



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**MACROSAN TECHNOLOGIES CO., LTD.  
MACROSAN MS3300**

**SPC-1 V1.14**

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**First Edition – January 2015**

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## AUDIT CERTIFICATION



Yi Shen  
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Hangzhou, China

January 13, 2015

The SPC Benchmark 1™ Reported Data listed below for the MacroSAN MS3300 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: MacroSAN MS3300	
Metric	Reported Result
SPC-1 IOPS™	154,985.90
SPC-1 Price-Performance	7,81CNY/SPC-1 IOPS™
Total ASU Capacity	3,000.000 GB
Data Protection Level	Protected 2 (Mirroring)
Total Price (including three-year maintenance)	1,210,000.00CNY
Currency Used	CNY
Target Country for availability, sales and support	China

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 Macro SAN Technologies Co., Ltd.:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

Storage Performance Council  
643 Bair Island Road, Suite 103  
Redwood City, CA 94062  
[AuditService@storageperformance.org](mailto:AuditService@storageperformance.org)  
650.556.9384

## AUDIT CERTIFICATION (CONT.)

MacroSAN MS3300  
SPC-1 Audit Certification

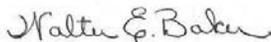
Page 2

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by Macro SAN Technologies Co., Ltd.:
  - ✓ 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 Macro SAN Technologies Co., Ltd. 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
- The documented difference between the Tested Storage Configuration (TSC) and Priced Storage Configuration, if applied to the TSC, would have no performance impact on the reported measurements..
- 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



Date: July 10, 2014

From: MacroSAN Technologies Co., Ltd.  
581 Huoju Avenue  
Hangzhou, China 310052

To: Walter E. Baker  
SPC Administrator and 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 MacroSAN MS3300

MacroSAN Technologies Co., Ltd. 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:

A handwritten signature in black ink, appearing to read 'Li Zhi', written over a horizontal line.

A handwritten date '2014.7.10' in black ink, written over a horizontal line.

Li Zhi  
President  
MacroSAN Technologies Co., Ltd.

## EXECUTIVE SUMMARY

### Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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### 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>	January 14, 2015
<b>Date the FDR was submitted to the SPC</b>	January 14, 2015
<b>Date the Priced Storage Configuration is available for shipment to customers</b>	currently available
<b>Date the TSC completed audit certification</b>	January 13, 2015

### Tested Storage Product (TSP) Description

The MS3300 is a new-generation mid-range storage product launched by MacroSAN, which incorporates various advanced design ideas and architecture technologies to provide a secure and reliable storage platform that supports flexible resource deployment for small and medium-sized data centers..

Regarding resource management, the MS3300 combines the cell-based virtualization technology to support flexible resource deployment through an innovative intelligent cell management technology (ICMT).

## Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: MacroSAN MS3300	
Metric	Reported Result
SPC-1 IOPS™	154,985.90
SPC-1 Price-Performance™	7.81CNY/SPC-1 IOPS™
Total ASU Capacity	3,000.000 GB
Data Protection Level	Protected 2 ( <i>mirroring</i> )
Total Price	1,210,000.00CNY
Currency Used	CNY
Target Country for availability, sales and support	China

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

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

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

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

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

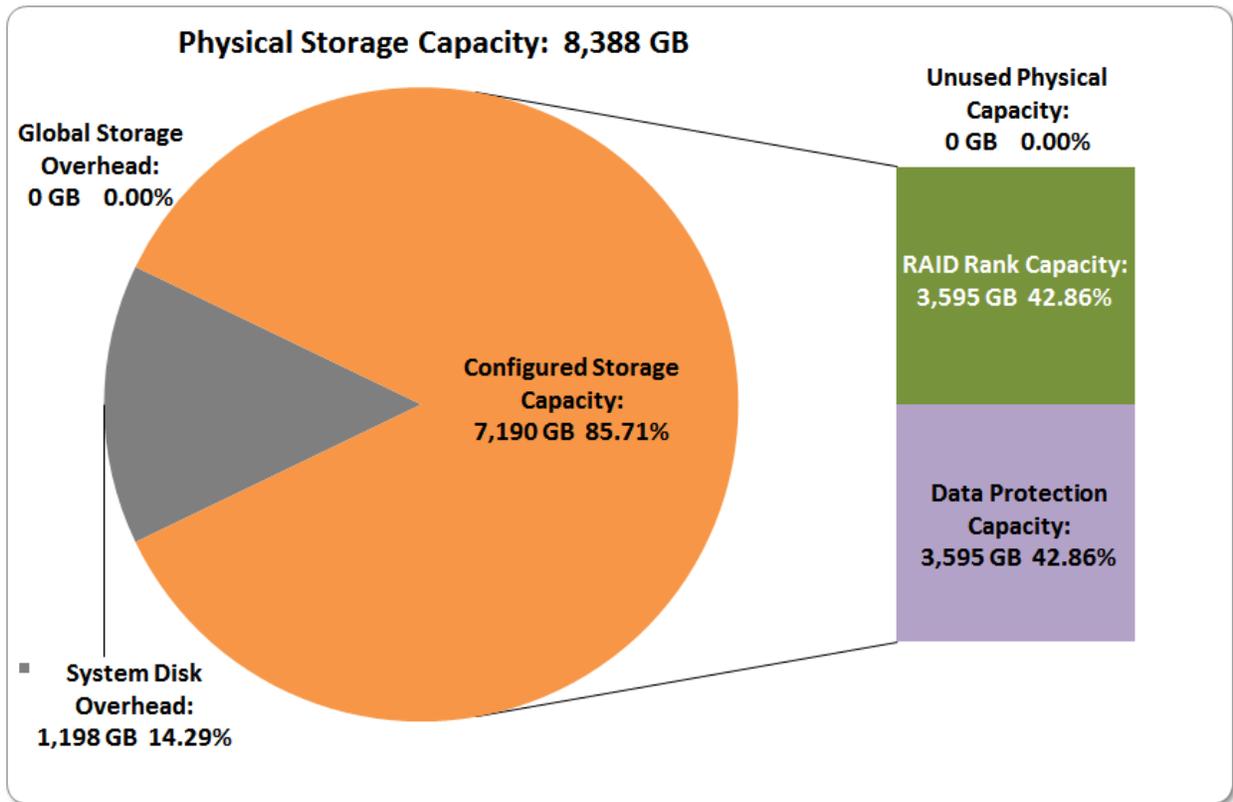
**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 16.

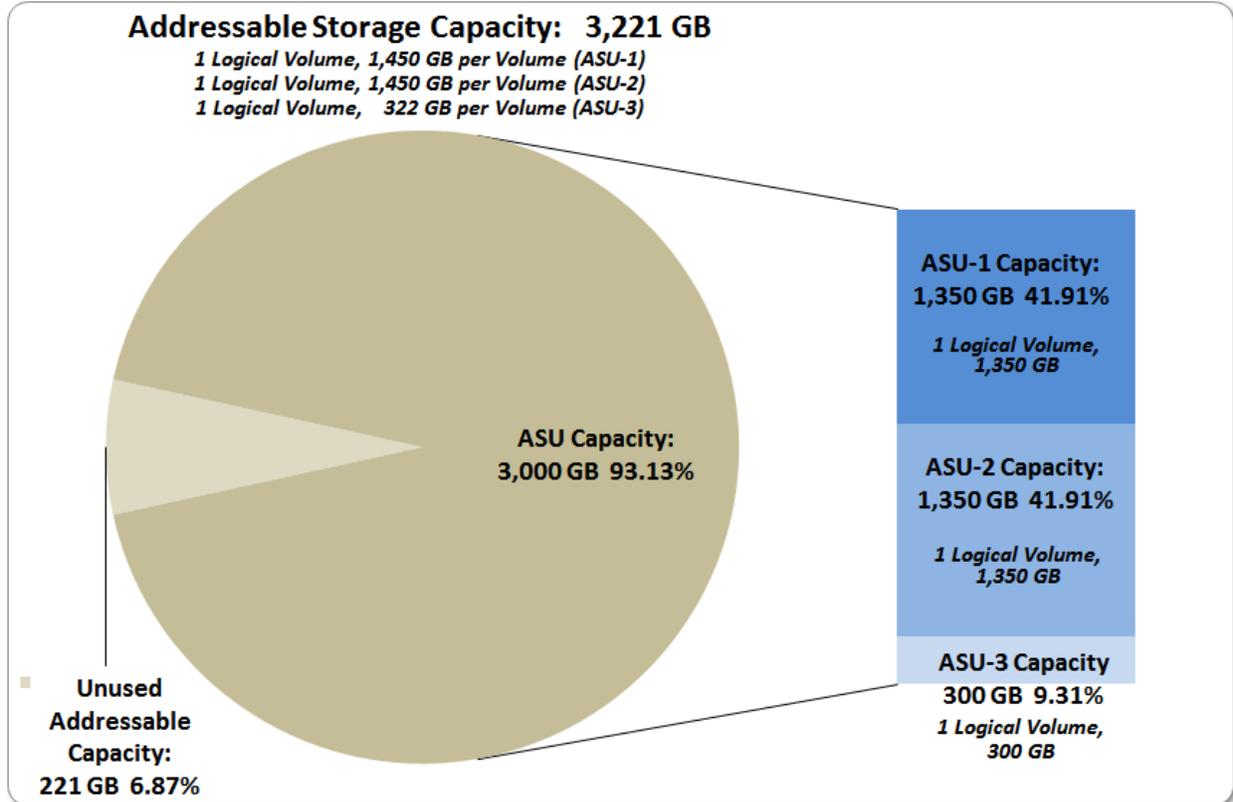
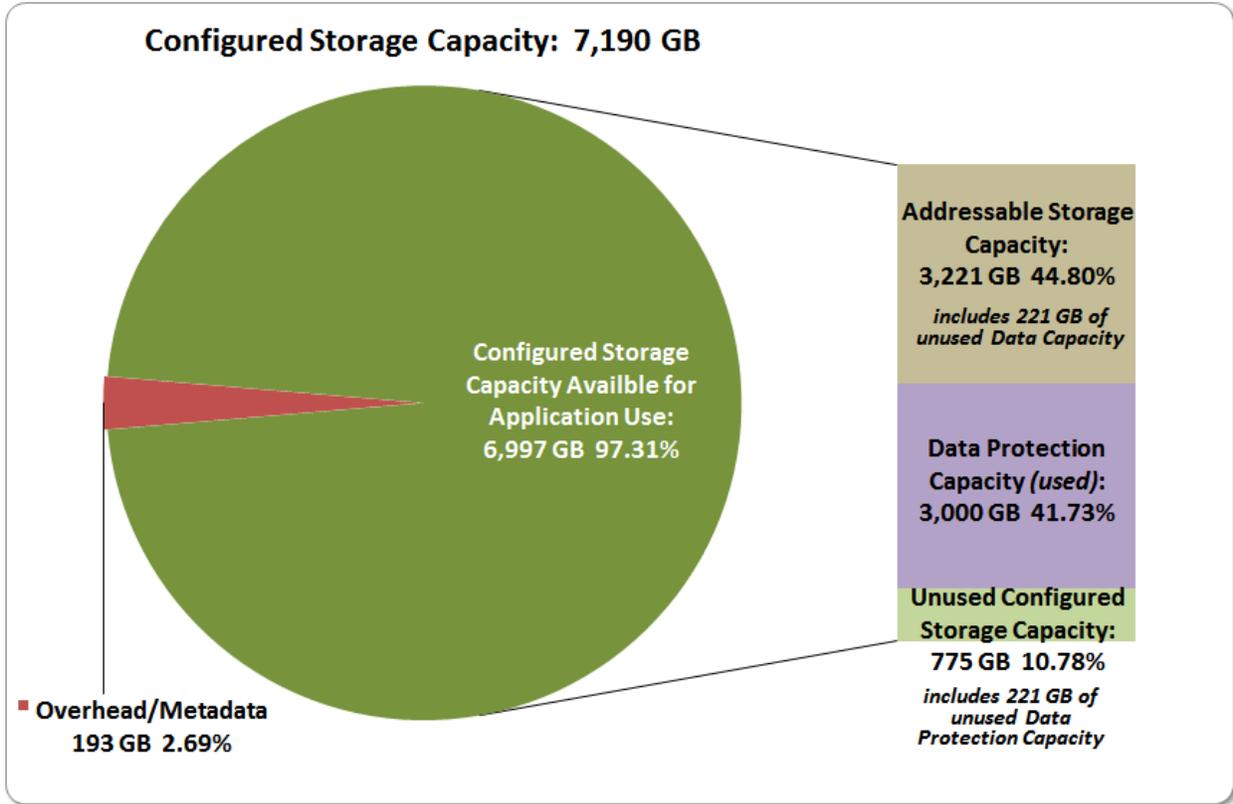
**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

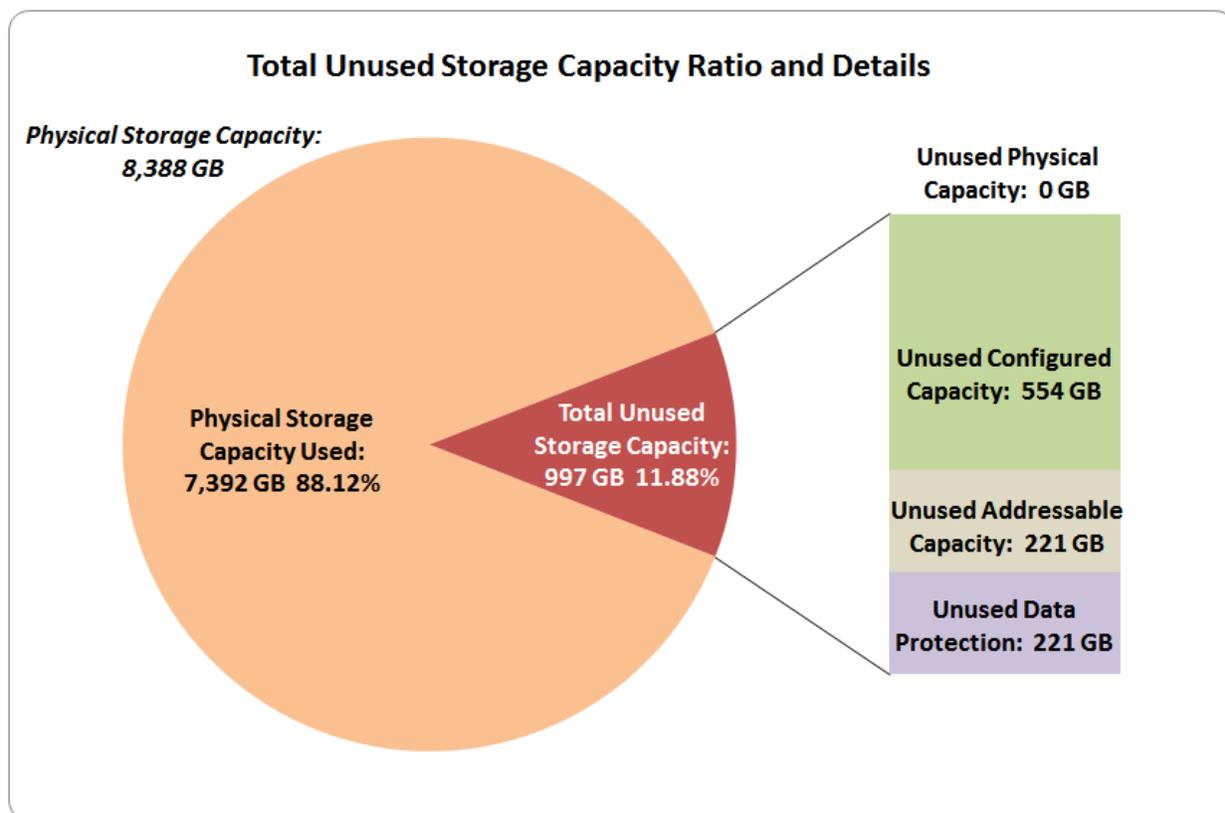
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

### Storage Capacities, Relationships, and Utilization

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







SPC-1 Storage Capacity Utilization	
Application Utilization	35.77%
Protected Application Utilization	72.68%
Unused Storage Ratio	11.88%

**Application Utilization:** Total ASU Capacity (3000.00 GB) divided by Physical Storage Capacity (8,388.071 GB).

**Protected Application Utilization:** Total ASU Capacity (3000.00 GB) plus total Data Protection Capacity (3,594.888 GB) minus unused Data Protection Capacity (498.251 GB) divided by Physical Storage Capacity (8,388.071 GB).

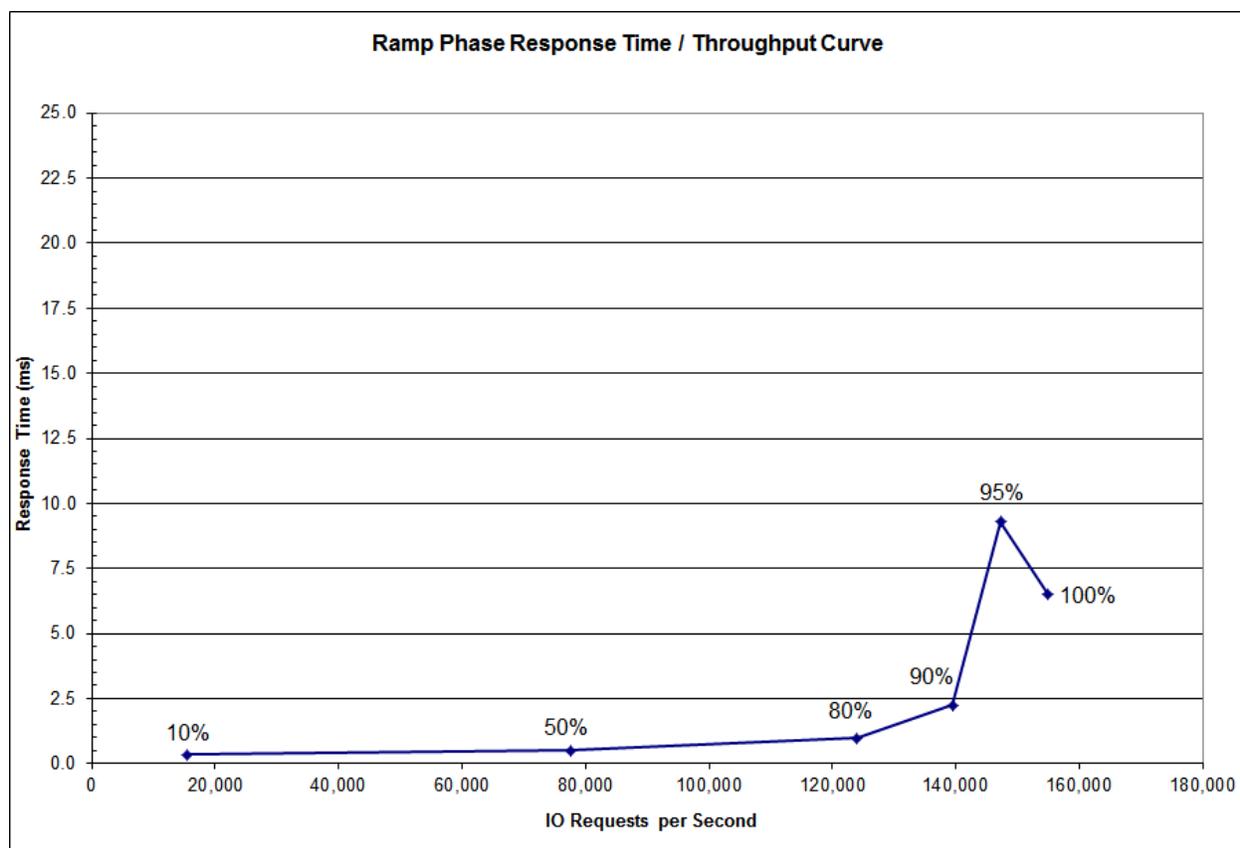
**Unused Storage Ratio:** Total Unused Capacity (GB) divided by Physical Storage Capacity (8,388.071 GB) and may not exceed 45%.

