



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**NETAPP, INC.  
NETAPP EF560 ALL-FLASH ARRAY**

**SPC-1 V1.14**

**Submitted for Review: April 18, 2016  
Submission Identifier: A00173**

**First Edition – April 2016**

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## Table of Contents

<b>Audit Certification</b> .....	<b>vii</b>
<b>Audit Certification (<i>cont.</i>)</b> .....	<b>viii</b>
<b>Letter of Good Faith</b> .....	<b>ix</b>
<b>Executive Summary</b> .....	<b>10</b>
<b>Test Sponsor and Contact Information</b> .....	<b>10</b>
<b>Revision Information and Key Dates</b> .....	<b>10</b>
<b>Tested Storage Product (TSP) Description</b> .....	<b>10</b>
<b>Summary of Results</b> .....	<b>11</b>
<b>Storage Capacities, Relationships, and Utilization</b> .....	<b>12</b>
<b>Response Time – Throughput Curve</b> .....	<b>15</b>
<b>Response Time – Throughput Data</b> .....	<b>15</b>
<b>Priced Storage Configuration Pricing</b> .....	<b>16</b>
<b>Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration</b> .....	<b>16</b>
<b>Priced Storage Configuration Diagram</b> .....	<b>17</b>
<b>Priced Storage Configuration Components</b> .....	<b>17</b>
<b>Configuration Information</b> .....	<b>18</b>
<b>Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram</b> .....	<b>18</b>
<b>Storage Network Configuration</b> .....	<b>18</b>
<b>Host System(s) and Tested Storage Configuration (TSC) Table of Components</b> .....	<b>18</b>
<b>Benchmark Configuration/Tested Storage Configuration Diagram</b> .....	<b>19</b>
<b>Host System and Tested Storage Configuration Components</b> .....	<b>20</b>
<b>Customer Tunable Parameters and Options</b> .....	<b>21</b>
<b>Tested Storage Configuration (TSC) Description</b> .....	<b>21</b>
<b>SPC-1 Workload Generator Storage Configuration</b> .....	<b>21</b>
<b>ASU Pre-Fill</b> .....	<b>22</b>
<b>SPC-1 Data Repository</b> .....	<b>23</b>
<b>Storage Capacities and Relationships</b> .....	<b>23</b>
SPC-1 Storage Capacities .....	<b>23</b>
SPC-1 Storage Hierarchy Ratios .....	<b>24</b>
SPC-1 Storage Capacity Charts .....	<b>24</b>
<b>Storage Capacity Utilization</b> .....	<b>26</b>
<b>Logical Volume Capacity and ASU Mapping</b> .....	<b>27</b>
<b>SPC-1 Benchmark Execution Results</b> .....	<b>28</b>
<b>SPC-1 Tests, Test Phases, and Test Runs</b> .....	<b>28</b>

<b>“Ramp-Up” Test Runs</b> .....	<b>29</b>
<b>Primary Metrics Test – Sustainability Test Phase</b> .....	<b>29</b>
SPC-1 Workload Generator Input Parameters .....	30
Sustainability Test Results File .....	30
Sustainability – Data Rate Distribution Data (MB/second) .....	30
Sustainability – Data Rate Distribution Graph .....	30
Sustainability – I/O Request Throughput Distribution Data .....	31
Sustainability – I/O Request Throughput Distribution Graph .....	31
Sustainability – Average Response Time (ms) Distribution Data .....	32
Sustainability – Average Response Time (ms) Distribution Graph .....	32
Sustainability – Response Time Frequency Distribution Data .....	33
Sustainability – Response Time Frequency Distribution Graph .....	33
Sustainability – Measured Intensity Multiplier and Coefficient of Variation.....	34
<b>Primary Metrics Test – IOPS Test Phase</b> .....	<b>35</b>
SPC-1 Workload Generator Input Parameters .....	35
IOPS Test Results File.....	35
IOPS Test Run – I/O Request Throughput Distribution Data .....	36
IOPS Test Run – I/O Request Throughput Distribution Graph.....	37
IOPS Test Run – Average Response Time (ms) Distribution Data .....	38
IOPS Test Run – Average Response Time (ms) Distribution Graph .....	39
IOPS Test Run –Response Time Frequency Distribution Data .....	40
IOPS Test Run –Response Time Frequency Distribution Graph.....	40
IOPS Test Run – I/O Request Information.....	41
IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation .....	41
<b>Primary Metrics Test – Response Time Ramp Test Phase</b> .....	<b>42</b>
SPC-1 Workload Generator Input Parameters .....	42
Response Time Ramp Test Results File.....	42
Response Time Ramp Distribution (IOPS) Data.....	43
Response Time Ramp Distribution (IOPS) Graph .....	43
SPC-1 LRT™ Average Response Time (ms) Distribution Data.....	44
SPC-1 LRT™ Average Response Time (ms) Distribution Graph .....	45
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation .....	46
<b>Repeatability Test</b> .....	<b>47</b>
SPC-1 Workload Generator Input Parameters .....	47
Repeatability Test Results File .....	48
Repeatability 1 LRT – I/O Request Throughput Distribution Data.....	49
Repeatability 1 LRT – I/O Request Throughput Distribution Graph .....	50
Repeatability 1 LRT –Average Response Time (ms) Distribution Data .....	51
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph.....	52

Repeatability 1 IOPS – I/O Request Throughput Distribution Data .....	53
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph.....	54
Repeatability 1 IOPS –Average Response Time (ms) Distribution Data.....	55
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph .....	56
Repeatability 2 LRT – I/O Request Throughput Distribution Data.....	57
Repeatability 2 LRT – I/O Request Throughput Distribution Graph .....	58
Repeatability 2 LRT –Average Response Time (ms) Distribution Data .....	59
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph.....	60
Repeatability 2 IOPS – I/O Request Throughput Distribution Data .....	61
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph.....	62
Repeatability 2 IOPS –Average Response Time (ms) Distribution Data.....	63
Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph .....	64
Repeatability 1 (LRT) Measured Intensity Multiplier and Coefficient of Variation .....	65
Repeatability 1 (IOPS) Measured Intensity Multiplier and Coefficient of Variation .....	65
Repeatability 2 (LRT) Measured Intensity Multiplier and Coefficient of Variation .....	65
Repeatability 2 (IOPS) Measured Intensity Multiplier and Coefficient of Variation .....	66
<b>Data Persistence Test.....</b>	<b>67</b>
SPC-1 Workload Generator Input Parameters .....	67
Data Persistence Test Results File .....	67
Data Persistence Test Results.....	68
<b>Priced Storage Configuration Availability Date.....</b>	<b>69</b>
<b>Pricing Information.....</b>	<b>69</b>
<b>Tested Storage Configuration (TSC) and Priced Storage Configuration Differences.....</b>	<b>69</b>
<b>Anomalies or Irregularities .....</b>	<b>69</b>
<b>Appendix A: SPC-1 Glossary .....</b>	<b>70</b>
“Decimal” ( <i>powers of ten</i> ) Measurement Units.....	70
“Binary” ( <i>powers of two</i> ) Measurement Units.....	70
SPC-1 Data Repository Definitions.....	70
SPC-1 Data Protection Levels .....	71
SPC-1 Test Execution Definitions .....	71
I/O Completion Types.....	73
SPC-1 Test Run Components.....	73
<b>Appendix B: Customer Tunable Parameters and Options.....</b>	<b>74</b>
HBA Parameters.....	74
Windows Registry Settings .....	74
Storage Array Parameters .....	74

<b>Appendix C: Tested Storage Configuration (TSC) Creation .....</b>	<b>75</b>
<b>QLogic HBA Parameters.....</b>	<b>75</b>
<b>Windows Registry Setting .....</b>	<b>75</b>
<b>Storage Array Volume Creation .....</b>	<b>75</b>
<b>SPC-1 Logical Volume Creation.....</b>	<b>76</b>
<b>SPC1_RAID_Config.script .....</b>	<b>77</b>
<b>Appendix D: SPC-1 Workload Generator Storage Commands and Parameters .....</b>	<b>78</b>
<b>ASU Pre-Fill.....</b>	<b>78</b>
<b>Primary Metrics and Repeatability Tests .....</b>	<b>78</b>
<b>SPC-1 Persistence Test.....</b>	<b>79</b>
<b>Slave JVMs.....</b>	<b>79</b>
<b>SPC-2 Persistence Test.....</b>	<b>80</b>
SPC-2 Persistence Test Run 1 ( <i>write phase</i> ).....	80
SPC-2 Persistence Test Run 2 ( <i>read phase</i> ).....	80
<b>Appendix E: SPC-1 Workload Generator Input Parameters .....</b>	<b>81</b>
<b>startSlaves.cmd.....</b>	<b>81</b>
slave1.cmd .....	81
<b>phase1.cmd.....</b>	<b>81</b>
<b>phase2.cmd.....</b>	<b>82</b>
<b>Third-Party Quotation .....</b>	<b>83</b>
<b>QLogic QLE2672-CK HBAs .....</b>	<b>83</b>
<b>Fibre Channel Cables.....</b>	<b>84</b>

## AUDIT CERTIFICATION



Mark Register  
 NetApp, Inc.  
 3718 North Rock Road  
 Wichita, KS 67226

April 14, 2016

The SPC Benchmark 1™ Reported Data listed below for the NetApp EF560 All-Flash Array 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: NetApp EF560 All-Flash Array	
Metric	Reported Result
SPC-1 IOPS™	319,980.28
SPC-1 Price-Performance	\$0.30/SPC-1 IOPS™
Total ASU Capacity	9,006.219 GB
Data Protection Level	Protected 2 ( <i>Mirroring</i> )
Total Price (including three-year maintenance)	\$97,050.48
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

Gradient Systems, Inc.  
 643 Bair Island Road, Suite 103  
 Redwood City, CA 94062  
[AuditService@storageperformance.org](mailto:AuditService@storageperformance.org)  
 650.556.9384

## AUDIT CERTIFICATION (CONT.)

NetApp EF560 All-Flash Array  
SPC-1 Audit Certification

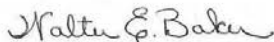
Page 2

- 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 NetApp, Inc.:
  - ✓ 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 NetApp, Inc. for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

**Audit Notes:**

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker  
SPC Auditor

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## LETTER OF GOOD FAITH



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3718 N. Rock Road  
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February 18, 2016

Mr. Walter E. Baker, SPC Auditor  
Gradient Systems  
643 Bair Island Road, Suite 103  
Redwood City, CA 94063

Subject: SPC-1 Letter of Good Faith for the NetApp EF560 Storage System w/11.25

NetApp Inc. is the SPC-1 test sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 results and materials we have submitted for that product are complete, accurate, and in full compliance with version 1.14 of the SPC-1 benchmark specification.

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

Sincerely,

  
Eric Stoltman (Feb 18, 2016)

Eric Stoltman  
VP & GM, HSG

February 18, 2016

Date

Legal Reference

## EXECUTIVE SUMMARY

### Test Sponsor and Contact Information

Test Sponsor and Contact Information	
<b>Test Sponsor Primary Contact</b>	NetApp, Inc. – <a href="http://www.netapp.com">http://www.netapp.com</a> Mark Regester – <a href="mailto:mark.regester@netapp.com">mark.regester@netapp.com</a> 3718 North Rock Road Wichita, KS 67226 Phone: (316) 636-8340
<b>Test Sponsor Alternate Contact</b>	NetApp, Inc. – <a href="http://www.netapp.com">http://www.netapp.com</a> Mike Phelan – <a href="mailto:mike.phelan@netapp.com">mike.phelan@netapp.com</a> 5400 Airport Blvd., Suite 100 Boulder, CO 80301 Phone: (303) 544-5414
<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">http://www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@StoragePerformance.org">AuditService@StoragePerformance.org</a> 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

### Revision Information and Key Dates

Revision Information and Key Dates	
<b>SPC-1 Specification revision number</b>	V1.14
<b>SPC-1 Workload Generator revision number</b>	V2.3.0
<b>Date Results were first used publicly</b>	April 18, 2016
<b>Date the FDR was submitted to the SPC</b>	April 18, 2016
<b>Date the Priced Storage Configuration is available for shipment to customers</b>	currently available
<b>Date the TSC completed audit certification</b>	April 14, 2016

### Tested Storage Product (TSP) Description

The NetApp® EF560 flash array is an all-SSD storage system that brings together extreme performance and enterprise-grade reliability to create a system optimized for latency-sensitive workloads. Designed for applications demanding the highest levels of performance, reliability, and availability and requiring just 2U of rack space, the EF560 flash array delivers consistent microsecond latency response times, and enterprise-proven availability features. Additionally, the EF560 can be seamlessly expanded to 120 SSDs to a maximum raw capacity of 384TB. The EF560's core architecture has been proven in the world's most demanding and complex computing environments. Its field-proven design is the culmination of over 20 years of industry knowledge focused on designing enterprise-class storage. The fully redundant EF-Series all-flash array is architected to provide the highest levels of reliability, availability, and data protection.

## Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: NetApp EF560 All-Flash Array	
Metric	Reported Result
SPC-1 IOPS™	319,980.28
SPC-1 Price-Performance™	\$0.30/SPC-1 IOPS™
Total ASU Capacity	9,006.219 GB
Data Protection Level	Protected 2 ( <i>Mirroring</i> )
Total Price	\$97,050.48
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

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

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

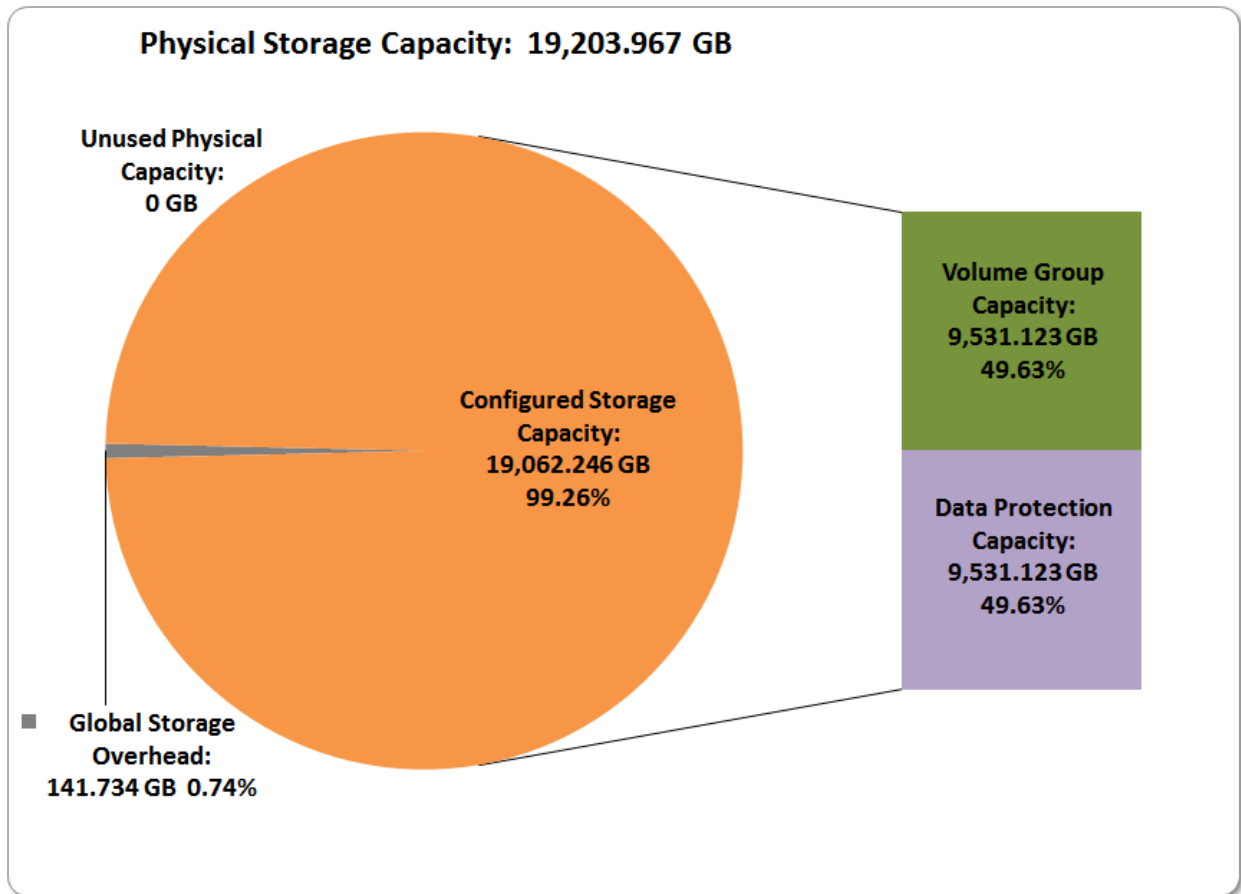
**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 16.

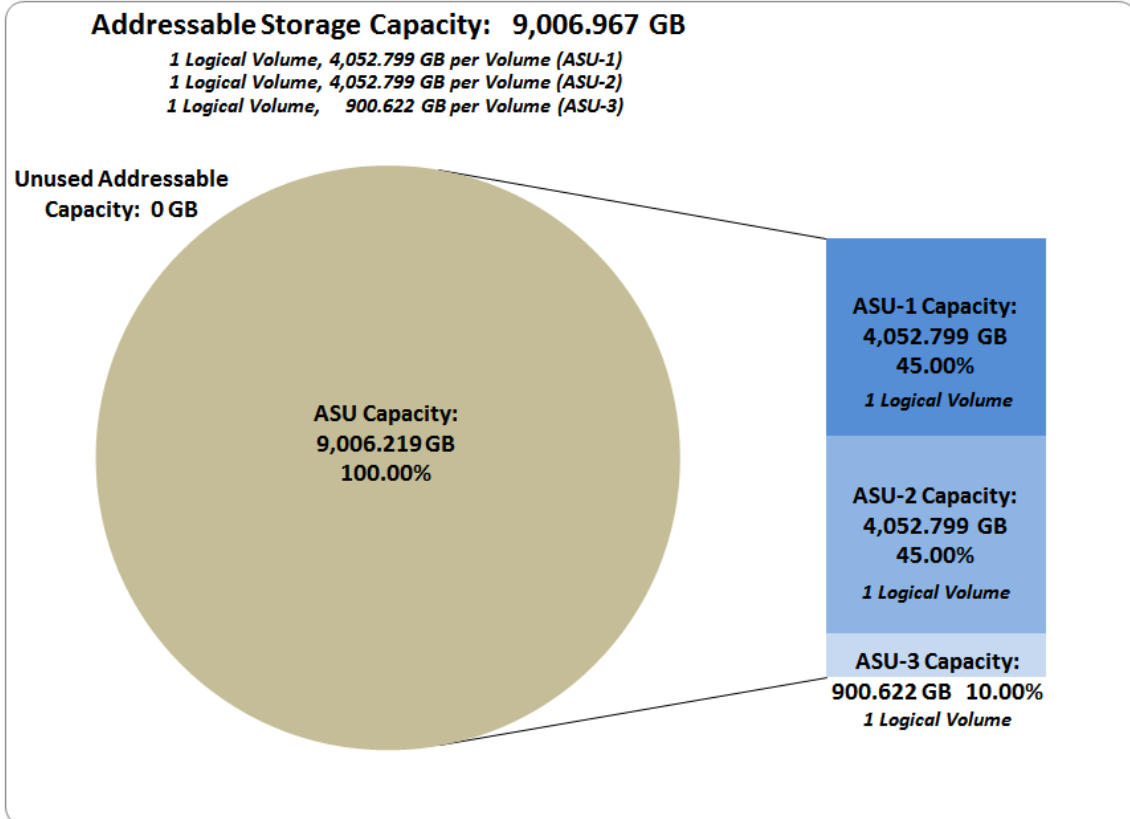
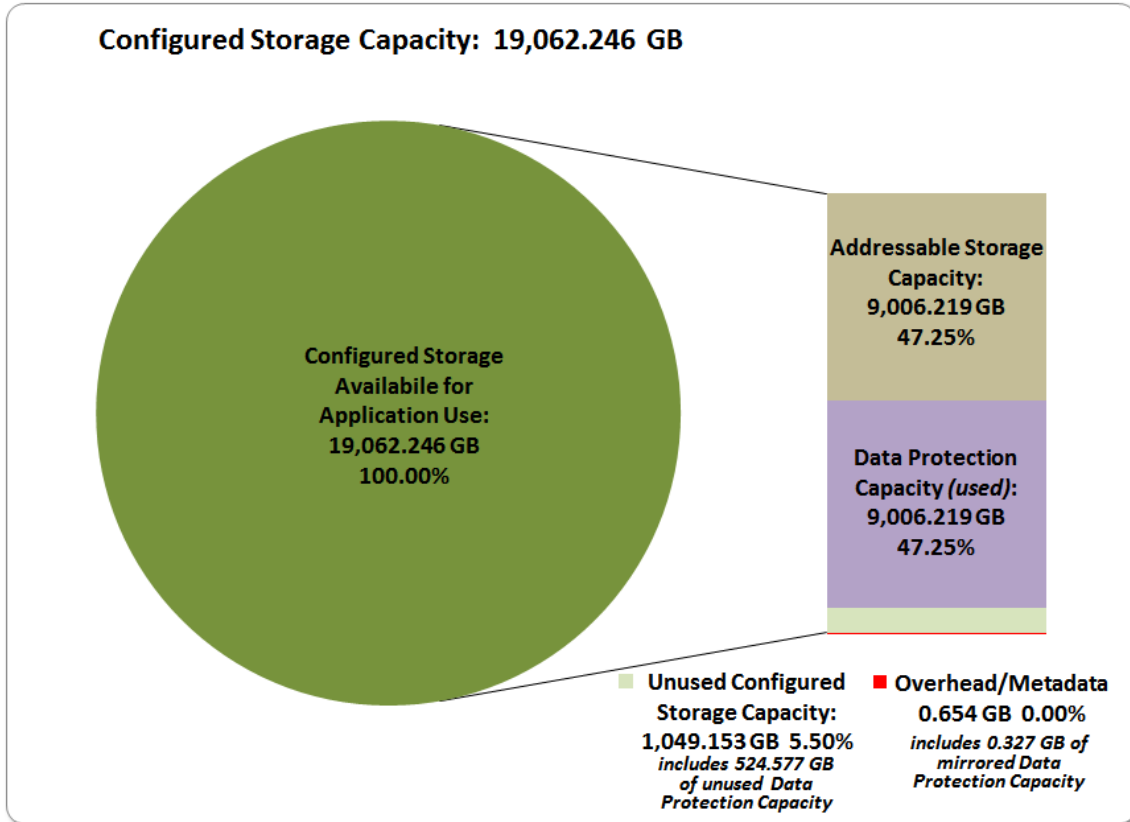
**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

