



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**XIOTECH CORPORATION  
XIOTECH EMPRISE™ 5000  
*(ISE 2.4 TB/15.1 DATAPAC)***

**SPC-1 V1.12**

**Submitted for Review: September 20, 2010  
Submission Identifier: A00096**

**First Edition – September 2010**

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## Table of Contents

<b>Audit Certification</b> .....	<b>vii</b>
<b>Audit Certification (cont.)</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>11</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>13</b>
<b>Response Time - Throughput Data</b> .....	<b>13</b>
<b>Priced Storage Configuration Pricing</b> .....	<b>14</b>
<b>Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration</b> .....	<b>14</b>
<b>Benchmark Configuration (BC)/Tested Storage Configuration (TSC)/ Priced Storage Configuration Diagram</b> .....	<b>15</b>
<b>Benchmark Configuration (BC)/Tested Storage Configuration (TSC)/ Priced Storage Configuration Components</b> .....	<b>15</b>
<b>Configuration Information</b> .....	<b>16</b>
<b>Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram</b> .....	<b>16</b>
<b>Storage Network Configuration</b> .....	<b>16</b>
<b>Host System and Tested Storage Configuration (TSC) Table of Components</b> .....	<b>16</b>
<b>Customer Tunable Parameters and Options</b> .....	<b>17</b>
<b>Tested Storage Configuration (TSC) Description</b> .....	<b>17</b>
<b>SPC-1 Workload Generator Storage Configuration</b> .....	<b>17</b>
<b>SPC-1 Data Repository</b> .....	<b>18</b>
<b>Storage Capacities and Relationships</b> .....	<b>18</b>
SPC-1 Storage Capacities .....	<b>18</b>
SPC-1 Storage Hierarchy Ratios .....	<b>18</b>
SPC-1 Storage Capacities and Relationships Illustration .....	<b>19</b>
<b>Logical Volume Capacity and ASU Mapping</b> .....	<b>19</b>
<b>Storage Capacity Utilization</b> .....	<b>20</b>
<b>SPC-1 Benchmark Execution Results</b> .....	<b>21</b>
<b>SPC-1 Tests, Test Phases, and Test Runs</b> .....	<b>21</b>
<b>Primary Metrics Test - Sustainability Test Phase</b> .....	<b>22</b>
SPC-1 Workload Generator Input Parameters .....	<b>22</b>

Sustainability Test Results File .....	22
Sustainability – Data Rate Distribution Data ( <i>MB/second</i> ).....	23
Sustainability – Data Rate Distribution Graph .....	24
Sustainability – I/O Request Throughput Distribution Data.....	25
Sustainability – I/O Request Throughput Distribution Graph .....	26
Sustainability – Average Response Time (ms) Distribution Data .....	27
Sustainability – Average Response Time (ms) Distribution Graph .....	28
Sustainability – Response Time Frequency Distribution Data .....	29
Sustainability – Response Time Frequency Distribution Graph .....	29
Sustainability – Measured Intensity Multiplier and Coefficient of Variation.....	30
<b>Primary Metrics Test – IOPS Test Phase.....</b>	<b>31</b>
SPC-1 Workload Generator Input Parameters .....	31
IOPS Test Results File.....	31
IOPS Test Run – I/O Request Throughput Distribution Data .....	32
IOPS Test Run – I/O Request Throughput Distribution Graph.....	32
IOPS Test Run – Average Response Time (ms) Distribution Data .....	33
IOPS Test Run – Average Response Time (ms) Distribution Graph .....	33
IOPS Test Run – Response Time Frequency Distribution Data .....	34
IOPS Test Run –Response Time Frequency Distribution Graph.....	34
IOPS Test Run – I/O Request Information.....	35
IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation.....	35
<b>Primary Metrics Test – Response Time Ramp Test Phase .....</b>	<b>36</b>
SPC-1 Workload Generator Input Parameters .....	36
Response Time Ramp Test Results File.....	36
Response Time Ramp Distribution (IOPS) Data.....	37
Response Time Ramp Distribution (IOPS) Graph .....	38
SPC-1 LRT™ Average Response Time (ms) Distribution Data.....	39
SPC-1 LRT™ Average Response Time (ms) Distribution Graph .....	39
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation .....	40
<b>Repeatability Test .....</b>	<b>41</b>
SPC-1 Workload Generator Input Parameters .....	41
Repeatability Test Results File .....	42
Repeatability 1 LRT – I/O Request Throughput Distribution Data.....	43
Repeatability 1 LRT – I/O Request Throughput Distribution Graph .....	43
Repeatability 1 LRT –Average Response Time (ms) Distribution Data .....	44
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph.....	44
Repeatability 1 IOPS – I/O Request Throughput Distribution Data .....	45
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph.....	45
Repeatability 1 IOPS –Average Response Time (ms) Distribution Data.....	46

Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph .....	46
Repeatability 2 LRT – I/O Request Throughput Distribution Data.....	47
Repeatability 2 LRT – I/O Request Throughput Distribution Graph .....	47
Repeatability 2 LRT –Average Response Time (ms) Distribution Data .....	48
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph.....	48
Repeatability 2 IOPS – I/O Request Throughput Distribution Data .....	49
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph.....	49
Repeatability 2 IOPS –Average Response Time (ms) Distribution Data.....	50
Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph .....	50
Repeatability 1 (LRT) Measured Intensity Multiplier and Coefficient of Variation .....	51
Repeatability 1 (IOPS) Measured Intensity Multiplier and Coefficient of Variation .....	51
Repeatability 2 (LRT) Measured Intensity Multiplier and Coefficient of Variation .....	51
Repeatability 2 (IOPS) Measured Intensity Multiplier and Coefficient of Variation .....	52
<b>Data Persistence Test.....</b>	<b>53</b>
SPC-1 Workload Generator Input Parameters .....	53
Data Persistence Test Results File .....	53
Data Persistence Test Results.....	54
<b>Priced Storage Configuration Availability Date.....</b>	<b>55</b>
<b>Pricing Information.....</b>	<b>55</b>
<b>Tested Storage Configuration (TSC) and Priced Storage Configuration Differences.....</b>	<b>55</b>
<b>Anomalies or Irregularities .....</b>	<b>55</b>
<b>Appendix A: SPC-1 Glossary .....</b>	<b>56</b>
“Decimal” ( <i>powers of ten</i> ) Measurement Units.....	56
“Binary” ( <i>powers of two</i> ) Measurement Units.....	56
SPC-1 Data Repository Definitions.....	56
SPC-1 Data Protection Levels .....	57
SPC-1 Test Execution Definitions .....	57
I/O Completion Types .....	59
SPC-1 Test Run Components .....	59
<b>Appendix B: Customer Tunable Parameters and Options.....</b>	<b>60</b>
<b>Appendix C: Tested Storage Configuration (TSC) Creation .....</b>	<b>61</b>
Eagle R1.sh.....	61
<b>Appendix D: SPC-1 Workload Generator Storage Commands and Parameters .....</b>	<b>62</b>
<b>Appendix E: SPC-1 Workload Generator Input Parameters .....</b>	<b>63</b>
<b>Primary Metrics Test, Repeatability Test, and Persistence Test Run 1 .....</b>	<b>63</b>

**Persistence Test Run 2.....63**

## AUDIT CERTIFICATION



Ken Bates  
 Xiotech Corporation  
 9950 Federal Drive, Suite 100  
 Colorado Spring, CO 80921

September 17, 2010

The SPC Benchmark 1™ Reported Data listed below for the Xiotech Emprise™ 5000 (*ISE 2.4 TB/15.1 DataPac*) were produced in compliance with the SPC Benchmark 1™ 1.12 Remote Audit requirements.

SPC Benchmark 1™ 1.12 Results	
Tested Storage Configuration (TSC) Name: Xiotech Emprise™ 5000 ( <i>ISE 2.4 TB/15.1 DataPac</i> )	
Metric	Reported Result
SPC-1 IOPS™	8,102.46
SPC-1 Price-Performance	\$5.08/SPC-1 IOPS™
Total ASU Capacity	2,319,262 GB
Data Protection Level	Protected ( <i>Mirroring</i> )
Total TSC Price (including three-year maintenance)	\$41,195.00

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with 1.12 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items, based on information supplied by Xiotech Corporation:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- 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.

Storage Performance Council  
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 Redwood City, CA 94062  
[AuditService@storageperformance.org](mailto:AuditService@storageperformance.org)  
 650.556.9384

**AUDIT CERTIFICATION (CONT.)**

Xiotech Emprise™ 5000 (ISE 2.4 TB/15.1 DataPac)  
SPC-1 Audit Certification

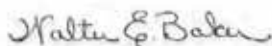
Page 2

- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements, based on information supplied by Xiotech Corporation:
  - ✓ The type of Host System 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 Test Results Files and resultant Summary Results Files received from Xiotech Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- The differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration were documented and, if applied to the TSC, would not have an impact on the reported SPC-1 performance.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

**Audit Notes:**

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker  
SPC Auditor

Storage Performance Council  
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Redwood City, CA 94062  
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**LETTER OF GOOD FAITH**

29-Jul-2010

Walter E. Baker  
Gradient Systems  
643 Blair Island Road, Suite 103  
Redwood City, CA 94063-2755

Subject: SPC-1 Letter of Good Faith for the XioTech Emprise 5000 Virtual Storage System (ISE 2.4 TB / 15.1 DataPac)

XioTech is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.12 of the SPC-1 benchmark specification.

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

Sincerely,

A handwritten signature in black ink, appearing to read "David", with a long horizontal flourish extending to the right.

David Gustavsson  
Vice President, Engineering  
XioTech

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Toll-Free: 866.472.6764 [www.xiotech.com](http://www.xiotech.com)

**EXECUTIVE SUMMARY****Test Sponsor and Contact Information**

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<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">http://www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@StoragePerformance.org">AuditService@StoragePerformance.org</a> 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

**Revision Information and Key Dates**

<b>Revision Information and Key Dates</b>	
<b>SPC-1 Specification revision number</b>	V1.12
<b>SPC-1 Workload Generator revision number</b>	V2.1.0
<b>Date Results were first used publicly</b>	September 20, 2010
<b>Date the FDR was submitted to the SPC</b>	September 20, 2010
<b>Date the priced storage configuration is available for shipment to customers</b>	currently available
<b>Date the TSC completed audit certification</b>	September 17, 2010

## Tested Storage Product (TSP) Description

Xiotech's Emprise 5000 system is a revolutionary concept in data storage. It is built on patented Intelligent Storage Element (ISE™) technology—a perfectly balanced building block of performance, reliability, and scalability.

Typical SAN systems come with high-level functionality you may not need, and all that functionality adds to the price tag. It also consumes performance and introduces a lot of complexity, which often requires high-priced administrators.

Emprise 5000, on the other hand, is a flexible, foundational building block of storage. It is a complete, self-enclosed virtualized storage solution that you can configure to meet your unique needs or optimize for a specific application.

Typical SAN performance is limited by bottlenecks in the system—from SAN controllers that slow data movement to back-end switches that add another point of contact. Scalability also is restricted by how many drives you can effectively put behind a set of controllers.

Emprise 5000 changes this paradigm. It eliminates the storage controllers on the front end and switches on the back, so data is free to flow at screaming speeds. And because storage is decoupled from the servers, you can add servers solely for processing power.

## Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: Xiotech Emprise™ 5000 (ISE 2.4 TB/15.1 DataPac)	
Metric	Reported Result
SPC-1 IOPS™	8,102.46
SPC-1 Price-Performance	\$5.08/SPC-1 IOPS™
Total ASU Capacity	2,319.282 GB
Data Protection Level	Protected ( <i>Mirroring</i> )
Total TSC Price (including three-year maintenance)	\$41,195.00

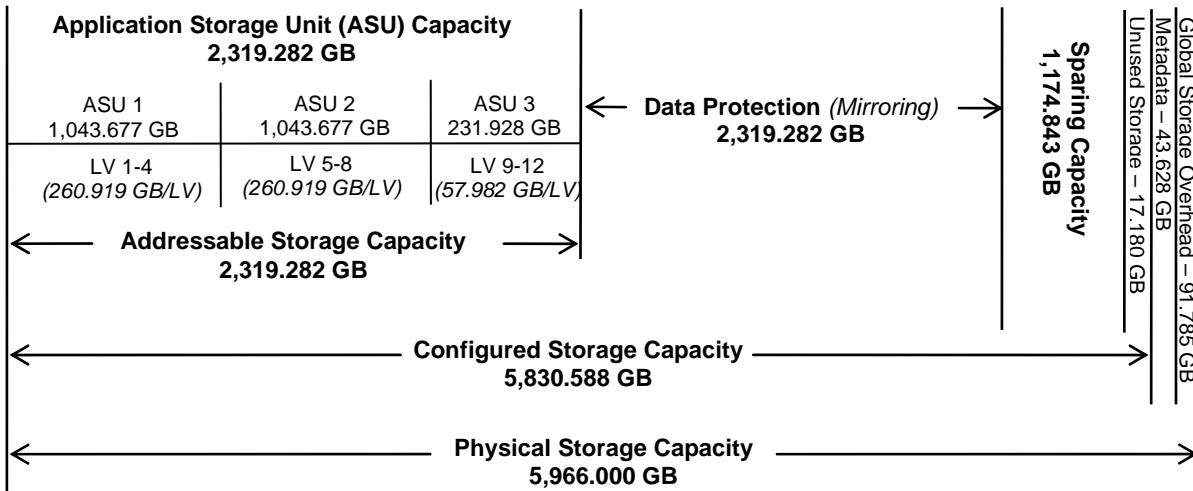
**SPC-1 IOPS™** represents the maximum I/O Request Throughput at the 100% load point.

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

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

### Storage Capacities, Relationships, and Utilization

The following diagram 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	38.87%
Protected Application Utilization	77.75%
Unused Storage Ratio	0.29%

**Application Utilization:** Total ASU Capacity (2,319.282 GB) divided by Physical Storage Capacity (5,966.000 GB).

**Protected Application Utilization:** Total ASU Capacity (2,319.282 GB) plus total Data Protection Capacity (2,319.282 GB) minus unused Data Protection Capacity (0.000 GB) divided by Physical Storage Capacity (5,966.000 GB).

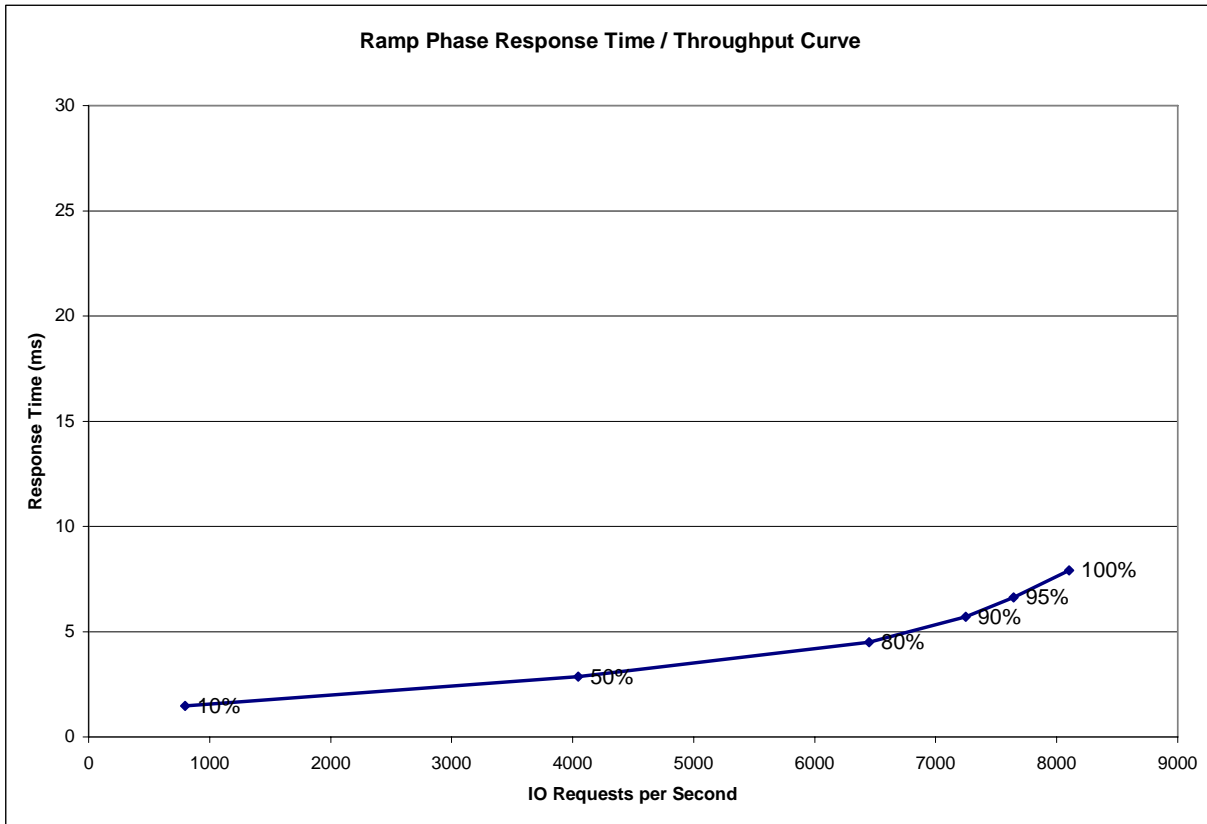
**Unused Storage Ratio:** Total unused capacity (17.180 GB) divided by Physical Storage Capacity (5,966.000 GB). The Unused Storage Ratio cannot exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 18-19 in the Full Disclosure Report.

