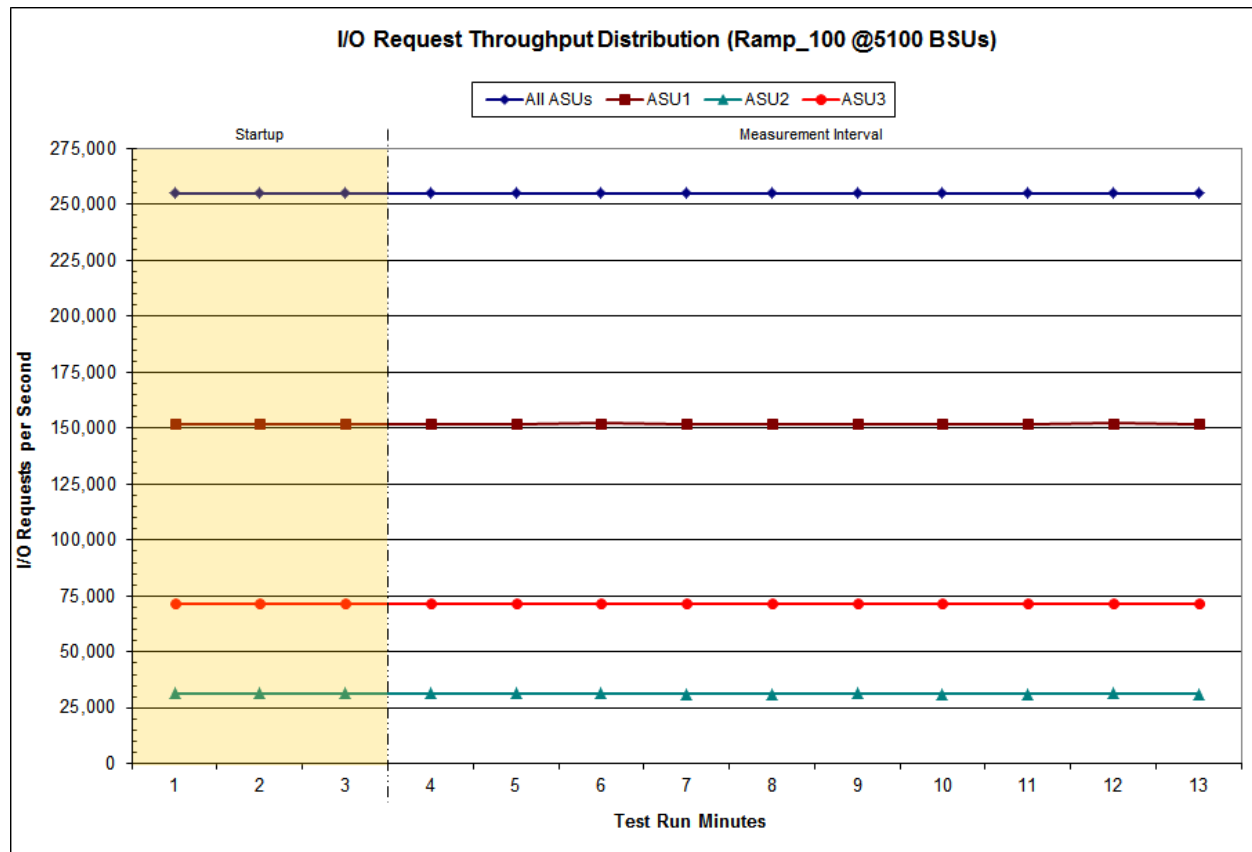
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

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

5,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	21:02:02	21:05:03	0-2	0:03:01
<i>Measurement Interval</i>	21:05:03	21:15:03	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	255,124.50	152,049.30	31,389.72	71,685.48
1	255,047.97	151,974.33	31,385.43	71,688.20
2	255,010.87	151,972.75	31,388.90	71,649.22
3	254,892.43	151,915.37	31,371.78	71,605.28
4	255,071.35	151,988.28	31,381.63	71,701.43
5	255,062.18	152,060.63	31,364.92	71,636.63
6	254,973.57	152,012.40	31,327.07	71,634.10
7	254,975.57	152,027.08	31,359.23	71,589.25
8	254,952.97	151,944.63	31,370.78	71,637.55
9	255,032.08	152,037.62	31,344.68	71,649.78
10	254,952.60	151,923.65	31,340.18	71,688.77
11	255,110.10	152,067.52	31,367.90	71,674.68
12	255,087.72	151,998.68	31,360.05	71,728.98
<b>Average</b>	<b>255,011.06</b>	<b>151,997.59</b>	<b>31,358.82</b>	<b>71,654.65</b>

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

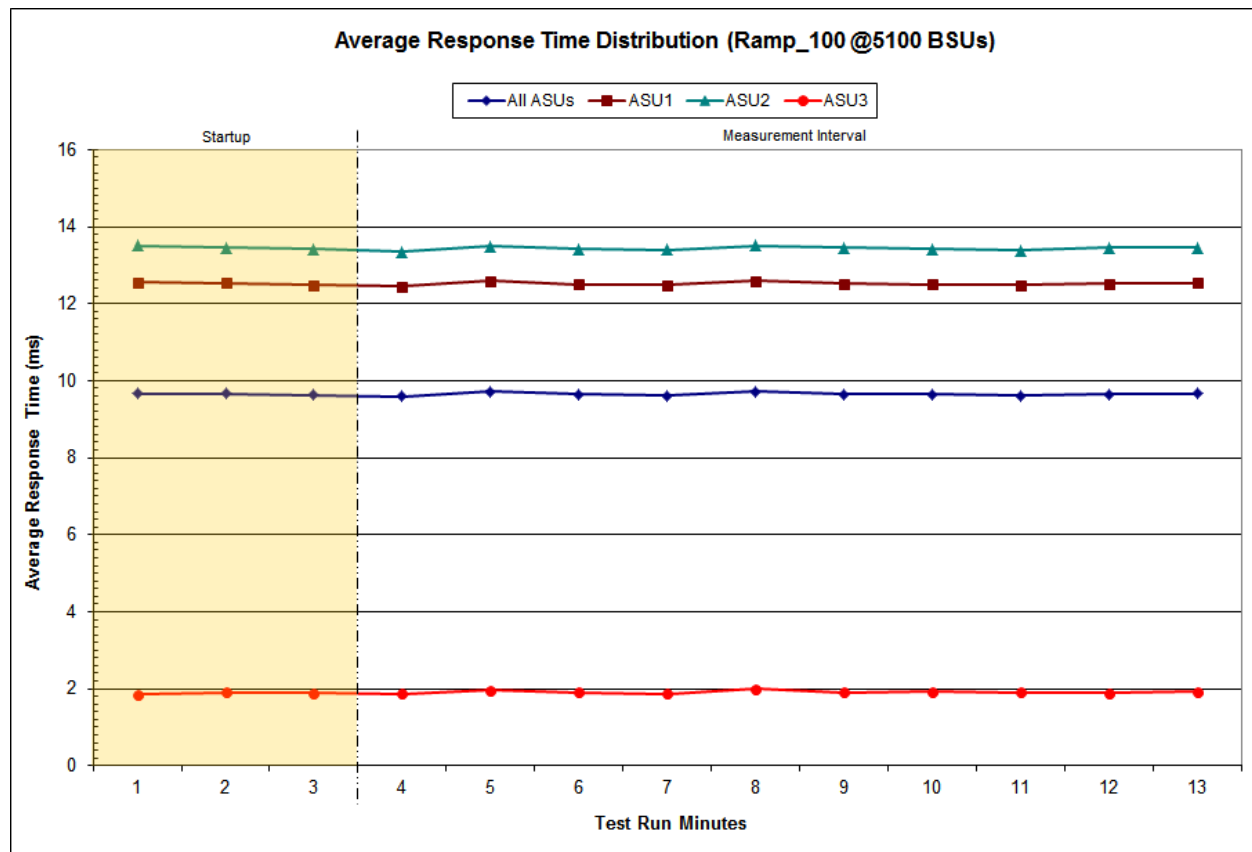




**IOPS Test Run – Average Response Time (ms) Distribution Data**

5,100 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	21:02:02	21:05:03	0-2	0:03:01
	21:05:03	21:15:03	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9.67	12.56	13.50	1.86
1	9.66	12.54	13.45	1.90
2	9.62	12.48	13.42	1.89
3	9.59	12.45	13.35	1.88
4	9.72	12.59	13.50	1.97
5	9.64	12.50	13.43	1.91
6	9.61	12.48	13.39	1.87
7	9.72	12.58	13.50	1.99
8	9.65	12.52	13.45	1.90
9	9.65	12.51	13.42	1.93
10	9.62	12.47	13.38	1.91
11	9.65	12.52	13.46	1.89
12	9.66	12.53	13.46	1.93
<b>Average</b>	<b>9.65</b>	<b>12.52</b>	<b>13.43</b>	<b>1.92</b>

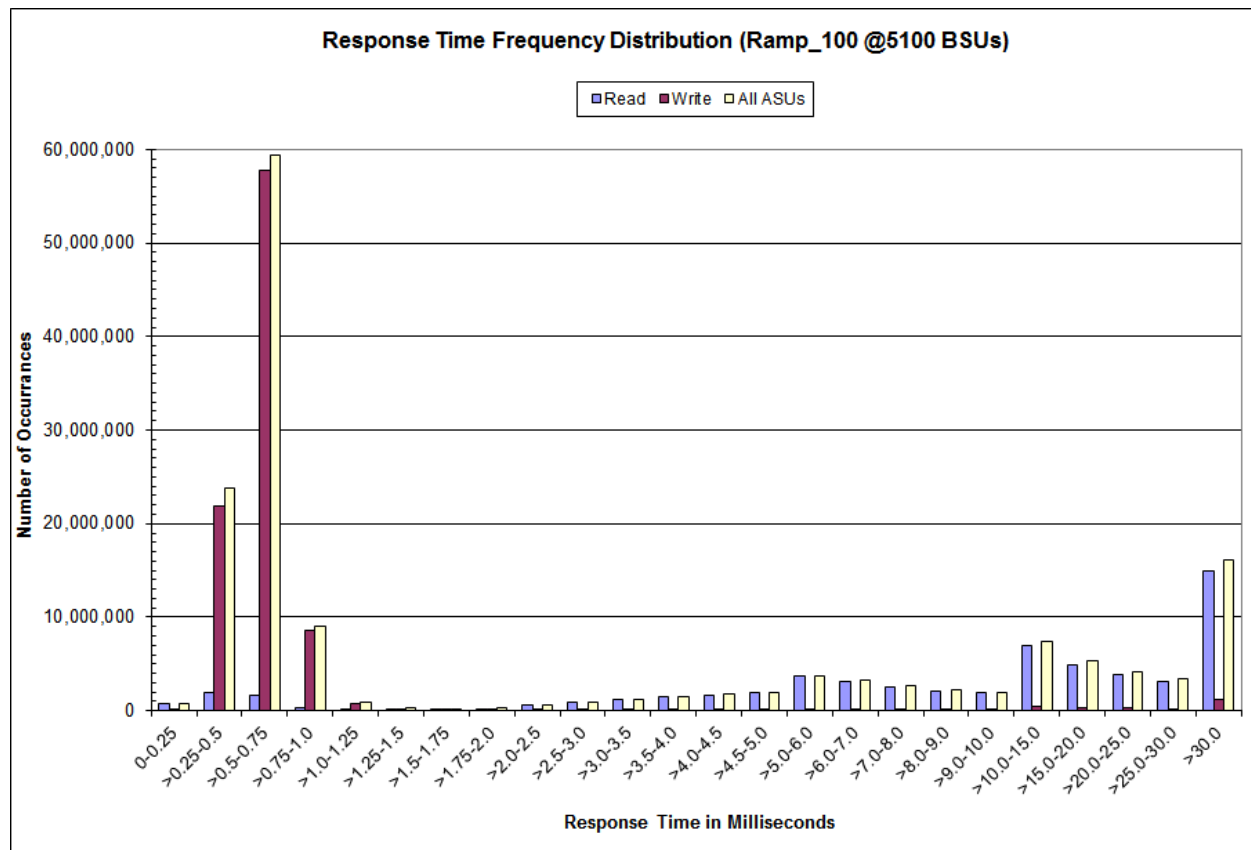
**IOPS Test Run – Average Response Time (ms) Distribution Graph**



**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	795,329	1,957,259	1,614,436	353,074	160,265	168,960	168,721	208,672
Write	254	21,830,075	57,779,227	8,633,041	695,483	148,293	63,201	40,485
All ASUs	795,583	23,787,334	59,393,663	8,986,115	855,748	317,253	231,922	249,157
ASU1	742,776	11,938,661	26,228,888	3,369,316	340,301	187,698	172,038	207,409
ASU2	52,716	3,000,863	6,418,771	832,668	90,603	45,771	23,452	17,370
ASU3	91	8,847,810	26,746,004	4,784,131	424,844	83,784	36,432	24,378
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	621,241	918,306	1,187,788	1,439,921	1,712,366	1,871,672	3,665,052	3,110,559
Write	57,859	57,868	49,968	57,108	50,925	60,728	114,985	113,182
All ASUs	679,100	976,174	1,237,756	1,497,029	1,763,291	1,932,400	3,780,037	3,223,741
ASU1	588,954	848,942	1,080,023	1,301,617	1,535,804	1,677,267	3,254,966	2,750,024
ASU2	55,143	91,955	127,412	161,910	197,425	220,629	460,098	409,547
ASU3	35,003	35,277	30,321	33,502	30,062	34,504	64,973	64,170
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	2,569,620	2,066,371	1,878,136	6,976,035	4,934,060	3,857,929	3,151,194	14,963,430
Write	110,357	106,866	102,708	455,974	374,210	305,451	247,177	1,198,425
All ASUs	2,679,977	2,173,237	1,980,844	7,432,009	5,308,270	4,163,380	3,398,371	16,161,855
ASU1	2,278,459	1,837,828	1,671,403	6,186,685	4,345,197	3,366,164	2,726,482	12,559,772
ASU2	338,790	274,710	250,507	972,457	728,209	601,149	512,931	2,929,802
ASU3	62,728	60,699	58,934	272,867	234,864	196,067	158,958	672,281

**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
153,004,246	136,842.391	16,161.855

### 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	0.002	0.000	0.001	0.001	0.001	0.001	0.002	0.000

## Primary Metrics Test – Response Time Ramp Test Phase

### Clause 5.4.4.3

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

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

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

### Clause 9.4.3.7.4

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [90](#).

## 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

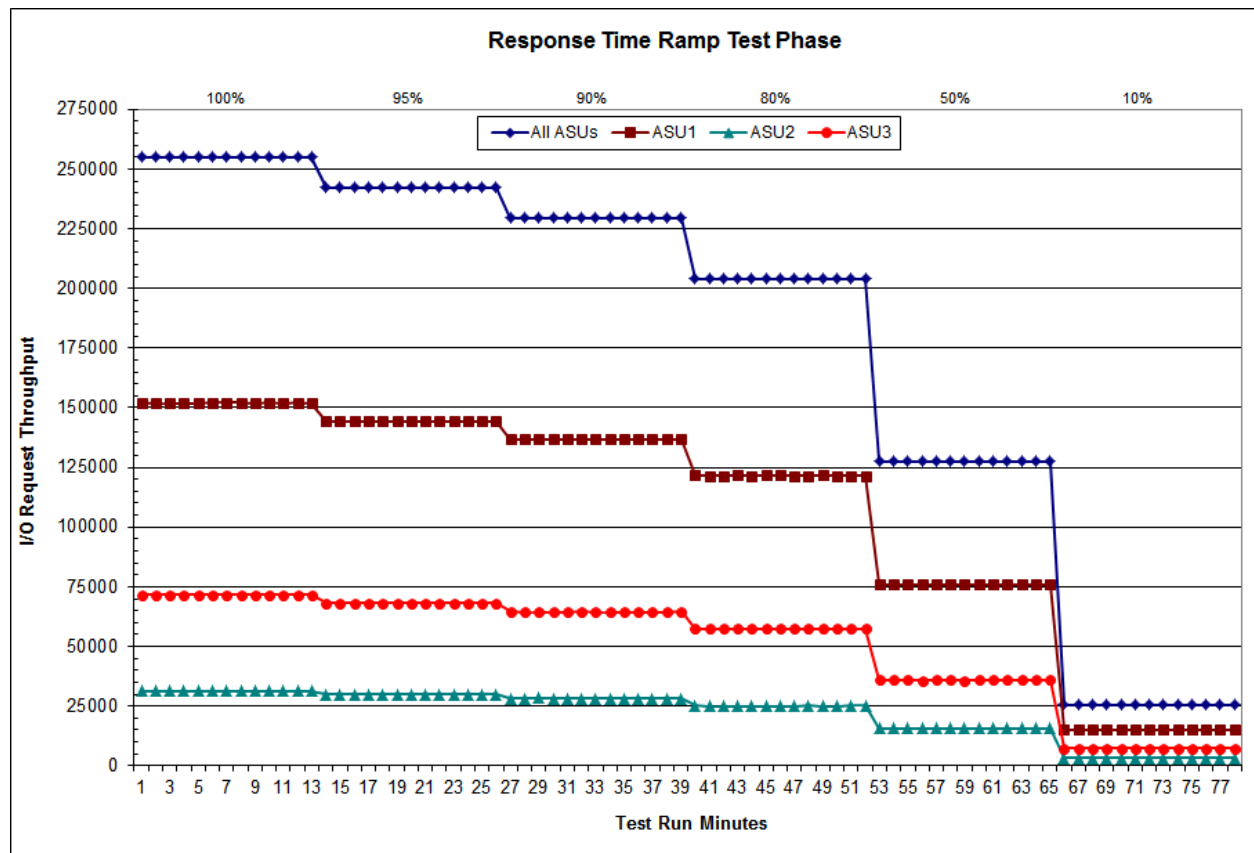
The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data table and graph for completeness.

