



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

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

SPC-1/E™ V1.12

**Submitted for Review: October 13, 2009
Submission Identifier: AE00002**

First Edition – October 2009

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AUDIT CERTIFICATION



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

October 9, 2009

The SPC Benchmark 1/Energy™ Reported Data listed below for the Xiotech Emprise™ 5000 (600 GB disk drives) were produced in compliance with the SPC Benchmark 1/Energy™ V1.12 Onsite Audit requirements.

SPC Benchmark 1/Energy™ V1.12 Reported Data	
Tested Storage Configuration (TSC) Name: Xiotech Emprise™ 5000 (600 GB disk drives)	
Metric	Reported Result
SPC-1 IOPS™	6,065.96
SPC-1 Price-Performance	\$9.55/SPC-1 IOPS™
Total ASU Capacity	4,638.565 GB
Data Protection Level	Protected (Mirroring)
Total TSC Price (including three-year maintenance)	\$57,939.00

Power Environment		Usage Profile					
Average RMS Voltage:	206.69	Average Power Factor:	0.786				
	Hours of Use per Day			Nominal Power, W	Nominal Traffic, IOPS	Nominal IOPS/W	Nominal Heat, BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	132.42	1017.02	7.68	451.82
Medium Daily Usage:	4	14	6	270.22	2686.22	9.57	922.02
High Daily Usage:	18	6	0	387.62	4391.76	12.26	1,219.89
Composite Metrics:		253.38		2,665.00		10.52	
Annual Energy Use, kWh:	2,219.65						
Energy Cost, \$/kWh:	\$ 0.12			Annual Energy Cost, \$:		\$ 266.36	

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AUDIT CERTIFICATION (CONT.)

Xiotech Emprise™ 5000 (600 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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AUDIT CERTIFICATION (CONT.)

Xiotech Emprise™ 5000 (600 GB disk drives)
SPC-1/E Audit Certification

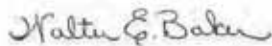
Page 3

- 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 (9.6 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 Krutsch", is written over a horizontal line.

Ken Krutsch
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	
Test Sponsor Primary Contact	Xiotech Corporation – http://www.xiotech.com Ken Bates – ken_bates@xiotech.com 9950 Federal Drive, Suite 100 Colorado Springs, CO 80921-3686 Phone: (719) 388-5509 FAX: (719) 388-5300
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Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
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 Xitech 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: Xitech Emprise™ 5000 (600 GB disk drives)	
Metric	Reported Result
SPC-1 IOPS™	6,065.96
SPC-1 Price-Performance	\$9.55/SPC-1 IOPS™
Total ASU Capacity	4,638.565 GB
Data Protection Level	Protected (<i>Mirroring</i>)
Total TSC Price (including three-year maintenance)	\$57,939

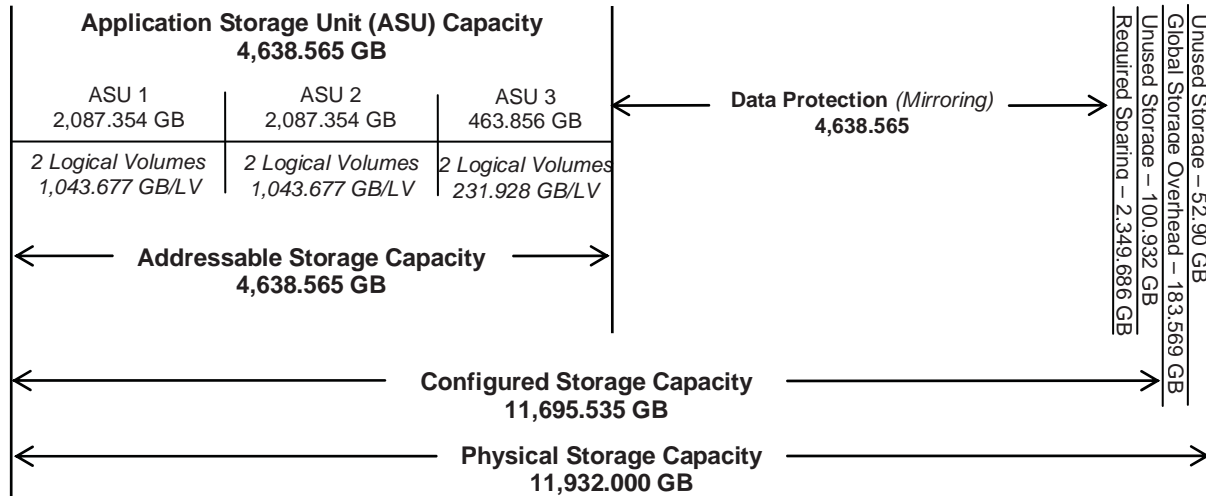
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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	36.87%
Protected Application Utilization	77.75%
Unused Storage Ratio	1.02%

Application Utilization: Total ASU Capacity (4,638.565 GB) divided by Physical Storage Capacity (11,932.000 GB)

Protected Application Utilization: (Total ASU Capacity (4,638.565 GB) plus total Data Protection Capacity (4,638.565 GB) minus unused Data Protection Capacity (0.000 GB)) divided by Physical Storage Capacity (11,932.000 GB)

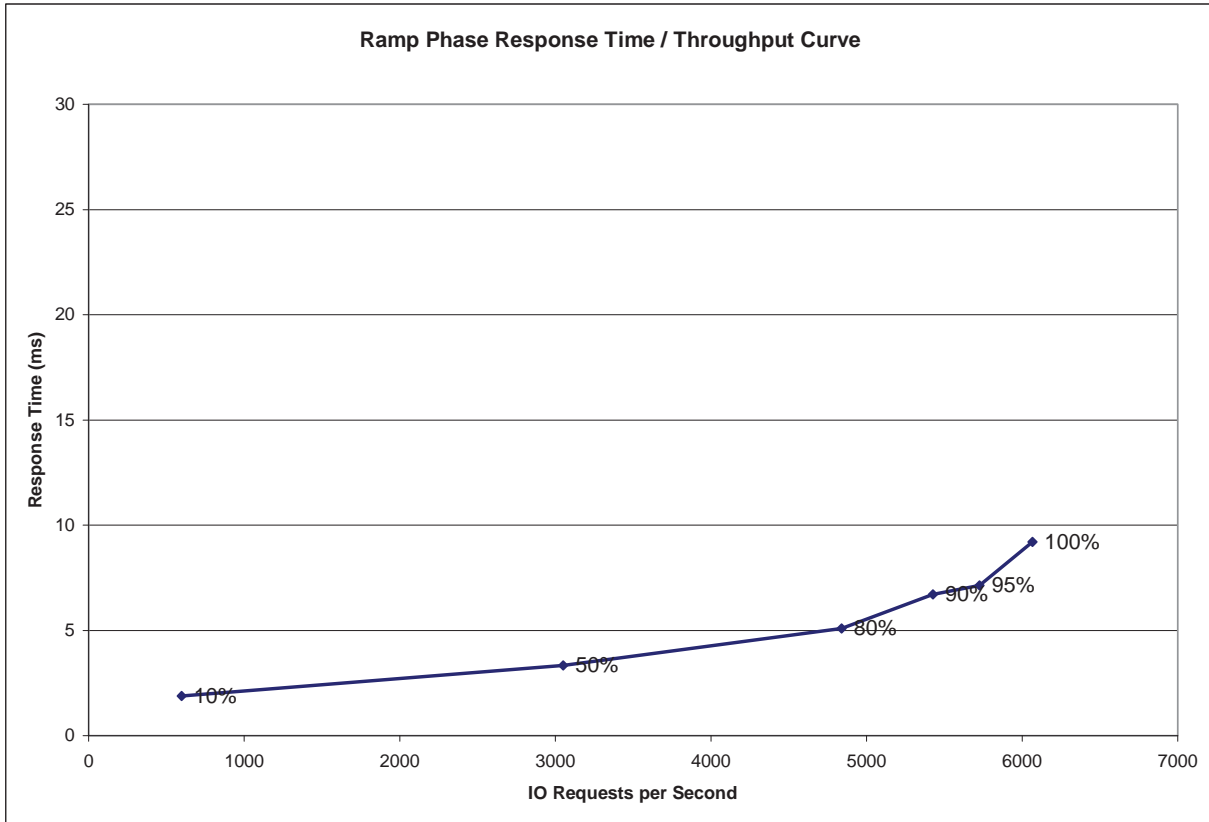
Unused Storage Ratio: Total Unused Capacity (121.615 GB) divided by Physical Storage Capacity (11,932.000 GB) and may not exceed 45%.

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	598.34	3,051.05	4,838.66	5,426.25	5,726.22	6,065.96
Average Response Time (ms):						
All ASUs	1.88	3.34	5.09	6.70	7.14	9.21
ASU-1	2.68	4.63	6.82	8.89	9.42	12.35
ASU-2	1.97	4.27	7.83	10.67	11.90	14.48
ASU-3	0.17	0.20	0.23	0.30	0.24	0.24
Reads	4.55	8.19	12.58	16.55	17.77	22.85
Writes	0.16	0.19	0.21	0.28	0.22	0.33

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:		206.69		Average Power Factor:		0.786	
	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	132.42	1017.02	7.68	451.82
Medium Daily Usage:	4	14	6	270.22	2586.22	9.57	922.02
High Daily Usage:	18	6	0	357.52	4391.76	12.28	1,219.89
Composite Metrics:				253.38	2,665.00	10.52	
Annual Energy Use, kWh:		2,219.65		Annual Energy Cost, \$:		\$ 266.36	
Energy Cost, \$/kWh:		\$ 0.12					

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: 359.91W at 80% of maximum reported performance (*4,838.66 SPC-1 IOPS*).

MODERATE SPC-1 Workload: 350.35W at 50% of maximum reported performance (*3,051.05 SPC-1 IOPS*).

IDLE SPC-1 Workload: 23.45W 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**.

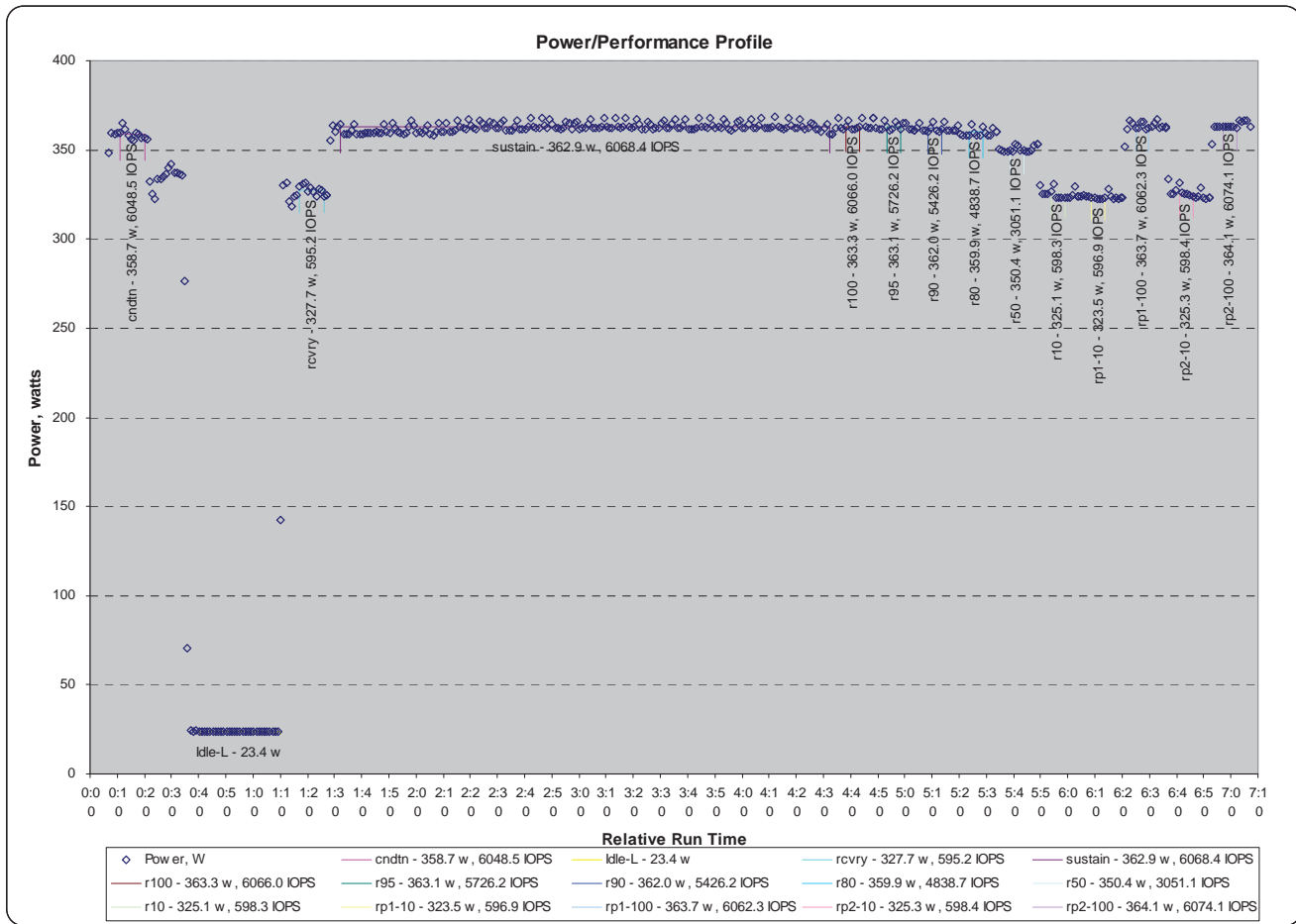
ANNUAL ENERGY USE, KWH: An estimate of the average energy use across the three environments over the course of a year and computed as (**NOMINAL POWER** * 24 * 0.365).

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 Capacity Emprise 5000 (9.6TB), including: <ul style="list-style-type: none"> • 1 800864-000: ISE array controller • 2 800938-000: 10 DataPac mounted 600 GB 10K 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. 	\$94,982	1	\$94,982	39%	\$57,939

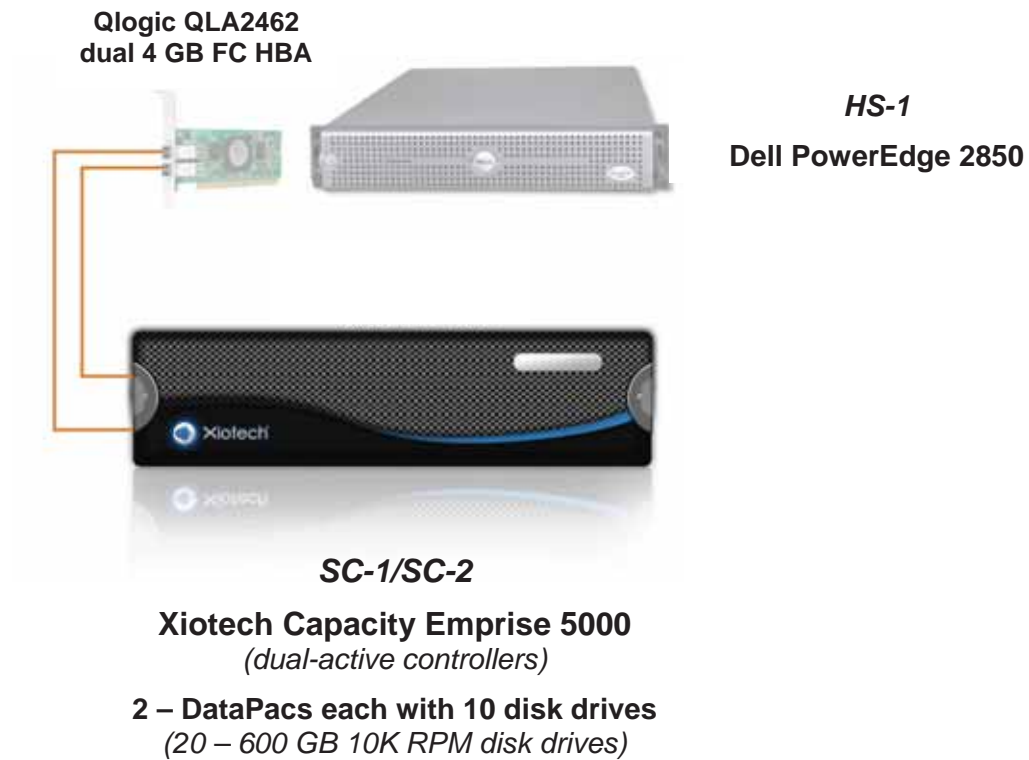
The above pricing includes hardware maintenance and software support for five years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- 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 Components:
1 – QLogic QLA2462 dual port 4 Gb FC HBA
SC-1/SC-2: XioTech PerformanceEmprise 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 – DataPacs each with 10 disk drives
20 – 600 GB 10K RPM FC 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.