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>	15,502.71	77,502.68	123,978.66	139,502.46	147,256.47	154,985.90
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	0.34	0.51	0.97	2.24	9.30	6.49
<b>ASU-1</b>	0.34	0.54	1.01	2.26	9.38	6.51
<b>ASU-2</b>	0.34	0.53	1.00	2.28	9.40	6.54
<b>ASU-3</b>	0.33	0.43	0.86	2.21	9.08	6.43
<b>Reads</b>	0.37	0.61	1.11	2.32	9.39	6.48
<b>Writes</b>	0.32	0.45	0.87	2.19	9.24	6.49

## Priced Storage Configuration Pricing

No.	Part Number	Description	Qty	Unit Price/¥	Extended Price/¥	Discount	Discounted Price/¥
1	MacroSAN MS3300 Enterprise System						
1.1	Control Module						
	1020025	MS3300 Storage Processor Unit (Dual Controllers,AC,64GB Cache, with Battery Cache Protected Module)	1	540,000.00	540,000.00	85.00%	81,000.00
1.2	Disk Enclosure						
	1020036	DSU1616(3U,2.5"/3.5",AC)	2	115,000.00	230,000.00	85.00%	34,500.00
1.3	Storage Devices						
	1020004	Reserved Disk Suite (4*300GB 15K RPM 3.5" SAS Drive)	1	86,000.00	86,000.00	85.00%	12,900.00
	2080054	200GB MLC SSD Drive(3.5")	36	150,000.00	5,400,000.00	85.00%	810,000.00
1.4	IO Interface						
	2080005	4*8Gbps Fibre Channel I/O modules (Total 4 ports)	2	60,000.00	120,000.00	85.00%	18,000.00
1.5	Storage Software						
	7050005	MacroSAN Open Data Storage Platform MS3000 Storage System Management Software	1	80,000.00	80,000.00	85.00%	12,000.00
1.6	Accessory						
	5040001	Patch Cord,DLC/PC-DLC/PC, Multimode,2mm-Parallel,5m	18	50.00	900.00	0.00%	900.00
1.7	FC Switch						
		Brocade300 8Gbps FC Switch with 24 available ports and 24 enabled ports, including 24*8Gbps SFPs,Single-Power Supply,AC	2	45,200.00	90,400.00	0.00%	90,400.00
1.8	Third Party						
		Qlogic QLE2562 HBA Card,PCIe,8Gbps DualPort, Fiber Channel Multimode LC Optic Interface	6	3,300.00	19,800.00	0.00%	19,800.00
<b>Total of Product</b>							<b>1,079,500.00</b>
1.9	Maintenance Support Service						
	53010041	MS3300 Installation Base Service per Set	1	20,000.00	20,000.00	70.00%	6,000.00
	53010042	Disk Enclosure Installation Base Service per Set	2	10,000.00	20,000.00	70.00%	6,000.00
	53010007	MS3300 SPU Gold-Level 24x7x4H Service (Per Set*3Year)	1	195,000.00	195,000.00	70.00%	58,500.00
	53010060	Disk Enclosure Gold-Level 24x7x4H Service (Per Set*3Year)	2	90,000.00	180,000.00	70.00%	54,000.00
		Brocade300 FC Switch 24x7x4H Service (Per Set*3Year), including Installation Base Service(Per Set)	1	6,000.00	6,000.00	0.00%	6,000.00
<b>Total of Service(3 years)</b>							<b>130,500.00</b>
<b>Total Price</b>							<b>1,210,000.00</b>

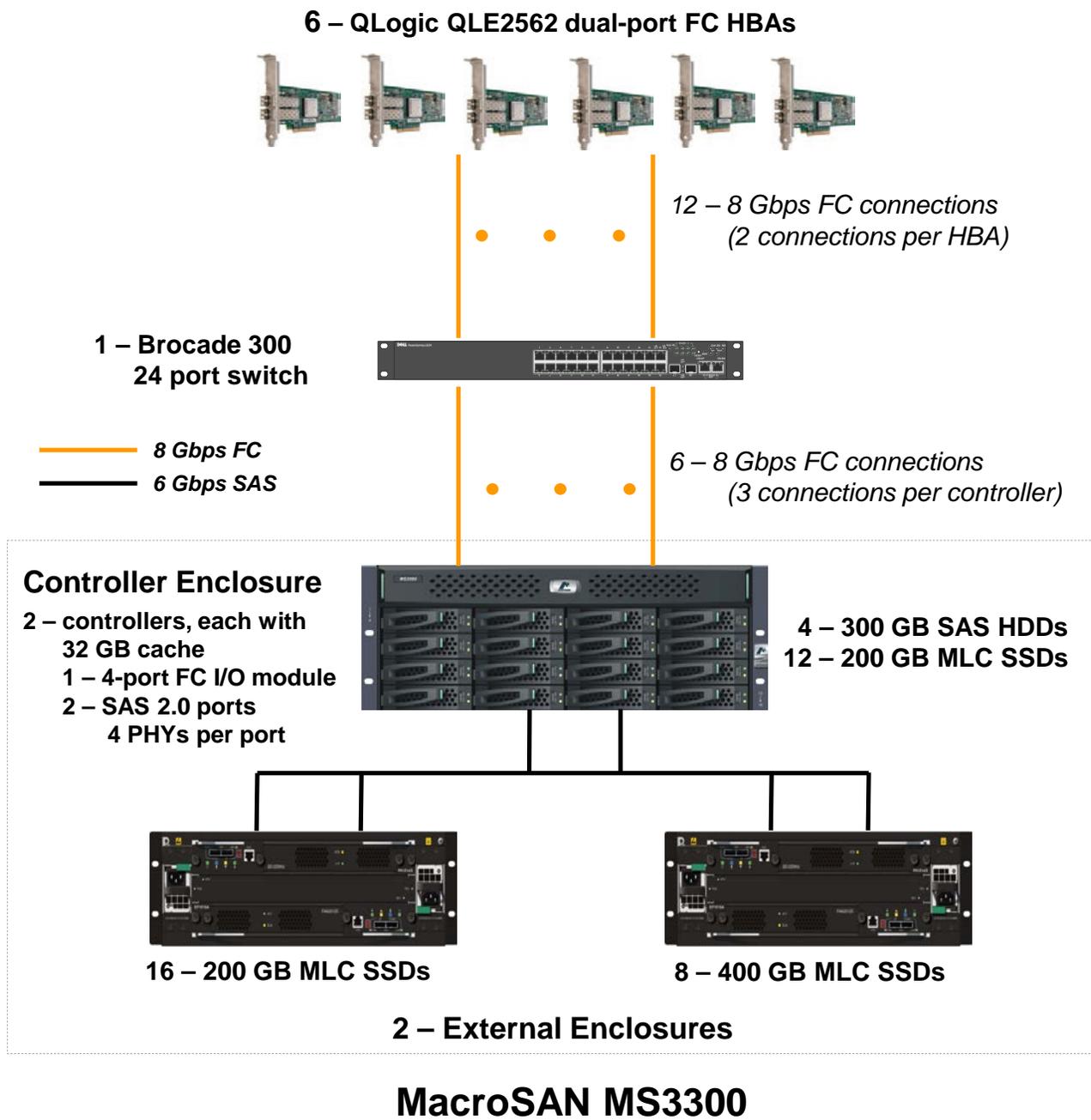
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- Acknowledgement of new and existing problems within four (4) hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative 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**

A second 24-port FC switch was included in the Priced Storage Configuration as a spare to fulfill one of the requirements for a data protection level of [Protected 2](#).

### Priced Storage Configuration Diagram



## Priced Storage Configuration Components

<b>Priced Storage Configuration</b>
6 – QLogic QLE2562 dual-port, 8 Gbps, FC HBAs
2 – Brocade 300 Fibre Channel 24-port switches with 24 ports enabled and SFPs included (2 <sup>nd</sup> switch included as a spare for the <a href="#">Protected 2</a> requirement)
<b>MacroSAN MS3300</b>
1 – Controller Enclosure with 2 – controllers, each controller includes: 64 GB cache (128 GB total) 1 – 4-port Fibre Channel I/O modules (2 modules/8 ports total) (6 ports total/3 per controller used) 2 – SAS 2.0 ports, 4 6Gbps PHYs per port (8 PHYs total) (2 ports/8 PHYs used per controller) (4 ports/16 PHYs total and used) 4 – 300GB SAS disk drives (HDDs) (system disks) 12 – 200GB MLC SSD drives
2 – External Enclosures (Enclosure 1: 8 200GB MLC SSDs) (Enclosure 2: 16 200GB MLC SSDs)
4 – 300 GB SAS disk drives (HDDs) 36 – 200 GB MLC SSDs (HDDs and SSDs distributed as documented above)

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](#)).

### **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 [23](#) ([Host System\(s\) and Tested Storage Configuration \(TSC\) Table of Components](#)).

## Storage Network Configuration

### Clause 9.4.3.4.1

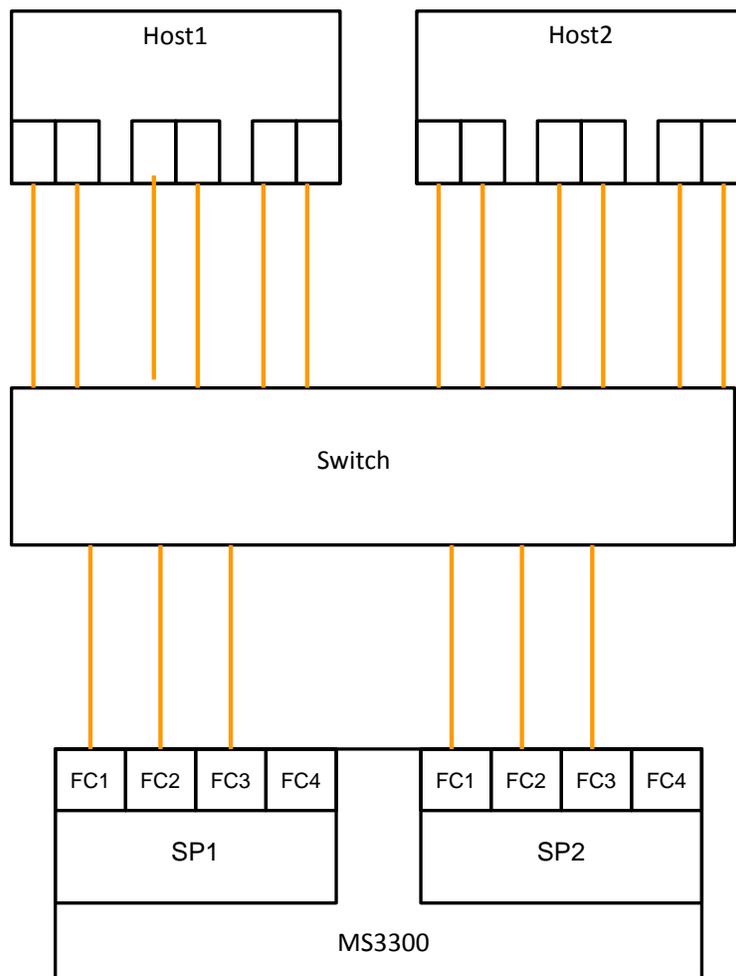
...

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.

## Storage Network Diagram



— 1 FC connection

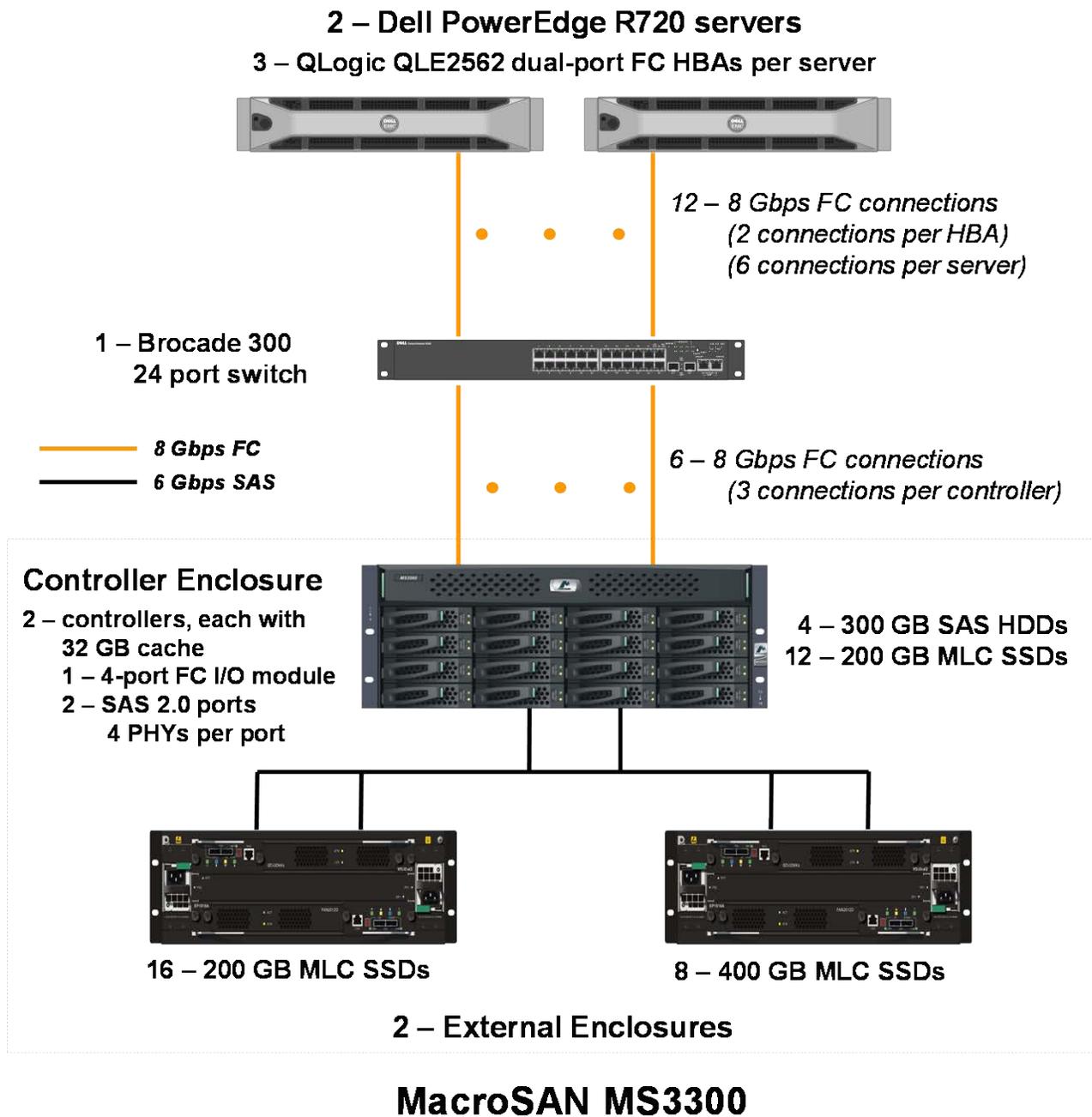
## Zone Configuration

# Switch 1

Effective configuration:

```
cfg:   spc1_3300_config
zone:  z1      21:00:00:24:ff:2f:89:0d
          21:00:00:24:ff:41:dd:19
          50:0b:34:20:01:21:4f:01
zone:  z11     21:00:00:24:ff:2f:88:f3
          50:01:43:80:12:06:d2:4a
          50:0b:34:20:01:15:6a:01
zone:  z2      21:00:00:24:ff:2f:89:0c
          21:00:00:24:ff:41:dd:18
          50:0b:34:20:01:21:4f:02
zone:  z22     21:00:00:24:ff:2f:88:f2
          50:01:43:80:12:06:d2:48
          50:0b:34:20:01:15:6a:02
zone:  z3      21:00:00:24:ff:2f:88:fd
          21:00:00:24:ff:37:0b:81
          50:0b:34:20:01:21:4f:03
zone:  z33     21:00:00:24:ff:41:dd:a3
          50:01:43:80:06:2d:66:30
          50:0b:34:20:01:15:6a:03
```

**Benchmark Configuration/Tested Storage Configuration Diagram**



**Host System and Tested Storage Configuration Components**

<b>Host Systems</b>
<p><b>2 – Dell PowerEdge R720 servers</b>, each with:</p> <ul style="list-style-type: none"> <li>2 – Intel® Xeon® E5-2643-0 processors 3.30 GHz each with 4 cores, 10 MB Intel® Smart Cache</li> <li>16 GB main memory</li> <li>Red Hat Enterprise Linux Server release 6.2 x86_64</li> <li>PCIe</li> </ul>
<b>Priced Storage Configuration</b>
6 – QLogic QLE2562 dual-port, 8 Gbps, FC HBAs
1 – Brocade 300 Fibre Channel 24-port switch with 24 ports enabled and SFPs included
<p><b>MacroSAN MS3300</b></p> <ul style="list-style-type: none"> <li>1 – Controller Enclosure with             <ul style="list-style-type: none"> <li>2 – controllers, each controller includes:                 <ul style="list-style-type: none"> <li>64 GB cache (<i>128 GB total</i>)                     <ul style="list-style-type: none"> <li>1 – 4-port Fibre Channel I/O modules (<i>2 modules/8 ports total</i>)</li> <li>(<i>6 ports total/3 per controller used</i>)</li> <li>2 – SAS 2.0 ports, 4 6Gbps PHYs per port (<i>8 PHYs total</i>)</li> <li>(<i>2 ports/8 PHYs used per controller</i>)</li> <li>(<i>4 ports/16 PHYs total and used</i>)</li> <li>4 – 300GB SAS disk drives (HDDs) (<i>system disks</i>)</li> <li>12 – 200GB MLC SSD drives</li> </ul> </li> </ul> </li> </ul> </li> <li>2 – External Enclosures             <ul style="list-style-type: none"> <li>(<i>Enclosure 1: 8 200GB MLC SSDs</i>)</li> <li>(<i>Enclosure 2: 16 200GB MLC SSDs</i>)</li> </ul> </li> <li>4 – 300 GB SAS disk drives (HDDs)</li> <li>36 – 200 GB MLC SSDs</li> <li>(<i>HDDs and SSDs distributed as documented above</i>)</li> </ul>

## Customer Tunable Parameters and Options

### Clause 9.4.3.5.1

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

[Appendix B: Customer Tunable Parameters and Options](#) on page 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 75.

## 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 [75](#).

## **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 1,198.296 GB distributed over 4 disk drives (HDDs), each with a formatted capacity of 299.574 GB and 7,189.775 GB distributed over 36 solid state storage devices (SSDs), each with a formatted capacity of 199.716 GB, for a total of 8,388.071 GB. There was 0.00 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.00 GB (0.00%) of the Physical Storage Capacity. There was 554.000 GB (7.71%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 93.13% of the Addressable Storage Capacity resulting in 221.251 GB (6.87%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*mirroring*) capacity was 3,594.888 GB of which 3,096.637 GB was utilized. The total Unused Storage capacity was 4,787.572 GB.