100% Load Level: 5,100 BSUs					95% Load Level: 4,845 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	21:02:02	21:05:03	0-3	0:03:01	<b>Start-Up/Ramp-Up</b>	21:20:00	21:23:01	0-3	0:03:01
<b>Measurement Interval</b>	21:05:03	21:15:03	3-12	0:10:00	<b>Measurement Interval</b>	21:23:01	21:33:01	3-12	0:10:00
<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>
0	255,124.50	152,049.30	31,389.72	71,685.48	0	242,222.77	144,361.63	29,782.62	68,078.52
1	255,047.97	151,974.33	31,385.43	71,688.20	1	242,238.83	144,374.47	29,761.22	68,103.15
2	255,010.87	151,972.75	31,388.90	71,649.22	2	242,273.15	144,422.87	29,790.03	68,060.25
3	254,892.43	151,915.37	31,371.78	71,605.28	3	242,364.27	144,438.75	29,839.98	68,085.53
4	255,071.35	151,988.28	31,381.63	71,701.43	4	242,292.17	144,435.48	29,797.08	68,059.60
5	255,062.18	152,060.63	31,364.92	71,636.63	5	242,349.23	144,387.05	29,840.37	68,121.82
6	254,973.57	152,012.40	31,327.07	71,634.10	6	242,192.77	144,265.48	29,830.18	68,097.10
7	254,975.57	152,027.08	31,359.23	71,589.25	7	242,248.08	144,338.95	29,831.97	68,077.17
8	254,952.97	151,944.63	31,370.78	71,637.55	8	242,233.33	144,342.02	29,786.05	68,105.27
9	255,032.08	152,037.62	31,344.68	71,649.78	9	242,249.05	144,408.87	29,771.30	68,068.88
10	254,952.60	151,923.65	31,340.18	71,688.77	10	242,241.77	144,369.22	29,782.58	68,089.97
11	255,110.10	152,067.52	31,367.90	71,674.68	11	242,340.32	144,418.37	29,788.15	68,133.80
12	255,087.72	151,998.68	31,360.05	71,728.98	12	242,232.83	144,354.20	29,800.40	68,078.23
<b>Average</b>	<b>255,011.06</b>	<b>151,997.59</b>	<b>31,358.82</b>	<b>71,654.65</b>	<b>Average</b>	<b>242,274.38</b>	<b>144,375.84</b>	<b>29,806.81</b>	<b>68,091.74</b>
90% Load Level: 4,590 BSUs					80% Load Level: 4,080 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	21:38:02	21:41:03	0-3	0:03:01	<b>Start-Up/Ramp-Up</b>	21:55:58	21:58:59	0-3	0:03:01
<b>Measurement Interval</b>	21:41:03	21:51:03	3-12	0:10:00	<b>Measurement Interval</b>	21:58:59	22:08:59	3-12	0:10:00
<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>
0	229,536.47	136,802.93	28,208.55	64,524.98	0	204,090.90	121,629.58	25,102.70	57,358.62
1	229,583.40	136,898.82	28,198.72	64,485.87	1	203,933.13	121,544.25	25,075.15	57,313.73
2	229,574.73	136,797.05	28,290.77	64,486.92	2	203,969.03	121,551.60	25,059.93	57,357.50
3	229,448.00	136,732.23	28,250.13	64,465.63	3	204,019.13	121,582.05	25,079.97	57,357.12
4	229,441.33	136,739.65	28,226.97	64,474.72	4	203,901.18	121,529.35	25,062.00	57,309.83
5	229,535.32	136,778.47	28,208.52	64,548.33	5	204,063.30	121,670.28	25,068.10	57,324.92
6	229,474.17	136,730.78	28,263.02	64,480.37	6	203,953.40	121,579.13	25,062.27	57,312.00
7	229,421.57	136,683.65	28,253.90	64,484.02	7	203,958.80	121,560.80	25,090.92	57,307.08
8	229,467.68	136,768.15	28,230.63	64,468.90	8	203,945.20	121,498.62	25,093.87	57,352.72
9	229,557.32	136,820.58	28,246.83	64,489.90	9	204,032.25	121,626.50	25,093.17	57,312.58
10	229,529.80	136,804.18	28,234.88	64,490.73	10	203,968.25	121,526.33	25,064.12	57,377.80
11	229,407.63	136,701.83	28,223.60	64,482.20	11	203,930.80	121,551.38	25,103.98	57,275.43
12	229,509.18	136,760.63	28,223.05	64,525.50	12	204,045.33	121,566.45	25,120.63	57,358.25
<b>Average</b>	<b>229,479.20</b>	<b>136,752.02</b>	<b>28,236.15</b>	<b>64,491.03</b>	<b>Average</b>	<b>203,981.77</b>	<b>121,569.09</b>	<b>25,083.90</b>	<b>57,328.77</b>

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

50% Load Level: 2,550 BSUs					10% Load Level: 510 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:13:58	22:16:59	0-3	0:03:01	Start-Up/Ramp-Up	22:31:52	22:34:53	0-3	0:03:01
Measurement Interval	22:16:59	22:26:59	3-12	0:10:00	Measurement Interval	22:34:53	22:44:53	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	127,510.47	75,996.58	15,666.12	35,847.77	0	25,488.48	15,210.60	3,136.72	7,141.17
1	127,510.83	75,987.17	15,691.95	35,831.72	1	25,509.07	15,190.78	3,136.93	7,181.35
2	127,546.70	76,031.70	15,697.53	35,817.47	2	25,502.15	15,191.83	3,129.95	7,180.37
3	127,419.95	75,957.63	15,664.05	35,798.27	3	25,519.12	15,203.18	3,136.42	7,179.52
4	127,494.25	75,980.33	15,681.32	35,832.60	4	25,536.50	15,209.32	3,144.40	7,182.78
5	127,520.05	75,993.32	15,681.98	35,844.75	5	25,507.25	15,206.72	3,133.47	7,167.07
6	127,478.43	76,022.07	15,668.52	35,787.85	6	25,463.60	15,183.12	3,126.62	7,153.87
7	127,472.78	75,943.45	15,691.13	35,838.20	7	25,490.13	15,202.17	3,127.47	7,160.50
8	127,550.90	76,016.78	15,683.87	35,850.25	8	25,532.52	15,208.43	3,141.63	7,182.45
9	127,482.42	75,943.98	15,683.35	35,855.08	9	25,523.17	15,193.30	3,142.37	7,187.50
10	127,532.67	76,014.87	15,682.32	35,835.48	10	25,483.75	15,200.73	3,133.13	7,149.88
11	127,471.95	75,958.25	15,681.22	35,832.48	11	25,495.00	15,199.62	3,150.35	7,145.03
12	127,488.68	75,992.17	15,682.10	35,814.42	12	25,505.68	15,213.68	3,129.45	7,162.55
Average	127,491.21	75,982.29	15,679.99	35,828.94	Average	25,505.67	15,202.03	3,136.53	7,167.12

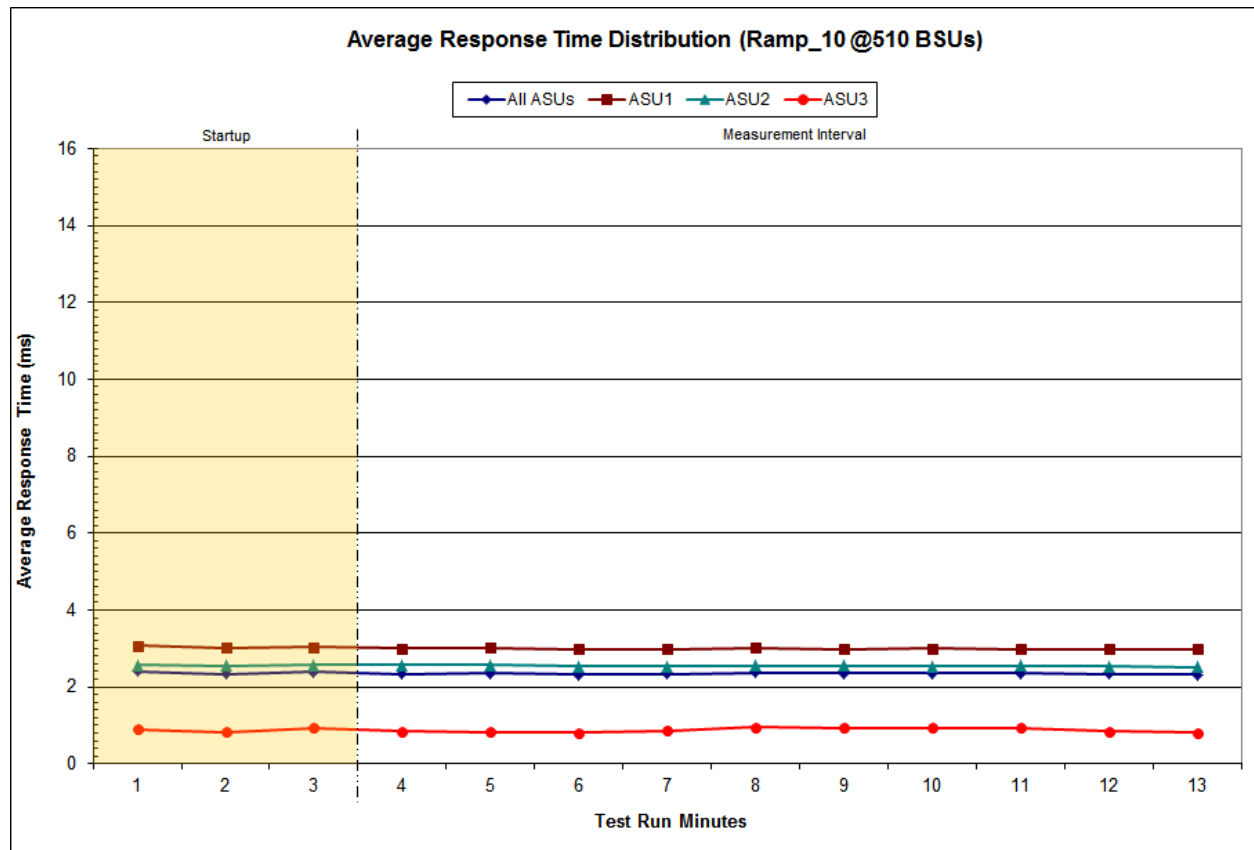
**Response Time Ramp Distribution (IOPS) Graph**



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

510 BSUs	Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	22:31:52	22:34:53	0-2	0:03:01
<b>Measurement Interval</b>	22:34:53	22:44:53	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.40	3.08	2.57	0.89
1	2.34	3.01	2.55	0.83
2	2.39	3.04	2.58	0.93
3	2.34	3.01	2.57	0.84
4	2.35	3.02	2.57	0.83
5	2.32	2.99	2.53	0.80
6	2.33	2.98	2.54	0.86
7	2.38	3.01	2.55	0.95
8	2.35	2.98	2.55	0.93
9	2.36	2.99	2.53	0.93
10	2.36	2.99	2.56	0.93
11	2.33	2.99	2.53	0.84
12	2.31	2.98	2.51	0.81
<b>Average</b>	<b>2.34</b>	<b>2.99</b>	<b>2.55</b>	<b>0.87</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
<b>IM</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0349	0.2810	0.0701	0.2100	0.0810	0.0700	0.0350	0.2810
COV	0.005	0.001	0.003	0.001	0.007	0.004	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 [90](#).

### 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>255,011.06</b>
<b>Repeatability Test Phase 1</b>	255,030.17
<b>Repeatability Test Phase 2</b>	254,967.06

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>2.34</b>
<b>Repeatability Test Phase 1</b>	2.40
<b>Repeatability Test Phase 2</b>	2.35

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 \(IOPS\)](#)

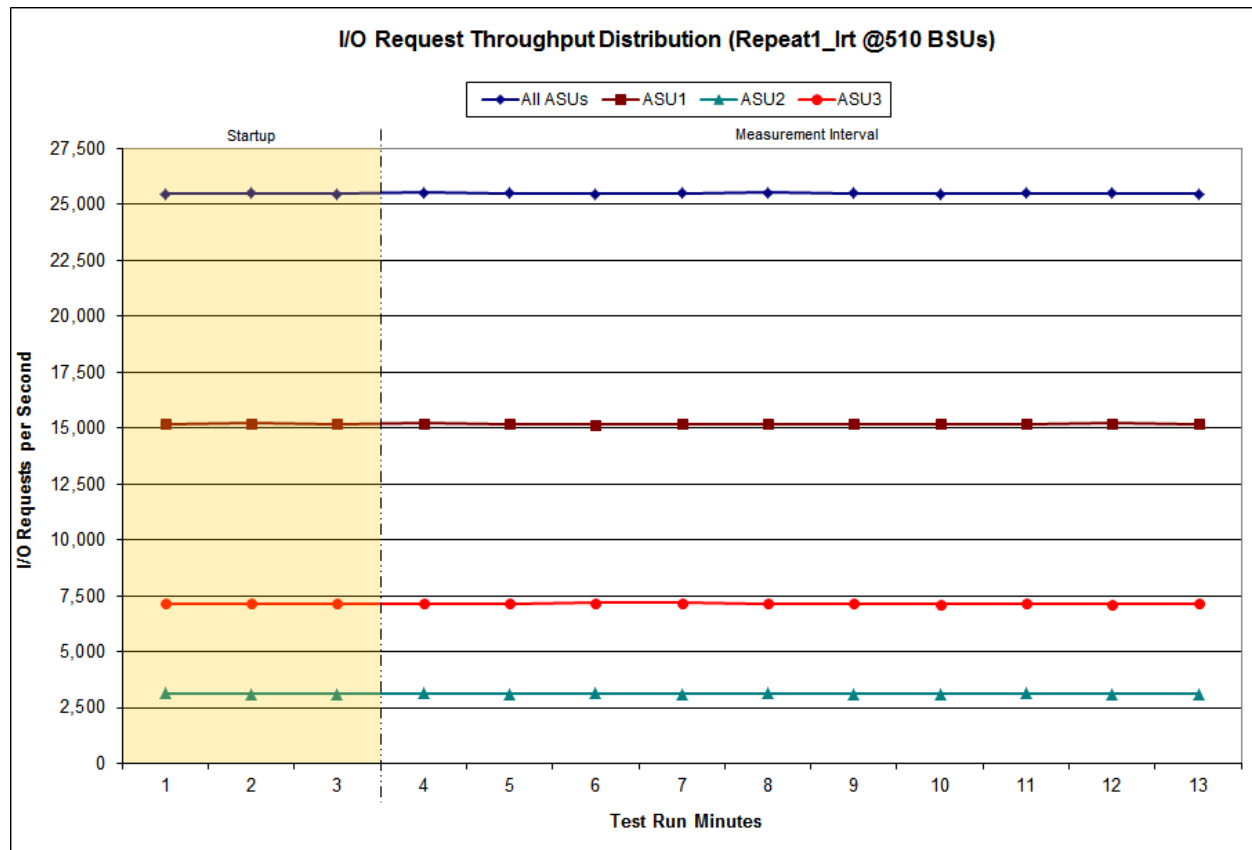
**Repeatability 1 LRT – I/O Request Throughput Distribution Data**

510 BSUs	Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	22:49:59	22:52:59	0-2	0:03:00
<b>Measurement Interval</b>	22:52:59	23:02:59	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25,473.17	15,178.70	3,140.82	7,153.65
1	25,509.12	15,206.83	3,134.43	7,167.85
2	25,474.07	15,181.33	3,131.55	7,161.18
3	25,538.07	15,227.10	3,136.88	7,174.08
4	25,500.88	15,193.08	3,134.60	7,173.20
5	25,483.07	15,160.87	3,137.87	7,184.33
6	25,489.02	15,180.60	3,127.77	7,180.65
7	25,522.58	15,203.87	3,145.90	7,172.82
8	25,486.17	15,187.57	3,122.55	7,176.05
9	25,477.40	15,196.07	3,132.50	7,148.83
10	25,484.62	15,177.75	3,145.40	7,161.47
11	25,486.95	15,217.58	3,128.78	7,140.58
12	25,467.77	15,192.07	3,125.95	7,149.75
<b>Average</b>	<b>25,493.65</b>	<b>15,193.66</b>	<b>3,133.82</b>	<b>7,166.18</b>