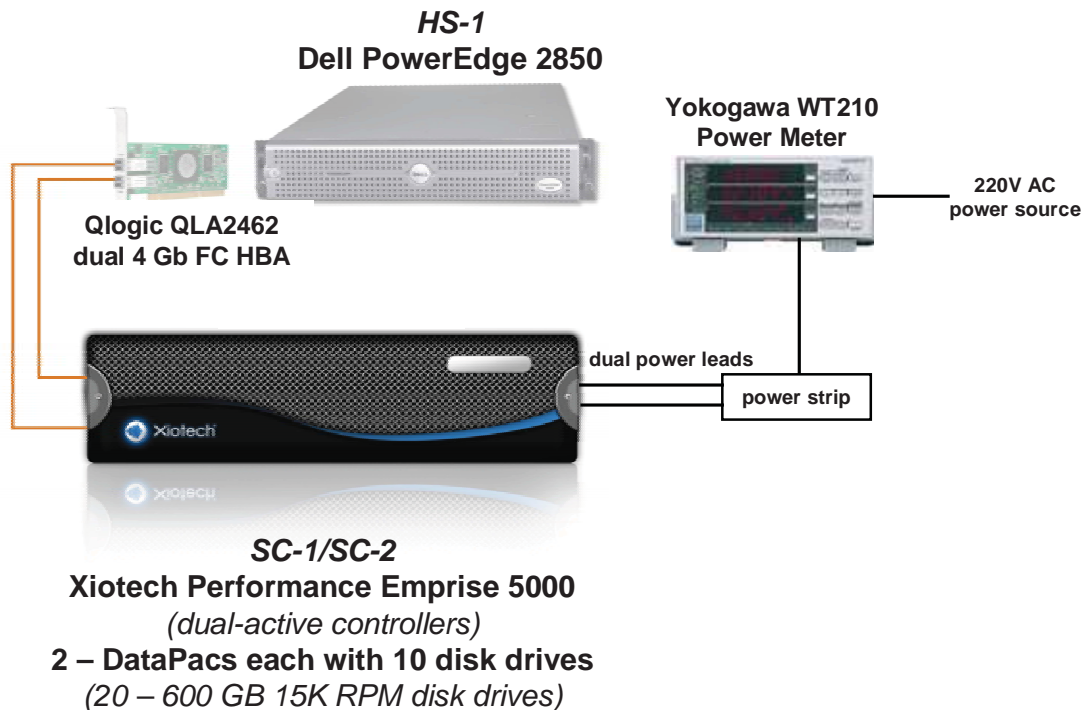
Host System and Tested Storage Configuration (TSC) Table of Components

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: XioTech 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	
XioTech MPIO driver, Build 280	
PCI-X	
WG	2 – DataPacs each with 10 disk drives
Other BC Components	20 – 600 GB 10K RPM FC 3.5" disk drives
1 – Yokogawa WT210 Digital Power Meter	
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)	4,638.565
Addressable Storage Capacity	Gigabytes (GB)	4,638.565
Configured Storage Capacity	Gigabytes (GB)	11,695.535
Physical Storage Capacity	Gigabytes (GB)	11,932.000
Data Protection (<i>Mirroring</i>)	Gigabytes (GB)	4,638.565
Required Storage (<i>metadata/overhead/spares</i>)	Gigabytes (GB)	2,349.686
Global Storage Overhead	Gigabytes (GB)	183.569
Total Unused Storage	Gigabytes (GB)	121.615

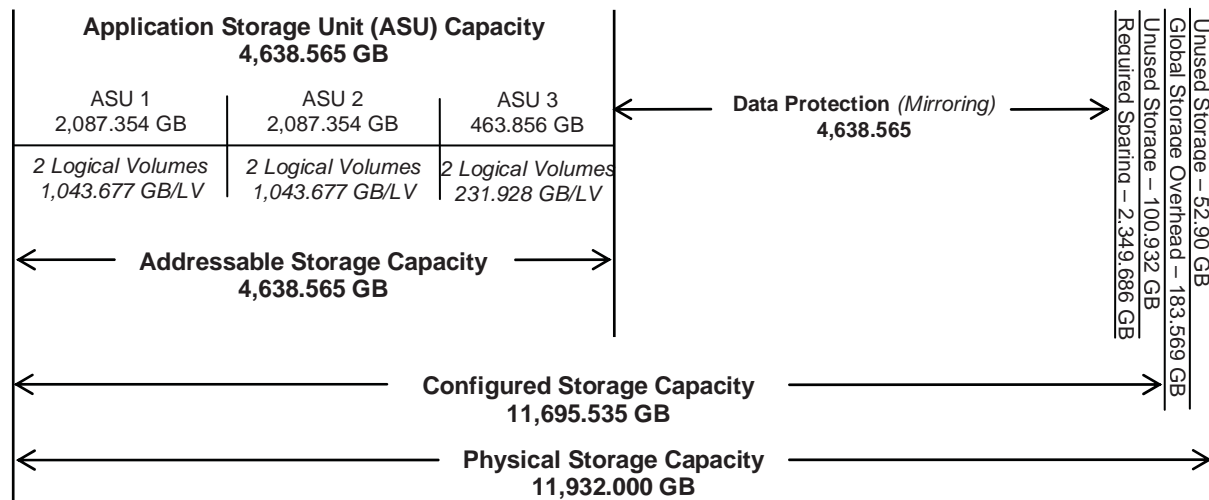
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	39.66%	38.87%
Required for Data Protection (RAID-6)		39.66%	38.86%
Addressable Storage Capacity		39.66%	38.87%
Required Storage (<i>metadata/overhead/spares</i>)		20.09%	19.69%
Configured Storage Capacity			98.02%
Global Storage Overhead			1.54%
Unused Storage:			
Addressable	0.00%		
Configured		0.29%	
Physical			0.44%

The Physical Storage Capacity consisted of 11,932.000 GB distributed over 20 disk drives each with a formatted capacity of 596.600 GB. There was 52.896 GB (0.44%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 183.569 GB (1.54%) of Physical Storage Capacity. There was 68.719 GB (0.29%) 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 4,638.565 GB of which 4,638.565 GB was utilized. The total Unused Storage was 121.615 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 (GB)	ASU-2 (GB)	ASU-3 (GB)
2 Logical Volumes 1,043.677 GB per Logical Volume (1,043.677 GB used per Logical Volume)	2 Logical Volumes 1,043.677 GB per Logical Volume (1,043.677 GB used per Logical Volume)	2 Logical Volumes 231.928 GB per Logical Volume (231.928 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	38.87%
Protected Application Utilization	77.75%
Unused Storage Ratio	1.02%

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

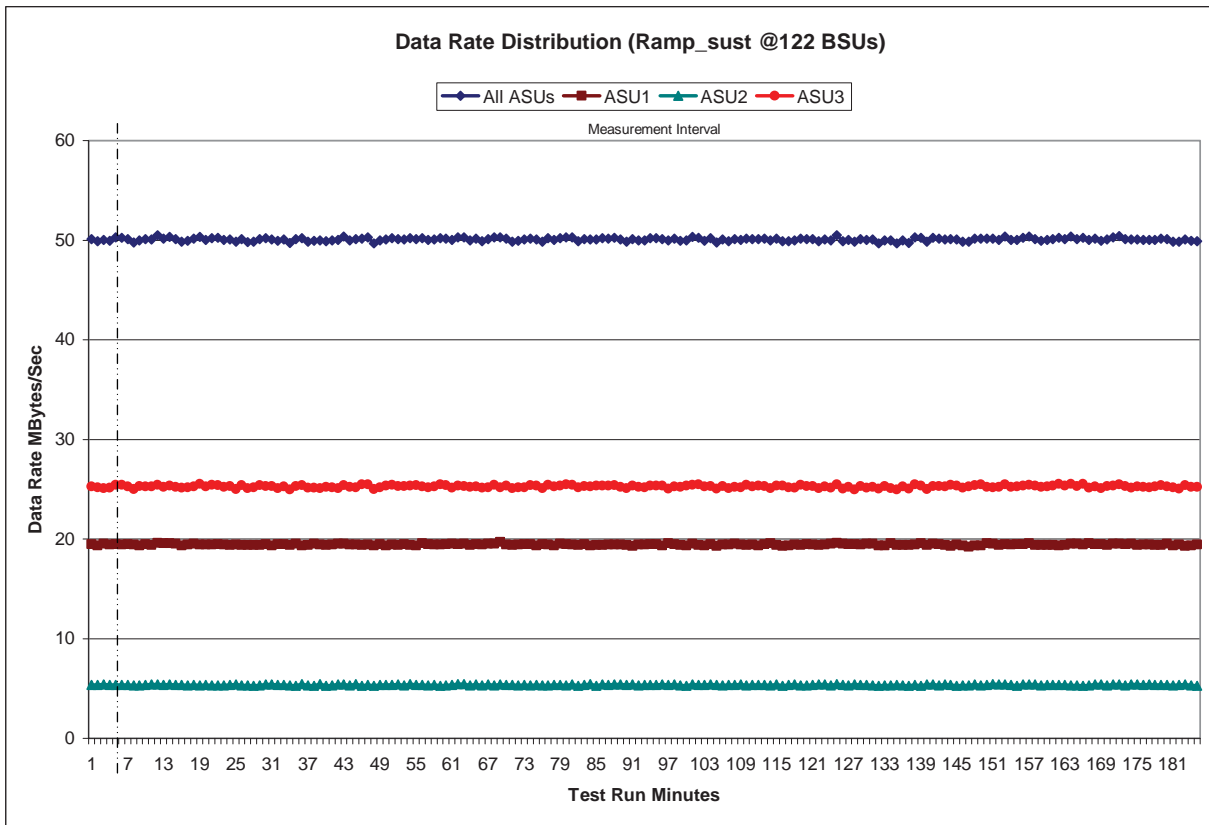
A link to the test results file generated from the Sustainability Test Run is listed below.

[Sustainability Test Results File](#)

Sustainability – Data Rate Distribution Data (MB/second)

Ramp-Up/Start-Up		Start	Stop	Interval	Duration												
Measurement Interval		21:17:18	21:22:18	0-4	0:05:00												
		21:22:18	0:22:18	5-185	3:00:00												
Interval	ytes per Sec	0	0	0	Interval	tes per Sec	0	0	0	Interval	tes per Sec	0	0	0			
Minutes of	All ASUs	ASU1	ASU2	ASU3	62	50.27	19.51	5.44	25.31	125	49.91	19.51	5.35	25.06			
0	50.11	19.48	5.35	25.28	63	49.97	19.41	5.32	25.24	126	50.04	19.49	5.31	25.24			
1	49.89	19.35	5.37	25.17	64	50.17	19.49	5.40	25.28	127	49.85	19.48	5.38	24.98			
2	50.02	19.51	5.39	25.12	65	49.90	19.44	5.33	25.12	128	50.11	19.43	5.36	25.33			
3	49.95	19.43	5.37	25.16	66	50.12	19.52	5.40	25.20	129	50.04	19.54	5.36	25.13			
4	50.26	19.48	5.35	25.43	67	50.29	19.51	5.33	25.45	130	50.06	19.51	5.32	25.23			
5	50.24	19.43	5.37	25.44	68	50.28	19.71	5.39	25.18	131	49.69	19.36	5.27	25.06			
6	50.11	19.49	5.35	25.27	69	50.16	19.43	5.35	25.37	132	49.99	19.36	5.30	25.33			
7	49.76	19.43	5.32	25.01	70	49.84	19.38	5.36	25.10	133	50.00	19.57	5.32	25.11			
8	49.99	19.35	5.33	25.31	71	49.95	19.46	5.33	25.17	134	49.70	19.38	5.34	24.97			
9	50.12	19.47	5.37	25.28	72	50.05	19.50	5.36	25.20	135	49.98	19.40	5.30	25.28			
10	50.08	19.41	5.39	25.28	73	50.16	19.47	5.30	25.38	136	49.73	19.41	5.26	25.06			
11	50.48	19.61	5.41	25.46	74	50.07	19.37	5.36	25.34	137	50.27	19.43	5.35	25.49			
12	50.15	19.56	5.36	25.23	75	49.87	19.49	5.29	25.08	138	50.22	19.59	5.29	25.34			
13	50.31	19.57	5.38	25.36	76	50.19	19.43	5.31	25.44	139	49.83	19.41	5.41	25.01			
14	50.12	19.53	5.37	25.22	77	50.01	19.37	5.37	25.26	140	50.24	19.52	5.40	25.31			
15	49.86	19.35	5.37	25.14	78	50.21	19.52	5.35	25.34	141	50.14	19.50	5.31	25.32			
16	49.92	19.43	5.32	25.17	79	50.30	19.49	5.32	25.49	142	50.06	19.38	5.42	25.26			
17	50.15	19.51	5.35	25.29	80	50.28	19.45	5.38	25.45	143	50.11	19.32	5.35	25.44			
18	50.31	19.46	5.32	25.53	81	49.87	19.38	5.29	25.20	144	50.06	19.44	5.28	25.34			
19	50.04	19.44	5.34	25.26	82	50.13	19.48	5.34	25.31	145	49.86	19.37	5.33	25.16			
20	50.21	19.44	5.33	25.43	83	50.04	19.37	5.42	25.25	146	49.83	19.24	5.32	25.28			
21	50.23	19.49	5.33	25.40	84	50.05	19.41	5.28	25.36	147	50.14	19.36	5.40	25.38			
22	50.00	19.45	5.31	25.24	85	50.17	19.41	5.41	25.35	148	50.14	19.35	5.32	25.47			
23	50.08	19.40	5.36	25.32	86	50.13	19.43	5.35	25.36	149	50.15	19.55	5.37	25.23			
24	49.83	19.43	5.40	25.00	87	50.23	19.43	5.39	25.42	150	50.16	19.54	5.43	25.19			
25	50.12	19.41	5.30	25.42	88	50.08	19.45	5.39	25.24	151	50.01	19.41	5.39	25.21			
26	49.81	19.41	5.31	25.09	89	49.83	19.38	5.34	25.11	152	50.36	19.46	5.42	25.48			
27	49.87	19.41	5.28	25.18	90	50.09	19.31	5.42	25.36	153	50.04	19.44	5.37	25.23			
28	50.10	19.41	5.30	25.38	91	49.98	19.44	5.33	25.21	154	50.03	19.47	5.26	25.29			
29	50.20	19.47	5.41	25.32	92	49.99	19.46	5.36	25.18	155	50.22	19.49	5.40	25.34			
30	50.07	19.36	5.39	25.31	93	50.21	19.50	5.36	25.35	156	50.37	19.56	5.38	25.42			
31	49.95	19.49	5.35	25.11	94	50.18	19.50	5.34	25.34	157	50.12	19.39	5.38	25.34			
32	50.08	19.46	5.35	25.27	95	50.09	19.35	5.38	25.36	158	49.92	19.39	5.29	25.23			
33	49.71	19.41	5.32	24.98	96	49.96	19.56	5.36	25.04	159	50.02	19.40	5.35	25.28			
34	50.11	19.52	5.29	25.30	97	50.14	19.50	5.38	25.26	160	50.11	19.40	5.34	25.37			
35	50.18	19.34	5.46	25.38	98	49.94	19.40	5.33	25.21	161	50.22	19.37	5.34	25.51			
36	49.85	19.39	5.33	25.13	99	49.97	19.35	5.27	25.34	162	50.09	19.41	5.34	25.35			
37	49.93	19.51	5.26	25.16	100	50.34	19.51	5.39	25.44	163	50.37	19.52	5.33	25.53			
38	49.99	19.42	5.45	25.11	101	50.26	19.41	5.36	25.49	164	50.13	19.52	5.30	25.31			
39	49.89	19.39	5.28	25.22	102	49.95	19.34	5.34	25.28	165	50.23	19.43	5.27	25.53			
40	49.96	19.45	5.32	25.19	103	50.21	19.50	5.41	25.30	166	50.03	19.57	5.33	25.13			
41	50.04	19.52	5.41	25.10	104	49.75	19.32	5.38	25.05	167	50.14	19.49	5.38	25.27			
42	50.35	19.52	5.41	25.42	105	50.08	19.43	5.33	25.32	168	49.95	19.48	5.39	25.08			
43	49.98	19.44	5.31	25.23	106	49.89	19.43	5.35	25.11	169	50.06	19.42	5.33	25.31			
44	50.09	19.46	5.44	25.19	107	50.11	19.52	5.36	25.23	170	50.26	19.52	5.40	25.34			
45	50.17	19.40	5.28	25.49	108	50.03	19.42	5.41	25.20	171	50.42	19.52	5.41	25.49			
46	50.27	19.44	5.36	25.47	109	50.13	19.40	5.31	25.43	172	50.09	19.46	5.33	25.30			
47	49.66	19.35	5.28	25.03	110	50.09	19.43	5.37	25.29	173	50.07	19.54	5.39	25.14			
48	49.99	19.49	5.34	25.17	111	50.09	19.36	5.37	25.36	174	50.06	19.40	5.39	25.27			
49	50.09	19.37	5.38	25.34	112	50.14	19.50	5.33	25.30	175	50.04	19.45	5.37	25.22			
50	50.20	19.43	5.35	25.42	113	49.98	19.57	5.32	25.09	176	50.01	19.46	5.38	25.17			
51	50.09	19.39	5.38	25.32	114	50.16	19.41	5.39	25.36	177	50.01	19.41	5.34	25.25			
52	50.07	19.46	5.31	25.29	115	49.91	19.29	5.27	25.35	178	50.15	19.38	5.37	25.40			
53	50.18	19.39	5.43	25.36	116	49.89	19.37	5.35	25.16	179	50.12	19.52	5.34	25.27			
54	50.10	19.34	5.35	25.41	117	50.00	19.42	5.42	25.16	180	49.83	19.34	5.30	25.19			
55	50.18	19.56	5.37	25.25	118	50.15	19.41	5.30	25.44	181	49.84	19.43	5.34	25.07			
56	50.01	19.50	5.32	25.19	119	50.11	19.48	5.31	25.32	182	50.08	19.29	5.39	25.39			
57	50.08	19.46	5.35	25.28	120	50.10	19.44	5.34	25.33	183	49.92	19.37	5.33	25.21			
58	50.19	19.42	5.29	25.48	121	49.90	19.39	5.40	25.11	184	49.91	19.42	5.28	25.21			
59	50.16	19.48	5.31	25.38	122	50.07	19.43	5.38	25.26								
60	50.03	19.53	5.37	25.13	123	49.99	19.51	5.32	25.16								
61	50.28	19.48	5.44	25.36	124	50.50	19.60	5.42	25.48								