### 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>	799.02	4,046.52	6,450.80	7,248.48	7,642.89	8,102.46
<b>Average Response Time (ms):</b>						
All ASUs	1.47	2.87	4.50	5.71	6.63	7.92
ASU-1	2.06	3.85	5.50	6.74	7.61	8.82
ASU-2	1.59	4.18	9.35	13.17	16.44	20.94
ASU-3	0.18	0.22	0.24	0.27	0.26	0.27
Reads	3.49	6.98	11.06	14.10	16.42	19.66
Writes	0.16	0.20	0.23	0.25	0.25	0.26

## Priced Storage Configuration Pricing

Qty	Name	Part Number	List Price	Discount	Unit Price	Extended Price
1	Emprise 5000 Virtual Storage System (Base Unit) Emprise 5000 Virtual Storage System (Base Unit) includes 1 Intelligent Storage Element (ISE) chassis for Emprise 5000 with 2 Fibre Channel host ports, power cords, bezel, rail kit, and accessory kit. Holds up to 2 DataPacs.	800864-000	\$12,500.00	30%	\$8,750.00	\$8,750.00
2	Cable - 5m LC Duplex/LC Duplex Fiber Optic Patch Cord Cable - 5m LC Duplex/LC Duplex Fiber Optic Patch Cord	840056-000	\$108.00	40%	\$65.00	\$130.00
1	QLogic - QLA2462 4Gb 64-bit 266MHz PCI-X 2.0 dual port Server HBA	770814-000	\$2,100.00	29%	\$1,499.00	\$1,499.00
2	ISE 2.4 TB /15.1 DataPac ISE 2.4 TB /15.1 DataPac with 2.4TB of storage.	800939-000	\$19,083.00	30%	\$13,358.00	\$26,716.00
1	Emprise 5000 - Installation	000229-000	\$4,083.33	40%	\$2,450.00	\$2,450.00
1	Emprise 5000 - 5 Year Hardware Warranty Emprise 5000 5 Year Hardware Warranty	020171-001	\$0.00	-	\$0.00	\$0.00
1	Emprise 5000 - Software Warranty (90 Days) Emprise 5000 Software Warranty for 90 Days	020171-004	\$0.00	-	\$0.00	\$0.00
1	Emprise 5000 - Software Maintenance - remainder of 1st year Emprise 5000 Software Maintenance Extension - Remainder of 1st Year. Extends initial Emprise 5000 Software warranty to 12 months.	020171-005	\$749.97	40%	\$450.00	\$450.00
24	Emprise 5000 - Software Maintenance - 1 month Emprise 5000 Software 1 month	020171-006	\$83.33	40%	\$50.00	\$1,200.00
					<b>Total:</b>	<b>\$41,195.00</b>

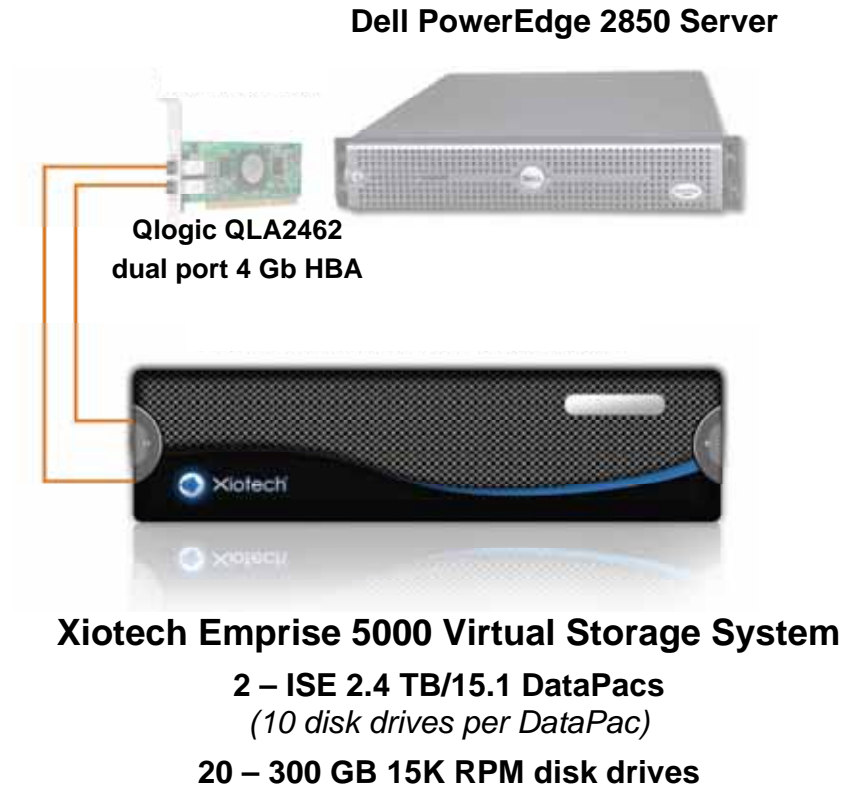
The above pricing includes hardware maintenance and software support for a minimum of three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- Acknowledgement of new and existing problems with four (4) hours.
- Onsite present 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 TSC and Priced Storage Configuration.

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



**Benchmark Configuration (BC)/Tested Storage Configuration (TSC)/  
Priced Storage Configuration Components**

Host System:	Tested Storage Configuration (TSC)/ Priced Storage Configuration:
<b>Dell PowerEdge 2850 Server</b>	1 – dual-ported, 4Gb Qlogic 2462 HBA
2 – 3.6 GHz Xeon CPUs with 2 MB L2 cache per CPU	<b>Xiotech Emprise 5000 Virtual Storage System</b> 2 – dual-active controllers each with: 512 MB cache <i>(1 GB total)</i> 1 – 4 Gb Fibre Channel front-end host port <i>(2 total, 2 used)</i> no backend connections due to the sealed DataPacs
2 GB main memory	
Windows Server 2003 Standard Edition with SP2	
Xiotech MPIO driver	
PCI-X	
	2 – ISE 2.4 TB/15.1 DataPacs <i>(10 disk drives per DataPac)</i>
	20 – 300 GB 15K RPM disk drives

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 15 (*Benchmark Configuration (BC)/Tested Storage Configuration (TSC)/Priced 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 did not utilize network storage.

### **Host System 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). Table 9-10 specifies the content, format, and appearance of the table.*

The Host System and Tested Storage Configuration (TSC) table of components appears on page 15 (*Benchmark Configuration (BC)/Tested Storage Configuration (TSC)/Priced Storage Configuration Components*).

## 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 60 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 61 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 62.

## **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 56 contains definitions of terms specific to the SPC-1 Data Repository.

### **Storage Capacities and Relationships**

#### **Clause 9.4.3.6.1**

*Two tables and an illustration documenting the storage capacities and relationships of the SPC-1 Storage Hierarchy (Clause 2.1) shall be included in the FDR.*

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

<b>SPC-1 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	2,319.282
Addressable Storage Capacity	Gigabytes (GB)	2,319.282
Configured Storage Capacity	Gigabytes (GB)	5,830.588
Physical Storage Capacity	Gigabytes (GB)	5,966.000
Data Protection ( <i>Mirroring</i> )	Gigabytes (GB)	2,319.282
Required Storage ( <i>metadata, sparing</i> )	Gigabytes (GB)	1,218.471
Global Storage Overhead	Gigabytes (GB)	91.785
Total Unused Storage	Gigabytes (GB)	17.180

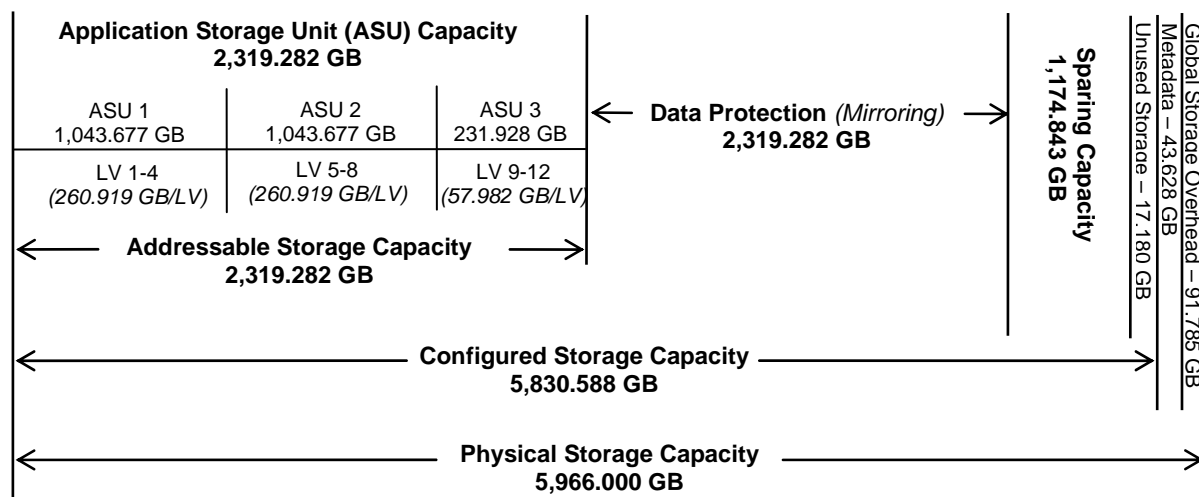
### **SPC-1 Storage Hierarchy Ratios**

	<b>Addressable Storage Capacity</b>	<b>Configured Storage Capacity</b>	<b>Physical Storage Capacity</b>
<b>Total ASU Capacity</b>	100.00%	39.78%	38.87%
<b>Required for Data Protection (<i>Mirrored</i>)</b>		39.78%	38.87%
<b>Addressable Storage Capacity</b>		39.78%	39.87%
<b>Required Storage (<i>metadata, sparing</i>)</b>		20.90%	20.42%
<b>Configured Storage Capacity</b>			97.73%
<b>Global Storage Overhead</b>			1.54%
<b>Unused Storage:</b>			
<b>Addressable</b>	0.00%		
<b>Configured</b>		0.29%	
<b>Physical</b>			0.00%

The Physical Storage Capacity consisted of 5,966.000 GB distributed over 20 disk drives each with a formatted capacity of 298.300 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 91.785 GB (1.54%) of Physical Storage Capacity. There was 42.950 GB (0.74%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100.00% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*mirroring*) capacity was 2,319.282 GB of which 2,391.282 GB was utilized. The total Unused Storage was 17.180 GB.

### SPC-1 Storage Capacities and Relationships Illustration

The various storage capacities configured in the benchmark result are illustrated below (not to scale).



### Logical Volume Capacity and ASU Mapping

#### Clause 9.4.3.6.3

A table illustrating the capacity of each ASU and the mapping of Logical Volumes to ASUs shall be provided in the FDR. ... Logical Volumes shall be sequenced in the table from top to bottom per its position in the contiguous address space of each ASU. The capacity of each Logical Volume shall be stated. ... In conjunction with this table, the Test Sponsor shall provide a complete description of the type of data protection (see Clause 2.4.5) used on each Logical Volume.

Logical Volume Capacity and Mapping		
ASU-1 (1,043.677 GB)	ASU-2 (1,043.677 GB)	ASU-3 (231.928 GB)
4 Logical Volumes 260.919 GB per Logical Volume (260.919 GB used per Logical Volume)	4 Logical Volumes 260.919 GB per Logical Volume (260.919 GB used per Logical Volume)	4 Logical Volumes 57.982 GB per Logical Volume (57.982 GB used per Logical Volume)

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

## 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%.

<b>SPC-1 Storage Capacity Utilization</b>	
Application Utilization	38.87%
Protected Application Utilization	77.75%
Unused Storage Ratio	0.29%

## **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. “SPC-1 Test Execution Definitions” on page 57 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.

## 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 three (3) 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 9.4.3.7.1

*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 63.

## Sustainability Test Results File

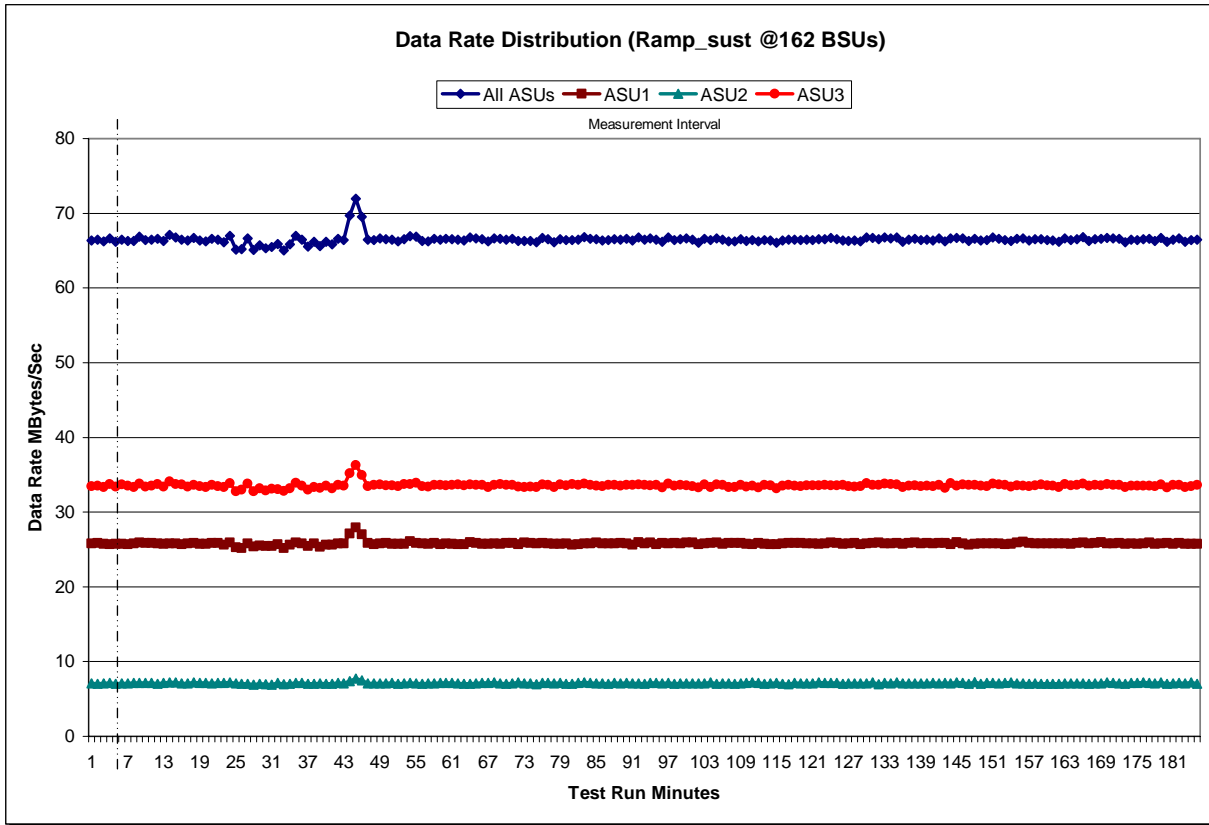
A link to the test results file generated from the Sustainability Test Run is listed below.

[Sustainability Test Results File](#)

**Sustainability – Data Rate Distribution Data (MB/second)**

	Start	Stop	Interval	Duration										
Ramp-Up/Start-Up	13:26:20	13:31:20	0-4	0:05:00										
Measurement Interval	13:31:20	16:31:20	4-184	3:00:00										
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	66.36	25.80	7.09	33.48	63	66.74	25.97	7.05	33.72	126	66.32	25.78	7.09	33.45
1	66.44	25.88	7.04	33.51	64	66.63	25.87	7.11	33.66	127	66.33	25.85	7.07	33.41
2	66.21	25.76	7.09	33.36	65	66.51	25.75	7.12	33.63	128	66.21	25.68	7.06	33.47
3	66.64	25.71	7.16	33.77	66	66.24	25.77	7.13	33.34	129	66.74	25.82	7.06	33.86
4	66.18	25.75	7.05	33.38	67	66.61	25.78	7.19	33.64	130	66.71	25.87	7.20	33.64
5	66.49	25.75	7.06	33.68	68	66.57	25.74	7.10	33.74	131	66.54	25.92	6.99	33.63
6	66.28	25.68	7.08	33.52	69	66.49	25.84	7.01	33.64	132	66.77	25.78	7.17	33.83
7	66.31	25.82	7.13	33.37	70	66.60	25.87	7.09	33.64	133	66.65	25.81	7.11	33.73
8	66.88	25.93	7.16	33.79	71	66.30	25.71	7.18	33.41	134	66.73	25.85	7.19	33.69
9	66.38	25.84	7.14	33.40	72	66.30	25.89	7.07	33.34	135	66.17	25.77	7.07	33.33
10	66.48	25.85	7.12	33.51	73	66.29	25.84	7.07	33.38	136	66.46	25.86	7.11	33.49
11	66.57	25.83	7.01	33.73	74	66.11	25.81	6.94	33.36	137	66.55	25.90	7.07	33.58
12	66.27	25.74	7.12	33.41	75	66.71	25.88	7.14	33.70	138	66.42	25.83	7.11	33.49
13	67.08	25.82	7.19	34.07	76	66.52	25.79	7.11	33.62	139	66.48	25.84	7.11	33.53
14	66.76	25.80	7.21	33.75	77	66.15	25.73	7.06	33.35	140	66.37	25.79	7.14	33.44
15	66.48	25.68	7.08	33.72	78	66.55	25.75	7.12	33.68	141	66.61	25.85	7.11	33.66
16	66.34	25.83	7.08	33.43	79	66.38	25.82	7.02	33.55	142	66.23	25.84	7.13	33.26
17	66.68	25.86	7.18	33.64	80	66.39	25.64	7.02	33.73	143	66.62	25.72	7.06	33.84
18	66.36	25.74	7.15	33.47	81	66.49	25.71	7.12	33.66	144	66.68	25.95	7.19	33.54
19	66.22	25.76	7.11	33.34	82	66.81	25.81	7.19	33.81	145	66.64	25.82	7.13	33.69
20	66.57	25.84	7.10	33.63	83	66.57	25.80	7.16	33.61	146	66.29	25.65	7.03	33.62
21	66.46	25.86	7.12	33.47	84	66.52	25.91	7.09	33.53	147	66.60	25.72	7.23	33.65
22	66.11	25.63	7.13	33.36	85	66.36	25.81	7.07	33.49	148	66.32	25.82	7.01	33.50
23	66.98	25.94	7.18	33.86	86	66.42	25.78	7.00	33.63	149	66.40	25.80	7.13	33.48
24	65.13	25.27	7.06	32.80	87	66.55	25.79	7.12	33.64	150	66.75	25.79	7.13	33.83
25	65.21	25.20	7.02	32.99	88	66.46	25.83	7.10	33.53	151	66.57	25.80	7.08	33.69
26	66.66	25.82	7.02	33.81	89	66.57	25.82	7.13	33.63	152	66.41	25.66	7.14	33.61
27	65.08	25.40	6.92	32.76	90	66.37	25.64	7.11	33.62	153	66.29	25.73	7.18	33.38
28	65.72	25.52	7.05	33.15	91	66.77	25.99	7.10	33.69	154	66.59	25.91	7.11	33.57
29	65.33	25.47	6.98	32.87	92	66.48	25.81	7.01	33.66	155	66.65	26.05	7.11	33.49
30	65.47	25.46	6.90	33.11	93	66.64	25.91	7.15	33.58	156	66.37	25.89	7.01	33.47
31	65.88	25.72	7.13	33.04	94	66.49	25.69	7.14	33.66	157	66.51	25.79	7.11	33.60
32	65.02	25.19	6.98	32.86	95	66.20	25.85	7.07	33.29	158	66.53	25.80	7.05	33.69
33	65.81	25.60	7.01	33.20	96	66.73	25.80	7.12	33.81	159	66.41	25.78	7.05	33.57
34	66.99	25.90	7.14	33.95	97	66.40	25.84	7.02	33.54	160	66.36	25.82	7.05	33.49
35	66.48	25.81	7.13	33.54	98	66.51	25.82	7.07	33.63	161	66.18	25.80	7.02	33.36
36	65.56	25.48	7.05	33.03	99	66.61	25.94	7.11	33.56	162	66.64	25.80	7.11	33.72
37	66.17	25.79	7.03	33.35	100	66.44	25.92	7.09	33.43	163	66.38	25.72	7.06	33.60
38	65.63	25.35	7.06	33.21	101	66.06	25.69	7.06	33.31	164	66.54	25.84	7.10	33.61
39	66.20	25.62	7.05	33.53	102	66.57	25.81	7.06	33.70	165	66.80	25.91	7.07	33.82
40	65.83	25.63	7.01	33.19	103	66.39	25.86	7.19	33.34	166	66.32	25.80	7.03	33.50
41	66.57	25.81	7.14	33.62	104	66.64	25.92	7.05	33.67	167	66.54	25.84	7.10	33.61
42	66.41	25.83	7.08	33.50	105	66.48	25.75	7.09	33.64	168	66.59	25.95	7.09	33.55
43	69.68	27.10	7.37	35.20	106	66.26	25.85	7.06	33.34	169	66.71	25.80	7.18	33.72
44	71.93	27.95	7.70	36.28	107	66.26	25.86	7.03	33.37	170	66.61	25.81	7.16	33.65
45	69.51	27.03	7.49	34.99	108	66.51	25.83	7.06	33.62	171	66.58	25.88	7.08	33.63
46	66.48	25.88	7.11	33.49	109	66.30	25.76	7.12	33.42	172	66.13	25.77	7.04	33.33
47	66.43	25.71	7.10	33.63	110	66.43	25.70	7.21	33.52	173	66.45	25.79	7.15	33.51
48	66.61	25.82	7.08	33.71	111	66.26	25.85	7.14	33.26	174	66.40	25.72	7.14	33.54
49	66.55	25.86	7.11	33.58	112	66.40	25.73	7.03	33.64	175	66.52	25.81	7.17	33.53
50	66.45	25.72	7.15	33.57	113	66.35	25.70	7.06	33.59	176	66.60	25.91	7.17	33.52
51	66.24	25.77	7.04	33.44	114	66.05	25.70	7.15	33.20	177	66.31	25.77	7.11	33.44
52	66.55	25.72	7.09	33.74	115	66.36	25.81	7.03	33.52	178	66.69	25.79	7.20	33.70
53	66.93	26.07	7.13	33.73	116	66.47	25.84	6.98	33.65	179	66.15	25.85	7.03	33.27
54	66.86	25.85	7.09	33.92	117	66.49	25.86	7.11	33.51	180	66.49	25.76	7.10	33.62
55	66.30	25.82	7.04	33.44	118	66.42	25.85	7.10	33.46	181	66.64	25.87	7.14	33.63
56	66.21	25.75	7.07	33.40	119	66.44	25.78	7.08	33.58	182	66.18	25.74	7.09	33.35
57	66.55	25.87	7.07	33.62	120	66.41	25.78	7.07	33.56	183	66.43	25.75	7.21	33.47
58	66.49	25.68	7.16	33.64	121	66.54	25.77	7.21	33.56	184	66.44	25.75	7.04	33.66
59	66.55	25.79	7.17	33.60	122	66.53	25.80	7.12	33.61					
60	66.52	25.77	7.14	33.61	123	66.70	25.94	7.17	33.59					
61	66.49	25.71	7.06	33.72	124	66.53	25.84	7.12	33.57					
62	66.33	25.69	7.05	33.59	125	66.37	25.73	7.00	33.64					