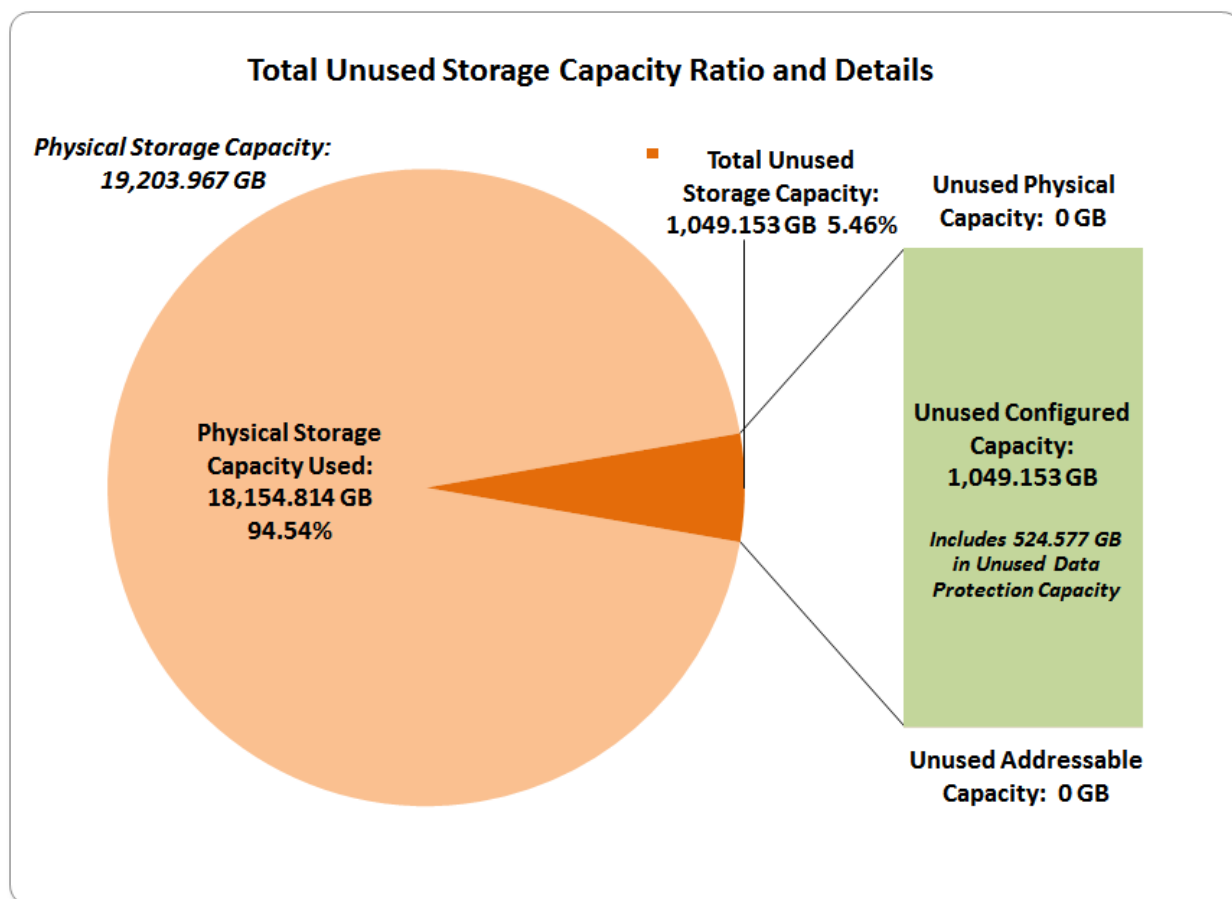
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

### Storage Capacities, Relationships, and Utilization

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







SPC-1 Storage Capacity Utilization	
Application Utilization	46.90%
Protected Application Utilization	93.80%
Unused Storage Ratio	5.46%

**Application Utilization:** Total ASU Capacity (9,006.219 GB) divided by Physical Storage Capacity (19,203.967 GB).

**Protected Application Utilization:** (Total ASU Capacity (9,006.219 GB) plus total Data Protection Capacity (9,531.123 GB) minus unused Data Protection Capacity (524.577 GB)) divided by Physical Storage Capacity (19,203.967 GB).

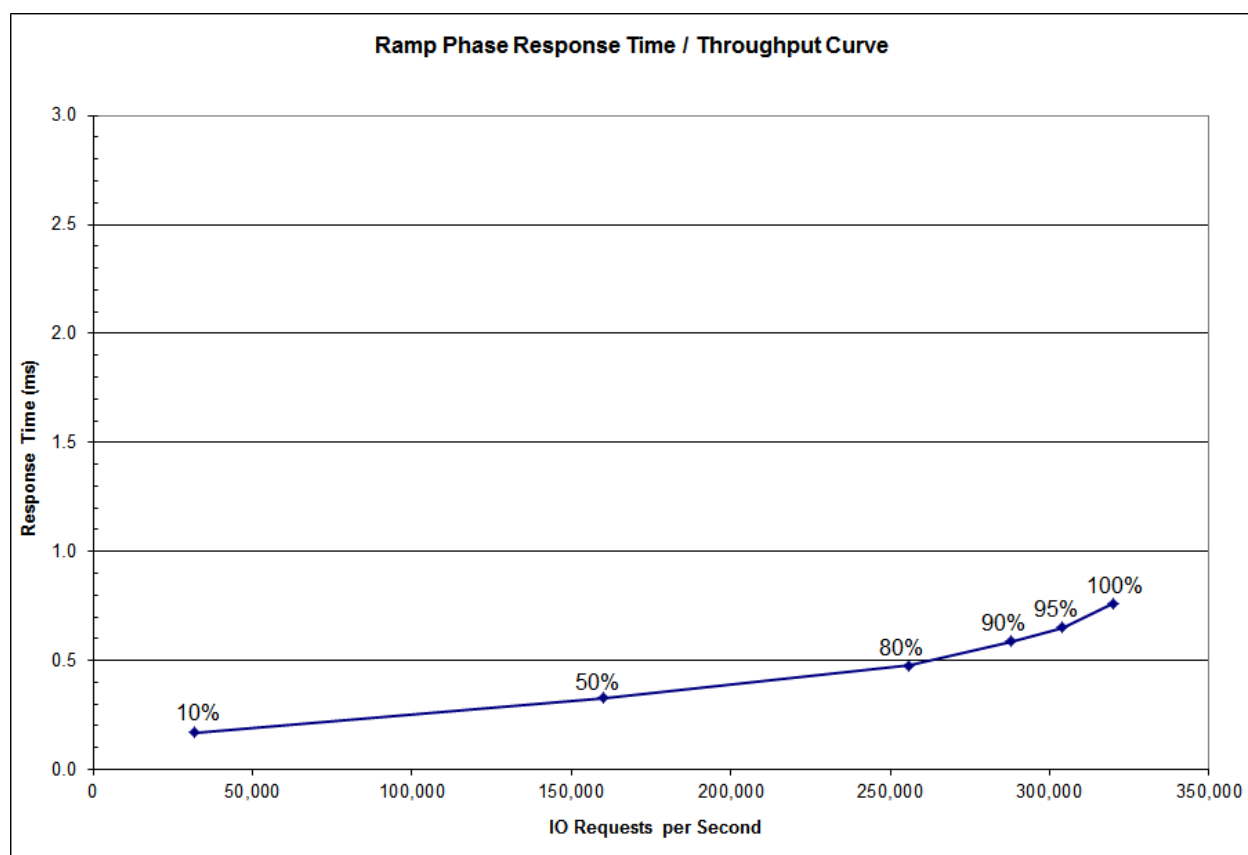
**Unused Storage Ratio:** Total Unused Capacity (1,049.153 GB) divided by Physical Storage Capacity (19,203.967 GB) and may not exceed 45%.

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

## Response Time – Throughput Curve

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

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



## Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
<b>I/O Request Throughput</b>	31,982.88	159,978.55	256,013.33	288,013.89	303,978.03	319,980.28
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	0.17	0.33	0.48	0.59	0.65	0.76
<b>ASU-1</b>	0.16	0.31	0.44	0.53	0.59	0.68
<b>ASU-2</b>	0.17	0.32	0.46	0.56	0.61	0.71
<b>ASU-3</b>	0.18	0.38	0.57	0.72	0.81	0.96
<b>Reads</b>	0.19	0.32	0.43	0.49	0.53	0.57
<b>Writes</b>	0.16	0.33	0.51	0.65	0.73	0.88

## Priced Storage Configuration Pricing

Part Number	Description	Quantity	Unit List Price	Extended LP
EF-X5681A-R6-C	Enclosure,EF5X0,Empty,2PSU,-C	1	\$ 3,880.00	\$ 3,880.00
EF-X561202A-R6-C	EF560A,12GB Controller,16Gb FC,4-ports,-C	2	\$ 21,925.00	\$ 43,850.00
EF-X4041C-C	SSD,800GB,Non-FDE,EF5X0,-C	24	\$ 2,705.00	\$ 64,920.00
OS-SANTRCTY-CAP3-EF-C	OS Enable,Per-0.1TB,SANTRCTY,Ultra-Stor,EF,-C	192	\$ 284.00	\$ 54,528.00
X-48895-00-R6-C	SFP,10Gb iSCSI/16Gb FC,Unified,E-Series,-C	8	\$ 600.00	\$ 4,800.00
	<b>NetApp Hardware/Software Subtotal</b>			\$ 171,978.00

CS-A2-4R-VA	Support, 3-yr 24/7, 4 hour on-site	1	\$ 11,355.12	\$ 11,355.12
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ServerSupply QLE2672-CK	QLE2672-CK Qlogic HBA, 16Gb FC, 2-ports	4	\$ 1,300.00	\$ 5,200.00
CDW 1148024	Tripp Lite, OM3 Optical cable, 2	8	\$ 22.99	\$ 183.92
	<b>Third-Party Subtotal</b>			\$ 5,383.92

Description	Extended LP	Discount	Discounted Price
NetApp Hardware/Software Subtotal	\$ 171,978.00	50%	\$ 85,989.00
Support	\$ 11,355.12	50%	\$ 5,677.56
Third-Party Subtotal	\$ 5,383.92	0%	\$ 5,383.92
<b>Totals</b>	<b>\$ 188,717.04</b>		<b>\$ 97,050.48</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:

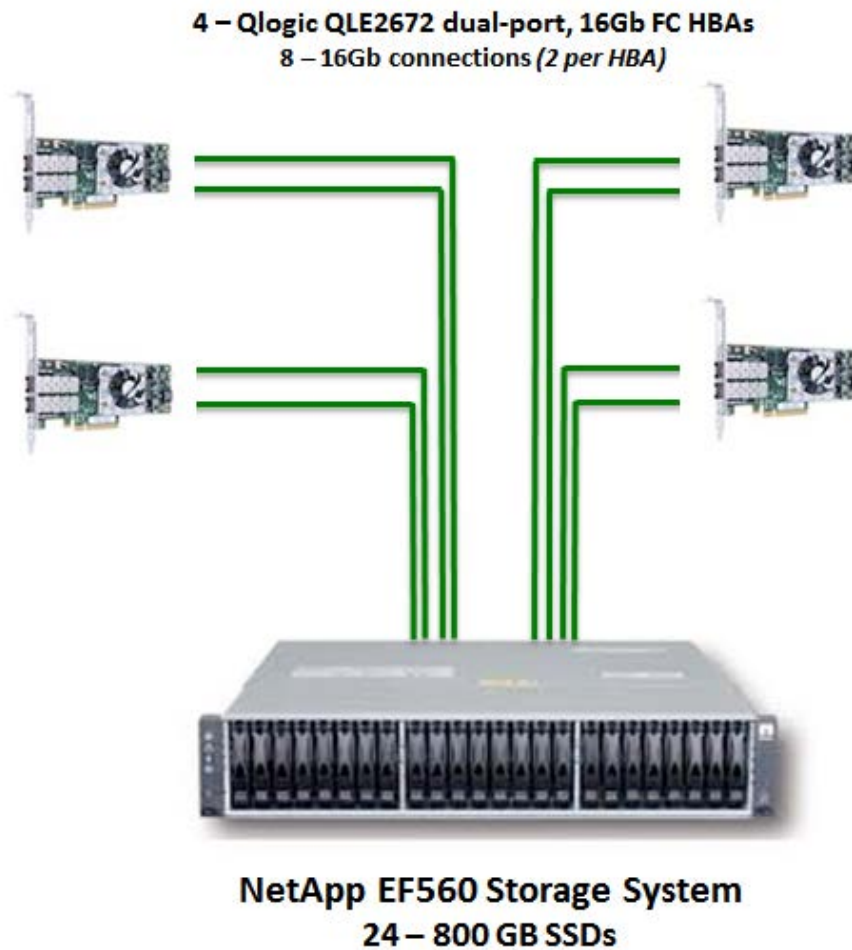
- Acknowledgement of new and existing problems within four (4) hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative Price Storage Configuration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

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



### Priced Storage Configuration Diagram



### Priced Storage Configuration Components

<b>Priced Storage Configuration</b>
4 – QLogic QLE2672-CK dual-port, 16Gb, FC HBAs
<b>NetApp EF560 All-Flash Array</b>
1 – Base Enclosure with
2 – controllers, each controller includes:
12 GB cache (24 GB total)
4 – 16 Gb FC front-end connections (8 total)
2 – 4 x 6Gb SAS backend connections (4 total)
24 – 800GB non FDE SSDs

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

## **CONFIGURATION INFORMATION**

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

#### **Clause 9.4.3.4.1**

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page [19 \(Benchmark Configuration/Tested Storage Configuration Diagram\)](#).

### **Storage Network Configuration**

#### **Clause 9.4.3.4.1**

...

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

#### **Clause 9.4.3.4.2**

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

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

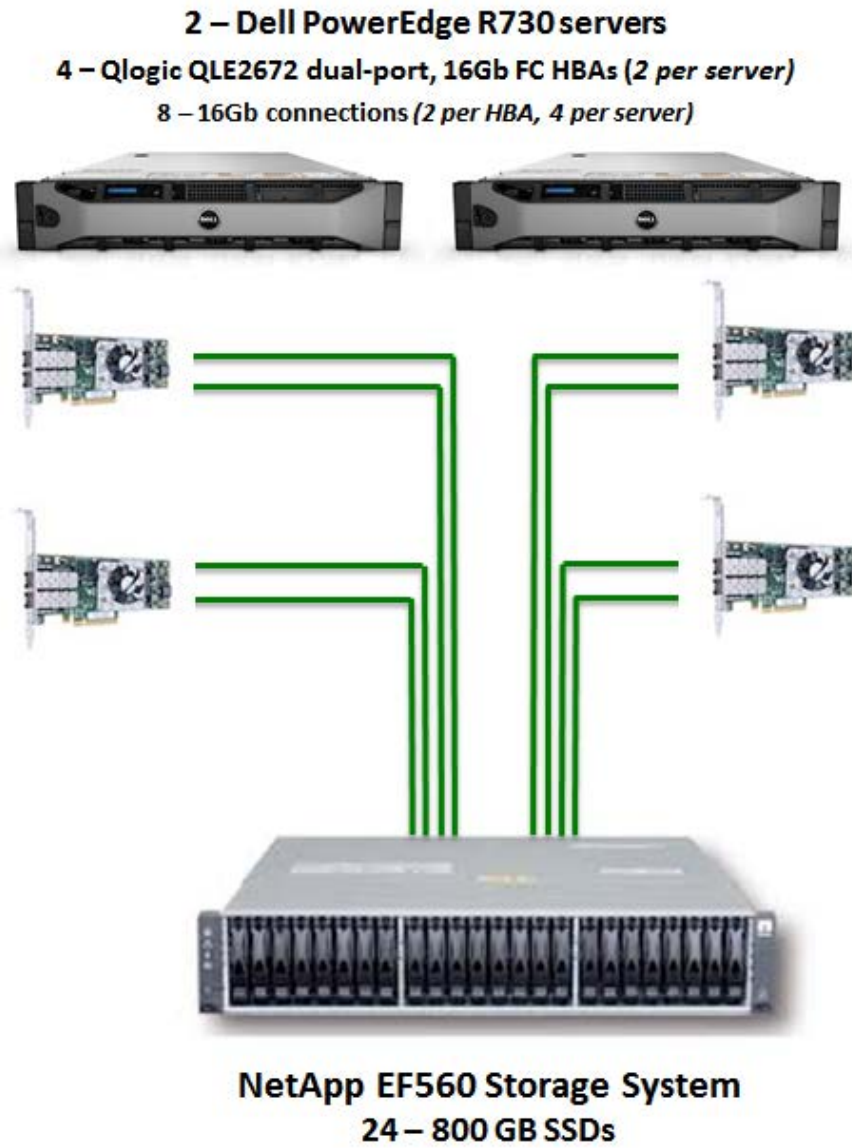
### **Host System(s) and Tested Storage Configuration (TSC) Table of Components**

#### **Clause 9.4.3.4.3**

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

The Host System(s) and TSC table of components may be found on page [20 \(Host System and Tested Storage Configuration Components\)](#).