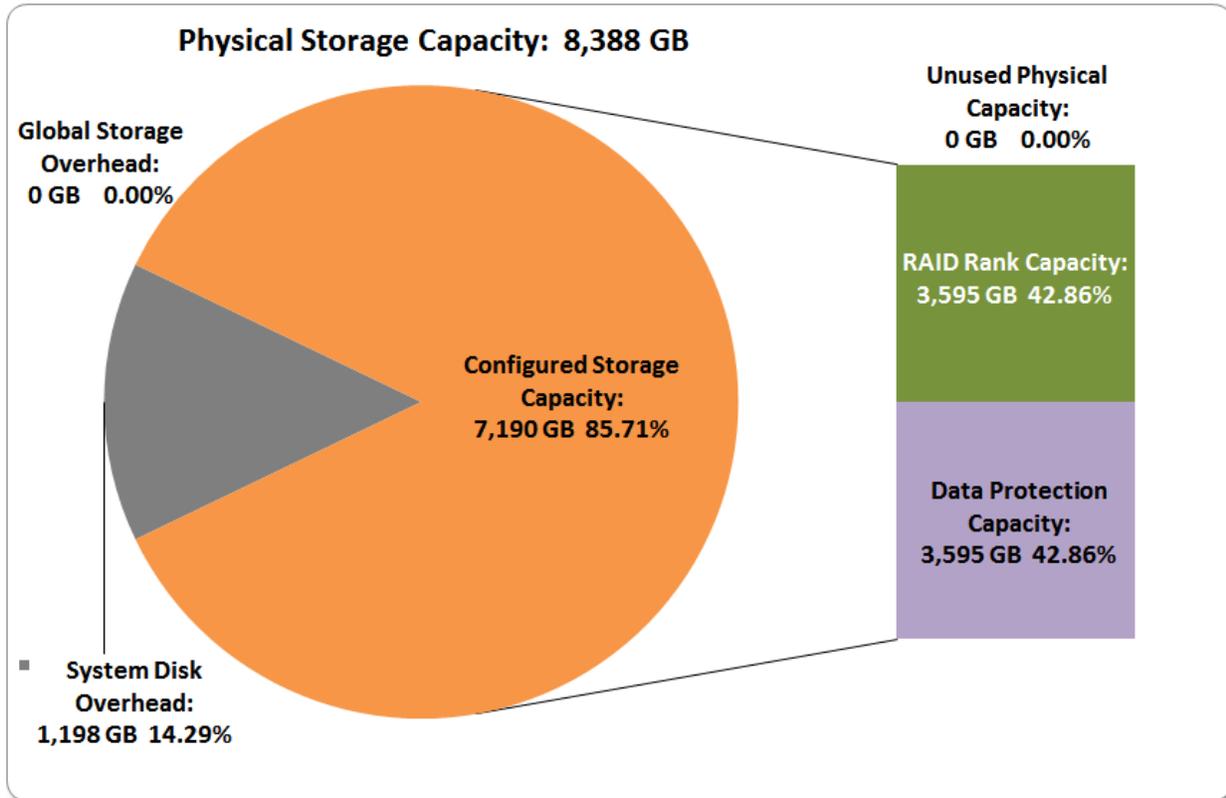
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

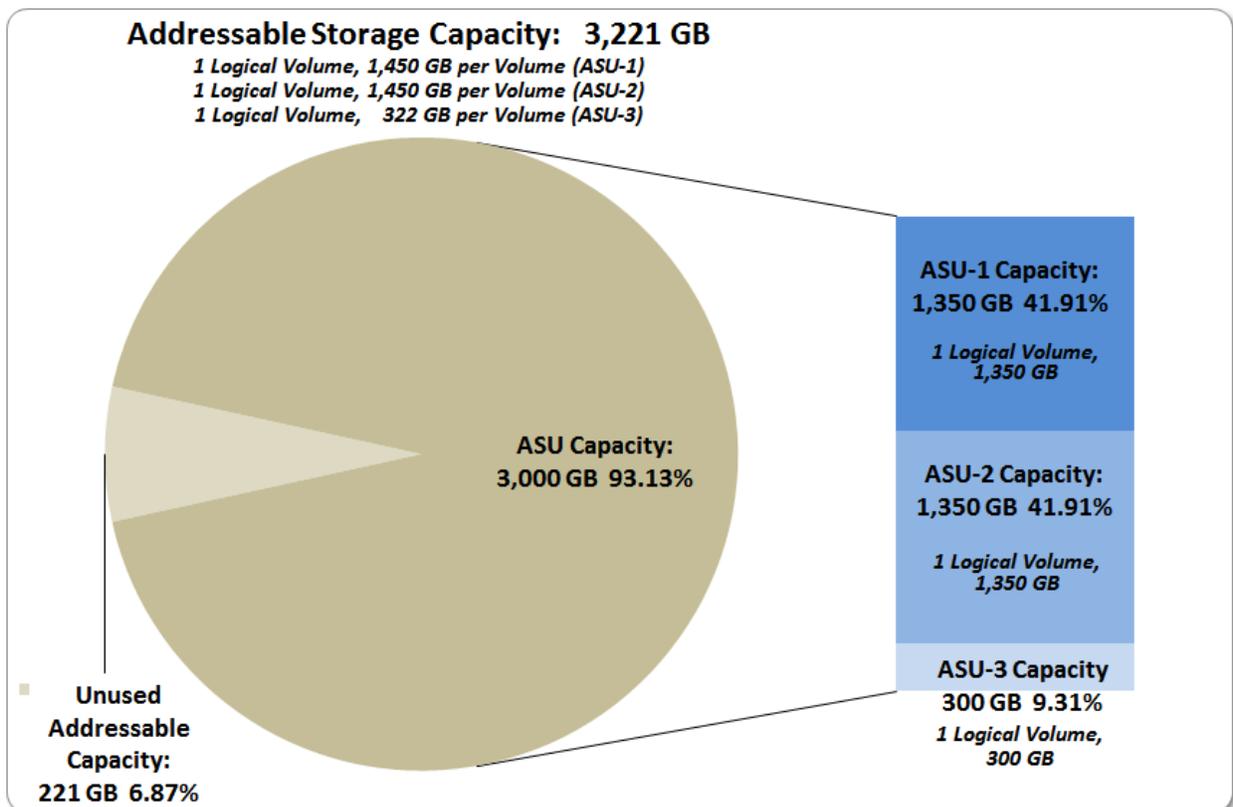
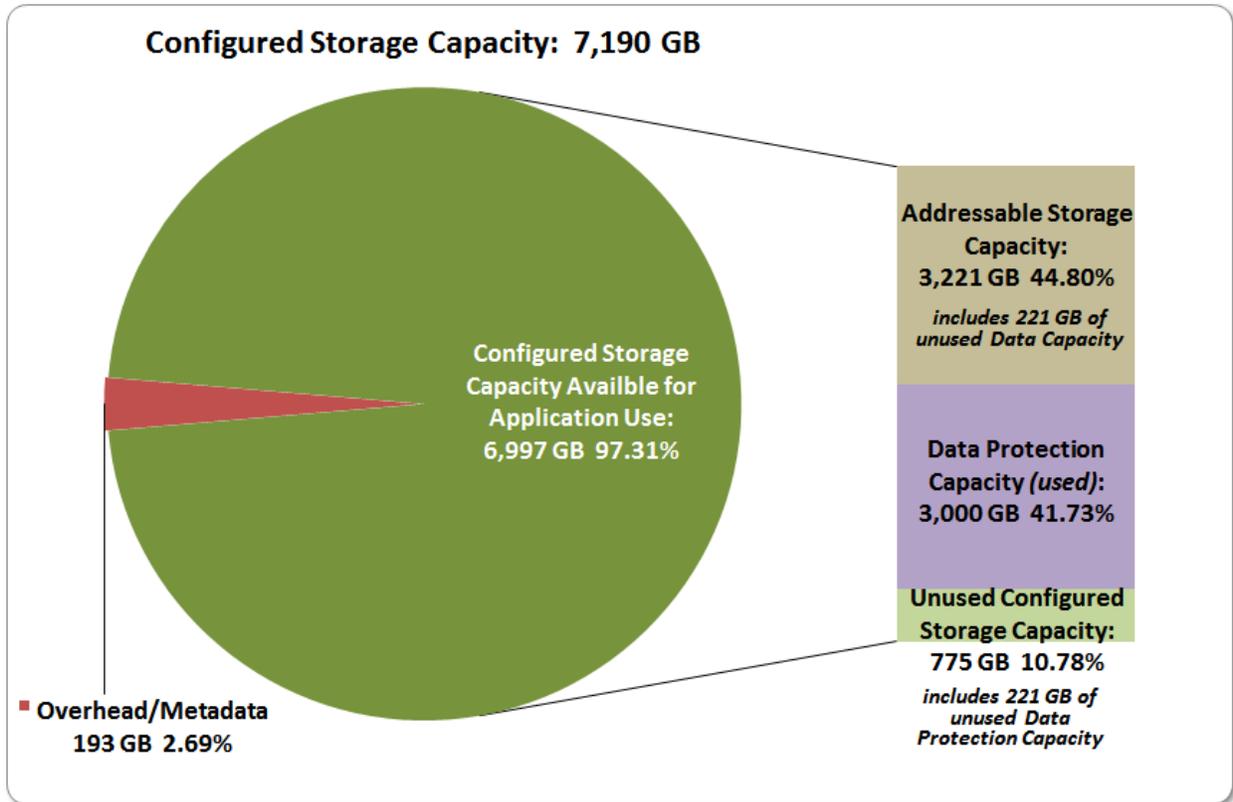
<b>SPC-1 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	3,000.000
Addressable Storage Capacity	Gigabytes (GB)	3,221.251
Configured Storage Capacity	Gigabytes (GB)	7,189.775
Physical Storage Capacity	Gigabytes (GB)	8,388.071
Data Protection ( <i>Mirroring</i> )	Gigabytes (GB)	3,594.888
Required Storage ( <i>system overhead</i> )	Gigabytes (GB)	1,391.569
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	996.502

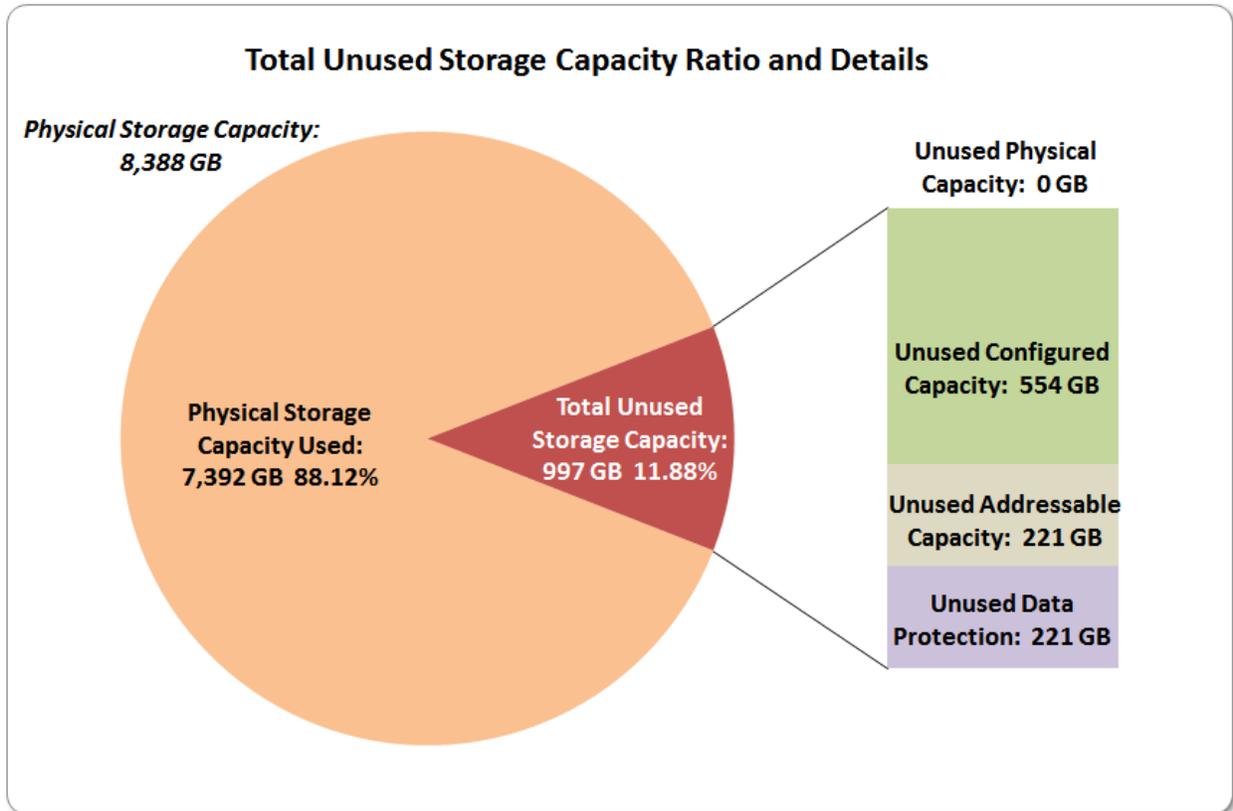
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	93.13%	41.73%	35.77%
Required for Data Protection ( <i>Mirroring</i> )		50.00%	42.86%
Addressable Storage Capacity		44.80%	38.40%
Required Storage ( <i>system overhead</i> )		19.35%	16.59%
Configured Storage Capacity			85.71%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	6.87%		
Configured		7.71%	
Physical			0.00%

SPC-1 Storage Capacity Charts







## Storage Capacity Utilization

### Clause 9.4.3.6.2

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

### Clause 2.8.1

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

### Clause 2.8.2

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

### Clause 2.8.3

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

SPC-1 Storage Capacity Utilization	
Application Utilization	35.77%
Protected Application Utilization	72.68%
Unused Storage Ratio	11.88%

### 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 (1,350.000 GB)	ASU-2 (1,350.000 GB)	ASU-3 (300.000 GB)
1 Logical Volume 1,449.551 GB per Logical Volume (1,350.000 GB used per Logical Volume)	1 Logical Volume 1,449.551 GB per Logical Volume (1,350.000 GB used per Logical Volume)	1 Logical Volume 322.148 GB per Logical Volume (300.000 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 2](#) using *Mirroring* as described on page [11](#). See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

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

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

## 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 77.

### Sustainability Test Results File

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

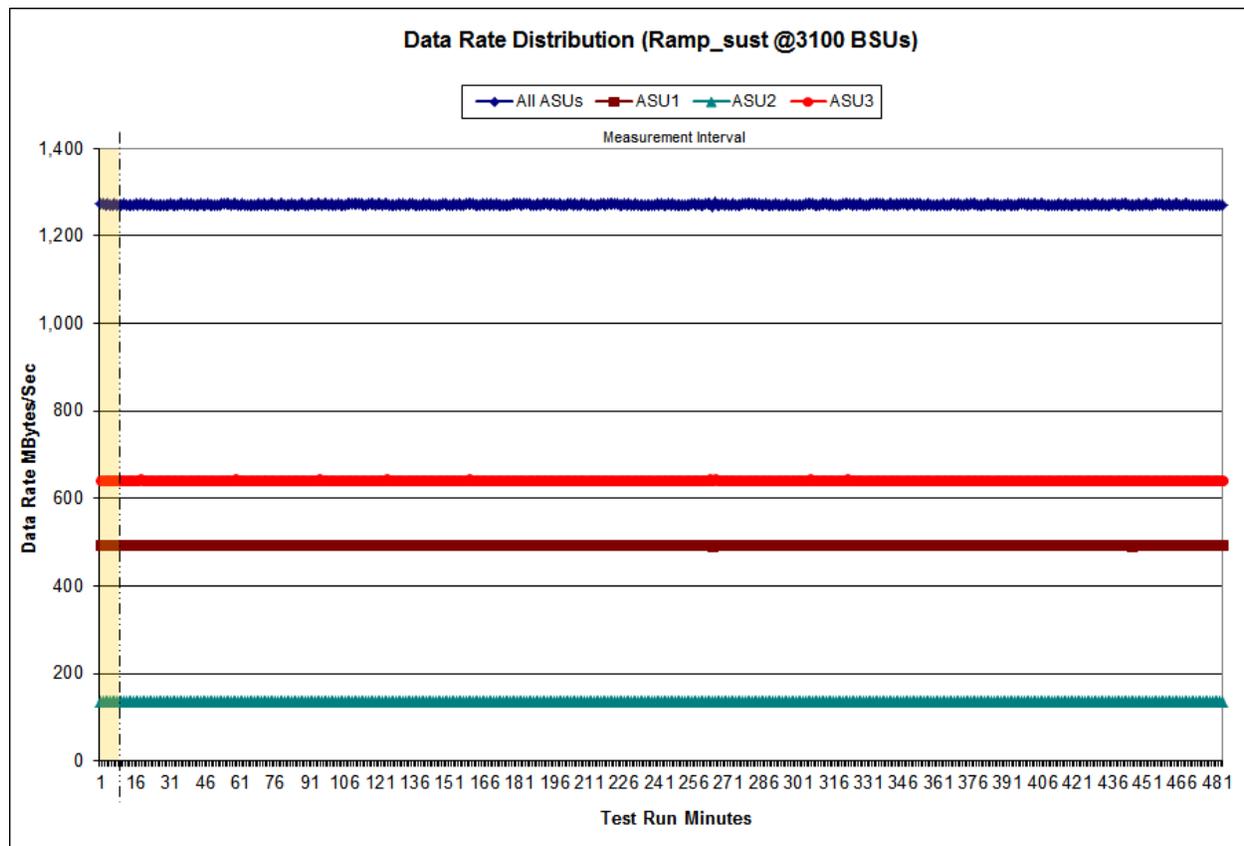
[Sustainability Test Results File](#)