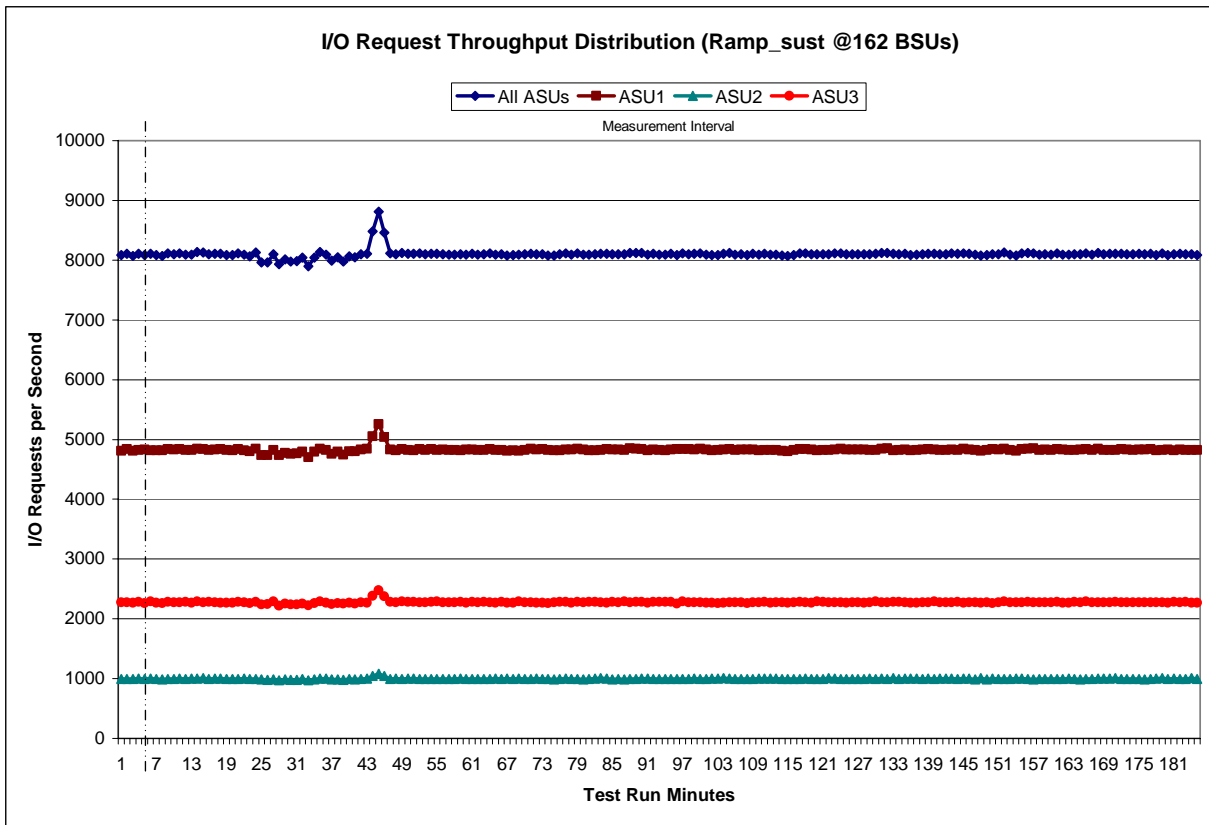
### Sustainability – Data Rate Distribution Graph



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

Ramp-Up/Start-Up Measurement Interval	Start	Stop	Interval	Duration										
	13:26:20	13:31:20	0-4	0:05:00										
	13:31:20	16:31:20	5-184	3:00:00										
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	8,082.57	4,809.20	996.80	2,276.57	63	8,111.83	4,840.00	993.43	2,278.40	126	8,095.78	4,827.27	993.07	2,275.45
1	8,107.73	4,837.70	994.47	2,275.57	64	8,092.45	4,823.95	998.42	2,270.08	127	8,099.40	4,832.83	995.93	2,270.63
2	8,072.20	4,811.42	992.82	2,267.97	65	8,097.78	4,823.67	994.63	2,279.48	128	8,097.35	4,823.68	1,000.85	2,272.82
3	8,107.42	4,823.02	999.72	2,284.68	66	8,080.25	4,808.50	1,000.47	2,271.28	129	8,107.33	4,826.13	992.60	2,288.60
4	8,083.40	4,830.68	990.28	2,262.43	67	8,084.17	4,818.40	996.25	2,269.52	130	8,119.22	4,843.73	1,002.40	2,273.08
5	8,108.98	4,817.40	1,003.50	2,288.08	68	8,093.85	4,807.25	998.38	2,288.22	131	8,119.40	4,851.72	993.78	2,273.90
6	8,083.03	4,819.90	993.78	2,269.35	69	8,096.75	4,824.70	994.30	2,277.75	132	8,103.68	4,819.18	1,004.45	2,280.05
7	8,067.27	4,814.48	989.88	2,262.90	70	8,108.98	4,842.05	993.02	2,273.92	133	8,102.08	4,824.35	995.47	2,282.27
8	8,110.67	4,835.75	996.22	2,278.70	71	8,097.68	4,831.93	999.95	2,265.80	134	8,104.50	4,830.35	999.63	2,274.52
9	8,101.53	4,832.73	995.28	2,273.52	72	8,101.62	4,841.25	994.35	2,266.02	135	8,084.58	4,816.47	997.75	2,270.37
10	8,113.15	4,837.53	1,000.22	2,275.40	73	8,081.15	4,823.40	995.80	2,261.95	136	8,089.07	4,825.07	998.97	2,265.03
11	8,095.20	4,822.97	990.87	2,281.37	74	8,080.12	4,818.52	985.07	2,276.53	137	8,098.90	4,827.73	992.85	2,278.32
12	8,091.62	4,823.12	997.35	2,271.15	75	8,099.80	4,819.25	996.25	2,284.30	138	8,110.00	4,838.03	998.20	2,273.77
13	8,133.68	4,842.42	998.60	2,292.67	76	8,117.17	4,834.25	998.48	2,284.43	139	8,106.75	4,827.27	992.07	2,287.42
14	8,124.57	4,839.68	1,006.72	2,278.17	77	8,091.02	4,827.75	995.27	2,268.00	140	8,098.67	4,825.40	997.37	2,275.90
15	8,098.00	4,825.33	993.58	2,279.08	78	8,114.03	4,843.93	991.43	2,278.67	141	8,098.27	4,825.33	997.35	2,275.58
16	8,104.60	4,832.68	998.55	2,273.37	79	8,094.08	4,833.85	985.60	2,274.63	142	8,110.47	4,833.95	1,002.55	2,273.97
17	8,107.63	4,835.13	1,002.18	2,270.32	80	8,094.72	4,817.05	996.23	2,281.43	143	8,102.97	4,824.65	993.85	2,284.47
18	8,087.93	4,823.72	996.78	2,267.43	81	8,100.98	4,819.38	1,001.87	2,279.73	144	8,114.57	4,845.53	1,001.95	2,267.08
19	8,085.33	4,819.48	995.60	2,270.25	82	8,106.30	4,825.50	1,005.48	2,275.32	145	8,104.30	4,828.50	1,000.40	2,275.40
20	8,114.62	4,836.05	994.10	2,284.52	83	8,105.52	4,837.28	1,001.12	2,267.12	146	8,091.00	4,825.75	989.45	2,275.80
21	8,090.52	4,817.88	997.83	2,274.80	84	8,102.40	4,832.28	988.75	2,281.37	147	8,081.33	4,810.48	1,005.28	2,265.57
22	8,063.55	4,805.20	995.55	2,262.80	85	8,102.27	4,834.40	995.27	2,272.60	148	8,083.23	4,822.68	987.33	2,273.22
23	8,124.62	4,842.65	996.28	2,285.68	86	8,101.65	4,825.28	988.58	2,287.78	149	8,099.27	4,837.65	997.98	2,263.63
24	7,965.50	4,740.63	985.48	2,239.38	87	8,124.03	4,849.88	996.30	2,277.85	150	8,097.63	4,827.50	995.72	2,274.42
25	7,960.98	4,735.12	982.18	2,243.68	88	8,117.52	4,841.98	992.45	2,283.08	151	8,129.93	4,845.00	994.98	2,289.95
26	8,100.77	4,827.15	987.42	2,286.20	89	8,120.43	4,838.72	1,000.62	2,281.10	152	8,090.47	4,820.03	994.03	2,276.40
27	7,930.32	4,736.82	972.62	2,220.88	90	8,089.08	4,817.18	1,001.80	2,270.10	153	8,076.87	4,805.67	998.87	2,272.33
28	8,015.60	4,776.68	988.52	2,250.40	91	8,105.05	4,830.05	996.02	2,278.98	154	8,117.23	4,840.50	999.15	2,277.58
29	7,976.38	4,760.98	976.98	2,238.42	92	8,092.65	4,821.98	990.85	2,279.82	155	8,119.65	4,843.25	994.12	2,282.28
30	7,984.23	4,767.53	977.97	2,238.73	93	8,095.57	4,819.73	996.82	2,279.02	156	8,111.85	4,849.08	989.88	2,272.88
31	8,042.32	4,797.85	992.00	2,252.47	94	8,107.07	4,829.15	997.00	2,280.92	157	8,089.23	4,820.23	991.58	2,277.42
32	7,901.13	4,703.23	970.75	2,227.15	95	8,082.42	4,834.72	991.70	2,256.00	158	8,101.80	4,830.55	995.03	2,276.22
33	8,041.97	4,793.03	985.72	2,263.22	96	8,115.00	4,835.52	992.80	2,286.68	159	8,092.68	4,821.98	992.72	2,277.98
34	8,133.33	4,843.25	998.97	2,291.12	97	8,102.13	4,835.15	992.47	2,274.52	160	8,112.32	4,841.05	989.93	2,281.33
35	8,094.82	4,823.35	1,000.82	2,270.65	98	8,105.37	4,828.53	999.18	2,277.65	161	8,089.00	4,827.57	990.45	2,270.98
36	7,991.75	4,760.00	985.00	2,246.75	99	8,112.58	4,843.43	992.25	2,276.90	162	8,094.37	4,827.17	997.65	2,269.55
37	8,045.83	4,795.65	989.45	2,260.73	100	8,094.92	4,830.17	995.43	2,269.32	163	8,099.20	4,820.87	994.78	2,283.55
38	7,976.27	4,744.25	982.07	2,249.95	101	8,083.90	4,813.50	1,000.58	2,269.82	164	8,095.80	4,833.58	989.25	2,272.97
39	8,062.32	4,798.82	992.30	2,271.20	102	8,081.42	4,820.22	998.02	2,263.18	165	8,115.25	4,834.78	994.60	2,285.87
40	8,047.25	4,805.15	989.88	2,252.22	103	8,106.13	4,834.23	1,005.18	2,266.72	166	8,094.10	4,826.57	995.83	2,271.70
41	8,102.80	4,833.00	992.08	2,277.72	104	8,117.92	4,841.25	998.75	2,277.92	167	8,120.27	4,842.85	999.37	2,278.05
42	8,108.60	4,844.83	997.23	2,266.53	105	8,093.55	4,826.97	991.97	2,274.62	168	8,097.88	4,823.67	998.13	2,276.08
43	8,483.45	5,057.20	1,042.30	2,383.95	106	8,099.25	4,828.48	994.00	2,276.77	169	8,105.82	4,824.82	1,002.63	2,278.37
44	8,809.73	5,255.42	1,079.05	2,475.27	107	8,088.20	4,833.98	994.22	2,260.00	170	8,108.63	4,823.07	1,005.88	2,279.68
45	8,459.33	5,040.12	1,046.35	2,372.87	108	8,105.00	4,831.38	995.37	2,278.25	171	8,106.97	4,834.80	995.18	2,276.98
46	8,113.32	4,833.38	995.97	2,283.97	109	8,094.53	4,817.15	1,002.33	2,275.05	172	8,095.92	4,828.67	995.17	2,272.08
47	8,097.87	4,819.88	1,003.13	2,274.85	110	8,103.48	4,820.27	1,003.67	2,279.55	173	8,095.78	4,825.58	994.77	2,275.43
48	8,118.38	4,835.87	993.85	2,288.67	111	8,095.65	4,827.15	998.32	2,270.18	174	8,103.18	4,827.77	997.08	2,278.33
49	8,104.52	4,825.73	999.78	2,279.00	112	8,094.15	4,821.80	1,000.10	2,272.25	175	8,096.73	4,829.58	989.13	2,278.02
50	8,103.13	4,819.25	998.78	2,285.10	113	8,075.98	4,808.97	991.78	2,275.23	176	8,107.13	4,839.07	995.72	2,272.35
51	8,111.83	4,839.58	995.68	2,276.57	114	8,067.80	4,804.80	997.02	2,265.98	177	8,086.85	4,817.13	997.80	2,271.92
52	8,096.28	4,822.77	995.75	2,277.77	115	8,085.70	4,820.42	992.30	2,272.98	178	8,110.22	4,826.92	1,006.33	2,276.97
53	8,110.10	4,834.95	994.85	2,280.30	116	8,114.02	4,839.93	993.27	2,280.82	179	8,088.38	4,828.87	992.68	2,266.83
54	8,109.27	4,821.70	995.48	2,292.08	117	8,112.33	4,841.08	997.35	2,273.90	180	8,101.60	4,819.97	1,000.00	2,281.63
55	8,099.50	4,832.12	994.88	2,272.50	118	8,099.40	4,834.22	995.13	2,270.05	181	8,104.55	4,831.30	996.62	2,276.63
56	8,093.67	4,820.10	995.72	2,277.85	119	8,095.95	4,815.12	994.50	2,286.33	182	8,097.12	4,820.87	996.33	2,279.92
57	8,089.45	4,822.97	992.22	2,274.27	120	8,100.20	4,825.45	993.40	2,281.35	183	8,101.02	4,824.97	1,004.93	2,271.12
58	8,099.17	4,815.87	999.97	2,283.33	121	8,101.33	4,820.52	1,006.92	2,273.90	184	8,085.92	4,822.78	992.28	2,270.85
59	8,095.35	4,828.50	997.03	2,269.82	122	8,111.65	4,833.97	1,000.62	2,277.07	<b>Average 8,100.58 4,828.29 996.33 2,275.96</b>				
60	8,106.57	4,830.97	994.67	2,280.93	123	8,113.68	4,841.82	995.92	2,275.95					
61	8,089.42	4,821.20	996.18	2,272.03	124	8,096.90	4,832.83	992.72	2,271.35					
62	8,100.87	4,826.03	993.33	2,281.50	125	8,102.47	4,830.05	996.95	2,275.47					

