



**SPC BENCHMARK 1/ENERGY™
FULL DISCLOSURE REPORT**

**XIOTECH CORPORATION
XIOTECH EMPRISE™ 5000
*(146 GB DISK DRIVES)***

SPC-1/E™ V1.12

**Submitted for Review: October 13, 2009
Submission Identifier: AE00001**

First Edition – October 2009

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AUDIT CERTIFICATION (CONT.)

Xiotech Emprise™ 5000 (146 GB disk drives)
SPC-1/E Audit Certification

Page 2

The following SPC Benchmark 1/Energy™ Onsite Audit requirements were reviewed and found compliant with V1.12 of the SPC Benchmark 1/Energy™ Specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and information supplied by 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/Tested Storage Configuration.
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1™ Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by physical inspection and information supplied by 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 the Host System.
 - ✓ A valid SPC-1™ site license.
 - ✓ The TSC boundary within the Host System.
- The execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from Xiotech Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC Benchmark 1/Energy™ Specification:
 - ✓ Idle Test
 - Conditioning Phase
 - Application Idle Phase
 - Recovery Phase
 - ✓ Primary Metrics Test:
 - Sustainability Test Phase
 - IOPS Test Phase
 - Response Time Ramp Test Phase
 - ✓ Repeatability Test
 - ✓ Data Persistence Test
- The Yokogawa WT210 Digital Power Meter, used to record power consumption, was verified as an SPC approved "Power Extension apparatus" with a current calibration certificate.
- All power supplies present in the Tested Storage Configuration were verified as active.

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AuditService@storageperformance.org
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AUDIT CERTIFICATION (CONT.)

Xiotech Emprise™ 5000 (146 GB disk drives)
SPC-1/E Audit Certification

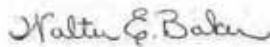
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- Xiotech Corporation provided documentation of the following:
 - ✓ Voltage (220), amperage (30), and phase characteristics (*angle*) of the AC inputs used for powering the Tested Storage Configuration.
 - ✓ The configured power supplies were configured for mutual failover.
- Concurrent power measurements were taken at each active AC input so that the total power requirement of the Tested Storage Configuration was recorded.
- The ambient temperature was recorded at the following times in near proximity to the Tested Storage configuration with a precision of at least $\pm 0.1^{\circ}\text{C}$:
 - ✓ During the first one minute of the Idle Test (*Initial Energy Extension temperature*).
 - ✓ During the last one minute of the Primary Metrics Test (*Final Energy Extension temperature*).
- The Benchmark Configuration/Tested Storage Configuration diagram included the electrical metering, which illustrates the measurement apparatus used and the relationship between the active AC inputs and the associated measurement apparatus inputs.
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC Benchmark 1/Energy™ Specification.
- The Full Disclosure Report (*FDR*) met all of the requirements in Clauses 9 and 11 of the SPC Benchmark 1/Energy™ Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH



14-Jul-2009

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

Subject: SPC-1/E Letter of Good Faith for the Xiotech Emprise 5000 (2.4 TB)

Xiotech is the SPC-1/E 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 V1.10.1 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 "Ken Kruttsch", with a large circular flourish at the end.

Ken Kruttsch
Senior Vice President of Operations
Xiotech

Xiotech Corporation - 9950 Federal Drive, Suite 100 - Colorado Springs, CO 80921-3686

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.12
SPC-1 Workload Generator revision number	V2.1.0
Date Results were first used publicly	October 13, 2009
Date the FDR was submitted to the SPC	October 13, 2009
Date the priced storage configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	October 9, 2009

Tested Storage Product (TSP) Description

Emprise 5000 from Xiotech Corporation is a revolutionary concept in data storage. It is built on a perfectly balanced building block of performance, reliability, and scalability known as Intelligent Storage Element (ISE) technology.

The ISE is a purpose-built storage environment of tightly integrated components, designed to maximize both performance and reliability. Each ISE includes one or two sealed DataPacs (capacity modules) and dual Managed Reliability Controllers, which locally manage cache, data protection processes, and more.

Built on this ISE foundation, Emprise 5000 is a complete, self-enclosed storage solution, which you can configure to meet your specific needs. In just 3U of rack space, you can have up to 16 terabytes of virtualized capacity or a high performance storage powerhouse for your transactional applications.

Emprise 5000 is easy to attach to your network—either directly or via a Fibre Channel switch. And it requires minimal configuration or administration, so it is perfect for departmental or branch office deployment.

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: Xiotech Emprise™ 5000 (146 GB disk drives)	
Metric	Reported Result
SPC-1 IOPS™	6,962.40
SPC-1 Price-Performance	\$3.05/SPC-1 IOPS™
Total ASU Capacity	1,073.742 GB
Data Protection Level	Protected (<i>Mirroring</i>)
Total TSC Price (including three-year maintenance)	\$21,257

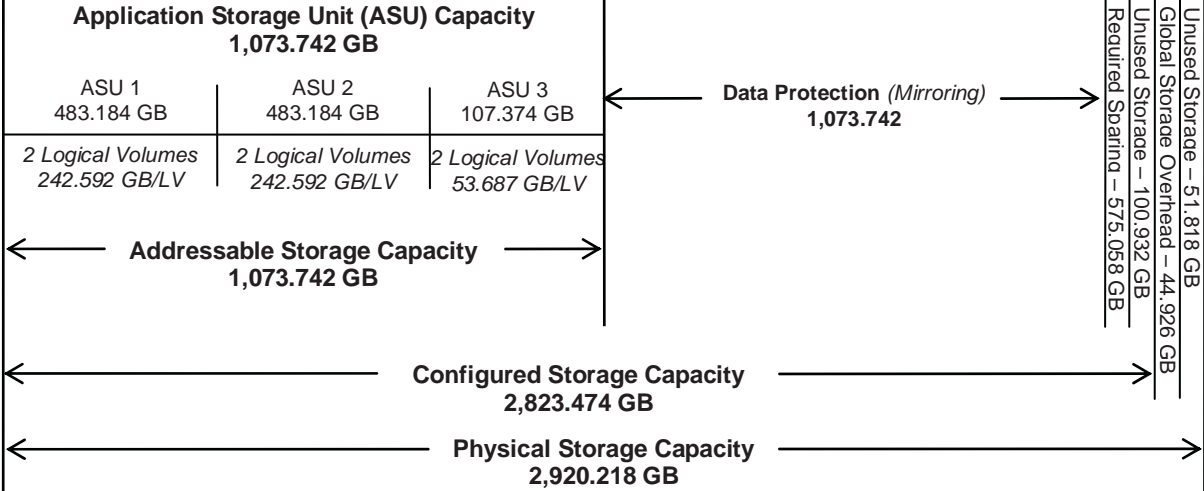
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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	36.77%
Protected Application Utilization	73.54%
Unused Storage Ratio	5.23%

Application Utilization: Total ASU Capacity (1,073.742 GB) divided by Physical Storage Capacity (2,920.218 GB)

Protected Application Utilization: (Total ASU Capacity (1,073.742 GB) plus total Data Protection Capacity (1,073.742 GB) minus unused Data Protection Capacity (0.000 GB)) divided by Physical Storage Capacity (2,920.218 GB)

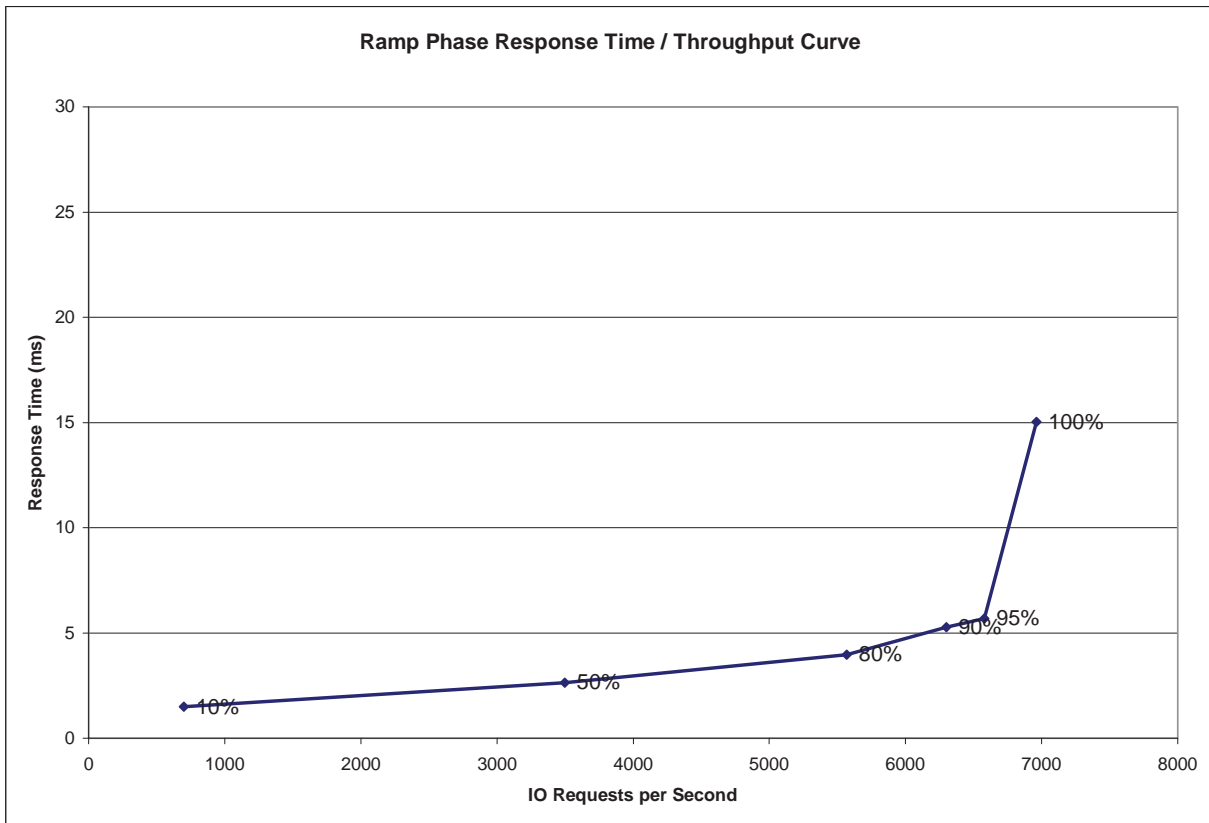
Unused Storage Ratio: Total Unused Capacity (152.750 GB) divided by Physical Storage Capacity (2,920.218 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 23-24 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
I/O Request Throughput	699.48	3,497.79	5,569.43	6,301.07	6,579.86	6,962.40
Average Response Time (ms):						
All ASUs	1.48	2.64	3.97	5.28	5.69	15.04
ASU-1	2.08	3.63	5.30	7.00	7.49	21.99
ASU-2	1.59	3.38	6.07	8.49	9.39	15.05
ASU-3	0.18	0.21	0.23	0.25	0.25	0.25
Reads	3.51	6.40	9.74	13.00	14.05	34.55
Writes	0.16	0.20	0.22	0.25	0.25	2.31

SPC-1/E Reported Data

The initial SPC-1/E energy extension temperature, recorded during the first one minute of the Idle Test was 72.0F. The final SPC-1/E energy extension temperature, recorded during the last one minute of the Primary Metrics Test was 72.7F.

Power Environment				Usage Profile			
Average RMS Voltage:		206.64		Average Power Factor:		0.832	
	Hours of Use per Day			Nominal	Nominal	Nominal	Nominal
	Heavy	Moderate	Idle	Power, W	Traffic, IOPS	IOPS/W	Heat, BTU/hr
Low Daily Usage:	0	8	16	164.58	1165.93	7.08	561.56
Medium Daily Usage:	4	14	6	342.46	2968.61	8.67	1,168.51
High Daily Usage:	18	6	0	453.15	5051.52	11.15	1,546.18
Composite Metrics:				320.06	3,062.02	9.57	
Annual Energy Use, kWh:		2,803.75					
Energy Cost, \$/kWh:		\$ 0.12		Annual Energy Cost, \$:		\$ 336.45	

The above usage profile describes conditions in environments that respectively impose light ("low"), moderate ("medium"), and extensive ("high") demands on the Tested Storage Configuration (TSC).

HEAVY SPC-1 Workload: 455.19W at 80% of maximum reported performance (*5,569.43 SPC-1 IOPS*).

MODERATE SPC-1 Workload: 447.01W at 50% of maximum reported performance (*3,497.79 SPC-1 IOPS*).

IDLE SPC-1 Workload: 23.37W at 0% of maximum reported performance (*0.00 SPC-1 IOPS*).

AVERAGE RMS VOLTAGE: The average supply voltage applied to the Tested Storage Product (TSP) as measured during the Measurement Intervals of the SPC-1/E Tests.

AVERAGE POWER FACTOR: The ratio of average real power, in watts, to the average apparent power, in volt-amperes flowing into the Tested Storage Product (TSP) during the Measurement Intervals of the SPC-1/E Tests.

NOMINAL POWER, W: The average power consumption over the course of a day (*24 hours*), taking into account hourly load variations.

NOMINAL TRAFFIC, IOPS: The average level of I/O requests over the course of a day (*24 hours*), taking into account hourly load variations.

NOMINAL IOPS/W: The overall efficiency with which I/O requests can be supported, reflected by the ratio of **NOMINAL TRAFFIC** versus the **NOMINAL POWER**.

NOMINAL HEAT, BTU/HR: The average amount of heat required to be dissipated over the course of a day (*24 hours*), taking into account hourly load variations. (*1 watt = 3.412 BTU/hr*)

COMPOSITE METRICS: The aggregated **NOMINAL POWER**, **NOMINAL TRAFFIC**, and **NOMINAL IOPS/W** for all three environments: **LOW**, **MEDIUM**, and **HIGH DAILY USAGE**.

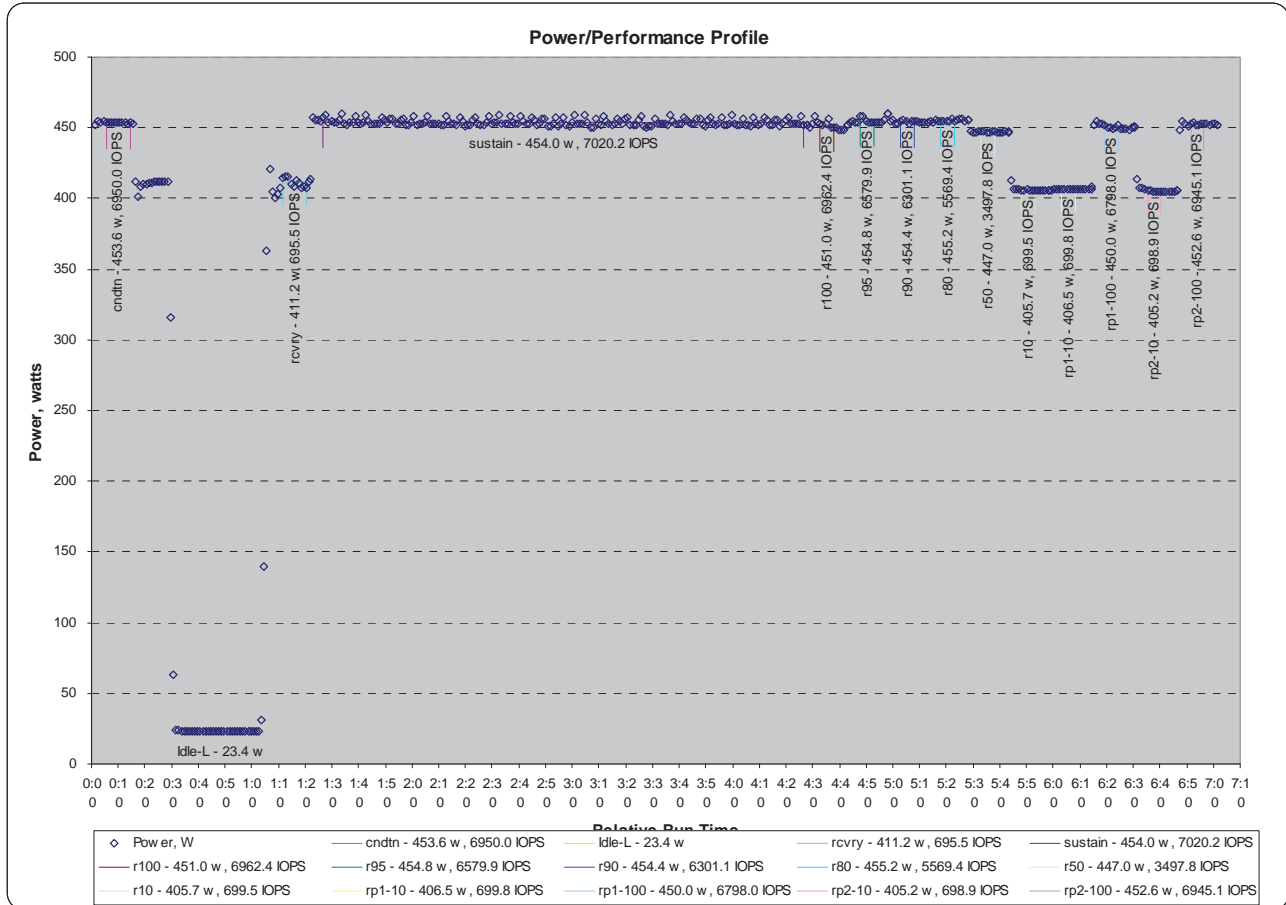
ANNUAL ENERGY USE, KWH: An estimate of the average energy use across the three environments over the course of a year and computed as (**NOMINAL POWER** * 24 * 0.365).

ENERGY COST, \$/KWH: A standardized energy cost per kilowatt hour.

ANNUAL ENERGY COST: An estimate of the annual energy use across the three environments over the course of a year and computed as (**ANNUAL ENERGY USE** * **ENERGY COST**).

SPC-1/E Power/Performance Profile

The SPC-1/E Power/Performance Profile chart provides a complete “at a glance” illustration and report for each SPC-1/E execution component. The power consumption at each step is reported and, where appropriate the measured SPC-1 performance (*SPC-1 IOPS™*) is also reported.