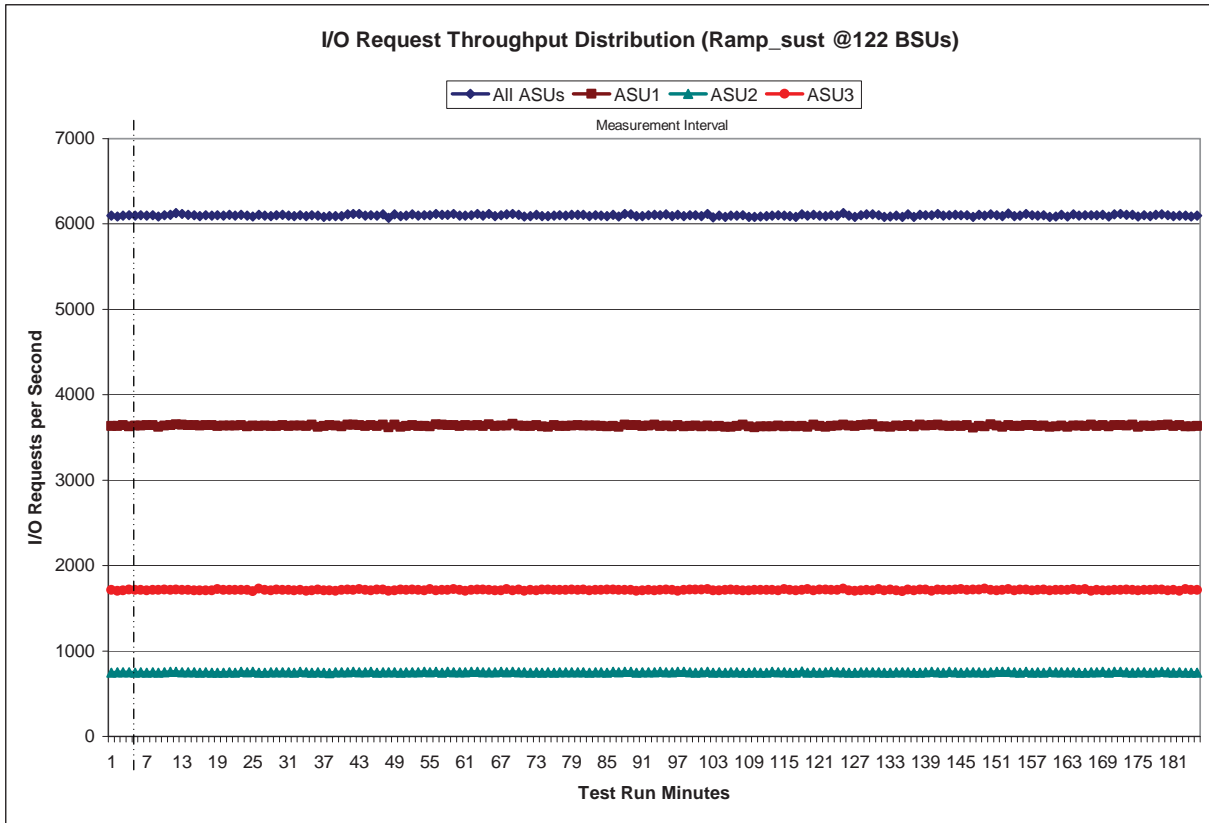
Sustainability – Data Rate Distribution Graph



Sustainability – I/O Request Throughput Distribution Data

Ramp-Up/Start-Up Measurement Interval		Start	Stop	Interval	Duration												
		21:17:18	21:22:18	0-4	0:05:00												
		21:22:18	0:22:18	5-185	3:00:00												
Interval	ytes per Sec	0	0	0	Interval	tes per Sec	0	0	0	Interval	tes per Sec	0	0	0			
0	6,095.63	3,635.02	747.65	1,712.97	63	6,098.28	3,632.98	749.28	1,716.02	126	6,080.73	3,634.93	743.97	1,701.83			
1	6,086.60	3,632.57	750.02	1,704.02	64	6,116.20	3,655.42	749.03	1,711.75	127	6,100.62	3,641.35	749.80	1,709.47			
2	6,099.57	3,643.42	749.82	1,706.33	65	6,093.08	3,634.52	750.18	1,708.38	128	6,112.77	3,646.53	751.28	1,714.95			
3	6,101.00	3,629.50	753.40	1,718.10	66	6,102.62	3,639.43	754.18	1,709.00	129	6,111.50	3,653.18	749.30	1,709.02			
4	6,097.35	3,636.90	745.95	1,714.50	67	6,111.13	3,636.15	749.38	1,725.60	130	6,100.48	3,629.28	749.35	1,721.85			
5	6,104.02	3,636.95	751.33	1,715.73	68	6,119.80	3,658.03	754.12	1,707.65	131	6,082.53	3,627.50	748.03	1,707.00			
6	6,099.90	3,641.83	747.97	1,710.10	69	6,108.80	3,639.50	752.37	1,716.93	132	6,088.98	3,625.25	747.15	1,716.58			
7	6,103.03	3,641.57	749.22	1,712.25	70	6,088.77	3,631.07	753.03	1,704.67	133	6,095.43	3,637.98	749.85	1,707.60			
8	6,087.50	3,625.57	747.20	1,714.73	71	6,092.12	3,632.45	746.77	1,712.90	134	6,085.02	3,633.92	750.82	1,700.28			
9	6,105.22	3,640.12	748.72	1,716.38	72	6,105.55	3,644.60	750.30	1,710.65	135	6,110.95	3,645.47	749.02	1,716.47			
10	6,110.22	3,645.00	754.15	1,711.07	73	6,095.02	3,627.92	747.20	1,719.90	136	6,083.47	3,629.87	746.78	1,706.82			
11	6,126.75	3,652.82	754.98	1,718.95	74	6,090.65	3,624.02	749.72	1,716.92	137	6,109.62	3,646.90	745.07	1,717.65			
12	6,116.47	3,647.97	753.23	1,715.27	75	6,100.17	3,641.85	747.20	1,711.12	138	6,105.13	3,639.18	748.70	1,717.25			
13	6,106.15	3,642.25	749.88	1,714.02	76	6,100.45	3,635.17	750.82	1,714.47	139	6,104.72	3,642.72	756.27	1,705.73			
14	6,101.73	3,641.22	751.85	1,708.67	77	6,095.43	3,632.92	748.48	1,714.03	140	6,120.52	3,649.75	751.50	1,719.27			
15	6,092.78	3,636.35	746.50	1,709.93	78	6,105.97	3,636.93	751.33	1,717.70	141	6,099.37	3,639.18	744.27	1,715.92			
16	6,101.47	3,643.78	749.15	1,708.53	79	6,107.20	3,642.78	749.18	1,715.23	142	6,104.25	3,635.08	755.72	1,713.45			
17	6,096.43	3,641.23	748.23	1,706.97	80	6,106.10	3,637.92	749.43	1,718.75	143	6,106.48	3,636.35	751.40	1,718.73			
18	6,104.33	3,634.92	747.62	1,721.80	81	6,094.98	3,639.20	748.07	1,707.72	144	6,102.98	3,631.73	747.68	1,723.57			
19	6,096.68	3,638.60	746.63	1,711.45	82	6,100.83	3,639.55	750.28	1,711.00	145	6,104.52	3,643.25	748.63	1,712.63			
20	6,106.05	3,637.75	752.58	1,715.72	83	6,098.42	3,633.02	749.80	1,715.60	146	6,082.28	3,614.98	749.88	1,717.42			
21	6,098.00	3,639.13	743.47	1,715.40	84	6,092.62	3,628.95	745.47	1,718.20	147	6,106.73	3,634.88	752.13	1,719.72			
22	6,107.58	3,641.37	754.07	1,712.15	85	6,106.37	3,634.22	753.88	1,718.27	148	6,099.15	3,628.23	744.18	1,726.73			
23	6,097.52	3,631.00	751.77	1,714.75	86	6,085.98	3,624.00	748.87	1,713.12	149	6,115.00	3,652.65	749.60	1,712.75			
24	6,089.72	3,636.92	755.08	1,697.72	87	6,118.90	3,647.32	757.08	1,714.50	150	6,105.22	3,640.08	758.35	1,706.78			
25	6,109.90	3,633.20	748.23	1,728.47	88	6,112.70	3,644.53	755.33	1,712.83	151	6,092.18	3,623.27	756.48	1,712.43			
26	6,100.33	3,639.37	746.38	1,714.58	89	6,091.95	3,642.08	746.58	1,703.28	152	6,121.65	3,641.20	756.00	1,724.45			
27	6,092.65	3,634.32	749.17	1,709.17	90	6,093.83	3,634.52	748.57	1,710.75	153	6,092.13	3,634.03	749.10	1,709.00			
28	6,103.13	3,633.85	752.35	1,716.93	91	6,101.92	3,637.92	749.57	1,714.43	154	6,097.85	3,634.27	744.82	1,718.77			
29	6,108.05	3,643.07	751.12	1,713.87	92	6,107.02	3,648.40	750.77	1,707.85	155	6,116.53	3,643.83	754.62	1,718.08			
30	6,098.15	3,633.15	752.72	1,712.28	93	6,105.23	3,635.90	754.60	1,714.73	156	6,103.63	3,644.97	748.20	1,710.47			
31	6,092.13	3,640.02	745.15	1,706.97	94	6,110.55	3,640.90	750.02	1,719.63	157	6,097.60	3,634.60	751.03	1,711.97			
32	6,102.55	3,637.60	753.47	1,711.48	95	6,092.75	3,628.40	751.27	1,713.08	158	6,104.68	3,638.83	748.13	1,717.72			
33	6,090.62	3,633.65	752.58	1,704.38	96	6,106.35	3,645.00	755.50	1,705.85	159	6,082.60	3,621.40	754.58	1,706.62			
34	6,104.33	3,646.98	747.18	1,710.17	97	6,095.30	3,628.60	754.78	1,711.92	160	6,089.85	3,627.57	750.03	1,712.25			
35	6,095.48	3,622.87	752.78	1,719.83	98	6,102.38	3,634.58	750.23	1,717.57	161	6,107.78	3,641.02	751.33	1,715.43			
36	6,084.67	3,634.22	743.97	1,706.48	99	6,101.85	3,637.18	746.28	1,718.38	162	6,088.78	3,622.63	751.42	1,714.73			
37	6,091.28	3,641.15	742.27	1,707.87	100	6,095.35	3,629.97	749.30	1,716.08	163	6,113.28	3,641.03	749.23	1,723.02			
38	6,093.25	3,638.63	751.77	1,702.85	101	6,116.82	3,639.80	753.97	1,723.05	164	6,099.60	3,636.70	747.93	1,714.97			
39	6,094.40	3,629.28	750.87	1,714.25	102	6,079.93	3,628.47	743.62	1,707.85	165	6,102.70	3,633.12	745.77	1,723.82			
40	6,112.23	3,646.48	748.43	1,717.32	103	6,098.12	3,634.32	753.25	1,710.55	166	6,103.33	3,649.37	750.40	1,703.57			
41	6,117.37	3,647.40	756.52	1,713.45	104	6,084.28	3,624.70	747.98	1,711.60	167	6,101.17	3,635.17	752.68	1,713.32			
42	6,117.15	3,642.10	752.10	1,722.95	105	6,096.43	3,624.35	751.63	1,720.45	168	6,109.97	3,643.17	756.97	1,709.83			
43	6,096.82	3,635.07	749.10	1,712.65	106	6,098.68	3,632.28	753.23	1,713.17	169	6,088.20	3,630.50	746.82	1,710.88			
44	6,103.40	3,642.75	754.58	1,706.07	107	6,104.00	3,647.15	747.33	1,709.52	170	6,110.55	3,642.48	753.78	1,714.28			
45	6,100.22	3,635.85	744.85	1,719.52	108	6,082.93	3,629.07	747.02	1,706.85	171	6,117.93	3,645.75	756.40	1,715.78			
46	6,115.17	3,647.42	748.83	1,718.92	109	6,084.33	3,620.12	749.10	1,715.12	172	6,107.02	3,638.73	749.85	1,718.43			
47	6,074.38	3,620.83	749.48	1,704.07	110	6,088.33	3,629.82	745.35	1,713.17	173	6,107.62	3,648.47	747.82	1,711.33			
48	6,112.85	3,651.12	751.95	1,709.78	111	6,090.58	3,630.22	747.30	1,713.07	174	6,089.37	3,625.58	753.17	1,710.62			
49	6,090.90	3,625.65	747.20	1,718.05	112	6,099.05	3,629.75	754.38	1,714.92	175	6,105.10	3,639.98	750.03	1,715.08			
50	6,096.82	3,632.77	748.92	1,715.13	113	6,101.38	3,640.55	750.07	1,710.77	176	6,091.90	3,631.13	745.48	1,715.28			
51	6,110.80	3,643.25	750.75	1,716.80	114	6,099.40	3,626.37	751.43	1,721.60	177	6,110.05	3,640.55	753.10	1,716.40			
52	6,097.45	3,634.87	749.32	1,713.27	115	6,091.67	3,632.20	743.57	1,715.90	178	6,113.23	3,641.63	753.62	1,717.98			
53	6,101.60	3,635.15	755.80	1,710.65	116	6,083.13	3,629.95	745.73	1,707.45	179	6,104.60	3,648.30	748.42	1,707.88			
54	6,103.45	3,629.02	748.53	1,725.90	117	6,110.67	3,635.43	759.27	1,715.97	180	6,094.52	3,632.93	746.38	1,715.20			
55	6,116.00	3,651.38	755.08	1,709.53	118	6,097.07	3,625.05	747.68	1,724.33	181	6,097.57	3,641.53	750.18	1,705.85			
56	6,105.72	3,646.90	747.12	1,711.70	119	6,108.13	3,648.38	749.13	1,710.62	182	6,098.52	3,628.38	747.83	1,722.30			
57	6,110.13	3,641.33	753.75	1,715.05	120	6,100.25	3,634.38	747.83	1,718.03	183	6,088.97	3,628.78	746.85	1,713.33			
58	6,115.60	3,644.87	749.15	1,721.58	121	6,093.32	3,624.10	750.40	1,718.82	184	6,095.88	3,634.80	746.62	1,714.47			
59	6,099.45	3,635.58	748.47	1,715.40	122	6,102.82	3,635.00	753.45	1,714.37	Average 6,100.99 3,637.11 750.18 1,713.70							
60	6,095.73	3,641.82	752.75	1,701.17	123	6,099.20	3,637.37	750.52	1,711.32								
61	6,104.27	3,636.70	755.05	1,712.52	124	6,128.38	3,648.92	752.32	1,727.15								
62	6,115.92	3,643.28	755.10	1,717.53	125	6,095.87	3,639.52	747.70	1,708.65								