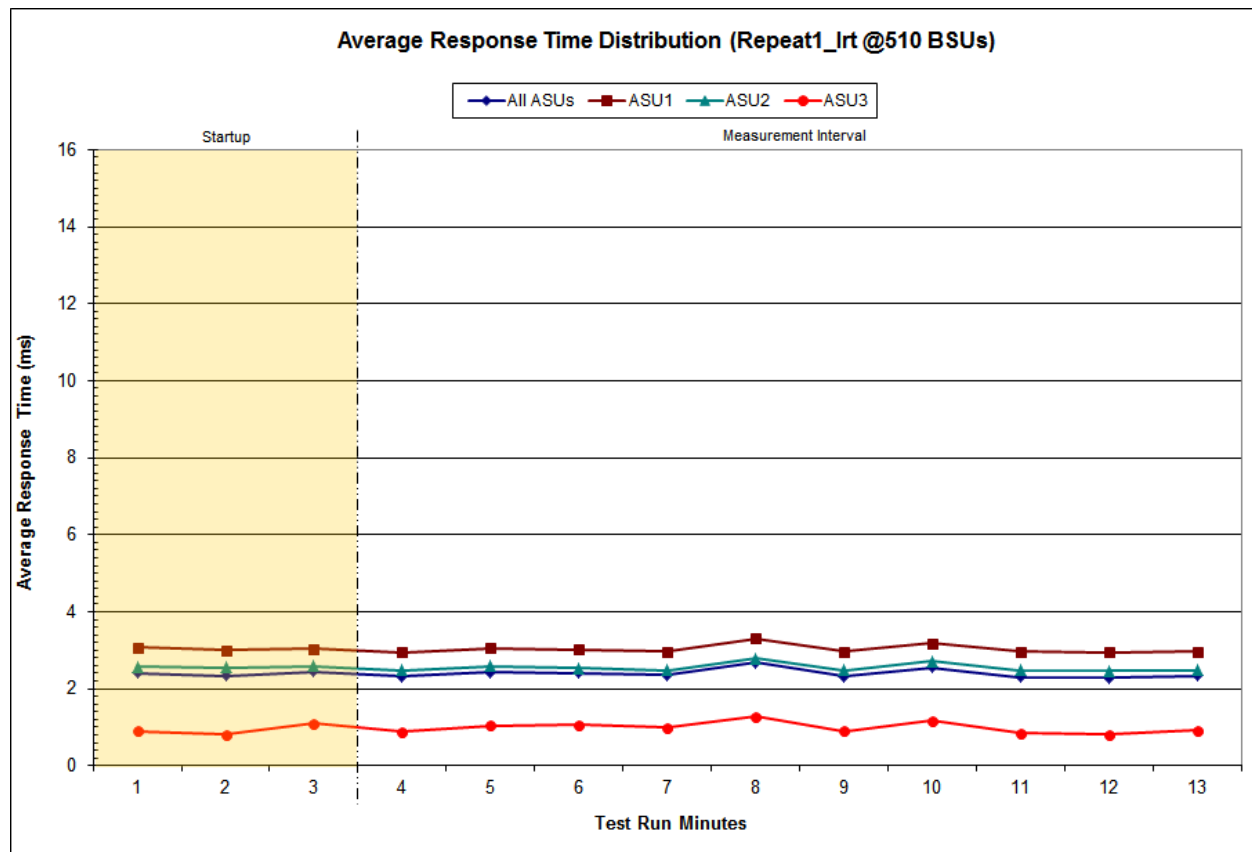
**Repeatability 1 LRT – I/O Request Throughput Distribution Graph**



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

510 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	22:49:59	22:52:59	0-2	0:03:00
<i>Measurement Interval</i>	22:52:59	23:02:59	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.40	3.08	2.56	0.90
1	2.34	3.01	2.56	0.82
2	2.44	3.04	2.59	1.10
3	2.31	2.95	2.49	0.88
4	2.43	3.06	2.58	1.04
5	2.41	3.03	2.53	1.05
6	2.35	2.96	2.48	0.99
7	2.67	3.31	2.78	1.27
8	2.33	2.96	2.48	0.91
9	2.56	3.18	2.71	1.17
10	2.31	2.96	2.47	0.85
11	2.29	2.94	2.46	0.80
12	2.33	2.96	2.48	0.92
<i>Average</i>	<i>2.40</i>	<i>3.03</i>	<i>2.55</i>	<i>0.99</i>

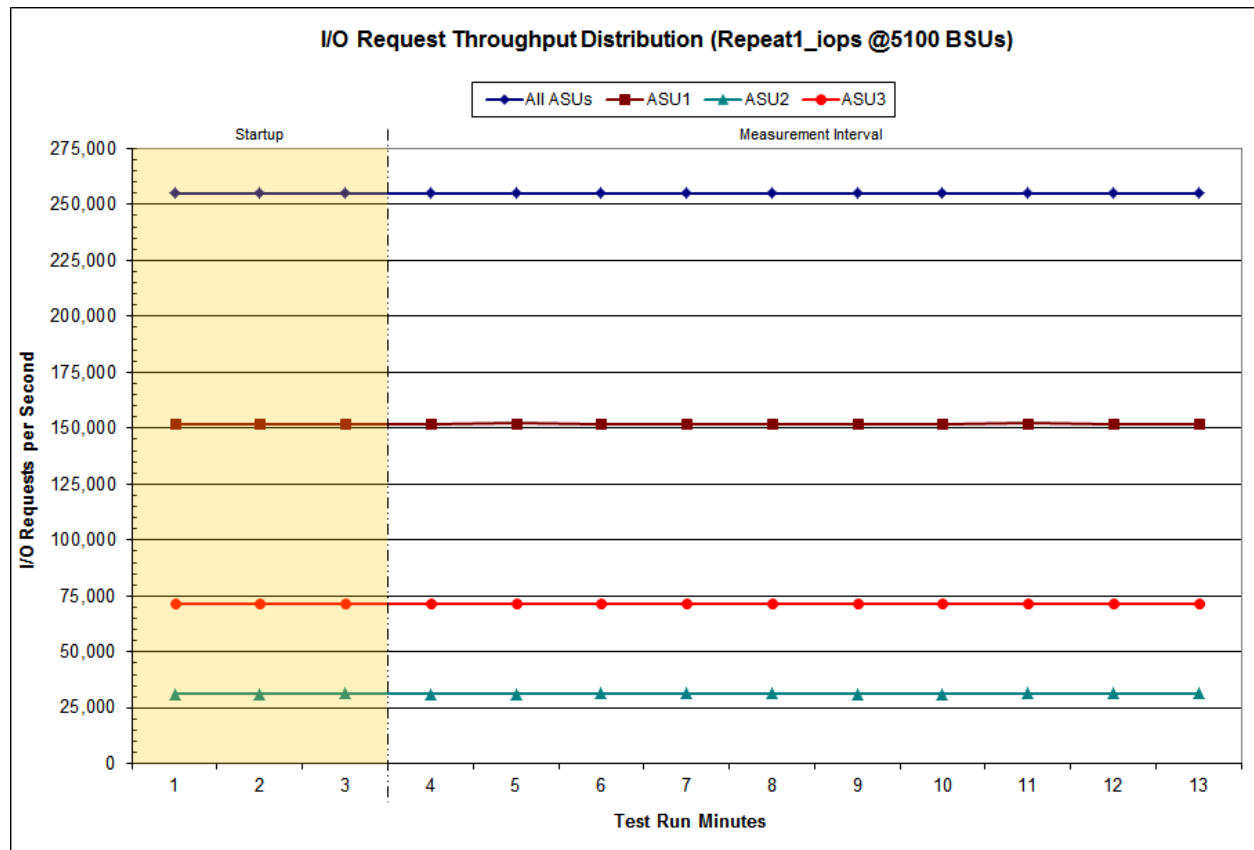
**Repeatability 1 LRT –Average Response Time (ms) Distribution Graph**



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

5,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	23:08:01	23:11:02	0-2	0:03:01
<i>Measurement Interval</i>	23:11:02	23:21:02	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	254,947.47	151,954.38	31,360.52	71,632.57
1	254,949.03	151,967.07	31,354.38	71,627.58
2	255,031.65	151,948.53	31,383.03	71,700.08
3	255,100.93	152,031.68	31,343.18	71,726.07
4	255,088.45	152,094.72	31,352.15	71,641.58
5	255,089.32	152,036.47	31,376.65	71,676.20
6	254,982.97	151,987.55	31,367.43	71,627.98
7	254,933.40	151,920.57	31,362.75	71,650.08
8	255,034.50	152,008.92	31,325.80	71,699.78
9	255,055.72	152,040.90	31,361.27	71,653.55
10	255,085.50	152,062.67	31,415.47	71,607.37
11	254,960.35	151,982.65	31,365.93	71,611.77
12	254,970.52	151,933.33	31,366.17	71,671.02
<i>Average</i>	<i>255,030.17</i>	<i>152,009.95</i>	<i>31,363.68</i>	<i>71,656.54</i>

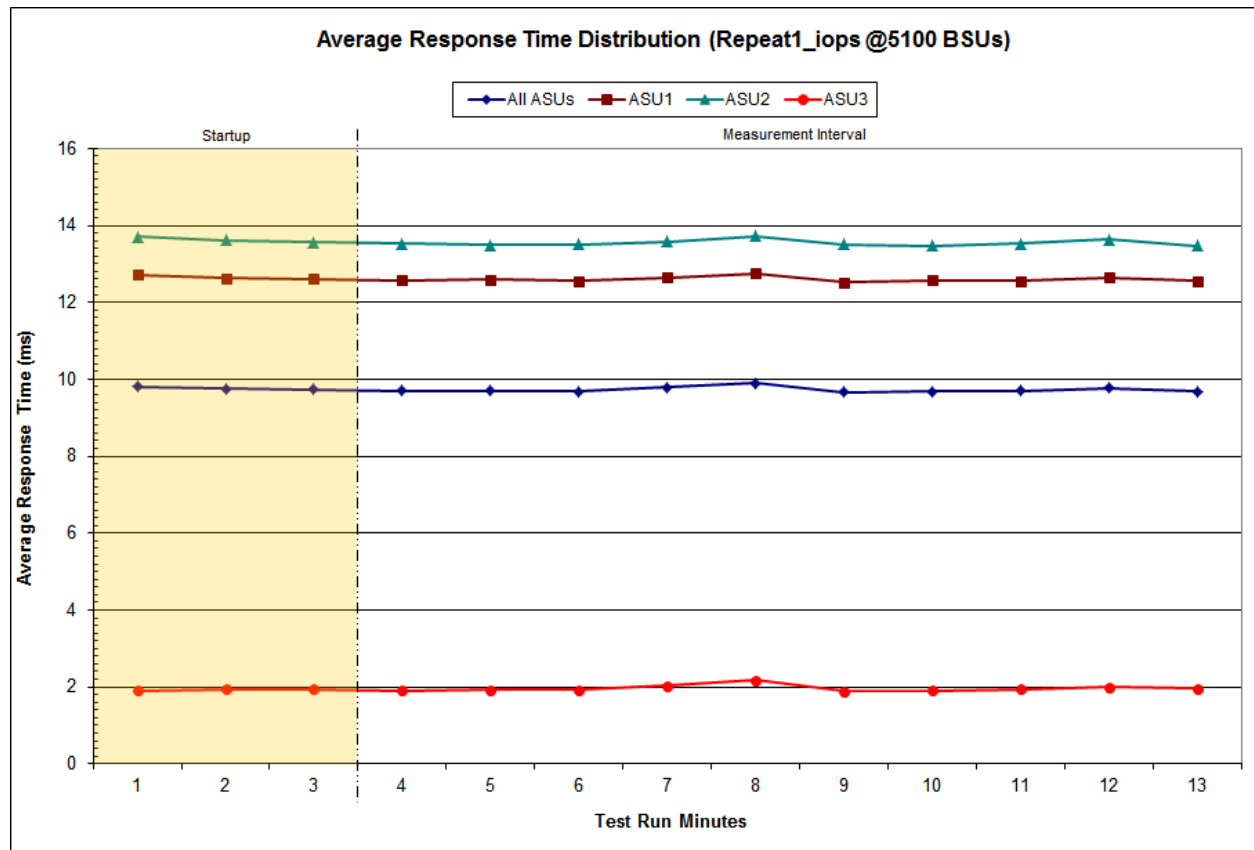
**Repeatability 1 IOPS – I/O Request Throughput Distribution Graph**



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

5,100 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	23:08:01	23:11:02	0-2	0:03:01
	23:11:02	23:21:02	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9.80	12.71	13.70	1.91
1	9.75	12.63	13.61	1.94
2	9.73	12.62	13.57	1.93
3	9.69	12.58	13.52	1.90
4	9.71	12.59	13.48	1.92
5	9.69	12.56	13.51	1.92
6	9.78	12.65	13.58	2.04
7	9.90	12.75	13.71	2.17
8	9.66	12.53	13.50	1.89
9	9.68	12.56	13.47	1.91
10	9.70	12.56	13.52	1.94
11	9.78	12.65	13.64	2.00
12	9.68	12.55	13.47	1.95
<b>Average</b>	<b>9.73</b>	<b>12.60</b>	<b>13.54</b>	<b>1.96</b>

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



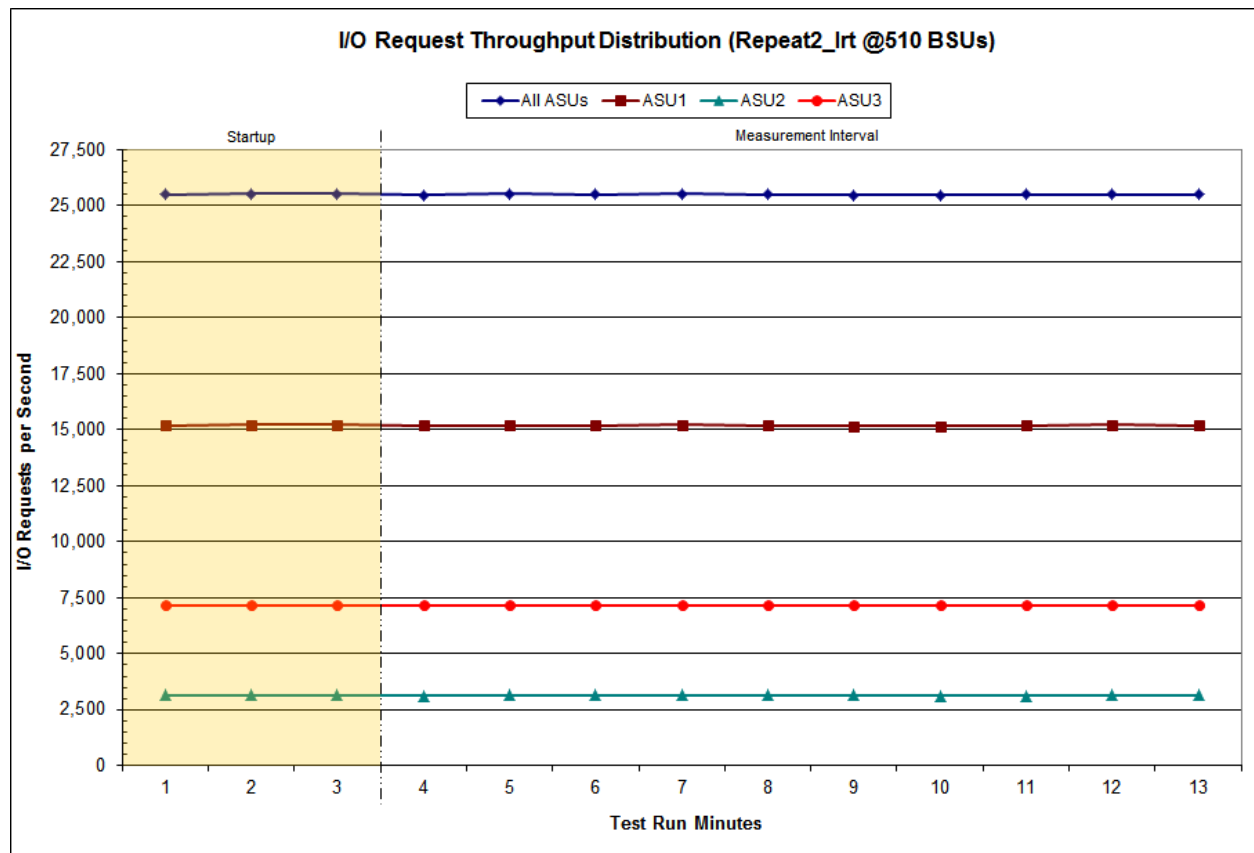
**Repeatability 2 LRT – I/O Request Throughput Distribution Data**