Priced Storage Configuration Pricing

P/N	Description	US List	Qty	Extended List	Discount	Total
	Xiotech Performance Emprise 5000 (2.4TB), including: <ul style="list-style-type: none"> • 1 800864-000: ISE Array controller • 2 800823-000: 10 DataPac mounted 146 GB 15K FC 3.5" disk drives • 1 Xiotech MPIO driver for Windows 2003 • 1 QLogic QLA2462 4 Gb dual port FC HBA • 2 6.6 foot optical FC cables • Five year 7/24 maintenance coverage with 4-hour response and resolution. 	\$34,848	1	\$34,848	39%	\$21,257

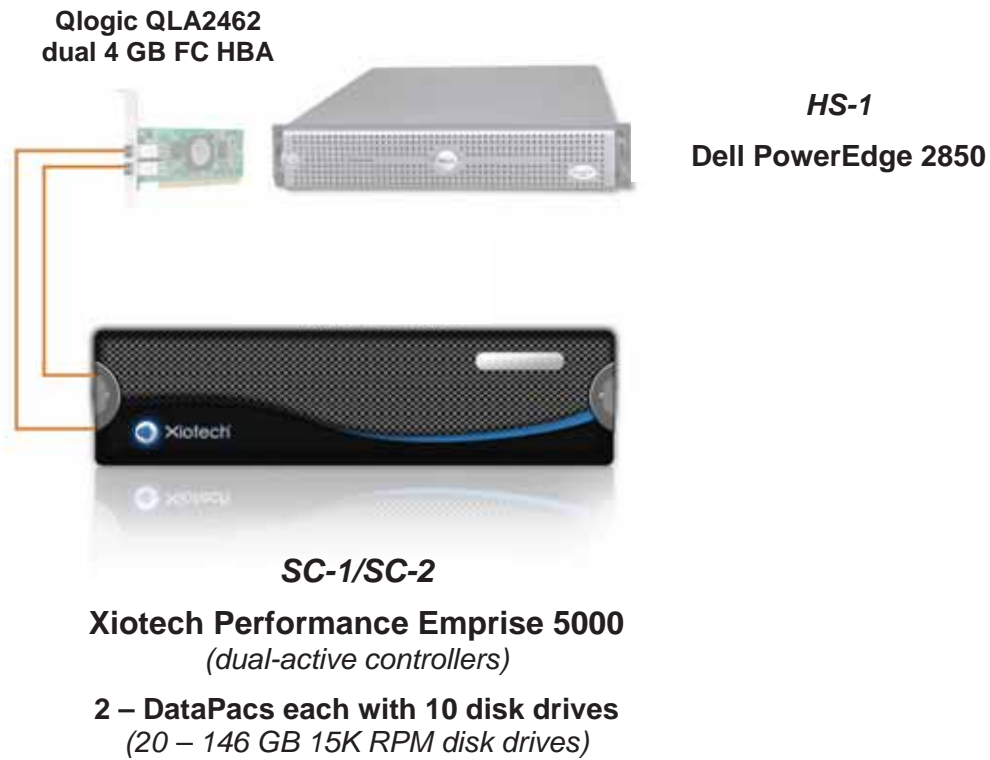
The above pricing includes hardware maintenance and software support for five years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- 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.

Priced Storage Configuration Diagram



Priced Storage Configuration Components

Priced Storage Configuration:
1 – QLogic QLA2462 dual port 4 Gb FC HBA
SC-1/SC-2: XioTech Performance Emprise 5000
2 – dual-active controllers each with:
512 MB cache
1 – 4 Gb Fibre Channel host connections (2 total, 2 used)
2 – 4 Gb Fibre Channel initiators (4 total, 4 used)
2 – DataPacs each with 10 disk drives
20 – 146 GB 15K RPM 3.5" 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 21 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Storage Network Configuration

Clause 9.4.3.4.1

...

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

Clause 9.4.3.4.2

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

The Tested Storage Configuration did not utilize network storage.

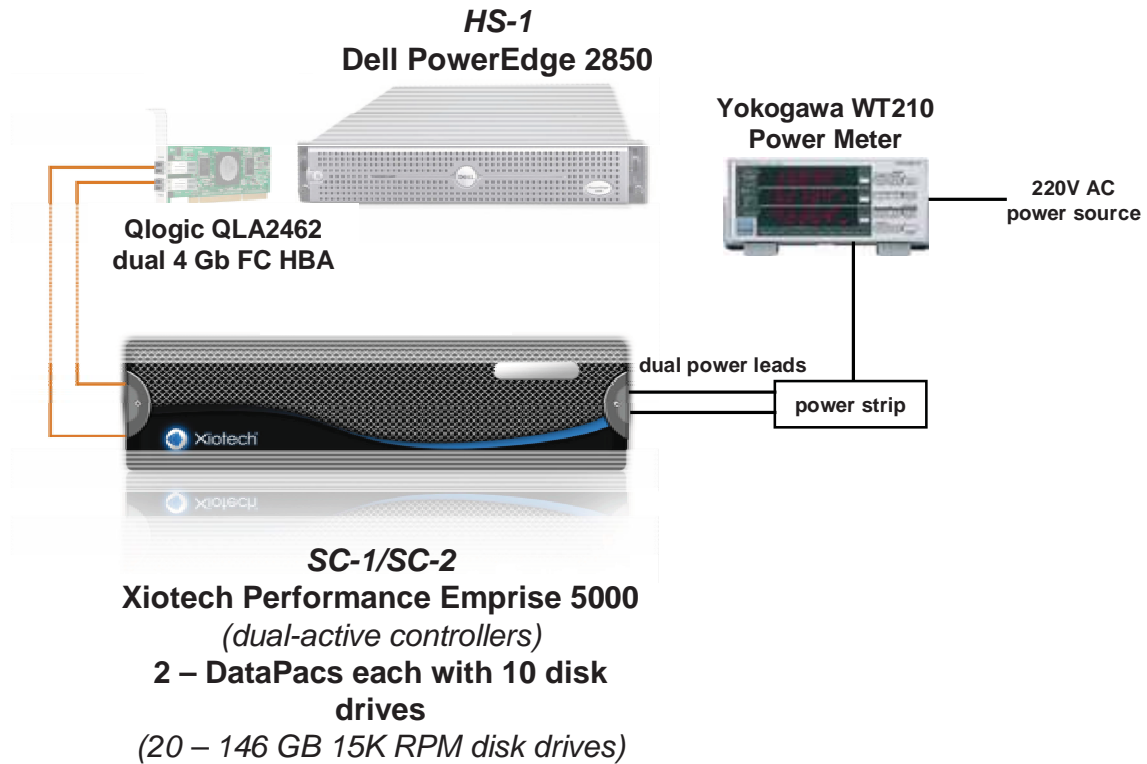
Host System and Tested Storage Configuration (TSC) Table of Components

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 is appears on page 21 (*Host System and Tested Storage Configuration Components*).

Benchmark Configuration/Tested Storage Configuration Diagram



Host System and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC)/ Priced Storage Configuration:
HS-1: Dell PowerEdge 2850	1 – QLogic QLA2462 dual port 4 Gb FC HBA
2 – 3.6 GHz Xeon CPUs with 2 MB L2 cache per CPU	SC-1/SC-2: Xiootech Performance Emprise 5000 2 – dual-active controllers each with: 512 MB cache 1 – 4 Gb Fibre Channel host connections <i>(2 total, 2 used)</i> 2 – 4 Gb Fibre Channel initiators <i>(4 total, 4 used)</i>
2 GB main memory	
Windows Server 2003 Standard Edition with SP2	
Xiootech MPIO driver, Build 280	
PCI-X	
WG	
Other BC Components	2 – DataPacs each with 10 disk drives
1 – Yokogawa WT210 Digital Power Meter	20 – 146 GB 15K RPM 3.5" disk drives
1 – Yokogawa-supplied power strip	

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 65 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 66 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 67.

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 61 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

SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	1,073.742
Addressable Storage Capacity	Gigabytes (GB)	1,073.742
Configured Storage Capacity	Gigabytes (GB)	2,823.474
Physical Storage Capacity	Gigabytes (GB)	2,920.218
Data Protection (<i>Mirroring</i>)	Gigabytes (GB)	1,073.742
Required Storage (<i>metadata/overhead/spares</i>)	Gigabytes (GB)	575.058
Global Storage Overhead	Gigabytes (GB)	44.926
Total Unused Storage	Gigabytes (GB)	152.750

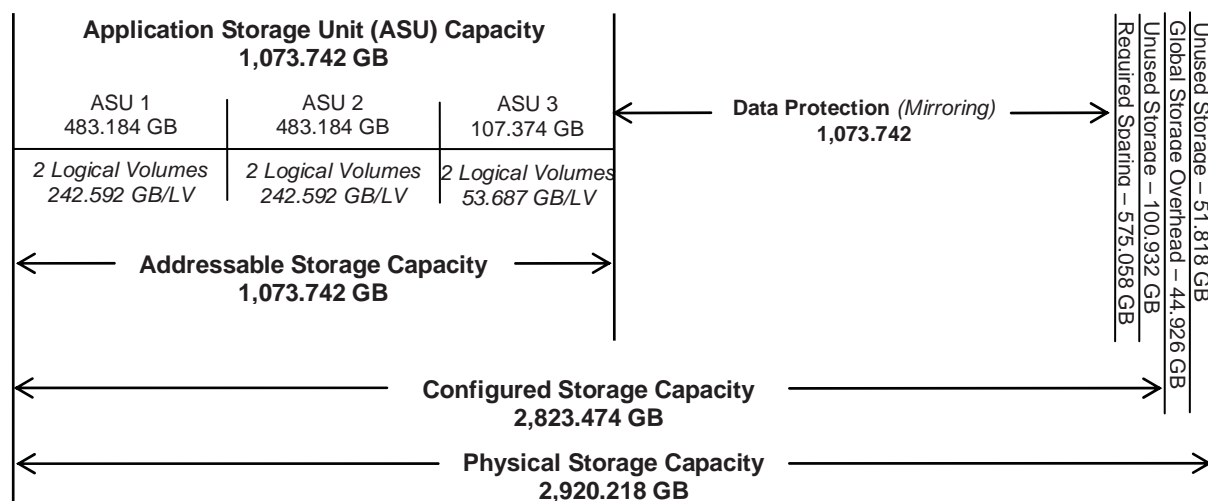
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	38.03%	36.77%
Required for Data Protection (RAID-6)		38.03%	36.77%
Addressable Storage Capacity		38.03%	36.77%
Required Storage (<i>metadata/overhead/spares</i>)		20.37%	19.69%
Configured Storage Capacity			96.69%
Global Storage Overhead			1.54%
Unused Storage:			
Addressable	0.00%		
Configured		3.57%	
Physical			1.77%

The Physical Storage Capacity consisted of 2,920.218 GB distributed over 20 disk drives each with a formatted capacity of 143.765 GB. There was 51.818 GB (1.77%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 44.926 GB (1.54%) of Physical Storage Capacity. There was 100.932 GB (3.57%) 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 1,073.742 GB of which 1,073.742 GB was utilized. The total Unused Storage was 152.750 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 (483.184 GB)	ASU-2 (483.184 GB)	ASU-3 (107.374 GB)
2 Logical Volumes 241.592 GB per Logical Volume (241.592 GB used per Logical Volume)	2 Logical Volumes 241.592 GB per Logical Volume (241.592 GB used per Logical Volume)	2 Logical Volumes 53.687 GB per Logical Volume (53.687 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **PROTECTED (MIRRORING)** as described on page 12. 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%.

SPC-1 Storage Capacity Utilization	
Application Utilization	36.77%
Protected Application Utilization	73.54%
Unused Storage Ratio	5.23%

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 62 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 68.

Sustainability Test Results File

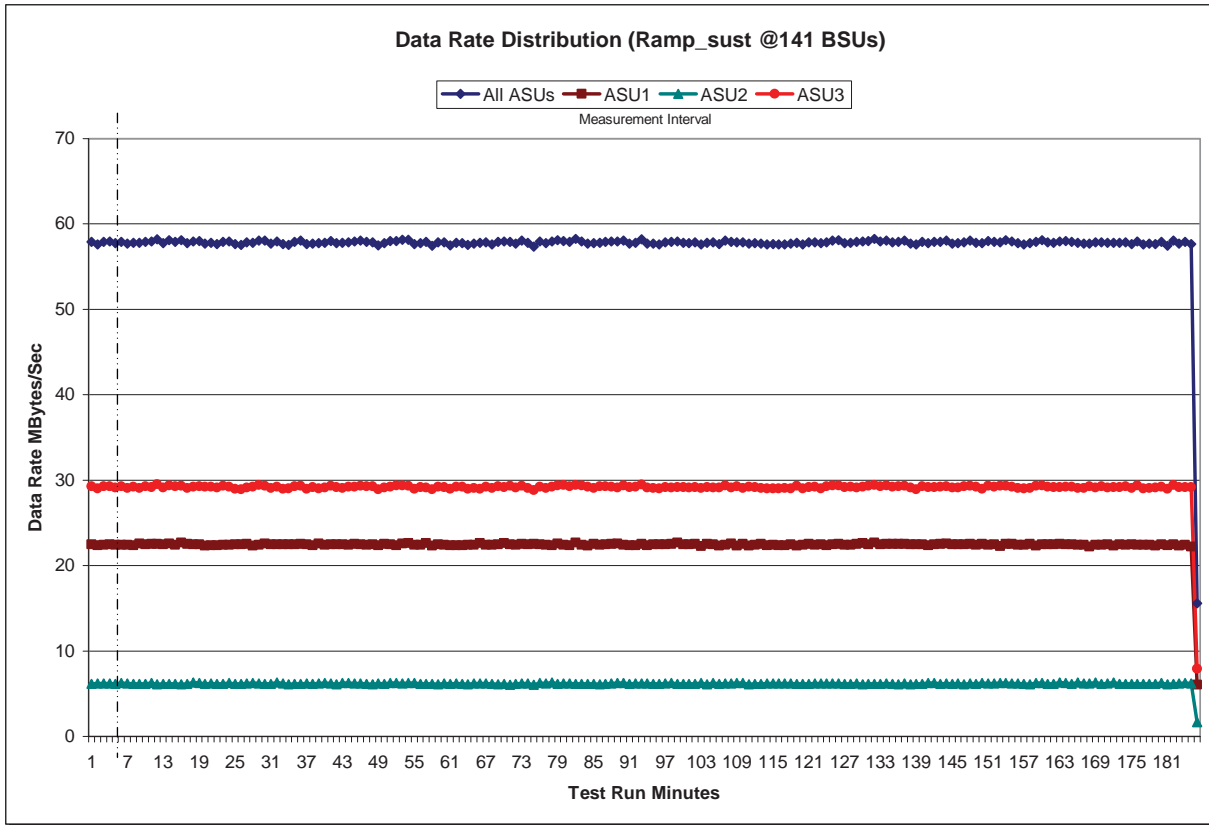
A link to the test results file generated from the Sustainability Test Run is listed below.

[Sustainability Test Results File](#)

Sustainability – Data Rate Distribution Data (MB/second)