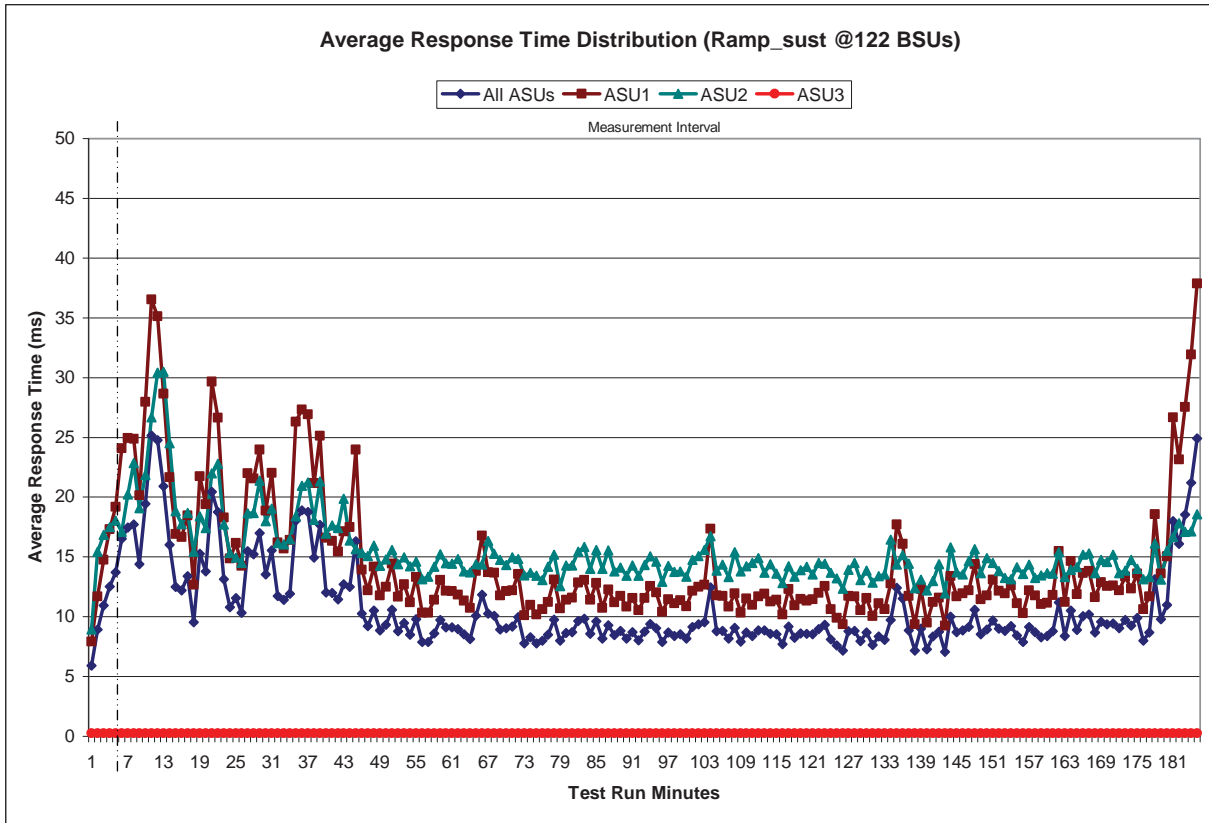
Sustainability – I/O Request Throughput Distribution Graph



Sustainability – Average Response Time (ms) Distribution Data

Ramp-Up/Start-Up		Start	Stop	Interval	Duration													
Measurement Interval		21:17:18	21:22:18	0-4	0:05:00													
		21:22:18	0:22:18	5-185	3:00:00													
Interval	ytes per Secc	0	0	0	0.24	Interval	tes per Sec	0	0	0	0.24	Interval	tes per Sec	0	0	0	0.24	
0	5.89	7.93	8.94	0.24		63	8.14	10.73	13.70	0.24		126	8.80	11.75	13.92	0.24		
1	8.94	11.68	15.45	0.24		64	10.09	13.81	14.39	0.24		127	8.83	11.69	14.50	0.24		
2	10.96	14.77	16.84	0.24		65	11.84	16.76	14.37	0.24		128	7.96	10.54	13.05	0.24		
3	12.52	17.30	17.49	0.24		66	10.26	13.71	16.33	0.24		129	8.67	11.55	13.87	0.24		
4	13.73	19.20	18.04	0.24		67	10.07	13.67	15.25	0.24		130	7.62	10.05	12.83	0.24		
5	16.51	24.07	17.08	0.24		68	8.91	11.76	14.76	0.24		131	8.34	11.11	13.38	0.24		
6	17.44	24.94	20.24	0.24		69	9.05	12.12	14.32	0.24		132	8.05	10.61	13.55	0.24		
7	17.71	24.86	22.86	0.24		70	9.19	12.19	14.98	0.24		133	9.72	12.79	16.45	0.25		
8	14.41	20.16	19.06	0.24		71	9.99	13.59	14.84	0.24		134	12.42	17.71	14.37	0.24		
9	19.43	27.98	21.85	0.24		72	7.77	10.13	13.46	0.24		135	11.52	16.08	15.15	0.24		
10	25.15	36.53	26.68	0.24		73	8.28	10.97	13.68	0.24		136	8.84	11.73	14.45	0.24		
11	24.77	35.15	30.41	0.24		74	7.78	10.18	13.42	0.24		137	7.16	9.34	12.39	0.24		
12	20.91	28.65	30.47	0.24		75	8.00	10.61	13.06	0.24		138	9.00	12.30	13.11	0.24		
13	16.01	21.69	24.51	0.24		76	8.50	11.23	14.17	0.24		139	7.26	9.52	12.19	0.24		
14	12.48	16.91	18.84	0.24		77	9.75	13.11	15.18	0.24		140	8.35	11.21	13.01	0.25		
15	12.19	16.68	17.74	0.24		78	7.97	10.68	12.57	0.24		141	8.74	11.59	14.40	0.24		
16	13.38	18.45	18.68	0.24		79	8.62	11.40	14.31	0.24		142	7.05	9.23	11.95	0.24		
17	9.53	12.66	15.44	0.24		80	8.72	11.57	14.29	0.24		143	10.00	13.41	15.81	0.24		
18	15.27	21.74	18.39	0.25		81	9.64	12.85	15.45	0.24		144	8.70	11.69	13.70	0.24		
19	13.79	19.41	17.43	0.24		82	9.82	13.08	15.85	0.24		145	8.86	11.95	13.55	0.24		
20	20.46	29.67	22.01	0.24		83	8.58	11.40	14.02	0.24		146	9.14	12.22	14.64	0.24		
21	18.74	26.63	22.79	0.24		84	9.61	12.82	15.58	0.24		147	10.58	14.42	15.68	0.24		
22	13.16	18.28	17.71	0.25		85	8.17	10.71	14.00	0.24		148	8.55	11.46	13.64	0.24		
23	10.80	14.85	15.33	0.25		86	9.29	12.27	15.55	0.25		149	8.94	11.79	14.92	0.24		
24	11.56	16.15	14.93	0.24		87	8.45	11.20	13.79	0.24		150	9.67	13.09	14.50	0.24		
25	10.33	14.27	14.52	0.24		88	8.80	11.73	14.10	0.24		151	9.01	12.15	13.81	0.24		
26	15.48	22.01	18.66	0.24		89	8.18	10.83	13.42	0.24		152	8.82	11.97	13.25	0.24		
27	15.22	21.56	18.69	0.24		90	8.73	11.57	14.29	0.24		153	9.21	12.61	13.14	0.24		
28	16.99	23.99	21.38	0.24		91	8.01	10.56	13.42	0.24		154	8.43	11.13	14.13	0.24		
29	13.53	18.86	18.01	0.25		92	8.74	11.57	14.33	0.24		155	7.87	10.28	13.58	0.24		
30	15.55	22.04	19.05	0.24		93	9.41	12.56	15.05	0.24		156	9.13	12.22	14.38	0.24		
31	11.73	16.21	16.17	0.24		94	9.02	12.02	14.62	0.24		157	8.72	11.78	13.24	0.24		
32	11.40	15.68	16.05	0.24		95	7.87	10.42	12.93	0.24		158	8.30	11.04	13.45	0.24		
33	11.91	16.43	16.48	0.24		96	8.66	11.45	14.25	0.24		159	8.40	11.16	13.63	0.24		
34	18.04	26.32	18.38	0.24		97	8.40	11.13	13.77	0.24		160	8.78	11.81	13.60	0.24		
35	18.89	27.31	20.96	0.24		98	8.53	11.36	13.79	0.24		161	11.18	15.47	15.42	0.24		
36	18.75	26.94	21.23	0.24		99	8.19	10.88	13.37	0.24		162	8.40	11.24	13.31	0.25		
37	14.94	21.18	18.12	0.24		100	9.13	12.17	14.77	0.24		163	10.50	14.65	13.93	0.24		
38	17.69	25.11	21.30	0.24		101	9.36	12.49	15.09	0.24		164	8.88	11.88	14.16	0.24		
39	12.04	16.60	16.97	0.24		102	9.53	12.65	15.59	0.24		165	10.04	13.64	15.19	0.24		
40	11.98	16.36	17.65	0.24		103	12.47	17.34	16.74	0.25		166	10.20	13.81	15.31	0.24		
41	11.43	15.45	17.42	0.24		104	8.77	11.76	13.85	0.24		167	8.67	11.62	13.64	0.24		
42	12.72	17.14	19.87	0.25		105	8.81	11.72	14.37	0.24		168	9.57	12.87	14.76	0.24		
43	12.50	17.48	16.37	0.25		106	8.17	10.85	13.32	0.24		169	9.35	12.56	14.59	0.24		
44	16.30	23.96	15.65	0.24		107	9.09	11.94	15.40	0.24		170	9.44	12.58	15.20	0.24		
45	10.25	13.94	15.32	0.24		108	7.92	10.32	13.79	0.24		171	9.04	12.22	13.65	0.25		
46	9.20	12.21	15.10	0.24		109	8.67	11.52	14.21	0.24		172	9.73	13.36	13.86	0.24		
47	10.50	14.19	15.95	0.24		110	8.40	10.99	14.52	0.24		173	9.25	12.34	14.75	0.24		
48	8.84	11.76	14.24	0.25		111	8.87	11.69	14.92	0.24		174	9.90	13.61	13.99	0.24		
49	9.32	12.49	14.81	0.24		112	8.85	11.91	13.69	0.24		175	8.01	10.61	13.14	0.24		
50	10.59	14.45	15.59	0.24		113	8.56	11.26	14.42	0.24		176	8.67	11.70	13.31	0.24		
51	8.80	11.68	14.39	0.24		114	8.54	11.43	13.60	0.24		177	13.12	18.58	16.12	0.24		
52	9.48	12.70	14.99	0.24		115	7.71	10.20	12.80	0.24		178	9.78	13.59	13.11	0.24		
53	8.51	11.20	14.23	0.24		116	9.17	12.33	14.22	0.24		179	10.97	15.05	15.52	0.24		
54	9.79	13.33	14.62	0.24		117	8.23	10.94	13.35	0.24		180	18.01	26.68	16.65	0.24		
55	7.87	10.35	13.16	0.24		118	8.59	11.47	13.91	0.24		181	16.09	23.15	17.83	0.24		
56	7.88	10.34	13.36	0.24		119	8.57	11.32	14.18	0.24		182	18.54	27.53	17.11	0.23		
57	8.62	11.41	14.20	0.24		120	8.55	11.45	13.54	0.24		183	21.19	31.93	17.12	0.24		
58	9.71	13.06	15.22	0.24		121	8.98	11.98	14.52	0.24		184	24.92	37.86	18.58	0.24		
59	9.09	12.16	14.46	0.24		122	9.33	12.56	14.45	0.24		Average	10.70	14.64	15.45	0.24		
60	9.10	12.14	14.43	0.24		123	8.09	10.62	13.69	0.24								
61	8.96	11.85	14.82	0.24		124	7.59	9.91	13.22	0.24								
62	8.52	11.34	13.78	0.24		125	7.17	9.36	12.34	0.24								

Sustainability – Average Response Time (ms) Distribution Graph



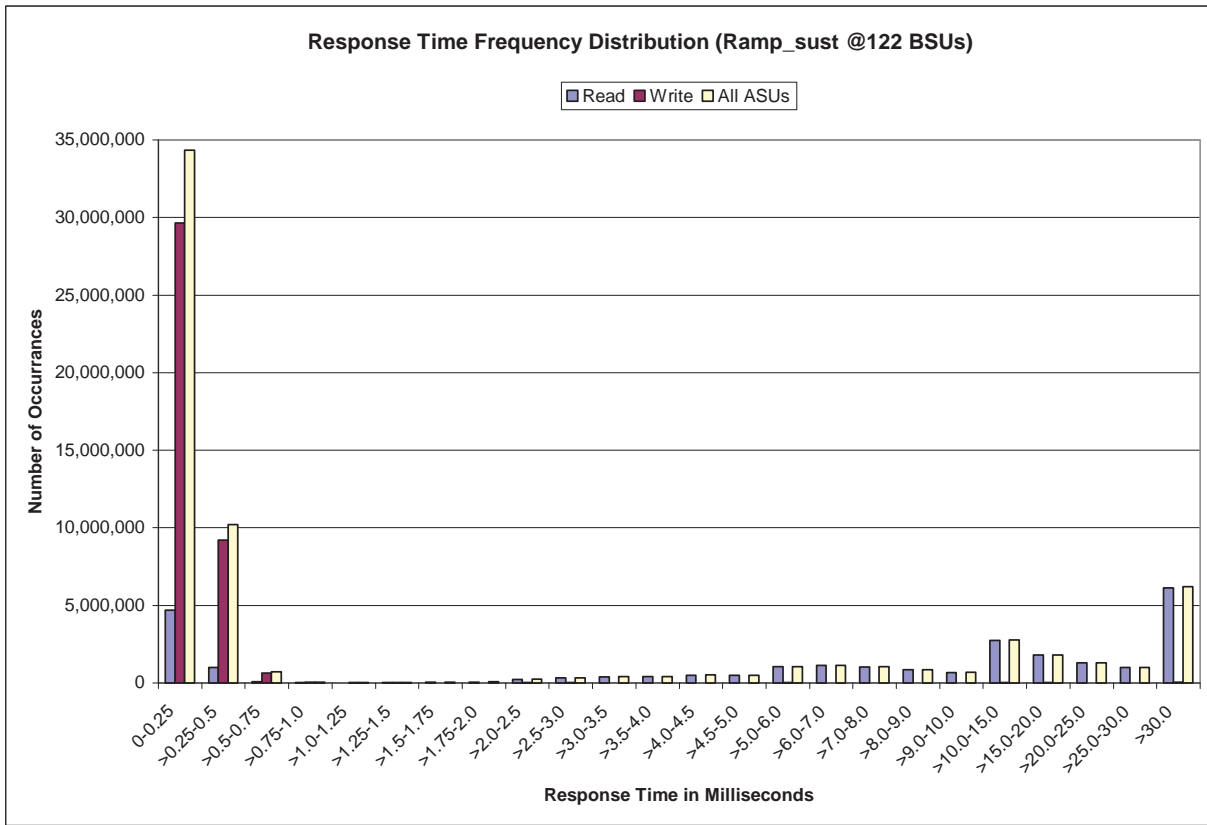
Sustainability – Response Time Frequency Distribution Data

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	4,685,996	1,004,268	79,656	15,314	9,211	16,745	43,773	61,008
Write	29,655,950	9,213,481	647,935	53,985	23,821	16,493	10,983	8,938
All ASUs	34,341,946	10,217,749	727,591	69,299	33,032	33,238	54,756	69,946
ASU1	16,956,137	3,919,122	167,570	32,378	21,400	26,179	50,414	66,186
ASU2	4,744,435	1,017,705	37,196	5,973	3,254	2,140	1,796	1,810
ASU3	12,641,374	5,280,922	522,825	30,948	8,378	4,919	2,546	1,950

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	224,627	319,531	396,201	413,972	506,756	502,582	1,043,677	1,132,820
Write	16,459	14,086	12,545	10,830	10,104	9,382	15,040	13,185
All ASUs	241,086	333,617	408,746	424,802	516,860	511,964	1,058,717	1,146,005
ASU1	233,021	324,579	396,306	410,057	495,468	488,168	1,004,309	1,083,113
ASU2	4,839	6,916	10,478	13,201	20,015	22,643	52,747	61,694
ASU3	3,226	2,122	1,962	1,544	1,377	1,153	1,661	1,198

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	1,034,668	856,043	675,577	2,748,855	1,793,619	1,298,155	995,009	6,141,745
Write	10,547	9,645	7,819	29,562	20,190	13,830	10,841	67,080
All ASUs	1,045,215	865,688	683,396	2,778,417	1,813,809	1,311,985	1,005,850	6,208,825
ASU1	981,110	799,919	625,741	2,541,500	1,627,095	1,158,150	873,674	5,006,309
ASU2	63,310	65,168	57,240	236,135	186,154	153,804	132,172	1,202,516
ASU3	795	601	415	782	560	31	4	-

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	0.0351	0.2810	0.0700	0.2101	0.0180	0.0699	0.0350	0.2809
COV	0.009	0.003	0.006	0.003	0.011	0.006	0.009	0.003