510 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	23:26:14	23:29:14	0-2	0:03:00
<i>Measurement Interval</i>	23:29:14	23:39:14	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25,501.12	15,192.57	3,136.28	7,172.27
1	25,516.37	15,217.37	3,136.32	7,162.68
2	25,517.35	15,205.50	3,141.73	7,170.12
3	25,465.98	15,177.32	3,130.52	7,158.15
4	25,519.17	15,200.37	3,142.68	7,176.12
5	25,495.12	15,188.58	3,141.47	7,165.07
6	25,518.85	15,214.58	3,139.97	7,164.30
7	25,505.02	15,194.88	3,139.73	7,170.40
8	25,470.62	15,173.87	3,140.12	7,156.63
9	25,457.93	15,162.58	3,130.00	7,165.35
10	25,484.02	15,184.57	3,135.45	7,164.00
11	25,514.10	15,205.15	3,143.07	7,165.88
12	25,510.95	15,196.80	3,145.28	7,168.87
<b>Average</b>	<b>25,494.18</b>	<b>15,189.87</b>	<b>3,138.83</b>	<b>7,165.48</b>

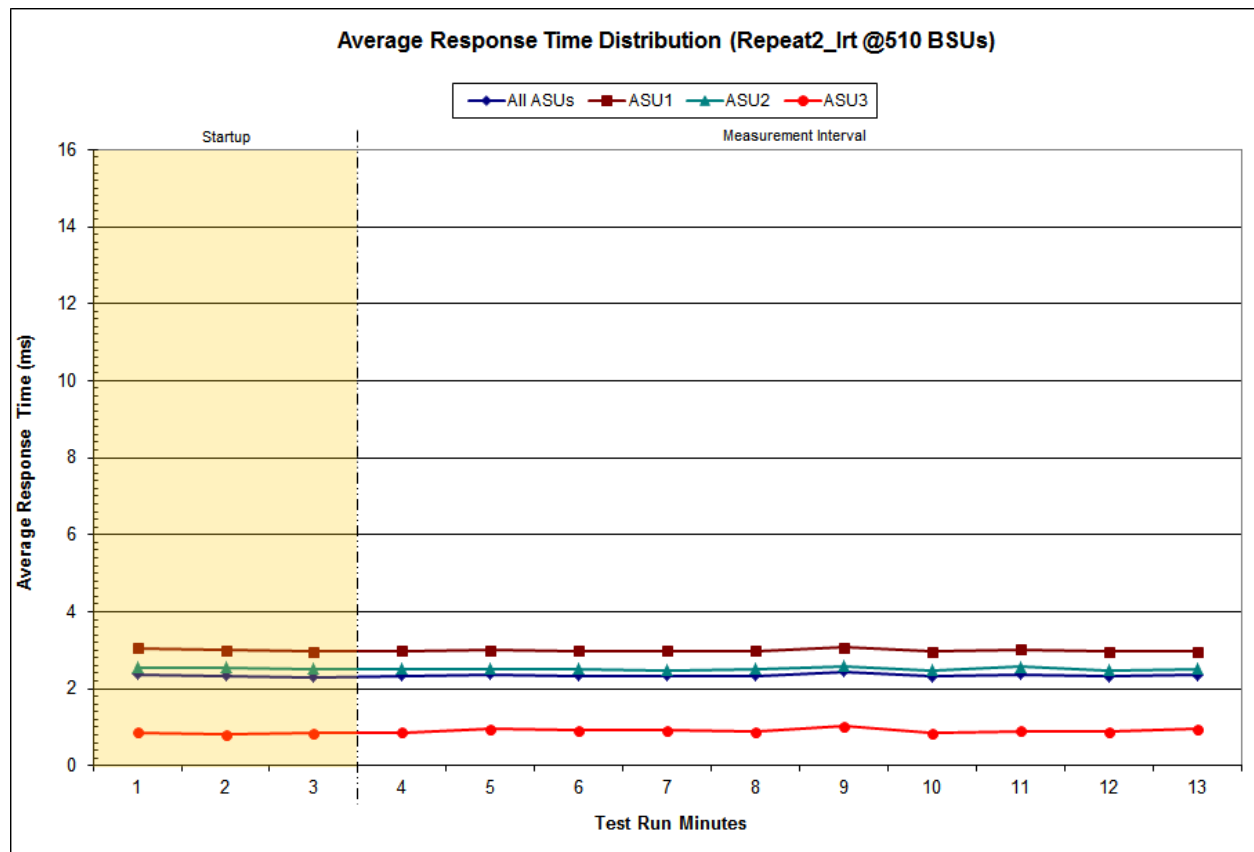
**Repeatability 2 LRT – I/O Request Throughput Distribution Graph**



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

510 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	23:26:14	23:29:14	0-2	0:03:00
<i>Measurement Interval</i>	23:29:14	23:39:14	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.38	3.06	2.55	0.86
1	2.33	3.00	2.55	0.82
2	2.31	2.96	2.52	0.84
3	2.33	2.98	2.52	0.87
4	2.36	3.00	2.52	0.95
5	2.35	2.99	2.51	0.91
6	2.34	2.98	2.49	0.91
7	2.33	2.98	2.52	0.89
8	2.44	3.07	2.59	1.03
9	2.31	2.97	2.49	0.84
10	2.37	3.02	2.57	0.90
11	2.32	2.96	2.47	0.87
12	2.35	2.97	2.52	0.95
<i>Average</i>	<i>2.35</i>	<i>2.99</i>	<i>2.52</i>	<i>0.91</i>

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

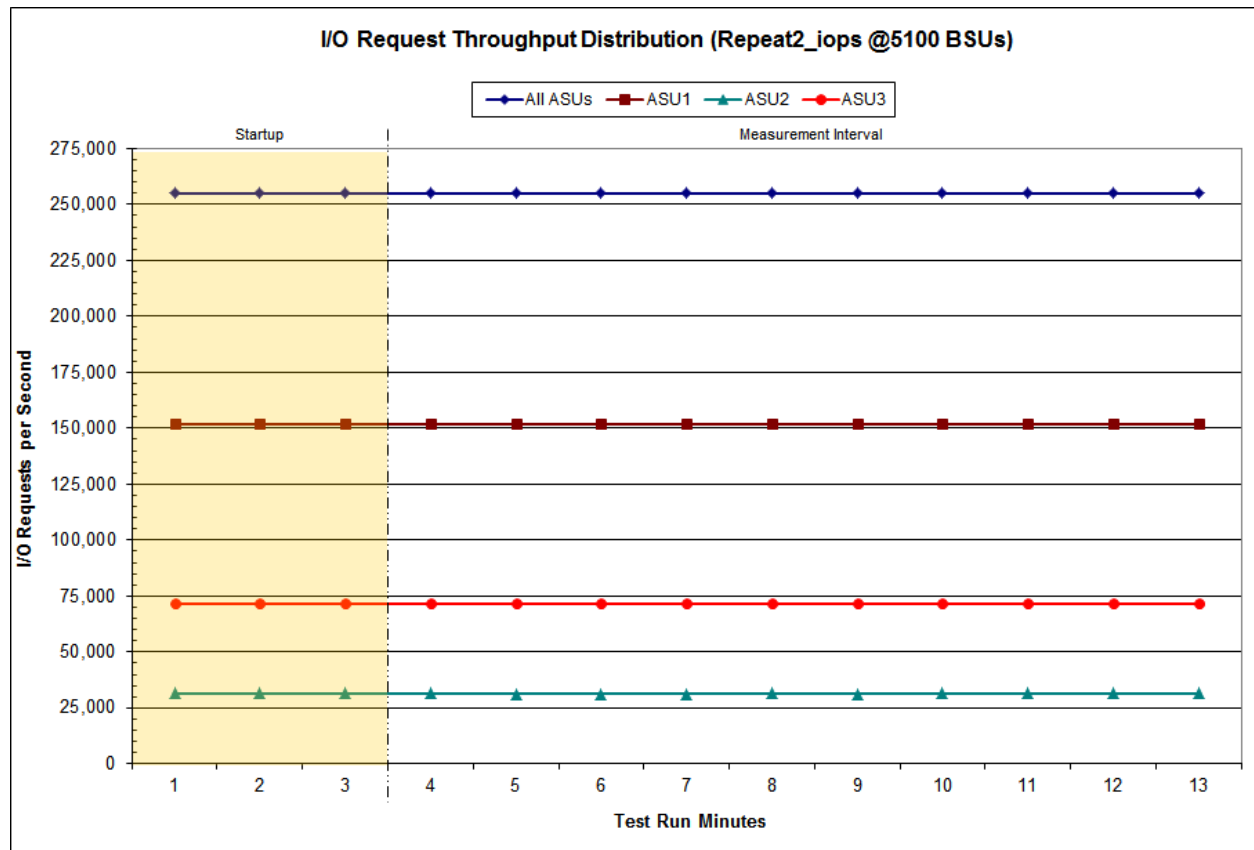




**Repeatability 2 IOPS – I/O Request Throughput Distribution Data**

5,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	23:44:18	23:47:19	0-2	0:03:01
<i>Measurement Interval</i>	23:47:19	23:57:19	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	255,035.37	151,996.62	31,364.02	71,674.73
1	255,131.53	152,031.18	31,390.68	71,709.67
2	255,002.50	151,987.15	31,364.93	71,650.42
3	254,977.37	151,977.63	31,387.47	71,612.27
4	254,902.32	151,923.00	31,310.95	71,668.37
5	254,924.40	151,927.27	31,328.47	71,668.67
6	254,873.90	151,934.23	31,327.98	71,611.68
7	254,900.13	151,877.67	31,395.02	71,627.45
8	254,915.65	151,986.02	31,357.83	71,571.80
9	255,085.60	152,007.25	31,406.38	71,671.97
10	255,011.70	151,993.18	31,387.43	71,631.08
11	255,007.58	152,006.15	31,374.00	71,627.43
12	255,071.97	152,035.88	31,380.13	71,655.95
<i>Average</i>	<i>254,967.06</i>	<i>151,966.83</i>	<i>31,365.57</i>	<i>71,634.67</i>

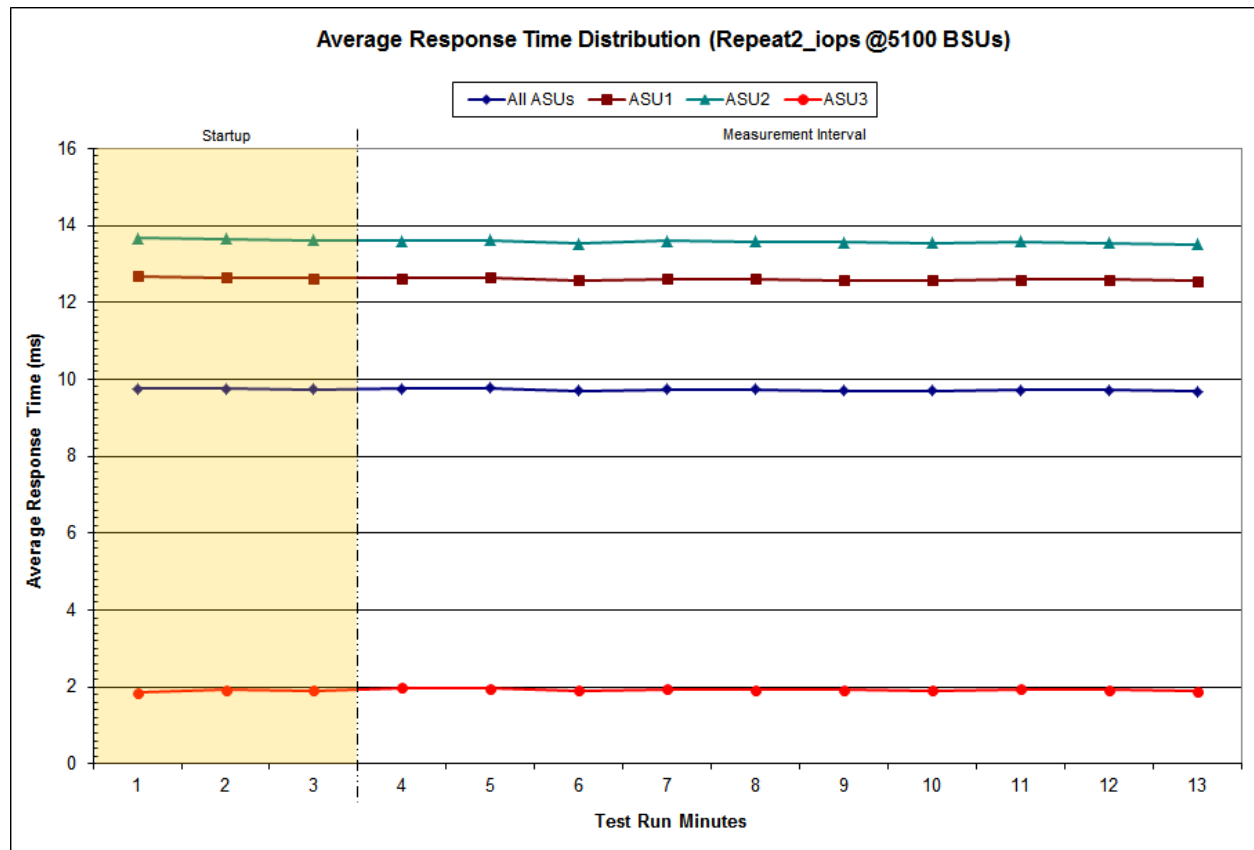
**Repeatability 2 IOPS – I/O Request Throughput Distribution Graph**



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

5,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	23:44:18	23:47:19	0-2	0:03:01
<i>Measurement Interval</i>	23:47:19	23:57:19	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9.76	12.68	13.67	1.85
1	9.76	12.65	13.65	1.93
2	9.73	12.62	13.62	1.90
3	9.75	12.62	13.60	1.97
4	9.76	12.65	13.62	1.96
5	9.69	12.58	13.52	1.91
6	9.73	12.61	13.60	1.94
7	9.73	12.62	13.59	1.92
8	9.70	12.57	13.56	1.92
9	9.69	12.57	13.54	1.90
10	9.72	12.59	13.58	1.94
11	9.71	12.58	13.55	1.93
12	9.67	12.55	13.52	1.89
<i>Average</i>	<i>9.72</i>	<i>12.59</i>	<i>13.57</i>	<i>1.93</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
<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	0.2809	0.0699	0.2102	0.0180	0.0699	0.0350	0.2811
COV	0.005	0.001	0.003	0.002	0.004	0.003	0.004	0.002

**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	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.002	0.001	0.002	0.001

**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	0.2809	0.0699	0.2101	0.0181	0.0700	0.0350	0.2811
COV	0.004	0.001	0.003	0.001	0.004	0.002	0.003	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<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	0.001	0.001	0.000	0.002	0.001	0.002	0.000

## Data Persistence Test

### Clause 6

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

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

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

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

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

### Clause 9.4.3.8

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [90](#).

## 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	356,096,704
Total Number of Logical Blocks Verified	73,912,128
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 9.4.3.9**

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

The NEC Storage M710 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 17.

## **TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES**

### **Clause 9.4.3.3.8**

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

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

## **ANOMALIES OR IRREGULARITIES**

### **Clause 9.4.3.10**

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the NEC Storage M710.