### 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

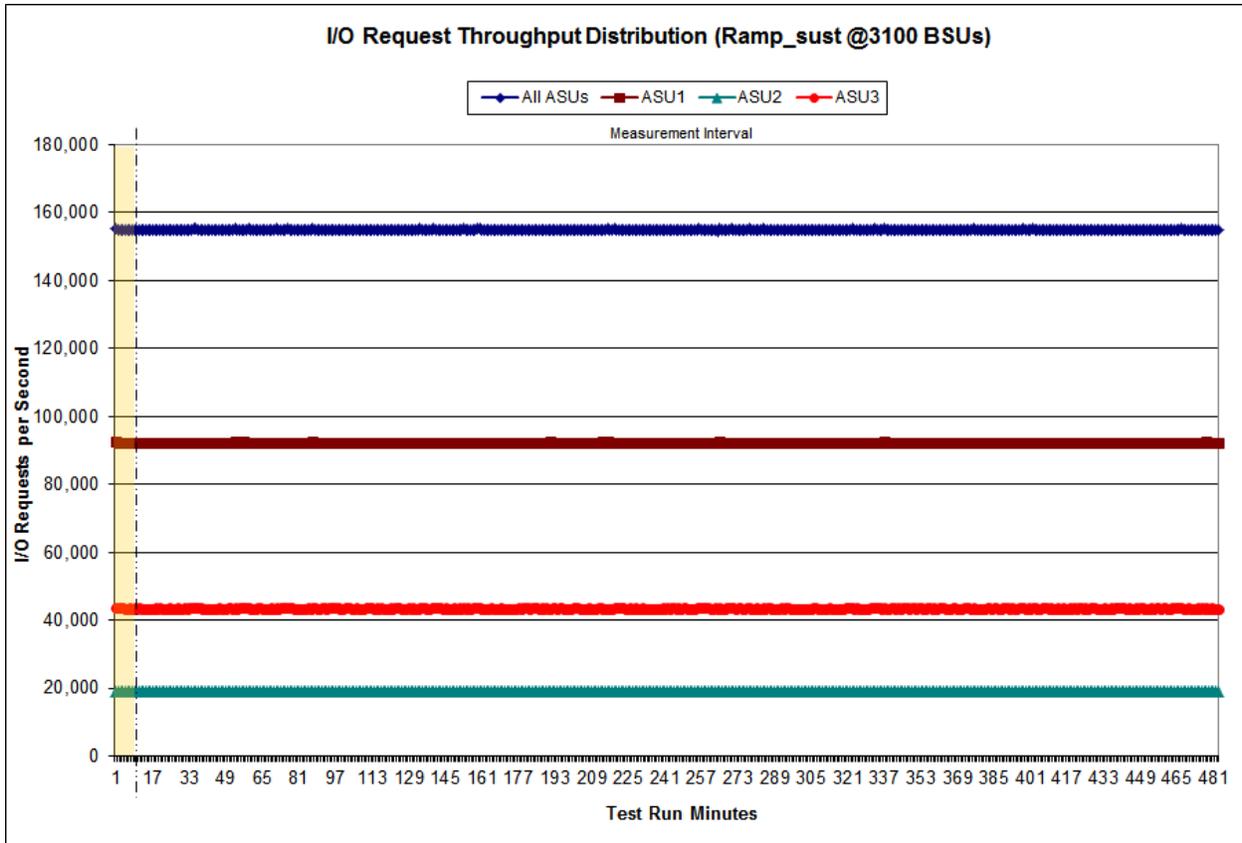


### Sustainability – I/O Request Throughput Distribution Data

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

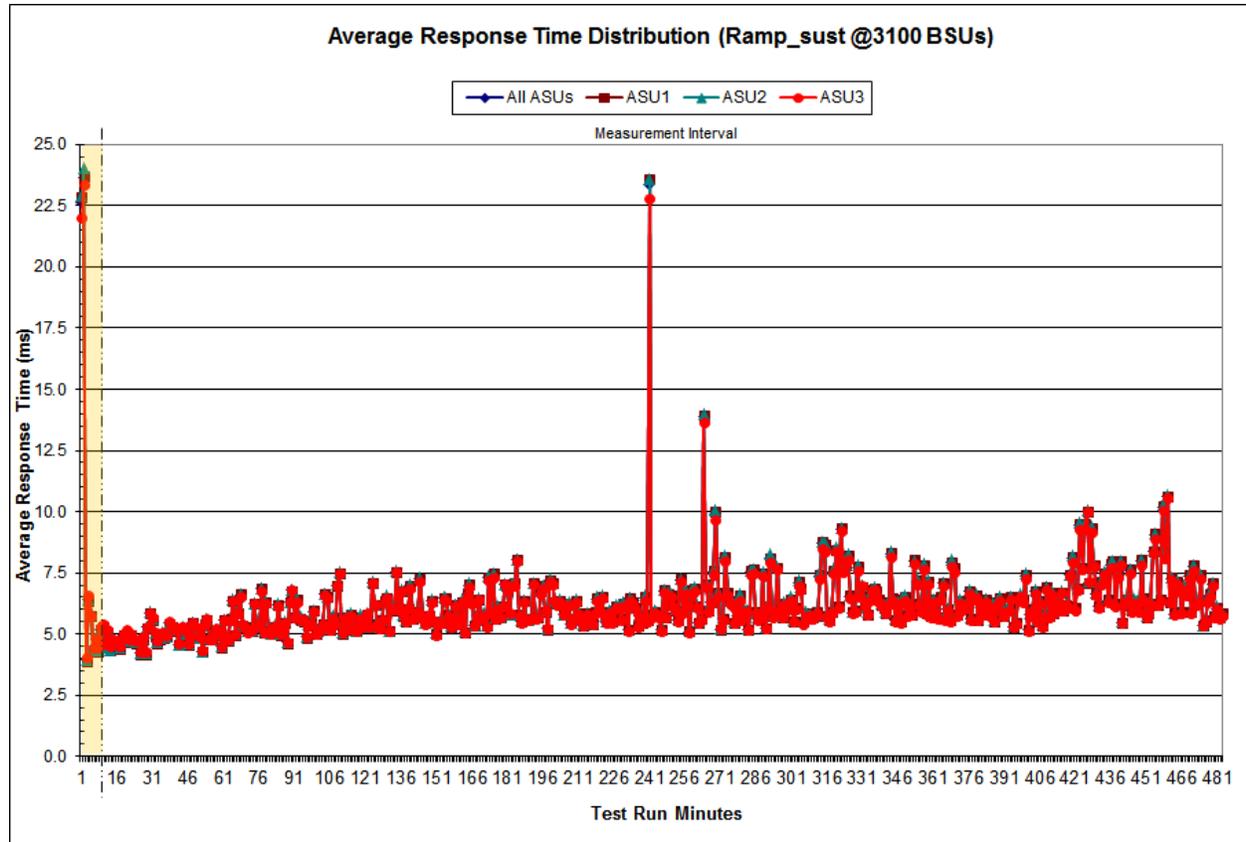


### Sustainability – Average Response Time (ms) Distribution Data

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](#)

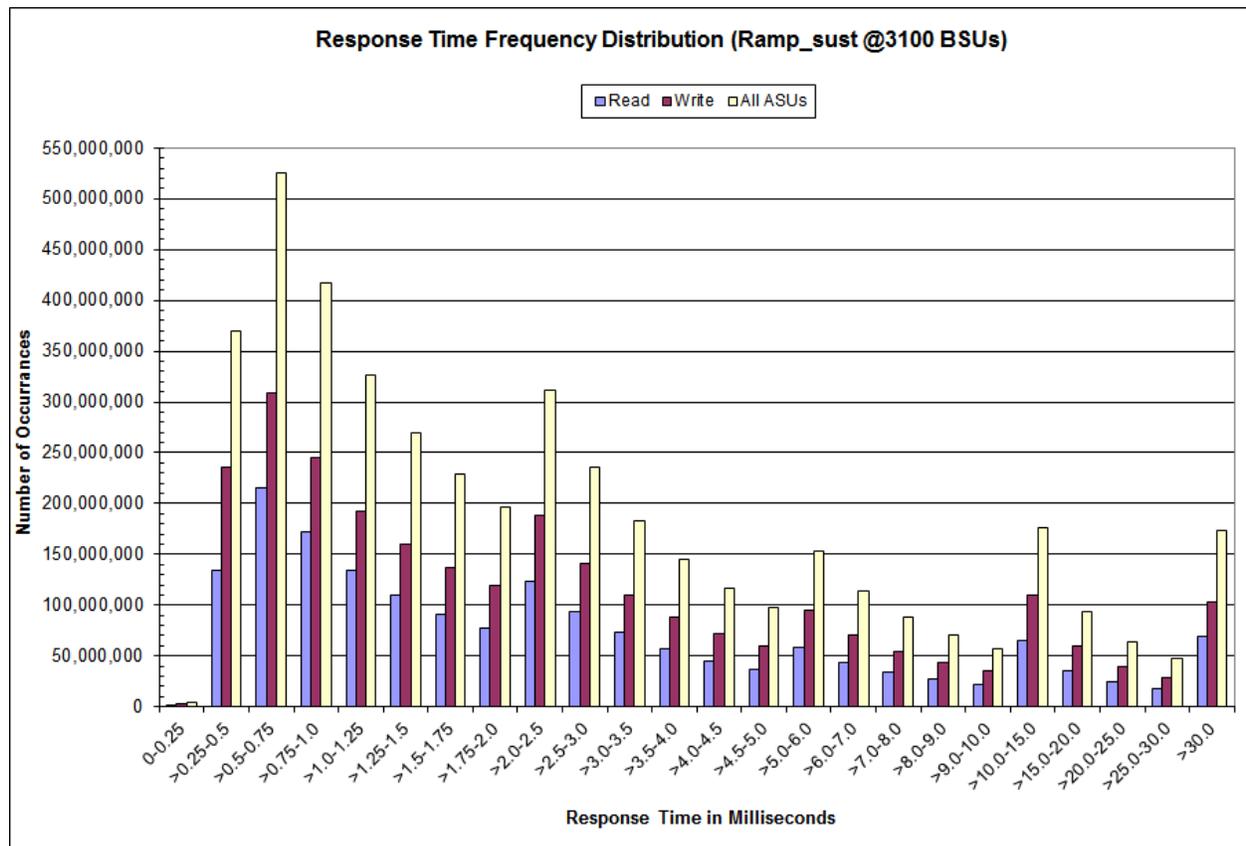
### Sustainability – Average Response Time (ms) Distribution Graph



**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	459,436	134,175,621	216,004,075	171,563,688	133,812,331	109,736,863	91,160,752	77,315,544
Write	3,578,995	236,144,282	308,868,658	245,191,306	192,122,169	160,331,591	137,360,298	118,984,763
All ASUs	4,038,431	370,319,903	524,872,733	416,754,994	325,934,500	270,068,454	228,521,050	196,300,307
ASU1	2,435,321	229,147,248	319,345,169	250,821,719	196,456,789	162,538,425	136,619,265	116,455,017
ASU2	559,136	45,686,366	64,665,410	51,407,704	40,098,254	33,112,159	27,927,594	23,921,064
ASU3	1,043,974	95,486,289	140,862,154	114,525,571	89,379,457	74,417,870	63,974,191	55,924,226
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	122,779,921	94,129,345	72,738,427	56,781,103	45,309,728	37,366,718	57,959,890	43,015,072
Write	189,022,645	141,396,023	109,663,371	88,138,589	71,868,934	60,196,750	94,862,732	70,873,263
All ASUs	311,802,566	235,525,368	182,401,798	144,919,692	117,178,662	97,563,468	152,822,622	113,888,335
ASU1	183,899,466	138,842,397	107,095,134	84,490,335	68,002,479	56,430,448	88,053,916	65,470,147
ASU2	38,029,569	29,010,746	22,700,322	18,032,174	14,542,755	12,081,775	18,881,068	13,996,870
ASU3	89,873,531	67,672,225	52,606,342	42,397,183	34,633,428	29,051,245	45,887,638	34,421,318
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	33,631,989	27,417,919	22,428,138	65,601,012	34,863,279	24,388,228	18,268,145	69,635,532
Write	54,438,672	43,009,105	34,903,140	110,183,014	59,314,304	40,087,318	29,218,085	103,713,823
All ASUs	88,070,661	70,427,024	57,331,278	175,784,026	94,177,583	64,475,546	47,486,230	173,349,355
ASU1	50,805,471	40,926,109	33,483,810	102,562,660	54,505,873	37,782,633	28,221,803	106,063,226
ASU2	10,780,307	8,602,612	6,990,051	21,121,254	11,282,079	7,828,380	5,857,741	21,980,195
ASU3	26,484,883	20,898,303	16,857,417	52,100,112	28,389,631	18,864,533	13,406,686	45,305,934

**Sustainability – Response Time Frequency Distribution Graph**



### Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

## Primary Metrics Test – IOPS Test Phase

### Clause 5.4.4.2

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

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

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

### Clause 9.4.3.7.3

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [77](#).

## IOPS Test Results File

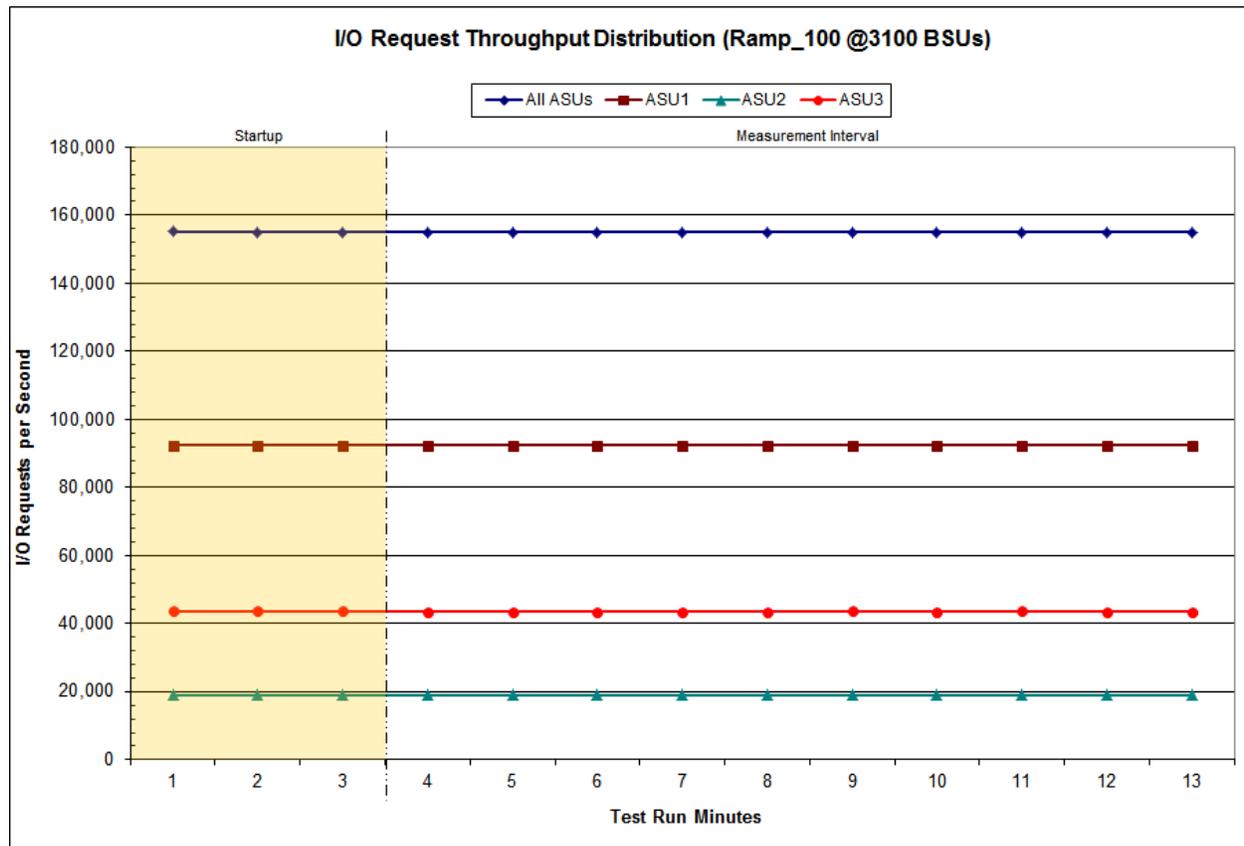
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

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

3,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	4:40:55	4:43:56	0-2	0:03:01
<i>Measurement Interval</i>	4:43:56	4:53:56	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	155,091.53	92,449.40	19,076.33	43,565.80
1	154,972.68	92,341.75	19,060.33	43,570.60
2	154,945.40	92,320.92	19,047.68	43,576.80
3	154,986.97	92,385.05	19,056.15	43,545.77
4	154,961.53	92,383.20	19,039.77	43,538.57
5	154,939.52	92,333.82	19,072.92	43,532.78
6	154,947.33	92,381.27	19,056.95	43,509.12
7	155,049.22	92,406.40	19,094.97	43,547.85
8	155,046.42	92,409.17	19,046.30	43,590.95
9	155,009.25	92,399.92	19,069.53	43,539.80
10	155,051.92	92,406.58	19,074.50	43,570.83
11	154,972.33	92,372.23	19,059.48	43,540.62
12	154,894.47	92,306.83	19,062.98	43,524.65
<i>Average</i>	<i>154,985.90</i>	<i>92,378.45</i>	<i>19,063.36</i>	<i>43,544.09</i>

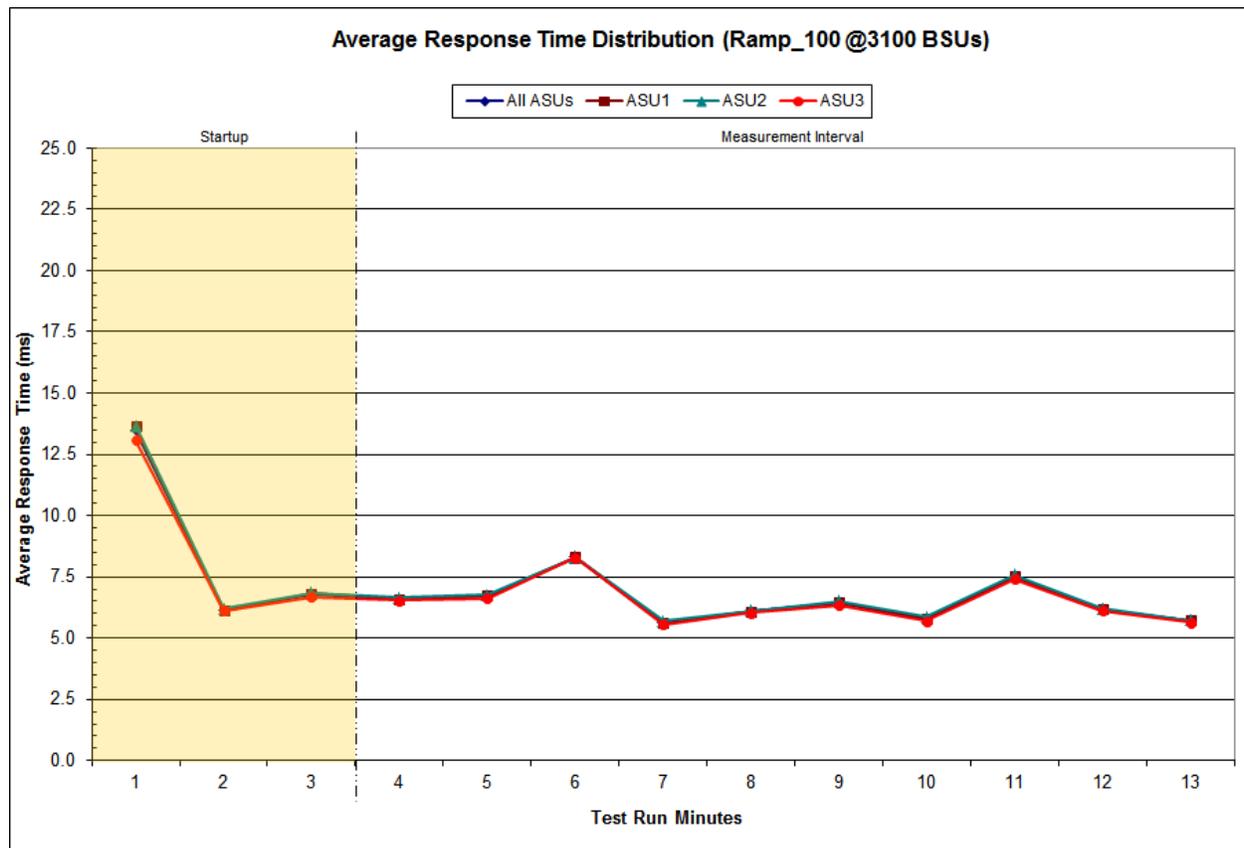
**IOPS Test Run – I/O Request Throughput Distribution Graph**



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

3,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	4:40:55	4:43:56	0-2	0:03:01
<i>Measurement Interval</i>	4:43:56	4:53:56	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	13.48	13.64	13.65	13.08
1	6.14	6.13	6.22	6.11
2	6.79	6.82	6.84	6.69
3	6.59	6.61	6.65	6.53
4	6.70	6.73	6.76	6.62
5	8.30	8.31	8.28	8.28
6	5.61	5.63	5.69	5.55
7	6.09	6.10	6.13	6.03
8	6.44	6.46	6.52	6.36
9	5.79	5.81	5.86	5.70
10	7.50	7.53	7.57	7.42
11	6.17	6.18	6.19	6.12
12	5.70	5.72	5.74	5.65
<i>Average</i>	<i>6.49</i>	<i>6.51</i>	<i>6.54</i>	<i>6.43</i>