Ramp-Up/Start-Up		Start	Stop	Interval	Duration										
Measurement Interval		13:21:46	13:26:46	0-4	0:05:00										
		13:26:46	16:27:46	5-185	3:01:00										
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	
0	57.88	22.47	6.14	29.27	63	57.53	22.45	6.10	28.99	126	57.77	22.45	6.15	29.17	
1	57.58	22.39	6.18	29.02	64	57.71	22.44	6.19	29.08	127	57.81	22.44	6.14	29.23	
2	57.89	22.42	6.20	29.27	65	57.81	22.64	6.18	28.99	128	57.91	22.54	6.22	29.14	
3	57.93	22.46	6.18	29.30	66	57.85	22.43	6.18	29.24	129	57.96	22.64	6.12	29.20	
4	57.75	22.43	6.17	29.15	67	57.62	22.42	6.13	29.07	130	57.99	22.47	6.17	29.35	
5	57.92	22.40	6.25	29.26	68	57.89	22.49	6.11	29.30	131	58.26	22.67	6.16	29.43	
6	57.70	22.41	6.20	29.09	69	57.95	22.62	6.13	29.20	132	57.97	22.49	6.17	29.30	
7	57.79	22.38	6.17	29.25	70	57.88	22.46	6.07	29.35	133	58.05	22.51	6.18	29.36	
8	57.79	22.57	6.13	29.09	71	57.73	22.45	6.14	29.14	134	57.86	22.51	6.12	29.23	
9	57.91	22.48	6.16	29.27	72	58.05	22.51	6.22	29.32	135	57.89	22.51	6.11	29.28	
10	57.95	22.51	6.25	29.19	73	57.78	22.49	6.19	29.10	136	58.04	22.54	6.19	29.31	
11	58.18	22.54	6.12	29.52	74	57.35	22.51	6.03	28.81	137	57.72	22.50	6.11	29.11	
12	57.78	22.46	6.17	29.15	75	57.97	22.49	6.24	29.23	138	57.59	22.50	6.17	28.92	
13	58.09	22.56	6.16	29.36	76	57.74	22.42	6.22	29.10	139	57.89	22.47	6.14	29.28	
14	57.90	22.45	6.16	29.29	77	57.95	22.40	6.31	29.24	140	57.75	22.35	6.24	29.16	
15	58.11	22.69	6.11	29.32	78	58.11	22.59	6.15	29.37	141	57.90	22.45	6.25	29.20	
16	57.76	22.53	6.14	29.09	79	58.02	22.43	6.18	29.42	142	57.93	22.51	6.16	29.25	
17	57.98	22.47	6.29	29.22	80	57.92	22.40	6.21	29.30	143	58.04	22.56	6.17	29.30	
18	58.01	22.48	6.24	29.29	81	58.23	22.65	6.16	29.42	144	57.70	22.46	6.13	29.11	
19	57.72	22.34	6.17	29.21	82	57.96	22.42	6.15	29.39	145	57.77	22.45	6.21	29.11	
20	57.81	22.39	6.18	29.23	83	57.72	22.34	6.14	29.24	146	57.84	22.45	6.11	29.28	
21	57.66	22.39	6.17	29.11	84	57.76	22.51	6.17	29.09	147	58.03	22.51	6.19	29.33	
22	57.91	22.41	6.15	29.35	85	57.80	22.44	6.08	29.29	148	57.81	22.44	6.16	29.21	
23	57.94	22.45	6.27	29.23	86	57.90	22.48	6.13	29.29	149	57.74	22.52	6.23	29.00	
24	57.64	22.50	6.15	28.99	87	57.98	22.53	6.21	29.24	150	58.01	22.44	6.22	29.35	
25	57.56	22.48	6.16	28.91	88	57.97	22.60	6.24	29.13	151	57.91	22.46	6.22	29.23	
26	57.87	22.50	6.22	29.15	89	58.05	22.45	6.24	29.36	152	57.88	22.29	6.26	29.33	
27	57.78	22.30	6.23	29.25	90	57.70	22.38	6.15	29.17	153	58.09	22.51	6.25	29.33	
28	58.04	22.45	6.19	29.41	91	57.82	22.40	6.19	29.22	154	57.96	22.51	6.20	29.24	
29	58.06	22.56	6.16	29.34	92	58.21	22.53	6.19	29.50	155	57.76	22.44	6.21	29.10	
30	57.68	22.45	6.15	29.08	93	57.69	22.35	6.21	29.14	156	57.59	22.43	6.14	29.01	
31	57.98	22.48	6.28	29.22	94	57.70	22.46	6.16	29.08	157	57.74	22.53	6.11	29.10	
32	57.67	22.48	6.19	29.00	95	57.62	22.46	6.14	29.02	158	57.89	22.34	6.24	29.31	
33	57.56	22.46	6.08	29.02	96	57.86	22.47	6.22	29.16	159	58.10	22.49	6.23	29.37	
34	57.90	22.50	6.14	29.26	97	57.90	22.55	6.23	29.12	160	57.87	22.47	6.15	29.25	
35	58.03	22.54	6.15	29.35	98	57.98	22.68	6.14	29.16	161	57.79	22.48	6.13	29.18	
36	57.67	22.50	6.20	28.98	99	57.82	22.49	6.16	29.17	162	57.94	22.51	6.27	29.15	
37	57.68	22.35	6.13	29.20	100	57.77	22.48	6.17	29.11	163	57.99	22.49	6.25	29.25	
38	57.77	22.56	6.20	29.00	101	57.87	22.55	6.15	29.17	164	57.89	22.49	6.17	29.23	
39	57.82	22.44	6.23	29.15	102	57.59	22.26	6.23	29.10	165	57.82	22.45	6.28	29.09	
40	58.00	22.47	6.21	29.31	103	57.81	22.53	6.12	29.16	166	57.72	22.44	6.21	29.07	
41	57.75	22.49	6.09	29.17	104	57.85	22.49	6.25	29.11	167	57.68	22.21	6.21	29.27	
42	57.82	22.50	6.23	29.10	105	57.64	22.32	6.16	29.15	168	57.87	22.43	6.29	29.15	
43	57.86	22.42	6.23	29.21	106	58.06	22.44	6.22	29.40	169	57.83	22.43	6.14	29.27	
44	57.97	22.53	6.22	29.23	107	57.92	22.58	6.21	29.13	170	57.80	22.46	6.20	29.14	
45	58.05	22.50	6.22	29.33	108	57.83	22.31	6.26	29.26	171	57.78	22.32	6.28	29.19	
46	57.89	22.44	6.15	29.29	109	57.83	22.51	6.24	29.08	172	57.82	22.50	6.14	29.17	
47	57.85	22.46	6.10	29.30	110	57.69	22.34	6.11	29.24	173	57.87	22.40	6.17	29.29	
48	57.49	22.36	6.18	28.95	111	57.74	22.41	6.16	29.17	174	57.66	22.46	6.14	29.06	
49	57.75	22.51	6.13	29.11	112	57.72	22.52	6.13	29.07	175	57.96	22.44	6.15	29.37	
50	58.01	22.48	6.27	29.25	113	57.59	22.37	6.21	29.02	176	57.63	22.42	6.16	29.05	
51	58.01	22.39	6.24	29.38	114	57.66	22.41	6.21	29.04	177	57.68	22.44	6.13	29.10	
52	58.17	22.58	6.20	29.39	115	57.58	22.36	6.19	29.03	178	57.63	22.33	6.15	29.15	
53	58.18	22.62	6.23	29.33	116	57.62	22.36	6.18	29.08	179	57.93	22.46	6.24	29.23	
54	57.63	22.42	6.22	28.99	117	57.70	22.50	6.18	29.02	180	57.45	22.37	6.11	28.97	
55	57.73	22.44	6.14	29.16	118	57.80	22.33	6.15	29.33	181	58.08	22.48	6.17	29.43	
56	57.88	22.61	6.16	29.11	119	57.61	22.45	6.13	29.04	182	57.71	22.34	6.19	29.19	
57	57.46	22.34	6.17	28.95	120	57.83	22.51	6.14	29.18	183	57.88	22.44	6.24	29.20	
58	57.83	22.50	6.12	29.21	121	57.84	22.43	6.19	29.22	184	57.64	22.22	6.22	29.20	
59	57.84	22.43	6.21	29.20	122	57.75	22.49	6.22	29.04	185	15.60	6.04	1.64	7.91	
60	57.50	22.35	6.16	28.98	123	57.87	22.39	6.18	29.30						
61	57.83	22.38	6.20	29.25	124	58.07	22.48	6.20	29.39						
62	57.74	22.38	6.13	29.22	125	58.10	22.52	6.22	29.36						

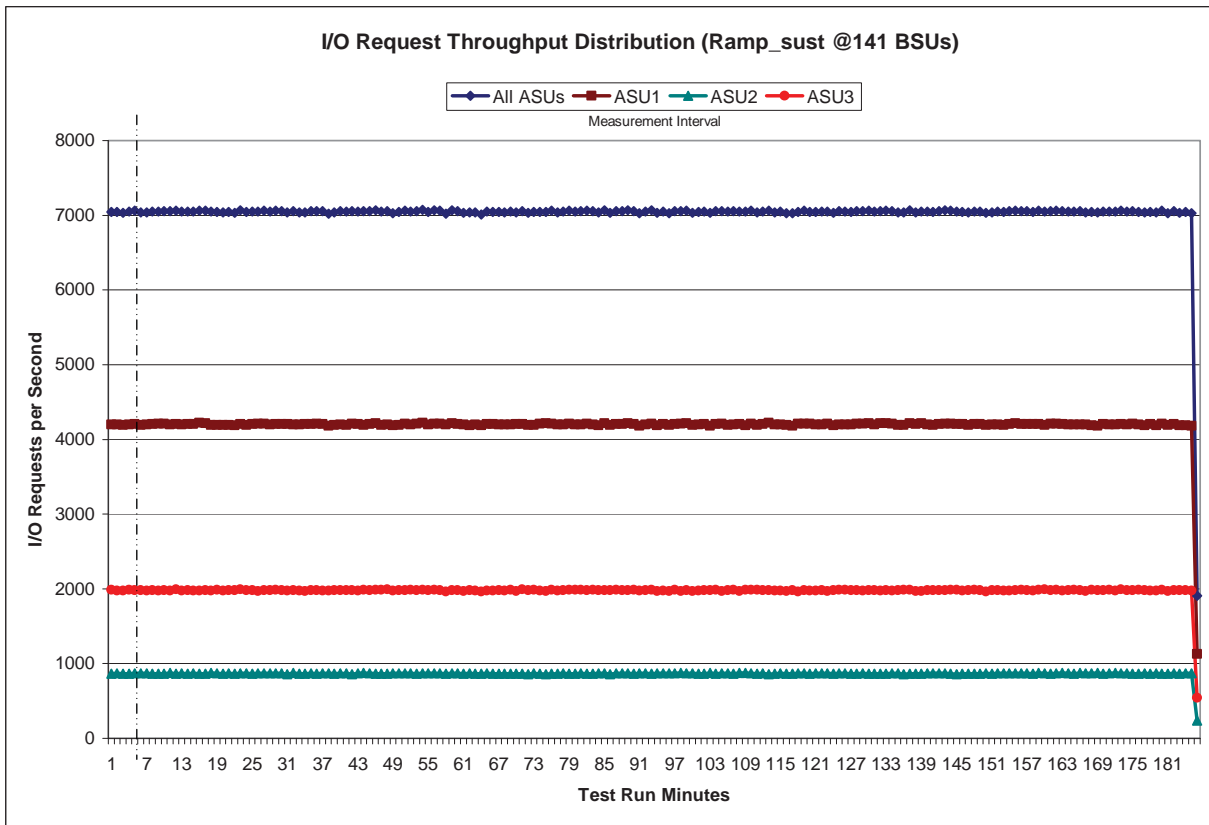
Sustainability – Data Rate Distribution Graph



Sustainability – I/O Request Throughput Distribution Data

		Start	Stop	Interval	Duration															
Ramp-Up/Start-Up		13:21:46	13:26:46	0-4	0:05:00															
Measurement Interval		13:26:46	16:27:46	5-185	3:01:00															
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3						
0	7,045.23	4,196.53	863.38	1,985.32	63	7,010.90	4,185.47	861.83	1,963.60	126	7,044.55	4,196.92	864.25	1,983.38						
1	7,043.30	4,201.12	869.47	1,972.72	64	7,049.90	4,204.30	870.73	1,974.87	127	7,053.57	4,208.62	864.15	1,980.80						
2	7,033.87	4,193.27	863.65	1,976.95	65	7,044.00	4,202.40	865.35	1,976.25	128	7,053.90	4,209.55	868.42	1,975.93						
3	7,051.15	4,200.55	865.20	1,985.40	66	7,041.28	4,200.63	861.63	1,979.02	129	7,062.52	4,215.88	863.77	1,982.87						
4	7,061.87	4,207.30	871.45	1,983.12	67	7,037.87	4,197.77	863.82	1,976.28	130	7,048.62	4,201.13	865.68	1,981.80						
5	7,039.53	4,190.17	869.38	1,979.98	68	7,051.10	4,200.05	866.07	1,984.98	131	7,057.53	4,215.28	864.33	1,977.92						
6	7,039.57	4,199.07	867.52	1,972.98	69	7,040.87	4,204.87	866.02	1,969.98	132	7,063.02	4,214.93	866.27	1,981.82						
7	7,050.78	4,204.38	862.72	1,983.68	70	7,058.13	4,204.05	863.33	1,990.75	133	7,054.23	4,208.32	867.97	1,977.95						
8	7,051.77	4,208.37	866.68	1,976.72	71	7,034.40	4,192.00	859.93	1,982.47	134	7,039.65	4,190.20	870.62	1,978.83						
9	7,057.82	4,212.20	866.47	1,979.15	72	7,045.17	4,190.48	869.48	1,985.20	135	7,038.12	4,194.87	857.00	1,986.25						
10	7,052.93	4,201.20	875.82	1,975.92	73	7,044.57	4,207.58	862.00	1,974.98	136	7,065.70	4,214.43	865.92	1,985.35						
11	7,062.28	4,206.05	864.05	1,992.18	74	7,044.32	4,216.55	859.12	1,968.65	137	7,038.37	4,205.05	861.85	1,971.47						
12	7,047.55	4,201.27	868.22	1,978.07	75	7,061.13	4,209.15	863.88	1,988.10	138	7,052.13	4,216.65	863.97	1,971.52						
13	7,047.52	4,203.52	862.97	1,981.03	76	7,038.17	4,200.55	863.38	1,974.23	139	7,046.98	4,196.43	867.95	1,982.60						
14	7,048.50	4,203.12	867.57	1,977.82	77	7,047.40	4,197.67	870.15	1,979.58	140	7,044.53	4,192.87	870.18	1,981.48						
15	7,061.87	4,219.07	866.15	1,976.65	78	7,059.85	4,207.57	864.97	1,987.32	141	7,052.70	4,203.33	867.08	1,982.28						
16	7,059.27	4,213.70	865.58	1,979.98	79	7,049.40	4,201.18	862.35	1,985.87	142	7,064.15	4,210.02	871.38	1,982.75						
17	7,049.63	4,195.22	877.57	1,976.85	80	7,055.80	4,198.98	870.75	1,986.07	143	7,062.73	4,211.87	866.07	1,984.80						
18	7,046.55	4,190.82	867.98	1,987.75	81	7,060.95	4,212.73	864.70	1,983.52	144	7,050.03	4,205.03	858.72	1,986.28						
19	7,037.87	4,194.00	866.78	1,977.08	82	7,054.47	4,199.18	866.17	1,989.12	145	7,041.92	4,207.13	862.10	1,972.68						
20	7,044.50	4,195.58	868.92	1,980.00	83	7,036.70	4,189.35	867.78	1,979.57	146	7,036.92	4,191.88	866.45	1,978.58						
21	7,034.52	4,188.83	865.27	1,980.42	84	7,065.80	4,214.15	872.37	1,979.28	147	7,052.53	4,202.03	862.05	1,988.45						
22	7,065.25	4,205.62	867.92	1,991.72	85	7,035.27	4,195.57	860.65	1,979.05	148	7,051.93	4,203.35	866.48	1,982.10						
23	7,045.60	4,195.45	871.40	1,978.75	86	7,057.65	4,203.48	869.52	1,984.65	149	7,031.77	4,193.02	872.18	1,966.57						
24	7,051.27	4,204.52	866.30	1,980.45	87	7,054.87	4,203.77	871.10	1,980.00	150	7,039.95	4,196.17	864.32	1,979.47						
25	7,049.42	4,209.28	868.80	1,971.33	88	7,067.87	4,215.52	870.07	1,982.28	151	7,050.95	4,201.12	869.73	1,980.10						
26	7,060.45	4,210.10	870.57	1,979.78	89	7,057.82	4,204.05	866.57	1,987.20	152	7,041.22	4,194.33	869.10	1,977.78						
27	7,048.15	4,198.72	867.17	1,982.27	90	7,024.02	4,182.63	867.32	1,974.07	153	7,053.95	4,206.62	870.80	1,976.53						
28	7,060.93	4,204.35	869.22	1,987.37	91	7,051.42	4,200.10	869.28	1,982.03	154	7,062.80	4,215.85	867.55	1,979.40						
29	7,053.23	4,204.77	867.63	1,980.83	92	7,065.78	4,209.73	866.75	1,989.30	155	7,056.82	4,203.78	867.87	1,985.17						
30	7,038.32	4,203.28	858.87	1,976.17	93	7,034.45	4,189.95	872.23	1,972.27	156	7,055.53	4,206.07	868.48	1,980.98						
31	7,054.85	4,196.88	877.60	1,980.37	94	7,048.47	4,204.07	868.32	1,976.08	157	7,044.60	4,201.78	865.17	1,977.65						
32	7,037.48	4,198.13	862.37	1,976.98	95	7,026.23	4,191.15	867.82	1,967.27	158	7,060.48	4,202.08	873.55	1,984.85						
33	7,037.33	4,202.43	864.28	1,970.62	96	7,054.18	4,202.07	867.87	1,984.25	159	7,052.27	4,192.08	870.12	1,990.07						
34	7,054.03	4,203.77	868.03	1,982.23	97	7,055.87	4,210.72	874.43	1,970.72	160	7,056.12	4,208.08	864.13	1,983.90						
35	7,057.63	4,207.88	866.02	1,983.73	98	7,062.27	4,215.63	867.12	1,979.52	161	7,060.88	4,208.30	867.37	1,985.22						
36	7,053.60	4,206.63	870.83	1,976.13	99	7,032.92	4,193.65	868.35	1,970.92	162	7,052.72	4,202.08	873.48	1,977.15						
37	7,022.38	4,180.40	867.12	1,974.87	100	7,044.47	4,200.90	866.55	1,977.02	163	7,052.12	4,198.20	870.42	1,983.50						
38	7,040.35	4,194.68	862.20	1,983.47	101	7,046.98	4,202.85	863.80	1,980.33	164	7,048.72	4,197.97	865.30	1,985.45						
39	7,052.73	4,200.97	870.63	1,981.13	102	7,032.13	4,179.30	872.82	1,980.02	165	7,056.42	4,200.10	873.43	1,982.88						
40	7,049.58	4,194.10	872.38	1,983.10	103	7,053.00	4,203.42	865.22	1,984.37	166	7,035.67	4,196.40	867.82	1,971.45						
41	7,054.03	4,210.33	861.05	1,982.65	104	7,052.75	4,209.05	871.47	1,972.23	167	7,045.93	4,189.60	869.42	1,986.92						
42	7,050.03	4,204.88	869.05	1,976.10	105	7,047.42	4,193.40	871.12	1,982.90	168	7,038.13	4,183.82	873.27	1,981.05						
43	7,053.02	4,194.65	872.87	1,985.50	106	7,052.63	4,200.27	865.32	1,987.05	169	7,049.80	4,202.63	865.33	1,981.83						
44	7,054.50	4,204.55	867.58	1,982.37	107	7,052.10	4,206.65	874.03	1,971.42	170	7,050.92	4,197.63	868.53	1,984.75						
45	7,067.47	4,217.90	862.00	1,987.57	108	7,050.52	4,187.95	876.17	1,986.40	171	7,052.32	4,201.35	874.10	1,976.87						
46	7,048.62	4,195.32	865.55	1,987.75	109	7,062.02	4,208.12	869.30	1,984.60	172	7,063.65	4,202.53	870.75	1,990.37						
47	7,055.43	4,200.07	865.05	1,990.32	110	7,038.52	4,191.70	862.17	1,984.65	173	7,050.75	4,197.50	871.43	1,981.82						
48	7,027.43	4,186.53	867.02	1,973.88	111	7,051.90	4,203.55	867.23	1,981.12	174	7,055.15	4,207.43	866.68	1,981.03						
49	7,046.03	4,193.97	869.90	1,982.17	112	7,059.92	4,220.53	860.97	1,978.42	175	7,045.12	4,197.03	862.52	1,985.57						
50	7,059.03	4,208.93	867.17	1,982.93	113	7,038.12	4,196.48	865.40	1,976.23	176	7,036.55	4,187.23	870.23	1,979.08						
51	7,051.90	4,196.25	868.80	1,986.85	114	7,048.30	4,200.27	871.67	1,976.37	177	7,045.57	4,206.72	863.92	1,974.93						
52	7,055.67	4,210.82	864.95	1,979.90	115	7,027.28	4,190.37	864.90	1,972.02	178	7,035.50	4,188.33	868.80	1,978.37						
53	7,074.80	4,219.50	870.85	1,984.45	116	7,027.13	4,181.65	865.93	1,979.55	179	7,061.57	4,207.72	866.22	1,987.63						
54	7,042.28	4,196.33	866.90	1,979.05	117	7,044.27	4,209.60	868.98	1,965.68	180	7,024.73	4,193.03	864.82	1,966.88						
55	7,064.67	4,210.23	867.97	1,986.47	118	7,060.75	4,209.08	867.85	1,983.82	181	7,057.50	4,205.37	868.22	1,983.92						
56	7,058.35	4,208.48	867.47	1,982.40	119	7,043.75	4,208.20	861.42	1,974.13	182	7,032.83	4,187.95	863.87	1,981.02						
57	7,022.53	4,197.07	863.18	1,962.28	120	7,045.45	4,197.03	871.27	1,977.15	183	7,041.82	4,188.95	870.78	1,982.08						
58	7,066.48	4,215.85	868.50	1,982.13	121	7,051.15	4,200.90	871.50	1,978.75	184	7,025.77	4,179.32	872.52	1,973.93						
59	7,053.35	4,205.98	868.07	1,979.30	122	7,052.23	4,208.65	871.50	1,972.08	185	1,903.62	1,129.52	233.93	540.17						
60	7,031.33	4,197.20	863.53	1,970.60	123	7,029.87	4,185.47	863.30	1,981.10	Average					7,020.24	4,184.26	863.80	1,972.19		
61	7,036.62	4,186.28	867.38	1,982.95	124	7,054.52	4,198.28	870.20	1,986.03											
62	7,039.10	4,198.32	863.20	1,977.58	125	7,051.25	4,196.82	868.40	1,986.03											