## **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.

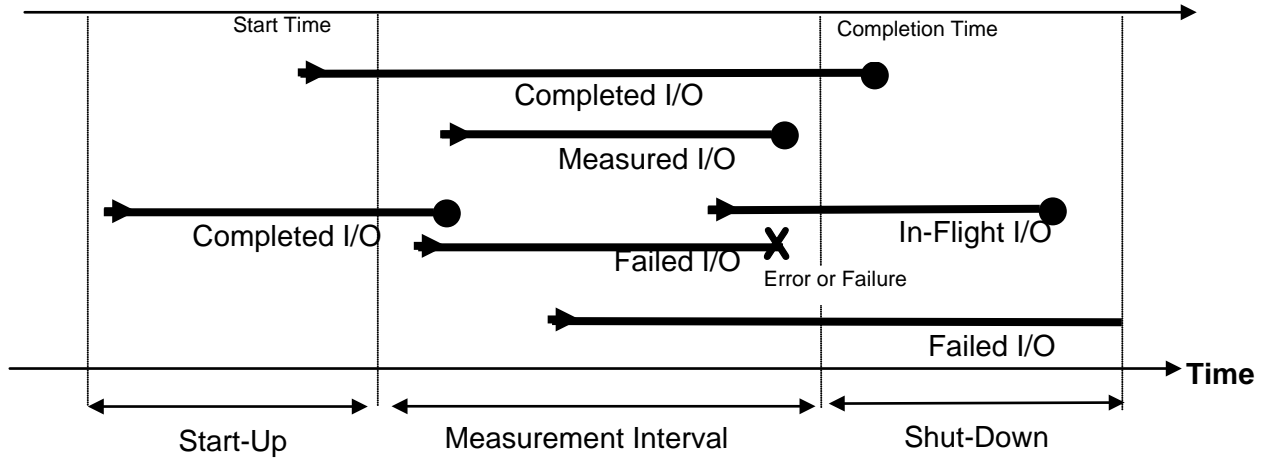
**Steady State:** The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

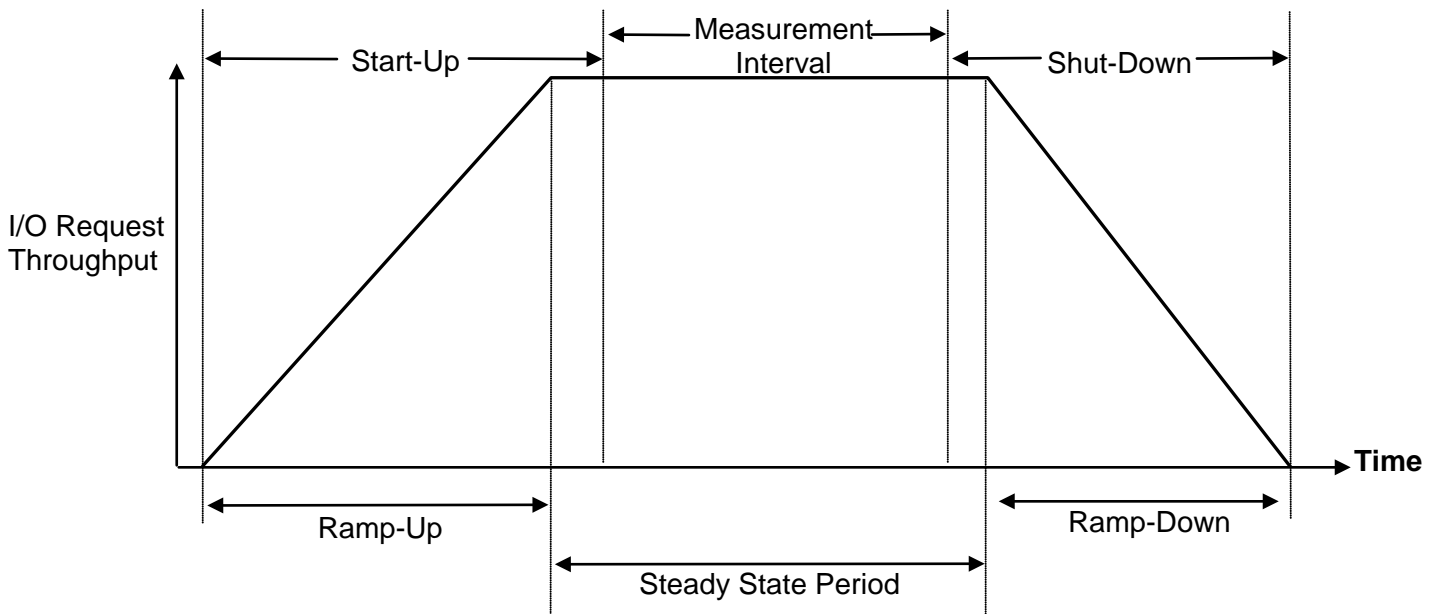
**Test Run:** The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall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

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

## APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The NEC Storage Manager was used to create and configure the Tested Storage Configuration. That storage management utility is standard component included with the NEC Storage M710.

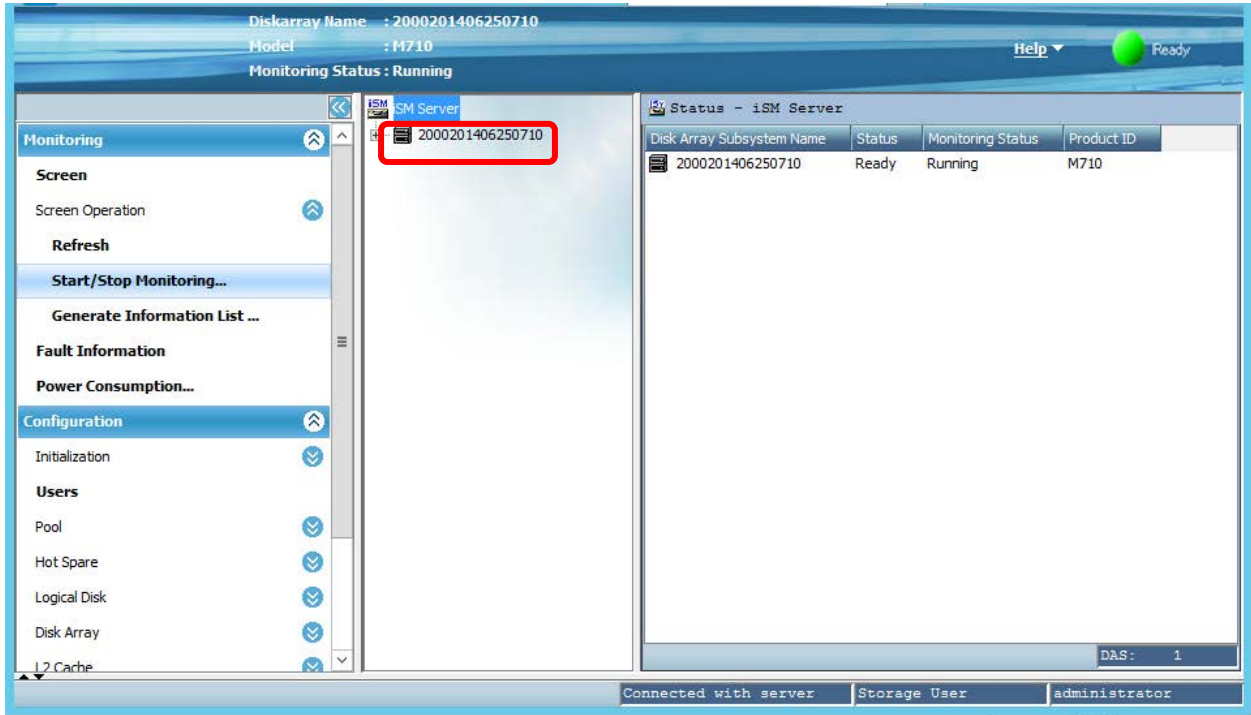
### 1. Starting the NEC Storage Manager Client

- a) Start a web browser on a Host System that has a network connection to the TSC.
- b) Start the NEC Storage Manager client by entering the IP address of the NEC Storage M710 (*10.1.0.11 is the default value*) in the address bar of the web browser. Perform the following to logon to the NEC Storage Manager client:
- c) Enter **sysadmin** in the **User Name** box
- d) Enter **sys123** (*default value*) in the **Password** box
- e) Click **Login** to open the client main menu.

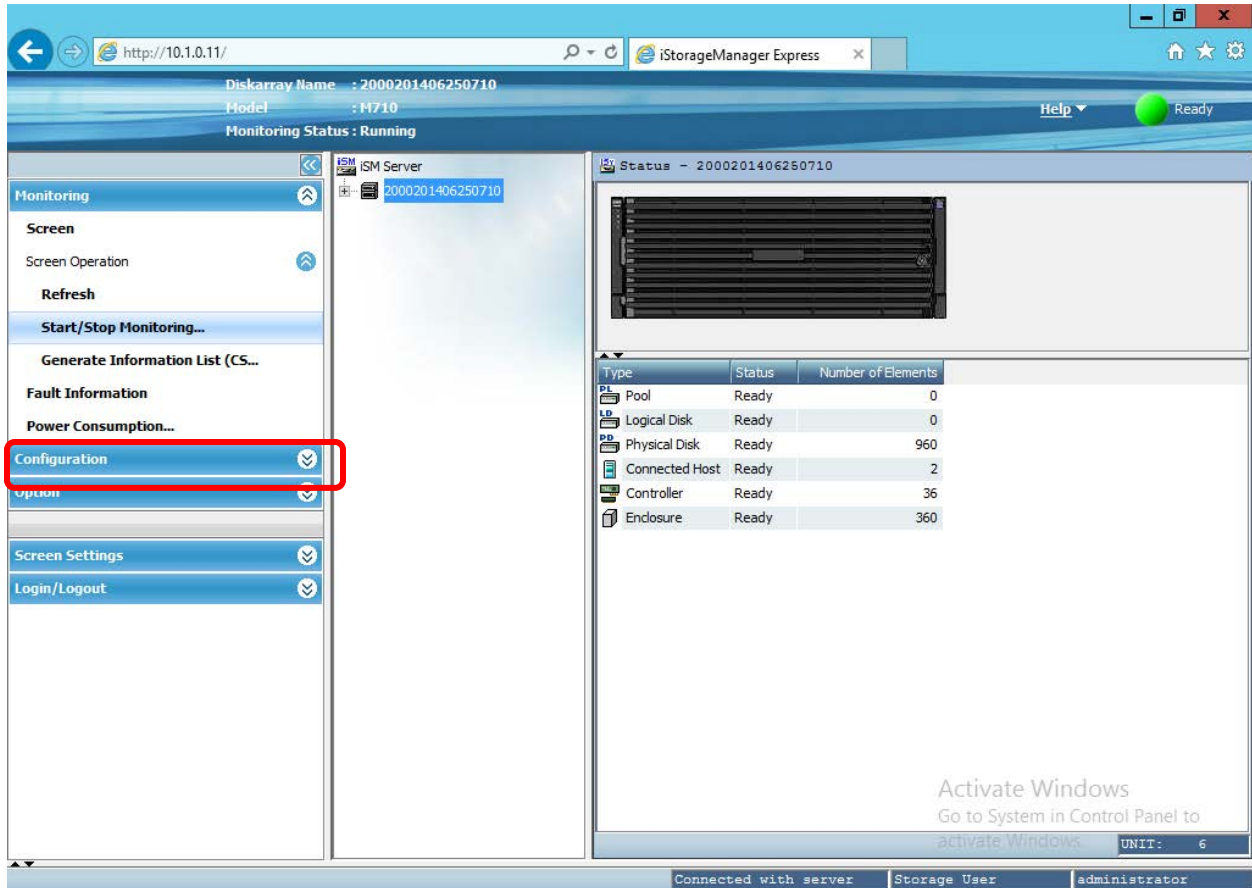


## 2. Create Volume Groups (*Create Pool*)

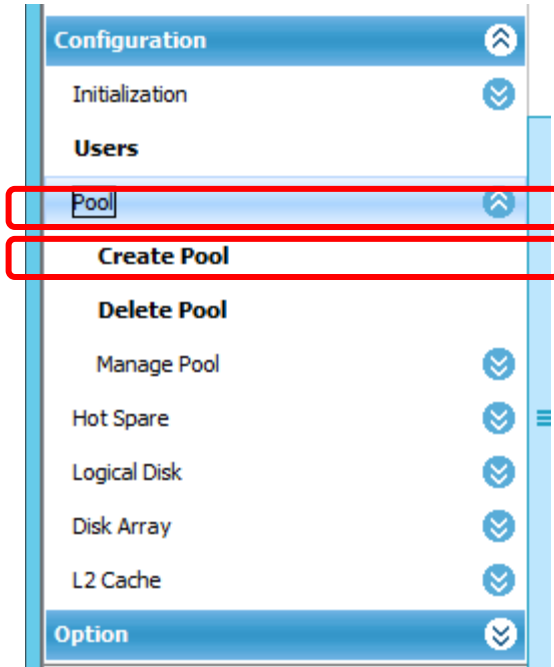
- a) Click on the disk array name for the M710



b) Click **Configuration**



- c) Click **Pool**.
- d) Click **Create Pool**.



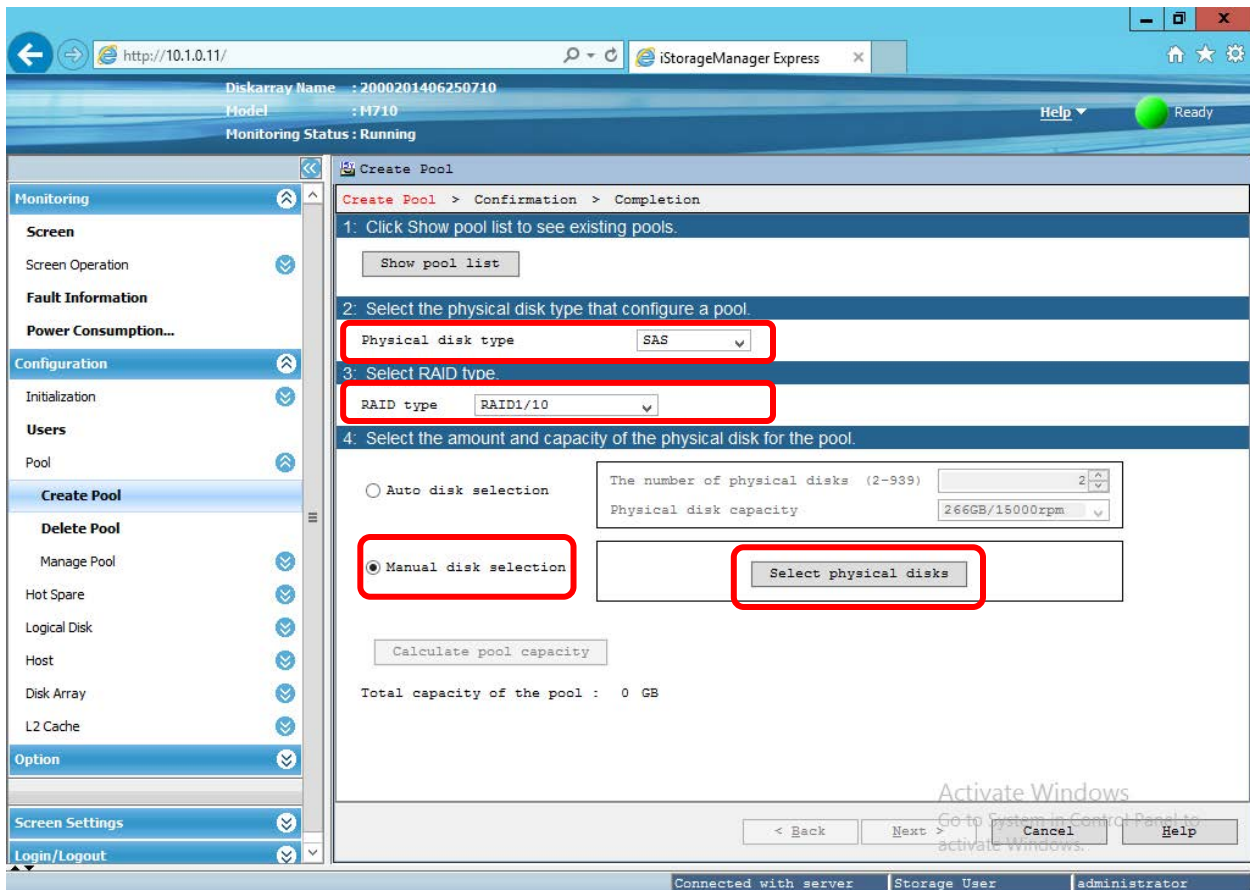


There were 30 volume groups created, each of which contained a single RAID1/10 (*mirrored*) volume.

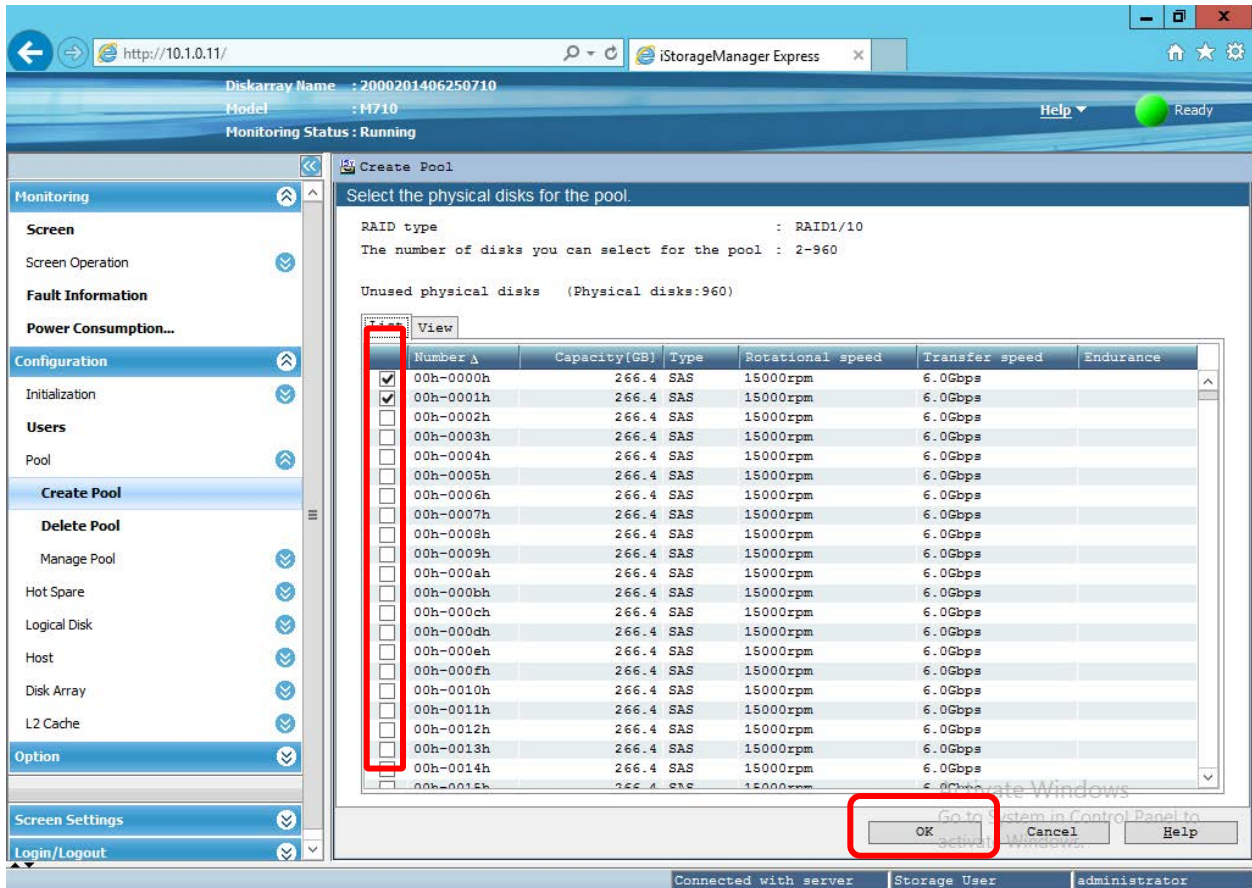
Examples of the **Create Pool** menus are listed below. The values displayed in the menus were not the values used to configure the TSC. The specific parameter values for each of the 30 volume groups are listed in the [Volume Group Parameters](#) section.