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

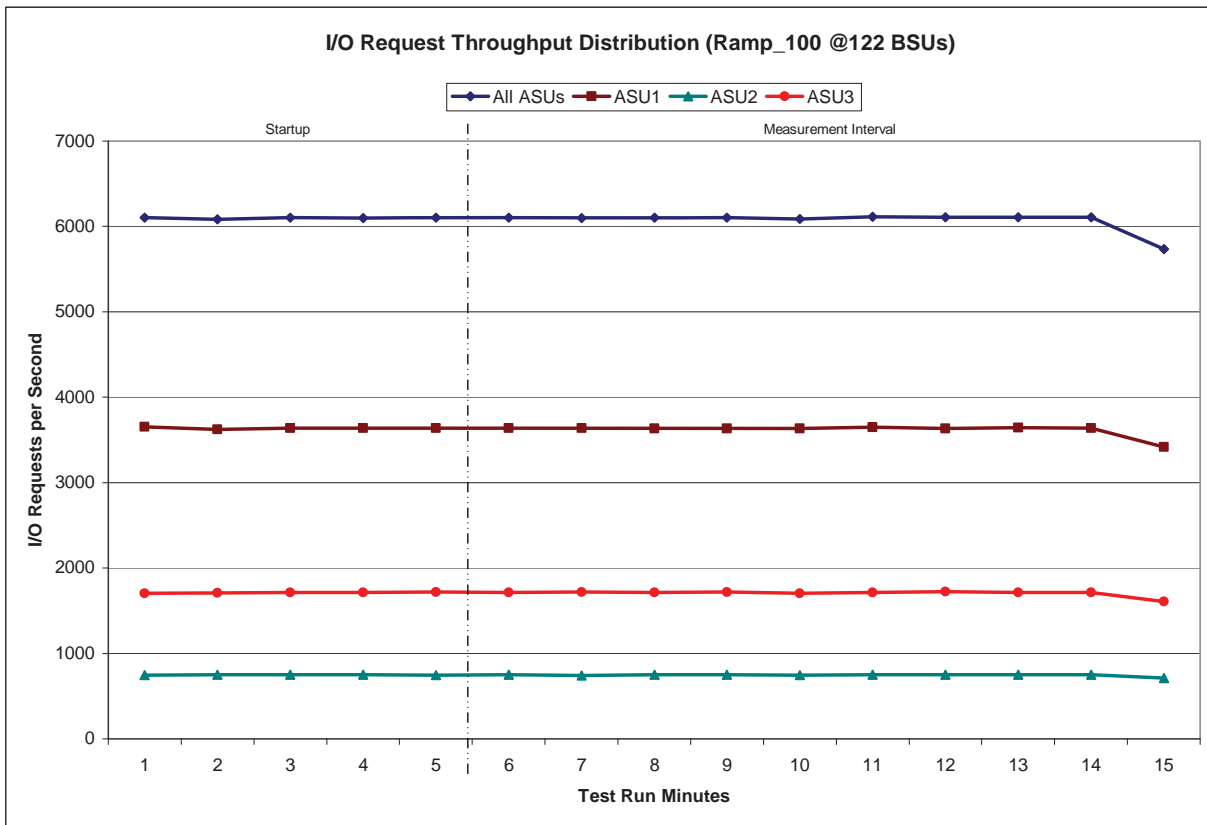
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

122 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:23:22	0:28:23	0-4	0:05:01
Measurement Interval	0:28:23	0:38:23	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6,101.32	3,653.97	746.35	1,701.00
1	6,084.73	3,623.63	750.35	1,710.75
2	6,104.43	3,641.00	748.72	1,714.72
3	6,098.48	3,637.17	748.57	1,712.75
4	6,100.75	3,637.30	745.38	1,718.07
5	6,102.48	3,638.32	750.57	1,713.60
6	6,099.28	3,638.33	742.50	1,718.45
7	6,100.53	3,635.97	750.05	1,714.52
8	6,100.88	3,635.78	749.10	1,716.00
9	6,086.02	3,634.50	748.33	1,703.18
10	6,111.33	3,646.55	753.38	1,711.40
11	6,109.43	3,634.13	751.62	1,723.68
12	6,107.22	3,643.40	749.47	1,714.35
13	6,106.25	3,640.08	752.17	1,714.00
14	5,736.15	3,417.57	708.45	1,610.13
Average	6,065.96	3,616.46	745.56	1,703.93

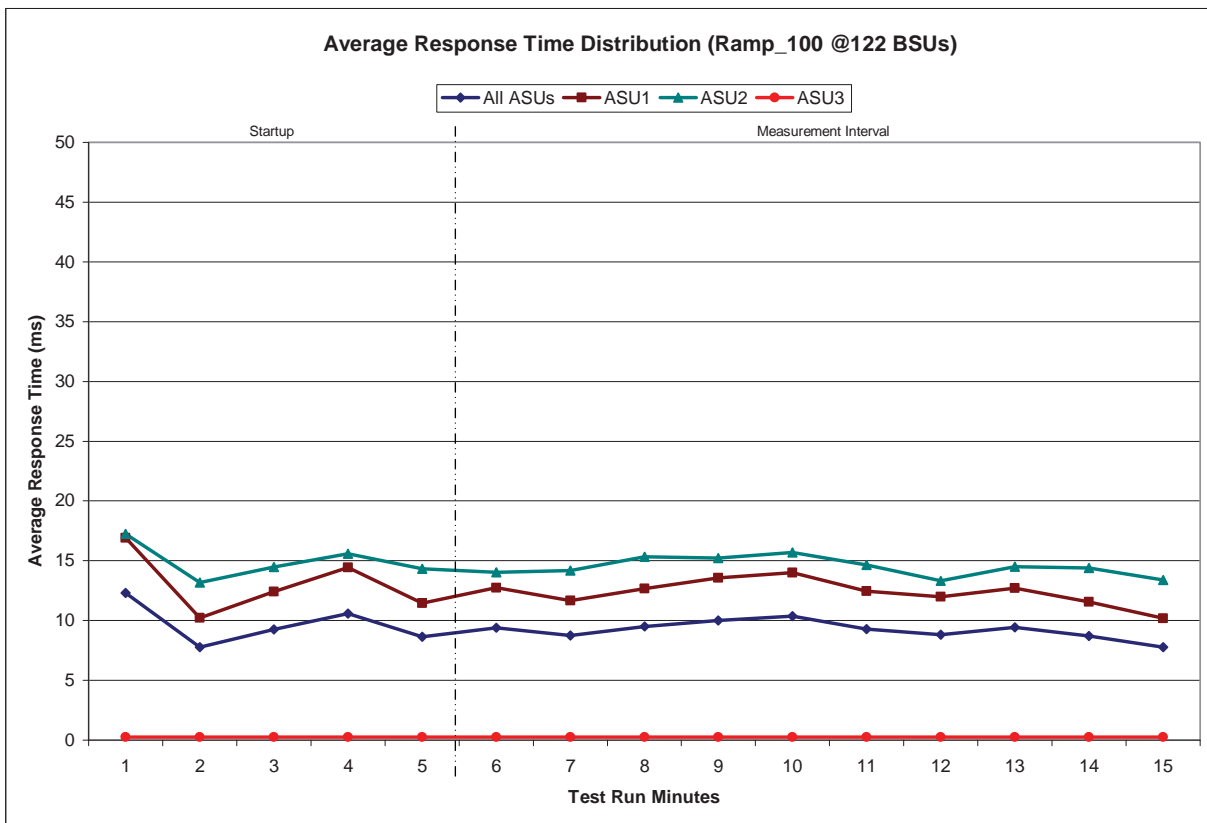
IOPS Test Run – I/O Request Throughput Distribution Graph



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

122 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	0:23:22	0:28:23	0-4	0:05:01
	0:28:23	0:38:23	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	12.31	16.92	17.26	0.24
1	7.79	10.24	13.19	0.25
2	9.26	12.43	14.48	0.24
3	10.60	14.44	15.60	0.24
4	8.64	11.44	14.32	0.24
5	9.39	12.74	14.06	0.24
6	8.74	11.65	14.17	0.24
7	9.52	12.68	15.34	0.25
8	10.02	13.56	15.22	0.24
9	10.37	14.01	15.70	0.24
10	9.30	12.45	14.65	0.24
11	8.83	11.98	13.33	0.24
12	9.44	12.72	14.50	0.25
13	8.73	11.55	14.41	0.24
14	7.79	10.18	13.41	0.24
Average	9.21	12.35	14.48	0.24

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



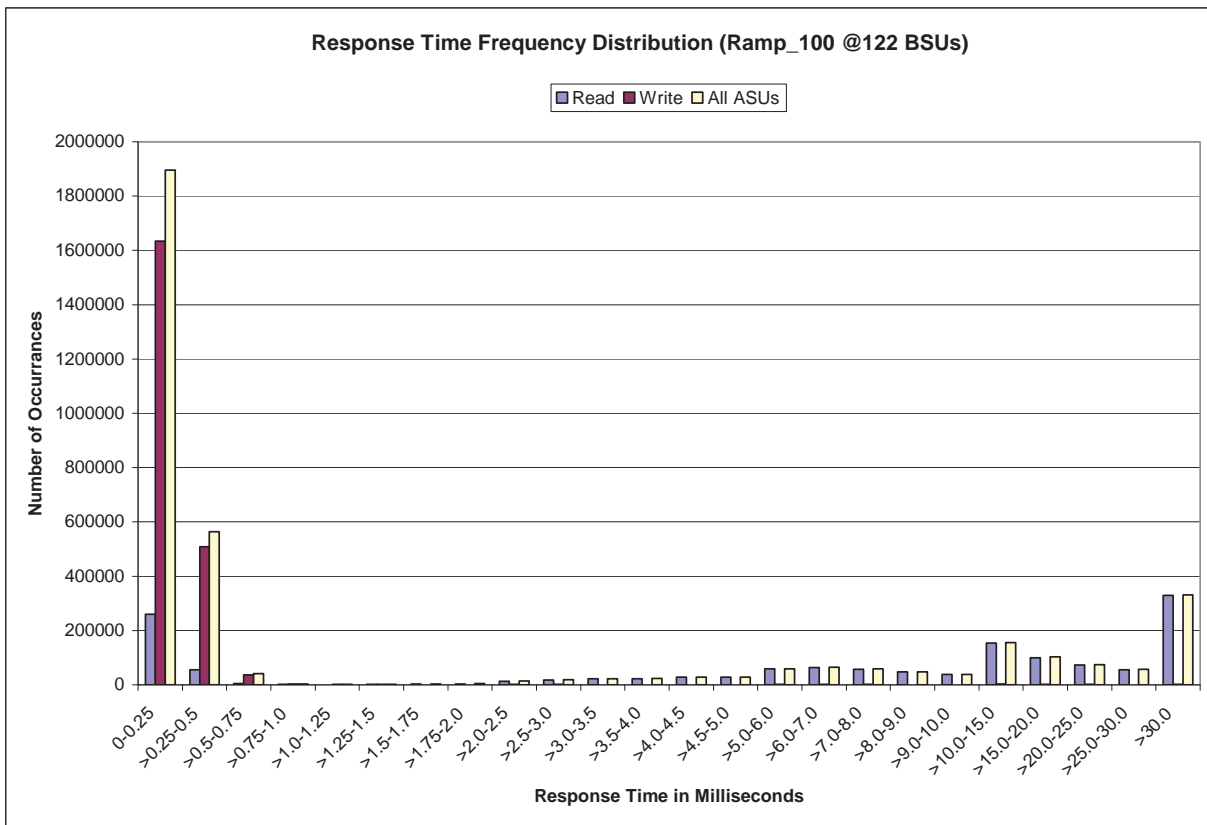
IOPS Test Run – Response Time Frequency Distribution Data

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	260,157	55,583	4,393	854	520	950	2,562	3,743
Write	1,634,688	509,113	36,169	3,093	1,425	1,117	684	552
All ASUs	1,894,845	564,696	40,562	3,947	1,945	2,067	3,246	4,295
ASU1	935,719	216,269	9,688	1,885	1,237	1,588	3,007	4,097
ASU2	261,605	56,303	1,994	310	182	125	94	99
ASU3	697,521	292,124	28,880	1,752	526	354	145	99

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	13,188	18,164	22,108	22,944	27,900	27,835	58,080	63,274
Write	1,058	945	785	712	629	631	989	946
All ASUs	14,246	19,109	22,893	23,656	28,529	28,466	59,069	64,220
ASU1	13,800	18,554	22,130	22,810	27,322	27,163	56,109	60,719
ASU2	285	422	652	753	1,138	1,250	2,908	3,436
ASU3	161	133	111	93	69	53	52	65

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	57,257	46,780	37,512	153,469	100,522	72,989	55,872	328,856
Write	875	704	661	2,500	1,790	1,189	764	2,043
All ASUs	58,132	47,484	38,173	155,969	102,312	74,178	56,636	330,899
ASU1	54,563	43,677	34,982	142,373	91,625	65,453	49,210	265,898
ASU2	3,488	3,780	3,172	13,543	10,647	8,725	7,426	65,001
ASU3	81	27	19	53	40	-	-	-

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
3,639,574	3,308,675	330,899

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	0.2809	0.0700	0.2103	0.0181	0.0699	0.0350	0.2809
COV	0.009	0.002	0.006	0.003	0.011	0.006	0.006	0.002

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](#)

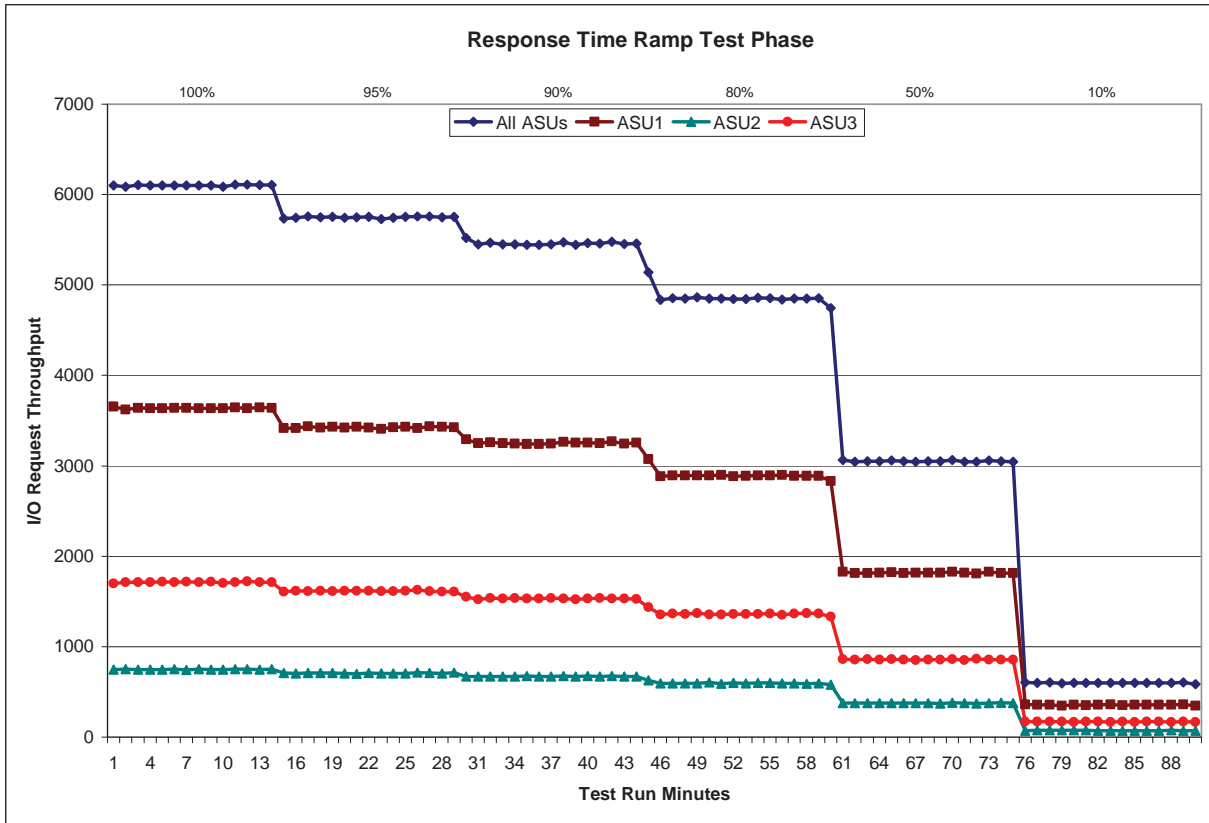
[10% Load Level](#)