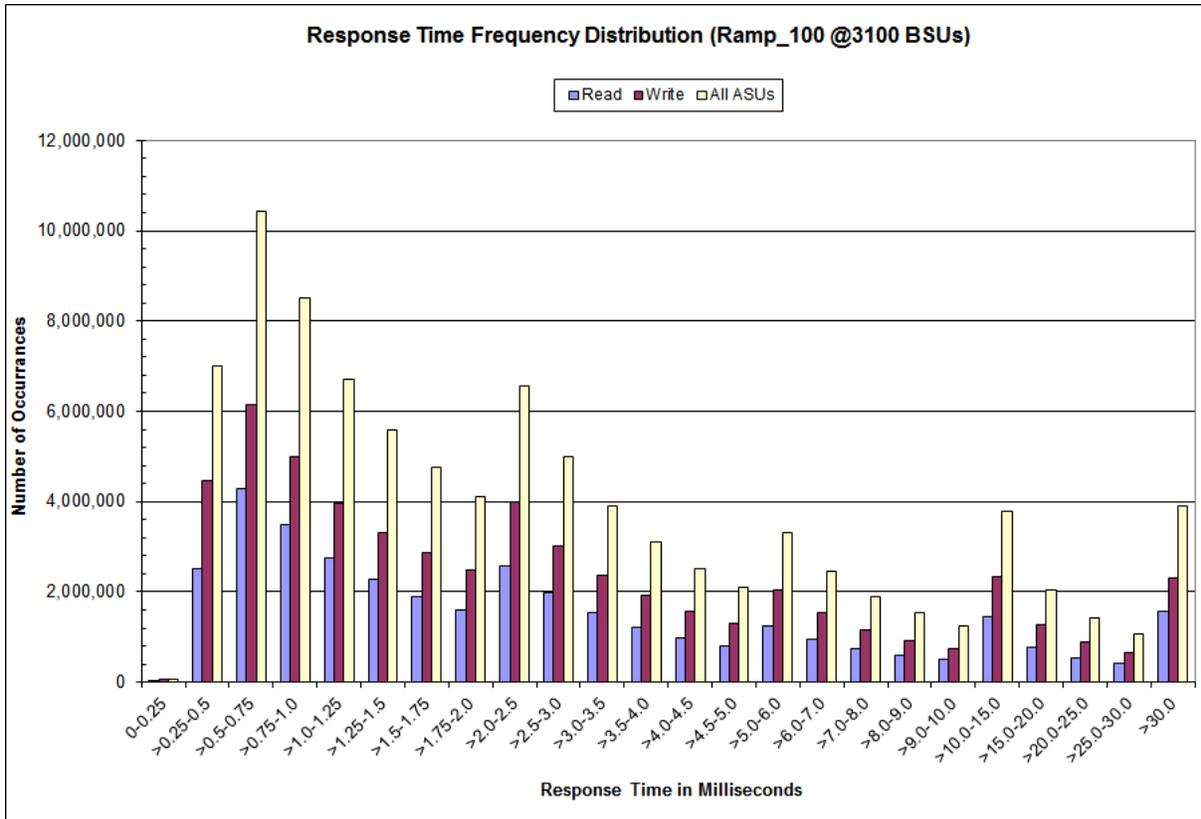
**IOPS Test Run – Average Response Time (ms) Distribution Graph**



**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	9,156	2,515,938	4,287,453	3,501,040	2,762,079	2,274,712	1,895,988	1,612,227
Write	62,494	4,474,296	6,148,156	4,996,229	3,954,178	3,313,009	2,856,636	2,485,178
All ASUs	71,650	6,990,234	10,435,609	8,497,269	6,716,257	5,587,721	4,752,624	4,097,405
ASU1	43,904	4,329,136	6,358,108	5,121,914	4,052,830	3,368,198	2,842,762	2,431,356
ASU2	9,754	862,055	1,284,194	1,047,493	826,482	685,316	580,973	499,092
ASU3	17,992	1,799,043	2,793,307	2,327,862	1,836,945	1,534,207	1,328,889	1,166,957
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	2,567,478	1,980,932	1,537,785	1,206,109	966,099	798,618	1,249,245	936,173
Write	3,986,464	3,015,359	2,361,713	1,914,024	1,558,761	1,304,364	2,050,293	1,526,999
All ASUs	6,553,942	4,996,291	3,899,498	3,120,133	2,524,860	2,102,982	3,299,538	2,463,172
ASU1	3,861,953	2,940,818	2,285,352	1,814,069	1,461,519	1,213,555	1,899,104	1,419,343
ASU2	799,710	613,910	482,839	387,092	313,343	259,977	407,585	302,549
ASU3	1,892,279	1,441,563	1,131,307	918,972	749,998	629,450	992,849	741,280
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	739,668	609,409	500,123	1,447,089	760,319	539,705	408,038	1,572,425
Write	1,169,490	918,681	745,465	2,343,647	1,275,085	882,361	651,583	2,319,041
All ASUs	1,909,158	1,528,090	1,245,588	3,790,736	2,035,404	1,422,066	1,059,621	3,891,466
ASU1	1,104,566	893,736	731,087	2,220,365	1,181,295	834,956	629,732	2,387,267
ASU2	234,644	187,415	152,798	458,967	244,107	172,435	131,715	493,548
ASU3	569,948	446,939	361,703	1,111,404	610,002	414,675	298,174	1,010,651

**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
92,991,314	89,099,848	3,891,466

### 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	0.001	0.000	0.001	0.001	0.002	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 15.*

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

### Clause 9.4.3.7.4

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [77](#).

## 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

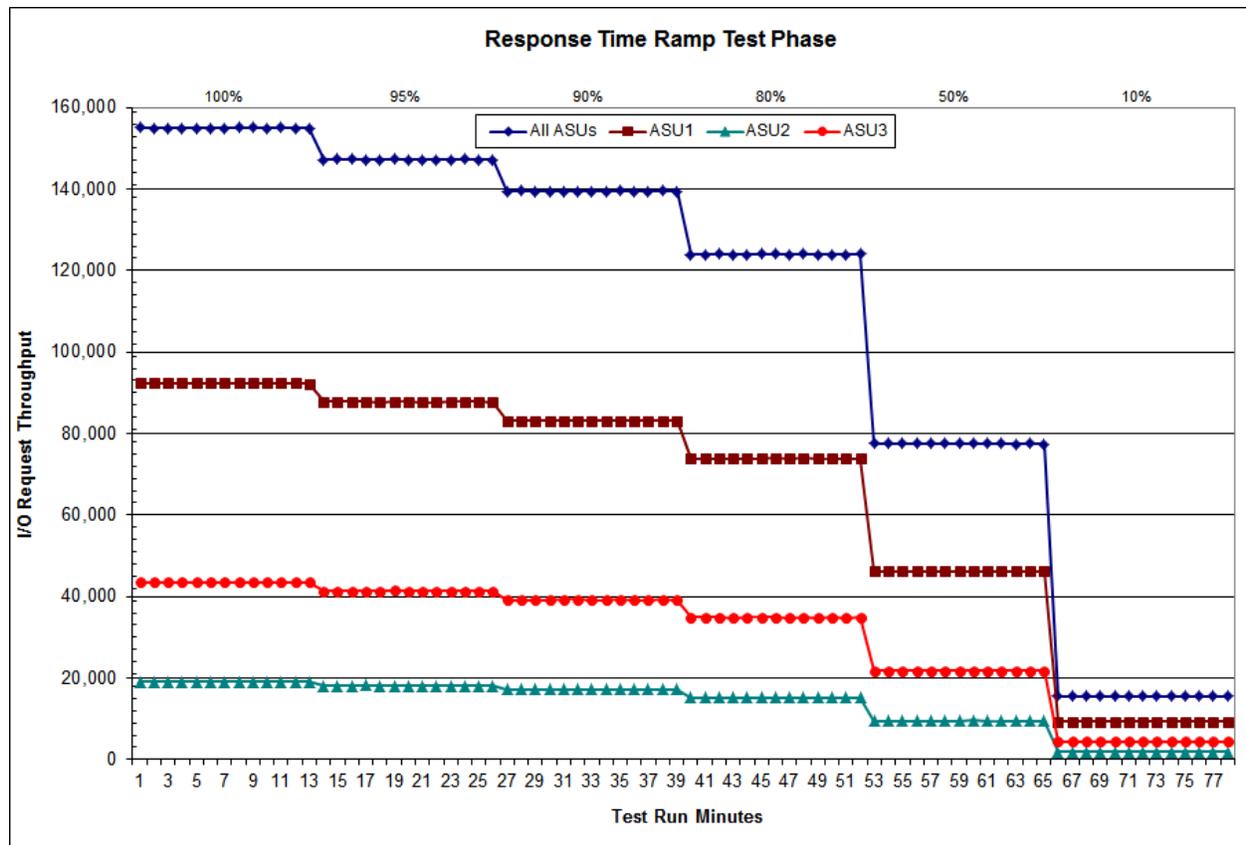
The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data table and graph for completeness.

100% Load Level: 3,100 BSUs					95% Load Level: 2,945 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	4:40:55	4:43:56	0-3	0:03:01	<b>Start-Up/Ramp-Up</b>	4:54:03	4:57:04	0-3	0:03:01
<b>Measurement Interval</b>	4:43:56	4:53:56	3-12	0:10:00	<b>Measurement Interval</b>	4:57:04	5:07:04	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	155,091.53	92,449.40	19,076.33	43,565.80	0	147,254.05	87,806.00	18,108.47	41,339.58
1	154,972.68	92,341.75	19,060.33	43,570.60	1	147,287.83	87,797.83	18,094.00	41,396.00
2	154,945.40	92,320.92	19,047.68	43,576.80	2	147,333.45	87,841.70	18,138.47	41,353.28
3	154,986.97	92,385.05	19,056.15	43,545.77	3	147,259.78	87,773.22	18,158.23	41,328.33
4	154,961.53	92,383.20	19,039.77	43,538.57	4	147,177.97	87,729.17	18,107.53	41,341.27
5	154,939.52	92,333.82	19,072.92	43,532.78	5	147,396.20	87,857.65	18,130.60	41,407.95
6	154,947.33	92,381.27	19,056.95	43,509.12	6	147,232.92	87,771.40	18,112.15	41,349.37
7	155,049.22	92,406.40	19,094.97	43,547.85	7	147,251.37	87,746.60	18,123.68	41,381.08
8	155,046.42	92,409.17	19,046.30	43,590.95	8	147,197.62	87,704.43	18,126.18	41,367.00
9	155,009.25	92,399.92	19,069.53	43,539.80	9	147,267.77	87,778.15	18,119.27	41,370.35
10	155,051.92	92,406.58	19,074.50	43,570.83	10	147,358.37	87,867.85	18,089.38	41,401.13
11	154,972.33	92,372.23	19,059.48	43,540.62	11	147,255.03	87,812.27	18,089.10	41,353.67
12	154,894.47	92,306.83	19,062.98	43,524.65	12	147,167.67	87,680.12	18,108.13	41,379.42
<b>Average</b>	<b>154,985.90</b>	<b>92,378.45</b>	<b>19,063.36</b>	<b>43,544.09</b>	<b>Average</b>	<b>147,256.47</b>	<b>87,772.09</b>	<b>18,116.43</b>	<b>41,367.96</b>
90% Load Level: 2,790 BSUs					80% Load Level: 2,780 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	5:07:10	5:10:11	0-3	0:03:01	<b>Start-Up/Ramp-Up</b>	5:20:16	5:23:17	0-3	0:03:01
<b>Measurement Interval</b>	5:10:11	5:20:11	3-12	0:10:00	<b>Measurement Interval</b>	5:23:17	5:33:17	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	139,444.47	83,092.88	17,161.60	39,189.98	0	123,939.55	73,855.90	15,250.95	34,832.70
1	139,522.67	83,162.35	17,154.12	39,206.20	1	124,002.70	73,903.07	15,241.77	34,857.87
2	139,503.47	83,117.12	17,190.35	39,196.00	2	124,032.63	73,901.15	15,256.50	34,874.98
3	139,446.25	83,084.37	17,150.72	39,211.17	3	123,979.63	73,901.90	15,256.20	34,821.53
4	139,493.02	83,096.97	17,158.98	39,237.07	4	123,949.73	73,835.08	15,260.93	34,853.72
5	139,501.57	83,139.38	17,149.35	39,212.83	5	124,016.00	73,929.90	15,253.45	34,832.65
6	139,456.55	83,092.58	17,171.53	39,192.43	6	124,036.57	73,963.22	15,228.10	34,845.25
7	139,511.65	83,179.83	17,170.03	39,161.78	7	123,968.67	73,887.97	15,268.30	34,812.40
8	139,631.42	83,187.93	17,161.53	39,281.95	8	124,060.85	73,971.93	15,258.20	34,830.72
9	139,462.58	83,151.55	17,164.78	39,146.25	9	123,872.48	73,852.80	15,223.62	34,796.07
10	139,496.63	83,140.00	17,160.08	39,196.55	10	123,901.60	73,814.52	15,253.33	34,833.75
11	139,552.83	83,156.67	17,172.15	39,224.02	11	123,974.93	73,895.23	15,262.90	34,816.80
12	139,472.07	83,134.15	17,129.52	39,208.40	12	124,026.10	73,927.60	15,265.48	34,833.02
<b>Average</b>	<b>139,502.46</b>	<b>83,136.34</b>	<b>17,158.87</b>	<b>39,207.25</b>	<b>Average</b>	<b>123,978.66</b>	<b>73,898.02</b>	<b>15,253.05</b>	<b>34,827.59</b>

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

50% Load Level: 1,550 BSUs					10% Load Level: 310 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
5:33:21	5:36:22	0-3	0:03:01		5:46:25	5:49:26	0-3	0:03:01	
5:36:22	5:46:22	3-12	0:10:00		5:49:26	5:59:26	3-12	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
All ASUs	ASU-1	ASU-2	ASU-3		All ASUs	ASU-1	ASU-2	ASU-3	
0	77,579.77	46,251.25	9,531.97	21,796.55	0	15,500.95	9,231.98	1,899.48	4,369.48
1	77,508.52	46,183.32	9,539.25	21,785.95	1	15,512.83	9,245.37	1,913.98	4,353.48
2	77,528.82	46,245.38	9,523.53	21,759.90	2	15,513.78	9,242.42	1,901.02	4,370.35
3	77,506.97	46,210.02	9,500.22	21,796.73	3	15,513.25	9,234.07	1,907.38	4,371.80
4	77,513.20	46,203.33	9,538.15	21,771.72	4	15,487.58	9,246.27	1,897.62	4,343.70
5	77,507.33	46,210.77	9,519.70	21,776.87	5	15,510.05	9,244.65	1,913.23	4,352.17
6	77,506.25	46,200.75	9,523.32	21,782.18	6	15,495.80	9,234.10	1,902.40	4,359.30
7	77,494.77	46,155.52	9,549.07	21,790.18	7	15,512.38	9,249.75	1,898.55	4,364.08
8	77,517.85	46,217.68	9,535.22	21,764.95	8	15,480.48	9,212.03	1,910.35	4,358.10
9	77,495.55	46,181.35	9,525.18	21,789.02	9	15,533.17	9,273.27	1,911.90	4,348.00
10	77,476.62	46,192.67	9,523.15	21,760.80	10	15,502.57	9,237.35	1,904.08	4,361.13
11	77,533.35	46,214.78	9,526.50	21,792.07	11	15,501.43	9,225.88	1,907.75	4,367.80
12	77,474.95	46,166.28	9,538.87	21,769.80	12	15,490.40	9,232.05	1,900.15	4,358.20
<b>Average</b>	<b>77,502.68</b>	<b>46,195.32</b>	<b>9,527.94</b>	<b>21,779.43</b>	<b>Average</b>	<b>15,502.71</b>	<b>9,238.94</b>	<b>1,905.34</b>	<b>4,358.43</b>

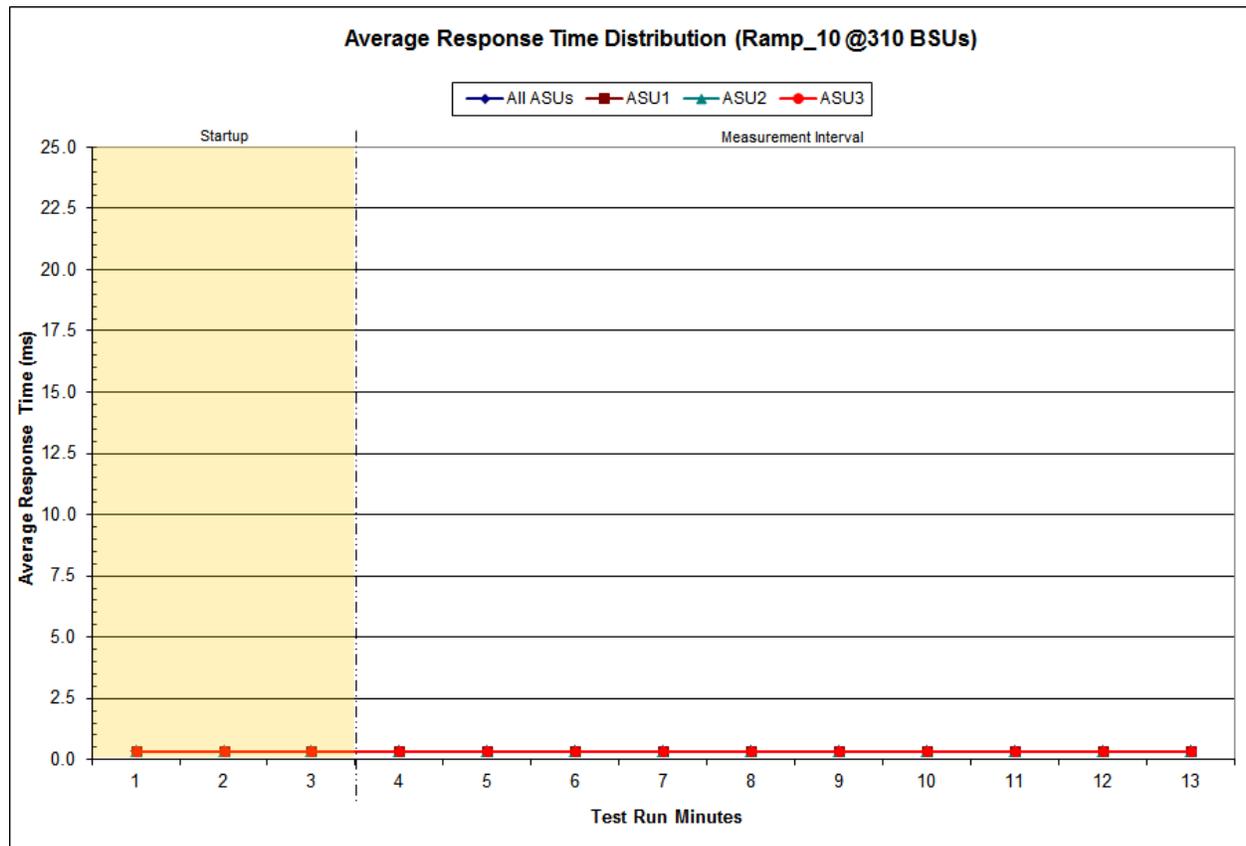
**Response Time Ramp Distribution (IOPS) Graph**



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

310 BSUs	Start	Stop	Interval	Duration
<b>Start-Up/R</b>	5:46:25	5:49:26	0-2	0:03:01
<b>Measuren</b>	5:49:26	5:59:26	3-12	0:10:00
l intervals	All ASUs	ASU1	ASU2	ASU3
0	0.34	0.34	0.33	0.33
1	0.34	0.34	0.34	0.33
2	0.34	0.34	0.33	0.33
3	0.34	0.34	0.33	0.33
4	0.34	0.34	0.34	0.33
5	0.34	0.34	0.34	0.33
6	0.34	0.34	0.34	0.33
7	0.34	0.34	0.33	0.33
8	0.34	0.34	0.34	0.33
9	0.34	0.35	0.34	0.33
10	0.34	0.34	0.33	0.33
11	0.34	0.34	0.34	0.33
12	0.34	0.35	0.34	0.33
<b>Average</b>	<b>0.34</b>	<b>0.34</b>	<b>0.34</b>	<b>0.33</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	0.0350	0.2812	0.0701	0.2097	0.0179	0.0700	0.0350	0.2811
COV	0.005	0.002	0.005	0.003	0.010	0.004	0.004	0.002

## Repeatability Test

### Clause 5.4.5

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

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

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

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

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

### Clause 9.4.3.7.5

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [77](#).