## Benchmark Configuration/Tested Storage Configuration Diagram



## Host System and Tested Storage Configuration Components

Host Systems
<p><b>2 – Dell PowerEdge R730 servers</b>, each with:</p> <ul style="list-style-type: none"><li>2 – Intel® Xeon® E5-2630 V3 processors 2.40 GHz each with 8 cores, 2x256 KB L2 Cache, 20 MB L3 Cache</li><li>64 GB main memory</li><li>Windows Server 2008 R2 Enterprise version 6.1 (Build 7601: Service Pack 1)</li><li>PCIe</li></ul>
Priced Storage Configuration
<p>4 – QLogic QLE2672-CK dual-port, 16Gb, FC HBAs</p>
<p><b>NetApp EF560 All-Flash Array</b></p> <ul style="list-style-type: none"><li>1 – Base Enclosure with<ul style="list-style-type: none"><li>2 – controllers, each controller includes:<ul style="list-style-type: none"><li>12 GB cache (24 GB total)</li><li>4 – 16 Gb FC front-end connections (8 total)</li><li>2 – 4 x 6Gb SAS backend connections (4 total)</li><li>24 – 800GB non FDE SSDs</li></ul></li></ul></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 74 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 75 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 78.

## 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 78.

## **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 [70](#) contains definitions of terms specific to the SPC-1 Data Repository.

### **Storage Capacities and Relationships**

#### **Clause 9.4.3.6.1**

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

#### **SPC-1 Storage Capacities**

The Physical Storage Capacity consisted of 19,203.967 GB distributed over 24 solid state devices (SSDs) each with a formatted capacity of 800.165 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 141.734 GB (0.74%) of the Physical Storage Capacity. There was 1,049.153 GB (5.50%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*Mirroring*) capacity was 9,531.123 GB of which 9,006.219 GB was utilized. The total Unused Storage capacity was 1,049.153 GB.

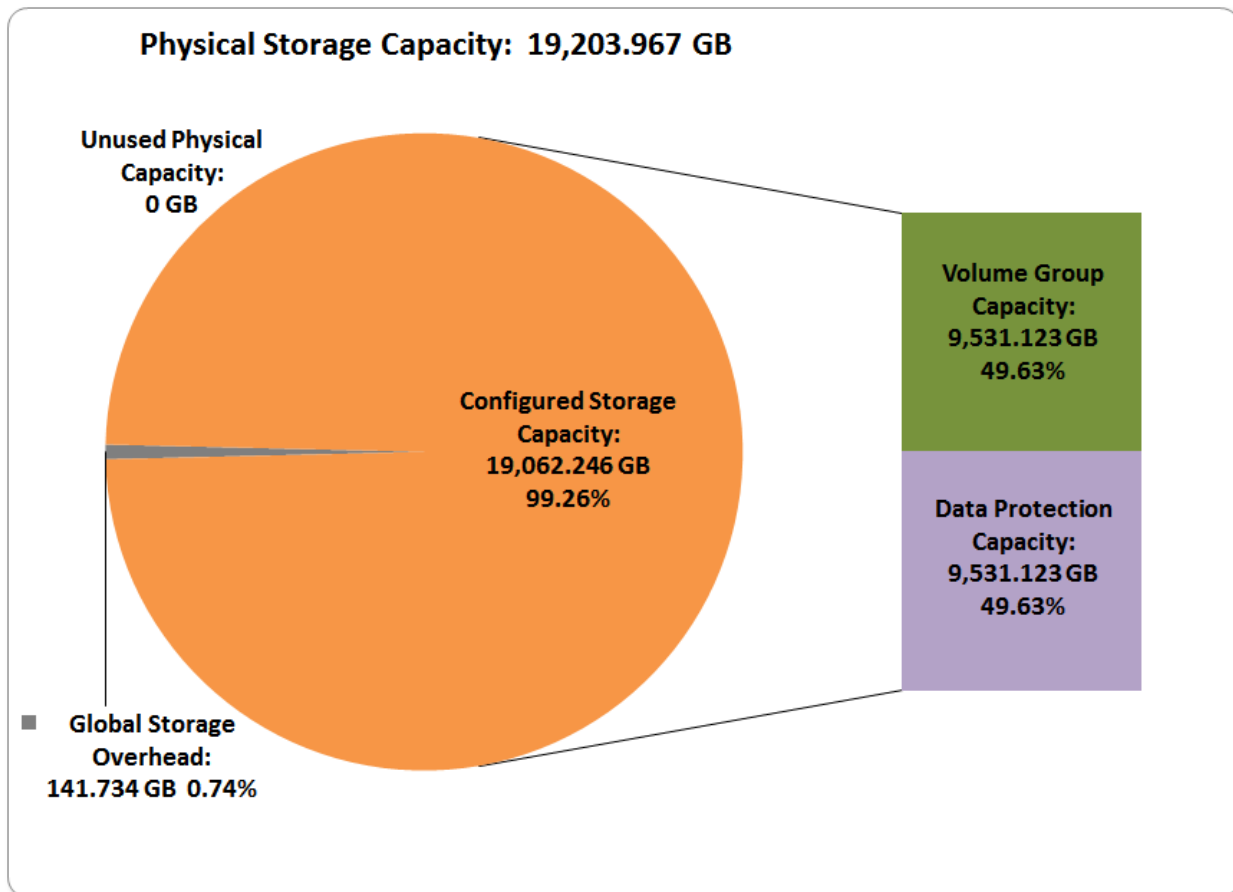
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

<b>SPC-1 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	9,006.219
Addressable Storage Capacity	Gigabytes (GB)	9,006.219
Configured Storage Capacity	Gigabytes (GB)	19,062.246
Physical Storage Capacity	Gigabytes (GB)	19,203.967
Data Protection ( <i>Mirroring</i> )	Gigabytes (GB)	9,531.123
Required Storage ( <i>mirrored metadata/overhead</i> )	Gigabytes (GB)	0.654
Global Storage Overhead	Gigabytes (GB)	141.734
Total Unused Storage	Gigabytes (GB)	1,049.153

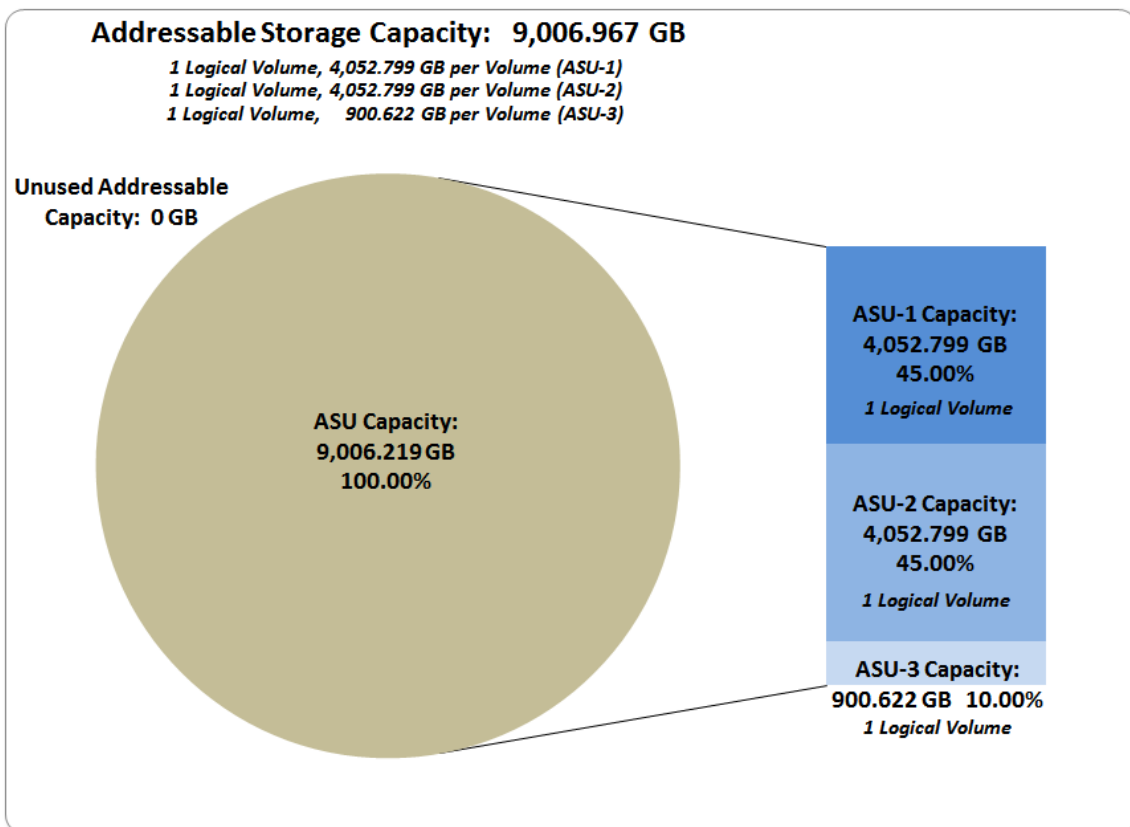
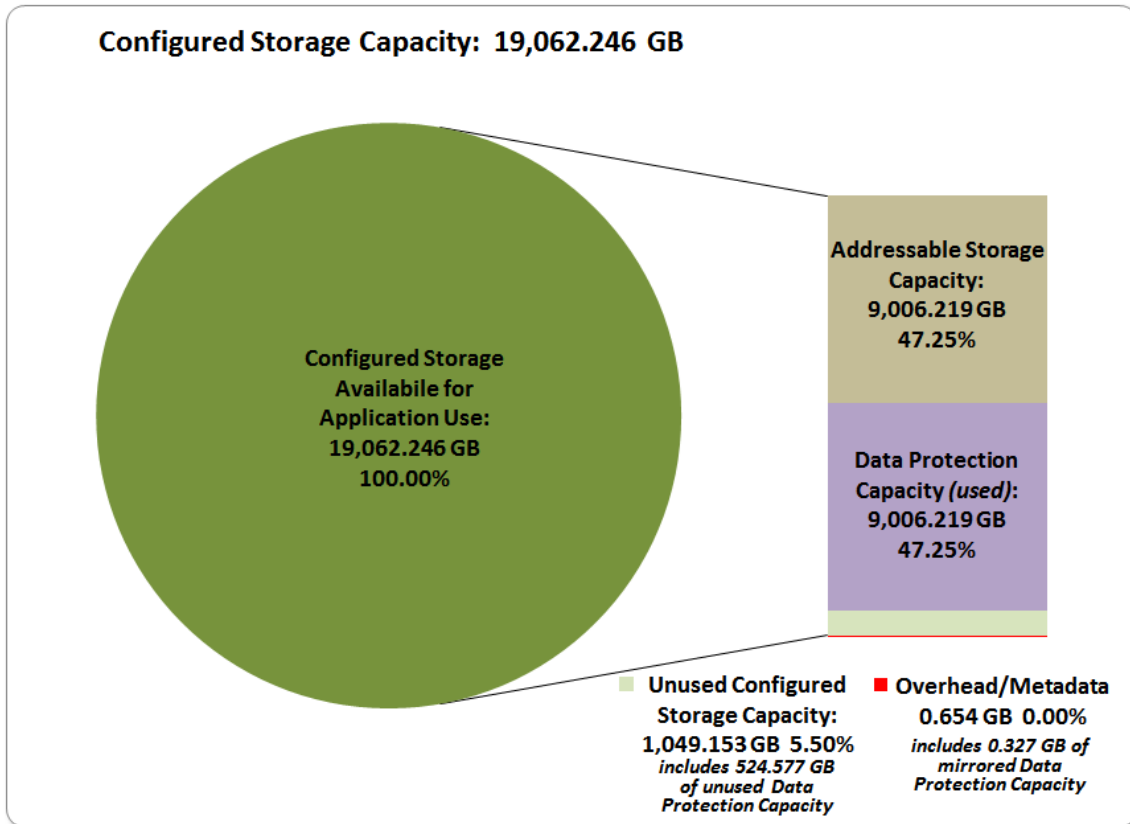
**SPC-1 Storage Hierarchy Ratios**

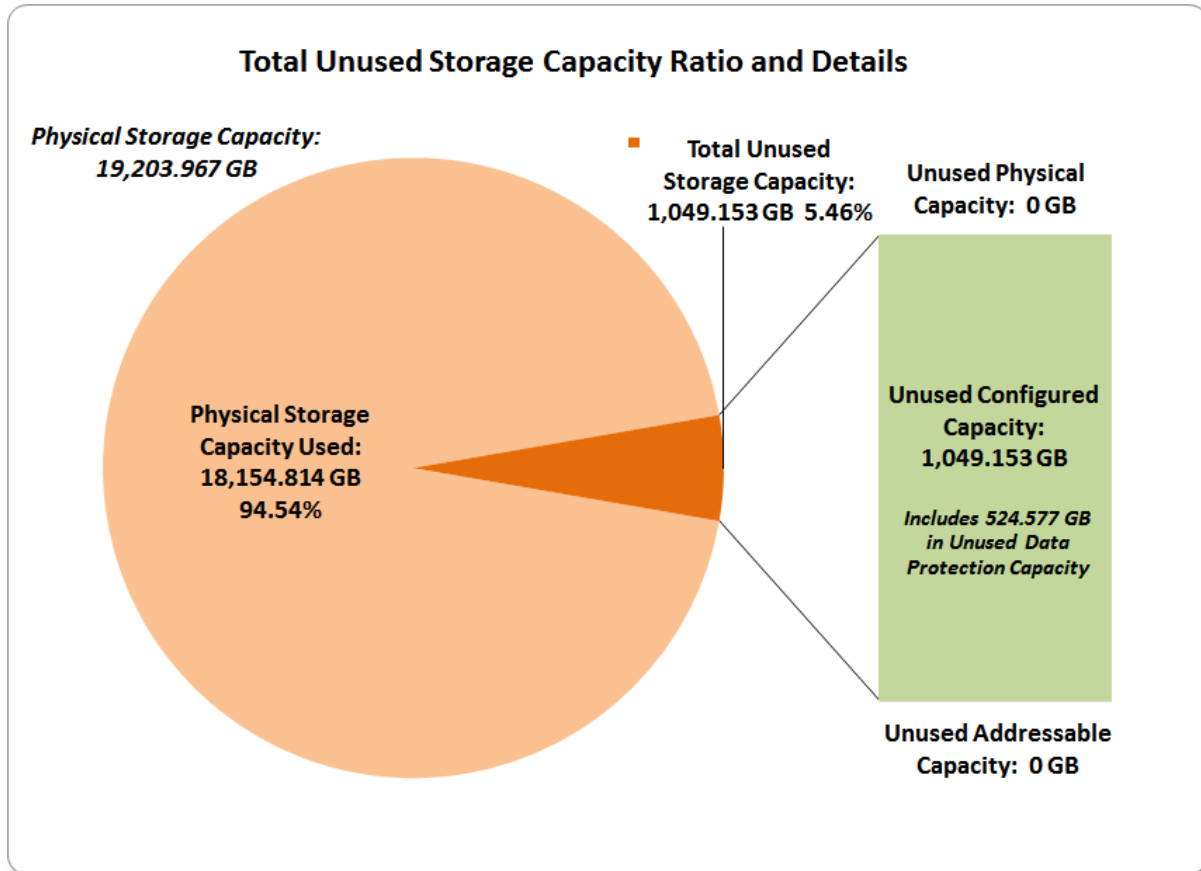
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	47.25%	46.90%
Required for Data Protection ( <i>Mirroring</i> )		50.00%	49.63%
Addressable Storage Capacity		47.25%	46.90%
Required Storage ( <i>mirrored metadata/overhead</i> )		0.003%	0.003%
Configured Storage Capacity			99.26%
Global Storage Overhead			0.74%
Unused Storage:			
Addressable	0.00%		
Configured		5.50%	
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	46.90%
Protected Application Utilization	93.80%
Unused Storage Ratio	5.46%

## 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
<b>ASU-1 (4,052.799 GB)</b>
1 Logical Volume 4,052.799 GB per Logical Volume (4,052.799 GB used per Logical Volume)
<b>ASU-2 (4,052.799 GB)</b>
1 Logical Volume 4,052.799 GB per Logical Volume (4,052.799 GB used per Logical Volume)
<b>ASU-3 (900.622 GB)</b>
1 Logical Volume 900.622 GB per Logical Volume (900.622 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 2](#), which used **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 70 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

### *Clause 5.4.3*

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

## **SPC-1 Tests, Test Phases, and Test Runs**

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

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

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

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

## “Ramp-Up” Test Runs

### Clause 5.3.13

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

### Clause 5.3.13.3

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

### Clause 9.4.3.7.1

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

There were no “Ramp-Up” Test Runs executed.

## Primary Metrics Test – Sustainability Test Phase

### Clause 5.4.4.1.1

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

### Clause 5.4.4.1.2

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

### Clause 5.4.4.1.4

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

### Clause 9.4.3.7.2

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

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

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page 81.

### Sustainability Test Results File

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

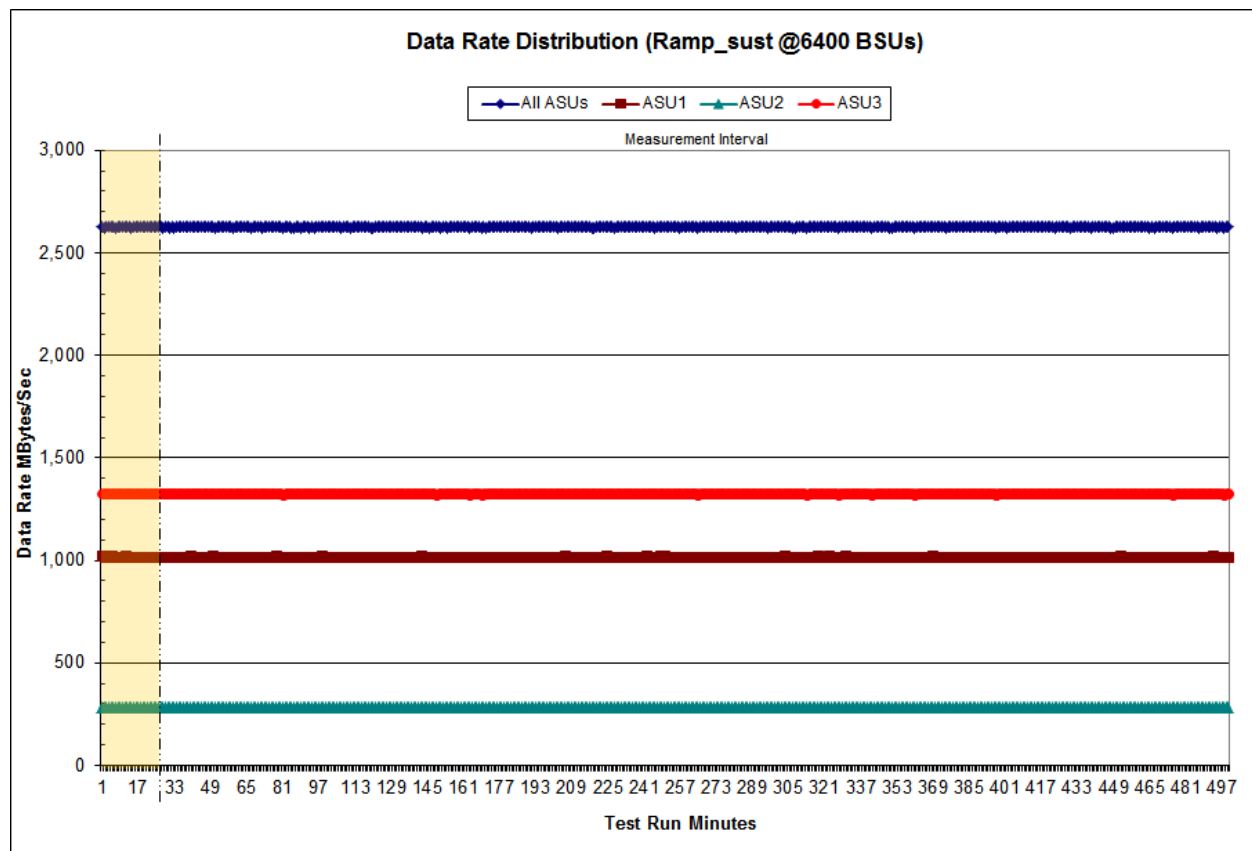
[Sustainability Test Results File](#)