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 - 122 BSUs					95% Load Level - 115 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
0:23:22	0:28:23	0-4	0:05:01		0:38:26	0:43:27	0-4	0:05:01	
Start-Up/Ramp-Up					Start-Up/Ramp-Up				
Measurement Interval					Measurement Interval				
<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	6,101.32	3,653.97	746.35	1,701.00	0	5,742.50	3,416.75	706.25	1,619.50
1	6,084.73	3,623.63	750.35	1,710.75	1	5,756.05	3,435.88	707.70	1,612.47
2	6,104.43	3,641.00	748.72	1,714.72	2	5,747.65	3,420.43	708.25	1,618.97
3	6,098.48	3,637.17	748.57	1,712.75	3	5,752.80	3,430.15	708.00	1,614.65
4	6,100.75	3,637.30	745.38	1,718.07	4	5,744.22	3,419.92	705.93	1,618.37
5	6,102.48	3,638.32	750.57	1,713.60	5	5,748.10	3,429.27	700.47	1,618.37
6	6,099.28	3,638.33	742.50	1,718.45	6	5,752.67	3,423.77	709.33	1,619.57
7	6,100.53	3,635.97	750.05	1,714.52	7	5,731.02	3,409.17	706.28	1,615.57
8	6,100.88	3,635.78	749.10	1,716.00	8	5,745.32	3,427.85	702.02	1,615.45
9	6,086.02	3,634.50	748.33	1,703.18	9	5,753.87	3,429.95	706.43	1,617.48
10	6,111.33	3,646.55	753.38	1,711.40	10	5,757.38	3,417.93	713.00	1,626.45
11	6,109.43	3,634.13	751.62	1,723.68	11	5,758.18	3,436.47	708.90	1,612.82
12	6,107.22	3,643.40	749.47	1,714.35	12	5,746.17	3,432.92	705.90	1,607.35
13	6,106.25	3,640.08	752.17	1,714.00	13	5,750.95	3,425.73	715.07	1,610.15
14	5,736.15	3,417.57	708.45	1,610.13	14	5,518.57	3,293.98	670.98	1,553.60
Average	6,065.96	3,616.46	745.56	1,703.93	Average	5,726.22	3,412.70	703.84	1,609.68
90% Load Level - 109 BSUs					80% Load Level - 97 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
0:53:30	0:58:31	0-4	0:05:01		1:08:34	1:13:35	0-4	0:05:01	
Start-Up/Ramp-Up					Start-Up/Ramp-Up				
Measurement Interval					Measurement Interval				
<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	5,447.58	3,251.08	671.58	1,524.92	0	4,836.58	2,883.35	596.70	1,356.53
1	5,467.75	3,258.15	673.35	1,536.25	1	4,851.47	2,892.30	594.02	1,365.15
2	5,447.87	3,248.72	668.97	1,530.18	2	4,849.38	2,892.55	595.67	1,361.17
3	5,450.85	3,246.67	669.03	1,535.15	3	4,864.20	2,894.45	597.12	1,372.63
4	5,445.62	3,240.20	675.35	1,530.07	4	4,850.93	2,892.58	602.17	1,356.18
5	5,445.12	3,241.83	669.35	1,533.93	5	4,849.83	2,899.80	591.47	1,358.57
6	5,451.02	3,245.43	669.10	1,536.48	6	4,845.00	2,885.48	598.92	1,360.60
7	5,470.52	3,262.08	676.82	1,531.62	7	4,841.95	2,887.12	596.20	1,358.63
8	5,445.38	3,254.20	668.92	1,522.27	8	4,857.67	2,895.32	601.43	1,360.92
9	5,461.47	3,257.05	674.33	1,530.08	9	4,855.33	2,892.53	597.38	1,365.42
10	5,458.15	3,250.43	669.63	1,538.08	10	4,841.38	2,896.67	593.28	1,351.43
11	5,477.93	3,269.30	675.35	1,533.28	11	4,850.62	2,889.37	594.10	1,367.15
12	5,454.27	3,247.75	672.87	1,533.65	12	4,847.62	2,887.03	592.13	1,368.45
13	5,459.18	3,256.82	672.67	1,529.70	13	4,852.23	2,888.90	596.88	1,366.45
14	5,139.43	3,074.32	628.73	1,436.38	14	4,745.00	2,830.43	580.53	1,334.03
Average	5,426.25	3,235.92	667.78	1,522.55	Average	4,838.66	2,885.27	594.23	1,359.17
50% Load Level - 61 BSUs					10% Load Level - 12 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
1:23:38	1:28:39	0-4	0:05:01		1:38:42	1:43:43	0-4	0:05:01	
Start-Up/Ramp-Up					Start-Up/Ramp-Up				
Measurement Interval					Measurement Interval				
<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	3,066.70	1,828.85	378.15	859.70	0	602.75	361.03	71.82	169.90
1	3,044.00	1,811.17	375.85	856.98	1	599.83	356.98	73.83	169.02
2	3,047.98	1,815.22	373.72	859.05	2	603.67	359.00	74.60	170.07
3	3,050.07	1,817.20	374.38	858.48	3	593.07	349.35	74.52	169.20
4	3,058.80	1,821.38	377.88	859.53	4	601.58	359.12	74.53	167.93
5	3,048.42	1,813.87	377.20	857.35	5	600.20	352.98	74.35	172.87
6	3,046.52	1,818.07	374.45	854.00	6	599.78	355.83	73.68	170.27
7	3,048.10	1,816.90	375.58	855.62	7	601.80	359.63	73.33	168.83
8	3,050.07	1,818.88	373.18	858.00	8	597.85	353.32	72.40	172.13
9	3,066.35	1,827.28	378.78	860.28	9	597.33	356.62	72.95	167.77
10	3,047.73	1,820.07	374.18	853.48	10	598.63	357.98	71.28	169.37
11	3,047.05	1,810.57	372.55	863.93	11	599.90	355.95	73.27	170.68
12	3,059.52	1,826.95	377.08	855.48	12	598.43	355.10	74.60	168.73
13	3,050.70	1,814.03	378.47	858.20	13	603.42	359.75	72.10	171.57
14	3,046.07	1,811.60	377.05	857.42	14	586.02	348.73	71.72	165.57
Average	3,051.05	1,817.82	375.85	857.38	Average	598.34	355.59	72.97	169.78

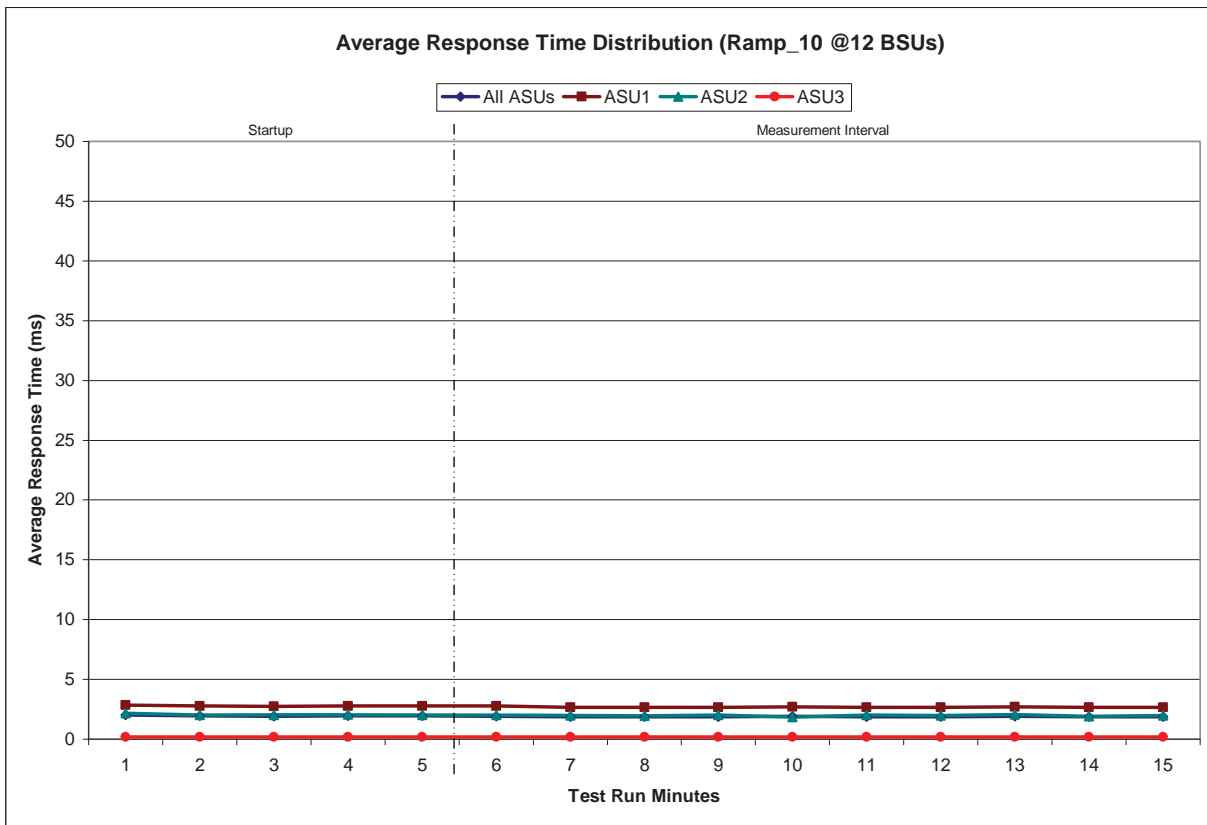
Response Time Ramp Distribution (IOPS) Graph



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

12 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	1:38:42	1:43:43	0-4	0:05:01
	1:43:43	1:53:43	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.01	2.85	2.16	0.17
1	1.94	2.77	2.00	0.17
2	1.92	2.72	2.03	0.17
3	1.93	2.75	2.05	0.17
4	1.95	2.76	2.00	0.17
5	1.92	2.76	2.00	0.17
6	1.87	2.66	1.99	0.17
7	1.88	2.67	1.94	0.17
8	1.86	2.65	2.02	0.17
9	1.89	2.71	1.84	0.17
10	1.88	2.67	2.00	0.17
11	1.88	2.67	1.97	0.17
12	1.91	2.70	2.04	0.17
13	1.86	2.66	1.90	0.17
14	1.88	2.67	1.98	0.17
Average	1.88	2.68	1.97	0.17

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	0.0352	0.2793	0.0702	0.2097	0.0179	0.0693	0.0348	0.2838
COV	0.027	0.007	0.019	0.010	0.039	0.018	0.028	0.009

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	6,065.96
Repeatability Test Phase 1	6,100.15
Repeatability Test Phase 2	6,10100

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	1.88 ms
Repeatability Test Phase 1	1.86 ms
Repeatability Test Phase 2	1.89 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).

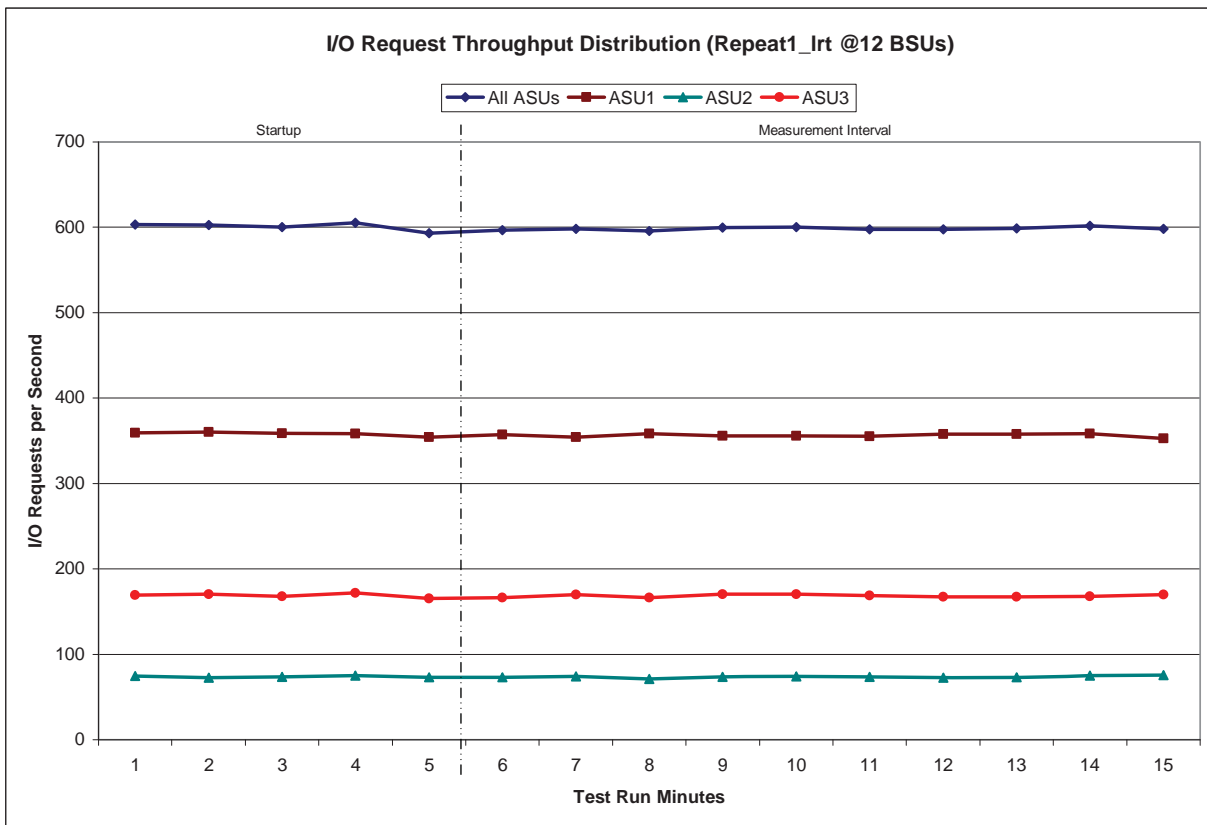
A link to the test result file generated from each Repeatability Test Run is listed below.

- [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

12 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	1:53:48	1:58:48	0-4	0:05:00
<i>Measurement Interval</i>	1:58:48	2:08:48	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	603.13	359.18	74.65	169.30
1	602.85	360.12	72.35	170.38
2	600.12	358.62	73.62	167.88
3	605.32	358.42	75.18	171.72
4	593.13	354.32	73.27	165.55
5	596.58	357.18	73.28	166.12
6	598.40	354.20	74.20	170.00
7	595.60	358.20	71.27	166.13
8	599.75	355.87	73.65	170.23
9	600.37	355.88	73.98	170.50
10	597.60	355.50	73.37	168.73
11	597.53	357.58	72.80	167.15
12	598.72	357.93	73.28	167.50
13	601.63	358.50	75.15	167.98
14	597.97	352.67	75.65	169.65
Average	598.42	356.35	73.66	168.40

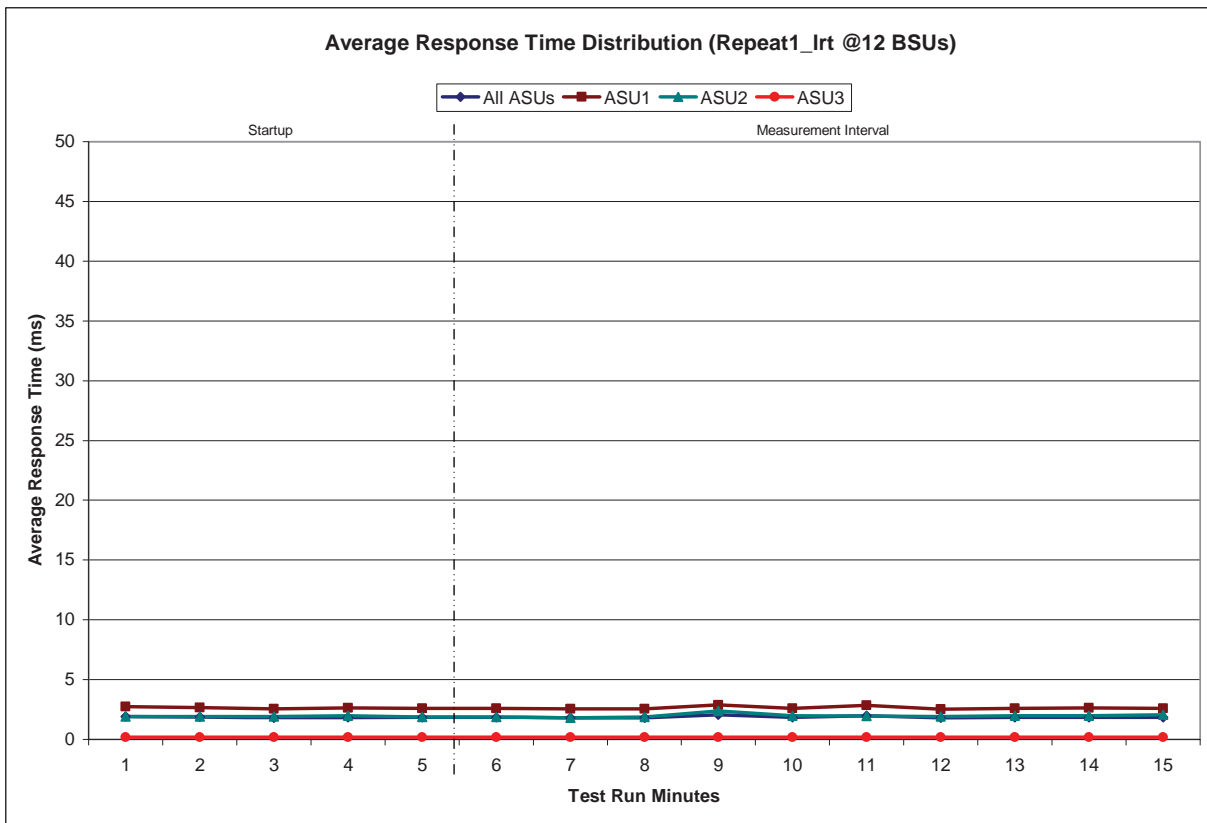
Repeatability 1 LRT - I/O Request Throughput Distribution Graph