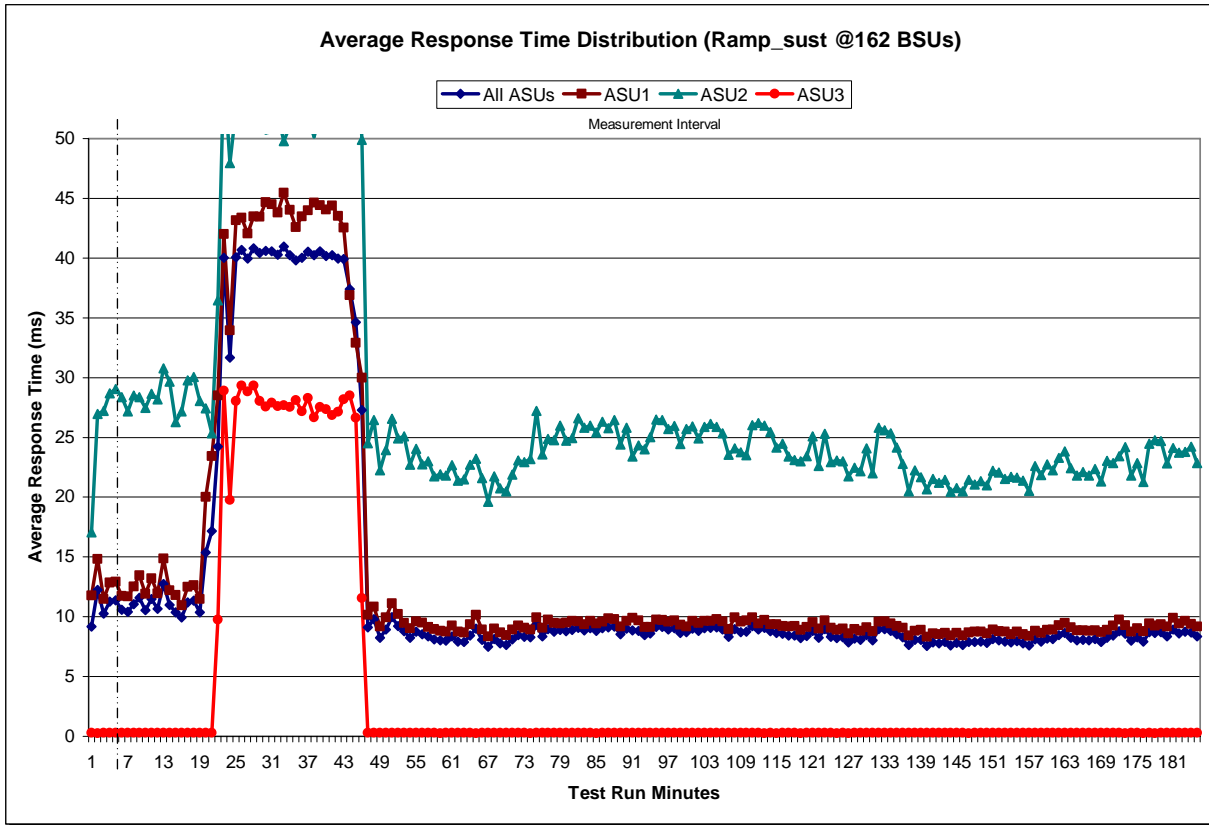
### Sustainability – I/O Request Throughput Distribution Graph



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

	Start	Stop	Interval	Duration										
Ramp-Up/Start-Up	13:26:20	13:31:20	0-4	0:05:00										
Measurement Interval	13:31:20	16:31:20	4-184	3:00:00										
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	9.19	11.77	17.08	0.27	63	8.44	9.35	22.72	0.27	126	7.86	8.59	21.73	0.27
1	12.24	14.85	26.96	0.27	64	8.99	10.15	23.23	0.27	127	8.19	8.96	22.45	0.28
2	10.27	11.49	27.22	0.27	65	8.05	8.94	21.58	0.27	128	8.08	8.83	22.18	0.27
3	11.26	12.86	28.67	0.27	66	7.48	8.35	19.62	0.27	129	8.45	9.10	24.07	0.28
4	11.36	12.93	29.06	0.27	67	8.12	9.00	21.73	0.28	130	8.03	8.78	22.01	0.27
5	10.57	11.75	28.37	0.28	68	7.79	8.67	20.74	0.27	131	8.97	9.59	25.82	0.27
6	10.39	11.70	27.18	0.27	69	7.64	8.47	20.49	0.28	132	8.97	9.61	25.59	0.27
7	11.05	12.54	28.50	0.27	70	8.09	8.93	21.90	0.27	133	8.81	9.44	25.34	0.27
8	11.59	13.47	28.35	0.28	71	8.46	9.27	23.08	0.27	134	8.54	9.21	24.17	0.27
9	10.56	11.92	27.46	0.28	72	8.32	9.08	22.92	0.27	135	8.29	9.07	22.77	0.28
10	11.49	13.21	28.64	0.28	73	8.26	8.93	23.18	0.27	136	7.63	8.42	20.50	0.27
11	10.65	11.96	28.20	0.28	74	9.33	9.95	27.23	0.27	137	8.05	8.80	22.26	0.28
12	12.73	14.86	30.77	0.27	75	8.36	9.05	23.58	0.27	138	8.05	8.90	21.66	0.28
13	10.99	12.21	29.66	0.27	76	8.96	9.77	24.87	0.29	139	7.56	8.33	20.66	0.28
14	10.37	11.81	26.27	0.28	77	8.76	9.45	24.78	0.27	140	7.86	8.62	21.51	0.28
15	9.94	10.96	27.18	0.28	78	8.88	9.42	26.00	0.28	141	7.77	8.53	21.22	0.28
16	11.20	12.50	29.79	0.27	79	8.77	9.51	24.74	0.28	142	7.89	8.65	21.46	0.28
17	11.32	12.63	30.05	0.28	80	8.89	9.66	24.94	0.27	143	7.60	8.43	20.44	0.28
18	10.37	11.47	28.03	0.27	81	9.08	9.60	26.59	0.27	144	7.80	8.63	20.77	0.28
19	15.39	20.02	27.41	0.28	82	8.84	9.35	25.80	0.28	145	7.62	8.41	20.47	0.28
20	17.16	23.44	25.36	0.28	83	9.05	9.66	25.99	0.28	146	7.87	8.67	21.46	0.27
21	24.22	28.51	36.46	9.76	84	8.81	9.45	25.42	0.27	147	7.89	8.73	21.05	0.27
22	40.02	42.00	55.71	28.89	85	9.03	9.58	26.31	0.28	148	7.91	8.76	21.33	0.27
23	31.67	33.95	47.93	19.75	86	9.11	9.88	25.77	0.28	149	7.79	8.59	20.98	0.27
24	40.05	43.16	52.46	28.03	87	9.18	9.81	26.44	0.28	150	8.13	8.92	22.22	0.27
25	40.69	43.36	53.75	29.35	88	8.54	9.18	24.41	0.28	151	8.02	8.80	22.06	0.28
26	39.96	42.06	55.44	28.84	89	9.00	9.64	25.83	0.27	152	7.93	8.75	21.52	0.27
27	40.84	43.49	54.13	29.35	90	8.87	9.90	23.38	0.28	153	7.84	8.52	21.70	0.28
28	40.41	43.44	53.91	28.05	91	8.83	9.67	24.35	0.28	154	7.96	8.75	21.65	0.27
29	40.59	44.67	50.48	27.59	92	8.47	9.15	24.01	0.27	155	7.78	8.52	21.39	0.27
30	40.58	44.48	50.59	27.89	93	8.59	9.13	25.01	0.28	156	7.60	8.40	20.51	0.27
31	40.28	43.81	51.94	27.61	94	9.16	9.77	26.51	0.28	157	8.12	8.84	22.62	0.28
32	40.98	45.46	49.78	27.67	95	9.14	9.72	26.46	0.28	158	7.92	8.65	21.84	0.27
33	40.25	44.03	51.10	27.52	96	8.93	9.58	25.71	0.28	159	8.17	8.90	22.75	0.27
34	39.82	42.59	53.21	28.11	97	9.04	9.70	25.95	0.28	160	8.12	8.93	22.24	0.27
35	40.03	43.49	52.47	27.19	98	8.64	9.32	24.43	0.28	161	8.48	9.29	23.30	0.28
36	40.52	43.97	51.74	28.30	99	8.70	9.18	25.69	0.27	162	8.65	9.45	23.84	0.28
37	40.26	44.63	50.13	26.66	100	9.02	9.64	25.92	0.28	163	8.26	9.12	22.42	0.27
38	40.58	44.40	51.94	27.55	101	8.80	9.48	24.90	0.28	164	8.02	8.84	21.81	0.28
39	40.18	44.06	50.77	27.36	102	9.02	9.65	25.87	0.27	165	8.06	8.85	22.09	0.27
40	40.26	44.40	50.67	26.84	103	9.08	9.65	26.14	0.27	166	8.03	8.84	21.81	0.27
41	39.95	43.53	51.91	27.14	104	9.11	9.81	25.88	0.28	167	8.12	8.87	22.36	0.27
42	39.93	42.54	53.91	28.19	105	8.93	9.63	25.35	0.27	168	7.90	8.72	21.29	0.27
43	37.40	36.91	60.06	28.52	106	8.30	8.95	23.53	0.27	169	8.23	8.91	23.05	0.27
44	34.62	32.92	61.20	26.63	107	8.97	9.92	24.09	0.28	170	8.41	9.24	22.85	0.27
45	27.28	29.99	49.90	11.54	108	8.70	9.57	23.75	0.27	171	8.78	9.77	23.43	0.28
46	9.12	10.13	24.52	0.28	109	8.76	9.70	23.50	0.28	172	8.58	9.27	24.18	0.27
47	9.80	10.84	26.44	0.28	110	9.22	9.95	26.01	0.28	173	7.98	8.77	21.82	0.28
48	8.26	9.16	22.26	0.27	111	8.93	9.42	26.22	0.28	174	8.27	9.03	22.84	0.28
49	8.94	9.92	23.95	0.28	112	9.06	9.70	25.98	0.27	175	7.91	8.77	21.28	0.27
50	9.96	11.11	26.56	0.27	113	8.78	9.37	25.44	0.28	176	8.72	9.44	24.48	0.29
51	9.23	10.21	24.89	0.29	114	8.64	9.37	24.15	0.27	177	8.65	9.26	24.78	0.27
52	8.80	9.46	25.10	0.27	115	8.57	9.21	24.48	0.28	178	8.72	9.37	24.70	0.28
53	8.26	9.05	22.73	0.27	116	8.42	9.19	23.39	0.28	179	8.36	9.18	22.82	0.28
54	8.76	9.63	24.06	0.27	117	8.43	9.23	23.12	0.28	180	8.94	9.89	24.11	0.28
55	8.54	9.50	22.76	0.27	118	8.20	8.87	22.99	0.27	181	8.61	9.42	23.71	0.27
56	8.35	9.14	23.01	0.28	119	8.39	9.13	23.43	0.27	182	8.74	9.63	23.80	0.27
57	8.09	8.97	21.75	0.28	120	8.83	9.54	25.07	0.27	183	8.68	9.40	24.23	0.28
58	8.02	8.81	21.92	0.27	121	8.23	8.98	22.61	0.27	184	8.36	9.18	22.87	0.27
59	7.99	8.76	21.82	0.27	122	8.97	9.68	25.31	0.27	<b>Average 12.90 14.08 27.86 3.87</b>				
60	8.37	9.24	22.69	0.27	123	8.31	9.09	22.92	0.28					
61	7.93	8.76	21.39	0.27	124	8.20	8.88	23.08	0.27					
62	7.89	8.69	21.51	0.27	125	8.28	9.01	22.99	0.27					

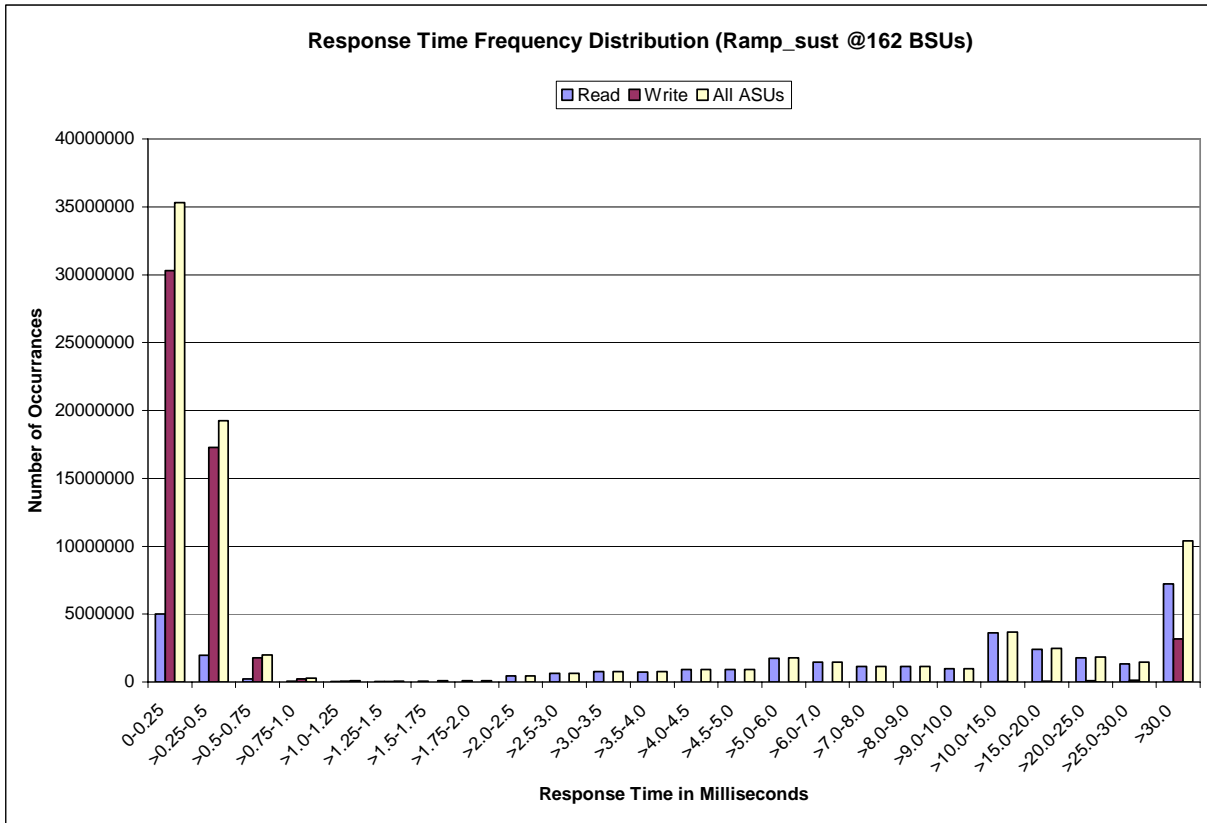
### Sustainability – Average Response Time (ms) Distribution Graph



**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	5,015,677	1,975,628	208,586	50,171	24,694	32,169	65,972	101,944
Write	30,293,397	17,272,653	1,781,798	221,691	79,231	39,443	15,528	7,795
All ASUs	35,309,074	19,248,281	1,990,384	271,862	103,925	71,612	81,500	109,739
ASU1	17,495,038	8,341,991	556,775	104,462	52,324	45,863	70,074	102,791
ASU2	4,669,738	2,159,678	133,984	24,472	12,211	6,836	4,124	3,847
ASU3	13,144,298	8,746,612	1,299,625	142,928	39,390	18,913	7,302	3,101
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	441,424	638,421	749,323	739,918	928,690	926,531	1,751,114	1,452,755
Write	10,333	8,228	6,849	5,699	5,351	5,280	8,560	7,542
All ASUs	451,757	646,649	756,172	745,617	934,041	931,811	1,759,674	1,460,297
ASU1	436,542	627,606	732,229	717,552	895,174	890,055	1,675,376	1,376,510
ASU2	11,750	16,823	21,985	26,555	37,373	40,436	82,065	81,902
ASU3	3,465	2,220	1,958	1,510	1,494	1,320	2,233	1,885
Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	1,132,748	1,135,694	985,807	3,625,426	2,394,471	1,766,036	1,332,683	7,216,560
Write	7,297	7,954	7,651	45,617	63,724	87,066	113,048	3,177,395
All ASUs	1,140,045	1,143,648	993,458	3,671,043	2,458,195	1,853,102	1,445,731	10,393,955
ASU1	1,068,470	1,075,525	933,013	3,402,566	2,230,884	1,641,385	1,243,834	6,718,797
ASU2	69,605	65,917	58,182	254,238	205,614	181,033	161,156	2,490,519
ASU3	1,970	2,206	2,263	14,239	21,697	30,684	40,741	1,184,639

**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 5.3.13.2

**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 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2811	0.0699	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.008	0.002	0.005	0.003	0.011	0.005	0.007	0.002

## 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 9.4.3.7.2

*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 63.