### 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

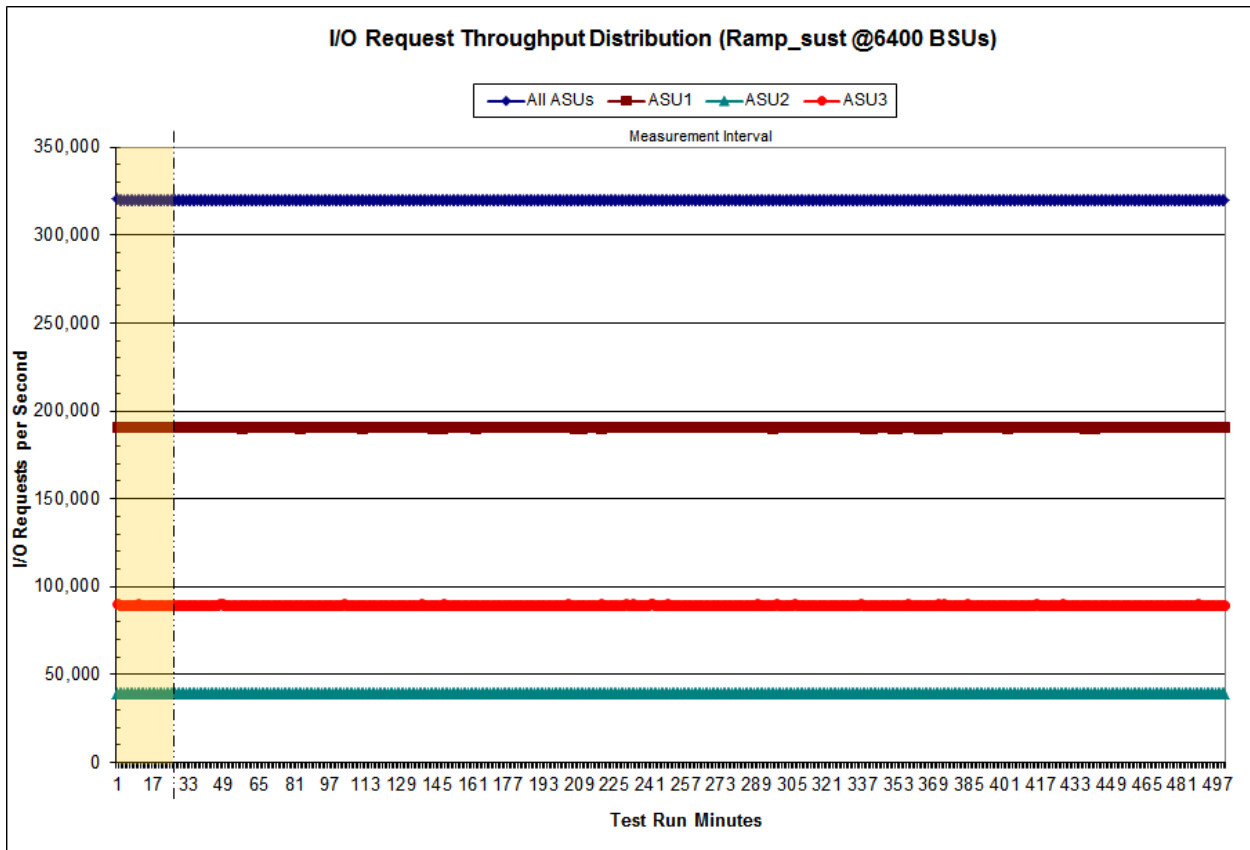


### Sustainability – I/O Request Throughput Distribution Data

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

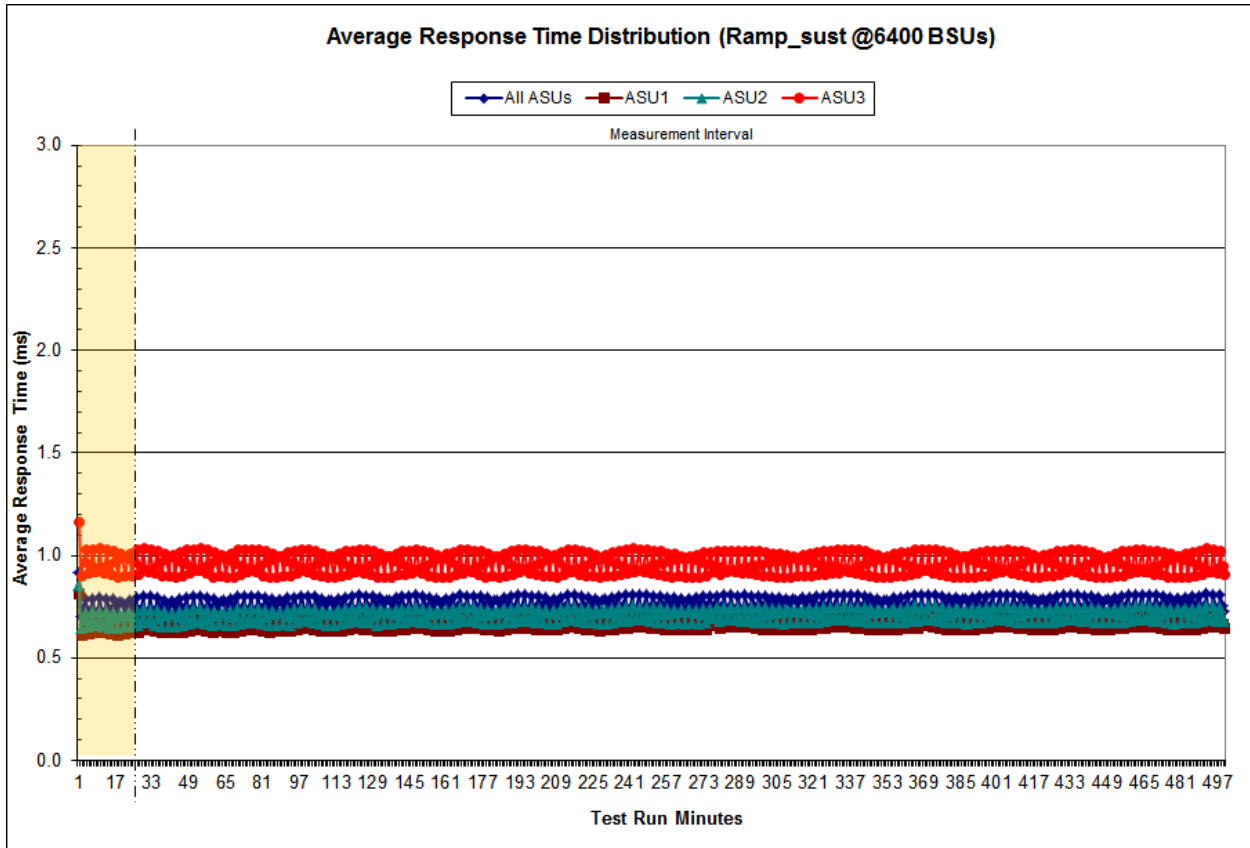


### Sustainability – Average Response Time (ms) Distribution Data

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

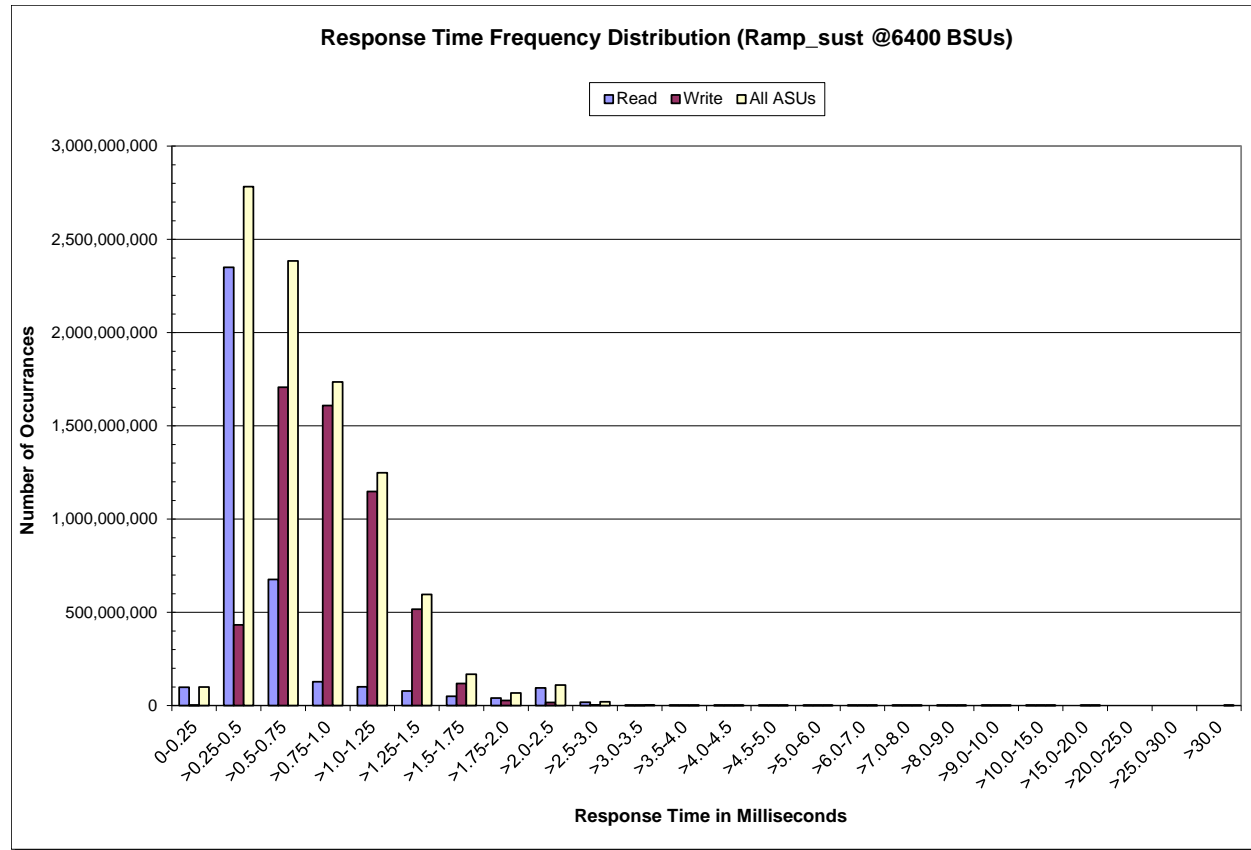




**Sustainability – Response Time Frequency Distribution Data**

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	98,071,021	2,350,198,548	676,650,833	127,540,819	100,175,345	78,322,009	49,928,352	40,752,243
Write	1,259,325	432,502,351	1,707,458,015	1,608,452,351	1,148,449,545	517,100,631	118,459,421	27,175,459
All ASUs	99,330,346	2,782,700,899	2,384,108,848	1,735,993,170	1,248,624,890	595,422,640	168,387,773	67,927,702
ASU1	87,993,945	2,268,427,864	1,448,452,762	782,459,911	487,443,637	208,348,309	70,244,429	41,112,264
ASU2	11,160,924	408,812,523	326,650,312	181,354,766	112,128,685	47,341,098	15,087,789	8,533,158
ASU3	175,477	105,460,512	609,005,774	772,178,493	649,052,568	339,733,233	83,055,555	18,282,280
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	94,344,115	17,408,539	950,385	190,887	82,678	26,456	17,223	6,860
Write	16,181,604	2,305,806	1,172,673	342,026	131,068	27,472	18,938	13,014
All ASUs	110,525,719	19,714,345	2,123,058	532,913	213,746	53,928	36,161	19,874
ASU1	82,264,613	14,272,268	1,160,709	264,828	108,882	29,734	21,213	11,157
ASU2	17,974,690	4,100,805	308,123	67,682	27,279	7,588	4,941	2,365
ASU3	10,286,416	1,341,272	654,226	200,403	77,585	16,606	10,007	6,352
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	3,608	1,583	1,160	677	223	97	32	141
Write	8,936	3,205	1,908	1,722	449	192	84	345
All ASUs	12,544	4,788	3,068	2,399	672	289	116	486
ASU1	6,532	2,553	1,760	1,239	378	166	70	305
ASU2	1,470	565	370	258	70	36	19	52
ASU3	4,542	1,670	938	902	224	87	27	129

**Sustainability – Response Time Frequency Distribution Graph**



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

## Primary Metrics Test – IOPS Test Phase

### Clause 5.4.4.2

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

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

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

### Clause 9.4.3.7.3

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [81](#).

## IOPS Test Results File

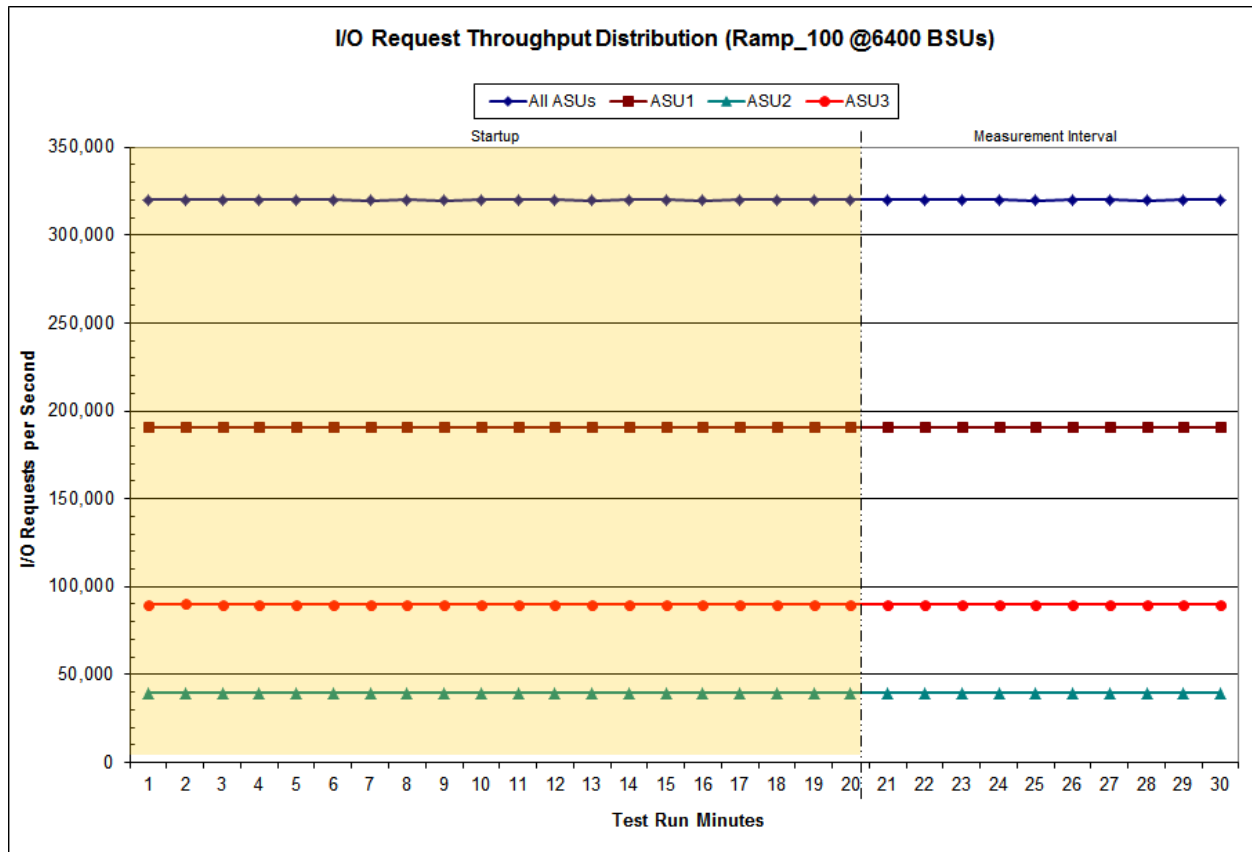
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

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

<b>6,400 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<i>Start-Up/Ramp-Up</i>	23:29:18	23:49:19	0-19	0:20:01
<i>Measurement Interval</i>	23:49:19	23:59:19	20-29	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	320,000.28	190,692.70	39,365.92	89,941.67
<b>1</b>	319,977.00	190,677.85	39,318.95	89,980.20
<b>2</b>	320,040.22	190,756.67	39,359.73	89,923.82
<b>3</b>	320,036.30	190,772.98	39,401.75	89,861.57
<b>4</b>	319,949.35	190,639.45	39,332.73	89,977.17
<b>5</b>	320,056.28	190,718.17	39,397.78	89,940.33
<b>6</b>	319,903.77	190,685.22	39,334.30	89,884.25
<b>7</b>	320,085.43	190,754.83	39,369.13	89,961.47
<b>8</b>	319,943.55	190,676.15	39,369.83	89,897.57
<b>9</b>	320,126.47	190,783.50	39,369.92	89,973.05
<b>10</b>	319,992.73	190,685.30	39,362.63	89,944.80
<b>11</b>	320,063.93	190,715.42	39,384.18	89,964.33
<b>12</b>	319,928.37	190,672.13	39,371.30	89,884.93
<b>13</b>	319,990.78	190,707.03	39,373.98	89,909.77
<b>14</b>	319,994.33	190,714.70	39,355.02	89,924.62
<b>15</b>	319,907.87	190,658.28	39,348.82	89,900.77
<b>16</b>	320,024.10	190,725.08	39,364.60	89,934.42
<b>17</b>	319,992.88	190,720.63	39,353.77	89,918.48
<b>18</b>	320,034.58	190,773.80	39,356.72	89,904.07
<b>19</b>	319,995.85	190,733.32	39,391.02	89,871.52
<b>20</b>	320,073.33	190,793.28	39,419.20	89,860.85
<b>21</b>	319,968.25	190,694.68	39,368.08	89,905.48
<b>22</b>	320,004.08	190,717.72	39,368.05	89,918.32
<b>23</b>	320,025.47	190,749.68	39,318.85	89,956.93
<b>24</b>	319,895.90	190,617.63	39,339.37	89,938.90
<b>25</b>	319,947.93	190,658.57	39,373.43	89,915.93
<b>26</b>	319,982.05	190,634.35	39,403.53	89,944.17
<b>27</b>	319,860.62	190,691.77	39,286.27	89,882.58
<b>28</b>	319,996.03	190,725.97	39,344.13	89,925.93
<b>29</b>	320,049.15	190,708.37	39,402.10	89,938.68
<b>Average</b>	<b>319,980.28</b>	<b>190,699.20</b>	<b>39,362.30</b>	<b>89,918.78</b>