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

12 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	1:53:48	1:58:48	0-4	0:05:00
<i>Measurement Interval</i>	1:58:48	2:08:48	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.91	2.73	1.92	0.18
1	1.88	2.68	1.91	0.17
2	1.81	2.56	1.91	0.18
3	1.85	2.62	1.98	0.17
4	1.82	2.59	1.86	0.17
5	1.83	2.59	1.89	0.18
6	1.79	2.56	1.79	0.19
7	1.81	2.55	1.89	0.18
8	2.05	2.87	2.38	0.18
9	1.82	2.58	1.99	0.18
10	1.98	2.85	1.95	0.17
11	1.80	2.53	1.91	0.18
12	1.83	2.58	1.97	0.18
13	1.85	2.61	1.96	0.17
14	1.83	2.57	2.07	0.17
Average	1.86	2.63	1.98	0.18

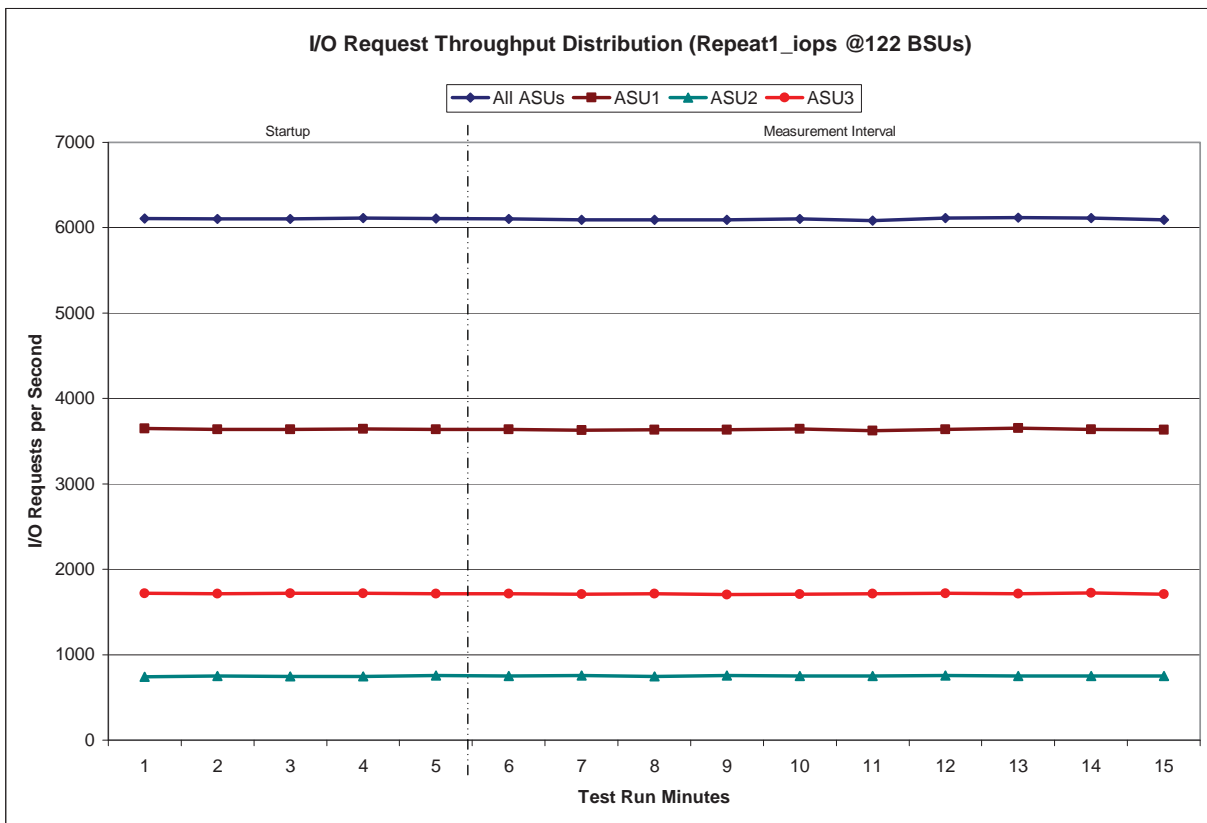
Repeatability 1 LRT -Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS - I/O Request Throughput Distribution Data

122 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	2:09:51	2:14:52	0-4	0:05:01
<i>Measurement Interval</i>	2:14:52	2:24:52	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6,107.25	3,648.88	740.43	1,717.93
1	6,100.85	3,637.67	752.07	1,711.12
2	6,101.30	3,637.07	747.00	1,717.23
3	6,111.98	3,645.38	746.42	1,720.18
4	6,108.45	3,637.38	756.02	1,715.05
5	6,102.47	3,640.80	750.17	1,711.50
6	6,093.72	3,628.45	754.47	1,710.80
7	6,091.83	3,633.33	746.52	1,711.98
8	6,090.37	3,631.12	753.62	1,705.63
9	6,101.72	3,641.63	751.27	1,708.82
10	6,084.73	3,622.67	750.32	1,711.75
11	6,114.55	3,638.92	755.58	1,720.05
12	6,115.92	3,651.57	753.13	1,711.22
13	6,112.68	3,636.97	752.07	1,723.65
14	6,093.50	3,634.97	751.15	1,707.38
Average	6,100.15	3,636.04	751.83	1,712.28

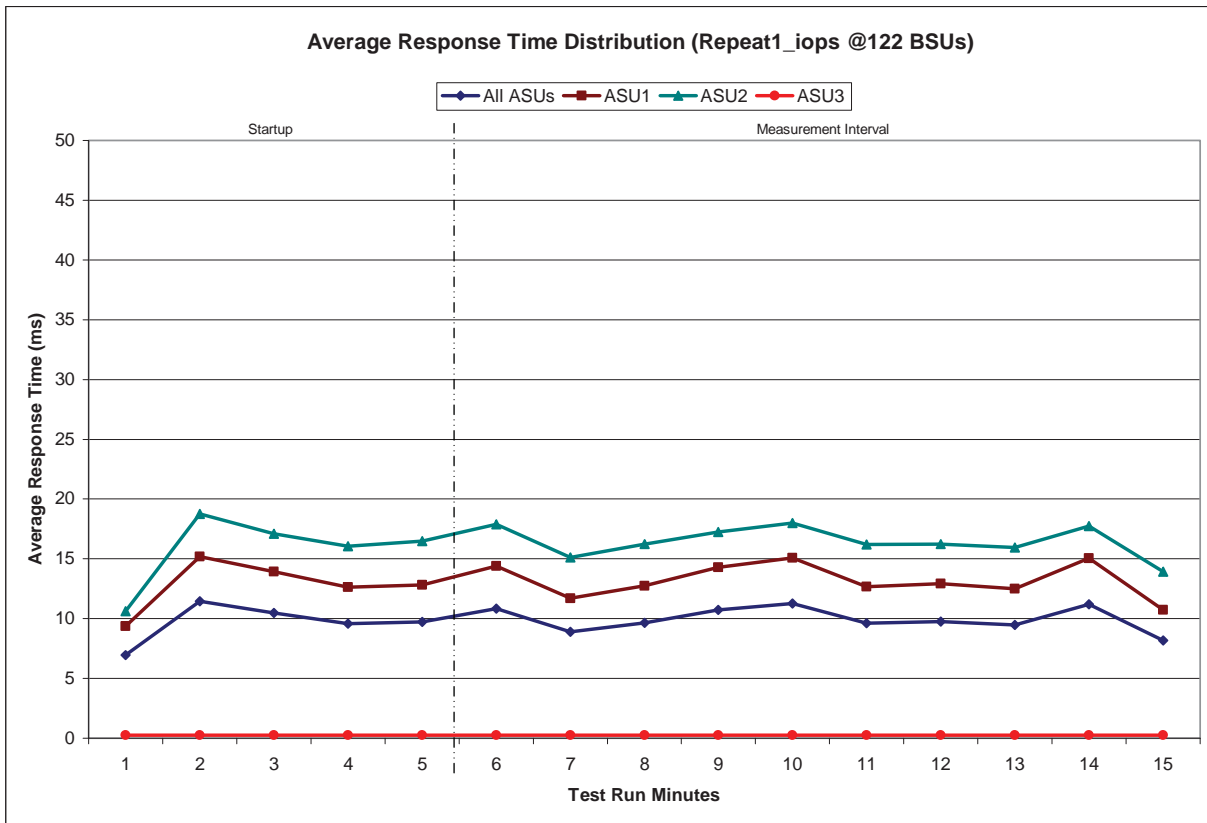
Repeatability 1 IOPS - I/O Request Throughput Distribution Graph



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

122 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	2:09:51	2:14:52	0-4	0:05:01
	2:14:52	2:24:52	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6.95	9.36	10.64	0.24
1	11.45	15.20	18.76	0.24
2	10.47	13.93	17.10	0.24
3	9.56	12.63	16.07	0.24
4	9.73	12.80	16.48	0.25
5	10.85	14.39	17.91	0.24
6	8.90	11.69	15.10	0.24
7	9.66	12.74	16.22	0.24
8	10.72	14.29	17.25	0.24
9	11.28	15.07	18.00	0.25
10	9.62	12.69	16.18	0.24
11	9.77	12.93	16.25	0.24
12	9.48	12.48	15.94	0.24
13	11.20	15.03	17.76	0.24
14	8.18	10.73	13.92	0.24
Average	9.97	13.20	16.45	0.24

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

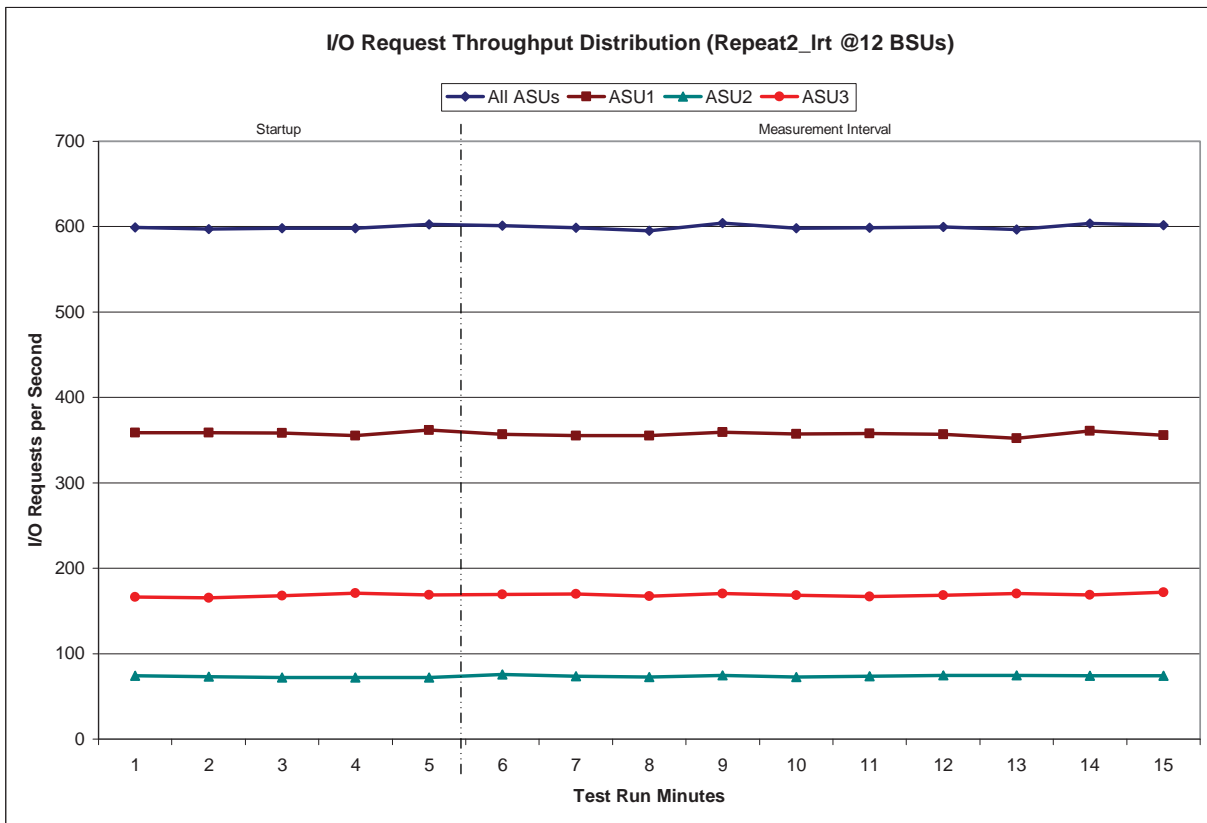


Repeatability 2 LRT - I/O Request Throughput Distribution Data

12 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	2:25:58	2:30:58	0-4	0:05:00
<i>Measurement Interval</i>	2:30:58	2:40:58	5-14	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	599.08	358.67	74.15	166.27
1	597.15	359.00	72.98	165.17
2	597.98	358.13	71.87	167.98
3	598.28	355.15	72.17	170.97
4	602.50	361.77	71.92	168.82
5	601.38	356.78	75.40	169.20
6	598.83	355.22	73.78	169.83
7	595.37	355.35	72.70	167.32
8	604.17	359.15	74.48	170.53
9	598.28	357.52	72.65	168.12
10	598.57	357.98	73.73	166.85
11	599.72	356.60	74.73	168.38
12	596.85	352.05	74.65	170.15
13	603.85	360.82	74.08	168.95
14	601.92	355.97	74.28	171.67
Average	599.89	356.74	74.05	169.10

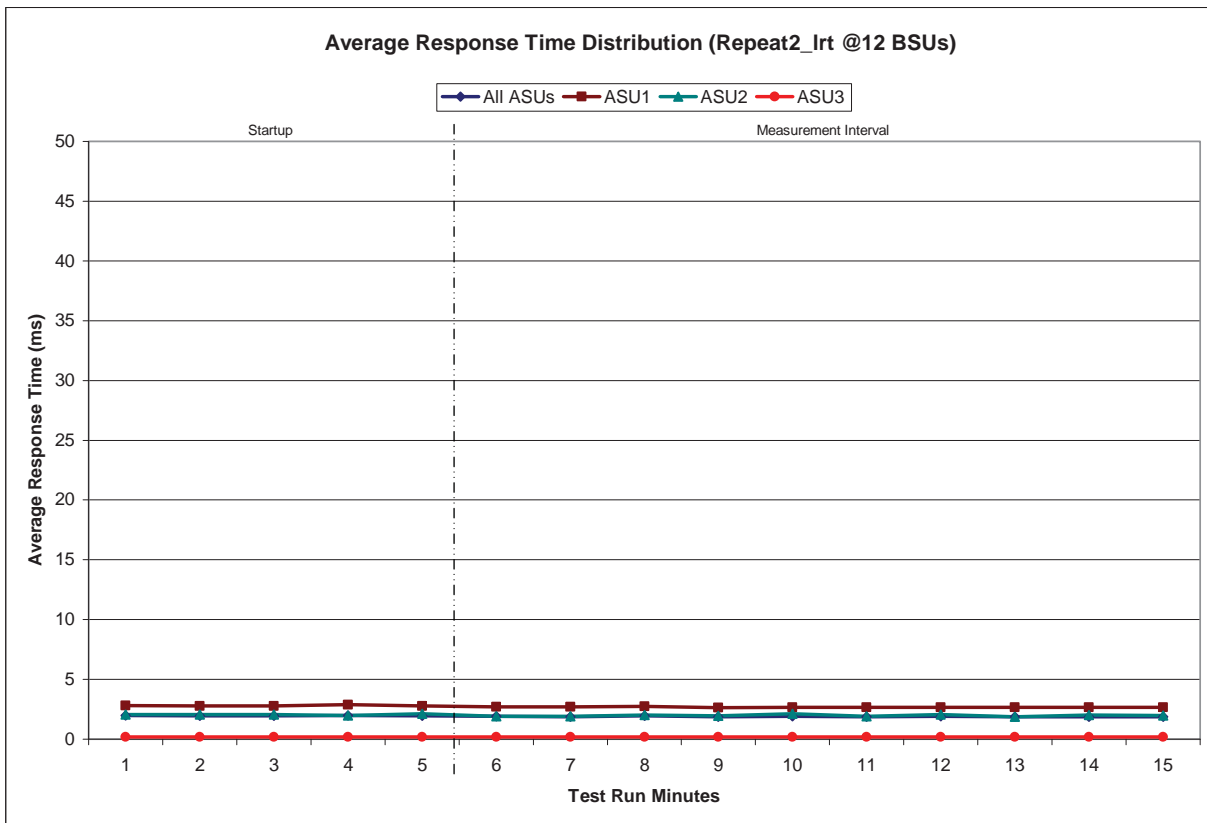
Repeatability 2 LRT - I/O Request Throughput Distribution Graph