## IOPS Test Results File

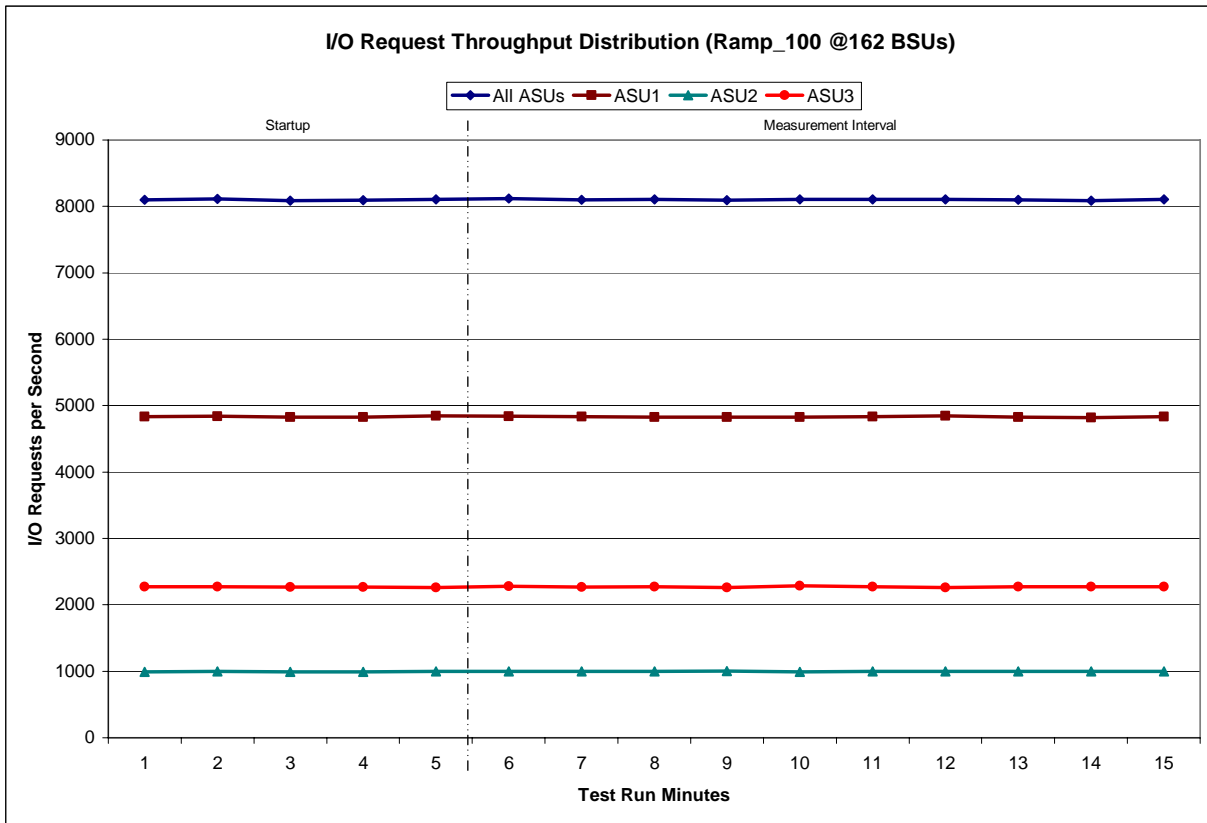
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

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

162 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	16:32:23	16:37:24	0-4	0:05:01
<i>Measurement Interval</i>	16:37:24	16:47:24	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	8,096.95	4,835.13	988.77	2,273.05
1	8,110.52	4,838.85	995.72	2,275.95
2	8,085.77	4,825.70	993.80	2,266.27
3	8,092.45	4,829.42	992.30	2,270.73
4	8,106.65	4,848.87	996.08	2,261.70
5	8,116.48	4,838.03	995.92	2,282.53
6	8,098.67	4,831.70	997.82	2,269.15
7	8,107.33	4,829.77	1,001.00	2,276.57
8	8,092.05	4,826.15	1,002.57	2,263.33
9	8,104.42	4,825.23	991.25	2,287.93
10	8,107.70	4,835.42	996.30	2,275.98
11	8,105.33	4,845.07	996.65	2,263.62
12	8,096.17	4,824.58	996.43	2,275.15
13	8,088.32	4,819.43	994.95	2,273.93
14	8,108.12	4,832.95	998.90	2,276.27
<b>Average</b>	<b>8,102.46</b>	<b>4,830.83</b>	<b>997.18</b>	<b>2,274.45</b>

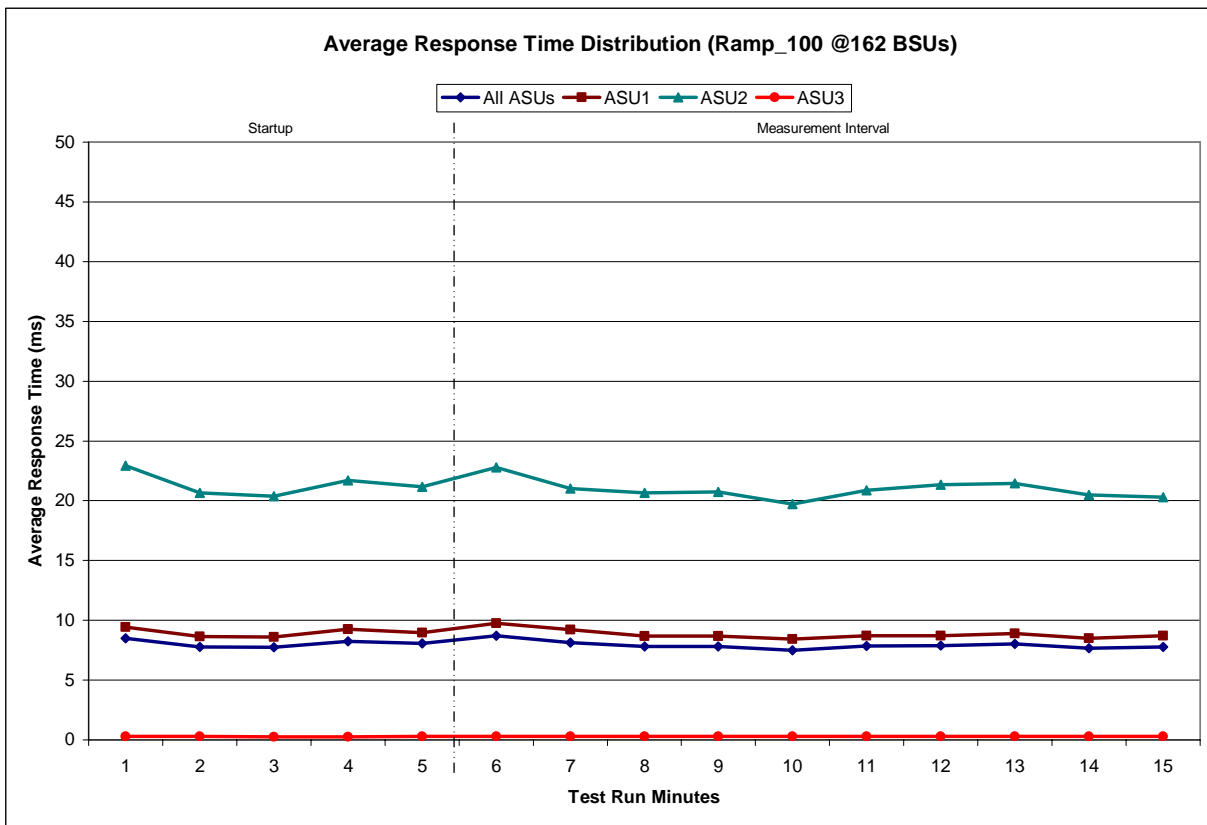
**IOPS Test Run – I/O Request Throughput Distribution Graph**



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

162 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:32:23	16:37:24	0-4	0:05:01
Measurement Interval	16:37:24	16:47:24	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	8.50	9.43	22.92	0.27
1	7.77	8.65	20.65	0.28
2	7.73	8.62	20.38	0.27
3	8.25	9.24	21.72	0.27
4	8.05	8.98	21.17	0.27
5	8.69	9.77	22.77	0.27
6	8.15	9.20	21.02	0.27
7	7.79	8.67	20.66	0.28
8	7.82	8.67	20.72	0.27
9	7.50	8.41	19.72	0.27
10	7.85	8.72	20.89	0.28
11	7.90	8.70	21.34	0.28
12	8.01	8.89	21.45	0.27
13	7.66	8.50	20.49	0.27
14	7.77	8.71	20.31	0.27
<b>Average</b>	<b>7.92</b>	<b>8.82</b>	<b>20.94</b>	<b>0.27</b>

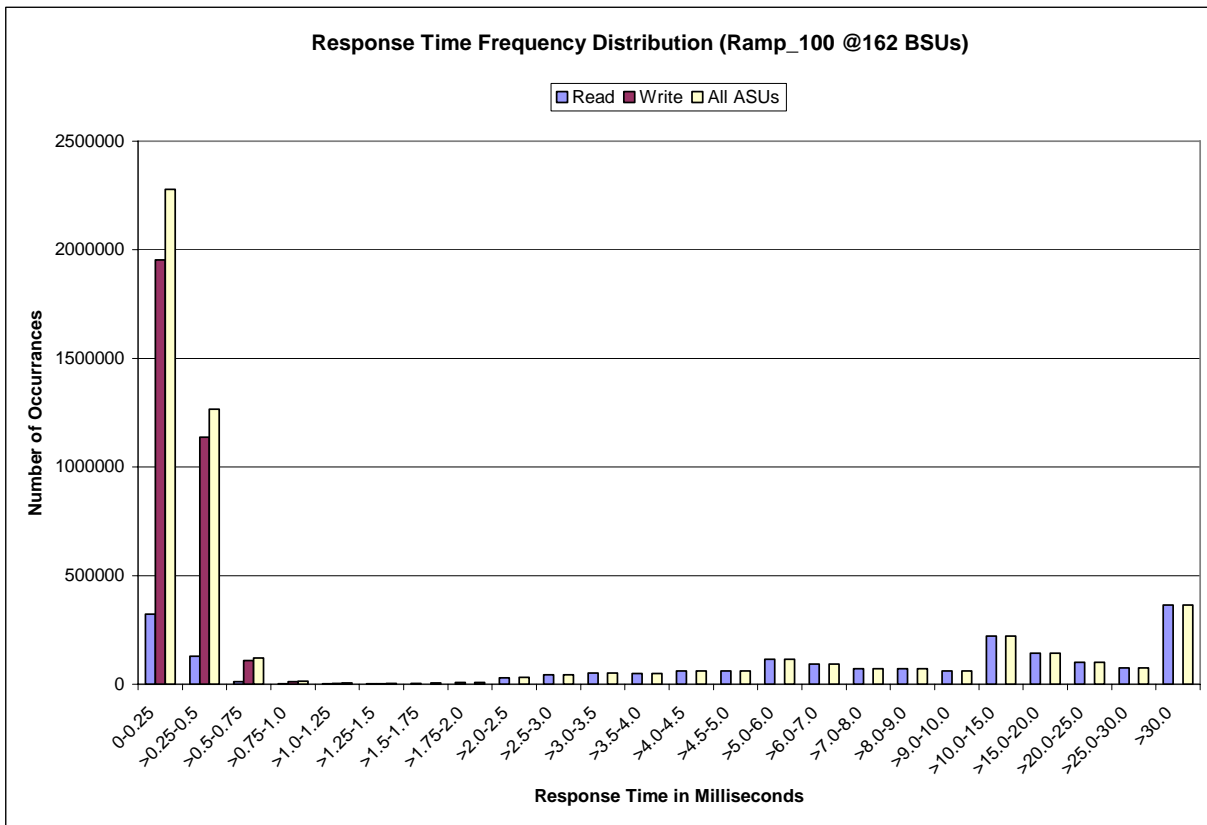
**IOPS Test Run – Average Response Time (ms) Distribution Graph**



**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	323355	128,819	11,780	2,700	1,407	2,056	4,591	7,224
Write	1954176	1,137,513	108,310	11,671	4,532	2,547	875	403
All ASUs	2277531	1,266,332	120,090	14,371	5,939	4,603	5,466	7,627
ASU1	1138261	552,326	31,008	5,266	3,011	2,914	4,780	7,192
ASU2	309955	143,104	7,904	1,290	693	411	233	255
ASU3	829315	570,902	81,178	7,815	2,235	1,278	453	180
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	30,678	43,363	50,904	49,657	61,723	61,473	115,094	93,363
Write	413	263	202	223	136	112	179	129
All ASUs	31,091	43,626	51,106	49,880	61,859	61,585	115,273	93,492
ASU1	30,207	42,539	49,683	48,214	59,593	59,074	110,124	88,419
ASU2	706	981	1,343	1,589	2,213	2,478	5,089	5,029
ASU3	178	106	80	77	53	33	60	44
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	71,919	71,958	61,872	222,597	141,956	101,858	75,116	364,580
Write	85	53	44	146	85	23	26	116
All ASUs	72,004	72,011	61,916	222,743	142,041	101,881	75,142	364,696
ASU1	68,012	68,095	58,702	208,412	130,775	91,985	66,523	248,567
ASU2	3,971	3,909	3,200	14,306	11,245	9,896	8,619	116,129
ASU3	21	7	14	25	21	-	-	-

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



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

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
5,322,305	4,957,609	364,696

**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 5.3.13.2

**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 5.3.13.3

**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	0.0351	0.2808	0.0700	0.2103	0.0180	0.0701	0.0350	0.2807
COV	0.006	0.002	0.004	0.003	0.012	0.004	0.008	0.003

## 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 13.*

*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 9.4.3.7.3

*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 63.

## 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](#)

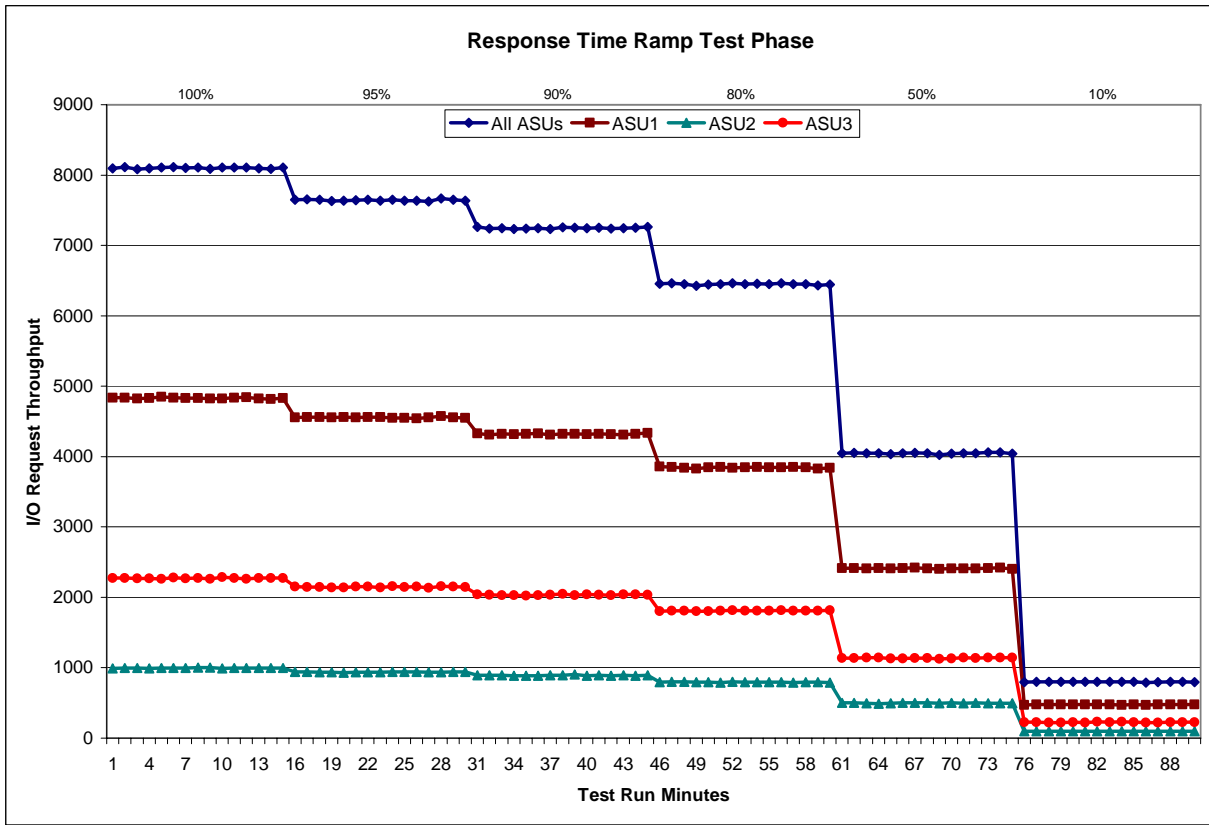
[10% Load Level](#)