### 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>154,985.90</b>
<b>Repeatability Test Phase 1</b>	154,988.91
<b>Repeatability Test Phase 2</b>	154,972.60

The SPC-1 IOPS™ values in the above table were generated using 100% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 IOPS™ must be greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
<b>Primary Metrics</b>	<b>0.34 ms</b>
<b>Repeatability Test Phase 1</b>	0.34 ms
<b>Repeatability Test Phase 2</b>	0.34 ms

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

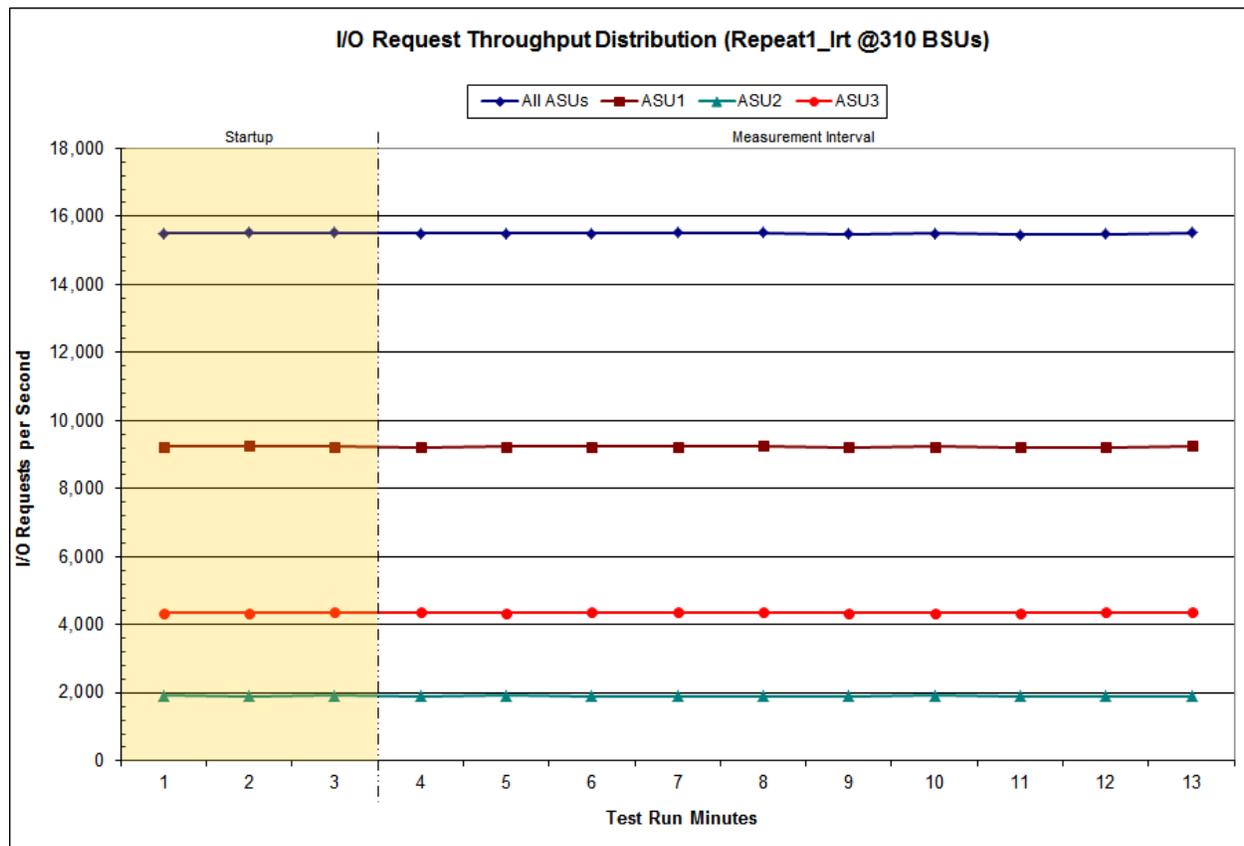
A link to the test result file generated from each Repeatability Test Run is listed below.

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

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

310 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	5:59:32	6:02:32	0-2	0:03:00
<i>Measurement Interval</i>	6:02:32	6:12:32	3-12	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
0	15,501.82	9,234.73	1,917.07	4,350.02
1	15,516.88	9,251.98	1,910.27	4,354.63
2	15,515.97	9,236.33	1,912.18	4,367.45
3	15,498.55	9,224.88	1,910.10	4,363.57
4	15,488.55	9,226.98	1,913.75	4,347.82
5	15,493.63	9,227.62	1,899.77	4,366.25
6	15,513.85	9,244.35	1,907.33	4,362.17
7	15,519.25	9,248.67	1,903.00	4,367.58
8	15,473.87	9,216.47	1,902.25	4,355.15
9	15,496.63	9,242.53	1,913.03	4,341.07
10	15,462.17	9,213.42	1,911.07	4,337.68
11	15,487.82	9,220.77	1,907.78	4,359.27
12	15,523.03	9,251.30	1,910.17	4,361.57
<i>Average</i>	<i>15,495.74</i>	<i>9,231.70</i>	<i>1,907.83</i>	<i>4,356.21</i>

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



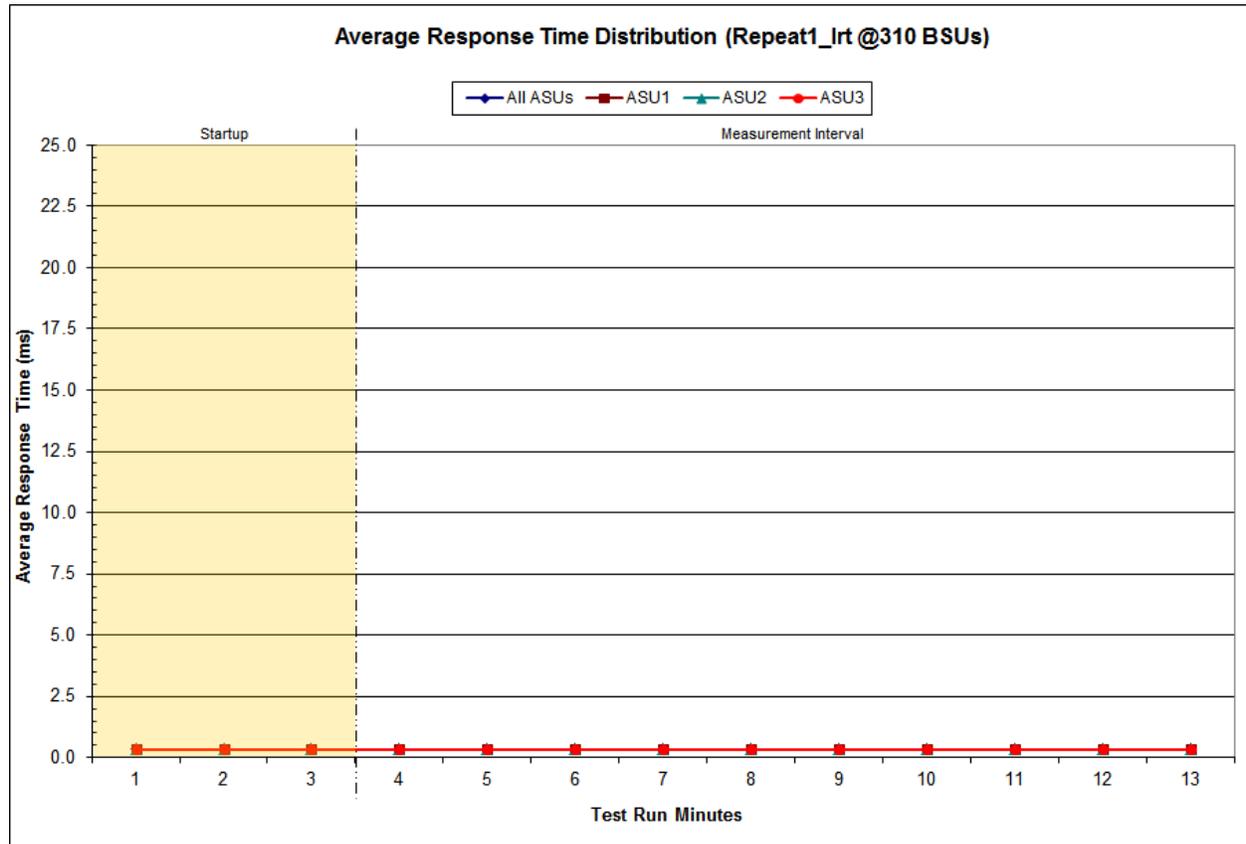
**Repeatability 1 LRT –Average Response Time (ms) Distribution Data**

310 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	5:59:32	6:02:32	0-2	0:03:00
<i>Measurement Interval</i>	6:02:32	6:12:32	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.34	0.34	0.33	0.33
1	0.34	0.34	0.34	0.33
2	0.34	0.34	0.34	0.33
3	0.34	0.34	0.34	0.33
4	0.34	0.35	0.34	0.33
5	0.34	0.34	0.34	0.33
6	0.34	0.34	0.33	0.33
7	0.34	0.34	0.34	0.33
8	0.34	0.34	0.34	0.33
9	0.34	0.35	0.34	0.33
10	0.34	0.34	0.33	0.33
11	0.34	0.34	0.34	0.33
12	0.34	0.34	0.33	0.33
<i>Average</i>	<i>0.34</i>	<i>0.34</i>	<i>0.34</i>	<i>0.33</i>

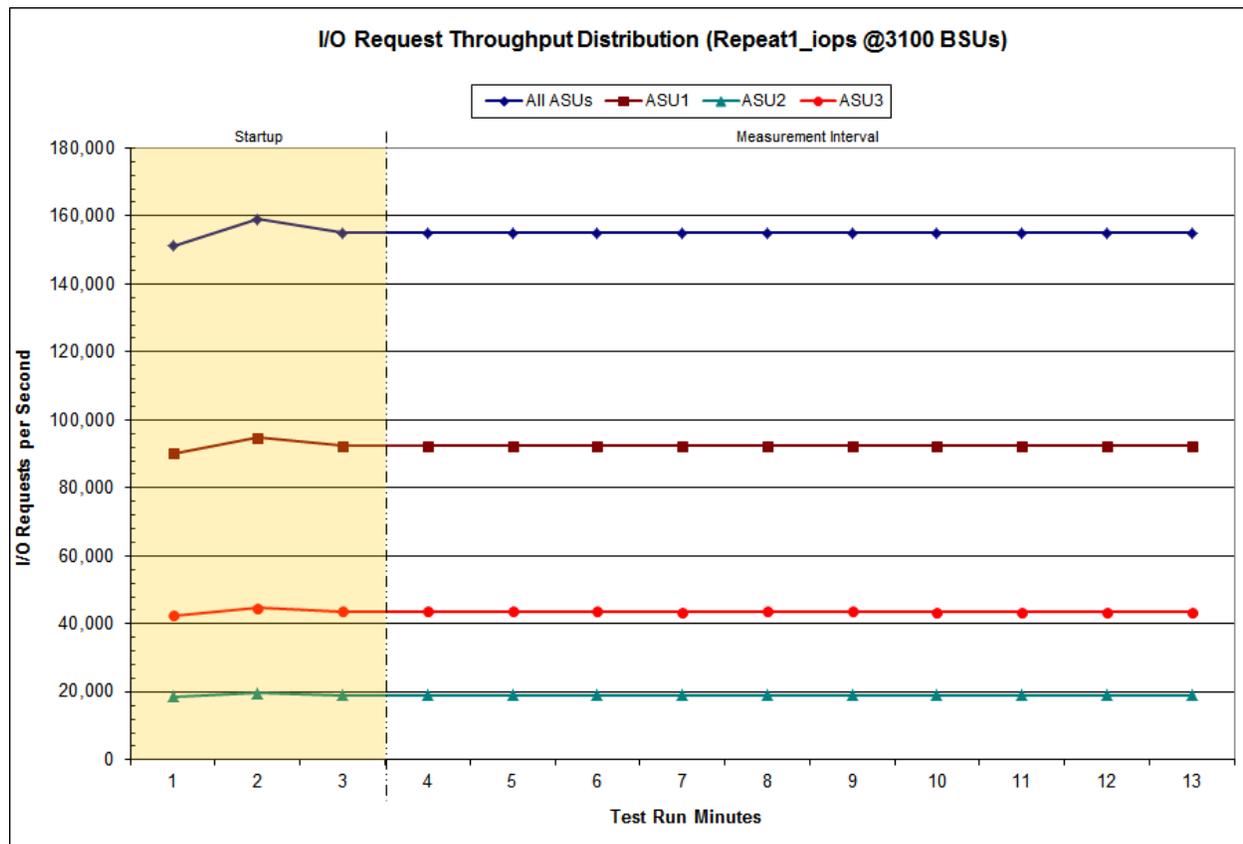
**Repeatability 1 LRT –Average Response Time (ms) Distribution Graph**



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

3,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	6:12:40	6:15:41	0-2	0:03:01
<i>Measurement Interval</i>	6:15:41	6:25:41	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	151,128.35	90,079.05	18,578.97	42,470.33
1	158,969.47	94,737.25	19,541.82	44,690.40
2	155,042.47	92,363.15	19,084.58	43,594.73
3	155,039.02	92,393.22	19,068.55	43,577.25
4	155,077.38	92,399.07	19,059.73	43,618.58
5	154,966.08	92,320.93	19,080.13	43,565.02
6	154,981.00	92,388.60	19,062.08	43,530.32
7	155,038.88	92,394.07	19,077.05	43,567.77
8	154,975.15	92,358.20	19,056.22	43,560.73
9	154,897.63	92,332.37	19,064.78	43,500.48
10	154,943.82	92,332.58	19,074.05	43,537.18
11	155,023.50	92,400.50	19,064.47	43,558.53
12	154,946.58	92,326.95	19,079.47	43,540.17
<b>Average</b>	<b>154,988.91</b>	<b>92,364.65</b>	<b>19,068.65</b>	<b>43,555.60</b>

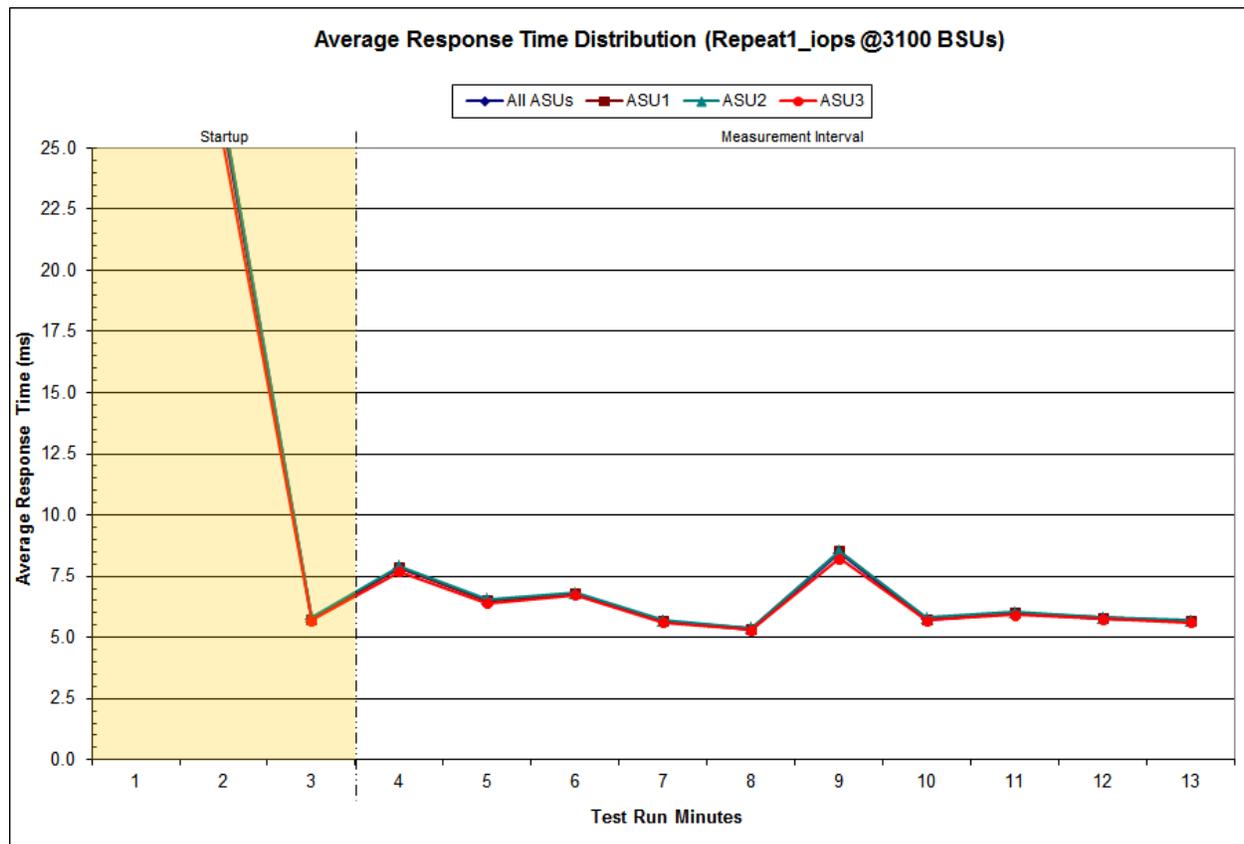
**Repeatability 1 IOPS – I/O Request Throughput Distribution Graph**



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

3,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	6:12:40	6:15:41	0-2	0:03:01
<i>Measurement Interval</i>	6:15:41	6:25:41	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	38.76	39.24	39.55	37.41
1	25.92	26.24	26.31	25.05
2	5.76	5.77	5.84	5.70
3	7.82	7.87	7.90	7.69
4	6.50	6.53	6.57	6.41
5	6.78	6.78	6.82	6.74
6	5.66	5.68	5.70	5.60
7	5.35	5.35	5.39	5.31
8	8.45	8.53	8.54	8.22
9	5.74	5.75	5.81	5.69
10	5.99	6.01	6.04	5.92
11	5.79	5.80	5.82	5.76
12	5.66	5.66	5.71	5.62
<i>Average</i>	<b>6.37</b>	<b>6.40</b>	<b>6.43</b>	<b>6.30</b>