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

12 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	2:25:58	2:30:58	0-4	0:05:00
	2:30:58	2:40:58	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.98	2.79	2.06	0.18
1	1.96	2.77	2.04	0.18
2	1.95	2.77	2.03	0.18
3	1.99	2.87	2.00	0.17
4	1.96	2.76	2.13	0.18
5	1.90	2.71	1.91	0.18
6	1.88	2.70	1.89	0.18
7	1.93	2.74	2.03	0.18
8	1.86	2.64	1.95	0.18
9	1.90	2.67	2.12	0.18
10	1.88	2.67	1.91	0.18
11	1.89	2.67	2.06	0.18
12	1.87	2.68	1.88	0.18
13	1.88	2.65	2.01	0.18
14	1.86	2.65	1.97	0.18
Average	1.89	2.68	1.97	0.18

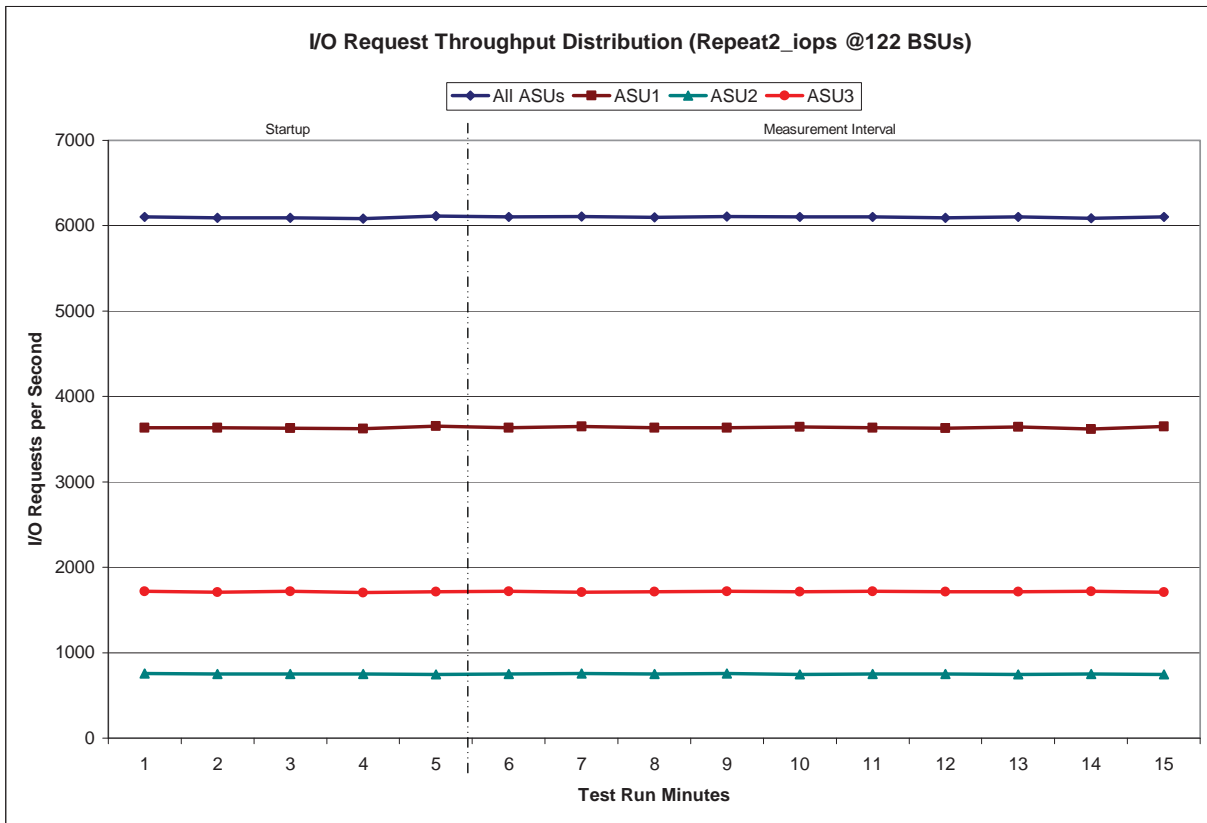
Repeatability 2 LRT -Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS - I/O Request Throughput Distribution Data

122 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:42:01	2:47:02	0-4	0:05:01
Measurement Interval	2:47:02	2:57:02	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6,102.90	3,631.05	755.73	1,716.12
1	6,093.20	3,631.85	752.67	1,708.68
2	6,095.10	3,626.02	752.65	1,716.43
3	6,080.57	3,625.95	753.20	1,701.42
4	6,113.47	3,651.27	747.50	1,714.70
5	6,102.20	3,634.45	748.70	1,719.05
6	6,110.27	3,646.23	756.63	1,707.40
7	6,097.87	3,634.60	748.85	1,714.42
8	6,108.70	3,634.23	754.50	1,719.97
9	6,102.42	3,643.03	747.28	1,712.10
10	6,102.32	3,632.52	748.93	1,720.87
11	6,094.82	3,629.73	753.33	1,711.75
12	6,101.32	3,645.08	744.63	1,711.60
13	6,087.13	3,618.77	751.00	1,717.37
14	6,102.97	3,648.20	747.75	1,707.02
Average	6,101.00	3,636.69	750.16	1,714.15

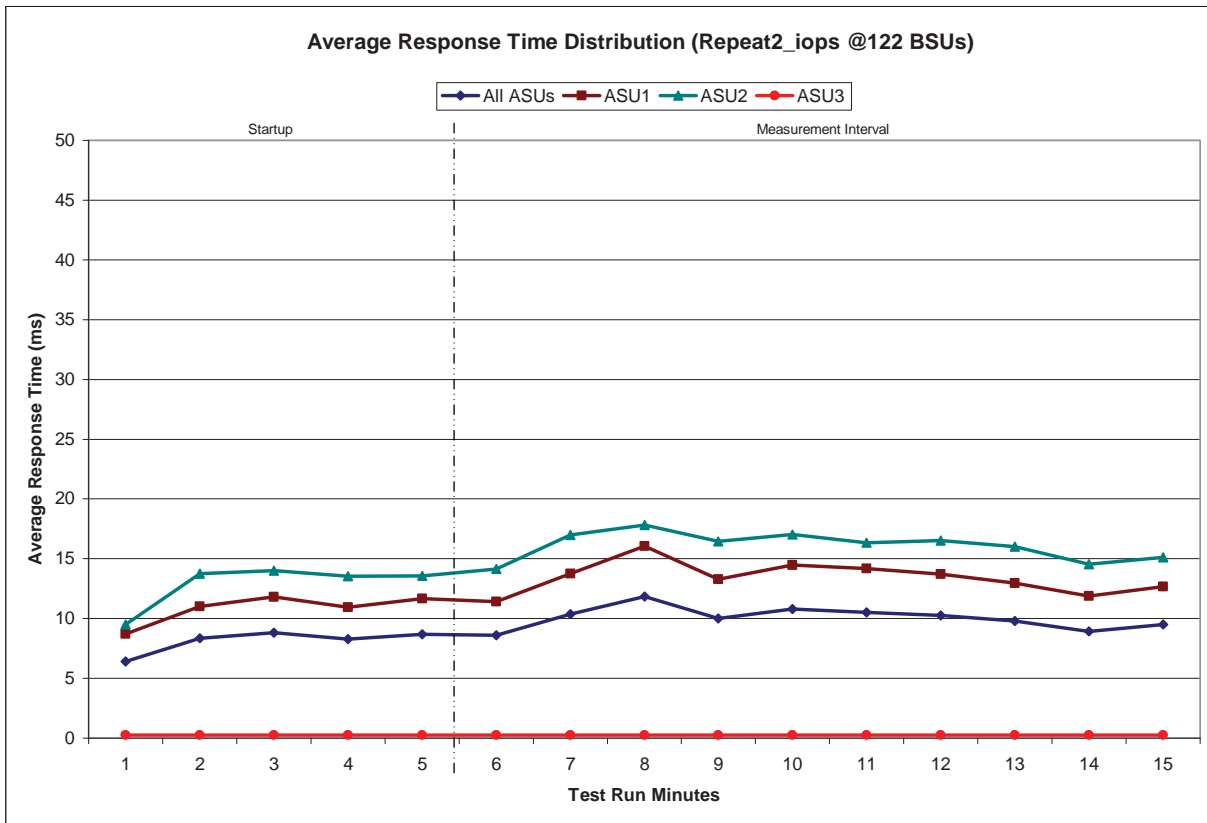
Repeatability 2 IOPS - I/O Request Throughput Distribution Graph



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

122 BSUs Start-Up/Ramp-Up Measurement Interval	Start 2:42:01 2:47:02	Stop 2:47:02 2:57:02	Interval 0-4 5-14	Duration 0:05:01 0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6.42	8.70	9.52	0.24
1	8.34	11.02	13.77	0.24
2	8.81	11.79	14.02	0.24
3	8.27	10.95	13.54	0.24
4	8.68	11.65	13.57	0.24
5	8.59	11.40	14.13	0.24
6	10.38	13.75	17.00	0.24
7	11.83	16.06	17.80	0.24
8	9.99	13.27	16.44	0.24
9	10.80	14.49	17.01	0.24
10	10.52	14.19	16.34	0.24
11	10.27	13.70	16.54	0.24
12	9.77	12.98	16.02	0.24
13	8.93	11.89	14.54	0.24
14	9.50	12.68	15.11	0.24
Average	10.06	13.44	16.09	0.24

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	0.0344	0.2794	0.0701	0.2116	0.0183	0.0695	0.0352	0.2814
COV	0.032	0.008	0.016	0.007	0.036	0.016	0.030	0.008

**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	0.0351	0.2811	0.0701	0.2098	0.0180	0.0702	0.0351	0.2807
COV	0.008	0.002	0.005	0.003	0.012	0.005	0.007	0.003

**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	0.0349	0.2810	0.0703	0.2093	0.0181	0.0699	0.0354	0.2819
COV	0.031	0.007	0.020	0.009	0.029	0.013	0.025	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	0.0305	0.2810	0.0699	0.2103	0.0180	0.0699	0.0351	0.2810
COV	0.011	0.002	0.007	0.002	0.015	0.005	0.009	0.003

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	14,347,552
Total Number of Logical Blocks Verified	13,956,688
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 (600 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 (600 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.

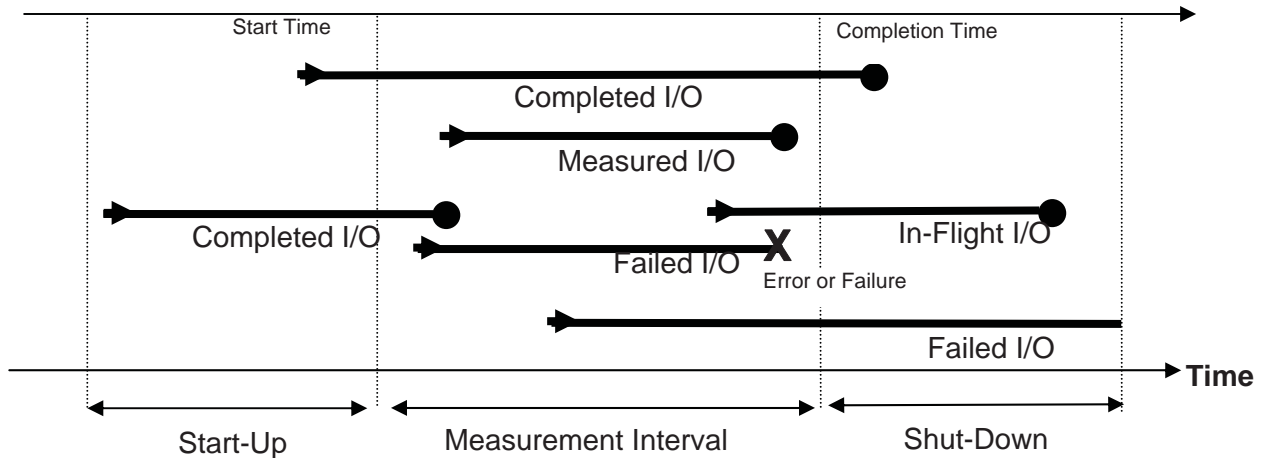
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

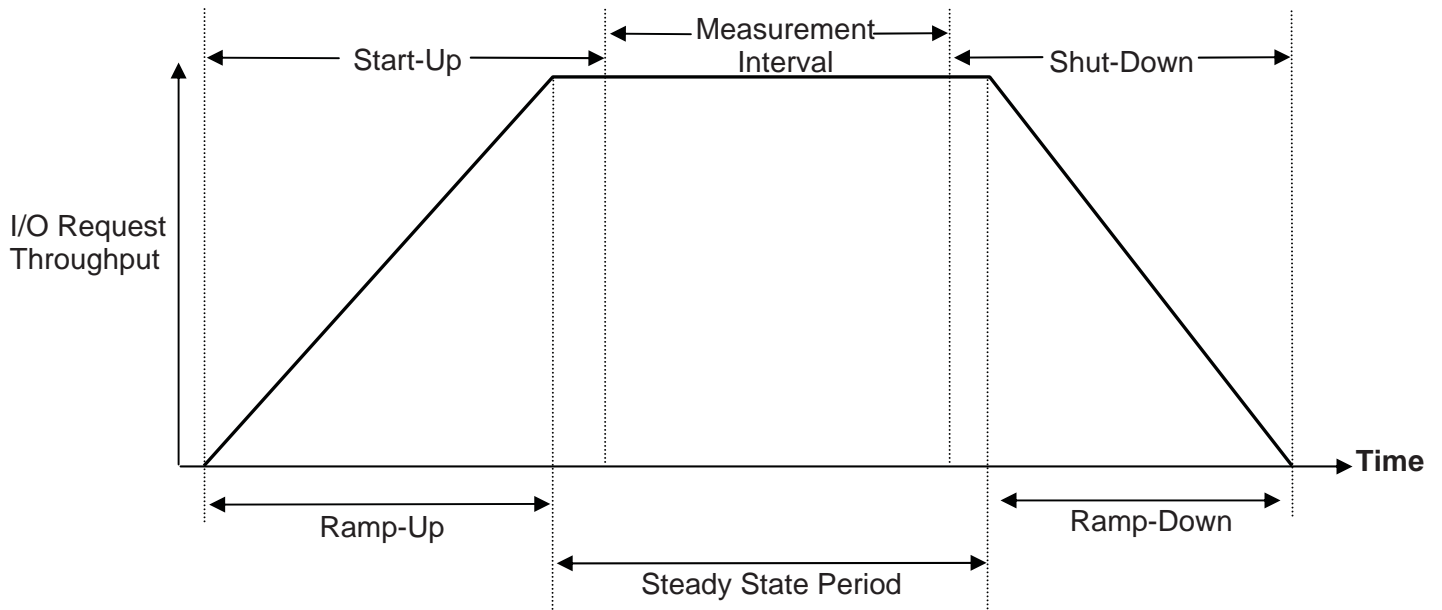
period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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.

SPC11-600.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 2100001B3200A4E8
2101001B3220A4E8"
#
# Now create 6 Raid-1 LUNs, alternating between DiskPacs.
# ASU 1 & ASU 2 are 972 GiB for each half (1944 GiB total per ASU)
# AUS 3 is 216 GiB for each half (432 GiB total)
#
/bin/nseash -c "create --volume=ASU1_1 --size=972 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=ASU1_2 --size=972 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=ASU2_1 --size=972 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=ASU2_2 --size=972 --raid1 --pool2 --write-back"
/bin/nseash -c "create --volume=ASU3_1 --size=216 --raid1 --pool1 --write-back"
/bin/nseash -c "create --volume=ASU3_2 --size=216 --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=bb398
set ISE_MAC=00:1F:93:00:03:8E
set /a BSU = 122
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 10800 -r 600
java -Xmx640m -Xms640m repeat1 -b %BSU% -s 300 -t 600
java -Xmx640m -Xms640m repeat2 -b %BSU% -s 300 -t 600
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
```