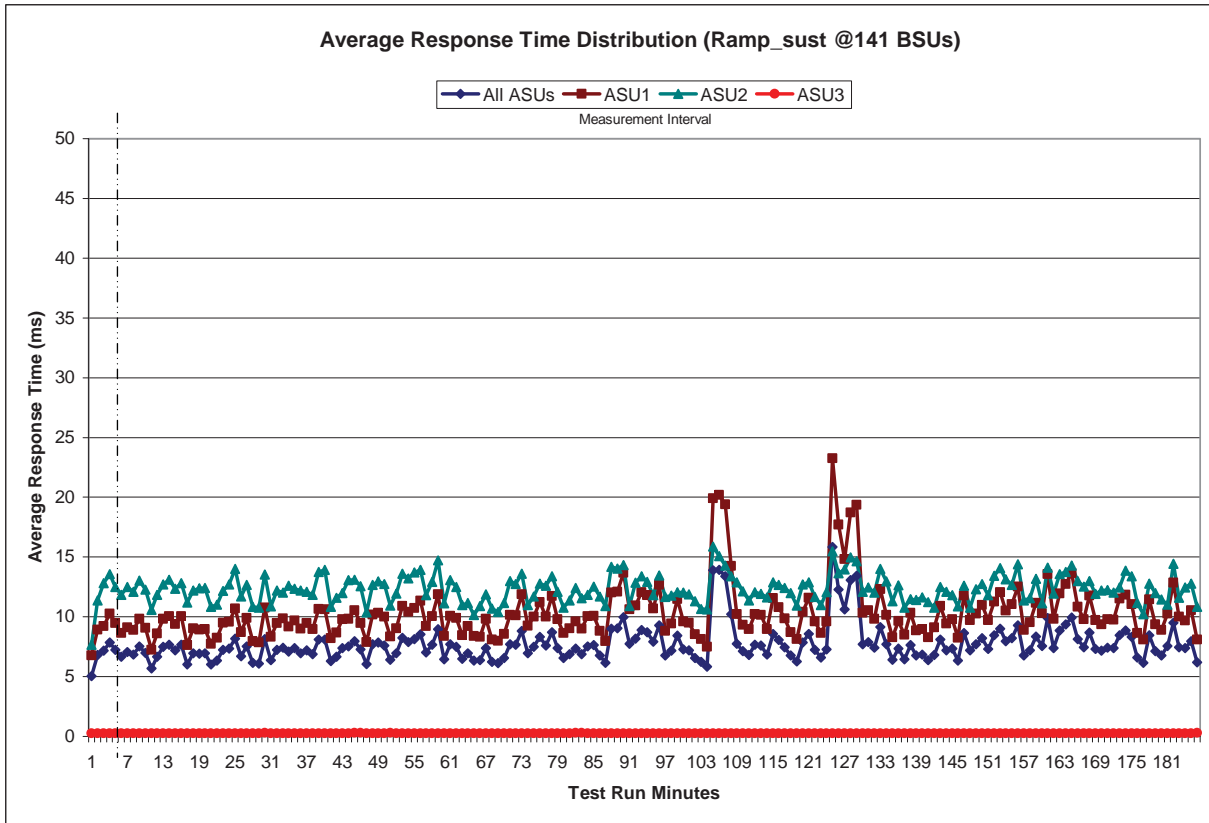
Sustainability – I/O Request Throughput Distribution Graph



Sustainability – Average Response Time (ms) Distribution Data

Ramp-Up/Start-Up		Start	Stop	Interval	Duration										
Measurement Interval		13:21:46	13:26:46	0-4	0:05:00										
		13:26:46	16:27:46	5-185	3:01:00										
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	
0	5.03	6.75	7.65	0.25	63	6.94	9.21	11.17	0.25	126	10.61	14.81	13.95	0.25	
1	6.81	8.94	11.36	0.25	64	6.32	8.37	10.15	0.25	127	13.08	18.72	14.97	0.25	
2	7.15	9.23	12.80	0.25	65	6.37	8.31	10.92	0.25	128	13.43	19.36	14.67	0.25	
3	7.84	10.25	13.57	0.25	66	7.40	9.84	11.87	0.25	129	7.71	10.32	12.09	0.25	
4	7.25	9.46	12.49	0.25	67	6.22	8.11	10.71	0.25	130	7.88	10.54	12.44	0.25	
5	6.68	8.64	11.84	0.26	68	6.11	7.99	10.41	0.26	131	7.41	9.82	12.04	0.26	
6	7.05	9.12	12.49	0.26	69	6.56	8.56	11.16	0.26	132	9.13	12.30	14.00	0.26	
7	6.85	8.88	12.09	0.26	70	7.71	10.16	12.99	0.25	133	7.72	10.15	12.94	0.25	
8	7.53	9.82	13.04	0.26	71	7.66	10.12	12.75	0.25	134	6.41	8.29	11.31	0.26	
9	7.00	9.08	12.29	0.26	72	8.82	11.89	13.61	0.25	135	7.35	9.63	12.64	0.25	
10	5.70	7.24	10.57	0.26	73	6.95	9.26	10.98	0.26	136	6.46	8.50	10.75	0.26	
11	6.66	8.62	11.86	0.26	74	7.49	10.00	11.70	0.26	137	7.65	10.32	11.49	0.26	
12	7.50	9.83	12.72	0.25	75	8.33	11.22	12.78	0.26	138	6.76	8.86	11.40	0.25	
13	7.66	10.03	13.09	0.26	76	7.60	10.02	12.60	0.25	139	6.85	8.97	11.63	0.25	
14	7.20	9.39	12.36	0.26	77	8.72	11.75	13.40	0.25	140	6.39	8.28	11.23	0.25	
15	7.65	10.06	12.82	0.26	78	7.38	9.78	12.08	0.25	141	6.81	9.10	10.75	0.25	
16	6.01	7.65	11.18	0.26	79	6.54	8.63	10.76	0.26	142	8.11	10.89	12.50	0.25	
17	6.96	9.02	12.21	0.26	80	6.86	9.05	11.38	0.27	143	7.19	9.44	12.11	0.26	
18	6.90	8.92	12.39	0.25	81	7.33	9.61	12.40	0.28	144	7.34	9.79	11.79	0.25	
19	6.94	8.96	12.43	0.25	82	6.86	9.01	11.56	0.28	145	6.33	8.25	10.88	0.25	
20	6.02	7.74	10.85	0.26	83	7.51	10.05	11.84	0.26	146	8.62	11.75	12.59	0.25	
21	6.34	8.25	11.00	0.25	84	7.64	10.09	12.54	0.25	147	7.18	9.73	10.77	0.26	
22	7.22	9.50	12.17	0.26	85	6.76	8.82	11.70	0.26	148	7.70	10.27	12.29	0.25	
23	7.35	9.59	12.70	0.26	86	6.15	7.95	10.91	0.26	149	8.19	10.97	12.74	0.25	
24	8.17	10.69	14.01	0.25	87	8.99	12.03	14.19	0.26	150	7.31	9.71	11.82	0.25	
25	6.71	8.71	11.69	0.26	88	9.02	12.11	14.03	0.26	151	8.44	11.27	13.42	0.25	
26	7.53	9.89	12.68	0.26	89	9.98	13.68	14.32	0.26	152	9.00	12.06	14.09	0.26	
27	6.15	7.96	10.85	0.25	90	7.75	10.63	10.92	0.26	153	7.97	10.53	13.16	0.25	
28	6.08	7.86	10.77	0.25	91	8.17	10.93	12.84	0.25	154	8.21	11.03	12.66	0.25	
29	8.15	10.75	13.52	0.27	92	8.89	12.04	13.40	0.26	155	9.30	12.51	14.38	0.26	
30	6.36	8.30	10.89	0.25	93	8.72	11.82	12.94	0.25	156	6.77	8.89	11.36	0.25	
31	7.23	9.47	12.21	0.26	94	7.90	10.69	11.79	0.25	157	7.18	9.54	11.56	0.25	
32	7.43	9.86	12.04	0.25	95	9.29	12.67	13.47	0.26	158	8.35	11.18	13.17	0.26	
33	7.10	9.18	12.59	0.25	96	6.75	8.80	11.68	0.25	159	7.56	10.29	11.12	0.26	
34	7.37	9.70	12.34	0.25	97	7.16	9.43	11.79	0.26	160	9.90	13.58	14.11	0.26	
35	6.93	8.99	12.20	0.25	98	8.41	11.48	12.07	0.25	161	7.39	9.82	11.95	0.25	
36	7.21	9.46	12.09	0.26	99	7.28	9.60	12.01	0.26	162	8.86	11.93	13.57	0.26	
37	6.88	8.98	11.86	0.27	100	7.21	9.51	11.87	0.26	163	9.36	12.75	13.75	0.26	
38	8.10	10.64	13.76	0.27	101	6.55	8.53	11.32	0.26	164	9.95	13.64	14.30	0.25	
39	8.11	10.62	13.92	0.26	102	6.24	8.15	10.64	0.27	165	8.12	10.82	12.99	0.25	
40	6.29	8.19	10.83	0.25	103	5.85	7.50	10.62	0.26	166	7.45	9.78	12.51	0.25	
41	6.65	8.66	11.59	0.25	104	13.91	19.91	15.88	0.25	167	8.68	11.77	13.01	0.25	
42	7.40	9.80	11.98	0.26	105	13.94	20.18	15.09	0.25	168	7.32	9.71	11.93	0.25	
43	7.53	9.81	13.05	0.26	106	13.38	19.41	14.30	0.25	169	7.15	9.37	12.20	0.25	
44	7.97	10.54	13.10	0.27	107	10.23	14.25	13.37	0.25	170	7.41	9.79	12.24	0.26	
45	7.26	9.48	12.56	0.28	108	7.75	10.23	12.87	0.25	171	7.38	9.76	12.01	0.25	
46	6.04	7.88	10.37	0.26	109	7.12	9.33	12.13	0.25	172	8.46	11.51	12.44	0.25	
47	7.69	10.19	12.69	0.26	110	6.81	8.97	11.39	0.25	173	8.84	11.85	13.87	0.26	
48	7.83	10.35	12.95	0.25	111	7.66	10.24	12.07	0.26	174	8.30	11.04	13.38	0.26	
49	7.59	10.00	12.73	0.25	112	7.60	10.16	11.93	0.25	175	6.58	8.64	11.15	0.25	
50	6.39	8.34	10.94	0.27	113	6.85	8.97	11.64	0.25	176	6.15	8.09	10.22	0.26	
51	6.93	9.05	11.96	0.26	114	8.56	11.57	12.87	0.25	177	8.47	11.45	12.77	0.25	
52	8.25	10.90	13.60	0.26	115	8.08	10.82	12.67	0.25	178	7.12	9.35	11.99	0.25	
53	7.90	10.40	13.19	0.25	116	7.47	9.86	12.42	0.25	179	6.78	8.91	11.44	0.26	
54	8.15	10.71	13.73	0.26	117	6.76	8.72	12.00	0.25	180	7.54	10.25	11.01	0.26	
55	8.54	11.34	13.92	0.26	118	6.26	8.13	10.93	0.26	181	9.51	12.86	14.45	0.26	
56	7.02	9.22	11.80	0.26	119	7.84	10.41	12.72	0.26	182	7.45	10.00	11.61	0.25	
57	7.67	10.06	12.92	0.25	120	8.57	11.60	12.88	0.25	183	7.37	9.69	12.45	0.25	
58	8.96	11.87	14.73	0.26	121	7.24	9.61	11.66	0.26	184	7.94	10.56	12.77	0.25	
59	6.45	8.40	11.11	0.26	122	6.59	8.65	10.99	0.25	185	6.21	8.09	10.85	0.27	
60	7.70	10.09	13.06	0.25	123	7.28	9.63	12.05	0.25	Average					
61	7.50	9.90	12.50	0.25	124	15.82	23.26	15.48	0.25		7.73	10.30	12.34	0.26	
62	6.47	8.47	10.96	0.26	125	12.29	17.71	13.65	0.25						

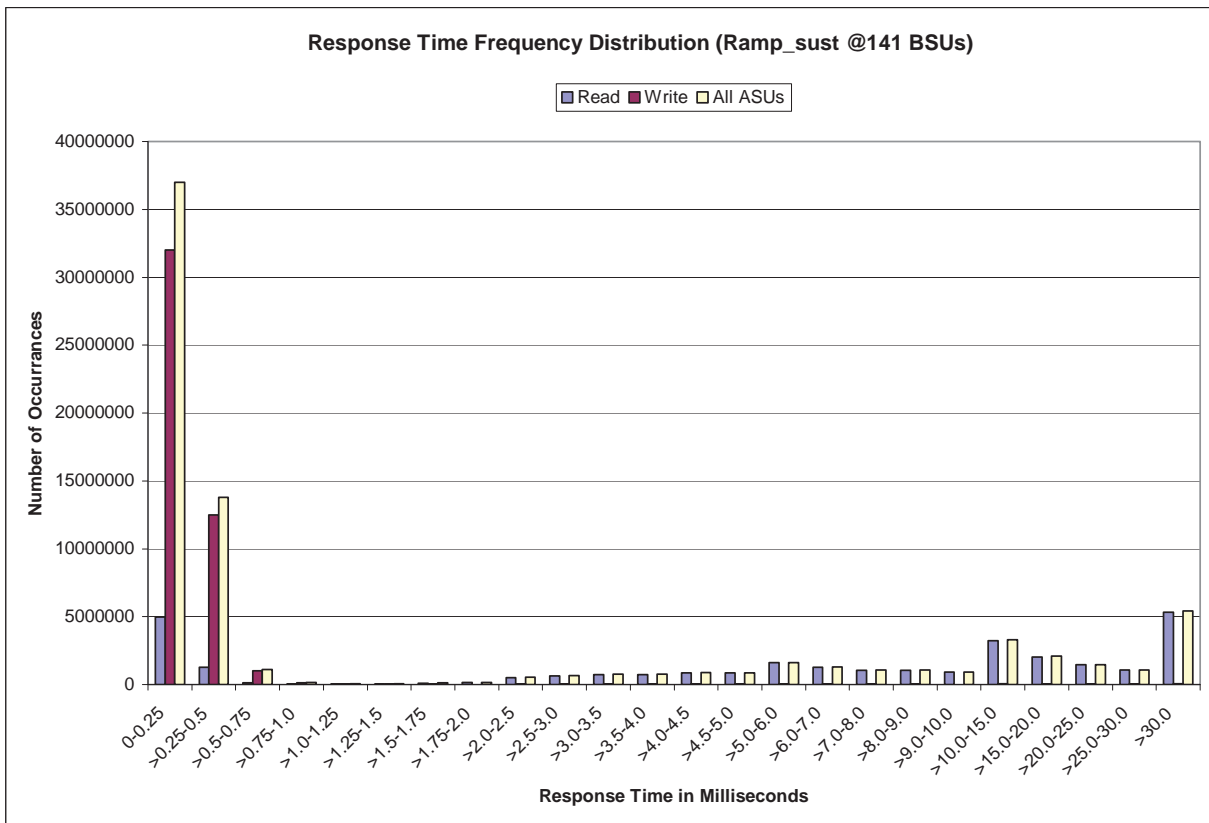
Sustainability – Average Response Time (ms) Distribution Graph



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	4,989,792	1,280,760	112,818	31,957	20,951	37,688	95,516	146,699
Write	32,012,894	12,501,543	998,492	115,162	46,466	31,487	20,766	15,791
All ASUs	37,002,686	13,782,303	1,111,310	147,119	67,417	69,175	116,282	162,490
ASU1	18,318,449	5,486,668	281,021	68,020	41,950	54,363	107,053	154,998
ASU2	5,034,939	1,418,253	66,248	15,179	7,349	5,019	4,168	4,245
ASU3	13,649,298	6,877,382	764,041	63,920	18,118	9,793	5,061	3,247
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	520,017	631,868	730,171	730,598	871,177	844,694	1,603,943	1,269,756
Write	27,982	25,105	21,675	18,295	17,893	16,921	26,377	23,277
All ASUs	547,999	656,973	751,846	748,893	889,070	861,615	1,630,320	1,293,033
ASU1	529,453	634,980	723,395	714,414	843,079	813,529	1,525,850	1,183,766
ASU2	13,455	18,447	25,392	32,079	43,671	46,139	101,749	107,365
ASU3	5,091	3,546	3,059	2,400	2,320	1,947	2,721	1,902
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	1,053,831	1,049,144	919,564	3,240,429	2,041,982	1,443,697	1,068,271	5,339,197
Write	18,100	16,394	13,312	52,220	34,842	24,084	17,086	69,150
All ASUs	1,071,931	1,065,538	932,876	3,292,649	2,076,824	1,467,781	1,085,357	5,408,347
ASU1	975,788	973,003	849,311	2,939,207	1,818,968	1,264,329	919,086	4,220,361
ASU2	95,024	91,883	83,116	352,530	257,221	203,393	166,264	1,187,720
ASU3	1,119	652	449	912	635	59	7	266

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	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.008	0.002	0.006	0.003	0.012	0.006	0.008	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 68.