**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 tables and graphs for completeness.

100% Load Level - 162 BSUs					95% Load Level - 153 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
16:32:23	16:37:24	0-4	0:05:01		16:48:26	16:53:27	0-4	0:05:01	
<b>Start-Up/Ramp-Up</b>					<b>Start-Up/Ramp-Up</b>				
<b>Measurement Interval</b>					<b>Measurement Interval</b>				
16:37:24	16:47:24	5-14	0:10:00		16:53:27	17:03:27	5-14	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>		<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	
0	8,096.95	4,835.13	988.77	2,273.05	0	7,650.27	4,555.68	940.30	2,154.28
1	8,110.52	4,838.85	995.72	2,275.95	1	7,654.57	4,562.20	943.95	2,148.42
2	8,085.77	4,825.70	993.80	2,266.27	2	7,646.08	4,562.18	937.58	2,146.32
3	8,092.45	4,829.42	992.30	2,270.73	3	7,630.28	4,554.90	938.35	2,137.03
4	8,106.65	4,848.87	996.08	2,261.70	4	7,637.45	4,563.20	932.00	2,142.25
5	8,116.48	4,838.03	995.92	2,282.53	5	7,643.57	4,555.43	935.73	2,152.40
6	8,098.67	4,831.70	997.82	2,269.15	6	7,651.07	4,563.83	935.15	2,152.08
7	8,107.33	4,829.77	1,001.00	2,276.57	7	7,636.47	4,560.15	937.95	2,138.37
8	8,092.05	4,826.15	1,002.57	2,263.33	8	7,647.10	4,545.88	942.53	2,158.68
9	8,104.42	4,825.23	991.25	2,287.93	9	7,634.67	4,551.58	939.57	2,143.52
10	8,107.70	4,835.42	996.30	2,275.98	10	7,636.03	4,541.40	940.63	2,154.00
11	8,105.33	4,845.07	996.65	2,263.62	11	7,625.63	4,552.47	937.50	2,135.67
12	8,096.17	4,824.58	996.43	2,275.15	12	7,666.73	4,571.57	936.80	2,158.37
13	8,088.32	4,819.43	994.95	2,273.93	13	7,648.40	4,554.58	943.23	2,150.58
14	8,108.12	4,832.95	998.90	2,276.27	14	7,639.27	4,550.85	944.23	2,144.18
<b>Average</b>	<b>8,102.46</b>	<b>4,830.83</b>	<b>997.18</b>	<b>2,274.45</b>	<b>Average</b>	<b>7,642.89</b>	<b>4,554.78</b>	<b>939.33</b>	<b>2,148.79</b>
90% Load Level - 145 BSUs					80% Load Level - 129 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
17:04:29	17:09:30	0-4	0:05:01		17:20:32	17:25:33	0-4	0:05:01	
<b>Start-Up/Ramp-Up</b>					<b>Start-Up/Ramp-Up</b>				
<b>Measurement Interval</b>					<b>Measurement Interval</b>				
17:09:30	17:19:30	5-14	0:10:00		17:25:33	17:35:33	5-14	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>		<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	
0	7,260.53	4,326.20	892.32	2,042.02	0	6,454.75	3,855.58	793.55	1,805.62
1	7,239.18	4,310.92	889.85	2,038.42	1	6,463.43	3,849.38	801.38	1,812.67
2	7,244.83	4,324.00	889.67	2,031.17	2	6,447.77	3,842.38	798.62	1,806.77
3	7,232.68	4,315.62	887.67	2,029.40	3	6,428.63	3,828.18	794.63	1,805.82
4	7,239.90	4,325.12	888.75	2,026.03	4	6,441.58	3,845.85	793.62	1,802.12
5	7,244.62	4,327.22	888.50	2,028.90	5	6,452.97	3,852.25	789.50	1,811.22
6	7,236.02	4,308.12	891.02	2,036.88	6	6,460.05	3,841.90	801.15	1,817.00
7	7,258.30	4,320.22	890.40	2,047.68	7	6,452.00	3,848.30	796.93	1,806.77
8	7,251.67	4,321.53	901.97	2,028.17	8	6,457.57	3,848.97	796.87	1,811.73
9	7,244.32	4,314.23	885.25	2,044.83	9	6,448.23	3,845.02	792.80	1,810.42
10	7,251.35	4,321.15	892.25	2,037.95	10	6,461.55	3,848.50	794.78	1,818.27
11	7,238.00	4,316.72	889.00	2,032.28	11	6,451.60	3,849.98	791.55	1,810.07
12	7,244.90	4,309.27	893.20	2,042.43	12	6,449.08	3,844.23	792.38	1,812.47
13	7,253.30	4,323.28	889.27	2,040.75	13	6,432.90	3,828.67	796.37	1,807.87
14	7,262.35	4,332.60	890.83	2,038.92	14	6,442.08	3,837.12	788.52	1,816.45
<b>Average</b>	<b>7,248.48</b>	<b>4,319.43</b>	<b>891.17</b>	<b>2,037.88</b>	<b>Average</b>	<b>6,450.80</b>	<b>3,844.49</b>	<b>794.09</b>	<b>1,812.23</b>
50% Load Level - 81 BSUs					10% Load Level - 16 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
17:36:35	17:41:36	0-4	0:05:01		17:52:37	17:57:38	0-4	0:05:01	
<b>Start-Up/Ramp-Up</b>					<b>Start-Up/Ramp-Up</b>				
<b>Measurement Interval</b>					<b>Measurement Interval</b>				
17:41:36	17:51:36	5-14	0:10:00		17:57:38	18:07:38	5-14	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>		<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	
0	4,050.55	2,412.93	501.38	1,136.23	0	795.57	472.42	97.20	225.95
1	4,056.13	2,416.08	500.90	1,139.15	1	801.32	478.55	97.33	225.43
2	4,046.92	2,406.72	497.78	1,142.42	2	799.28	478.98	97.85	222.45
3	4,050.60	2,415.65	489.63	1,145.32	3	799.43	478.50	98.43	222.50
4	4,034.68	2,409.40	494.65	1,130.63	4	799.45	477.67	97.72	224.07
5	4,047.08	2,415.15	498.38	1,133.55	5	799.23	476.17	100.13	222.93
6	4,054.90	2,419.43	499.48	1,135.98	6	802.82	474.25	99.22	229.35
7	4,047.88	2,406.13	503.85	1,137.90	7	798.47	474.90	97.47	226.10
8	4,023.70	2,403.33	497.65	1,122.72	8	800.07	472.23	98.07	229.77
9	4,042.57	2,410.13	498.67	1,133.77	9	802.63	479.95	98.95	223.73
10	4,047.65	2,406.18	497.77	1,143.70	10	791.53	471.02	98.77	221.75
11	4,046.55	2,409.78	498.72	1,138.05	11	796.48	476.57	99.78	220.13
12	4,056.90	2,416.88	496.17	1,143.85	12	799.13	475.40	98.87	224.87
13	4,057.20	2,418.55	498.08	1,140.57	13	802.47	476.28	99.07	227.12
14	4,040.77	2,402.03	494.22	1,144.52	14	797.35	476.47	95.82	225.07
<b>Average</b>	<b>4,046.52</b>	<b>2,410.76</b>	<b>498.30</b>	<b>1,137.46</b>	<b>Average</b>	<b>799.02</b>	<b>475.32</b>	<b>98.61</b>	<b>225.08</b>

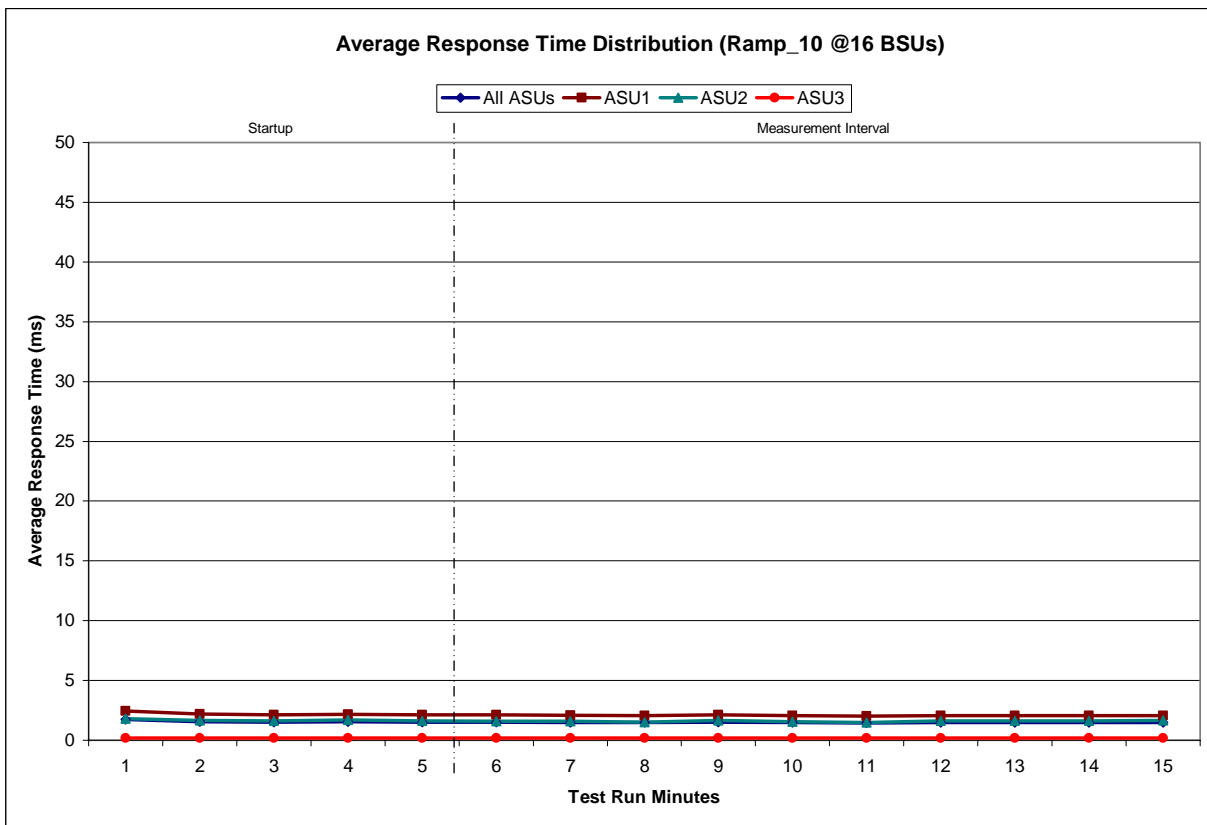
### Response Time Ramp Distribution (IOPS) Graph



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

16 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:52:37	17:57:38	0-4	0:05:01
<i>Measurement Interval</i>	17:57:38	18:07:38	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.72	2.45	1.79	0.18
1	1.56	2.19	1.66	0.18
2	1.52	2.12	1.63	0.18
3	1.55	2.17	1.68	0.18
4	1.51	2.12	1.61	0.18
5	1.51	2.12	1.57	0.18
6	1.48	2.08	1.60	0.18
7	1.46	2.06	1.52	0.18
8	1.50	2.11	1.65	0.18
9	1.48	2.06	1.56	0.18
10	1.44	2.02	1.48	0.18
11	1.49	2.06	1.62	0.18
12	1.46	2.04	1.63	0.18
13	1.47	2.06	1.61	0.18
14	1.46	2.04	1.64	0.18
<i>Average</i>	<i>1.47</i>	<i>2.06</i>	<i>1.59</i>	<i>0.18</i>

**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 5.3.13.2

**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 5.3.13.3

**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	0.0348	0.2813	0.0696	0.2092	0.0181	0.0699	0.0355	0.2817
COV	0.024	0.007	0.013	0.008	0.028	0.017	0.038	0.012

## Repeatability Test

### Clause 5.4.5

*The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ primary metric and 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 9.4.3.7.4

*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 63.

**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™
<i>Primary Metrics</i>	<b>8,102.46</b>
Repeatability Test Phase 1	8,095.34
Repeatability Test Phase 2	8,098.28

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™
<i>Primary Metrics</i>	<b>1.47 ms</b>
Repeatability Test Phase 1	1.45 ms
Repeatability Test Phase 2	1.46 ms

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

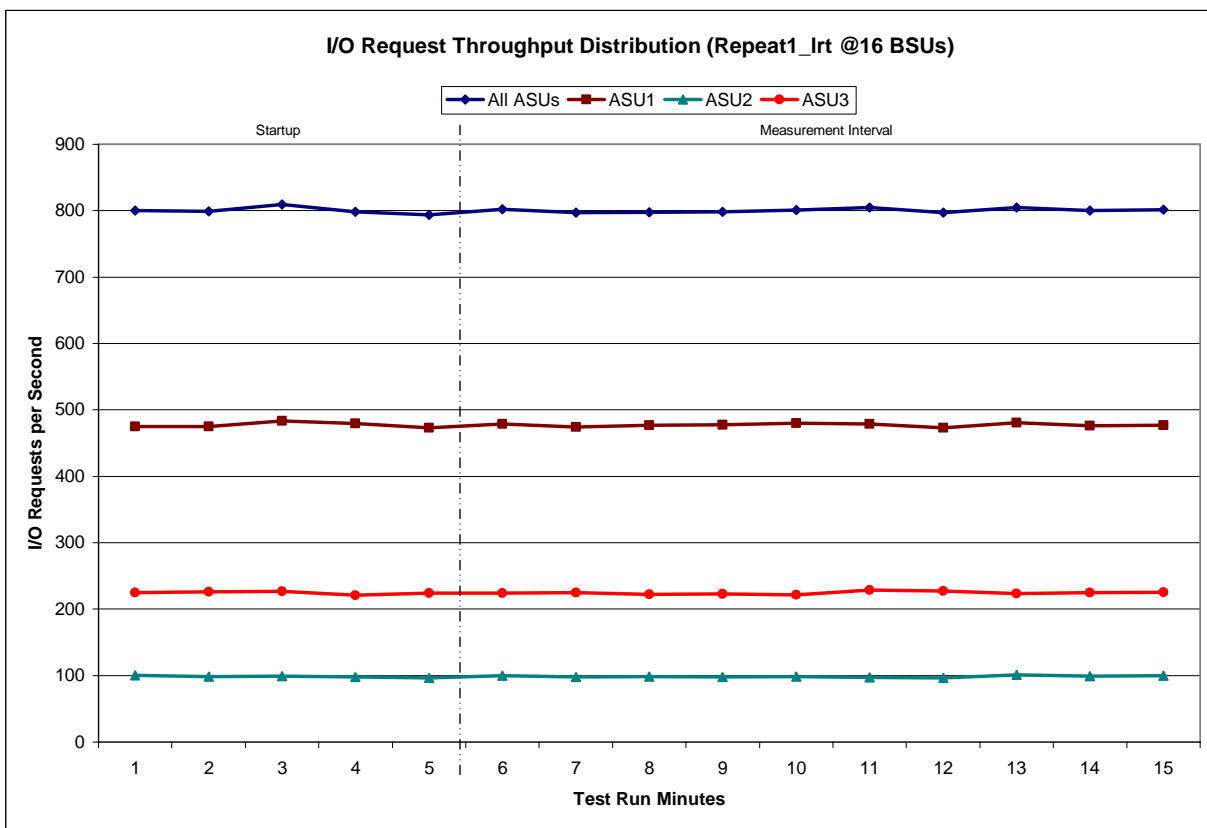
A link to the test result file generated from each Repeatability Test Run is listed below.

- [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**

16 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:08:42	18:13:42	0-4	0:05:00
<i>Measurement Interval</i>	18:13:42	18:23:42	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	800.22	475.23	100.42	224.57
1	799.15	475.05	98.17	225.93
2	809.05	483.18	99.28	226.58
3	798.45	479.23	98.10	221.12
4	793.82	472.93	96.68	224.20
5	802.35	478.60	99.55	224.20
6	796.73	474.05	97.58	225.10
7	797.88	476.78	98.57	222.53
8	798.25	477.25	97.95	223.05
9	800.57	480.37	98.32	221.88
10	804.53	478.62	97.15	228.77
11	796.78	473.18	96.35	227.25
12	804.93	480.80	100.85	223.28
13	800.05	476.25	98.82	224.98
14	801.63	476.90	99.48	225.25
<i>Average</i>	<i>800.37</i>	<i>477.28</i>	<i>98.46</i>	<i>224.63</i>

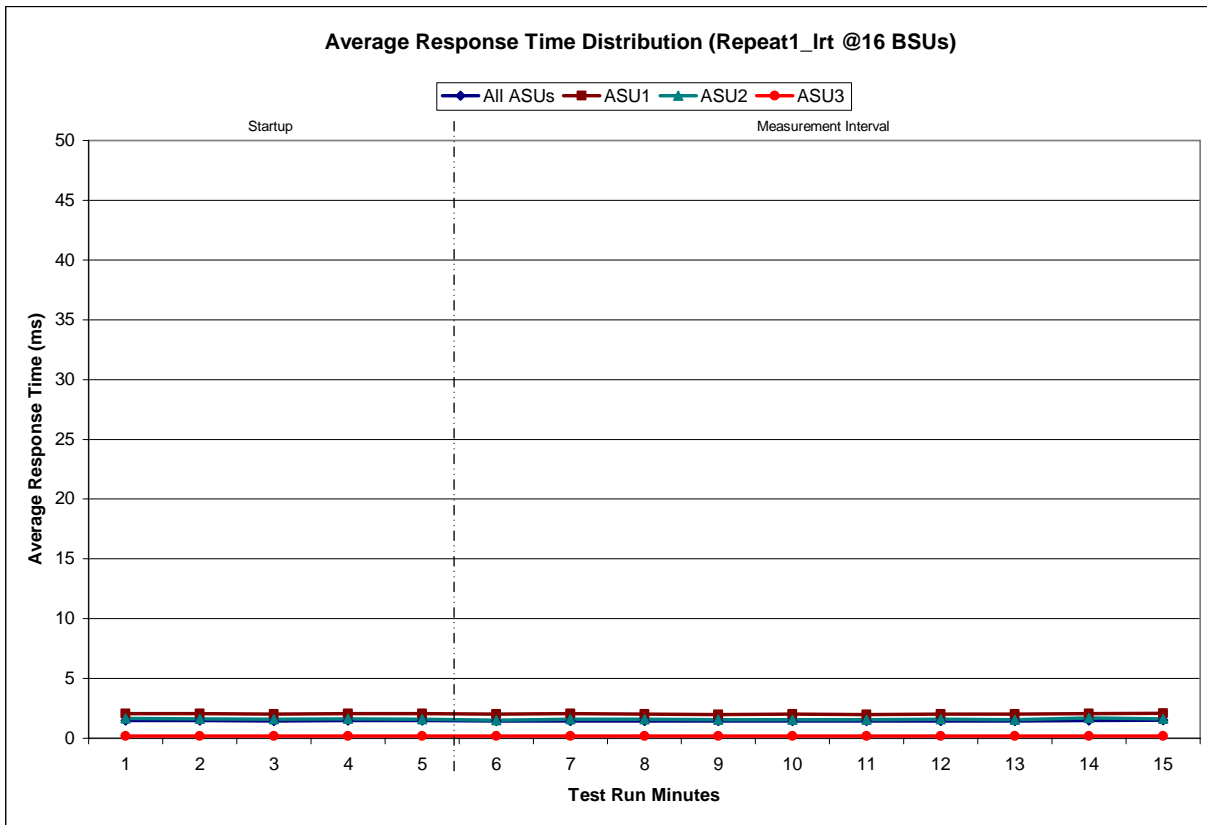
**Repeatability 1 LRT - I/O Request Throughput Distribution Graph**



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

16 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:08:42	18:13:42	0-4	0:05:00
<i>Measurement Interval</i>	18:13:42	18:23:42	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.49	2.07	1.65	0.18
1	1.46	2.04	1.61	0.18
2	1.45	2.02	1.58	0.18
3	1.48	2.05	1.63	0.18
4	1.47	2.06	1.60	0.18
5	1.44	2.03	1.50	0.18
6	1.46	2.04	1.57	0.18
7	1.45	2.01	1.57	0.18
8	1.43	1.98	1.57	0.18
9	1.44	2.00	1.55	0.18
10	1.42	1.99	1.55	0.18
11	1.44	2.02	1.57	0.18
12	1.45	2.01	1.56	0.18
13	1.47	2.04	1.68	0.18
14	1.50	2.09	1.60	0.18
<i>Average</i>	<i>1.45</i>	<i>2.02</i>	<i>1.57</i>	<i>0.18</i>