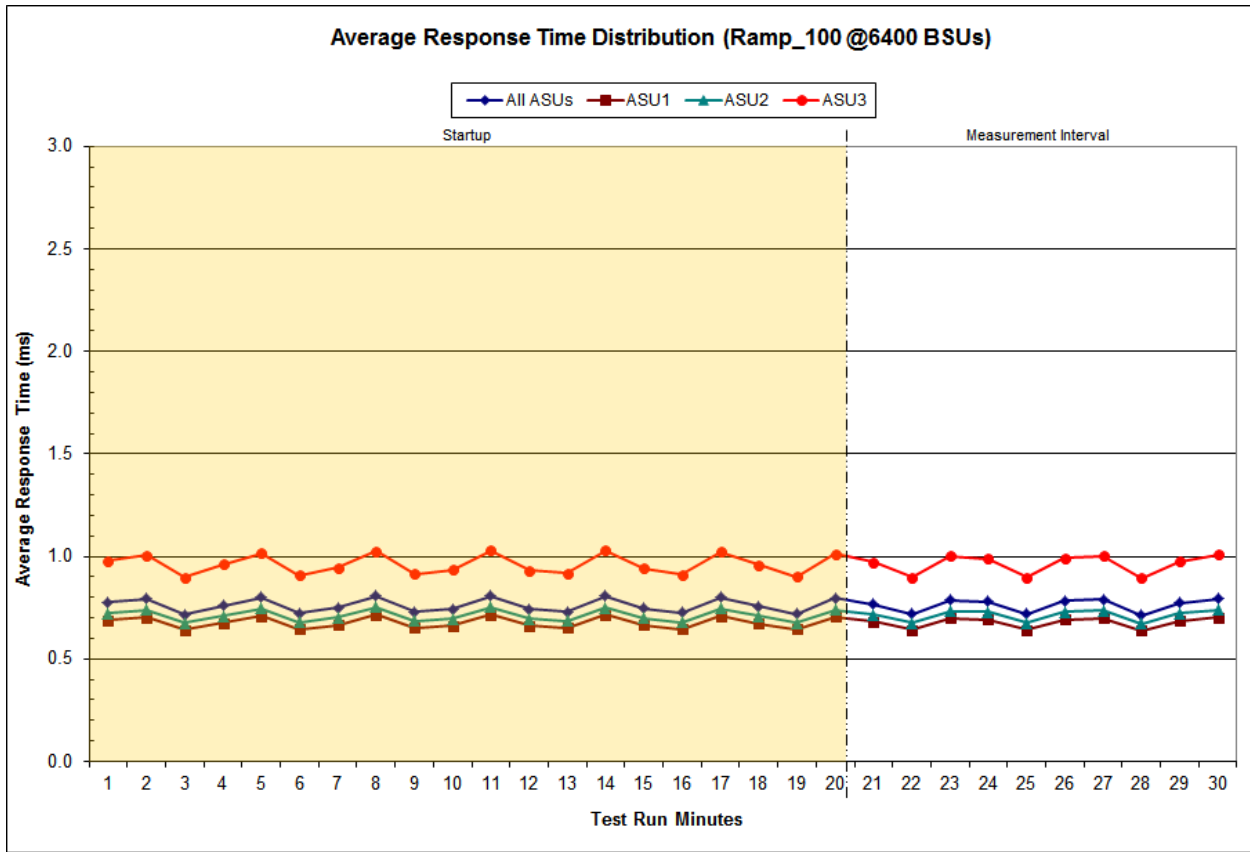
### IOPS Test Run – I/O Request Throughput Distribution Graph



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

<b>6,400 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	23:29:18	23:49:19	0-19	0:20:01
<b>Measurement Interval</b>	23:49:19	23:59:19	20-29	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	0.78	0.69	0.72	0.98
<b>1</b>	0.79	0.70	0.74	1.01
<b>2</b>	0.72	0.64	0.67	0.90
<b>3</b>	0.76	0.68	0.71	0.96
<b>4</b>	0.80	0.71	0.75	1.02
<b>5</b>	0.72	0.64	0.68	0.91
<b>6</b>	0.75	0.67	0.70	0.94
<b>7</b>	0.81	0.71	0.75	1.03
<b>8</b>	0.73	0.65	0.68	0.92
<b>9</b>	0.74	0.66	0.70	0.93
<b>10</b>	0.81	0.71	0.75	1.03
<b>11</b>	0.74	0.66	0.70	0.93
<b>12</b>	0.73	0.65	0.69	0.92
<b>13</b>	0.81	0.71	0.75	1.03
<b>14</b>	0.75	0.66	0.70	0.94
<b>15</b>	0.72	0.65	0.68	0.91
<b>16</b>	0.80	0.71	0.75	1.02
<b>17</b>	0.76	0.67	0.71	0.96
<b>18</b>	0.72	0.64	0.68	0.90
<b>19</b>	0.80	0.70	0.74	1.01
<b>20</b>	0.77	0.68	0.72	0.97
<b>21</b>	0.72	0.64	0.67	0.90
<b>22</b>	0.79	0.70	0.73	1.00
<b>23</b>	0.78	0.69	0.73	0.99
<b>24</b>	0.72	0.64	0.67	0.90
<b>25</b>	0.78	0.69	0.73	0.99
<b>26</b>	0.79	0.70	0.74	1.00
<b>27</b>	0.71	0.64	0.67	0.89
<b>28</b>	0.77	0.69	0.72	0.98
<b>29</b>	0.79	0.70	0.74	1.01
<b>Average</b>	<b>0.76</b>	<b>0.68</b>	<b>0.71</b>	<b>0.96</b>

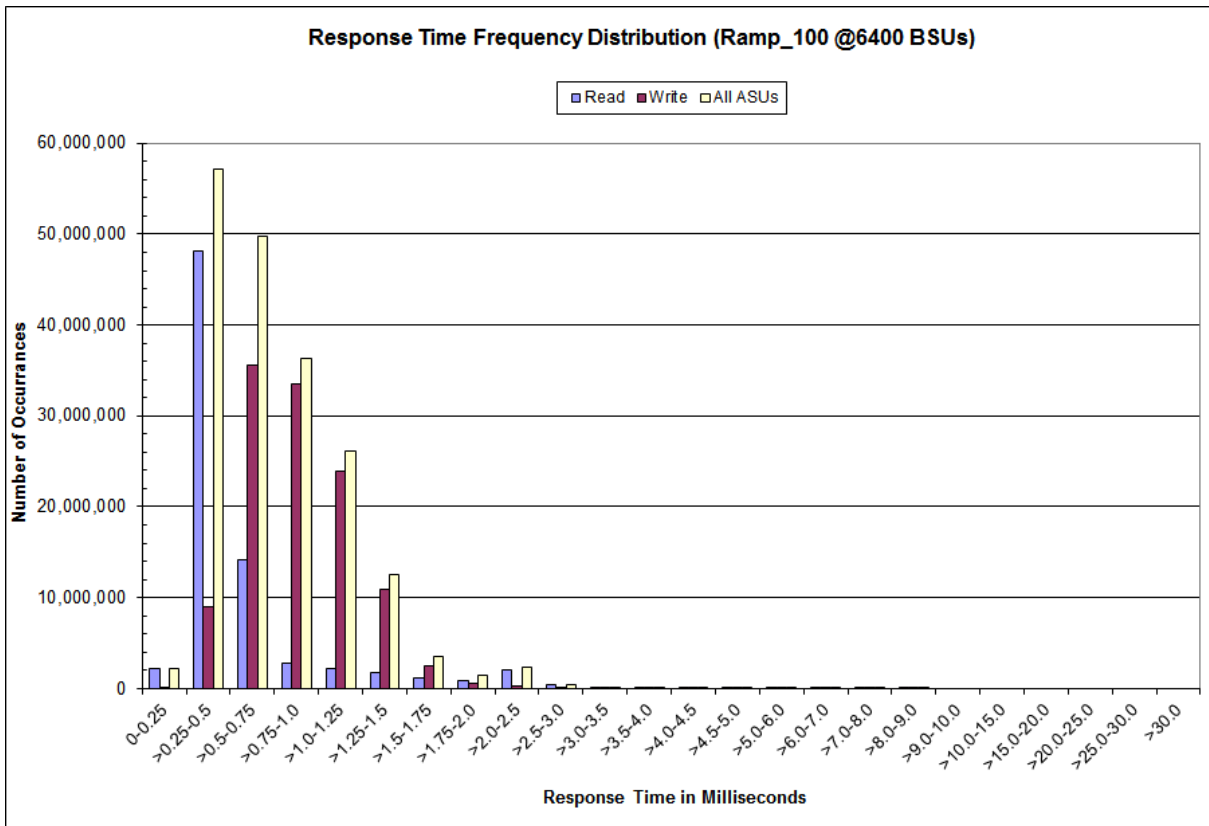
### IOPS Test Run – Average Response Time (ms) Distribution Graph



**IOPS Test Run –Response Time Frequency Distribution Data**

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	2,199,465	48,210,965	14,229,941	2,740,416	2,159,664	1,715,664	1,088,376	886,293
Write	25,382	8,927,035	35,526,463	33,532,291	23,930,378	10,889,145	2,468,360	564,291
All ASUs	2,224,847	57,138,000	49,756,404	36,272,707	26,090,042	12,604,809	3,556,736	1,450,584
ASU1	1,998,782	46,557,633	30,271,502	16,404,085	10,224,305	4,438,102	1,500,832	885,816
ASU2	222,620	8,400,483	6,831,841	3,799,736	2,352,302	1,008,206	322,831	185,216
ASU3	3,445	2,179,884	12,653,061	16,068,886	13,513,435	7,158,501	1,733,073	379,552
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	2,057,440	390,398	21,158	3,752	1,526	442	214	57
Write	337,207	48,818	23,672	6,608	1,855	207	133	126
All ASUs	2,394,647	439,216	44,830	10,360	3,381	649	347	183
ASU1	1,786,994	318,613	24,937	5,232	1,724	407	224	100
ASU2	393,477	92,057	6,603	1,273	494	110	60	19
ASU3	214,176	28,546	13,290	3,855	1,163	132	63	64
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	43	9	5	0	0	0	0	0
Write	103	13	0	0	0	0	3	2
All ASUs	146	22	5	0	0	0	3	2
ASU1	72	13	4	0	0	0	3	2
ASU2	18	2	1	0	0	0	0	0
ASU3	56	7	0	0	0	0	0	0

**IOPS Test Run –Response Time Frequency Distribution Graph**





### IOPS Test Run – I/O Request Information

<b>I/O Requests Completed in the Measurement Interval</b>
191,987,920
<b>I/O Requests Completed with Response Time = or &lt; 30 ms</b>
191,987,918
<b>I/O Requests Completed with Response Time &gt; 30 ms</b>
2

### 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>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.002	0.001	0.001	0.000

## Primary Metrics Test – Response Time Ramp Test Phase

### Clause 5.4.4.3

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

*The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 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 [81](#).

## 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](#)

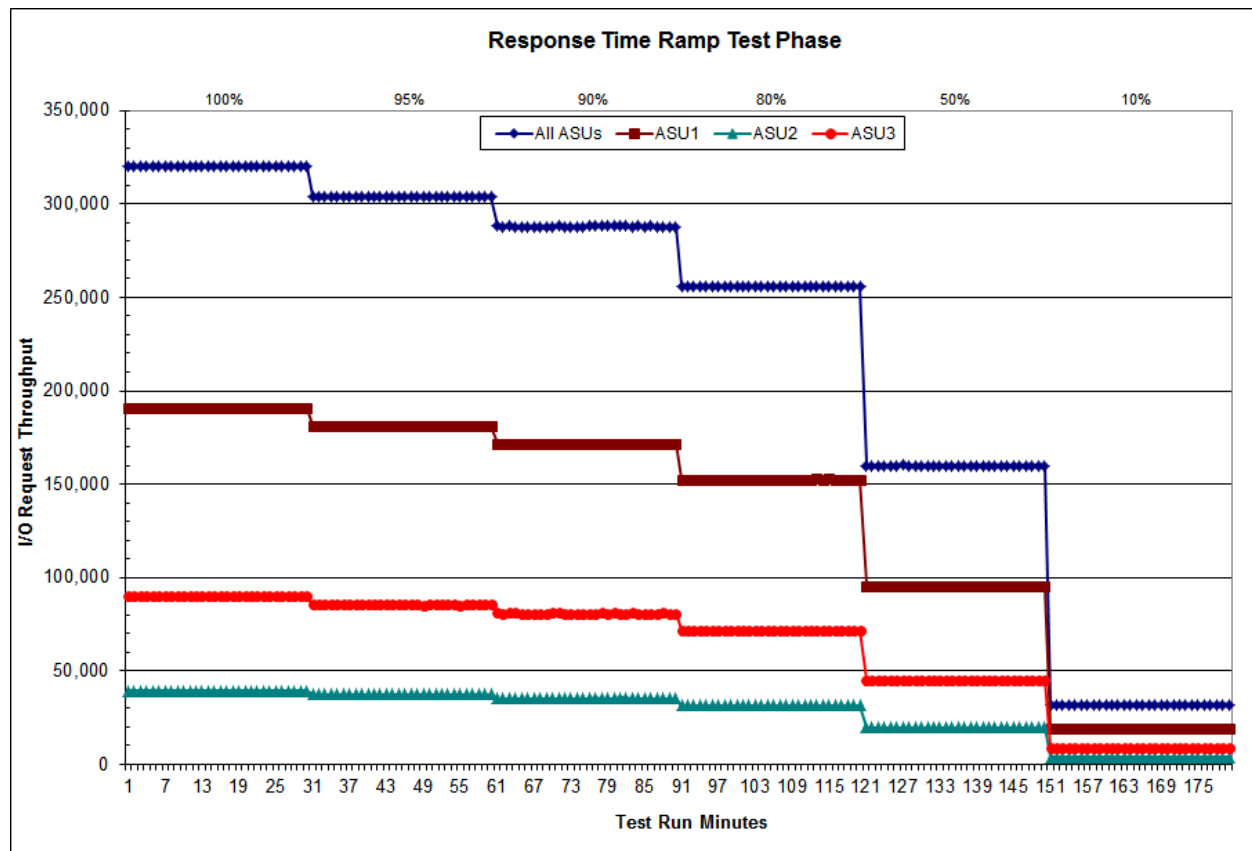
### Response Time Ramp Distribution (IOPS) Data

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.

The Response Time Ramp Distribution (IOPS) Data table is not embedded in this document due to its size. The table is available via the following URL:

### Response Time Ramp Distribution (IOPS) Data Table

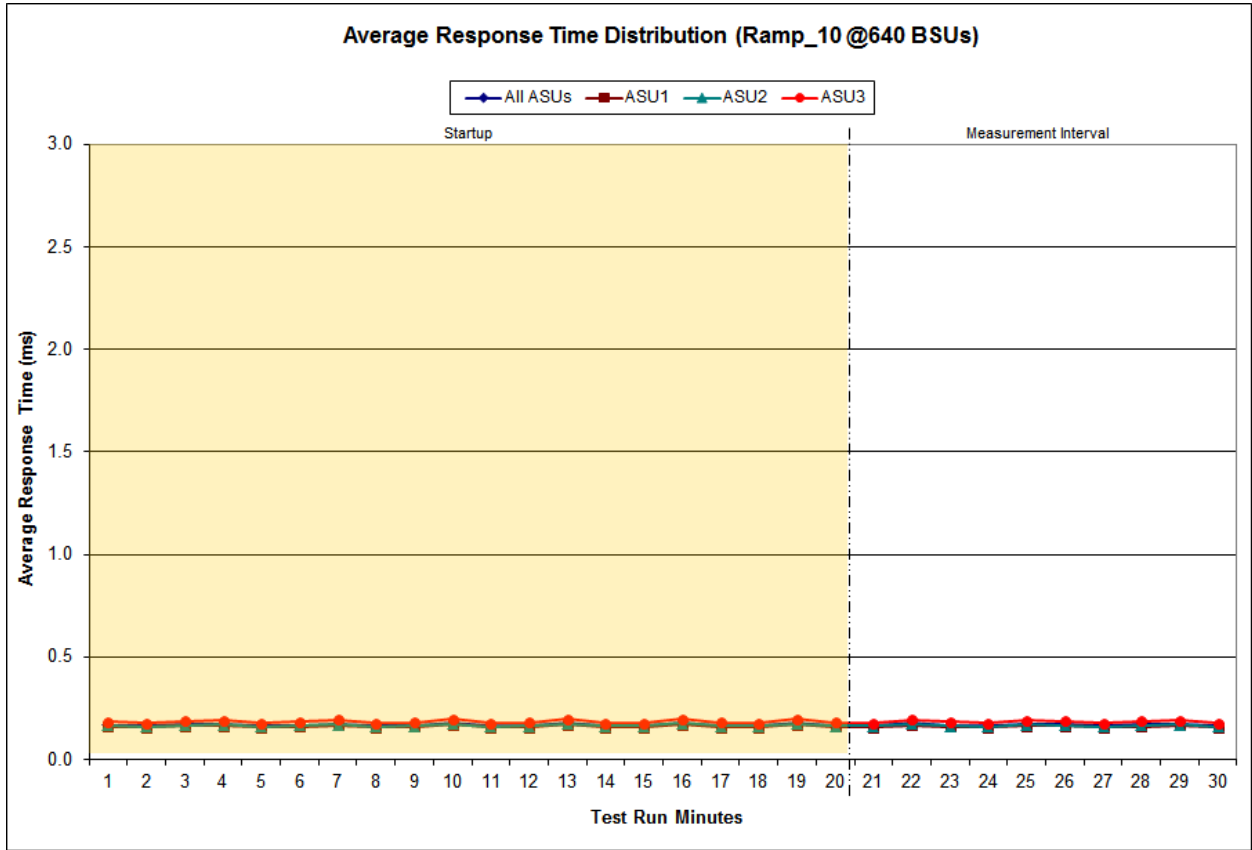
### Response Time Ramp Distribution (IOPS) Graph



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

1,210 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	2:03:03	2:23:04	0-19	0:20:01
<i>Measurement Interval</i>	2:23:04	2:33:04	20-29	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.17	0.16	0.17	0.18
1	0.16	0.16	0.16	0.18
2	0.17	0.16	0.17	0.19
3	0.17	0.16	0.17	0.19
4	0.16	0.16	0.16	0.18
5	0.17	0.16	0.17	0.18
6	0.17	0.17	0.17	0.19
7	0.16	0.16	0.16	0.18
8	0.17	0.16	0.16	0.18
9	0.18	0.17	0.17	0.20
10	0.16	0.16	0.16	0.18
11	0.16	0.16	0.16	0.18
12	0.18	0.17	0.17	0.20
13	0.16	0.16	0.16	0.18
14	0.16	0.16	0.16	0.18
15	0.18	0.17	0.18	0.20
16	0.16	0.16	0.16	0.18
17	0.16	0.16	0.16	0.18
18	0.18	0.17	0.17	0.20
19	0.16	0.16	0.16	0.18
20	0.16	0.16	0.16	0.18
21	0.18	0.17	0.17	0.19
22	0.17	0.16	0.16	0.18
23	0.16	0.16	0.16	0.18
24	0.17	0.16	0.17	0.19
25	0.17	0.16	0.17	0.19
26	0.16	0.16	0.16	0.18
27	0.17	0.16	0.17	0.19
28	0.17	0.16	0.17	0.19
29	0.16	0.16	0.16	0.18
<b>Average</b>	<b>0.17</b>	<b>0.16</b>	<b>0.17</b>	<b>0.18</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>	<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	0.0700	0.2099	0.0180	0.0700	0.0350	0.2809
COV	0.005	0.001	0.003	0.002	0.008	0.003	0.004	0.001

## Repeatability Test

### Clause 5.4.5

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

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

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

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

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

### Clause 9.4.3.7.5

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [81](#).