Each volume group is created, starting with the first **Create Pool** menu, by selecting the following:

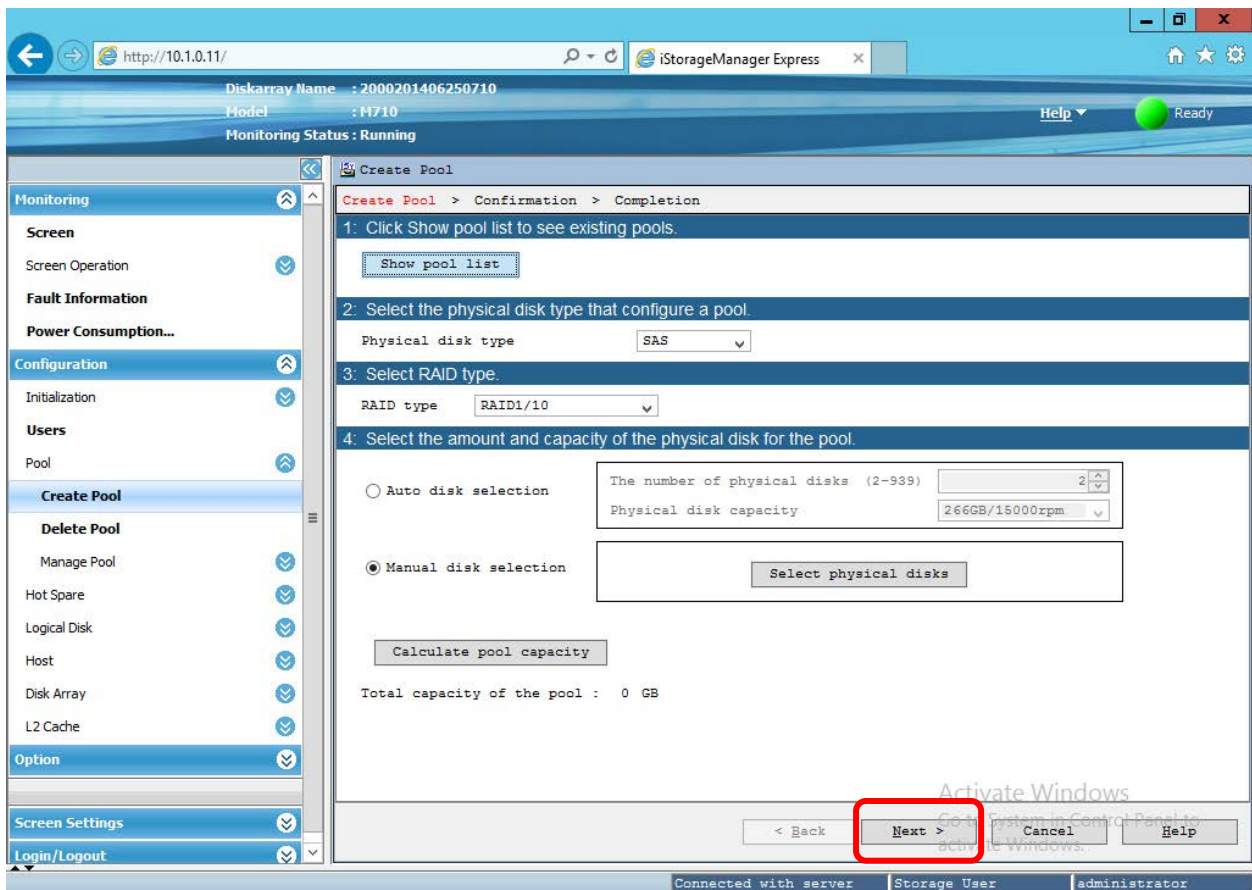
- e) **Physical disk type** value of **SAS**.
- f) **RAID type** value of **RAID1/10**
- g) Select **Manual disk selection** in order to specify the 32 physical disks to be assigned to a pool in the next menu.
- h) Click **Select physical disks** to display the next menu.



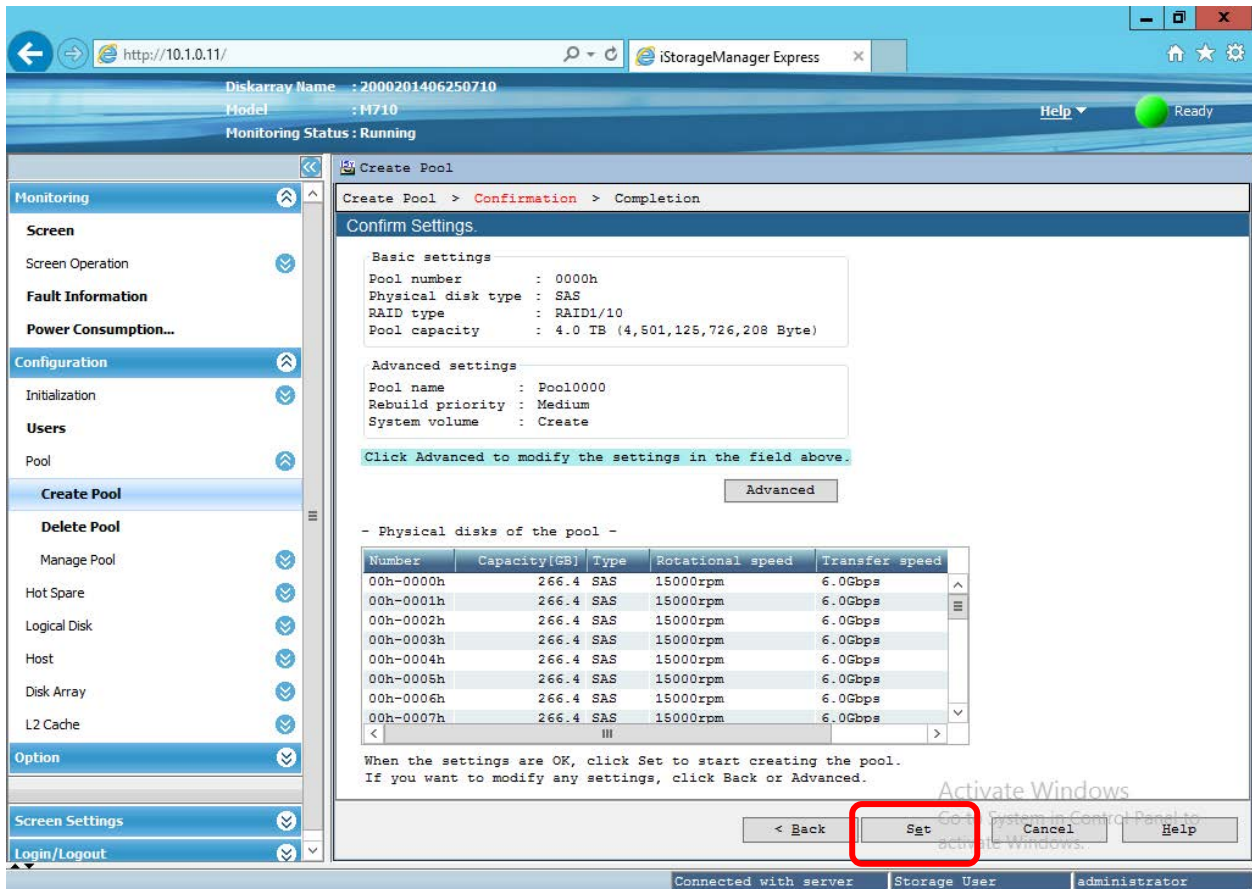
- i) Select the appropriate 32 physical disks as defined in the [Volume Group Parameters](#) section.
- j) Click **OK**, which will return to the first **Create Pool** menu.



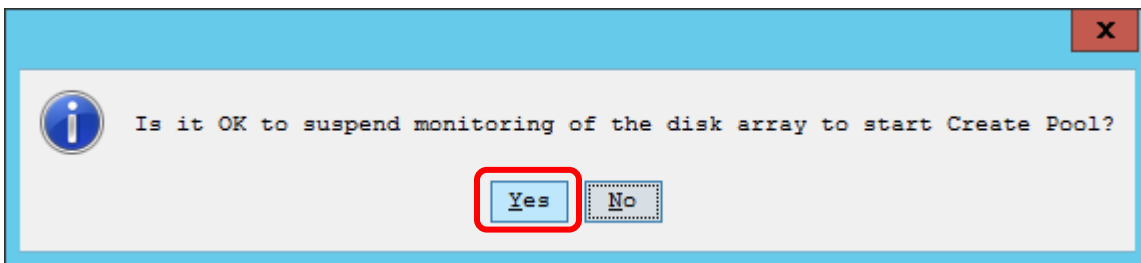
k) Click on the **Next** button, which will cause a confirmation menu to be displayed.



This confirmation menu will display the pool number, physical disk type, RAID type and physical disks selected to configure the pool. The pool number is automatically assigned.

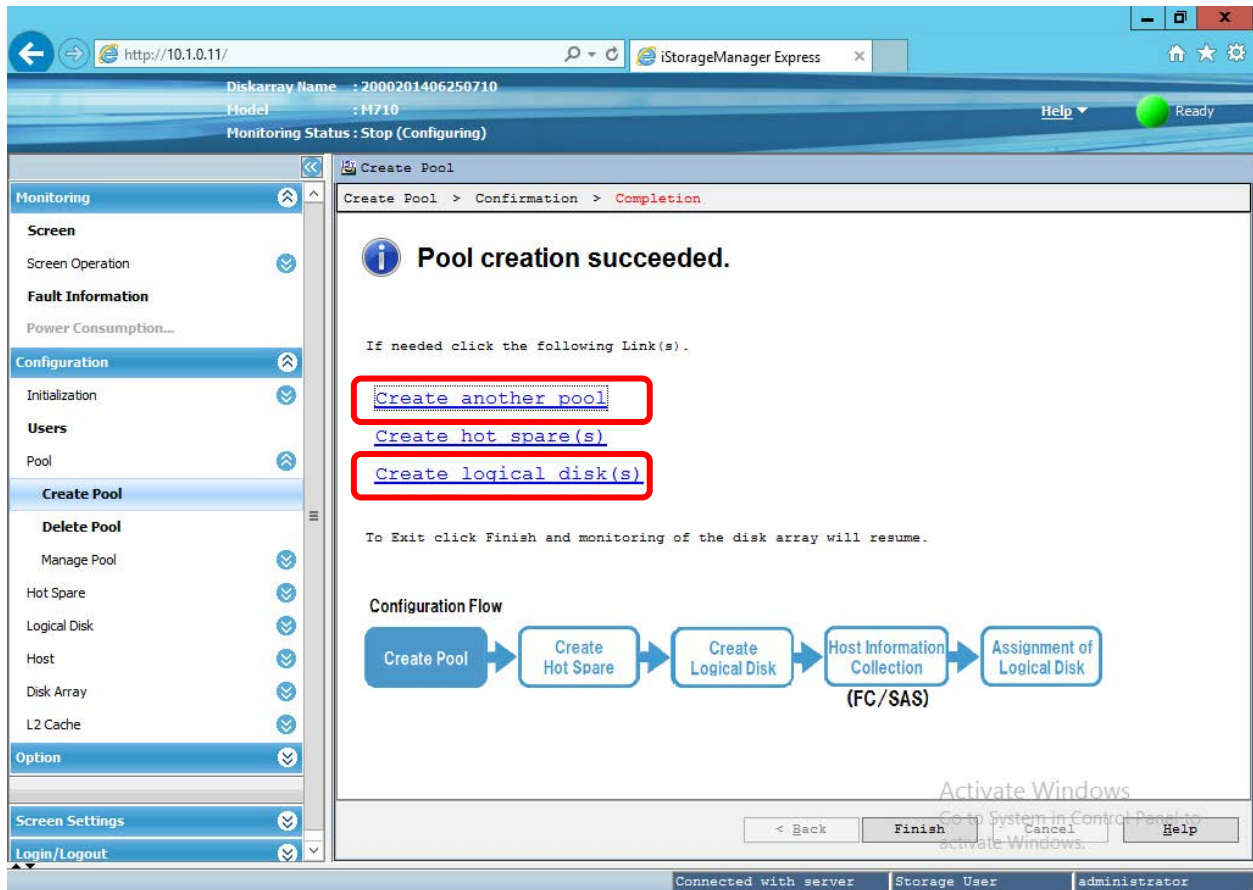


- l) If all of the displayed information is correct, click on the **Set** button to display the following confirmation message.



- m) Click on the **Yes** button to complete the Create Pool and creation of the volume group.

When the Pool Creation is successfully completed the following window is displayed.



- m) Click on **Create another pool** to repeat the above pool creation process (*steps 'e'-'m', in this Create Volume Groups (Create Pool) section*) until all 30 volume groups have been created.
- n) After the 30 volumes groups have been created, click on **Create logical disk(s)** to create the logical disks described in the next section.



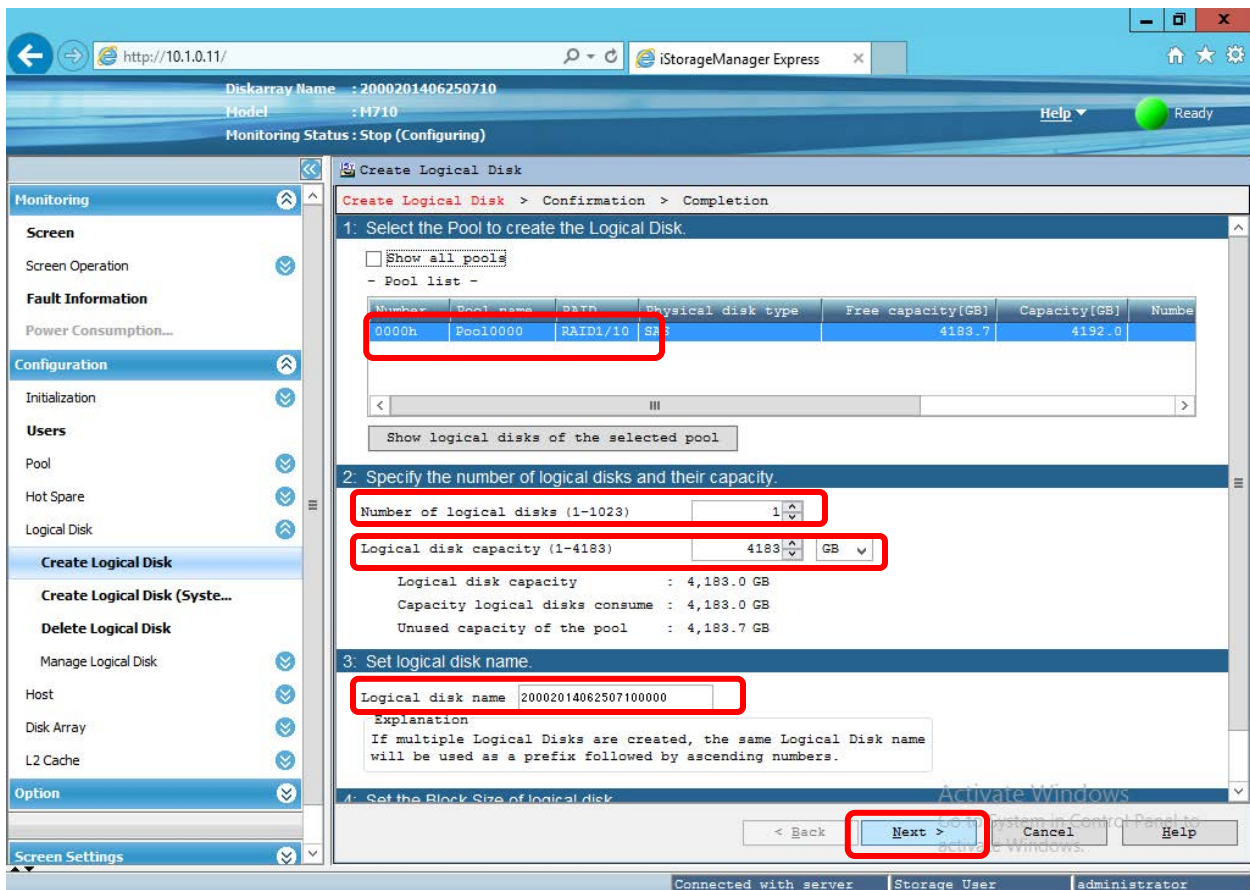
### 3. Create Logical Disks

One logical disk was created from each of the 30 RAID1/10 volumes.