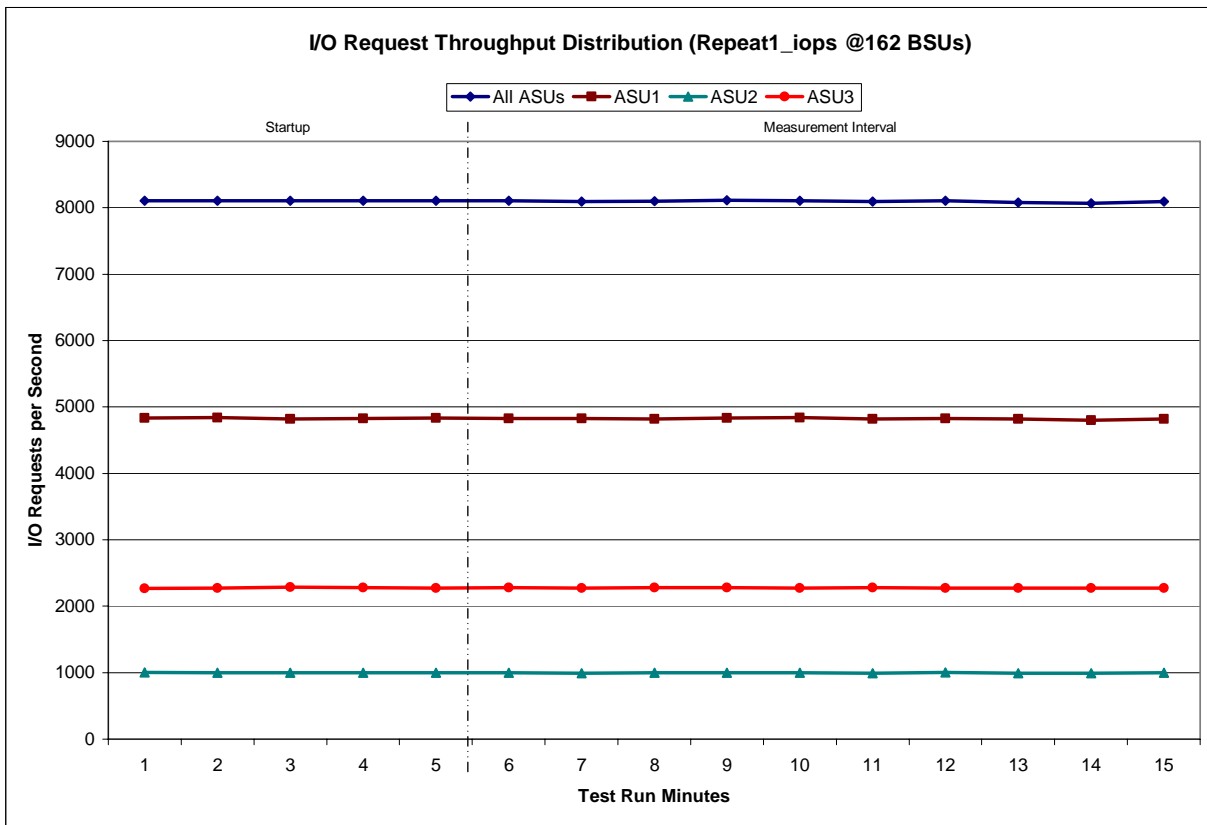
**Repeatability 1 LRT –Average Response Time (ms) Distribution Graph**



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

162 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:24:44	18:29:45	0-4	0:05:01
<i>Measurement Interval</i>	18:29:45	18:39:45	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	8,107.85	4,833.02	1,004.35	2,270.48
1	8,107.52	4,838.32	996.50	2,272.70
2	8,107.00	4,819.93	1,000.63	2,286.43
3	8,107.32	4,828.97	998.93	2,279.42
4	8,107.57	4,834.27	996.98	2,276.32
5	8,102.97	4,825.57	995.73	2,281.67
6	8,093.75	4,828.78	991.07	2,273.90
7	8,096.42	4,821.23	996.50	2,278.68
8	8,111.17	4,833.42	996.13	2,281.62
9	8,107.85	4,839.30	995.33	2,273.22
10	8,095.52	4,822.22	990.67	2,282.63
11	8,108.13	4,830.00	1,001.57	2,276.57
12	8,079.87	4,818.60	989.78	2,271.48
13	8,067.87	4,800.35	992.00	2,275.52
14	8,089.82	4,819.53	997.92	2,272.37
<b>Average</b>	<b>8,095.34</b>	<b>4,823.90</b>	<b>994.67</b>	<b>2,276.77</b>

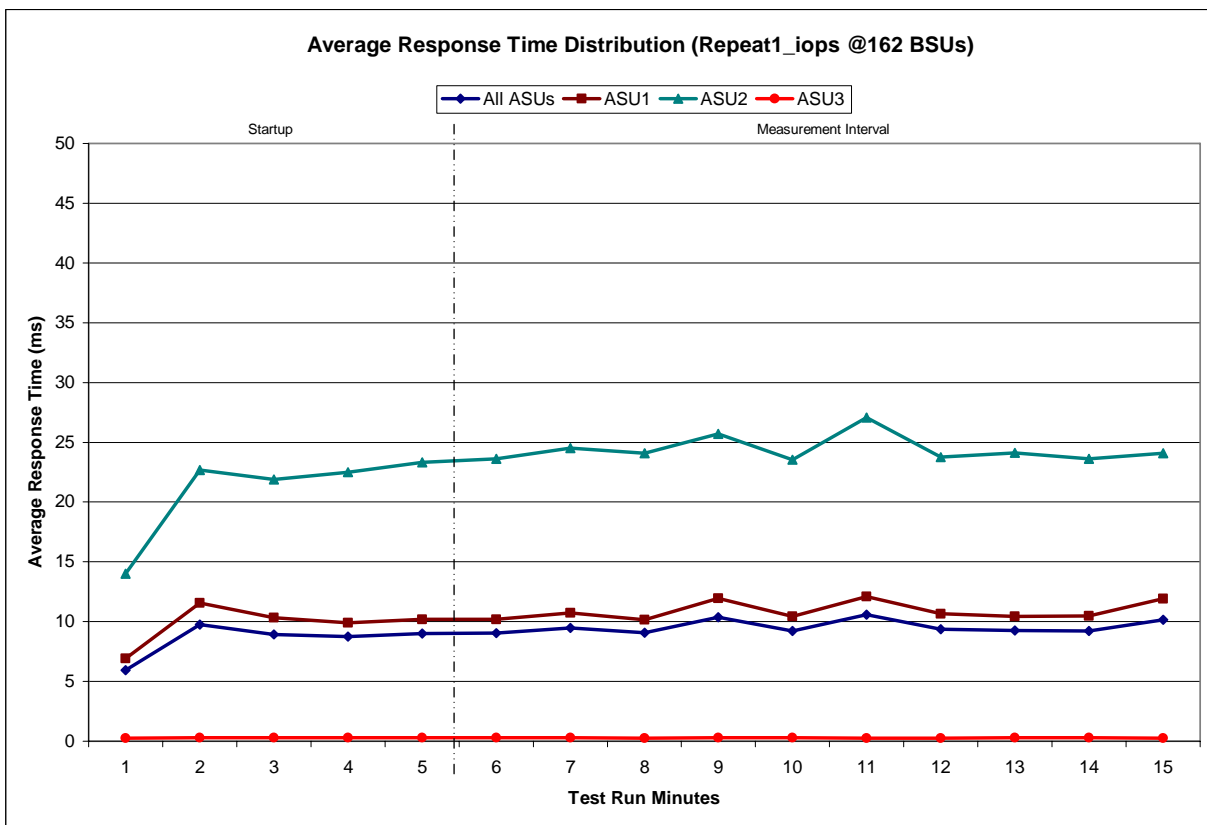
**Repeatability 1 IOPS - I/O Request Throughput Distribution Graph**



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

162 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:24:44	18:29:45	0-4	0:05:01
<i>Measurement Interval</i>	18:29:45	18:39:45	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5.92	6.91	14.00	0.27
1	9.76	11.56	22.69	0.27
2	8.91	10.32	21.87	0.27
3	8.75	9.91	22.50	0.27
4	9.01	10.17	23.32	0.27
5	9.05	10.19	23.62	0.27
6	9.47	10.72	24.50	0.27
7	9.09	10.16	24.09	0.27
8	10.35	11.94	25.71	0.27
9	9.20	10.44	23.54	0.27
10	10.59	12.08	27.09	0.27
11	9.36	10.66	23.77	0.27
12	9.27	10.46	24.11	0.27
13	9.22	10.49	23.62	0.27
14	10.14	11.92	24.09	0.27
<i>Average</i>	<i>9.57</i>	<i>10.91</i>	<i>24.41</i>	<i>0.27</i>

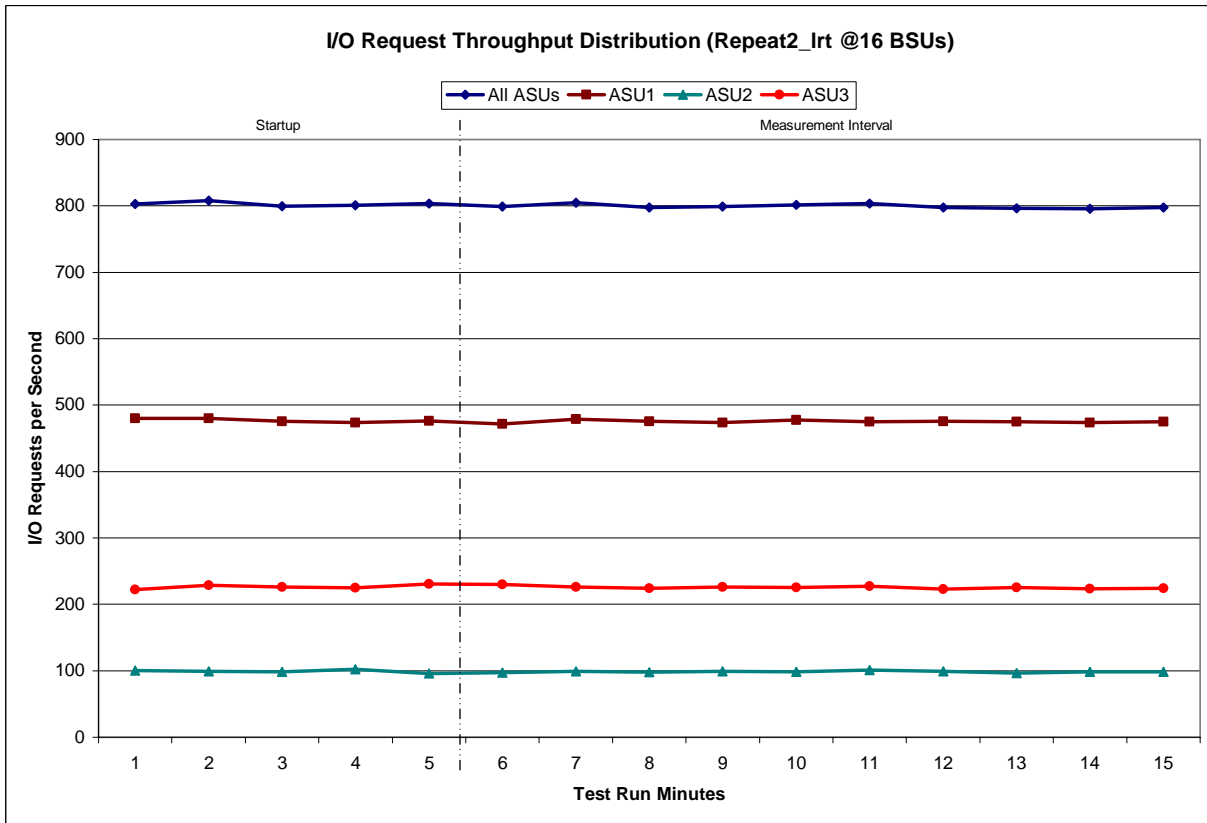
**Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph**



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

16 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:40:50	18:45:50	0-4	0:05:00
<i>Measurement Interval</i>	18:45:50	18:55:50	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	802.68	479.90	100.33	222.45
1	808.02	479.97	99.07	228.98
2	799.77	475.57	98.37	225.83
3	800.67	473.70	102.08	224.88
4	803.32	476.30	96.17	230.85
5	798.75	471.53	97.33	229.88
6	804.47	478.77	99.43	226.27
7	797.65	475.40	97.87	224.38
8	798.92	473.58	99.00	226.33
9	801.72	477.42	98.72	225.58
10	803.27	474.88	101.03	227.35
11	797.67	475.58	99.22	222.87
12	796.50	474.67	96.30	225.53
13	795.37	473.70	98.40	223.27
14	797.38	474.65	98.67	224.07
<i>Average</i>	<i>799.17</i>	<i>475.02</i>	<i>98.60</i>	<i>225.55</i>

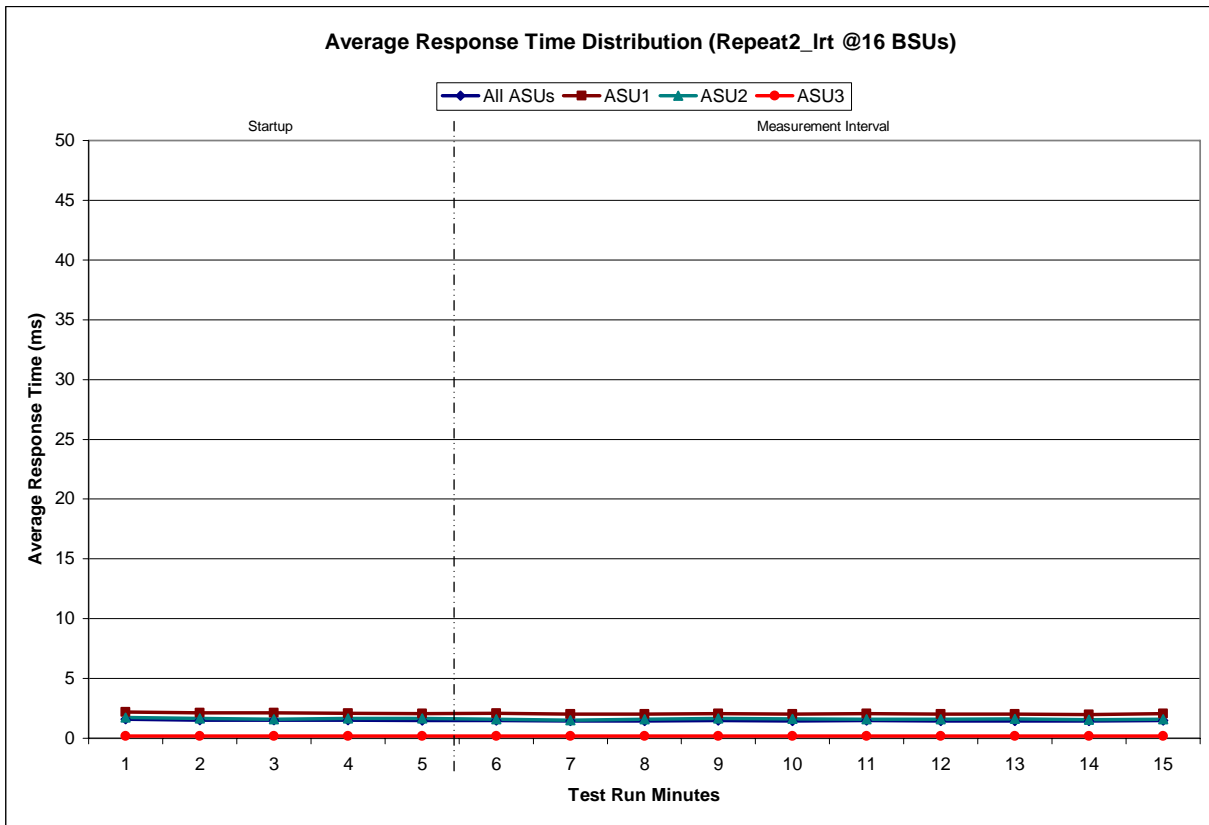
**Repeatability 2 LRT - I/O Request Throughput Distribution Graph**



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

16 BSUs Start-Up/Ramp-Up Measurement Interval	Start 18:40:50 18:45:50	Stop 18:45:50 18:55:50	Interval 0-4 3-14	Duration 0:05:00 0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
0	1.58	2.21	1.72	0.18
1	1.51	2.12	1.65	0.18
2	1.51	2.12	1.58	0.17
3	1.49	2.08	1.66	0.18
4	1.47	2.05	1.66	0.18
5	1.49	2.10	1.59	0.18
6	1.44	2.03	1.52	0.18
7	1.45	2.03	1.58	0.18
8	1.47	2.06	1.64	0.18
9	1.45	2.02	1.61	0.18
10	1.46	2.05	1.60	0.18
11	1.44	2.01	1.58	0.18
12	1.46	2.03	1.63	0.18
13	1.43	1.99	1.55	0.18
14	1.46	2.04	1.59	0.18
<b>Average</b>	<b>1.46</b>	<b>2.03</b>	<b>1.59</b>	<b>0.18</b>

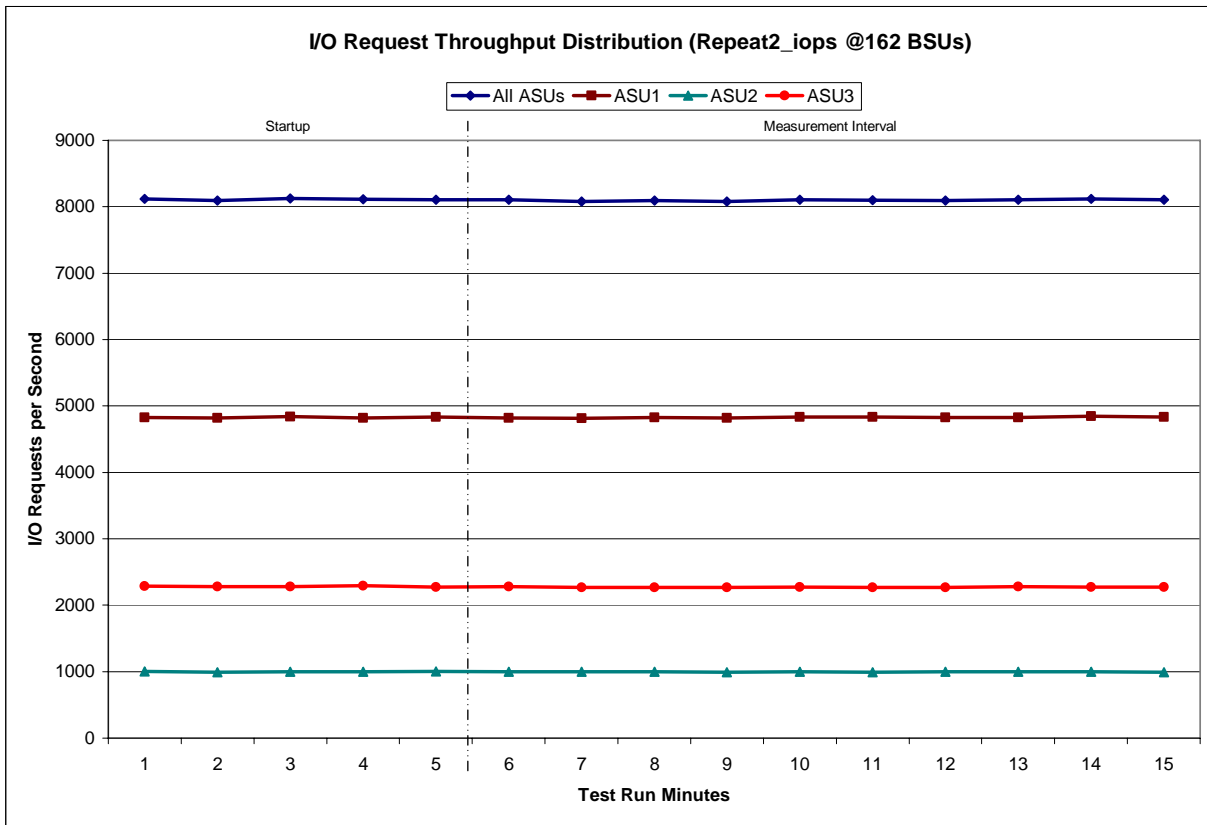
**Repeatability 2 LRT –Average Response Time (ms) Distribution Graph**