### 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>319,980.28</b>
<b>Repeatability Test Phase 1</b>	320,000.09
<b>Repeatability Test Phase 2</b>	319,975.76

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>0.17</b>
<b>Repeatability Test Phase 1</b>	0.17
<b>Repeatability Test Phase 2</b>	0.17

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 \(LRT\)](#)

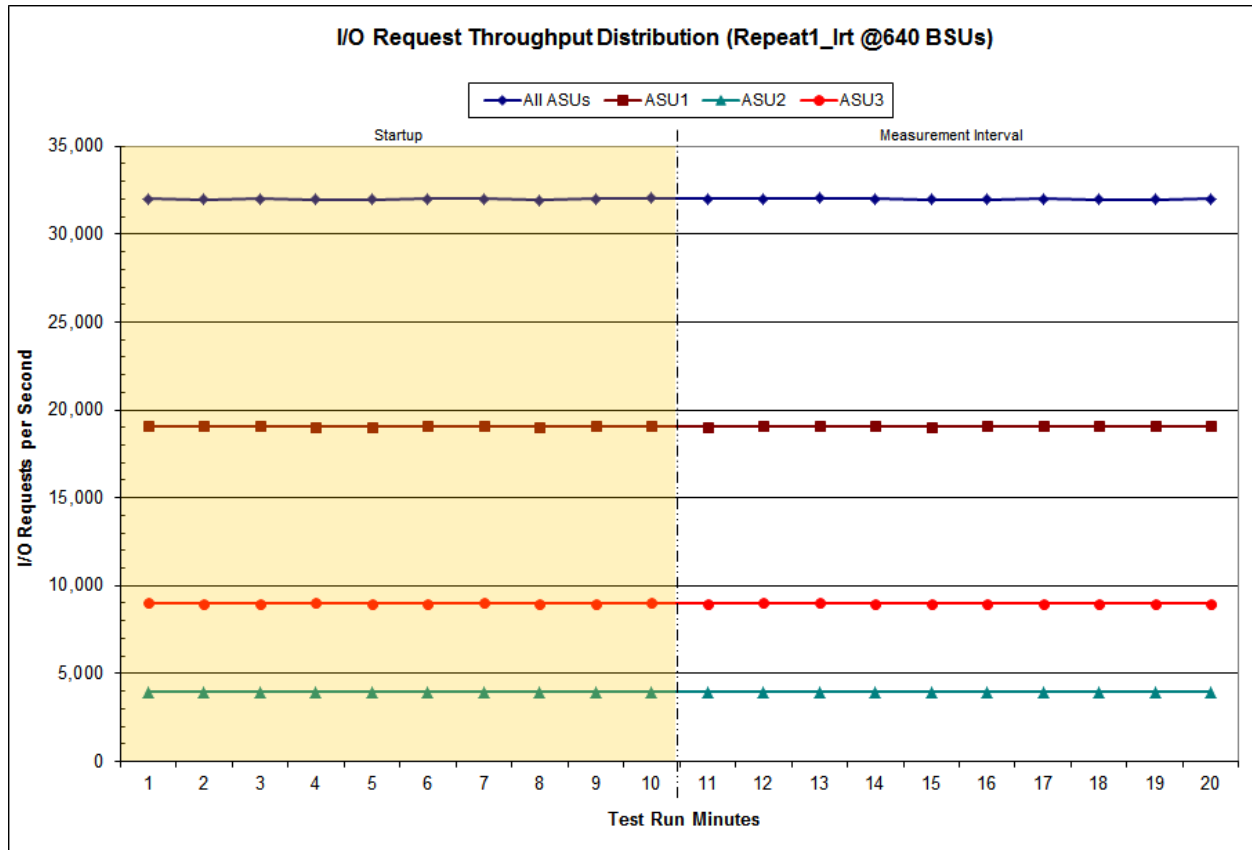
[Repeatability Test Phase 2, Test Run 2 \(IOPS\)](#)



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

<b>640 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	2:33:48	2:43:48	0-9	0:10:00
<b>Measurement Interval</b>	2:43:48	2:53:48	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	32,013.20	19,077.35	3,934.77	9,001.08
<b>1</b>	31,985.82	19,067.07	3,934.62	8,984.13
<b>2</b>	32,014.30	19,094.12	3,928.27	8,991.92
<b>3</b>	31,989.85	19,041.03	3,944.30	9,004.52
<b>4</b>	31,972.92	19,050.85	3,949.28	8,972.78
<b>5</b>	32,005.93	19,094.12	3,933.08	8,978.73
<b>6</b>	32,007.83	19,070.42	3,939.02	8,998.40
<b>7</b>	31,923.88	19,032.70	3,927.67	8,963.52
<b>8</b>	32,017.62	19,088.87	3,938.38	8,990.37
<b>9</b>	32,059.70	19,079.47	3,963.98	9,016.25
<b>10</b>	31,994.43	19,057.85	3,943.13	8,993.45
<b>11</b>	32,017.78	19,066.38	3,953.02	8,998.38
<b>12</b>	32,038.45	19,069.52	3,940.20	9,028.73
<b>13</b>	32,014.87	19,081.60	3,937.28	8,995.98
<b>14</b>	31,985.57	19,058.52	3,934.27	8,992.78
<b>15</b>	31,969.42	19,067.72	3,929.30	8,972.40
<b>16</b>	32,001.17	19,077.27	3,927.57	8,996.33
<b>17</b>	31,992.60	19,063.12	3,937.95	8,991.53
<b>18</b>	31,977.92	19,070.50	3,931.70	8,975.72
<b>19</b>	32,004.45	19,080.02	3,934.92	8,989.52
<b>Average</b>	<b>31,999.67</b>	<b>19,069.25</b>	<b>3,936.93</b>	<b>8,993.48</b>

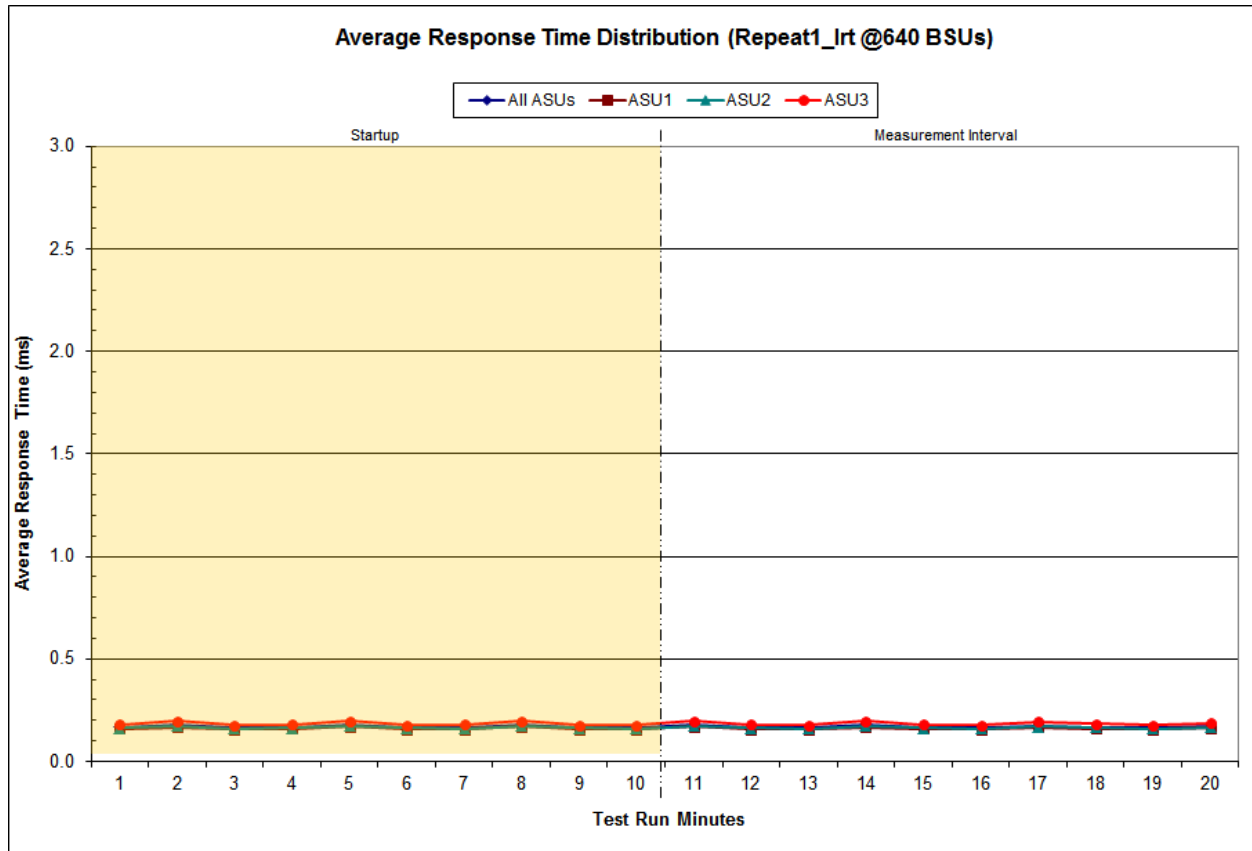
### Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

<b>640 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	2:33:48	2:43:48	0-9	0:10:00
<b>Measurement Interval</b>	2:43:48	2:53:48	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	0.17	0.16	0.16	0.18
<b>1</b>	0.18	0.17	0.17	0.20
<b>2</b>	0.16	0.16	0.16	0.18
<b>3</b>	0.17	0.16	0.16	0.18
<b>4</b>	0.18	0.17	0.17	0.20
<b>5</b>	0.16	0.16	0.16	0.18
<b>6</b>	0.16	0.16	0.16	0.18
<b>7</b>	0.18	0.17	0.17	0.20
<b>8</b>	0.16	0.16	0.16	0.18
<b>9</b>	0.16	0.16	0.16	0.18
<b>10</b>	0.18	0.17	0.17	0.20
<b>11</b>	0.16	0.16	0.16	0.18
<b>12</b>	0.16	0.16	0.16	0.18
<b>13</b>	0.18	0.17	0.17	0.20
<b>14</b>	0.17	0.16	0.16	0.18
<b>15</b>	0.16	0.16	0.16	0.18
<b>16</b>	0.17	0.17	0.17	0.19
<b>17</b>	0.17	0.16	0.17	0.18
<b>18</b>	0.16	0.16	0.16	0.18
<b>19</b>	0.17	0.16	0.17	0.19
<b>Average</b>	<b>0.17</b>	<b>0.16</b>	<b>0.17</b>	<b>0.19</b>

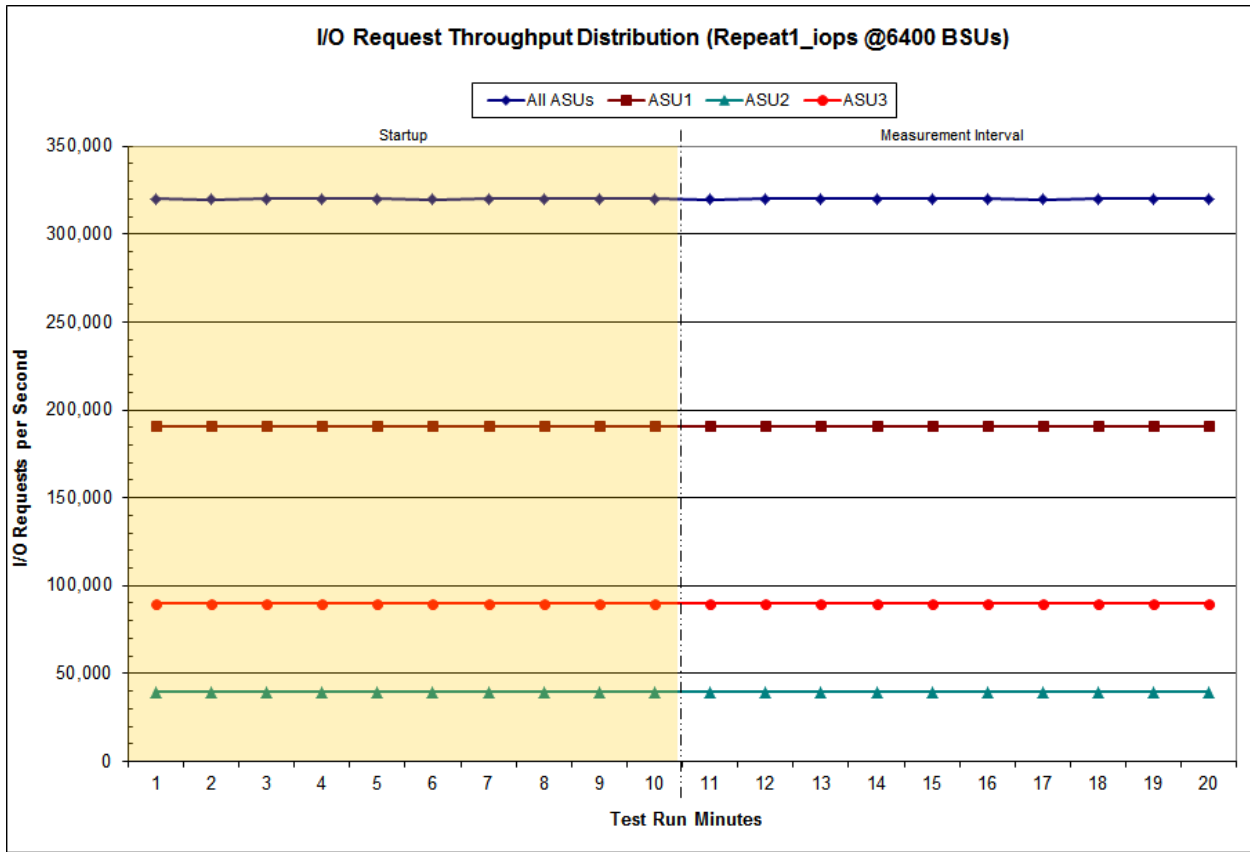
### Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



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

<b>6,400 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	2:54:41	3:04:42	0-9	0:10:01
<b>Measurement Interval</b>	3:04:42	3:14:42	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	319,999.45	190,759.75	39,348.28	89,891.42
<b>1</b>	319,936.32	190,630.22	39,393.72	89,912.38
<b>2</b>	320,004.28	190,725.02	39,349.72	89,929.55
<b>3</b>	319,979.08	190,774.17	39,376.72	89,828.20
<b>4</b>	320,018.18	190,734.38	39,356.28	89,927.52
<b>5</b>	319,911.57	190,714.85	39,326.48	89,870.23
<b>6</b>	320,078.48	190,719.00	39,386.47	89,973.02
<b>7</b>	320,024.35	190,747.22	39,327.80	89,949.33
<b>8</b>	319,967.22	190,732.05	39,361.67	89,873.50
<b>9</b>	320,023.70	190,736.42	39,374.57	89,912.72
<b>10</b>	319,889.67	190,654.82	39,320.45	89,914.40
<b>11</b>	319,957.48	190,640.48	39,404.18	89,912.82
<b>12</b>	319,992.82	190,751.77	39,313.38	89,927.67
<b>13</b>	319,996.30	190,740.32	39,351.30	89,904.68
<b>14</b>	320,000.93	190,703.73	39,342.38	89,954.82
<b>15</b>	320,051.88	190,715.82	39,385.15	89,950.92
<b>16</b>	319,922.37	190,652.88	39,319.07	89,950.42
<b>17</b>	320,092.48	190,691.02	39,421.60	89,979.87
<b>18</b>	320,062.33	190,731.60	39,380.50	89,950.23
<b>19</b>	320,034.67	190,736.83	39,323.78	89,974.05
<b>Average</b>	<b>320,000.09</b>	<b>190,701.93</b>	<b>39,356.18</b>	<b>89,941.99</b>

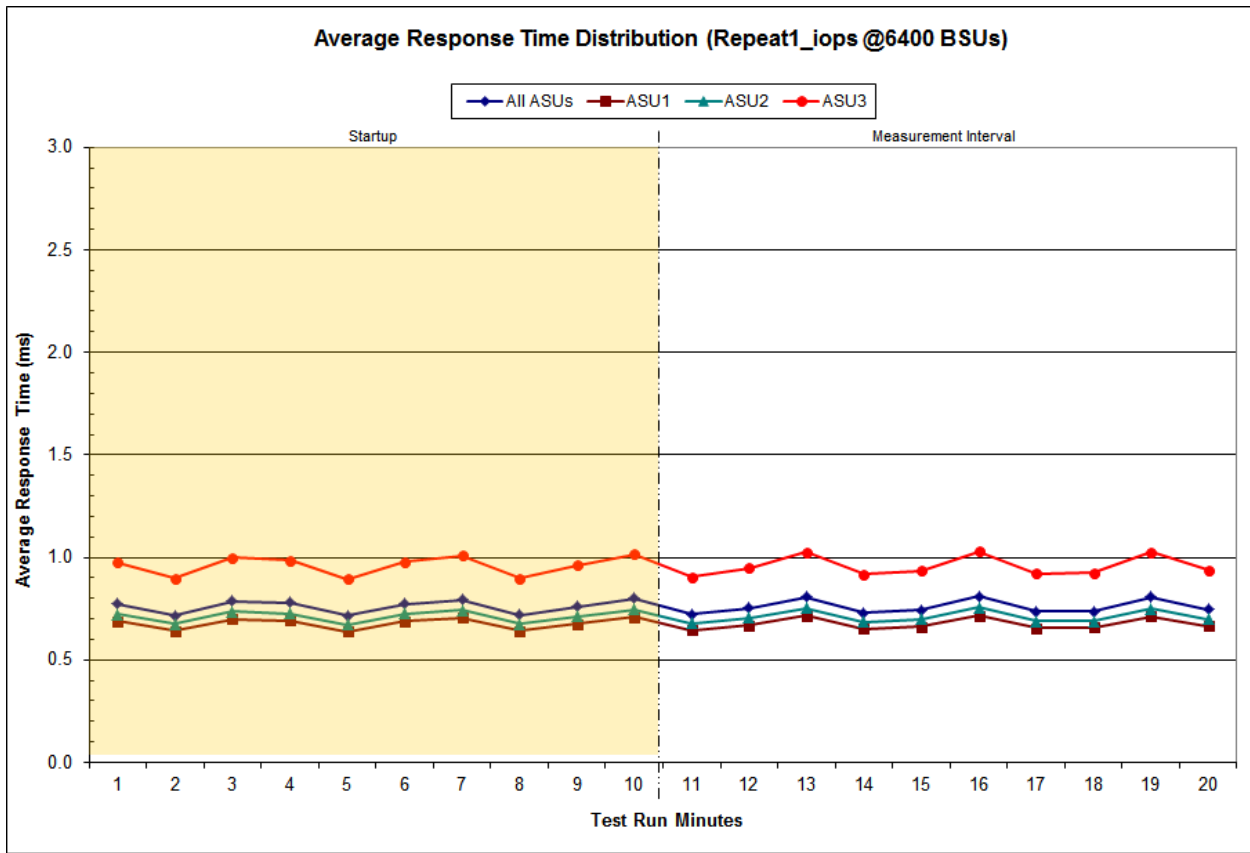
### Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

<b>6,400 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	2:54:41	3:04:42	0-9	0:10:01
<b>Measurement Interval</b>	3:04:42	3:14:42	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	0.77	0.69	0.72	0.98
<b>1</b>	0.72	0.64	0.67	0.90
<b>2</b>	0.79	0.70	0.74	1.00
<b>3</b>	0.78	0.69	0.73	0.99
<b>4</b>	0.72	0.64	0.67	0.89
<b>5</b>	0.77	0.69	0.72	0.98
<b>6</b>	0.79	0.70	0.74	1.01
<b>7</b>	0.72	0.64	0.68	0.90
<b>8</b>	0.76	0.68	0.71	0.96
<b>9</b>	0.80	0.71	0.75	1.01
<b>10</b>	0.72	0.65	0.68	0.90
<b>11</b>	0.75	0.67	0.70	0.95
<b>12</b>	0.81	0.71	0.75	1.03
<b>13</b>	0.73	0.65	0.68	0.92
<b>14</b>	0.74	0.66	0.70	0.94
<b>15</b>	0.81	0.72	0.75	1.03
<b>16</b>	0.74	0.66	0.69	0.92
<b>17</b>	0.74	0.66	0.69	0.92
<b>18</b>	0.81	0.71	0.75	1.02
<b>19</b>	0.75	0.67	0.70	0.94
<b>Average</b>	<b>0.76</b>	<b>0.68</b>	<b>0.71</b>	<b>0.96</b>