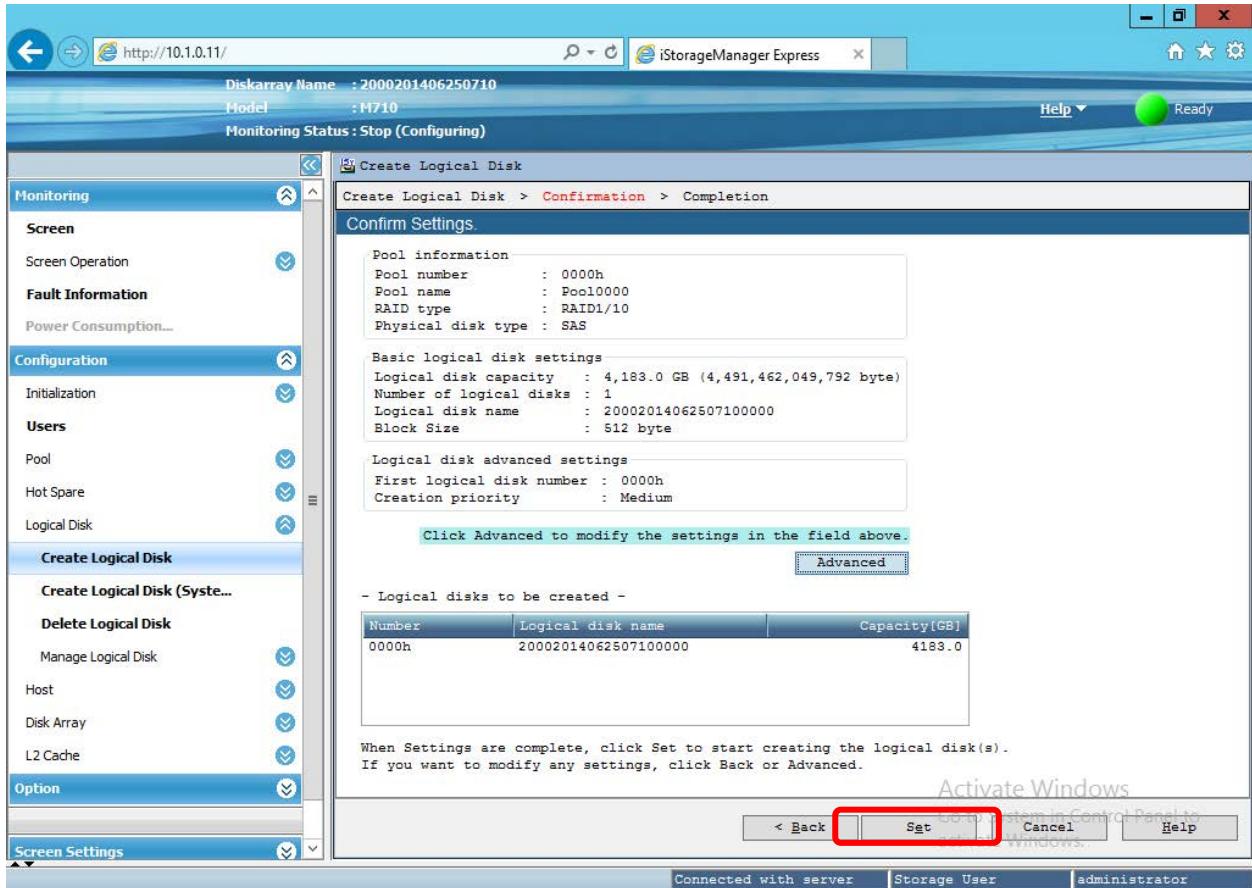
Examples of the **Create Logical Disk** menus are listed below. The values displayed in example menus were not the values used to configure the TSC. The specific parameter values for each of the 30 logical disks are listed in the [Logical Disk Parameters](#) section.

Each logical disk was created, starting from the first **Create Logical Disk** menu, with the following specifications:

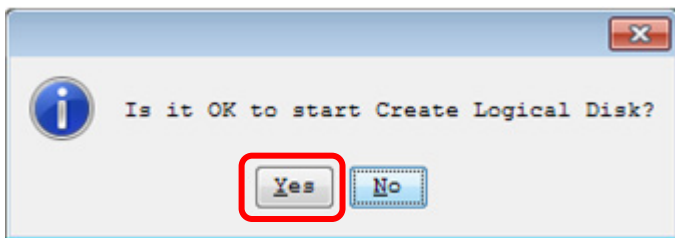
- a) **Pool list:** Select the pool in which the logical disk will be bound.
- b) **Number of logical disks:** Select **1** as the number of logical disks.
- c) **Logical disk capacity:** Enter the capacity in 4183GB
- d) The **logical disk name** is assigned automatically.
- e) After entering the appropriate parameter values, click **Next**, which will display the following confirmation menu.



- f) This confirmation menu will list the settings of the logical disk to be bound. If all of the displayed information is correct, click on the **Set** button, which will display the following final confirmation menu

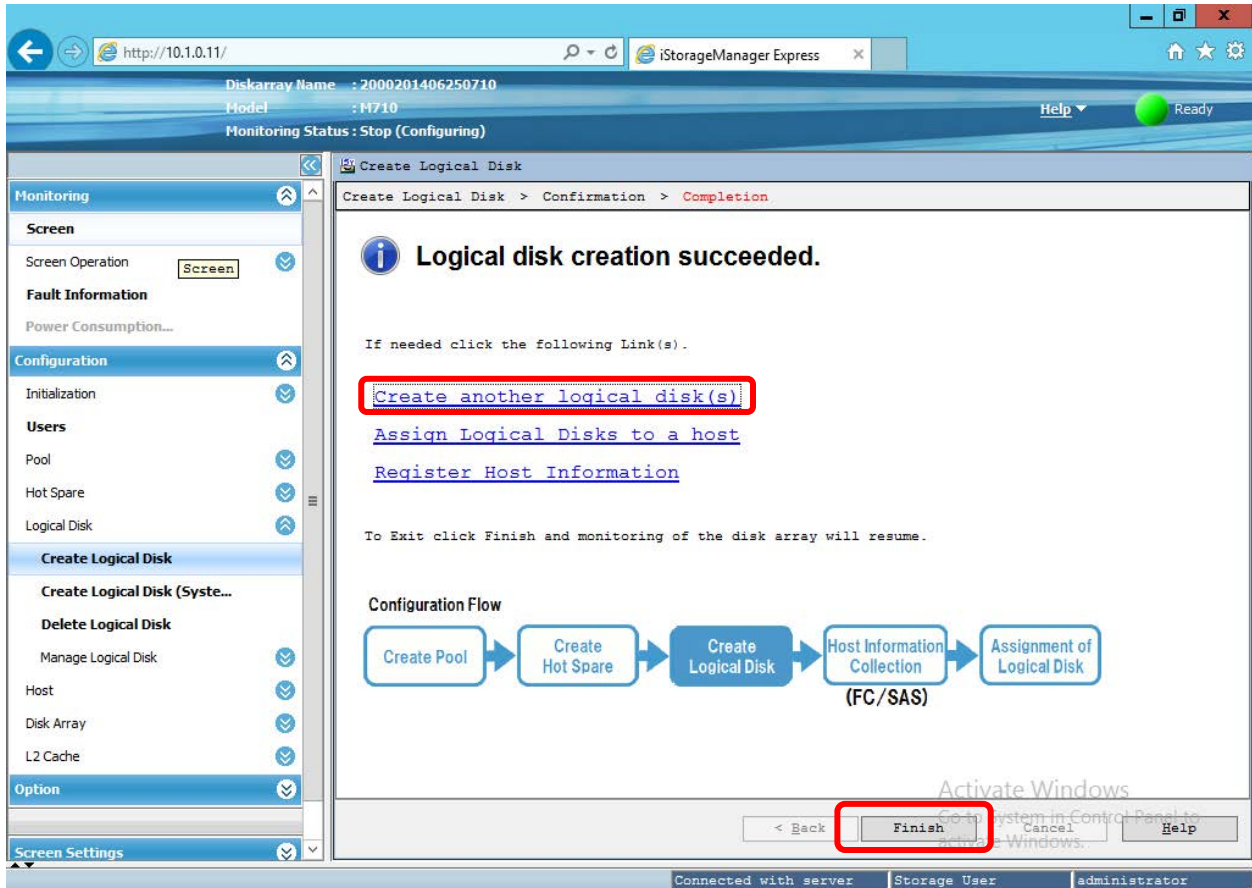


- g) Click **Yes** to create the logical disk.



After that is completed, the following window is displayed.

- h) Select **Create another logical disk(s)** to repeat the above logical disk creation process, steps 'a' – 'h' in this section (**Create Logical Disks**), until all 30 logical disks are created.
- i) Click the **Finish** button after creating the last logical disk.





#### 4. SPC-1 Logical Volume Creation

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

- a) Start the Windows Disk Management utility and confirm that the 30 logical disks, created above, are present as 30 Windows “Disks”.
- b) Convert all 30 Windows “Disks” to GPT Disks.
- c) Convert all 30 Windows “Disks” to Dynamic Disks.
- d) Create a Windows striped (RAID-0) volume for ASU-1 as follows:
  - i. Select all 30 Windows “Disks”.
  - ii. Set the capacity of each stripe to 1,927,467 MB
  - iii. Assign drive letter “E” to the volume.
  - iv. Do not format the volume.
- e) Create a Windows striped (RAID-0) volume for ASU-2 as follows:
  - i. Select all 30 Windows “Disks”.
  - ii. Set the capacity of each stripe to 1,927,467 MB
  - iii. Assign drive letter “F” to the volume.
  - iv. Do not format the volume.
- f) Create a Windows striped (RAID-0) volume for ASU-3 as follows:
  - i. Select all 30 Windows “Disks”.
  - ii. Set the capacity of each stripe to 428,327 MB
  - iii. Assign drive letter “G” to the volume.
  - iv. Do not format the volume.
- g) Reboot the Host Systems.
- h) After the reboot completes, start the Windows Disk Management utility on each of the Host Systems.
- i) On each Host System, select either the import foreign disk or reactivate Windows stripe sets option, as necessary, then assign drive letters to the stripe sets as were defined in steps ‘d’ – ‘f’ above.

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

## Referenced Parameter Details

### Volume Group Parameters

<b>Pool Number</b>	<b>Physical Disk</b>	<b>RAID type</b>	<b>Select physical disks</b>
0000	SAS	RAID1/10	00-0000,00-0001,00-0002,00-0003, 00-0004,00-0005,00-0006,00-0007, 00-0800,00-0801,00-0802,00-0803, 00-0804,00-0805,00-0806,00-0807, 00-1000,00-1001,00-1002,00-1003, 00-1004,00-1005,00-1006,00-1007, 00-1800,00-1801,00-1802,00-1803, 00-1804,00-1805,00-1806,00-1807
0001	SAS	RAID1/10	00-0008,00-0009,00-000a,00-000b, 00-000c,00-000d,00-000e,00-000f, 00-0808,00-0809,00-080a,00-080b, 00-080c,00-080d,00-080e,00-080f, 00-1008,00-1009,00-100a,00-100b, 00-100c,00-100d,00-100e,00-100f, 00-1808,00-1809,00-180a,00-180b, 00-180c,00-180d,00-180e,00-180f
0002	SAS	RAID1/10	00-0010,00-0011,00-0012,00-0013, 00-0014,00-0015,00-0016,00-0017, 00-0810,00-0811,00-0812,00-0813, 00-0814,00-0815,00-0816,00-0817, 00-1010,00-1011,00-1012,00-1013, 00-1014,00-1015,00-1016,00-1017, 00-1810,00-1811,00-1812,00-1813, 00-1814,00-1815,00-1816,00-1817
0003	SAS	RAID1/10	00-0100,00-0101,00-0102,00-0103, 00-0104,00-0105,00-0106,00-0107, 00-0900,00-0901,00-0902,00-0903, 00-0904,00-0905,00-0906,00-0907, 00-1100,00-1101,00-1102,00-1103, 00-1104,00-1105,00-1106,00-1107, 00-1900,00-1901,00-1902,00-1903, 00-1904,00-1905,00-1906,00-1907
0004	SAS	RAID1/10	00-0108,00-0109,00-010a,00-010b, 00-010c,00-010d,00-010e,00-010f, 00-0908,00-0909,00-090a,00-090b, 00-090c,00-090d,00-090e,00-090f, 00-1108,00-1109,00-110a,00-110b, 00-110c,00-110d,00-110e,00-110f, 00-1908,00-1909,00-190a,00-190b, 00-190c,00-190d,00-190e,00-190f

Pool Number	Physical Disk	RAID type	Select physical disks
0005	SAS	RAID1/10	00-0110,00-0111,00-0112,00-0113, 00-0114,00-0115,00-0116,00-0117, 00-0910,00-0911,00-0912,00-0913, 00-0914,00-0915,00-0916,00-0917, 00-1110,00-1111,00-1112,00-1113, 00-1114,00-1115,00-1116,00-1117, 00-1910,00-1911,00-1912,00-1913, 00-1914,00-1915,00-1916,00-1917
0006	SAS	RAID1/10	00-2000,00-2001,00-2002,00-2003, 00-2004,00-2005,00-2006,00-2007, 00-2800,00-2801,00-2802,00-2803, 00-2804,00-2805,00-2806,00-2807, 00-3000,00-3001,00-3002,00-3003, 00-3004,00-3005,00-3006,00-3007, 00-3800,00-3801,00-3802,00-3803, 00-3804,00-3805,00-3806,00-3807
0007	SAS	RAID1/10	00-2008,00-2009,00-200a,00-200b, 00-200c,00-200d,00-200e,00-200f, 00-2808,00-2809,00-280a,00-280b, 00-280c,00-280d,00-280e,00-280f, 00-3008,00-3009,00-300a,00-300b, 00-300c,00-300d,00-300e,00-300f, 00-3808,00-3809,00-380a,00-380b, 00-380c,00-380d,00-380e,00-380f
0008	SAS	RAID1/10	00-2010,00-2011,00-2012,00-2013, 00-2014,00-2015,00-2016,00-2017, 00-2810,00-2811,00-2812,00-2813, 00-2814,00-2815,00-2816,00-2817, 00-3010,00-3011,00-3012,00-3013, 00-3014,00-3015,00-3016,00-3017, 00-3810,00-3811,00-3812,00-3813, 00-3814,00-3815,00-3816,00-3817
0009	SAS	RAID1/10	00-2100,00-2101,00-2102,00-2103, 00-2104,00-2105,00-2106,00-2107, 00-2900,00-2901,00-2902,00-2903, 00-2904,00-2905,00-2906,00-2907, 00-3100,00-3101,00-3102,00-3103, 00-3104,00-3105,00-3106,00-3107, 00-3900,00-3901,00-3902,00-3903, 00-3904,00-3905,00-3906,00-3907
000a	SAS	RAID1/10	00-2108,00-2109,00-210a,00-210b, 00-210c,00-210d,00-210e,00-210f, 00-2908,00-2909,00-290a,00-290b, 00-290c,00-290d,00-290e,00-290f, 00-3108,00-3109,00-310a,00-310b, 00-310c,00-310d,00-310e,00-310f, 00-3908,00-3909,00-390a,00-390b, 00-390c,00-390d,00-390e,00-390f