IOPS Test Results File

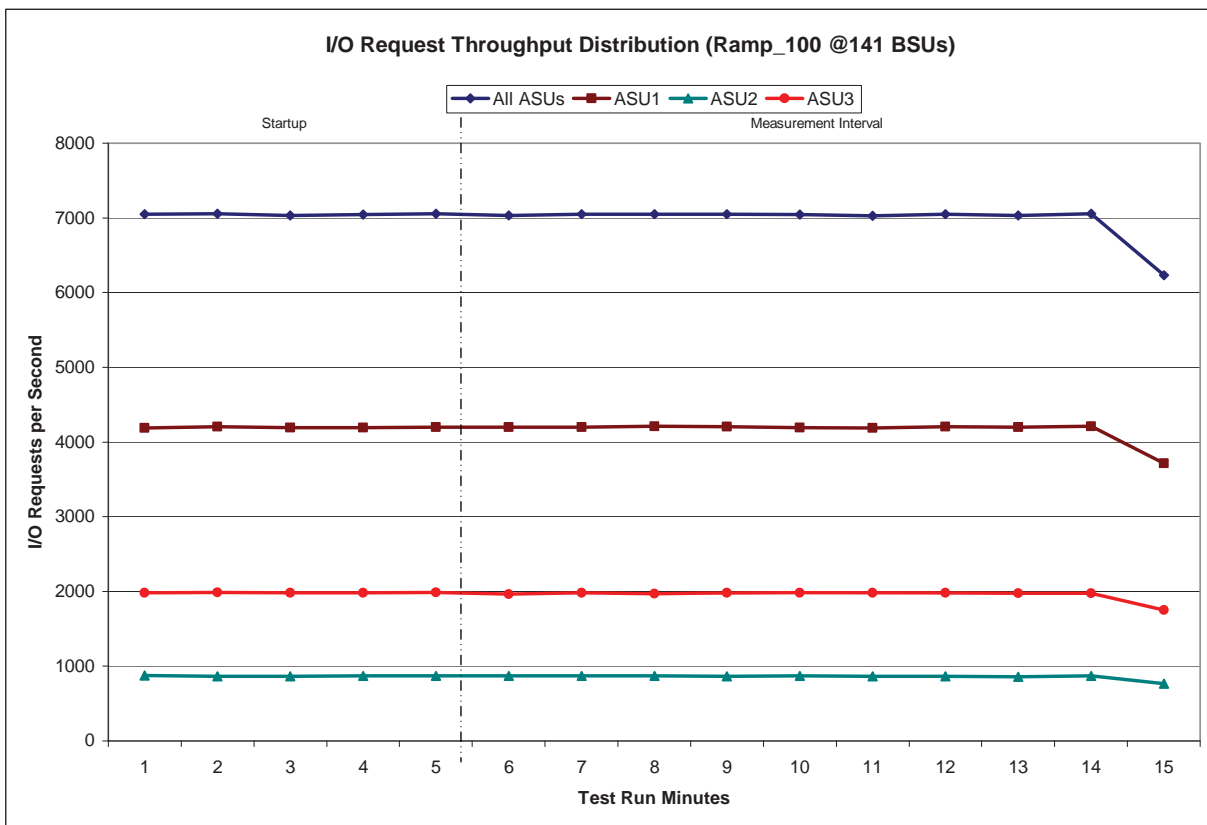
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

141 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	16:27:50	16:32:51	0-4	0:05:01
<i>Measurement Interval</i>	16:32:51	16:42:51	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	7,048.02	4,189.00	874.88	1,984.13
1	7,053.57	4,202.28	865.08	1,986.20
2	7,031.85	4,191.43	861.40	1,979.02
3	7,041.13	4,193.67	866.97	1,980.50
4	7,058.08	4,197.55	871.45	1,989.08
5	7,032.23	4,200.55	867.38	1,964.30
6	7,050.08	4,201.02	866.92	1,982.15
7	7,047.45	4,208.03	869.33	1,970.08
8	7,049.10	4,202.05	864.50	1,982.55
9	7,044.58	4,194.72	869.17	1,980.70
10	7,028.73	4,184.33	865.12	1,979.28
11	7,050.30	4,207.30	861.22	1,981.78
12	7,030.38	4,196.18	860.68	1,973.52
13	7,056.55	4,209.23	869.65	1,977.67
14	6,234.55	3,716.28	764.55	1,753.72
Average	6,962.40	4,151.97	855.85	1,954.58

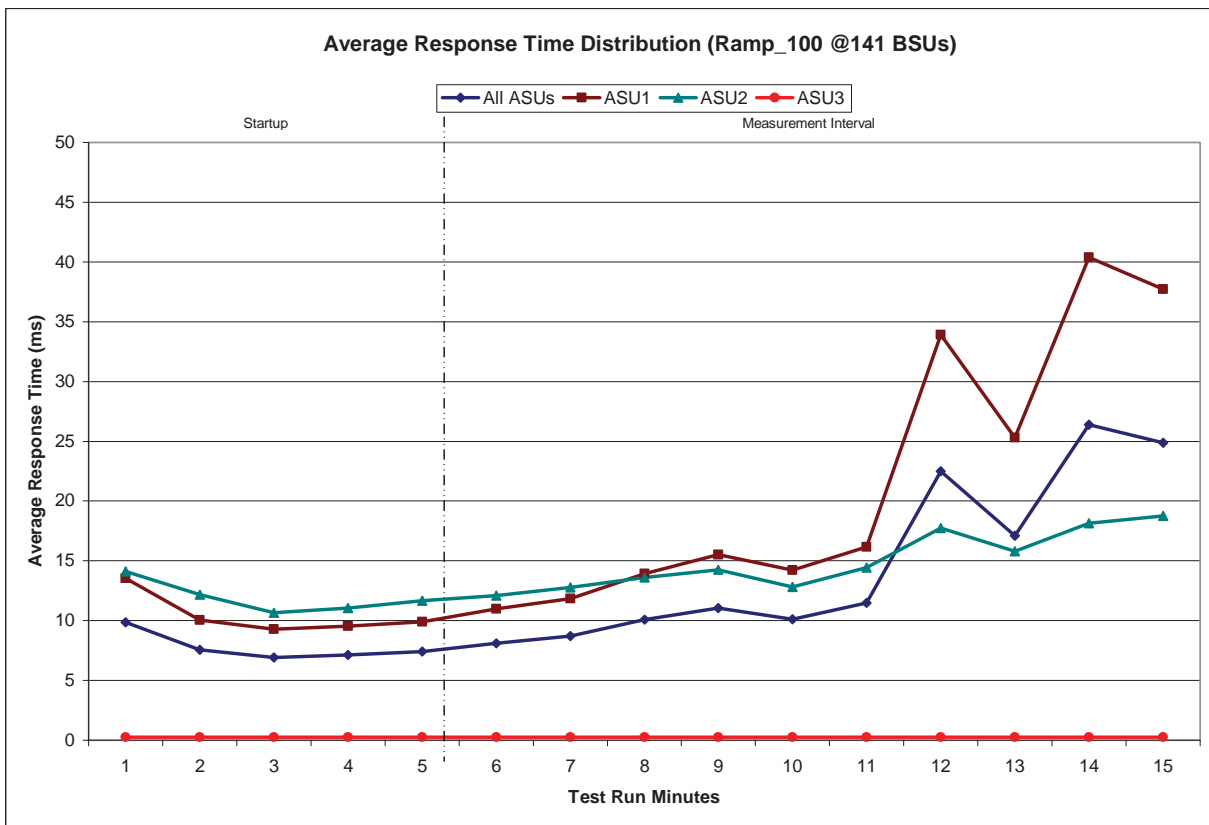
IOPS Test Run – I/O Request Throughput Distribution Graph



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

141 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:27:50	16:32:51	0-4	0:05:01
Measurement Interval	16:32:51	16:42:51	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9.86	13.53	14.11	0.25
1	7.54	10.03	12.17	0.25
2	6.91	9.29	10.67	0.25
3	7.12	9.55	11.06	0.25
4	7.41	9.91	11.65	0.26
5	8.11	10.97	12.08	0.25
6	8.70	11.84	12.78	0.25
7	10.06	13.92	13.62	0.26
8	11.06	15.50	14.25	0.25
9	10.12	14.21	12.82	0.25
10	11.47	16.17	14.42	0.25
11	22.48	33.92	17.75	0.25
12	17.10	25.29	15.82	0.25
13	26.39	40.38	18.15	0.24
14	24.86	37.73	18.77	0.24
Average	15.04	21.99	15.05	0.25

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



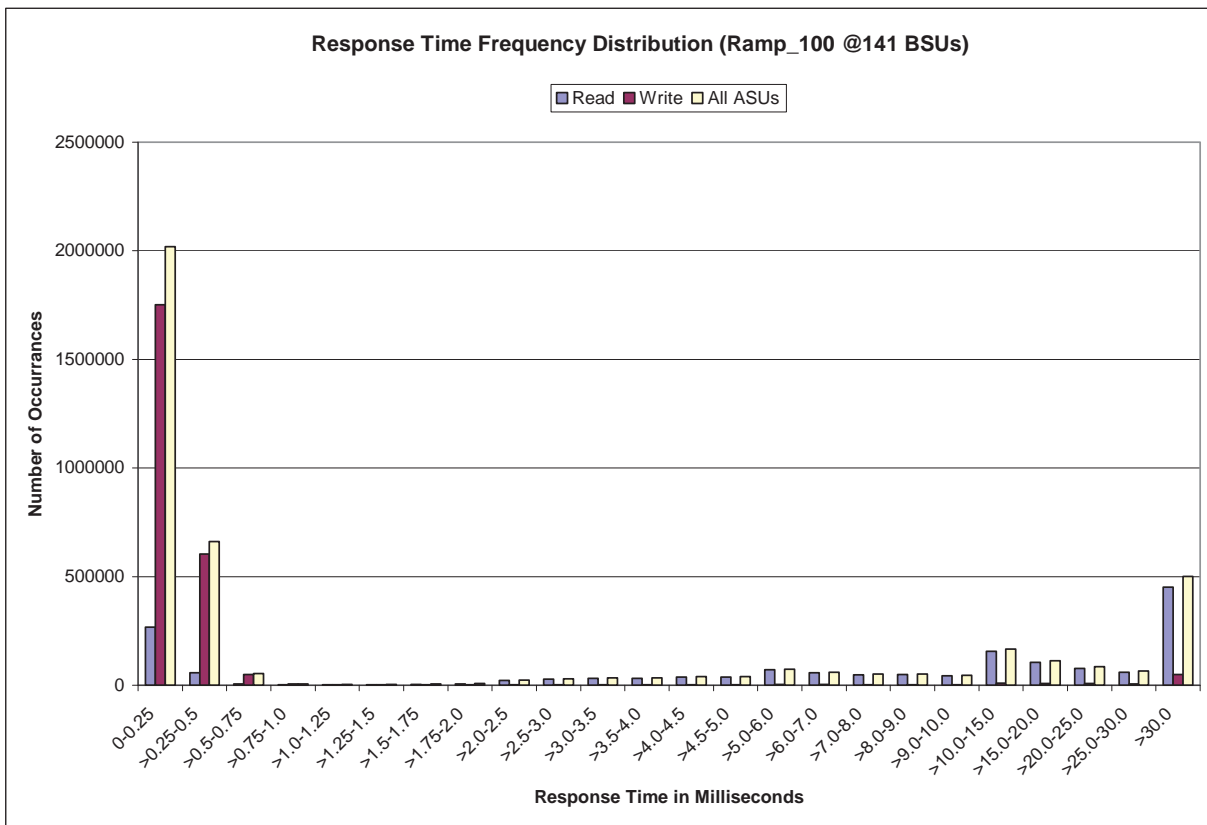
IOPS Test Run – Response Time Frequency Distribution Data

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	266,693	58,010	5,063	1,568	1,136	1,703	4,290	6,399
Write	1,751,678	604,512	49,100	5,222	2,549	1,965	1,613	1,305
All ASUs	2,018,371	662,522	54,163	6,790	3,685	3,668	5,903	7,704
ASU1	964,182	232,669	12,398	3,510	2,555	3,000	5,454	7,306
ASU2	284,643	71,238	3,068	578	326	222	201	230
ASU3	769,546	358,615	38,697	2,702	804	446	248	168

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	21,787	27,178	31,297	30,998	37,648	37,002	70,830	57,242
Write	2,414	2,559	2,309	1,926	1,938	1,964	3,341	3,124
All ASUs	24,201	29,737	33,606	32,924	39,586	38,966	74,171	60,366
ASU1	23,262	28,642	32,198	31,274	37,431	36,655	69,132	55,083
ASU2	641	872	1,208	1,519	2,008	2,195	4,865	5,192
ASU3	298	223	200	131	147	116	174	91

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	48,534	48,848	43,010	156,850	104,105	77,909	60,161	451,460
Write	2,742	2,637	2,342	10,371	8,476	7,261	5,972	50,397
All ASUs	51,276	51,485	45,352	167,221	112,581	85,170	66,133	501,857
ASU1	46,594	46,717	41,079	149,091	99,701	74,895	57,568	430,786
ASU2	4,619	4,746	4,256	18,102	12,871	10,275	8,565	71,071
ASU3	63	22	17	28	9	-	-	-

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
4,177,438	3,675,581	430,786

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
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2811	0.0702	0.2100	0.0180	0.0699	0.0351	0.2807
COV	0.009	0.002	0.004	0.004	0.006	0.004	0.010	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 14.

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 68.

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](#)

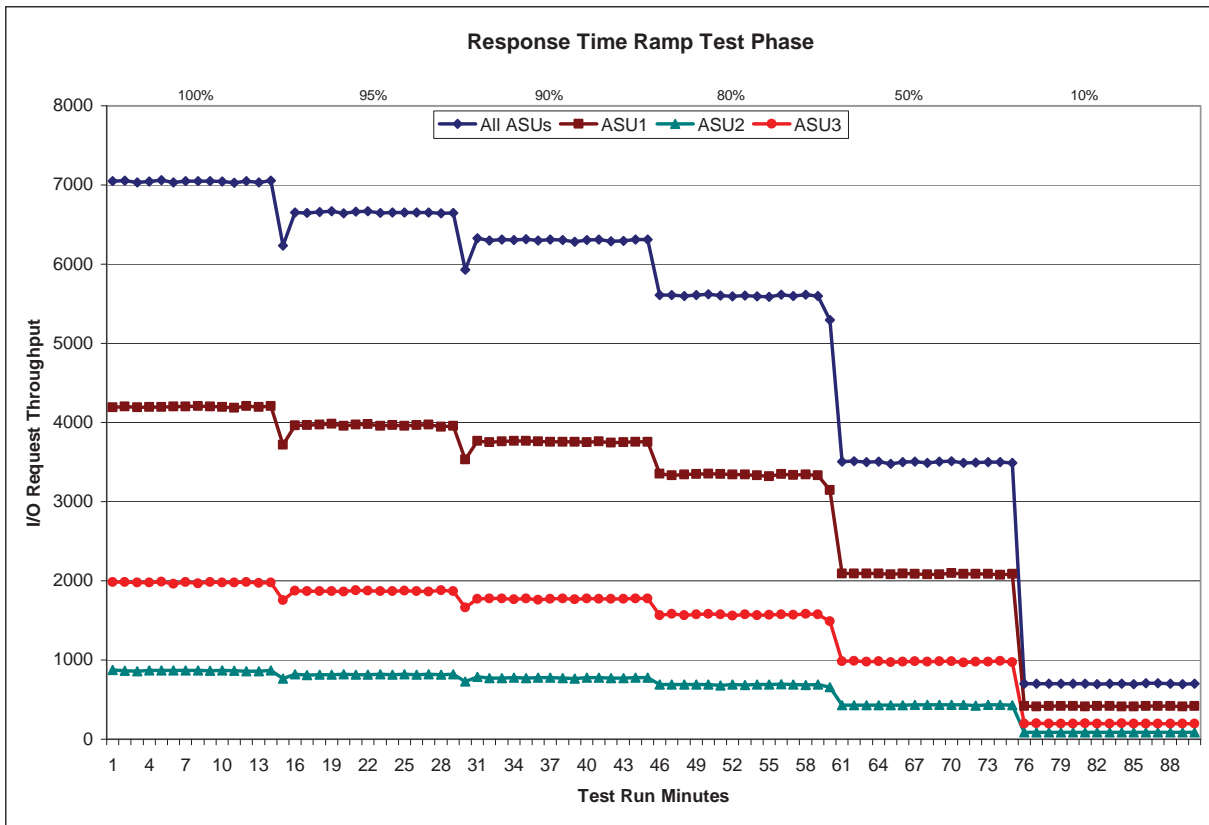
[10% Load Level](#)