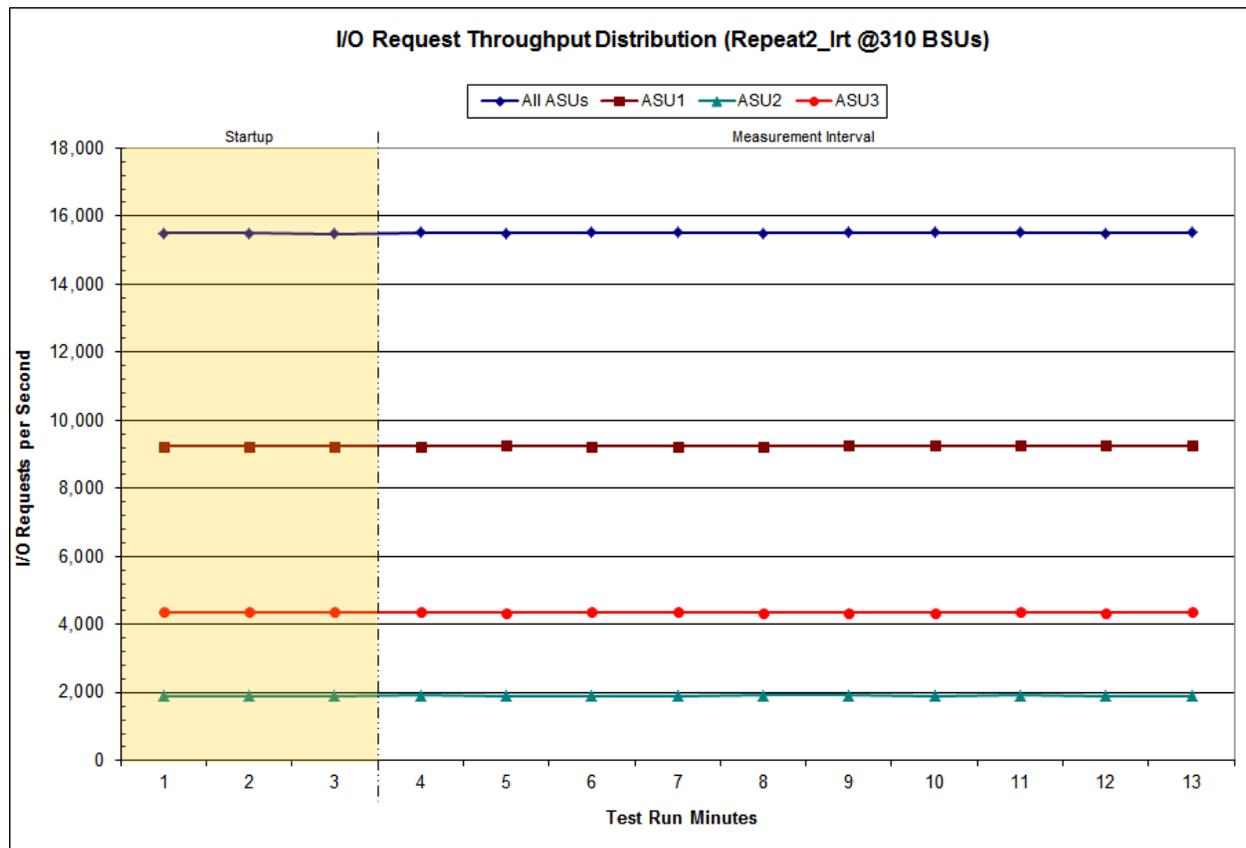
**Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph**



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

310 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	6:25:48	6:28:48	0-2	0:03:00
<i>Measurement Interval</i>	6:28:48	6:38:48	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	15,501.22	9,227.42	1,907.77	4,366.03
1	15,491.93	9,235.90	1,896.45	4,359.58
2	15,485.98	9,227.67	1,897.27	4,361.05
3	15,510.92	9,235.18	1,915.62	4,360.12
4	15,499.35	9,245.77	1,898.75	4,354.83
5	15,518.40	9,241.87	1,905.23	4,371.30
6	15,513.42	9,244.40	1,909.78	4,359.23
7	15,493.98	9,234.25	1,912.43	4,347.30
8	15,521.87	9,253.00	1,915.75	4,353.12
9	15,516.43	9,254.07	1,907.33	4,355.03
10	15,521.85	9,247.17	1,911.68	4,363.00
11	15,494.58	9,245.53	1,901.18	4,347.87
12	15,515.70	9,254.78	1,901.52	4,359.40
<i>Average</i>	<i>15,510.65</i>	<i>9,245.60</i>	<i>1,907.93</i>	<i>4,357.12</i>

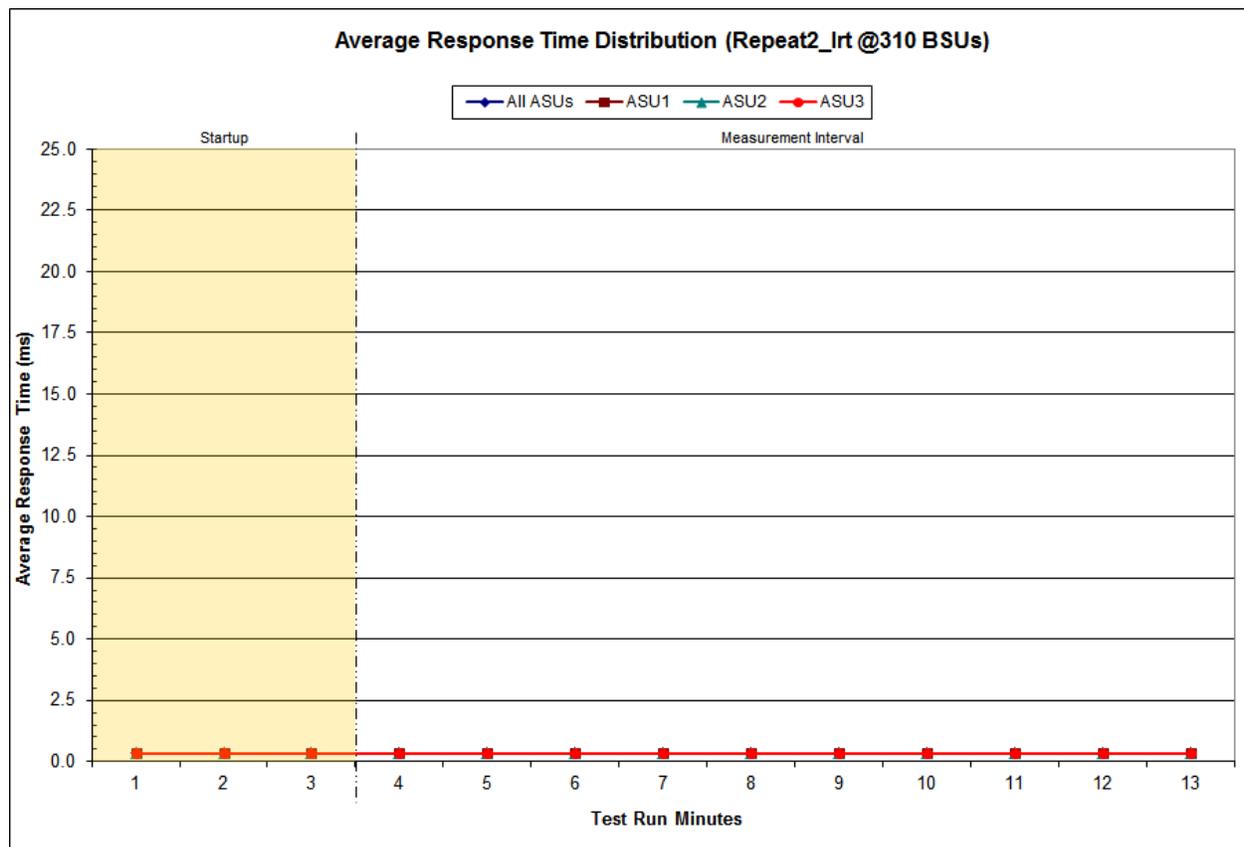
**Repeatability 2 LRT – I/O Request Throughput Distribution Graph**



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

310 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	6:25:48	6:28:48	0-2	0:03:00
<i>Measurement Interval</i>	6:28:48	6:38:48	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.34	0.34	0.34	0.33
1	0.34	0.34	0.33	0.33
2	0.34	0.34	0.34	0.33
3	0.34	0.34	0.34	0.33
4	0.34	0.34	0.33	0.33
5	0.34	0.34	0.33	0.33
6	0.34	0.34	0.33	0.33
7	0.34	0.34	0.33	0.33
8	0.34	0.34	0.34	0.33
9	0.34	0.34	0.34	0.33
10	0.34	0.34	0.34	0.33
11	0.34	0.34	0.34	0.33
12	0.34	0.34	0.34	0.33
<i>Average</i>	<i>0.34</i>	<i>0.34</i>	<i>0.34</i>	<i>0.33</i>

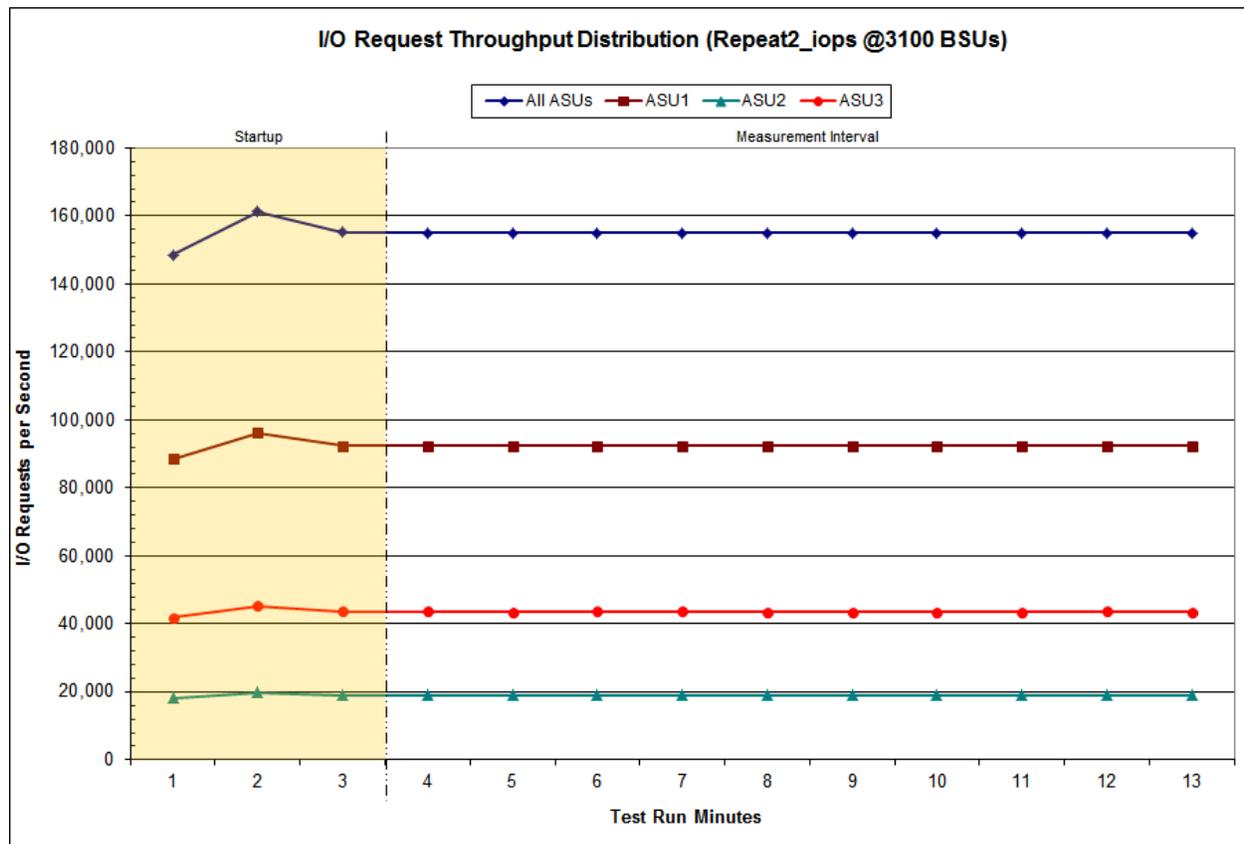
**Repeatability 2 LRT –Average Response Time (ms) Distribution Graph**



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

3,100 BSUs	Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	6:38:55	6:41:56	0-2	0:03:01
<b>Measurement Interval</b>	6:41:56	6:51:56	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	148,586.05	88,538.93	18,284.68	41,762.43
1	161,257.03	96,144.95	19,822.17	45,289.92
2	155,093.27	92,437.12	19,084.78	43,571.37
3	154,983.15	92,332.33	19,056.62	43,594.20
4	154,949.53	92,410.25	19,051.88	43,487.40
5	155,020.57	92,403.00	19,055.45	43,562.12
6	155,003.70	92,330.67	19,069.27	43,603.77
7	154,913.65	92,317.77	19,045.50	43,550.38
8	154,948.78	92,364.98	19,042.07	43,541.73
9	155,008.82	92,358.63	19,101.87	43,548.32
10	154,905.07	92,311.03	19,050.85	43,543.18
11	155,010.27	92,365.68	19,040.73	43,603.85
12	154,982.42	92,380.48	19,046.82	43,555.12
<b>Average</b>	<b>154,972.60</b>	<b>92,357.48</b>	<b>19,056.11</b>	<b>43,559.01</b>

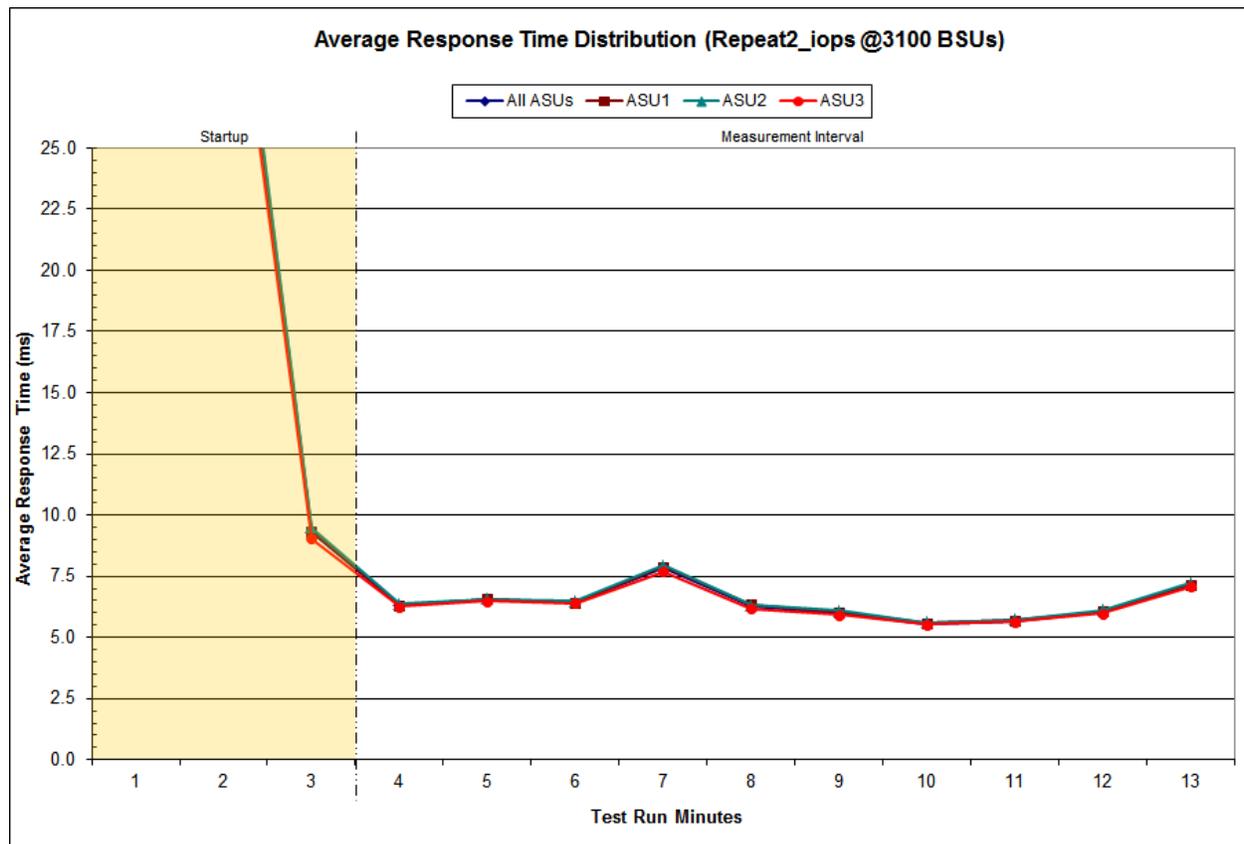
### Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

3,100 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	6:38:55	6:41:56	0-2	0:03:01
<i>Measurement Interval</i>	6:41:56	6:51:56	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	40.16	40.66	40.68	38.86
1	37.20	37.52	37.84	36.23
2	9.28	9.36	9.47	9.04
3	6.32	6.33	6.37	6.27
4	6.55	6.57	6.58	6.48
5	6.42	6.42	6.47	6.39
6	7.84	7.88	7.93	7.70
7	6.29	6.33	6.32	6.18
8	6.02	6.05	6.09	5.93
9	5.57	5.58	5.61	5.52
10	5.68	5.70	5.73	5.63
11	6.05	6.07	6.11	5.99
12	7.14	7.17	7.23	7.06
<b>Average</b>	<b>6.39</b>	<b>6.41</b>	<b>6.44</b>	<b>6.32</b>

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



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

*Clause 3.4.3*

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

*Clauses 5.1.10 and 5.3.15.2*

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

*Clause 5.3.15.3*

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0349	0.2809	0.0701	0.2098	0.0180	0.0700	0.0351	0.2811
COV	0.005	0.002	0.004	0.002	0.011	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	0.002	0.000	0.001	0.001	0.002	0.001	0.002	0.000

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<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	0.2811	0.0701	0.2099	0.0180	0.0701	0.0349	0.2809
COV	0.005	0.001	0.003	0.002	0.007	0.004	0.005	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	0.2811
COV	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001

## Data Persistence Test

### Clause 6

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

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

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

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

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

### Clause 9.4.3.8

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [77](#).

## Data Persistence Test Results File

A link to each test result file generated from each Data Persistence Test is listed below.

[Persistence 1 Test Results File](#)

[Persistence 2 Test Results File](#)

### Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	371,887,008
Total Number of Logical Blocks Verified	188,503,008
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 MacroSAN MS3300 as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

## **PRICING INFORMATION**

### **Clause 9.4.3.3.6**

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

Pricing information may be found in the Priced Storage Configuration Pricing section on page 16.

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

### **Clause 9.4.3.3.8**

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 16.

## **ANOMALIES OR IRREGULARITIES**

### **Clause 9.4.3.10**

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the MacroSAN MS3300.