Pool Number	Physical Disk	RAID type	Select physical disks
000b	SAS	RAID1/10	00-2110,00-2111,00-2112,00-2113, 00-2114,00-2115,00-2116,00-2117, 00-2910,00-2911,00-2912,00-2913, 00-2914,00-2915,00-2916,00-2917, 00-3110,00-3111,00-3112,00-3113, 00-3114,00-3115,00-3116,00-3117, 00-3910,00-3911,00-3912,00-3913, 00-3914,00-3915,00-3916,00-3917
000c	SAS	RAID1/10	00-4000,00-4001,00-4002,00-4003, 00-4004,00-4005,00-4006,00-4007, 00-4800,00-4801,00-4802,00-4803, 00-4804,00-4805,00-4806,00-4807, 00-5000,00-5001,00-5002,00-5003, 00-5004,00-5005,00-5006,00-5007, 00-5800,00-5801,00-5802,00-5803, 00-5804,00-5805,00-5806,00-5807
000d	SAS	RAID1/10	00-4008,00-4009,00-400a,00-400b, 00-400c,00-400d,00-400e,00-400f, 00-4808,00-4809,00-480a,00-480b, 00-480c,00-480d,00-480e,00-480f, 00-5008,00-5009,00-500a,00-500b, 00-500c,00-500d,00-500e,00-500f, 00-5808,00-5809,00-580a,00-580b, 00-580c,00-580d,00-580e,00-580f
000e	SAS	RAID1/10	00-4010,00-4011,00-4012,00-4013, 00-4014,00-4015,00-4016,00-4017, 00-4810,00-4811,00-4812,00-4813, 00-4814,00-4815,00-4816,00-4817, 00-5010,00-5011,00-5012,00-5013, 00-5014,00-5015,00-5016,00-5017, 00-5810,00-5811,00-5812,00-5813, 00-5814,00-5815,00-5816,00-5817
000f	SAS	RAID1/10	00-4100,00-4101,00-4102,00-4103, 00-4104,00-4105,00-4106,00-4107, 00-4900,00-4901,00-4902,00-4903, 00-4904,00-4905,00-4906,00-4907, 00-5100,00-5101,00-5102,00-5103, 00-5104,00-5105,00-5106,00-5107, 00-5900,00-5901,00-5902,00-5903, 00-5904,00-5905,00-5906,00-5907
0010	SAS	RAID1/10	00-4108,00-4109,00-410a,00-410b, 00-410c,00-410d,00-410e,00-410f, 00-4908,00-4909,00-490a,00-490b, 00-490c,00-490d,00-490e,00-490f, 00-5108,00-5109,00-510a,00-510b, 00-510c,00-510d,00-510e,00-510f, 00-5908,00-5909,00-590a,00-590b, 00-590c,00-590d,00-590e,00-590f

Pool Number	Physical Disk	RAID type	Select physical disks
0011	SAS	RAID1/10	00-4110,00-4111,00-4112,00-4113, 00-4114,00-4115,00-4116,00-4117, 00-4910,00-4911,00-4912,00-4913, 00-4914,00-4915,00-4916,00-4917, 00-5110,00-5111,00-5112,00-5113, 00-5114,00-5115,00-5116,00-5117, 00-5910,00-5911,00-5912,00-5913, 00-5914,00-5915,00-5916,00-5917
0012	SAS	RAID1/10	00-6000,00-6001,00-6002,00-6003, 00-6004,00-6005,00-6006,00-6007, 00-6800,00-6801,00-6802,00-6803, 00-6804,00-6805,00-6806,00-6807, 00-7000,00-7001,00-7002,00-7003, 00-7004,00-7005,00-7006,00-7007, 00-7800,00-7801,00-7802,00-7803, 00-7804,00-7805,00-7806,00-7807
0013	SAS	RAID1/10	00-6008,00-6009,00-600a,00-600b, 00-600c,00-600d,00-600e,00-600f, 00-6808,00-6809,00-680a,00-680b, 00-680c,00-680d,00-680e,00-680f, 00-7008,00-7009,00-700a,00-700b, 00-700c,00-700d,00-700e,00-700f, 00-7808,00-7809,00-780a,00-780b, 00-780c,00-780d,00-780e,00-780f
0014	SAS	RAID1/10	00-6010,00-6011,00-6012,00-6013, 00-6014,00-6015,00-6016,00-6017, 00-6810,00-6811,00-6812,00-6813, 00-6814,00-6815,00-6816,00-6817, 00-7010,00-7011,00-7012,00-7013, 00-7014,00-7015,00-7016,00-7017, 00-7810,00-7811,00-7812,00-7813, 00-7814,00-7815,00-7816,00-7817
0015	SAS	RAID1/10	00-6100,00-6101,00-6102,00-6103, 00-6104,00-6105,00-6106,00-6107, 00-6900,00-6901,00-6902,00-6903, 00-6904,00-6905,00-6906,00-6907, 00-7100,00-7101,00-7102,00-7103, 00-7104,00-7105,00-7106,00-7107, 00-7900,00-7901,00-7902,00-7903, 00-7904,00-7905,00-7906,00-7907
0016	SAS	RAID1/10	00-6108,00-6109,00-610a,00-610b, 00-610c,00-610d,00-610e,00-610f, 00-6908,00-6909,00-690a,00-690b, 00-690c,00-690d,00-690e,00-690f, 00-7108,00-7109,00-710a,00-710b, 00-710c,00-710d,00-710e,00-710f, 00-7908,00-7909,00-790a,00-790b, 00-790c,00-790d,00-790e,00-790f

Pool Number	Physical Disk	RAID type	Select physical disks
0017	SAS	RAID1/10	00-6110,00-6111,00-6112,00-6113, 00-6114,00-6115,00-6116,00-6117, 00-6910,00-6911,00-6912,00-6913, 00-6914,00-6915,00-6916,00-6917, 00-7110,00-7111,00-7112,00-7113, 00-7114,00-7115,00-7116,00-7117, 00-7910,00-7911,00-7912,00-7913, 00-7914,00-7915,00-7916,00-7917
0018	SAS	RAID1/10	00-0200,00-0201,00-0202,00-0203, 00-0204,00-0205,00-0206,00-0207, 00-0a00,00-0a01,00-0a02,00-0a03, 00-0a04,00-0a05,00-0a06,00-0a07, 00-4200,00-4201,00-4202,00-4203, 00-4204,00-4205,00-4206,00-4207, 00-4a00,00-4a01,00-4a02,00-4a03, 00-4a04,00-4a05,00-4a06,00-4a07
0019	SAS	RAID1/10	00-0208,00-0209,00-020a,00-020b, 00-020c,00-020d,00-020e,00-020f, 00-0a08,00-0a09,00-0a0a,00-0a0b, 00-0a0c,00-0a0d,00-0a0e,00-0a0f, 00-4208,00-4209,00-420a,00-420b, 00-420c,00-420d,00-420e,00-420f, 00-4a08,00-4a09,00-4a0a,00-4a0b, 00-4a0c,00-4a0d,00-4a0e,00-4a0f
001a	SAS	RAID1/10	00-0210,00-0211,00-0212,00-0213, 00-0214,00-0215,00-0216,00-0217, 00-0a10,00-0a11,00-0a12,00-0a13, 00-0a14,00-0a15,00-0a16,00-0a17, 00-4210,00-4211,00-4212,00-4213, 00-4214,00-4215,00-4216,00-4217, 00-4a10,00-4a11,00-4a12,00-4a13, 00-4a14,00-4a15,00-4a16,00-4a17
001b	SAS	RAID1/10	00-2200,00-2201,00-2202,00-2203, 00-2204,00-2205,00-2206,00-2207, 00-2a00,00-2a01,00-2a02,00-2a03, 00-2a04,00-2a05,00-2a06,00-2a07, 00-6200,00-6201,00-6202,00-6203, 00-6204,00-6205,00-6206,00-6207, 00-6a00,00-6a01,00-6a02,00-6a03, 00-6a04,00-6a05,00-6a06,00-6a07
001c	SAS	RAID1/10	00-2208,00-2209,00-220a,00-220b, 00-220c,00-220d,00-220e,00-220f, 00-2a08,00-2a09,00-2a0a,00-2a0b, 00-2a0c,00-2a0d,00-2a0e,00-2a0f, 00-6208,00-6209,00-620a,00-620b, 00-620c,00-620d,00-620e,00-620f, 00-6a08,00-6a09,00-6a0a,00-6a0b, 00-6a0c,00-6a0d,00-6a0e,00-6a0f

Pool Number	Physical Disk	RAID type	Select physical disks
001d	SAS	RAID1/10	00-2210,00-2211,00-2212,00-2213, 00-2214,00-2215,00-2216,00-2217, 00-2a10,00-2a11,00-2a12,00-2a13, 00-2a14,00-2a15,00-2a16,00-2a17, 00-6210,00-6211,00-6212,00-6213, 00-6214,00-6215,00-6216,00-6217, 00-6a10,00-6a11,00-6a12,00-6a13, 00-6a14,00-6a15,00-6a16,00-6a17

**Logical Disk Parameters**

Pool list	Number of Logical Disks	Logical disk Capacity	Logical disk name
0000	1	4183	20002014062507100000
0001	1	4183	20002014062507100001
0002	1	4183	20002014062507100002
0003	1	4183	20002014062507100003
0004	1	4183	20002014062507100004
0005	1	4183	20002014062507100005
0006	1	4183	20002014062507100006
0007	1	4183	20002014062507100007
0008	1	4183	20002014062507100008
0009	1	4183	20002014062507100009
000a	1	4183	2000201406250710000a
000b	1	4183	2000201406250710000b
000c	1	4183	2000201406250710000c
000d	1	4183	2000201406250710000d
000e	1	4183	2000201406250710000e
000f	1	4183	2000201406250710000f
0010	1	4183	20002014062507100010
0011	1	4183	20002014062507100011
0012	1	4183	20002014062507100012
0013	1	4183	20002014062507100013
0014	1	4183	20002014062507100014
0015	1	4183	20002014062507100015
0016	1	4183	20002014062507100016
0017	1	4183	20002014062507100017
0018	1	4183	20002014062507100018
0019	1	4183	20002014062507100019
001a	1	4183	2000201406250710001a
001b	1	4183	2000201406250710001b
001c	1	4183	2000201406250710001c
001d	1	4183	2000201406250710001d

## **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=sd1,lun=\\.e:,size=60632869109760
sd=sd2,lun=\\.f:,size=60632869109760
sd=sd3,lun=\\.g:,size=13474002370560

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

### **Primary Metrics and Repeatability Tests**

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

```
* spc1_metrics.cfg

host=master

# ns59/60/61/62/66 6slaves, ns63/64/65 7slaves
slaves=(ns59_1,ns59_2,ns59_3,ns59_4,ns59_5,ns59_6,ns60_1,ns60_2,ns60_3,ns60_4,ns60_5,ns60_6,ns61_1,ns61_2,ns61_3,ns61_4,ns61_5,ns61_6,ns62_1,ns62_2,ns62_3,ns62_4,ns62_5,ns62_6,ns63_1,ns63_2,ns63_3,ns63_4,ns63_5,ns63_6,ns63_7,ns64_1,ns64_2,ns64_3,ns64_4,ns64_5,ns64_6,ns64_7,ns65_1,ns65_2,ns65_3,ns65_4,ns65_5,ns65_6,ns65_7,ns66_1,ns66_2,ns66_3,ns66_4,ns66_5,ns66_6)

sd=asu1_1,lun=\\.e:,size=60632869109760
sd=asu2_1,lun=\\.f:,size=60632869109760
sd=asu3_1,lun=\\.g:,size=13474002370560
```

### **SPC-1 Persistence**

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

```
* spc1_persist.cfg

sd=asu1_1,lun=\\.e:,size=60632869109760
sd=asu2_1,lun=\\.f:,size=60632869109760
sd=asu3_1,lun=\\.g:,size=13474002370560
```



## Slave JVMs

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

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

There were 51 Slave JVMs used in the Primary Metrics and Repeatability Tests. Those Slave JVMs were started as the first step in the execution sequence. The [Slave JVMs](#) section below documents that step.

The following script, [master script M710.bat](#), was executed to invoke the following in an uninterrupted execution sequence:

- A script, [profile.bat](#), to capture the first detailed TSC system profile listing required for a SPC-1 Remote Audit.
- The ASU pre-fill script, [prepssd.bat](#).
- The commands to execute the Primary Metrics Test (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*), Repeatability Test (*Repeatability Test Phase 1 and Repeatability Test Phase 2*), and SPC-1 Persistence Test Run 1 (*write phase*).
- A script, [shutdown.bat](#), to power off the TSC.

The following script, [master script 2 M710.bat](#), was executed after the required TSC power off/power on cycle to invoke the following:

- The command to execute the SPC-1 Persistence Test Run 2 (*read phase*).
- A script, [profile.bat](#), to capture the second detailed TSC system profile listing required for a SPC-1 Remote Audit.

### **Slave JVMs**

There were 51 Slave JVMs used in the Primary Metrics and Repeatability Tests. The script, [ns59\\_start\\_slave\\_6.bat](#), listed below, illustrates the commands to start the six Slave JVMs ([ns59\\_s1](#) – [ns59\\_s6](#)) that executed on the first Host System ([ns59](#)).

#### **ns59\_start\_slave\_6.bat**

```
start java -Xmx1024m -Xms1024m spc1 -fns59_s1.parm -ons59_s1
start java -Xmx1024m -Xms1024m spc1 -fns59_s2.parm -ons59_s2
start java -Xmx1024m -Xms1024m spc1 -fns59_s3.parm -ons59_s3
start java -Xmx1024m -Xms1024m spc1 -fns59_s4.parm -ons59_s4
start java -Xmx1024m -Xms1024m spc1 -fns59_s5.parm -ons59_s5
start java -Xmx1024m -Xms1024m spc1 -fns59_s6.parm -ons59_s6
```

The following scripts were used to start the remaining 45 Slave JVMs on the remaining seven Host Systems ([ns60](#) – [ns66](#)):

- [ns60\\_start\\_slave\\_6.bat](#)
- [ns61\\_start\\_slave\\_6.bat](#)
- [ns62\\_start\\_slave\\_6.bat](#)
- [ns63\\_start\\_slave\\_7.bat](#)
- [ns64\\_start\\_slave\\_7.bat](#)
- [ns65\\_start\\_slave\\_7.bat](#)
- [ns66\\_start\\_slave\\_6.bat](#)

The file, listed below, is the configuration file for the first Slave JVM (**ns59\_s1**)

### **ns59\_s1.parm**

```
host=ns59_1
master=192.168.10.161

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

The following sets of configuration files were used for the remaining 50 Slave JVMs.

- **ns59\_s2.parm – ns59\_s6.parm**
- **ns60\_s1.parm – ns60\_s6.parm**
- **ns61\_s1.parm – ns61\_s6.parm**
- **ns62\_s1.parm – ns62\_s6.parm**
- **ns63\_s1.parm – ns63\_s7.parm**
- **ns64\_s1.parm – ns64\_s7.parm**
- **ns65\_s1.parm – ns65\_s7.parm**
- **ns66\_s1.parm – ns66\_s6.parm**

### **master\_script\_M710.bat**

```
call profile.bat
call prepssd.bat

copy /y spc1_metrics.cfg spc1.cfg
java metrics -b 5100 -t 28800
java repeat1 -b 5100
java repeat2 -b 5100

copy /y spc1_persist.cfg spc1.cfg
java persist1 -b 5100

call shutdown.bat
```

### **Detailed TSC System Profile**

The following script and command file were used to capture the detailed TSC profile listings required for a Remote Audit.

#### **profile.bat**

```
c:\spc\teraterm\ttermpro.exe /M=C:\spc\teraterm\M710_profile.ttl
```

#### **M710\_profile.ttl**

```
;; connection user/password
HOSTADDR = '192.168.70.236'
USERNAME = 'sysadmin'
PASSWORD = 'sys123'
```

```
=====
;; config
COMMAND = HOSTADDR
strconcat COMMAND ':23 /nossh /T=1'
;; connect
connect COMMAND
;; login
wait 'login: '
sendln USERNAME
wait 'Password: '
sendln PASSWORD

;; command1
wait 'sysadmin@2000201406250710-0# '
sendln 'iSMenv gettime'

;; command2
wait 'sysadmin@2000201406250710-0# '
sendln 'iSMview -all'

;; command3
wait 'sysadmin@2000201406250710-0# '
sendln 'iSMenv gettime'

;; finish
sendln 'exit'

end
```

## ASU Pre-Fill

The following script was invoked to execute the required ASU pre-fill using the [command and parameter file](#) documented in [Appendix D: SPC-1 Workload Generator Storage Commands and Parameters](#) on page 88.

### prepssd.bat

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

## TSC Power Off

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

### shutdown.bat

```
c:\spc\teraterm\ttermpro.exe /M=c:\spc\teraterm\M710_shutdown.ttl
```

### M710\_shutdown.ttl

```
;; connection user/password
HOSTADDR = '192.168.70.236'
USERNAME = 'sysadmin'
PASSWORD = 'sys123'
=====
;; config
```

```
COMMAND = HOSTADDR
strconcat COMMAND ':23 /nossh /T=1'
;; connect
connect COMMAND
;; login
wait 'login: '
sendln USERNAME
wait 'Password: '
sendln PASSWORD

;; command1
wait 'sysadmin@2000201406250710-0# '
sendln 'iSMenv gettime'

;; command2
wait 'sysadmin@2000201406250710-0# '
sendln 'iSMview -all'

;; command3
wait 'sysadmin@2000201406250710-0# '
sendln 'iSMcfg shutdown -time 5'

;; finish
sendln 'exit'

end
```

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

The following script, **master\_script\_2\_M710.bat**, was executed after the required TSC power off/power on cycle to invoke the following:

- The command to execute the SPC-1 Persistence Test Run 2 (*read phase*).
- A script, [profile.bat](#), to capture the second detailed TSC system profile listing required for a SPC-1 Remote Audit.

#### **master\_script\_2\_M710.bat**

```
java persist2

call profile.bat
```