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 - 141 BSUs					95% Load Level - 133 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
16:27:50	16:32:51	0-4	0:05:01		16:42:54	16:47:55	0-4	0:05:01	
16:32:51	16:42:51	5-14	0:10:00		16:47:55	16:57:55	5-14	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
All ASUs	ASU-1	ASU-2	ASU-3		All ASUs	ASU-1	ASU-2	ASU-3	
0	7,048.02	4,189.00	874.88	1,984.13	0	6,652.45	3,959.27	819.93	1,873.25
1	7,053.57	4,202.28	865.08	1,986.20	1	6,648.55	3,966.28	811.38	1,870.88
2	7,031.85	4,191.43	861.40	1,979.02	2	6,659.37	3,972.83	815.32	1,871.22
3	7,041.13	4,193.67	866.97	1,980.50	3	6,670.03	3,981.28	817.38	1,871.37
4	7,058.08	4,197.55	871.45	1,989.08	4	6,641.48	3,957.82	819.18	1,864.48
5	7,032.23	4,200.55	867.38	1,964.30	5	6,662.35	3,971.13	812.73	1,878.48
6	7,050.08	4,201.02	866.92	1,982.15	6	6,667.27	3,976.62	817.20	1,873.45
7	7,047.45	4,208.03	869.33	1,970.08	7	6,646.65	3,958.18	820.12	1,868.35
8	7,049.10	4,202.05	864.50	1,982.55	8	6,653.02	3,967.00	817.50	1,868.52
9	7,044.58	4,194.72	869.17	1,980.70	9	6,652.28	3,957.67	822.07	1,872.55
10	7,028.73	4,184.33	865.12	1,979.28	10	6,652.00	3,965.98	817.53	1,868.48
11	7,050.30	4,207.30	861.22	1,981.78	11	6,654.27	3,973.17	819.20	1,861.90
12	7,030.38	4,196.18	860.68	1,973.52	12	6,639.97	3,943.87	814.57	1,881.53
13	7,056.55	4,209.23	869.65	1,977.67	13	6,644.03	3,953.88	822.57	1,867.58
14	6,234.55	3,716.28	764.55	1,753.72	14	5,926.72	3,532.02	729.85	1,664.85
Average	6,962.40	4,151.97	855.85	1,954.58	Average	6,579.86	3,919.95	809.33	1,850.57
90% Load Level - 126 BSUs					80% Load Level - 112 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
16:57:58	17:02:59	0-4	0:05:01		17:13:02	17:18:03	0-4	0:05:01	
17:02:59	17:12:59	5-14	0:10:00		17:18:03	17:28:03	5-14	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
All ASUs	ASU-1	ASU-2	ASU-3		All ASUs	ASU-1	ASU-2	ASU-3	
0	6,324.13	3,765.37	787.62	1,771.15	0	5,609.43	3,354.00	689.40	1,566.03
1	6,299.73	3,752.45	770.45	1,776.83	1	5,606.00	3,332.45	692.52	1,581.03
2	6,307.65	3,759.07	772.47	1,776.12	2	5,596.63	3,340.25	688.77	1,567.62
3	6,306.32	3,766.22	775.08	1,765.02	3	5,610.97	3,346.08	690.05	1,574.83
4	6,317.90	3,767.97	773.42	1,776.52	4	5,620.62	3,351.53	689.22	1,579.87
5	6,301.30	3,762.03	777.48	1,761.78	5	5,605.32	3,346.82	681.55	1,576.95
6	6,307.57	3,758.08	776.53	1,772.95	6	5,595.05	3,344.88	688.68	1,561.48
7	6,305.10	3,755.55	774.30	1,775.25	7	5,601.13	3,341.17	685.98	1,573.98
8	6,285.30	3,755.70	765.90	1,763.70	8	5,591.55	3,333.83	690.93	1,566.78
9	6,304.52	3,747.30	779.27	1,777.95	9	5,585.95	3,322.87	691.68	1,571.40
10	6,308.45	3,760.90	777.23	1,770.32	10	5,615.82	3,345.27	693.95	1,576.60
11	6,286.05	3,742.12	773.77	1,770.17	11	5,599.87	3,337.92	691.95	1,570.00
12	6,295.98	3,750.70	773.08	1,772.20	12	5,611.97	3,344.95	687.48	1,579.53
13	6,307.38	3,754.15	777.47	1,775.77	13	5,596.12	3,330.58	691.10	1,574.43
14	6,309.05	3,754.18	778.93	1,775.93	14	5,291.48	3,146.60	656.03	1,488.85
Average	6,301.07	3,754.07	775.40	1,771.60	Average	5,569.43	3,319.49	685.94	1,564.00
50% Load Level - 70 BSUs					10% Load Level - 14 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
17:28:06	17:33:07	0-4	0:05:01		17:43:10	17:48:11	0-4	0:05:01	
17:33:07	17:43:07	5-14	0:10:00		17:48:11	17:58:11	5-14	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
All ASUs	ASU-1	ASU-2	ASU-3		All ASUs	ASU-1	ASU-2	ASU-3	
0	3,504.53	2,093.42	427.33	983.78	0	702.30	420.98	87.22	194.10
1	3,508.88	2,090.48	428.53	989.87	1	701.43	413.55	88.88	199.00
2	3,501.98	2,092.00	429.77	980.22	2	701.42	416.92	86.95	197.55
3	3,504.87	2,091.68	431.97	981.22	3	700.55	416.45	87.98	196.12
4	3,480.02	2,078.88	429.77	971.37	4	699.73	416.82	86.57	196.35
5	3,499.93	2,092.15	429.73	978.05	5	699.87	415.50	85.43	198.93
6	3,504.13	2,085.55	432.92	985.67	6	697.80	417.02	85.28	195.50
7	3,491.35	2,079.40	433.08	978.87	7	698.57	418.70	84.85	195.02
8	3,502.97	2,083.35	434.10	985.52	8	700.85	414.33	87.87	198.65
9	3,511.42	2,096.77	433.45	981.20	9	695.28	414.32	85.43	195.53
10	3,488.53	2,087.87	432.15	968.52	10	704.32	421.07	85.27	197.98
11	3,493.97	2,087.73	426.28	979.95	11	705.05	420.70	87.23	197.12
12	3,497.45	2,085.93	432.27	979.25	12	698.80	417.45	86.95	194.40
13	3,500.65	2,078.38	433.52	988.75	13	694.93	412.37	85.83	196.73
14	3,487.48	2,088.32	428.77	970.40	14	699.30	418.68	85.72	194.90
Average	3,497.79	2,086.55	431.63	979.62	Average	699.48	417.01	85.99	196.48

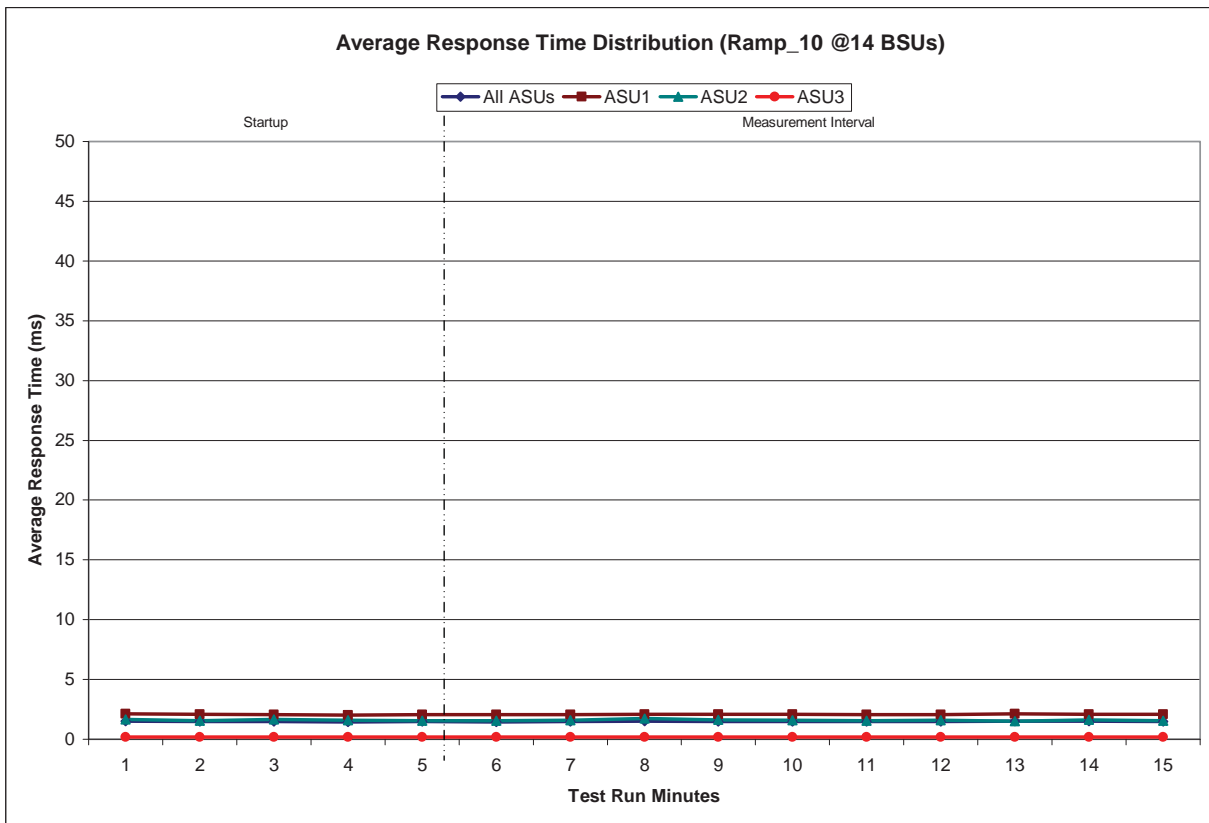
Response Time Ramp Distribution (IOPS) Graph



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

14 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:43:10	17:48:11	0-4	0:05:01
<i>Measurement Interval</i>	17:48:11	17:58:11	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.52	2.11	1.66	0.18
1	1.47	2.08	1.54	0.18
2	1.47	2.05	1.65	0.17
3	1.44	2.02	1.58	0.17
4	1.46	2.05	1.54	0.17
5	1.46	2.05	1.56	0.17
6	1.47	2.06	1.58	0.18
7	1.52	2.10	1.72	0.17
8	1.48	2.08	1.61	0.17
9	1.48	2.07	1.60	0.18
10	1.47	2.07	1.55	0.18
11	1.47	2.06	1.58	0.18
12	1.50	2.11	1.53	0.18
13	1.50	2.10	1.63	0.17
14	1.49	2.09	1.55	0.18
Average	1.48	2.08	1.59	0.18

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	0.0350	0.2821	0.0697	0.2094	0.0180	0.0695	0.0354	0.2809
COV	0.017	0.007	0.015	0.009	0.032	0.015	0.016	0.008

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 68.

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™
Primary Metrics	6,962.40
Repeatability Test Phase 1	7,056.31
Repeatability Test Phase 2	7,053.84

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™
Primary Metrics	1.48 ms
Repeatability Test Phase 1	1.49 ms
Repeatability Test Phase 2	1.48 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).

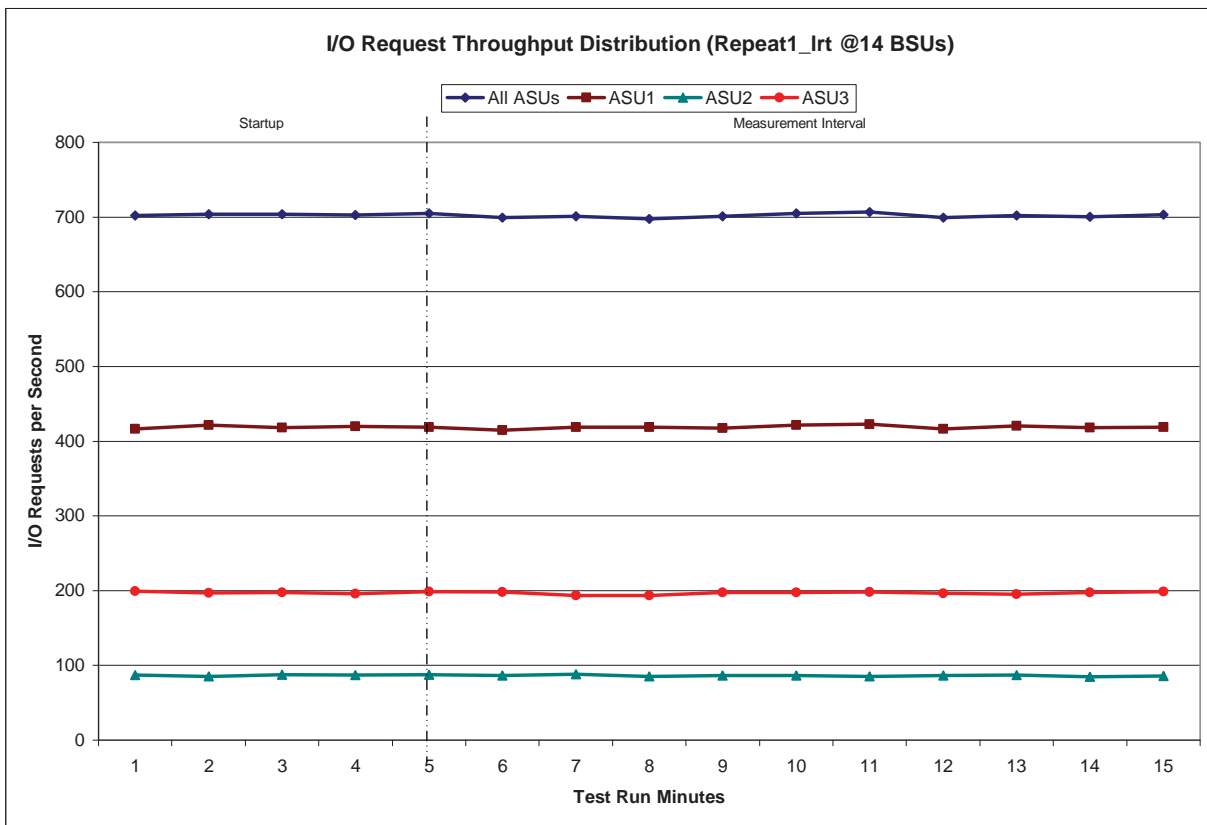
A link to the test result file generated from each Repeatability Test Run is listed below.

- [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

14 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:58:16	18:03:16	0-4	0:05:00
Measurement Interval	18:03:16	18:13:16	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	702.35	416.25	87.10	199.00
1	703.75	421.42	85.47	196.87
2	703.60	418.03	87.80	197.77
3	702.62	419.80	86.83	195.98
4	704.90	418.92	87.42	198.57
5	699.15	414.72	86.53	197.90
6	700.75	418.78	88.28	193.68
7	697.67	418.67	85.25	193.75
8	700.98	417.33	86.17	197.48
9	705.25	421.60	86.12	197.53
10	706.62	422.85	85.52	198.25
11	699.23	416.48	86.35	196.40
12	702.12	420.33	86.78	195.00
13	700.33	417.93	84.93	197.47
14	703.10	418.43	85.75	198.92
Average	702.16	418.77	86.42	196.97

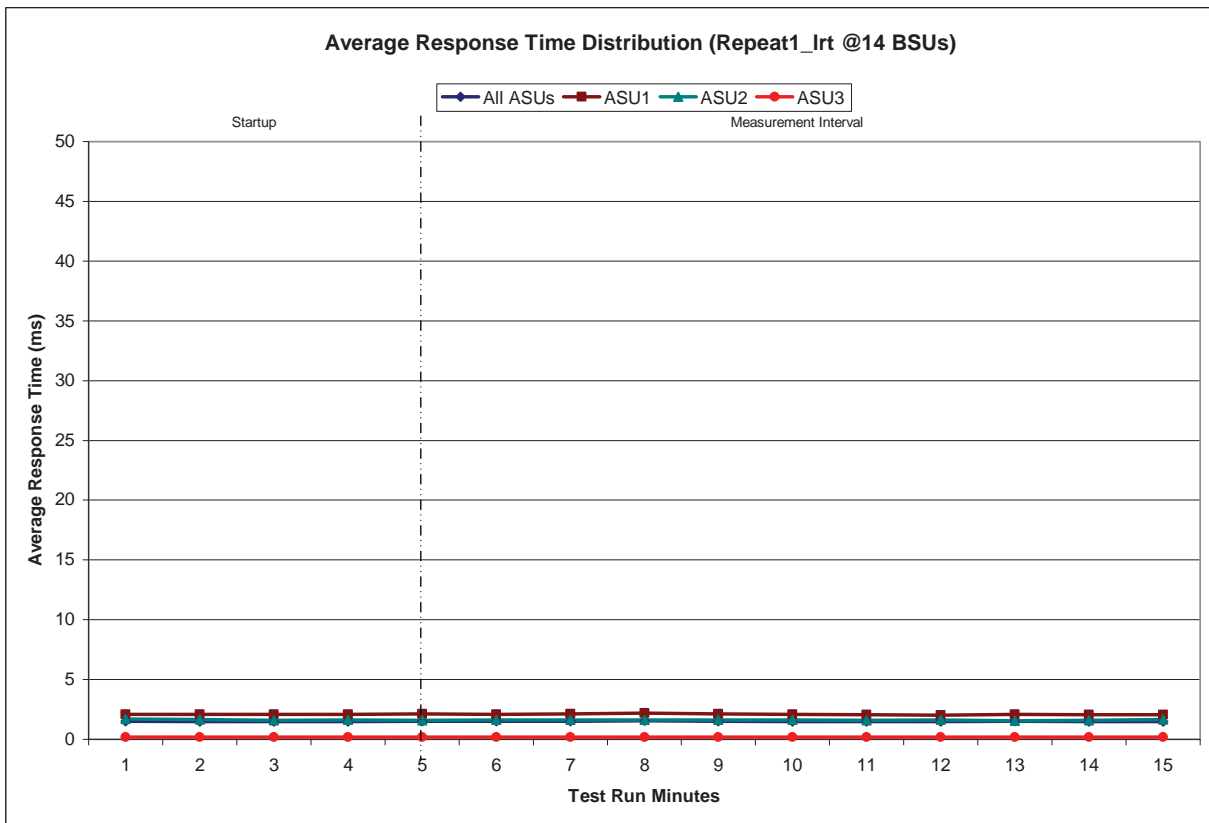
Repeatability 1 LRT - I/O Request Throughput Distribution Graph