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

162 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:56:52	19:01:53	0-4	0:05:01
<i>Measurement Interval</i>	19:01:53	19:11:53	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	8,115.63	4,829.42	1,001.28	2,284.93
1	8,093.87	4,822.25	993.05	2,278.57
2	8,123.65	4,839.90	999.78	2,283.97
3	8,110.38	4,820.73	998.45	2,291.20
4	8,107.35	4,830.58	1,002.08	2,274.68
5	8,103.42	4,822.90	998.95	2,281.57
6	8,082.00	4,813.87	999.58	2,268.55
7	8,094.27	4,828.25	996.32	2,269.70
8	8,081.40	4,819.72	994.08	2,267.60
9	8,103.23	4,831.03	998.80	2,273.40
10	8,097.47	4,833.82	993.05	2,270.60
11	8,092.42	4,826.25	996.08	2,270.08
12	8,106.22	4,829.70	996.62	2,279.90
13	8,118.10	4,844.15	997.60	2,276.35
14	8,104.27	4,835.72	992.63	2,275.92
<i>Average</i>	<i>8,098.28</i>	<i>4,828.54</i>	<i>996.37</i>	<i>2,273.37</i>

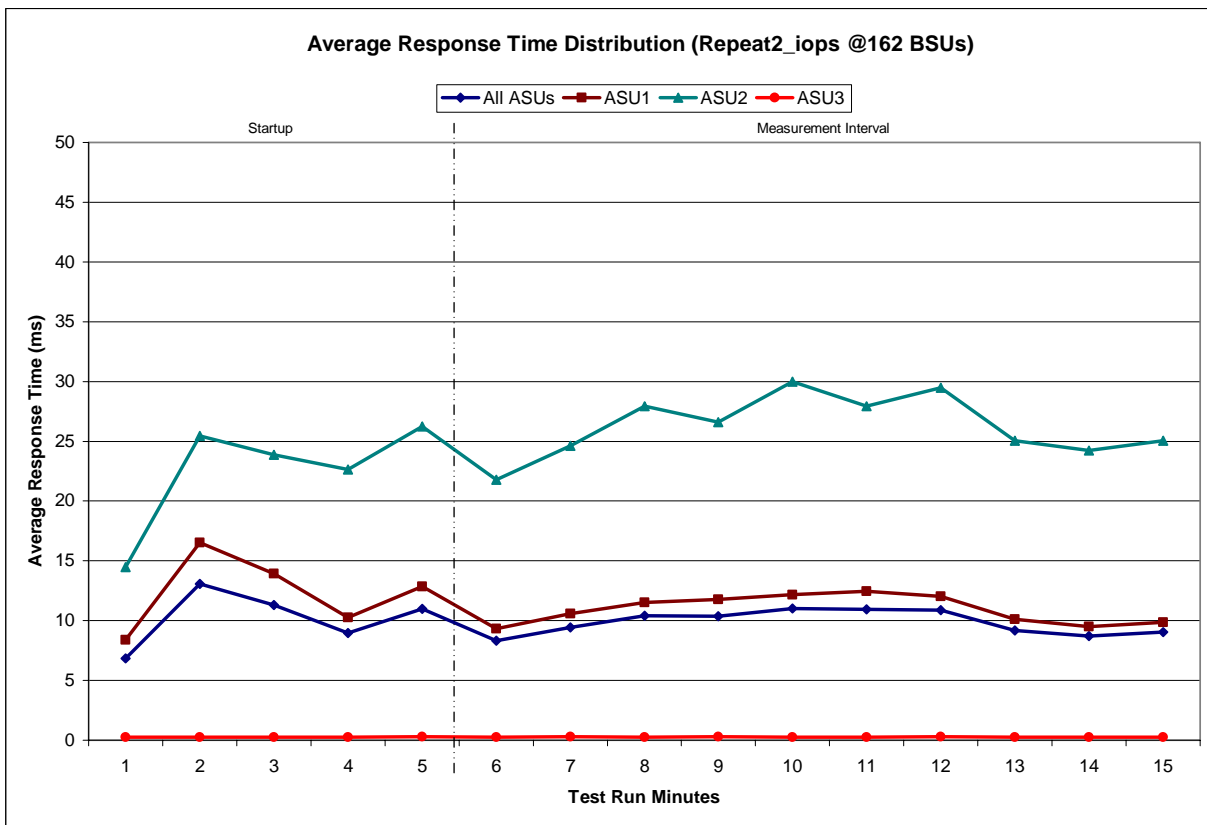
**Repeatability 2 IOPS - I/O Request Throughput Distribution Graph**



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

162 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:56:52	19:01:53	0-4	0:05:01
<i>Measurement Interval</i>	19:01:53	19:11:53	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6.85	8.38	14.47	0.27
1	13.05	16.54	25.47	0.27
2	11.31	13.92	23.87	0.27
3	8.97	10.28	22.65	0.27
4	10.97	12.84	26.24	0.27
5	8.32	9.33	21.79	0.26
6	9.42	10.57	24.64	0.27
7	10.39	11.53	27.93	0.27
8	10.38	11.78	26.59	0.27
9	11.03	12.17	29.98	0.27
10	10.93	12.45	27.92	0.26
11	10.88	12.03	29.49	0.27
12	9.19	10.13	25.05	0.27
13	8.72	9.49	24.24	0.27
14	9.03	9.87	25.07	0.27
<i>Average</i>	<i>9.83</i>	<i>10.94</i>	<i>26.27</i>	<i>0.27</i>

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



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

*Clause 3.4.3*

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

*Clauses 5.1.10 and 5.3.13.2*

*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 5.3.13.3*

*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
<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	0.0352	0.2804	0.0703	0.2105	0.0181	0.0698	0.0352	0.2807
COV	0.020	0.008	0.024	0.009	0.044	0.014	0.020	0.010

**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
<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	0.0351	0.2810	0.0701	0.2097	0.0181	0.0699	0.0349	0.2812
COV	0.008	0.003	0.005	0.004	0.013	0.004	0.007	0.002

**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
<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	0.0348	0.2809	0.0692	0.2095	0.0183	0.0699	0.0351	0.2822
COV	0.022	0.007	0.021	0.008	0.019	0.014	0.018	0.008

**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	0.2813	0.0700	0.2100	0.179	0.0701	0.0351	0.2807
COV	0.009	0.002	0.005	0.002	0.009	0.004	0.007	0.001

## Data Persistence Test

### Clause 6

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

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

*Execution of Persistence Test Run 1 will cause the SPC-1 Workload Generator to write a specific pattern at randomly selected locations throughout the Total ASU Capacity. The SPC-1 Workload Generator will retain the information necessary to later validate the pattern written at each location*

*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. If the TSC includes the Host System(s), the Host System(s) must also be shutdown and restarted using a power off/power on cycle.*

*Persistence Test Run 2, executed after the TSC has been restarted, will utilize the retained data from Persistence Test Run 1 to validate the patterns written at each location during Persistence Test Run 1.*

### 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 (may optionally be referenced in an appendix).*
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 9-16. 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.*

## 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 63.

## 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	19,195,232
Total Number of Logical Blocks Verified	18,493,392
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 9.2.4.9**

*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 XioTech Emprise™ 5000 (ISE 2.4 TB/15.1 DataPac) 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 14.

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

### **Clause 9.4.3.3.7**

*The Executive Summary shall contain a pricing a list of all differenced 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 14.

## **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 XioTech Emprise™ 5000 (ISE 2.4 TB/15.1 DataPac).

## **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:** This level will ensure data protection in the event of a single point of failure of any configured storage device. A brief description of the data protection utilized is included in the Executive Summary.

**Unprotected:** No claim of data protection is asserted in the event of a single point of failure.

## **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.

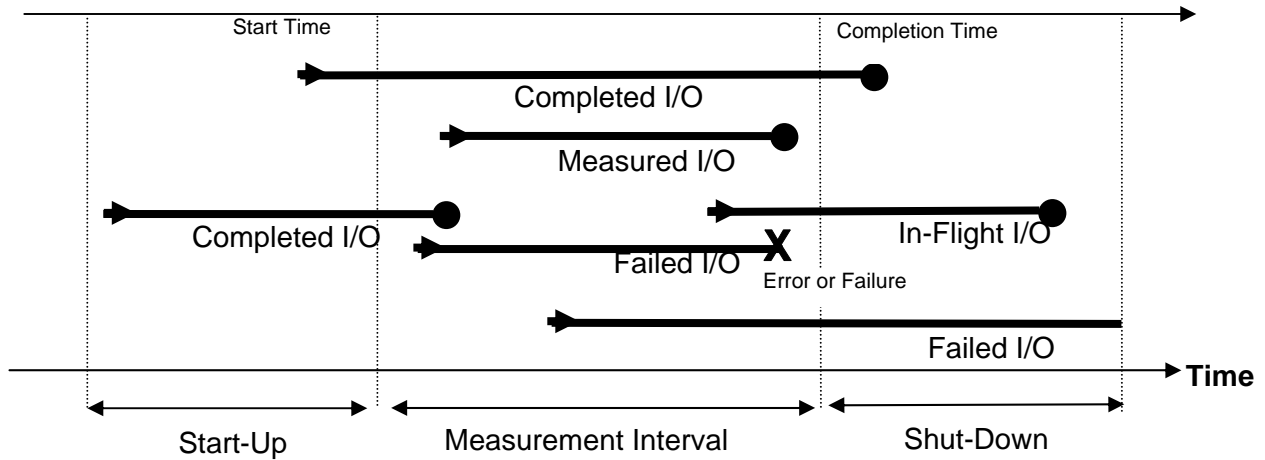
**Test:** A collection of Test Phases and or Test Runs sharing a common objective.

**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

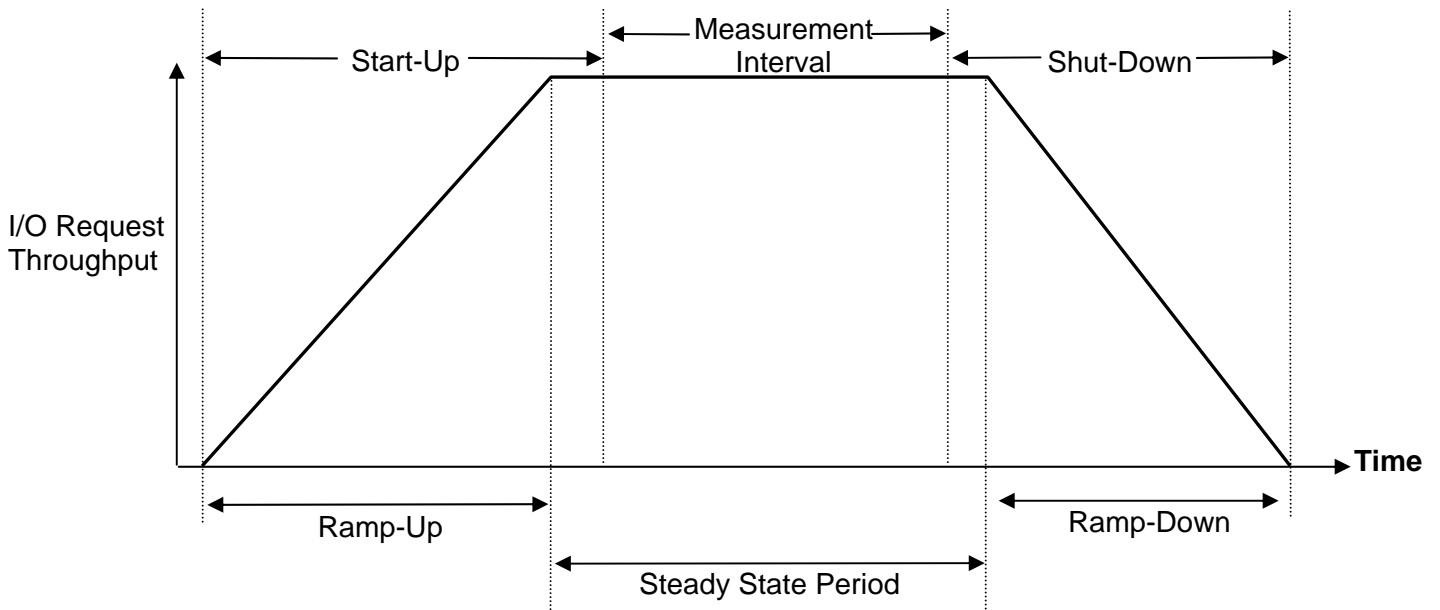
period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

**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**

The Qlogic HBA EXECUTION THROTTLE parameter was set to 4,096 for both HBA ports.

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

The following script, **EAGLE R1.SH**, is executed from a command window on the Host System and creates the twelve SPC-1 Logical Volumes as follows:

- The Emprise 5000 is first initialized with a spare level of 20% of the storage capacity available for application use.
- UPS mode is set to maintain write-back caching in the event of battery failure
- The twelve RAID-1 volumes are then created, four with a capacity of 54 GiB and the remaining eight with a capacity of 243 GiB. The DataPacs (pools) on which the volumes reside are alternated between DataPac 1 and DataPac 2.
- Next, the two Qlogic HBA ports are initialized and named.
- Finally, the twelve volumes are presented to both Qlogic HBA ports

After the script completes its execution, the Qlogic HBA is configured for the benchmark measurements by changing the **EXECUTION THROTTLE** parameter to a value of 4,096 for both HBA ports.

### **Eagle R1.sh**

```
#
#   Initialize brick
#
/bin/nseash -c "initialize --sparelevel=20"
/bin/nseash -c "configure --upsmode=enable"
#
#   Create Raid-1 volumes for SPC-1 testing on 600 GB DataPacs at 99.8% utilization
#
/bin/nseash -c "create --volume=L1 --size=54 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=L2 --size=54 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=L3 --size=54 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=L4 --size=54 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=L5 --size=243 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=L6 --size=243 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=L7 --size=243 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=L8 --size=243 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=L9 --size=243 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=L10 --size=243 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=L11 --size=243 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=L12 --size=243 --raid1 --pool2 --write-back"
sleep 10
#
#   Create the QLogic hosts
#
/bin/nseash -c "create --host=\"Dell_3 P0\" --windows 2100001B3200EEE7"
/bin/nseash -c "create --host=\"Dell_3 P1\" --windows 2101001B3220EEE7"
#
#   Present the SPC-1 LUNs to the Dell HBAs
#
/bin/nseash -c "present --host=\"Dell_3 P0\" L1:0 L2:1 L3:2 L4:3 L5:4 L6:5 L7:6 L8:7
L9:8 L10:9 L11:10 L12:11"
/bin/nseash -c "present --host=\"Dell_3 P1\" L1:0 L2:1 L3:2 L4:3 L5:4 L6:5 L7:6 L8:7
L9:8 L10:9 L11:10 L12:11"
```

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

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

```
javaparms="-Xmx512m"
*
* Raw storage
*
sd=asu1_1,lun=\\.\PhysicalDrive6
sd=asu1_2,lun=\\.\PhysicalDrive5
sd=asu1_3,lun=\\.\PhysicalDrive7
sd=asu1_4,lun=\\.\PhysicalDrive8
*
sd=asu2_1,lun=\\.\PhysicalDrive9
sd=asu2_2,lun=\\.\PhysicalDrive10
sd=asu2_3,lun=\\.\PhysicalDrive11
sd=asu2_4,lun=\\.\PhysicalDrive12
*
sd=asu3_1,lun=\\.\PhysicalDrive1
sd=asu3_2,lun=\\.\PhysicalDrive2
sd=asu3_3,lun=\\.\PhysicalDrive3
sd=asu3_4,lun=\\.\PhysicalDrive4
*
* Formatted storage
*
*sd=asu1_1,lun=z$,size=450g
*sd=asu2_1,lun=y$,size=450g
*sd=asu3_1,lun=x$,size=100g
javaparms="-Xmx512m"
*
* Raw storage
*
sd=asu1_1,lun=\\.\PhysicalDrive6
sd=asu1_2,lun=\\.\PhysicalDrive5
sd=asu1_3,lun=\\.\PhysicalDrive7
sd=asu1_4,lun=\\.\PhysicalDrive8
*
sd=asu2_1,lun=\\.\PhysicalDrive9
sd=asu2_2,lun=\\.\PhysicalDrive10
sd=asu2_3,lun=\\.\PhysicalDrive11
sd=asu2_4,lun=\\.\PhysicalDrive12
*
sd=asu3_1,lun=\\.\PhysicalDrive1
sd=asu3_2,lun=\\.\PhysicalDrive2
sd=asu3_3,lun=\\.\PhysicalDrive3
sd=asu3_4,lun=\\.\PhysicalDrive4
```

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

### **Primary Metrics Test, Repeatability Test, and Persistence Test Run 1**

The following script was used to execute the Primary Metrics Test (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*), Repeatability Test (*Repeatability Test Phase 1 and Repeatability Test Phase 2*), and Persistence Test Run 1 in an uninterrupted sequence.

```
@echo off
::
:: SPC-1 batch execution file
::
set /a BSU = 162
::
:: Run the "standard" SPC-1 run up to persistence phase 1
::
echo Executing SPC-1 metrics, repeatability, and persistence phase 1...
java -Xmx640m -Xms640m metrics -b %BSU% -s 300 -t 10860 -r 660
java -Xmx640m -Xms640m repeat1 -b %BSU% -s 300 -t 660
java -Xmx640m -Xms640m repeat2 -b %BSU% -s 300 -t 660
java -Xmx640m -Xms640m persist1 -b %BSU%

:: Manual intervention: Shut down all systems, then power back on
echo Shutdown all systems in preparation for persistence phase 2!
echo Run persistence test part 2: java -Xmx640m -Xms640m persist2
```

### **Persistence Test Run 2**

The following CLI command was used to execute Persistence Test Run 2.

```
java -Xmx640m -Xms640m persist2
```