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

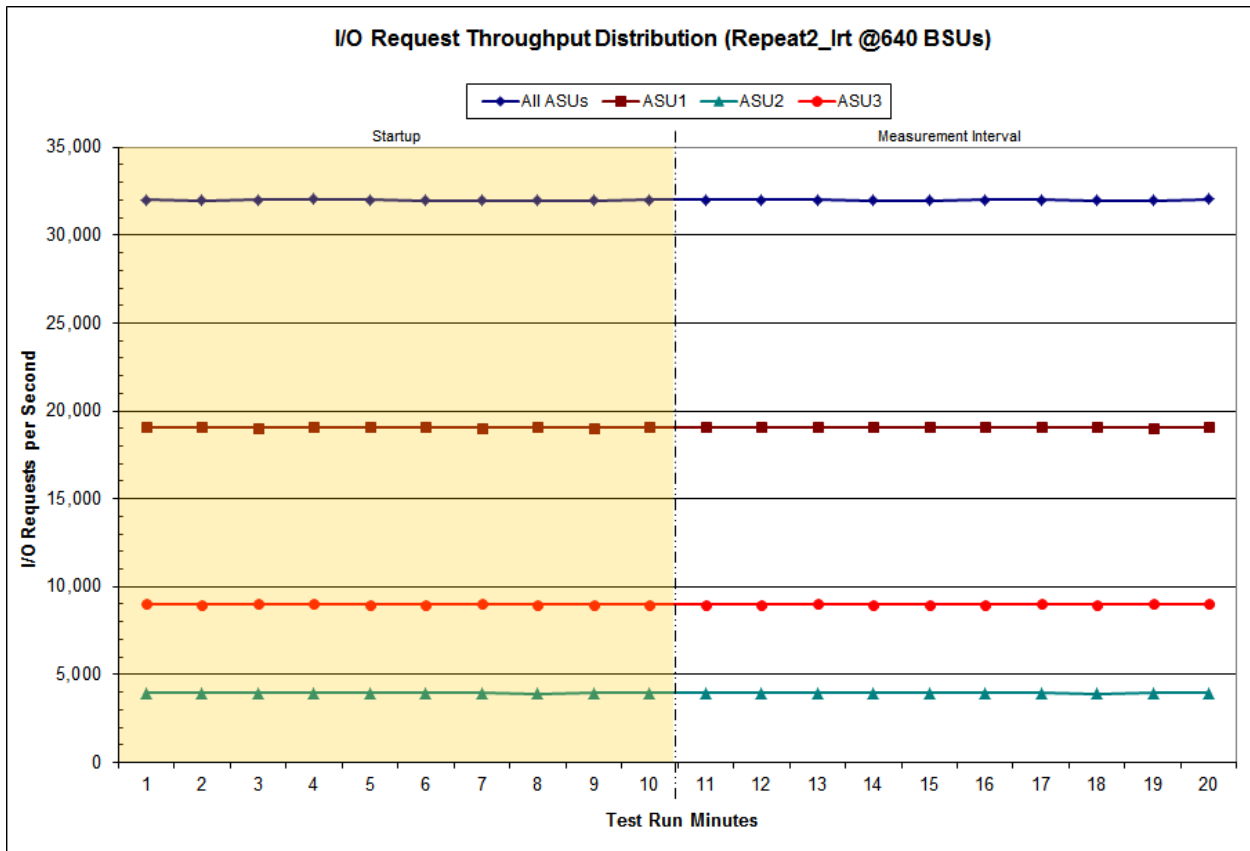




**Repeatability 2 LRT – I/O Request Throughput Distribution Data**

<b>640 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<i>Start-Up/Ramp-Up</i>	3:15:24	3:25:24	0-9	0:10:00
<i>Measurement Interval</i>	3:25:24	3:35:24	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	32,023.65	19,073.33	3,934.30	9,016.02
<b>1</b>	31,990.87	19,066.63	3,939.80	8,984.43
<b>2</b>	31,997.05	19,055.05	3,936.57	9,005.43
<b>3</b>	32,053.33	19,098.90	3,942.52	9,011.92
<b>4</b>	31,997.47	19,065.40	3,940.33	8,991.73
<b>5</b>	31,991.13	19,080.82	3,931.12	8,979.20
<b>6</b>	31,973.97	19,035.87	3,928.72	9,009.38
<b>7</b>	31,990.40	19,089.72	3,922.07	8,978.62
<b>8</b>	31,956.92	19,049.95	3,935.05	8,971.92
<b>9</b>	32,024.98	19,090.05	3,943.35	8,991.58
<b>10</b>	32,021.90	19,085.87	3,956.55	8,979.48
<b>11</b>	31,998.85	19,084.45	3,946.92	8,967.48
<b>12</b>	32,010.75	19,073.98	3,933.17	9,003.60
<b>13</b>	31,987.02	19,072.52	3,929.65	8,984.85
<b>14</b>	31,989.38	19,066.35	3,937.53	8,985.50
<b>15</b>	32,002.98	19,071.83	3,944.95	8,986.20
<b>16</b>	32,029.57	19,095.05	3,934.88	8,999.63
<b>17</b>	31,982.20	19,077.72	3,925.12	8,979.37
<b>18</b>	31,983.27	19,036.43	3,947.43	8,999.40
<b>19</b>	32,041.17	19,078.75	3,944.57	9,017.85
<b>Average</b>	<b>32,004.71</b>	<b>19,074.30</b>	<b>3,940.08</b>	<b>8,990.34</b>

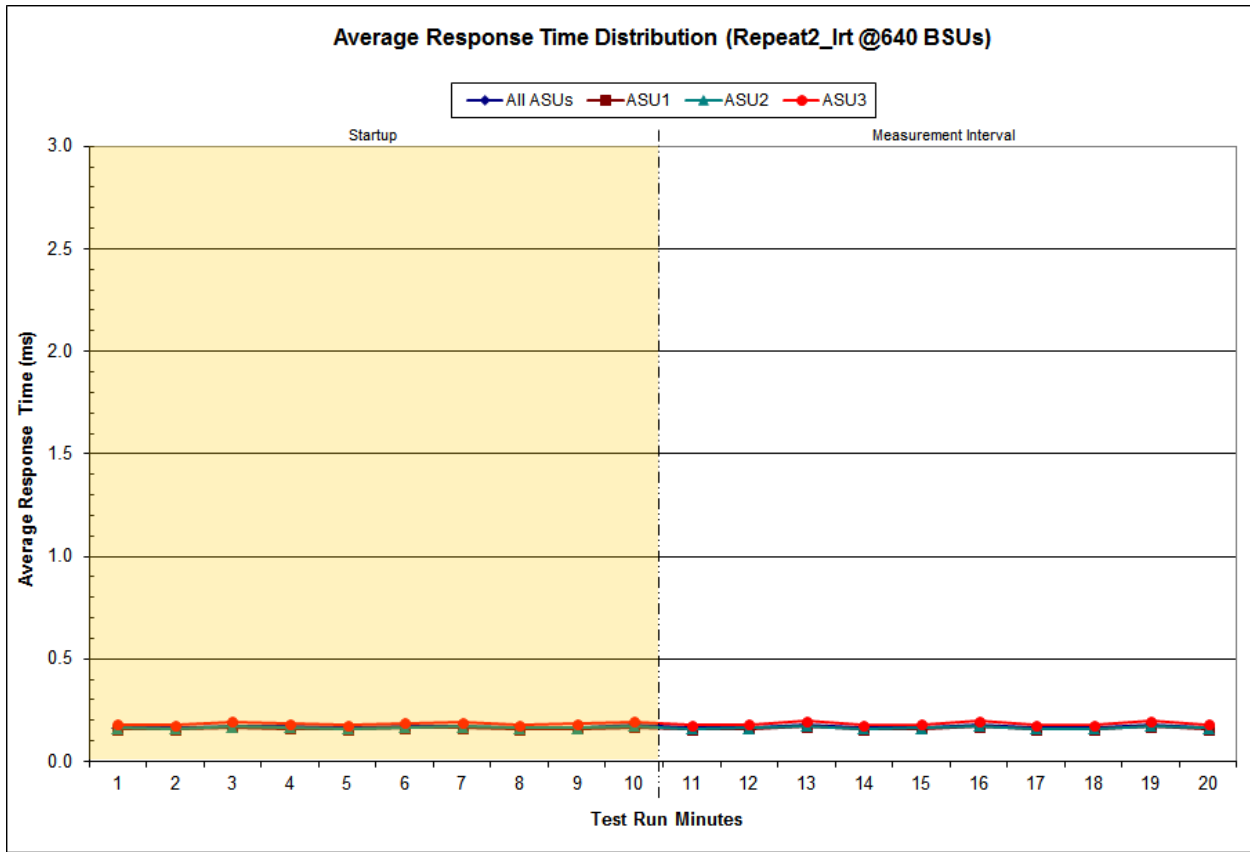
### Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

<b>640 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	3:15:24	3:25:24	0-9	0:10:00
<b>Measurement Interval</b>	3:25:24	3:35:24	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	0.16	0.16	0.16	0.18
<b>1</b>	0.16	0.16	0.16	0.18
<b>2</b>	0.17	0.17	0.17	0.19
<b>3</b>	0.17	0.16	0.17	0.18
<b>4</b>	0.16	0.16	0.16	0.18
<b>5</b>	0.17	0.16	0.17	0.19
<b>6</b>	0.17	0.16	0.17	0.19
<b>7</b>	0.16	0.16	0.16	0.18
<b>8</b>	0.17	0.16	0.16	0.18
<b>9</b>	0.18	0.17	0.17	0.19
<b>10</b>	0.16	0.16	0.16	0.18
<b>11</b>	0.17	0.16	0.16	0.18
<b>12</b>	0.18	0.17	0.17	0.20
<b>13</b>	0.16	0.16	0.16	0.18
<b>14</b>	0.16	0.16	0.16	0.18
<b>15</b>	0.18	0.17	0.17	0.20
<b>16</b>	0.16	0.16	0.16	0.18
<b>17</b>	0.16	0.16	0.16	0.18
<b>18</b>	0.18	0.17	0.17	0.20
<b>19</b>	0.16	0.16	0.16	0.18
<b>Average</b>	<b>0.17</b>	<b>0.16</b>	<b>0.17</b>	<b>0.18</b>

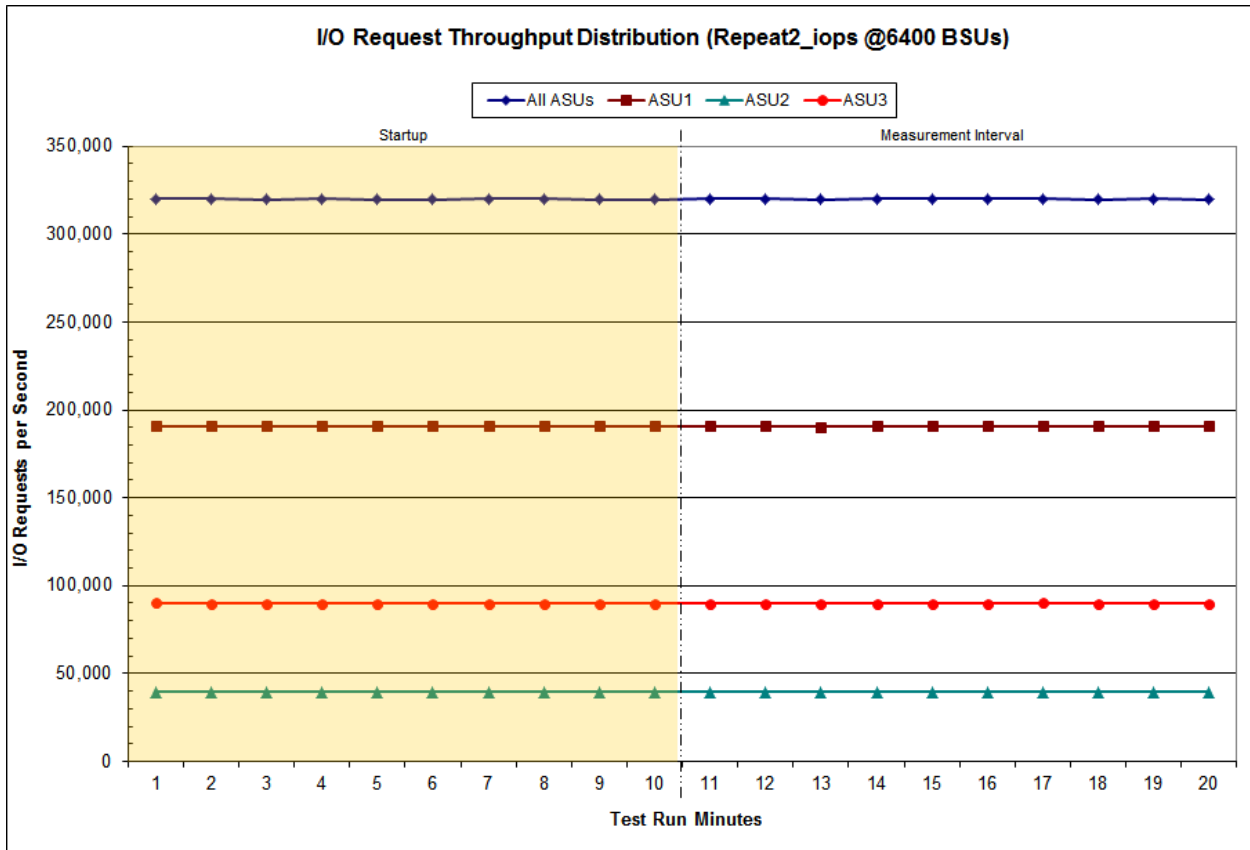
### Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



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

<b>6,400 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	3:36:14	3:46:15	0-9	0:10:01
<b>Measurement Interval</b>	3:46:15	3:56:15	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	320,197.17	190,788.70	39,419.52	89,988.95
<b>1</b>	320,019.50	190,690.88	39,393.50	89,935.12
<b>2</b>	319,937.72	190,674.32	39,353.77	89,909.63
<b>3</b>	320,086.70	190,811.25	39,382.18	89,893.27
<b>4</b>	319,919.93	190,701.70	39,306.07	89,912.17
<b>5</b>	319,936.87	190,705.50	39,336.50	89,894.87
<b>6</b>	320,006.17	190,735.77	39,331.93	89,938.47
<b>7</b>	320,046.17	190,738.07	39,372.68	89,935.42
<b>8</b>	319,880.17	190,629.12	39,325.37	89,925.68
<b>9</b>	319,916.82	190,677.78	39,344.35	89,894.68
<b>10</b>	319,954.38	190,707.98	39,333.68	89,912.72
<b>11</b>	320,077.23	190,838.27	39,356.87	89,882.10
<b>12</b>	319,831.60	190,577.77	39,343.75	89,910.08
<b>13</b>	319,985.83	190,714.58	39,358.45	89,912.80
<b>14</b>	319,958.27	190,663.30	39,363.23	89,931.73
<b>15</b>	320,043.37	190,745.03	39,391.63	89,906.70
<b>16</b>	320,155.68	190,787.13	39,365.20	90,003.35
<b>17</b>	319,908.00	190,675.32	39,326.70	89,905.98
<b>18</b>	320,001.00	190,738.45	39,374.35	89,888.20
<b>19</b>	319,842.18	190,621.78	39,350.42	89,869.98
<b>Average</b>	<b>319,975.76</b>	<b>190,706.96</b>	<b>39,356.43</b>	<b>89,912.37</b>

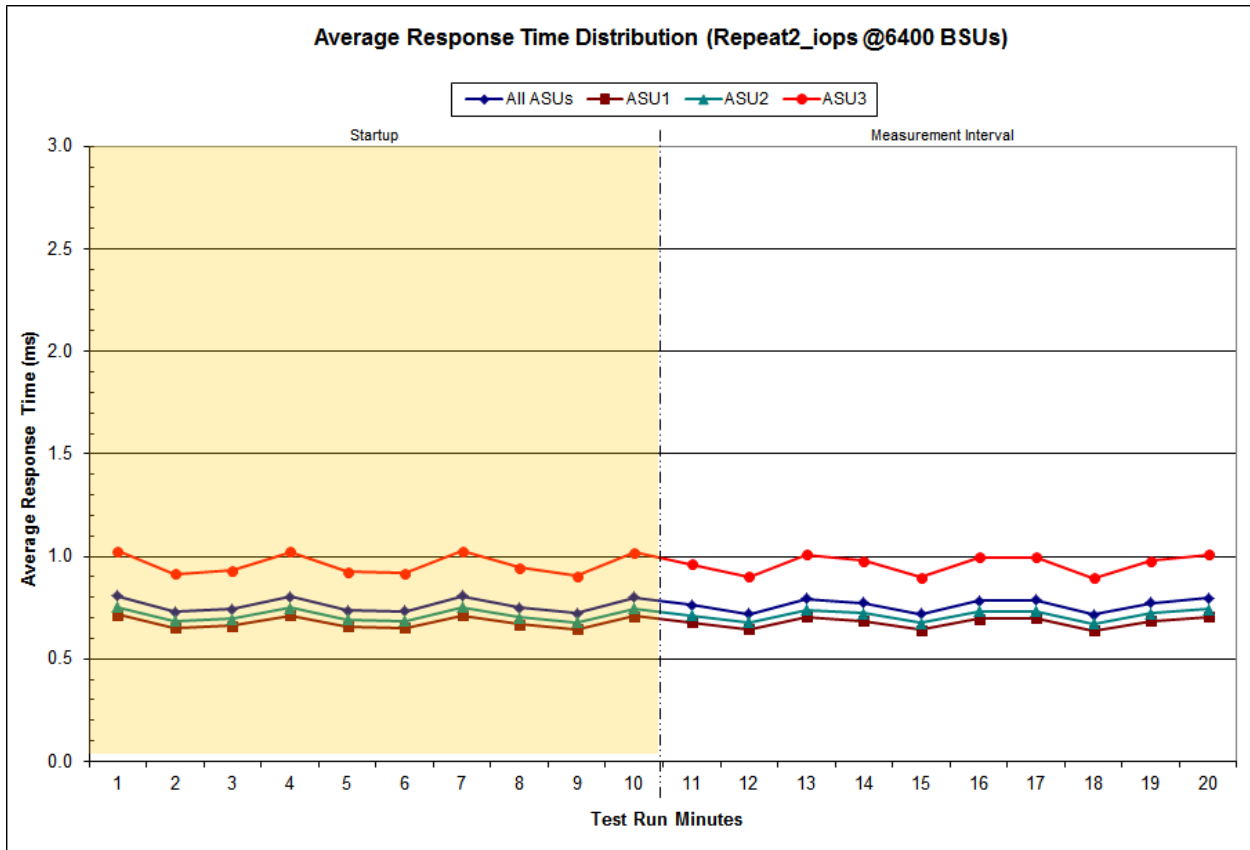
### Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

<b>6,400 BSUs</b>	<b>Start</b>	<b>Stop</b>	<b>Interval</b>	<b>Duration</b>
<b>Start-Up/Ramp-Up</b>	3:36:14	3:46:15	0-9	0:10:01
<b>Measurement Interval</b>	3:46:15	3:56:15	10-19	0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
<b>0</b>	0.81	0.72	0.75	1.02
<b>1</b>	0.73	0.65	0.68	0.91
<b>2</b>	0.74	0.66	0.70	0.93
<b>3</b>	0.80	0.71	0.75	1.02
<b>4</b>	0.74	0.66	0.69	0.92
<b>5</b>	0.73	0.65	0.69	0.92
<b>6</b>	0.81	0.71	0.75	1.02
<b>7</b>	0.75	0.67	0.70	0.94
<b>8</b>	0.72	0.65	0.68	0.91
<b>9</b>	0.80	0.71	0.75	1.02
<b>10</b>	0.76	0.68	0.71	0.96
<b>11</b>	0.72	0.64	0.68	0.90
<b>12</b>	0.79	0.70	0.74	1.01
<b>13</b>	0.77	0.69	0.72	0.98
<b>14</b>	0.72	0.64	0.67	0.90
<b>15</b>	0.78	0.70	0.73	1.00
<b>16</b>	0.79	0.70	0.73	1.00
<b>17</b>	0.72	0.64	0.67	0.90
<b>18</b>	0.77	0.69	0.72	0.98
<b>19</b>	0.80	0.71	0.74	1.01
<b>Average</b>	<b>0.76</b>	<b>0.68</b>	<b>0.71</b>	<b>0.96</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	0.0350	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.001	0.001	0.006	0.003	0.003	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<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	0.2811
COV	0.001	0.000	0.001	0.000	0.001	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	0.2809	0.0701	0.2099	0.0180	0.0701	0.0351	0.2809
COV	0.003	0.001	0.001	0.002	0.007	0.003	0.003	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.000	0.001	0.000	0.002	0.000	0.001	0.000

## Data Persistence Test

### Clause 6

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

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

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

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

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

### Clause 9.4.3.8

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

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

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [81](#).