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

14 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:58:16	18:03:16	0-4	0:05:00
<i>Measurement Interval</i>	18:03:16	18:13:16	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.50	2.08	1.71	0.18
1	1.49	2.07	1.65	0.18
2	1.49	2.10	1.59	0.18
3	1.49	2.08	1.60	0.18
4	1.50	2.11	1.59	0.18
5	1.50	2.11	1.62	0.18
6	1.51	2.11	1.61	0.18
7	1.56	2.19	1.62	0.18
8	1.51	2.12	1.61	0.18
9	1.49	2.08	1.61	0.18
10	1.48	2.07	1.59	0.18
11	1.46	2.03	1.61	0.18
12	1.50	2.10	1.56	0.18
13	1.48	2.06	1.60	0.17
14	1.47	2.05	1.64	0.18
Average	1.49	2.09	1.61	0.18

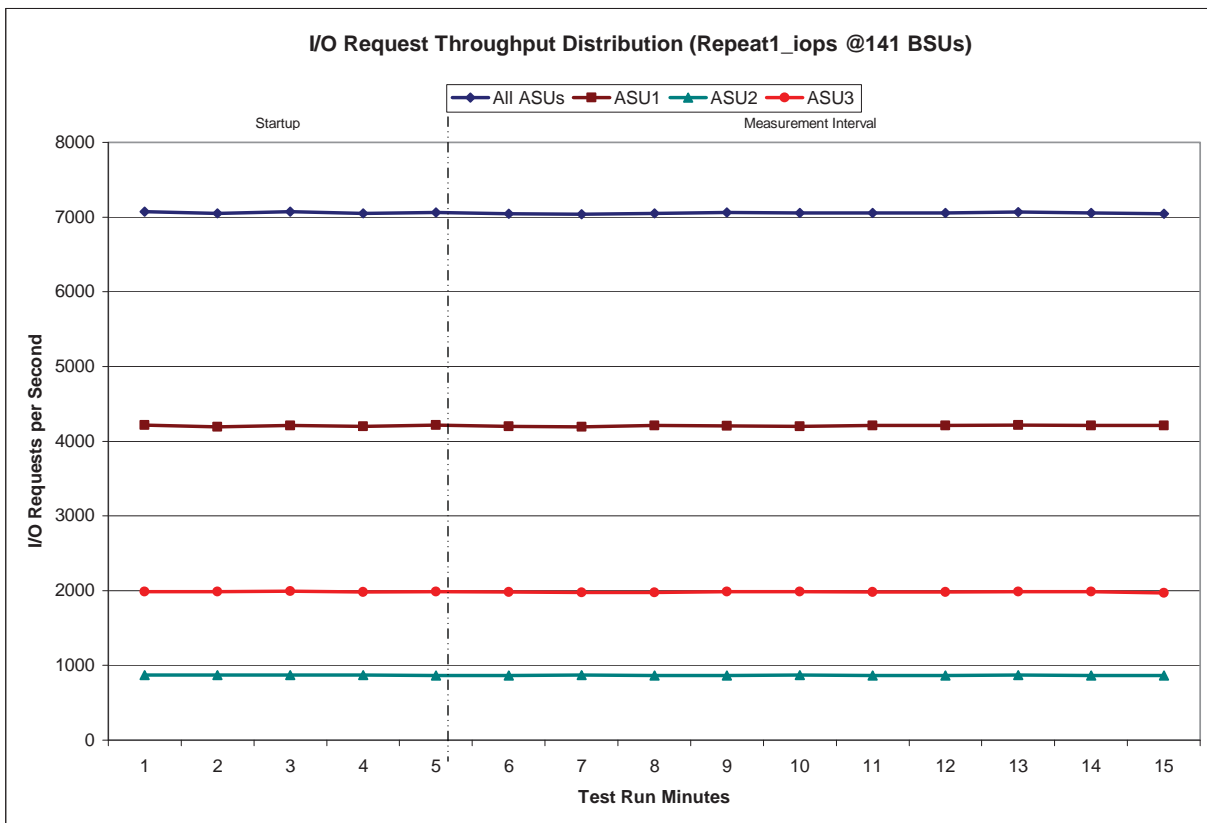
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS - I/O Request Throughput Distribution Data

141 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:14:19	18:19:20	0-4	0:05:01
<i>Measurement Interval</i>	18:19:20	18:29:20	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	7,073.57	4,215.92	871.67	1,985.98
1	7,051.93	4,194.42	871.05	1,986.47
2	7,070.78	4,207.62	870.87	1,992.30
3	7,051.43	4,196.97	871.03	1,983.43
4	7,063.98	4,216.17	862.23	1,985.58
5	7,046.08	4,200.72	866.38	1,978.98
6	7,037.87	4,193.40	869.62	1,974.85
7	7,048.35	4,209.72	861.52	1,977.12
8	7,060.03	4,205.97	865.77	1,988.30
9	7,056.63	4,199.83	869.85	1,986.95
10	7,056.93	4,208.83	864.98	1,983.12
11	7,058.03	4,209.70	865.77	1,982.57
12	7,067.55	4,213.43	869.20	1,984.92
13	7,057.13	4,210.57	861.88	1,984.68
14	7,044.30	4,209.05	864.82	1,970.43
Average	7,056.31	4,206.15	867.11	1,983.05

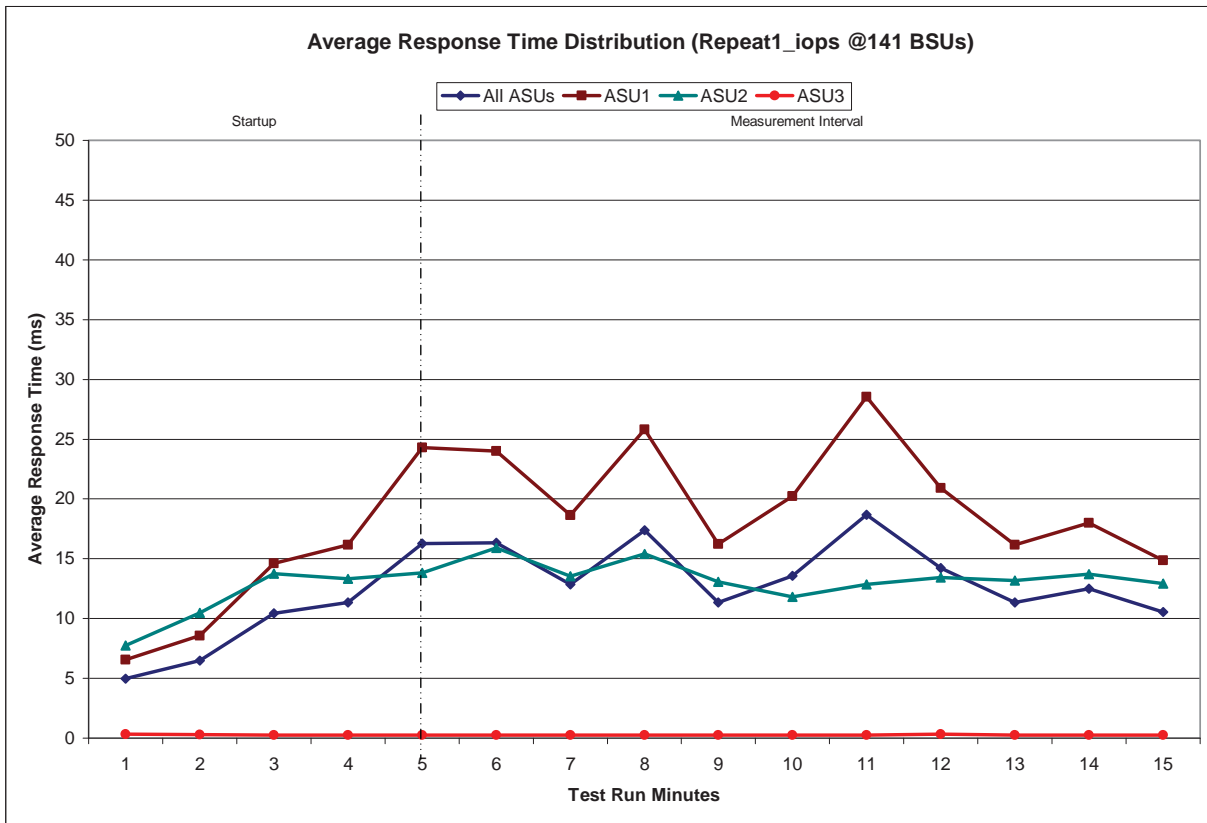
Repeatability 1 IOPS - I/O Request Throughput Distribution Graph



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

141 BSUs Start-Up/Ramp-Up Measurement Interval	Start 18:14:19	Stop 18:19:20	Interval 0-4	Duration 0:05:01
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4.96	6.56	7.75	0.34
1	6.46	8.56	10.49	0.28
2	10.45	14.60	13.74	0.25
3	11.33	16.15	13.33	0.25
4	16.25	24.29	13.81	0.25
5	16.34	24.00	15.92	0.26
6	12.86	18.65	13.55	0.26
7	17.38	25.83	15.41	0.24
8	11.34	16.23	13.06	0.25
9	13.58	20.25	11.81	0.26
10	18.67	28.55	12.84	0.26
11	14.22	20.93	13.42	0.32
12	11.33	16.17	13.18	0.25
13	12.48	17.98	13.73	0.25
14	10.54	14.86	12.93	0.26
Average	12.55	18.24	13.00	0.27

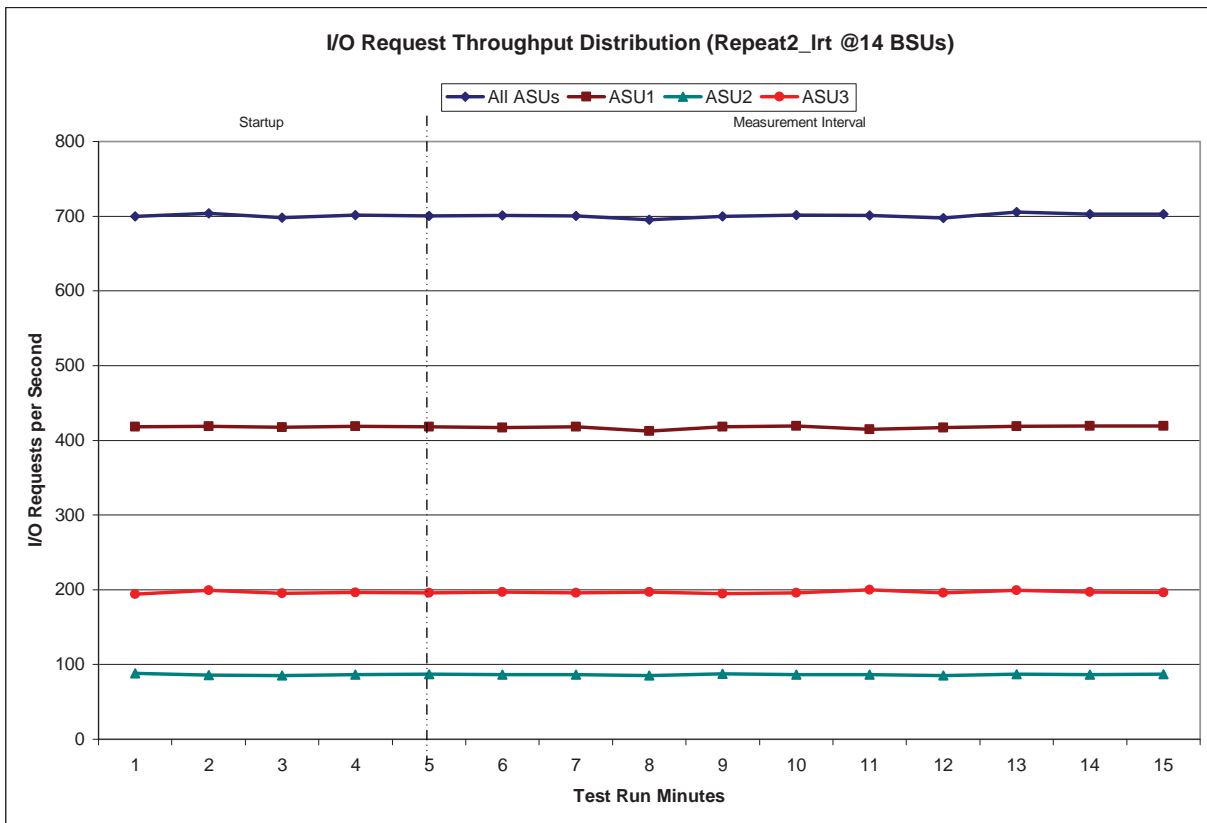
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT - I/O Request Throughput Distribution Data

14 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:30:25	18:35:25	0-4	0:05:00
<i>Measurement Interval</i>	18:35:25	18:45:25	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	700.05	418.30	87.92	193.83
1	704.05	418.73	85.87	199.45
2	698.20	417.73	85.23	195.23
3	701.38	418.93	86.28	196.17
4	700.62	418.02	86.98	195.62
5	700.75	417.08	86.57	197.10
6	700.30	418.42	86.12	195.77
7	695.08	412.67	85.48	196.93
8	699.92	417.88	87.63	194.40
9	701.53	419.48	86.20	195.85
10	701.18	414.90	86.60	199.68
11	697.55	416.73	85.17	195.65
12	705.38	418.70	87.17	199.52
13	702.60	419.32	86.20	197.08
14	702.47	419.22	87.12	196.13
Average	700.74	417.74	86.44	196.56

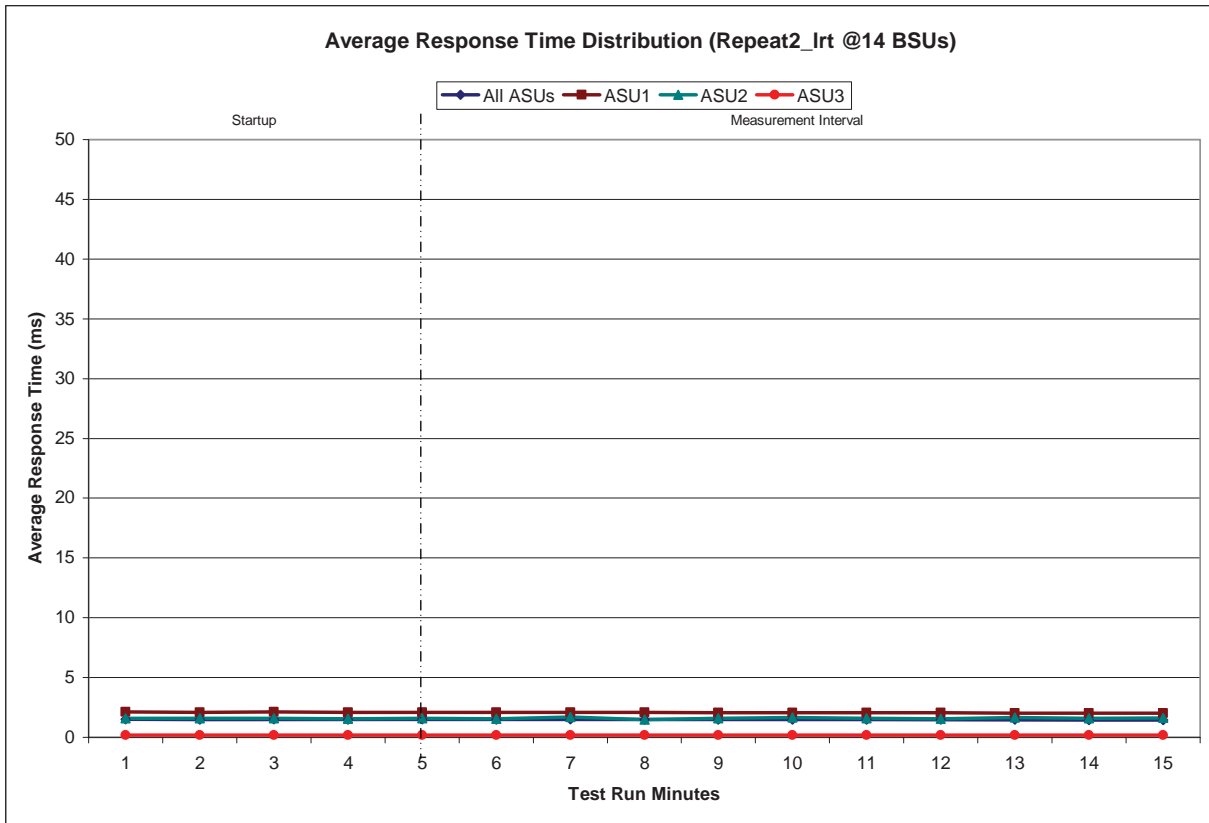
Repeatability 2 LRT - I/O Request Throughput Distribution Graph



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

14 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:30:25	18:35:25	0-4	0:05:00
<i>Measurement Interval</i>	18:35:25	18:45:25	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.52	2.12	1.60	0.17
1	1.49	2.10	1.59	0.17
2	1.50	2.11	1.59	0.18
3	1.49	2.09	1.56	0.18
4	1.50	2.10	1.60	0.17
5	1.49	2.10	1.55	0.18
6	1.50	2.08	1.68	0.17
7	1.46	2.08	1.47	0.18
8	1.48	2.07	1.59	0.18
9	1.47	2.04	1.67	0.18
10	1.47	2.06	1.60	0.17
11	1.47	2.06	1.55	0.18
12	1.46	2.03	1.66	0.18
13	1.45	2.02	1.59	0.18
14	1.45	2.01	1.62	0.18
Average	1.48	2.07	1.59	0.18