## **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.

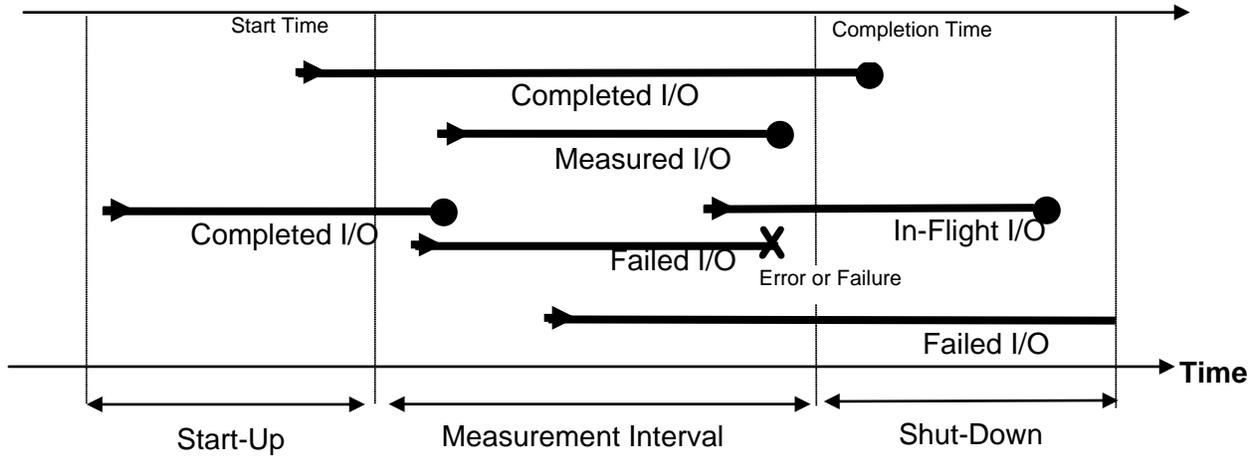
**Steady State:** The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

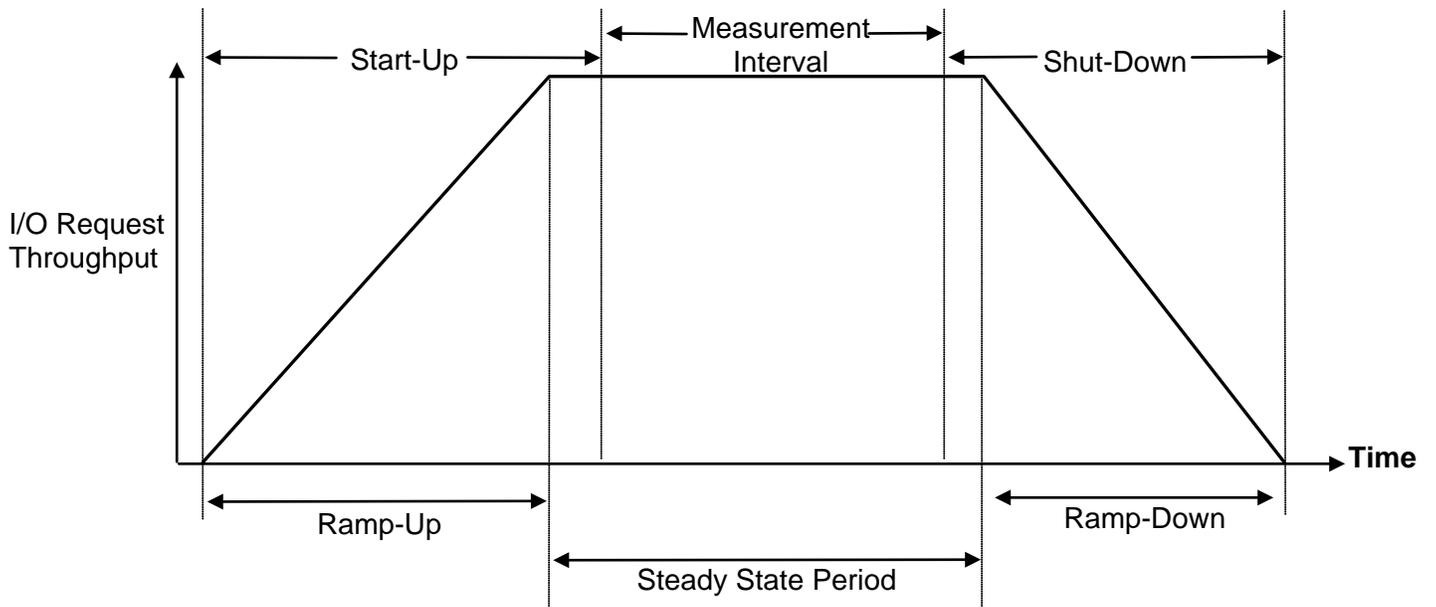
**Test Run:** The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall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

### **Red Hat Enterprise Linux 6.2 (64-bit)**

Change the I/O scheduler from **cfq** to **noop** on each Host System, which will result in all incoming I/O requests inserted into a simple, unordered FIFO queue. This change was done by the execution of the [scheduler.sh](#) script as documented in [Appendix C: Tested Storage Configuration \(TSC\) Creation](#).

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

The scripts referenced in Steps 1–3 appear in the section, [Referenced Scripts](#).

### **Step 1: Create Storage Pool, RAID1 Groups, LUNs, Clients, Mapping and Deploy LUNs**

Execute the [init\\_environment\\_ms3300.sh](#) script, via a Host System CLI session, on either of the Storage Controllers to complete the following:

1. Create 1 storage pool: **Pool-1**
2. Create 18 RAID-1 Groups in **Pool-1**
3. Create 18 LUNs (*1 LUN per RAID1 Group, 181 GiB per LUN*)
4. Create 6 Clients
5. Add Host System FC Initiators to Clients  
(*2 Initiators per Client and each Initiator from one Host System*)
6. Create Storage Targets to Clients  
(*1 Target per Client and each Target is associated with 1 FC port*)
7. Add LUNs to Targets  
(*3 LUNs per Target for 18 Targets*)

### **Step 2: Create Volumes on the Master Host System**

Execute the [mkvolumes\\_ms3300.sh](#) script on the Master Host System to create 3 logical volumes as follows:

1. **Create Physical Volumes:**  
Create 18 physical volumes using the **pvcreate** command.
2. **Create Volume Groups:**  
Create 1 volume group (**vg1**) using the **vgcreate** command using the following 18 physical volumes: **/dev/sdb, /dev/sdc, /dev/sdd, /dev/sde, /dev/sdf, /dev/sdg, /dev/sdh, /dev/sdi, /dev/sdj, /dev/sdk, /dev/sdl, /dev/sdm, /dev/sdn, /dev/sdo, /dev/sdp, /dev/sdq, /dev/sdr, /dev/sds**.
3. **Create Logical Volumes:**
  - a. Create 1 logical volume with a capacity of 1,350 GiB on **vg1** for ASU-1.
  - b. Create 1 logical volume with a capacity of 1,350 GiB on **vg1** for ASU-2.
  - c. Create 1 logical volume with a capacity of 300 GiB on **vg1** for ASU-3.
4. **Scan Physical Volumes, Volume Group, Logical Volumes and Activate each Logical Volume:**  
Execute the [lv\\_scan.sh](#) script on the Slave Host Systems to scan the physical volumes, volume group and logical volumes. In addition, the script will make each logical volume available (activate).

### Step 3: Change the Scheduler on each Host System

Execute the [scheduler.sh](#) script on each Host System to change the scheduler of each block device from *cfq* to *noop*.

### Referenced Scripts

#### init\_environment\_ms3300.sh

```
#!/bin/bash

#Create Pool-1
echo pool mgt create -n Pool-1 -t t | /odsp/bin/odsp-cli

#Create RAID: 18
echo raid mgt create -n RAID-1 -p Pool-1 -l RAID1 -d 1:1:1:5,1:1:1:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-2 -p Pool-1 -l RAID1 -d 1:1:1:7,1:1:1:8 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-3 -p Pool-1 -l RAID1 -d 1:1:1:9,1:1:1:10 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-4 -p Pool-1 -l RAID1 -d 1:1:1:11,1:1:1:12 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-9 -p Pool-1 -l RAID1 -d 1:1:1:13,1:1:1:14 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-10 -p Pool-1 -l RAID1 -d 1:1:1:15,1:1:1:16 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-11 -p Pool-1 -l RAID1 -d 1:1:2:1,1:1:2:2 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-12 -p Pool-1 -l RAID1 -d 1:1:2:3,1:1:2:4 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-17 -p Pool-1 -l RAID1 -d 1:1:2:5,1:1:2:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-18 -p Pool-1 -l RAID1 -d 1:1:2:7,1:1:2:8 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-5 -p Pool-1 -l RAID1 -d 1:2:1:1,1:2:1:2 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-6 -p Pool-1 -l RAID1 -d 1:2:1:3,1:2:1:4 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-7 -p Pool-1 -l RAID1 -d 1:2:1:5,1:2:1:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-8 -p Pool-1 -l RAID1 -d 1:2:1:7,1:2:1:8 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-13 -p Pool-1 -l RAID1 -d 1:2:1:9,1:2:1:10 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-14 -p Pool-1 -l RAID1 -d 1:2:1:11,1:2:1:12 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-15 -p Pool-1 -l RAID1 -d 1:2:1:13,1:2:1:14 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-16 -p Pool-1 -l RAID1 -d 1:2:1:15,1:2:1:16 |
/odsp/bin/odsp-cli

#Create LUN : 18
echo lun mgt create -n LUN-1 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-1 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-2 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-2 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-3 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-3 | /odsp/bin/odsp-cli
```

```
echo lun mgt create -n LUN-4 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-4 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-5 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-5 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-6 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-6 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-7 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-7 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-8 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-8 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-9 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-9 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-10 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-10 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-11 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-11 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-12 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-12 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-13 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-13 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-14 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-14 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-15 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-15 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-16 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-16 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-17 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-17 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-18 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-18 | /odsp/bin/odsp-cli

#Create Client
echo client mgt create -n Client-SP1-A -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-B -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-C -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-a -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-b -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-c -m N | /odsp/bin/odsp-cli

#Add Initiator with Client
echo client mgt addinitiator -c Client-SP1-A -t FC -i 21-00-00-24-ff-41-dd-19 -f |
/odsp/bin/odsp-cli
echo client mgt addinitiator -c Client-SP1-A -t FC -i 21-00-00-24-ff-2f-89-0d -f |
/odsp/bin/odsp-cli

echo client mgt addinitiator -c Client-SP1-B -t FC -i 21-00-00-24-ff-41-dd-18 -f |
/odsp/bin/odsp-cli
echo client mgt addinitiator -c Client-SP1-B -t FC -i 21-00-00-24-ff-2f-89-0c -f |
/odsp/bin/odsp-cli

echo client mgt addinitiator -c Client-SP1-C -t FC -i 21-00-00-24-ff-2f-88-fd -f |
/odsp/bin/odsp-cli
echo client mgt addinitiator -c Client-SP1-C -t FC -i 21-00-00-24-ff-37-0b-81 -f |
/odsp/bin/odsp-cli

echo client mgt addinitiator -c Client-SP2-a -t FC -i 21-00-00-24-ff-2f-88-f3 -f |
/odsp/bin/odsp-cli
echo client mgt addinitiator -c Client-SP2-a -t FC -i 50-01-43-80-12-06-d2-4a -f |
/odsp/bin/odsp-cli

echo client mgt addinitiator -c Client-SP2-b -t FC -i 21-00-00-24-ff-2f-88-f2 -f |
/odsp/bin/odsp-cli
```

```
echo client mgt addinitiator -c Client-SP2-b -t FC -i 50-01-43-80-12-06-d2-48 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-c -t FC -i 21-00-00-24-ff-41-dd-a3 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-c -t FC -i 50-01-43-80-06-2d-66-30 -f |  
/odsp/bin/odsp-cli  
  
#Create Target  
echo client target create -c Client-SP1-A -t FC -n Target-SP1-A -f 50-0b-34-20-01-  
21-4f-01 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-B -t FC -n Target-SP1-B -f 50-0b-34-20-01-  
21-4f-02 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-C -t FC -n Target-SP1-C -f 50-0b-34-20-01-  
21-4f-03 | /odsp/bin/odsp-cli  
  
echo client target create -c Client-SP2-a -t FC -n Target-SP2-a -s 50-0b-34-20-01-  
15-6a-01 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-b -t FC -n Target-SP2-b -s 50-0b-34-20-01-  
15-6a-02 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-c -t FC -n Target-SP2-c -s 50-0b-34-20-01-  
15-6a-03 | /odsp/bin/odsp-cli  
  
#Add LUN  
echo client target addlun -t FC -n Target-SP1-A -l LUN-1 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-A -l LUN-10 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-A -l LUN-3 | /odsp/bin/odsp-cli  
  
echo client target addlun -t FC -n Target-SP1-B -l LUN-4 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-B -l LUN-5 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-B -l LUN-6 | /odsp/bin/odsp-cli  
  
echo client target addlun -t FC -n Target-SP1-C -l LUN-7 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-C -l LUN-8 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-C -l LUN-17 | /odsp/bin/odsp-cli  
  
echo client target addlun -t FC -n Target-SP2-a -l LUN-9 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-a -l LUN-2 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-a -l LUN-11 | /odsp/bin/odsp-cli  
  
echo client target addlun -t FC -n Target-SP2-b -l LUN-12 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-b -l LUN-13 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-b -l LUN-14 | /odsp/bin/odsp-cli  
  
echo client target addlun -t FC -n Target-SP2-c -l LUN-15 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-c -l LUN-16 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-c -l LUN-18 | /odsp/bin/odsp-cli
```

### **mkvolumes\_ms3300.sh**

```
#!/bin/bash

#pv
pvcreate /dev/sdb
pvcreate /dev/sdc
pvcreate /dev/sdd
pvcreate /dev/sde
pvcreate /dev/sdf
pvcreate /dev/sdg
pvcreate /dev/sdh
pvcreate /dev/sdi
pvcreate /dev/sdj
pvcreate /dev/sdk
pvcreate /dev/sdl
pvcreate /dev/sdm
pvcreate /dev/sdn
pvcreate /dev/sdo
pvcreate /dev/sdp
pvcreate /dev/sdq
pvcreate /dev/sdr
pvcreate /dev/sds

#vg
vgcreate vg1 /dev/sdb /dev/sdc /dev/sdd /dev/sde /dev/sdf /dev/sdg /dev/sdh /dev/sdi
/dev/sdj /dev/sdk /dev/sdl /dev/sdm /dev/sdn /dev/sdo /dev/sdp /dev/sdq /dev/sdr
/dev/sds

#lv
lvcreate -n asu11 -i 18 -I 512 -C y -L 1350g vg1

lvcreate -n asu21 -i 18 -I 512 -C y -L 1350g vg1

lvcreate -n asu31 -i 18 -I 512 -C y -L 300g vg1

exit 0
```

### **lv\_scan.sh**

```
#!/bin/bash

echo '-----pvscan-----'
pvscan
echo '-----vgscan-----'
vgscan
echo '-----lvscan-----'
lvscan

lvchange -ay /dev/vg1/asu11

lvchange -ay /dev/vg1/asu21

lvchange -ay /dev/vg1/asu31
```

## **scheduler.sh**

```
#!/bin/bash

#default: noop anticipatory deadline [cfq]
for i in sdb sdc sdd sde sdf sdg sdh sdi sdj sdk sdl sdm sdn sdo sdp sdq sdr sds sdt
sdu sdv sdw sdx sdy sdz sdaa sdab sdac sdad sdae
do
    echo noop > /sys/block/$i/queue/scheduler
done

#show
cat -n /sys/block/sd[b-z]/queue/scheduler /sys/block/sd[a][a-z]/queue/scheduler
```

## **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=sd1,lun=/dev/vg1/asu11,size=1350g,openflags=o_direct,threads=32

sd=sd2,lun=/dev/vg1/asu21,size=1350g,openflags=o_direct,threads=32

sd=sd3,lun=/dev/vg1/asu31,size=300g,openflags=o_direct,threads=32

wd=wd1,sd=sd*,rdpct=0,seekpct=-1,xfersize=128K

rd=asu_prefill,wd=wd1,iorate=max,elapsed=36000,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.

```
host=master
slaves=(slave1,slave2,slave3,slave4,slave5,slave6,slave7,slave8,slave9,slave10,slave11,slave12,slave13,slave14,slave15,slave16,slave17,slave18,slave19,slave20,slave21,slave22,slave23,slave24,slave25,slave26,slave27,slave28,slave29,slave30,slave31,slave32,slave33,slave34,slave35,slave36,slave37,slave38,slave39,slave40)
sd=asu1_1,lun=/dev/vg1/asu11,size=1350g
sd=asu2_1,lun=/dev/vg1/asu21,size=1350g
sd=asu3_1,lun=/dev/vg1/asu31,size=300g
```

### **SPC-1 Persistence Test**

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

```
sd=asu1_1,lun=/dev/vg1/asu11,size=1350g
sd=asu2_1,lun=/dev/vg1/asu21,size=1350g
sd=asu3_1,lun=/dev/vg1/asu31,size=300g
```

## Slave JVMs

Each Slave JVM was invoked with a command and parameter file similar to the example listed below. The only difference in each file was **host** parameter value, which was unique to each Slave JVM, e.g. **slave1...slave40**.

```
master=10.77.77.23
host=slave1
sd=asu1_1,lun=/dev/vg1/asu11,size=1350g
sd=asu2_1,lun=/dev/vg1/asu21,size=1350g
sd=asu3_1,lun=/dev/vg1/asu31,size=300g
```

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

The first script, [master\\_execution\\_script1\\_ms3300.sh](#), was invoked to execute the required ASU pre-fill, 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 Persistence Test Run 1 (*write phase*) in an uninterrupted sequence. This script also invoked a separate script, [slave\\_multi\\_run.sh](#), to manually start the Slave JVMs.

The second script, [master\\_execution\\_script2\\_ms3300.sh](#), was invoked to execute SPC-1 Persistence Test Run 2 (read phase).

Both scripts also invoked additional scripts to capture the detailed TSC profile listings required for a Remote Audit.

### **master\_execution\_script1\_ms3300.sh**

```
#!/bin/bash

# Create the first storage profile at the start of run...
echo "Create the first storage profile at the start of run..."
ssh root@172.0.0.93 >/dev/null 2>&1 << eeoff
/root/profile_ms3300.sh start
exit
eeoff

# Create the first volume listing at the start of run...
echo "Create the first volume listing at the start of run..."
/root/volume_listing.sh start

# ASU prefill
echo "ASU prefill started....."
/root/vdbench503/vdbench -f /root/spc/spc1_prefill_ms3300.parm -o
/root/spc/prefill_out_ms3300
echo "ASU prefill complete....."

# Start Slave JVMs
cd /root/spc/

\cp spc1_iops_ms3300.cfg spc1.cfg

/root/slave_multi_run.sh 1 20

ssh root@172.0.10.22 >/dev/null 2>&1 << eeoff
/root/slave_multi_run.sh 21 40
exit
eeoff

# SPC-1 Primary Metrics Test 28800
java -Xmx640m -Xms640m metrics -b 3100 -t 28800

# SPC-1 Repeatability Test
java -Xmx640m -Xms640m repeat1 -b 3100

java -Xmx640m -Xms640m repeat2 -b 3100

killall java
ssh root@172.0.10.22 killall java
```

```
# SPC-1 Persistence Test Run 1
\cp spc1_persist_ms3300.cfg spc1.cfg

java -Xmx640m -Xms640m persist1 -b 3100

exit 0
```

### **slave\_multi\_run.sh**

```
#!/bin/bash

start_index=$1
end_index=$2
for ((i=$start_index;i<=$end_index;i++))do
    java spc1 -f /root/spc/slave/slave$i.txt > /root/spc/slaveOut/slave$i.out &
done
```

### **master\_execution\_script2\_ms3300.sh**

```
#!/bin/bash

# SPC-1 Persistence Test Run 2
cd /root/spc
\cp spc1_persist_ms3300.cfg spc1.cfg

java -Xmx640m -Xms640m persist2

cd /root/
# Create the second storage profile at the end of run...
echo "Create the second storage profile at the end of run..."
ssh root@172.0.0.93 >/dev/null 2>&1 << eeoff
/root/profile_ms3300.sh end
exit
eeoff

# Create the second volume listing at the start of run...
echo "Create the second volume listing at the second of run..."
/root/volume_listing.sh end

exit 0
```

## APPENDIX F: THIRD-PARTY QUOTATION

### Host Bus Adapter (HBA)



The screenshot displays a Taobao.com product listing for a Qlogic QLE2562 FC8 HBA. The product is described as a Gen2 x4 full original product. The price is listed as ¥3300.00. Shipping is from Guangdong Shenzhen to Zhejiang Hangzhou Jiangsu District, with a shipping fee of ¥22.00. The quantity is set to 1, with 20 items in stock. The page includes buttons for '立即购买' (Buy Now) and '加入购物车' (Add to Cart). The seller is '陌然盛科数码商城' (Moran Shengke Digital Mall) with a 4.9 rating for description, service, and logistics. The page also features a '皇冠卖家' (Crown Seller) badge and a '2014 11月11日 嘉年华会场' (2014 11.11 Carnival) banner.

Qlogic QLE2562 FC8 双通道 HBA, PCI-E  
Gen2 x4 全新 原装正品

价格 **¥3300.00**

配送 广东深圳 至 浙江杭州滨江区  
快递 ¥22.00

数量  件(库存20件)

[立即购买](#) [加入购物车](#)

承诺 **7**天无理由

支付 集分宝 支付宝支付

皇冠卖家  
陌然盛科数码商城  
信誉:   
掌柜: 陌然盛科数码商城  
联系: [和我联系](#)  
资质:

描述	服务	物流
4.9	4.9	4.9

进入店铺 收藏店铺

看了又看