## Data Persistence Test Results File

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

[Persistence 1 Test Results File](#)

[Persistence 2 Test Results File](#)

**Data Persistence Test Results**

<b>Data Persistence Test Results</b>	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	772,078
Total Number of Logical Blocks Verified	737,527
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	5 minutes
Size in bytes of each Logical Block	1,048,576 (1024 KiB)
Number of Failed I/O Requests in the process of the Test	0

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

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

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

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 9.4.3.9**

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

The NetApp EF560 All-Flash Array 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 NetApp EF560 All-Flash Array.

## **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.

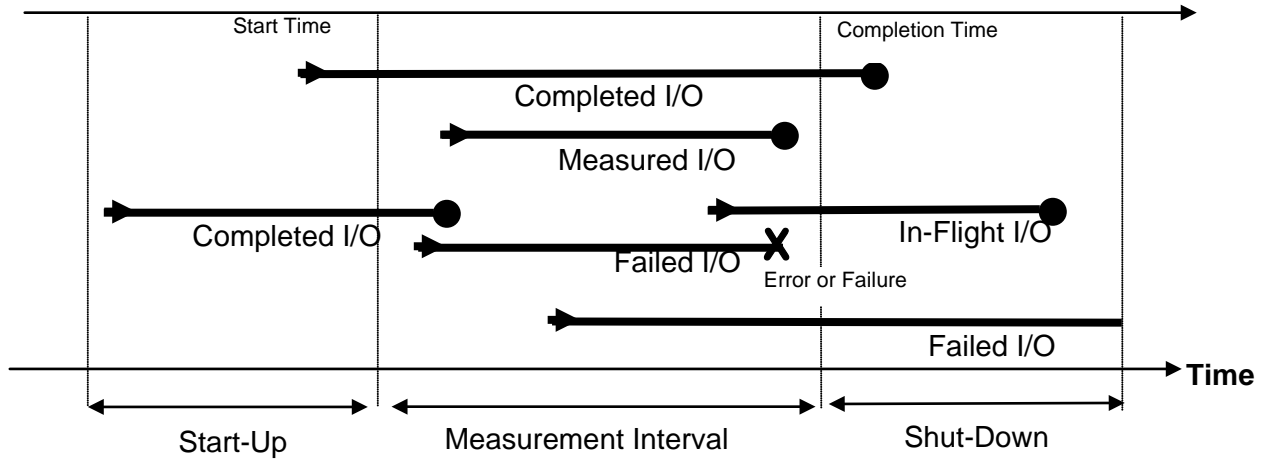
**Test:** A collection of Test Phases and or Test Runs sharing a common objective.

**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.

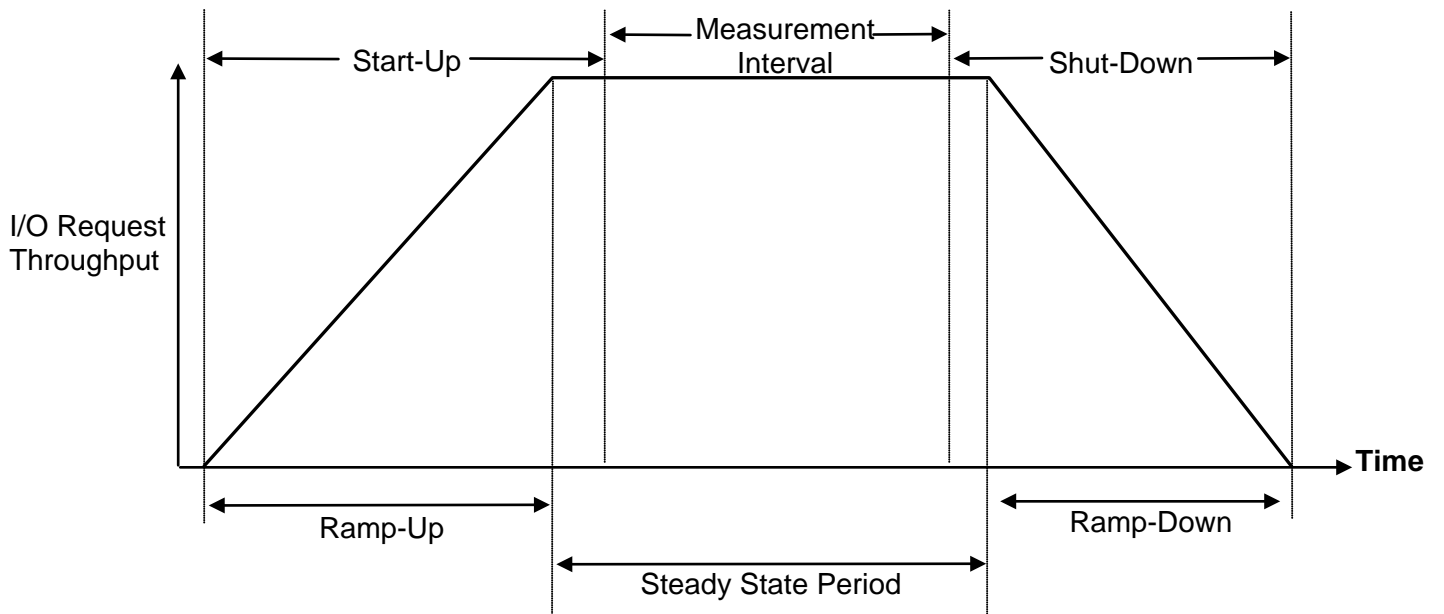


**Test Phase:** A collection of one or more SPC-1 Test Runs sharing a common objective and intended to be run in a specific sequence.

**I/O Completion Types**



**SPC-1 Test Run Components**



## APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

### HBA Parameters

The following QLogic Fibre Channel HBA parameters/options were changed from their default values using the [QConvergeConsole CLI](#) utility:

	Default Value	New Value
<b>Operation Mode</b>	<i>Interrupt when Interrupt Delay Timer expires or no active IO</i>	<i>Interrupt for every IO Completion</i>
<b>LUNs Per Target</b>	<b>8</b>	<b>128</b>
<b>Port Down Retry Count</b>	<b>30</b>	<b>70</b>

**Operation Mode:** Disable HBA interrupt coalescing.

**LUNs Per Target:** Specifies the number of LUNs per target.

**Port Down Retry Count:** Specifies the number of times the driver retries a command to a port returning port down status.

### Windows Registry Settings

Set the maximum queue depth in the QLogic driver from a default value of 254 to 32 using the following Windows registry setting:

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\ql2300\Parameters\Device\DriverParameter\qd=254
```

### Storage Array Parameters

The following storage array parameter were changed from its default value as documented in “Appendix C: Tested Storage Configuration (TSC) Creation”.

	Default Value	New Value
<b>cacheBlockSize</b>	<b>8</b>	<b>16</b>
<b>cacheFlushStart</b>	<b>80</b>	<b>50</b>

**CacheBlockSize:** disk array controller cache allocation unit size in KiB (1,024 bytes).

**CacheFlushStart:** specifies percentage of cache fill at which to start flushing.

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

### **QLogic HBA Parameters**

The QLogic HBA parameters/options, documented in [Appendix B, HBA Parameters](#), are changed prior to creating volumes on the storage array.

### **Windows Registry Setting**

The Windows registry setting, documented in [Appendix B, Windows Registry Settings](#), may be changed prior to or after creating volumes on the storage array.

### **Storage Array Volume Creation**

The storage management utility software, **SANtricity Storage Manager**, is installed on both Host Systems. It is a required software package that provides configuration, monitoring, and failover path management. The software is installed as a Windows installable package.

After installation, it can be found in **\\Program Files (x86)\\StorageManager\\client** and is typically started with **Start→All Programs→SANtricity Storage Manager →SANtricity Storage Manager client**.

The **SANtricity Storage Manager** was used to create 3 volume groups on the storage subsystem. Each volume group contains two RAID1 (*mirrored*) volumes. All 6 RAID1 volumes are visible by each Host System.

The physical storage volumes are created on the storage array using the **SANtricity Storage Manager** script editor as follows:

- Launch **SANtricity Storage Manager**.
- From the Enterprise Management window, right-click the name of the storage array that you will be creating volumes on and select **Execute Script** from the pop-up menu.
- In the Script Editor window, load the [SPC1 RAID Config.script](#) script (*listed at the end of this appendix*).
- Once the script is loaded, select **Execute** from the Tools menu.

## SPC-1 Logical Volume Creation

The steps that follow are executed on a single Host System to define the Windows partitions, volumes, and stripe sets that comprise the SPC-1 Logical Volumes/Application Storage Units (ASUs).

1. Start the Windows Disk Administrator, which will automatically discover the six RAID volumes, and then exit the Disk Administrator.
2. Use the Windows **diskpar** utility (**diskpar.exe**) to set the starting offset for each of the storage system volumes. Starting offset is 65,536 sectors (*512 bytes per sector*). Use all of the remaining capacity to create a single volume in each partition.
3. Start the Disk Management utility under Computer Management.
4. Convert all of the storage system volumes to Dynamic Disks.
5. Create a Windows Striped (RAID 0) volume using all six 32 MB partitions.
6. Delete the remaining large volume on each of the Dynamic Disks.
7. Create a Windows Striped (RAID 0) volume for ASU 3.
  - a. Select all six volumes.
  - b. Set capacity to 143,150 MB.
  - c. Assign drive letter "T" to the volume. Do not format the volume.
8. Create a Windows Striped (RAID 0) volume for ASU 1.
  - a. Select all six volumes.
  - b. Set capacity to 644,175 MB.
  - c. Assign drive letter "R" to the volume. Do not format the volume.
9. Create a Windows Striped (RAID 0) volume for ASU 2.
  - a. Select all six volumes.
  - b. Set capacity to 644,175 MB.
  - c. Assign drive letter "S" to the volume. Do not format the volume.
10. Reboot the Host Systems.
11. After each reboot completes, start the Disk Administrator utility on each of the Host Systems.
12. On each Host System, select either the import foreign disk or reactivate Windows stripe sets option, as necessary, then assign drive letters to the stripe sets as they were assigned in steps 7-9 above.

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

## SPC1\_RAID\_Config.script

```
/* SPC-1 RAID Volume Configuration Script */

create volume drives[ 0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_0"
volumeGroupUserLabel="VG_0"
capacity=1398 gb
owner = A;

create volume volumeGroup["VG_0"] RAIDLevel=1 segmentSize=128 userLabel="LUN_1"
capacity=1398 gb owner = b;

create volume drives[ 0,9 0,10 0,11 0,12 0,13 0,14 0,15 0,16 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_2"
volumeGroupUserLabel="VG_1"
capacity=1398 gb
owner = b;

create volume volumeGroup["VG_1"] RAIDLevel=1 segmentSize=128 userLabel="LUN_3"
capacity=1398 gb owner = A;

create volume drives[ 0,17 0,18 0,19 0,20 0,21 0,22 0,23 0,24 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN_4"
volumeGroupUserLabel="VG_2"
capacity=1398 gb
owner = A;

create volume volumeGroup["VG_2"] RAIDLevel=1 segmentSize=128 userLabel="LUN_5"
capacity=1398 gb owner = b;

/* define host mappings */
set volume["LUN_0"] logicalUnitNumber=0 hostGroup=defaultGroup;
set volume["LUN_1"] logicalUnitNumber=1 hostGroup=defaultGroup;
set volume["LUN_2"] logicalUnitNumber=2 hostGroup=defaultGroup;
set volume["LUN_3"] logicalUnitNumber=3 hostGroup=defaultGroup;
set volume["LUN_4"] logicalUnitNumber=4 hostGroup=defaultGroup;
set volume["LUN_5"] logicalUnitNumber=5 hostGroup=defaultGroup;

set allVolumes mirrorEnabled = True writeCacheEnabled = True
cacheWithoutBatteryEnabled = False cacheReadPrefetch = False;

set storageArray cacheBlockSize = 16;
set storageArray cacheFlushStart = 50;
```

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

### ASU Pre-Fill

```
* SPC-1 Pre-Fill
* 512K sequential writes

*pattern=random
*compression=100          * vdBench version 5.02
compratio=1.0            * vdBench version 5.03

sd=sd1,lun=\\.R:,threads=4
sd=sd2,lun=\\.S:,threads=4
sd=sd3,lun=\\.T:,threads=4

wd=wd1,sd=sd1,xfersize=524288,readpct=0,seekpct=-1
wd=wd2,sd=sd2,xfersize=524288,readpct=0,seekpct=-1
wd=wd3,sd=sd3,xfersize=524288,readpct=0,seekpct=-1

rd=rd1,wd=wd*,elapsed=36000,interval=10,iorate=max
```

### Primary Metrics and Repeatability Tests

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

```
* spc1.cfg

host=master

* For 68 JVM's
slaves=(bmr730c_s1,bmr730c_s2,bmr730c_s3,bmr730c_s4,bmr730c_s5,bmr730c_s6,bmr730c_s7
,bmr730c_s8,bmr730c_s9,bmr730c_s10,bmr730c_s11,bmr730c_s12,bmr730c_s13,bmr730c_s14,b
mr730c_s15,bmr730c_s16,bmr730c_s17,bmr730c_s18,bmr730c_s19,bmr730c_s20,bmr730c_s21,b
mr730c_s22,bmr730c_s23,bmr730c_s24,bmr730c_s25,bmr730c_s26,bmr730c_s27,bmr730c_s28,b
mr730c_s29,bmr730c_s30,bmr730c_s31,bmr730c_s32,bmr730c_s33,bmr730c_s34,bmr730d_s1,bm
r730d_s2,bmr730d_s3,bmr730d_s4,bmr730d_s5,bmr730d_s6,bmr730d_s7,bmr730d_s8,bmr730d_s
9,bmr730d_s10,bmr730d_s11,bmr730d_s12,bmr730d_s13,bmr730d_s14,bmr730d_s15,bmr730d_s1
6,bmr730d_s17,bmr730d_s18,bmr730d_s19,bmr730d_s20,bmr730d_s21,bmr730d_s22,bmr730d_s2
3,bmr730d_s24,bmr730d_s25,bmr730d_s26,bmr730d_s27,bmr730d_s28,bmr730d_s29,bmr730d_s3
0,bmr730d_s31,bmr730d_s32,bmr730d_s33,bmr730d_s34)

javaparms="-Xmx384m -Xms384m"

sd=asu1_1,lun=\\.R:,size=4052798668800
sd=asu2_1,lun=\\.S:,size=4052798668800
sd=asu3_1,lun=\\.T:,size=900621926400
```

## SPC-1 Persistence Test

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

```
* spc1_persist.cfg

javaparms="-Xmx640m -Xms640m"

sd=asu1_1,lun=\\.R:,size=4052798668800
sd=asu2_1,lun=\\.S:,size=4052798668800
sd=asu3_1,lun=\\.T:,size=900621926400
```

## 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. **bmr730c\_s1...bmr730d\_s34**.

```
*slavel.parm

host=bmr730c_s1
master=bmr730c

eof
```

## SPC-2 Persistence Test

The SPC-2 Persistence Test was approved for use to meet the SPC-1 persistence requirements. Both the SPC-1 and SPC-2 Persistence Tests provide the same level of functionality and verification of data integrity.

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

\* SPC-1 Persistence Write Phase using SPC-2

host=localhost,jvms=1,maxstreams=300

sd=asu1\_1,lun=\\.R:,size=4052798668800

sd=asu2\_1,lun=\\.S:,size=4052798668800

sd=asu3\_1,lun=\\.T:,size=900621926400

maxlatestart=1

reportinginterval=5

segmentlength=512m

rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1

rd=default,rdpct=0,xfersize=1024k

rd=TR1-214s\_SPC-2-persist-w,streams=214

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

\* SPC-1 Persistence Read Phase using SPC-2

host=localhost,jvms=1,maxstreams=300

sd=asu1\_1,lun=\\.R:,size=4052798668800

sd=asu2\_1,lun=\\.S:,size=4052798668800

sd=asu3\_1,lun=\\.T:,size=900621926400

maxlatestart=1

reportinginterval=5

segmentlength=512m

maxpersistenceerrors=10

rd=default,buffers=1,rdpct=100,xfersize=1024k

rd=TR1-214s\_SPC-2-persist-r



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

The Slave JVMs are started as the first step in the execution sequence by execution of the [startSlaves.cmd](#) script, which invokes the appropriate execution script, using the appropriate parameter file, for each Slave JVM.

The [phase1.cmd](#) script is executed, after the Slave JVMs has successfully started, to complete the following in an uninterrupted sequence:

- The required ASU pre-fill.
- Generate the first set of detailed storage configuration information required for a remote audit.
- 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*)
- A reduced level SPC-1 Persistence Test Run 1 (*write phase*)
- The SPC-2 Persistence Test Run 1 (*write phase*)

The [phase2.cmd](#) script is then executed after the required TSC power off/power on cycle to complete the following in an uninterrupted sequence:

- The SPC-2 Persistence Test Run 2 (*read phase*)
- Generate the second set of detailed storage configuration information required for a remote audit.

### **startSlaves.cmd**

```
echo off
for /L %%G in (1,1,34) do (start slave%%G)
```

### **slave1.cmd**

The execution script to start the first Slave JVM, which uses the [slave1.cmd](#) configuration file. The remaining Slave JVMs are started with similar execution scripts and configuration files, specifying the appropriate Slave JVM.

```
@echo off
echo *****
echo * Sleeping 15 seconds... *
echo *****
timeout /t 15

java -Xmx384m -Xms384m spc1 -fslave1.parm -oslave1

exit
```

### **phase1.cmd**

```
echo "ASU prefill started....."
pushd \bench\vdbench\vdbench50401
call vdbench -f \bench\vdbench\spc1\spc1_prefill.parm -o \bench\vdbench\spc1\PreFill
popd
```

```
echo "ASU prefill complete....."

echo "Capture a storage profile at the start of the run....."
pushd "\Program Files\StorageManager\client"
smcli 10.113.120.156 10.113.120.157 -c "set storageArray time; show storageArray
time; show storageArray profile; show storageArray time;" -o
\bench\vdbench\spc1\config_at_start.txt -quick
popd

copy /Y spc1_iops.cfg spc1.cfg

java -Xmx768m -Xms768m metrics -b 6400 -s 1200 -t 28800

java -Xmx768m -Xms768m repeat1 -b 6400 -s 600

java -Xmx768m -Xms768m repeat2 -b 6400 -s 600

copy /Y spc1_persist.cfg spc1.cfg

java -Xmx1024m -Xms1024m persist1 -b 640

echo "Move to SPC-2 to use SPC-2 Persistence..."

pushd \bench\vdbench\spc2

java -Xmx1536m -Xms512m -Xss96k vdbench -w SPC2 -f
\bench\vdbench\spc1\spc2_persist1.cfg -o \bench\vdbench\spc1\init_spc2 -init

java -Xmx1536m -Xms512m -Xss96k vdbench -w SPC2 -f
\bench\vdbench\spc1\spc2_persist1.cfg -o \bench\vdbench\spc1\persistencel_spc2

popd
```

## phase2.cmd

```
cd \bench\vdbench\spc2


java -Xmx1536m -Xms512m -Xss96k vdbench -w SPC2 -f
\bench\vdbench\spc1\spc2_persist2.cfg -o \bench\vdbench\spc1\persistence2_spc2

cd \bench\vdbench\spc1

echo "Capture a storage profile at the end of the run....."
pushd "\Program Files\StorageManager\client"
smcli 10.113.120.156 10.113.120.157 -c "show storageArray time; show storageArray
profile; show storageArray time;" -o \bench\vdbench\spc1\config_at_end.txt -quick
popd
```



## THIRD-PARTY QUOTATION

### QLogic QLE2672-CK HBAs



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Delete	QLE2672-CK	QLOGIC - SANBLADE 16GB DUAL PORT PCIE FIBRE CHANNEL HOST BUS ADAPTER WITH STANDARD BRACKET CARD ONLY (QLE2672-CK). NEW RETAIL FACTORY SEALED. IN STOCK.	4	\$1,300.00	\$5,200.00
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## Fibre Channel Cables

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<b>Sub Total:</b>				\$183.92
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