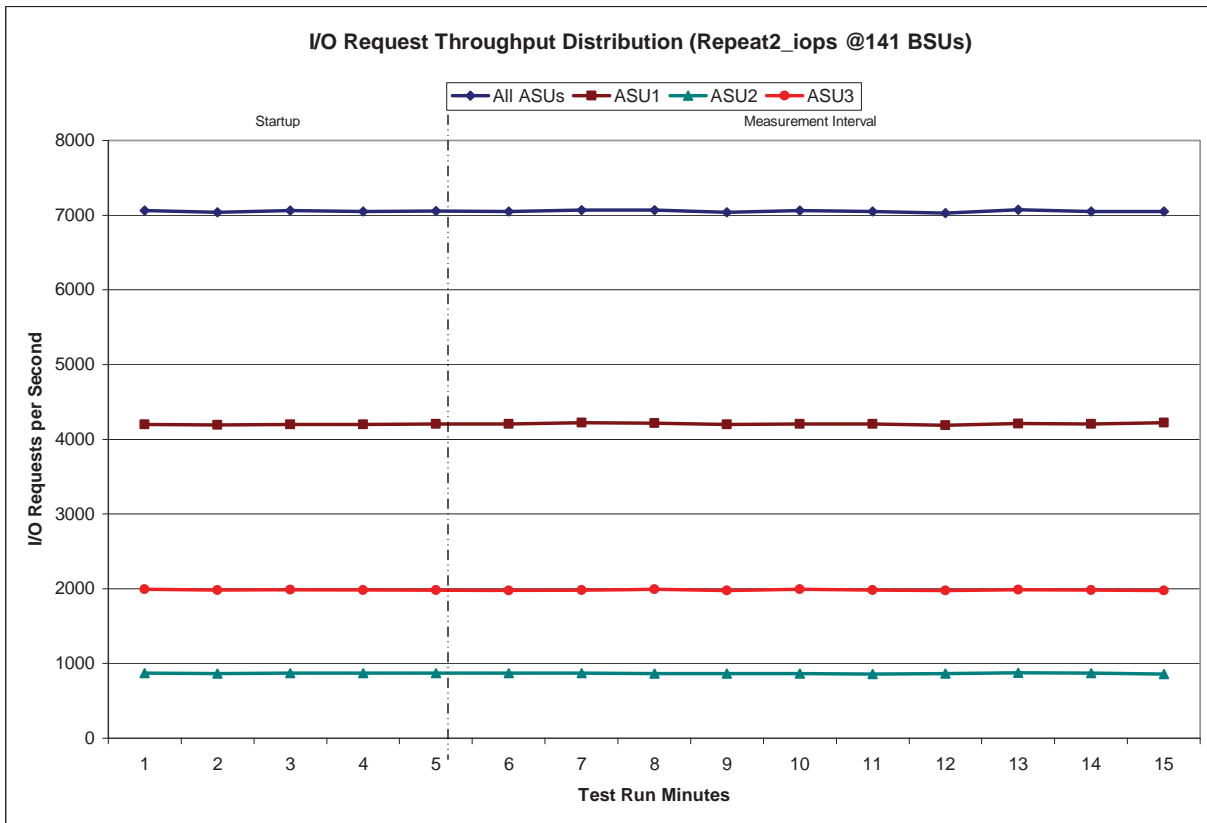
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS - I/O Request Throughput Distribution Data

14 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:46:28	18:51:29	0-4	0:05:01
Measurement Interval	18:51:29	19:01:29	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	7,063.57	4,199.63	871.12	1,992.82
1	7,038.40	4,195.35	862.65	1,980.40
2	7,058.72	4,199.52	870.95	1,988.25
3	7,052.28	4,200.77	872.10	1,979.42
4	7,052.87	4,202.50	868.75	1,981.62
5	7,052.52	4,205.63	868.75	1,978.13
6	7,067.58	4,219.50	869.23	1,978.85
7	7,068.48	4,213.72	864.73	1,990.03
8	7,037.50	4,196.45	865.63	1,975.42
9	7,058.82	4,202.35	865.05	1,991.42
10	7,051.58	4,207.27	860.17	1,984.15
11	7,027.00	4,188.93	864.83	1,973.23
12	7,074.68	4,210.87	875.72	1,988.10
13	7,052.40	4,204.83	868.38	1,979.18
14	7,051.18	4,219.87	858.62	1,972.70
Average	7,053.84	4,204.48	867.11	1,982.25

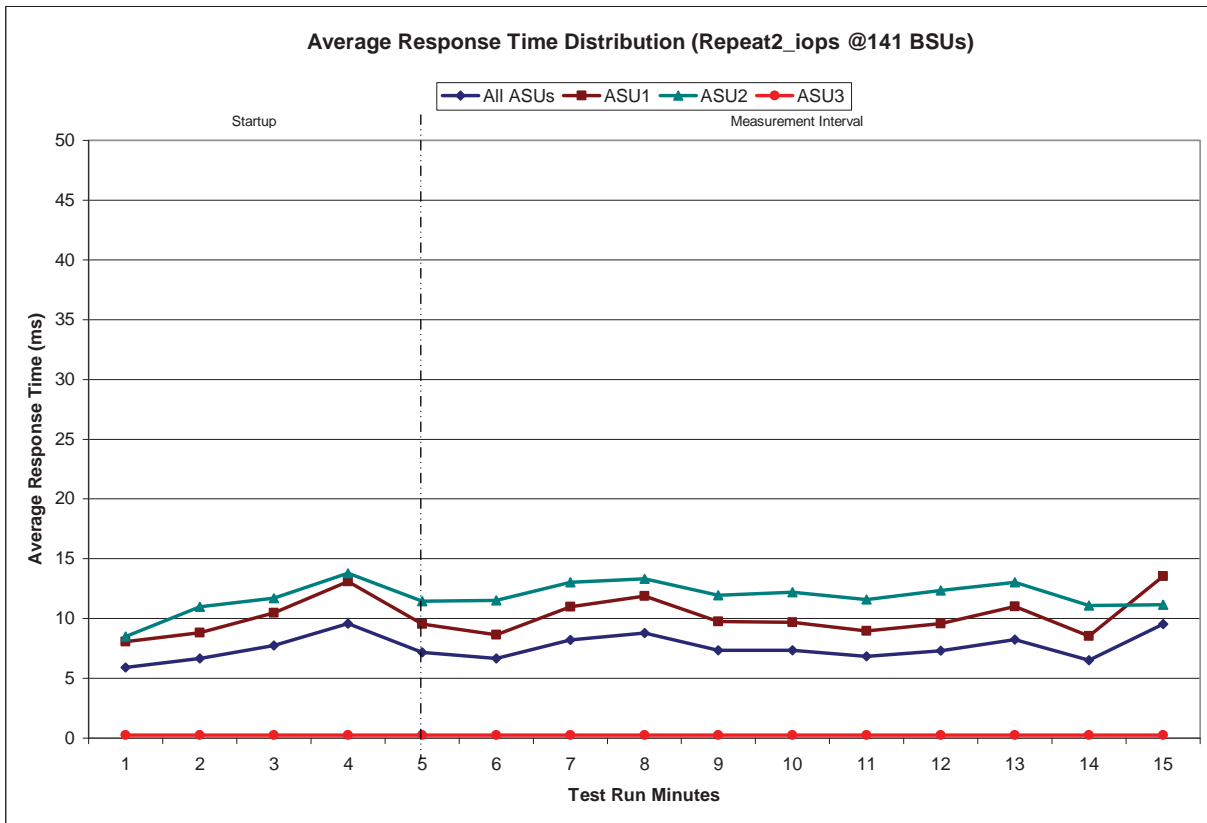
Repeatability 2 IOPS - I/O Request Throughput Distribution Graph



Repeatability 2 IOPS -Average Response Time (ms) Distribution Data

14 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:46:28	18:51:29	0-4	0:05:01
<i>Measurement Interval</i>	18:51:29	19:01:29	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	5.91	8.05	8.50	0.25
1	6.67	8.82	10.97	0.25
2	7.75	10.49	11.68	0.25
3	9.59	13.12	13.79	0.25
4	7.17	9.55	11.43	0.25
5	6.65	8.66	11.53	0.25
6	8.22	10.97	13.02	0.25
7	8.80	11.90	13.33	0.26
8	7.35	9.74	11.94	0.25
9	7.34	9.69	12.20	0.25
10	6.83	8.96	11.61	0.25
11	7.30	9.58	12.33	0.25
12	8.25	11.03	13.02	0.26
13	6.53	8.54	11.10	0.25
14	9.53	13.54	11.14	0.26
Average	7.59	10.18	11.84	0.25

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
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0347	0.2817	0.0697	0.2105	0.0178	0.0702	0.0348	0.2806
COV	0.024	0.006	0.018	0.010	0.024	0.015	0.027	0.009

**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
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0349	0.2812	0.0701	0.2101	0.0180	0.0698	0.0350	0.2809
COV	0.011	0.003	0.006	0.002	0.011	0.005	0.009	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
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0347	0.2812	0.0698	0.2102	0.0180	0.0700	0.0350	0.2810
COV	0.019	0.007	0.018	0.010	0.044	0.021	0.027	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	0.2814	0.0699	0.2101	0.0179	0.0699	0.0350	0.2808
COV	0.010	0.002	0.006	0.003	0.013	0.006	0.007	0.002

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 68.

Data Persistence Test Results File

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

[Persistence 1 Test Results File](#)

[Persistence 2 Test Results File](#)

Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	16,784,032
Total Number of Logical Blocks Verified	15,743,104
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 (146 GB disk drives) 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 15.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.7

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 15.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the Xiotech Emprise™ 5000 (146 GB disk drives).

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.

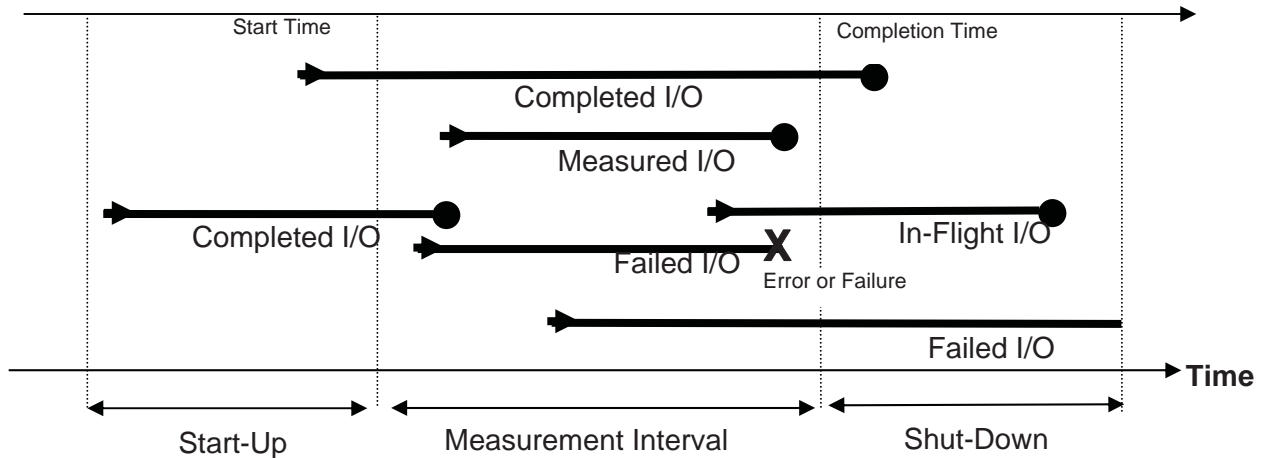
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

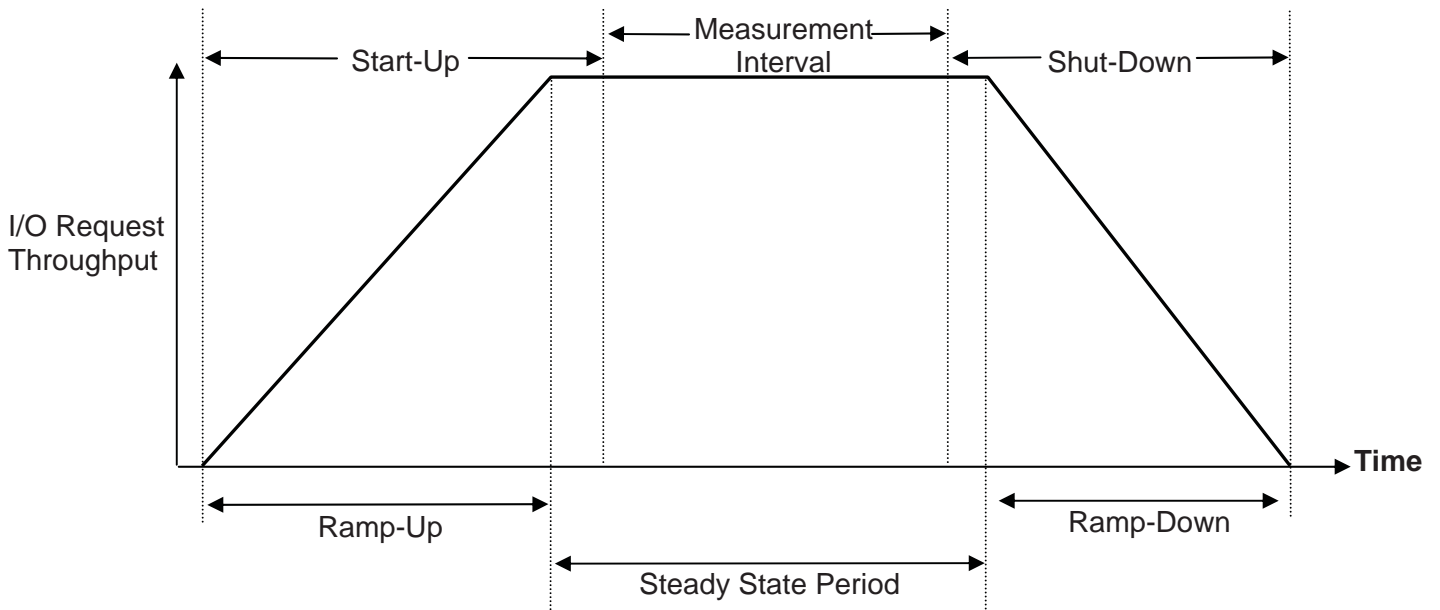
period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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 QLA2462 HBA execution throttle was been changed from its default of 16 to a value of 255.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The CLI script, listed below, was executed to create and configure the TSC.

SPC1-146.sh

```
#
#   Set up SPC-1 LUNs DAS for testing with Dell 4
#
# First, initialize the ISE with 20% sparing
#
/bin/nseash -c "initialize --sparelevel=20"
#
# Next, create the two QLogic HBA ports
#
/bin/nseash -c "create --host=\"QLogic4\" --windows 2100001B321F6E3C
2101001B323F6E3C"
#
# Now create 6 Raid-1 LUNs, alternating between DiskPacs.
# ASU 1 & ASU 2 are 225 GiB for each half (450 GiB total per ASU)
# AUS 3 is 50 GiB for each half (100 GiB total)
#
/bin/nseash -c "create --volume=ASU1_1 --size=225 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=ASU1_2 --size=225 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=ASU2_1 --size=225 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=ASU2_2 --size=225 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=ASU3_1 --size=50 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=ASU3_2 --size=50 --raid1 --pool2 --write-back"
#
# Finally, present all LUNs to both HBA ports
#

/bin/nseash -c "present --host=\"QLogic4\" ASU1_1:0 ASU2_1:1 ASU3_1:2 ASU1_2:3
ASU2_2:4 ASU3_2:5"
```

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

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

```
sd=asu1_1,lun=\\.\PhysicalDrive1
sd=asu1_2,lun=\\.\PhysicalDrive4
*
sd=asu2_1,lun=\\.\PhysicalDrive5
sd=asu2_2,lun=\\.\PhysicalDrive2
*
sd=asu3_1,lun=\\.\PhysicalDrive6
sd=asu3_2,lun=\\.\PhysicalDrive3
```

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 Idle Test (*Conditioning Phase, Application Idle Phase, and Recovery Phase*) 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
rem
rem SPC-1C batch execution file
rem

set ISE_IP=bb395
set ISE_MAC=00:1F:93:00:03:8B
set /a BSU = 141

if {%1}=={} (
    set /p ISE_PASS="ISE root password: "
) else (
    set ISE_PASS=%1
)
if {%2}=={} (
    set /p ETHER_PASS="Ether-wake system password: "
) else (
    set ETHER_PASS=%2
)

set /a IDLE_MIN = 35 * 60
set /a BSU_10 = BSU / 10

rem 10 minute pre-condition at 100% load
echo Starting 10 minute pre-conditioning run...
java -Xmx640m -Xms640m range -b %BSU% -s 300 -t 600

rem Let things settle down a bit after the pre-condition
echo Flushing cache and cooling down...
sleep 180

rem Hang out in no host I/O idle state for a bit
echo No host I/O idle state
sleep 600

rem Put the ISE to sleep
echo Entering low power state...
plink -ssh root@%ISE_IP% -pw %ISE_PASS% /bin/nseash -c "shutdown ise --force"

rem Hang out for a while
sleep %IDLE_MIN%

rem Nap time is over - wake up the storage
echo Waking up ISE...
plink -ssh batesk@cos-lab-depdl -pw %ETHER_PASS% sudo /sbin/ether-wake -b %ISE_MAC%
sleep 180

rem 10 minute pre-condition at 10% of maximum load
echo Starting 10 Minute pre-condition at 10% load...
java -Xmx640m -Xms640m range -b %BSU_10% -s 300 -t 600

rem Now 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 600
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%

rem Manual intervention: Shut down all systems, then power back on
echo Shutdown all systems in preparation for persistence phase 2!
rem plink -ssh root@%ISE_IP% -pw %ISE_PASS% /bin/nseash -c "shutdown ise --force"
rem sleep 30
rem shutdown -s 10
rem Run persistence test part 2: java -Xmx640m -Xms640m persist2
```

Persistence Test Run 2

The following script was used to execute Persistence Test Run 2.

```
rem Run persistence test part 2
java -Xmx640m -Xms640m persist2
```